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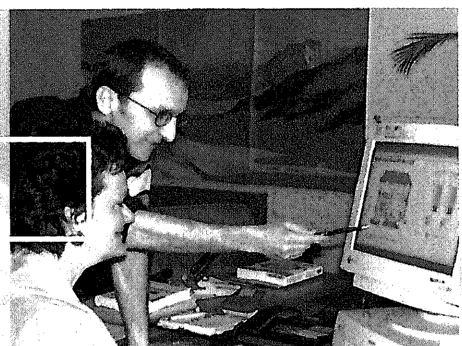
# Modeling



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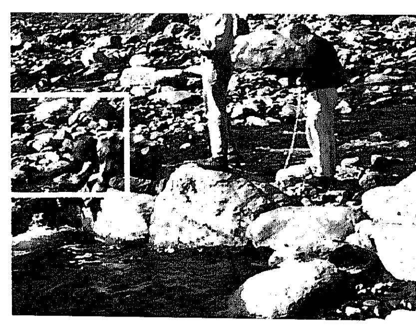

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# EAWAG news – The Bridge to the Outside World

In these times of change communication becomes more and more important, and EAWAG news is putting on a new face. Its basic qualities will be preserved, while it is made more open and more user-friendly. A makeover of its slightly antiquated layout is part of the renewal; we also plan to publish three issues, instead of two, per year.

EAWAG news is an important link to the "outside" world. It is targeted to professionals in the field of water science and technology, to consulting companies, government agencies, industry, and non-governmental organizations and entities. At the same time, it should also be of interest to scientists in Switzerland and abroad. All of our partners have a right to be informed about EAWAG's activities and the progress made in our research. Information is, in fact, the main purpose of EAWAG news. Highly specific scientific and technical needs, however, are beyond the scope of this publication, which has a readership with a broad spectrum of interests. EAWAG offers other products as well, including scientific publications, technical reports, expert knowledge, methods, models, and courses. It is the function of EAWAG news to open doors to these resources, and it is to do so at an appropriate technical level, both in terms of content and presentation.

Each future issue will deal with a certain theme or topic. It has been our experience that issues which focus on a certain topic have been especially appreciated by our audience and will, therefore, have more impact. A lead article will summarize the current status of a certain topic or problem area; research directions which are currently being pursued will be discussed as well as varying opinions about the topic from within EAWAG. Three to five contributions from research, consulting and teaching will illustrate various aspects of the topic. Under the heading of "Forum", our external partners will have a place to comment on EAWAG's activities and to enter into a dialogue with EAWAG, This will also be a place to highlight important achievements and major events at EAWAG. The category "In Brief" will list information on events, meetings, and new products available at EAWAG.

Models and simulation software play an increasingly important role in water management. The current issue of EAWAG news is devoted to this topic. In particular, I would like to point out the interview with Ernst Basler, a prominent expert in the analysis of growth problems and a long-time companion of EAWAG. I hope you find enjoyment and stimulation in reading the "new" EAWAG news, and I encourage you to pass on any ideas or suggestions you may have for improving our institute publication. We are looking forward to more two-way traffic across the bridge that EAWAG news represents.

Ueli Bundi

**Ueli Bundi**
**Vice-Director of the EAWAG**

# How can Models Contribute to Environmental Decisions?

**Decisions relating to environmental protection and sustainable resource use have to be made on an ever broader basis. Tools to compare and evaluate the various options and scenarios are, therefore, becoming ever more important. Models can play a critical role in this process.**

How do we appropriately deal with acid rain, low capacities in waste incineration plants, increasing temperatures in a stream? The more complex an environmental problem is, the more diverse and complicated are the strategies for its solution. We would like to demonstrate in this article how models (the central theme of this issue of EAWAG news), together with methods borrowed from decision-making theory, can assist in solving these problems. Already structuring the decision process in appropriate sub-decisions can clarify the causes of differences in opinion between interested parties and facilitate the process of finding a solution. In order to illustrate the contribution models can make in the decision-making process, we first need to discuss how models can improve our understanding of complex systems. This will be followed by a few examples of models used in research and in practical applications. At the end of the discussion, we will return to the decision process.

## Understanding = Modeling

In order to assess the consequences of a certain management strategy, one has to have a detailed understanding of the structure and function of the system to be managed. This knowledge is translated into an abstract reproduction of the system, a model. Models are a crucial element in science. Predictions about system behavior are almost always based on models. In a strict sense, predictions can only be made for the behavior of the model, not that of the system. The quality of the prediction depends on how accurately the model represents the real system. The more the model predictions can be shown to describe actual system behavior, the higher the confidence that all of the relevant mechanisms of a system are represented in the model, and that the system is understood. Since environmental systems are inherently complex, any model will be a more or less simplified representation of the actual system. The requirement is, however, that all of the relevant aspects of a system are recognized and described in adequate detail. The intended application of the model, therefore, determines to a large extent the choice of the model. For these reasons already the choice of the model depends on the judgements of the involved scientists, which often involves subjective decisions. Development of a model can be performed in the form of an intensive dialogue between participants, which we refer to as model moderation. The complexity of the model will depend on the complexity of the system to be described as well as the questions the model is expected to answer. The spectrum extends from relatively simple qualitative concepts to complicated mathematical constructs (see box on p. 4: examples of different types of mathematical models). Figure 1 shows the graphic user interface for AQUASIM, a simulation and data analysis software package developed at EAWAG.

## Areas of Model Application

The following discussion is dedicated to the most important areas in which models are applied; namely, identification, prediction and communication.

### a) Identification

"Identification" represents the determination of the structure of a system as well as the way the individual parts function as a whole; it is the scientific description of a system. In the context of modeling, the task is to find the simplest model which will reproduce all of the observed system properties. Figure 2 illustrates "process identification" using the lake model described in the article by Martin Omlin (p. 7). Shown are measured and calculated concentrations of nitrate ($NO_3^-$) and phosphate ($PO_4^{3-}$) as a function of depth in Lake Zurich. The results from three different models of increasing complexity are plotted. It can be seen that a more complex system description predicts nitrate and phosphate concentrations which are closer to the observed values. Allowing the phosphorus content of algae to be variable (i.e., lower phosphorus content of algae growing in the presence of lower ambient phosphate concentrations) results in a better description of the concentration profile for nitrate. Adding another process, namely phosphate adsorption on settling particles, results in better reproduction of the phosphate profile. The reason for the better description of nitrate behavior lies in the fact that algae can actually form more biomass with the available phosphorus, thus removing more nitrate from the epilimnion, the uppermost layer of the lake. Phosphate adsorption on settling particles can explain the relatively low phosphate concentration between 15 and 35 meters depth, where algal growth is not possible because of the lack of light penetration. The model suggests the presence of a phosphate-removing process, but cannot explain what biochemical processes might be at work. This process has been studied in detail by René Gächter and his group at EAWAG.

### b) Prediction

The purpose of "prediction" is to project the future behavior of a system as accurately as possible. With the exception of simple extrapolation models, predictive models are typi-

## System – Model – Simulation Program

**The terms system, model and simulation program are often not defined very clearly. In particular, a simulation program is often referred to as a "model" or a "computer model". It is useful, however, to make a clear distinction in terminology between the model and the computer code (program) describing it.**

### System
**Part of the environment which is relevant for the problem under consideration (e.g., lake, stream, wastewater treatment plant).**

### Model
**Conceptual representation of a system, possibly, but not necessarily, formulated in mathematical terms (mathematical model).**

### Simulation program
**Computer program used to solve the equations defined in a mathematical model and to present model predictions in numerical or graphical form.**

cally more complex than models which are only used for process identification. The reason for this is that the best possible prediction requires as much detailed information about the system as possible [1]. An example of a model which is used primarily for predictive purposes is that of a wastewater treatment plant, as discussed in the article by Willi Gujer on p. 8. These more complex models cannot be identified using a single data set, but require input from experimental data obtained under various different conditions.

### c) Communication

Mathematically formulated models, both for identification or prediction, have the advantage that their clearly visible structure allows the investigator to observe differences in underlying assumptions. This is important because model predictions are critically dependent on underlying assumptions.

The aspect of communication is discussed in more detail by Daniel Bernasconi in his article on the modeling of urban drainage systems (see p. 9). Other projects described in this issue also have a significant communication component. The models describing wastewater treatment plants presented by Willi Gujer (p. 8), for example, have stimulated discussions about the mechanisms involved in wastewater treatment.

Communication is also important issue for so-called integrated assessment models [2]. In addition to scientific predictions, such models need to provide information for decision-making entities, such as governments, agencies or industry. These models typically describe the complete chain of causality – from the source of the problem (e.g., the combustion of fossil fuels) to the effect of concrete measures (e.g., the reduction of the acitdity of rain achieved by the institution of limits on sulfur emissions). They are not limited to the environmental system, but include the effect of regulatory measures. Due to the extreme complexity of such problems, not every aspect will be covered by solid scientific knowledge; there has to be room for expert opinions and for subjective speculation. Such highly "aggregated" models usually cannot be tested empirically, but rather serve to uncover complex interdependencies and reveal significant gaps in our knowledge of a particular system. It is, therefore, especially important for integrated assessment models to analyze and to convey uncertainties associated with the model predictions.

## Model Predictions Carry Uncertainties

There are different types of uncertainty [3] and, consequently, different approaches for representing it. Important tools for describing uncertainties are scenario or sensitivity analyses. Their purpose is to determine the degree of variability in the model prediction based on changes in input parameters. More elaborate methods involve techniques of probability calculus for the description of uncertainties. An important distinction is made between uncertainties caused by random fluctuations in the system and those stemming from a lack of knowledge on the mechanisms of the system. The two types of uncertainties are described by two different schools of probability theory (Bayesian vs. frequentist statistics; see box insert). Unfortunately, the two schools are entangled in a dispute which, in our opinion, is rather unnecessary. Which statistical approach is more appropriate in a given situation is largely determined by the problem itself; uncertainties caused by random fluctuations should be described by frequentist statistics, while only the Bayesian statistical approach allows us to combine subjective expert opinions with information gained from data. A simple example of such an application is shown in Fig. 3.

## From Model Prediction to Decision

The decision process must weigh and compare the consequences of alternative scenarios based on the predicted system behavior. In a traditional policy advice process, predictions are not clearly distinguished from value judgements. In our opinion, this separation can be achieved by formally including the benefits in the decision-making process. Care must be taken, however, that all of these elements of "decision theory" [5] do not lead to a decision process running on auto-pilot. Predictions, uncertainties and value judgements need to be clearly separated in order to achieve an objective discussion and to identify areas of disagreement. This is particularly important when a large number of interested parties is involved in the decision-making process. Interactive models and simulation programs are especially useful in these kinds of situations as they provide rapid feedback on changes in scenarios or underlying assumptions.

## Involving Society

There are a number of relatively straightforward questions, such as the dimensions of a water supply system or that of a wastewater treatment plant. For more complex problems, however, the goals themselves are often controversial. It is perhaps more fruitful to approach a problem as a system of unknowns and options rather than with one simple question. For example, take the increased frequency of extreme weather events due to climate change. One possible response to increased flooding problems would be the construction of new flood protection or the improvement of existing levies; alternatively, one could sacrifice certain areas to flooding. In these kinds of situations, it is often beneficial to involve responsible parties and government entities at the beginning of the modeling process in order to determine system boundaries and generally acceptable margins for solutions. Boundaries for possible actions are often unnecessarily limited by institutional structures and established procedures. Integrated models are able to represent the behavior of the various actors and allow us to examine new approaches and solutions and to discuss them with all involved parties. Interactive simulation programs are particularly useful because of their immediate feedback and their ability to facilitate multi-dimensional analyses. There

## Examples of different types of mathematical models

### Extrapolation model

**For short-term predictions, simple extrapolation models (trend analyses) often describe the system behavior adequately. These models do not describe the underlying mechanisms. Examples: Water level increases as a function of heavy precipitation; simple estimate of temperature increases due to global climate changes.**

### Equilibrium models

**Equilibrium models are often used when the processes controlling intrinsic system behavior are rapid compared to the rate of change of external parameters. Usually, a set of algebraic equations needs to be solved. Examples: Chemical equilibria; relationship between stream gauge readings and water flow; many economic models (see article by Irene Peters, p. 10).**

### Dynamic models

**The behavior of environmental systems over time is usually described by dynamic models which require the solution of differential equations. Examples: water temperature in mountain streams (see article by Werner Meier et al., p. 6); mixing and dynamics of nutrients in Lake Zurich (Frank Peters et al., Martin Omlin et al., p. 7); models for wastewater treatment plants (Willi Gujer, p. 8); mechanistic climate models.**

## Bayesian versus Frequentist Statistics

**Both schools of statistics use the same generally-accepted basis of probability theory. The difference lies in the way probability theory is applied:**

### Frequentist Statistics

**Probability distributions represent the results of measurements for the limiting case of an infinite number of measurements. All statements based on frequentist statistics are, in principle, testable.**

### Bayesian Statistics

**Probability distributions represent the state of knowledge on the value of a parameter. This "knowledge" not only depends on the parameter itself, but it depends also on the current state of science, or even on the knowledge of an individual researcher. Techniques of Bayesian statistics describe how the uncertainty in knowledge is reduced by additional data.**

still is a lot of room for new applications of these kinds of models.

An example of a prediction which forms the basis for an environmental assessment is discussed in the article by Werner Meier et al. (p. 6). The prediction concerns the temperature changes in a mountain stream as a function of water usage for electricity generation. In the project "Ecoelectricity", the model prediction is used to assess the residual flow regime. In models applied to economic questions, as described in the article by Irene Peters (p. 10), the mathematical formulation of cost-benefit analyses is already widely in use.

## Activities at EAWAG

Despite the fact that models are frequently used at EAWAG, they have been rarely used as a tool in decision-making as discussed in this issue. One of the primary goals of the department "System Analysis, Integrated Assessment and Modeling (SIAM)", which was proposed to be established in EAWAG's reorganization process, is to further develop formal methods of environmental decision making and to apply them to problems which are currently being investigated at EAWAG.

**Claudia Pahl-Wostl**
**is a biochemist working on modeling complex ecological and socio-economic systems. She is developing new methods to structure the dialogue between science and society as a whole.**

**Peter Reichert**
**is a physicist specializing in modeling and system analysis. He works at EAWAG, but is also Lecturer for System Analysis at ETHZ.**

[1] Reichert, P., and Omlin, M., "On the usefulness of overparameterized ecological models", Ecological Modelling 95, 289–299, 1996.

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[5] Laux, H.: "Entscheidungstheorie", 4. Auflage, Springer, 1998.

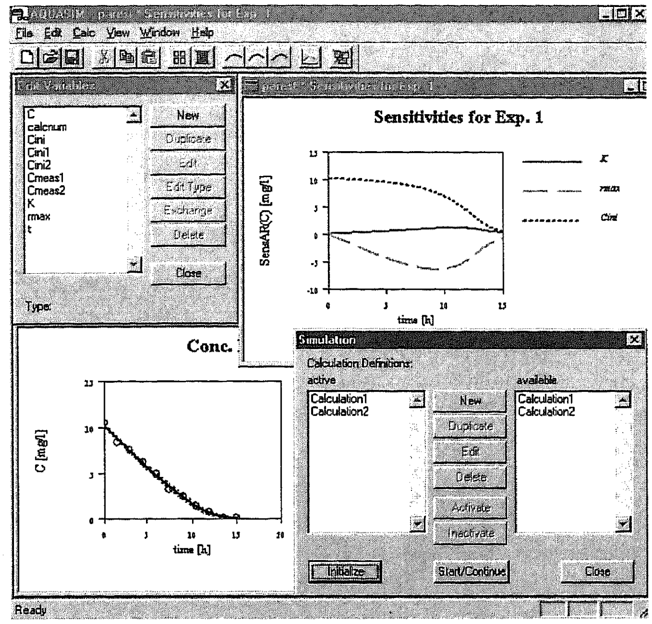



**Fig. 1**
**Sample screen of the user interface for the simulation and data analysis program AQUASIM (see also p. 16). The dialog boxes shown are used to edit model definitions and to initiate a simulation calculation. The graphics windows show the results of a (virtual) degradation experiment: displayed are concentration vs. time (lower left) and the effect of the various model parameters on the calculated concentration (upper right).**

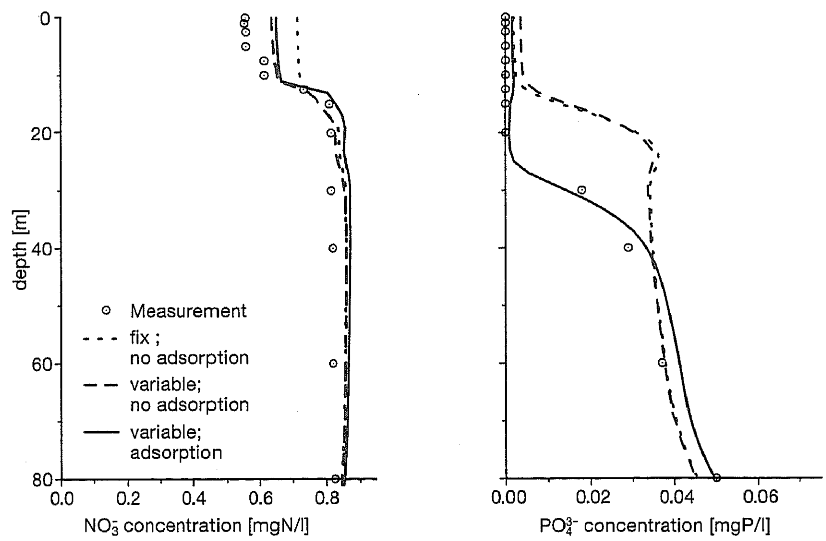



**Fig. 2**
**Measured concentration profile for nitrate and phosphate in Lake Zürich (circles; data from Public Water Supply Zürich) and the calculated results based on three different model assumptions (lines):**
**a) Fixed phosphorus content of algae, no phosphate adsorption by settling particles (short dashes)**
**b) Variable phosphorus content of algae, no phosphate adsorption by settling particles (long dashes)**
**c) Variable phosphorus content of algae, phosphate adsorption by settling particles (solid line)**
**For interpretation, see text.**

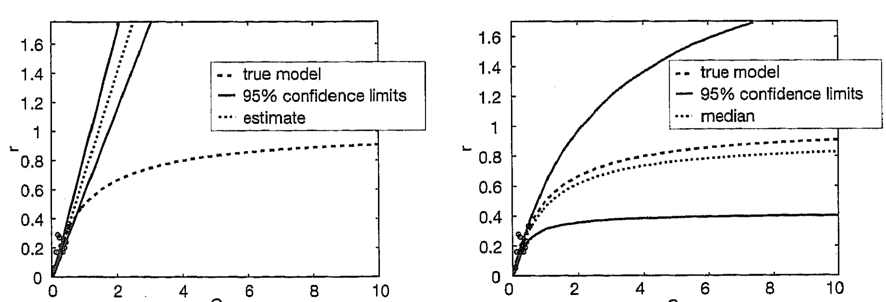



**Fig. 3**
**Synthetic data points (circles), actual values (dashed line) and model prediction (dotted line with confidence intervals as solid lines) for the growth rate of micro-organisms as a function of the concentration, C.**
**Left: extrapolation based on frequentist methods with no additional information incorporated into the model.**
**Right: Bayesian analysis, taking into account prior information about the maximum growth rate. If this growth rate is known with sufficient accuracy, this model yields a far better prediction than the simple extrapolation model [4].**

# Green Hydropower:

## Assessing the Impact of Hydropower Generation on the Temperature of Mountain Streams

**Extraction of water from alpine streams for hydropower generation reduces stream discharge and may impact stream ecology negatively. The project "green hydropower" is quantifying these impacts with the aid of computer models as well as field-based investigations of the physical, chemical and biological systems involved. The resulting knowledge will be used to minimize the ecological impact of hydropower generation.**

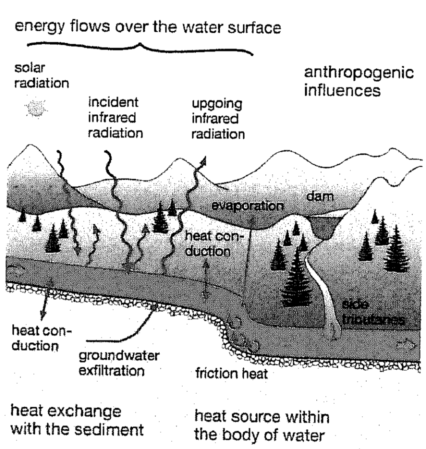



**Fig. 1**
**Simplified depiction of energy flows influencing water temperatures in mountain streams.**

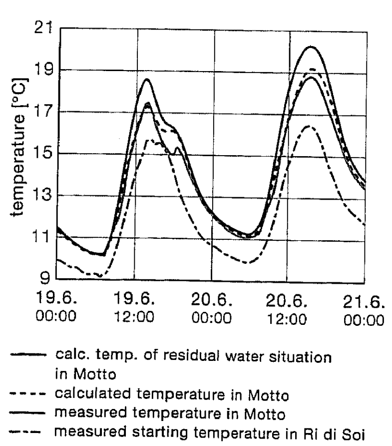



**Fig. 2**
**Measured and modelled water temperatures of a situation with residual water in the Brenno between Ri di Soi and Motto on June 19 and 20, 1998.**
**The water along the four kilometer stretch increases at noon by an additional 1 °C if the water flow is decreased by half.**

The project "green hydropower" ("Ökostrom") [1], in which about 30 EAWAG, as well as other external researchers, are participating, is developing a certification procedure for "green hydropower". Hydroelectric plants which produce their electricity in an environmentally compatible way should be able to sell their so-called "green hydropower" at a higher price. Part of this additional cost paid by consumers will be invested in upgrading aquatic ecosystems. The investigations are being conducted through a case study in the Blenio valley, the watershed of the Brenno River, in the Canton of Ticino.

Several aspects of a river system need to be evaluated for such a certification. One very important parameter in aquatic ecosystems is water temperature.The impact of hydropower on water temperature can be assessed by developing an energy budget for the river system on the basis of model calculations and measurements. The model will be used to optimise efforts to improve an impacted river system's ecological status.

### Models as Tools for Analysis and Prediction

The energy budget model developed in this project takes into consideration all relevant energy flows in a mountain stream (Fig. 1). In order to calibrate the model, measurements of the meteorological and hydraulic properties of the stream as well as its temperature regime are needed. In the Blenio Valley, several tracer experiments were conducted under varying flow conditions. In addition, two weather stations as well as some 35 temperature sensors were installed (see photo* on title page). After entering the data in the model, water temperatures along the stretch being investigated were calculated.

The water temperature of mountain streams is mainly influenced by friction, solar radiation, longwave infrared radiation and heat exchange with the sediment [2]. The first modelling result is that, for steep and shady stream sections, the water temperatures are insensitive to variations in flow rate. In less steep river sections, where solar radiation and heat exchange with the sediment exert a larger influence, temperature is sensitive to flow rate (Fig. 2).

In the future, the model will be used to study transport and chemical reaction of nutrients and pollutants as well as the deposition of particles. These results will also be part of the evaluation process of "green hydropower".

* 2. Photo on title page:
**M. Schurter, W. Meier and P. Reichert installing a temperature monitoring station in the Blenio Valley. Photo: C. Bonjour**

**Werner Meier**
**Environmental scientist and doctoral student at EAWAG**
**in collaboration with**
**Cyrill Bonjour, Michael Schurter, Alfred Wüest and Peter Reichert.**

[1] Truffer B., Bloesch J., Bratrich C. und B. Wehrli (1998): "Ökostrom": Transdisziplinarität auf der Werkbank. GAIA, 7, 26–35; "Green Hydropower", EAWAG news *46E*, p. 27.
[2] Bonjour C. (1998): Modellierung des Wärmeaustausches über die Wasseroberfläche eines Gebirgbachs. Diplomarbeit EAWAG/ETH Zürich.

# A Model of Lake Zürich:

## Today's Research Tool, Tomorrow's Means of Predicting Water Quality

**With the goal of improving our understanding of mixing processes and of time-scale trends in the concentrations of oxygen, nutrients and plankton, both a physical and a biochemical model have been developed for Lake Zürich. The models provide a good description of phenomena observed in the lake.**

The water quality of Lake Zürich is very important to the Water Supply Agency of Zürich (WVZ) because about 70% of the drinking water for the region is obtained from the lake. For the early identification of problems in the quality of raw water from the lake, the WVZ has a water quality monitoring program. The model for the lake that is currently under development should be able to quantitatively describe the essential processes which lead to the dynamics of nutrients, oxygen and plankton in Lake Zürich. At present the emphasis of the modelling is on gaining an understanding of the processes taking place in the lake. An investigation of the predictive properties of the model is also being planned in order to be able to use it in a later phase for forecasting water quality.

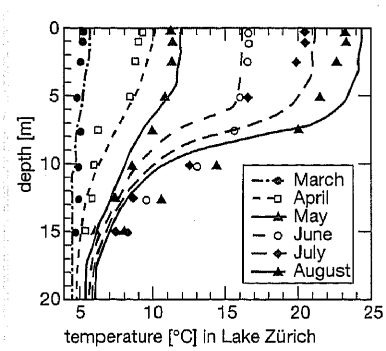
The biochemical model for simulating the dynamics of plankton, nutrients (phosphate, ammonia and nitrate) and oxygen is based on changes in concentrations with time as a result of the effects of vertical mixing, sedimentation, inflow and outflow as well as biochemical transformation processes in the water column and in the sediments. Simulation and measurements of concentrations of algae and phosphate are depicted in Figs. 1 and 2. The sediment layers contain not only the growth and death of plankton but also the aerobic and anoxic mineralization of organic material and the nitrification and uptake of phosphorus by organic particles sinking through the hypolimnion (Fig. 2).

The vertical mixing has to be fed into the model; the results of the physical model can be used for this purpose (see insert by Frank Peeters).

**Martin Omlin**
**Environmental scientist and doctoral student in the Department of Informatics and Systems Analysis at EAWAG**
**Co-author: Peter Reichert**

### Physical Transport Model of Lake Zürich

**Convection (e.g., during the seasonal mixing in autumn) and turbulence induced by the wind are the most important causes of vertical transport of dissolved substances in lakes. Sedimentation is an additional transportation factor for suspended particles. In the physical model, the heat balance and the input of wind energy into the lake are calculated using meteorological data. Subsequently, the fraction of energy converted to turbulent motion is modelled, and turbulent vertical transport is calculated.**
**The physical model was tested by simulating temperatures in Lake Zürich using meteorological data from the Swiss Meteorological Institute (SMA) and temperature data from 1981 (see graph below). Even from a period of only 10 years (1981–1991), the simulated temperatures correlate very well with those measured by the WVZ.**




**Frank Peeters, physicist, PhD, ETH and Gerrit Goudsmit, chemist, PhD, University of Zürich; both at EAWAG, Dept. of Environmental Sciences.**

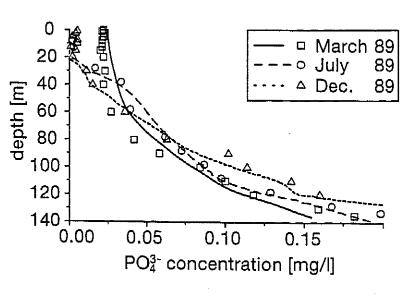



**Fig. 1**
**Modelled (lines) and measured (dots) phosphate concentrations in Lake Zürich in 1989.**
**The decrease of phosphorus from March to July in the uppermost 20 m as a result of algal production shows that algal growth is limited by phosphorus in the lake. Between March and December the concentration of phosphate also decreases to a depth of 40 m and increases correspondingly below 60 m in this time period.**
**This effect is attained in the model using an adsorption process as observed in Lake Sempbach (results from René Gächter's research group, EAWAG, 1995). In this case, inorganic phosphorus is adsorbed to sinking organic particles and transported into the sediment. The mineralization of organic material in the sediment and the desorption of inorganic phosphate causes phosphorus to diffuse from the depths back into the water column.**

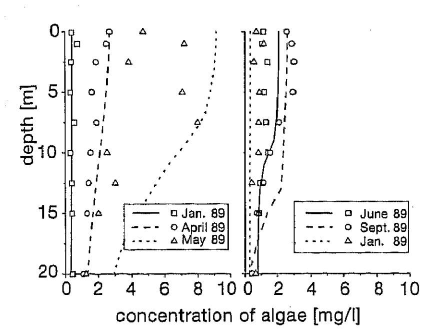



**Fig. 2**
**The concentrations of algae measured (dots) in Lake Zürich in 1989 can be simulated well by the model (lines).**
**At the beginning of the stagnation phase in April, net algal growth begins in the uppermost 20 m. After a maximum in May, the concentration of algae becomes drastically reduced by grazing zooplankton and reaches the summer minimum in June. In the subsequent months, the algae recover until they decrease again towards the end of December due to reduced layering of the water mass.**

# Biological Sewage Treatment – Marked by New Dynamics

**Demanding biotechnological processes are employed in the treatment of today's sewage. The processes have to fulfill several requirements simultaneously under difficult and sometimes marginal conditions, such as daily and seasonal variations in pollutant concentrations and temperature or input of storm water.**

For these reasons, the biological removal of nutrients (organic carbon, nitrogen and phosphorus) requires the use of at least four groups of microorganisms, whose simultaneous enrichment is coordinated in the treatment processes for optimal performance; sewage is an extremely dilute nutrient solution whose composition can only be characterized using compound parameters (CSB); that is, it is not very specific and changes continuously (see Fig. 1).

Technically speaking, this problem is solved using high hydraulic residence times, a complicated process cycle (Fig. 2) and comprehensive control and regulation programs. The design of such processes is mainly based on statistical models (models and calculations which are not able to incorporate time dependence) which are based on experiences in comparable situations. The details of the process are then worked out and optimized using extensive simulations which describe time-dependent phenomena. The controlling program of the system is then designed.

Over the past 20 years, EAWAG has intensively participated in developing the foundations for sucessfully dimensioning and simulating activated sludge systems:

- Through collaboration in the IAWQ (International Association of Water Quality) Task Group on Mathematical Modelling for Design and Operation of Biological Wastewater Treatment, which has developed the models for describing the microbiological and chemical processes in the form of the Activated Sludge Models No 1 to 3 [1–3], the internationally and most widely applied models.
- By developing models for the characterization of different fractions of compounds in wastewater and describe the condition of the processes in the extensive models.
- By making software available for easy testing and application of the developed models and control programs. Over 200 copies of the program ASIM (Activated Sludge SIMulation Program) have been sold to date. ASIM is being used in research, for teaching at many universities and by consulting engineers.
- Through identification of model parameters within the framework of laboratory and industrial scale experiments. Nowadays it is almost impossible to interpret experimental results without the use of mathematical models.
- Through the education of students and practicing engineers. Here the mathematical models have proven to be an excellent medium for transferring knowledge in a structured fashion.

The immense progress which has been achieved in biological sewage treatment over the past several years would not have been possible without such models. Analyses, as well as the transfer and application of research results, would have been stymied due to the wealth of data without the framework provided by the models.

It is now up to the engineers working hands-on to integrate the valuable tools of dynamic simulation in their field and to apply it in a productive manner. Both the corresponding software and the theoretical basics are ready.

**Willi Gujer**
**has been Professor for Urban Water Management at the ETH in Zürich since 1992 but continues to carry out his research at EAWAG. His work focuses both on the mathematical modelling of biological sewage treatment systems and increasingly on a comprehensive approach to urban water management.**

[1] Henze, M., Grady, C.P.L., Gujer, W., Marais, G.v.R, Matsuo, T. (1987): Activated Sludge Model No. 1, IAWQ Scientific and Technical Report, No. 1, IAWQ London, ISSN: 1010-707X.
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[3] Gujer, W., Henze, M., Mino, T. and van Loosdrecht, M. (1999): Activated Sludge Model No. 3, Wat. Sci. Tech. 39:1, 183–193.

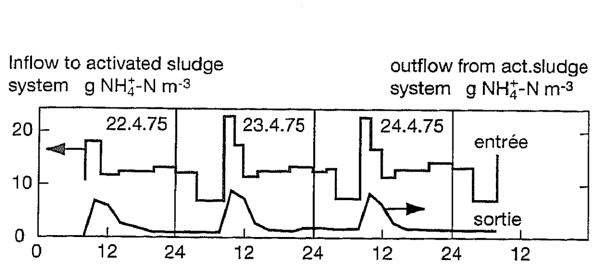



**Fig. 1**
**An example showing how the daily variations in concentrations of pollutants in the influent of a nitrifying activated sludge tank affect concentrations in the effluent. During the morning hours, the productive capacity of the nitrifying bacteria (which degrade ammonium) is routinely exceeded.**

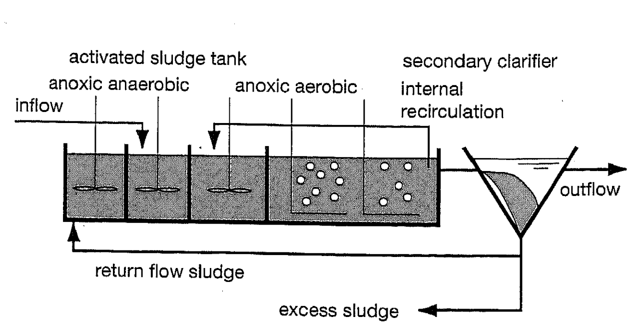



**Fig. 2**
**Example of a flow diagram of an activated sludge tank with biological nutrient removal. The activated sludge tank maintains three different environmental conditions (aerobic, anoxic, anaerobic) and has to be run under appropriate conditions (solids retention time, aeration, etc.) using different sludge flows (recirculation, return flow, excess sludge).**

# Do you know what "Reach" is?

**Communication between different entities involved in urban drainage systems (engineers, communities, associations, cantons) does not typically fail because of technical problems, but because of inconsistent use of terminology which leads to misunderstandings between "sender" and "receiver".**

Even commonly used terms such as "reach" and "Sonderbauwerk" (custom structure, special purpose construction) are being used by different people to mean different things. For example, "Haltung" or "reach" is used to refer to

- the hydraulically homogeneous portion of a canal
- the connecting structure between two shafts
- sections of a canal system which have common structural characteristics.

Such multiple usage causes misunderstandings and unnecessary costs. Planning and management of urban drainage systems will necessarily become ever more integrated and will need to consider the complete water cycle, which is difficult to achieve when subdisciplines in the water management business use incompatible terminology. EAWAG (along with the Swiss Association of Wastewater and Water Protection Experts, VSA) would like to contribute to unification of the conceptual data structure in urban drainage system planning by developing and publishing guidelines for information management [1].

The conceptual data base for urban drainage systems (DSS) is intended to act as a common reference point for experts and organizations in the field of water management and will be designed to be flexible and expandable. The data base will clearly define what structural components "Haltung" or "reach" will refer to, e.g., only the hydraulically homogeneous sections of a canal system, and what physical parameters are needed to describe a "reach" (i.e., materials, diameter, friction coefficient). For the other uses of "Haltung" or "reach", different terms need to be chosen. In the example quoted above, the connection between two shafts will be called "Kanal" (pipe), while a section of a drainage system with common structural characteristics will be referred to as "Strang" (train; see Fig. 1).

## Building the Data Base

Formally defining terms in the way described above leads to a structure which can be used in electronic information transfer and storage [2]. This is of particular interest in an area of interdisciplinary research and planning such as urban water management, since an integrated and consistent data base allows experts from all disciplines (water protection, financial management, system maintenance) to operate on a common data set. Data related to urban water management will no longer be collected and stored by different individuals, in different locations and with different areas of emphasis, but there will be a common framework for the organization and administration of data and information. This will eliminate most of the previous problems in planning ascribed to heterogeneity in data management.

Loss of information: During a transfer of responsibilities within an organization, valuable information can be lost when a new person does not have access to the data base of his or her predecessor, or does not have the background information needed for correct interpretation of data.

Inconsistencies: Because data have been collected by different organizations or offices, they have not been updated consistently, which leads to inconsistencies between the various planning offices.

Work interruptions: Because data are only available locally, questions and clarifications often have to be referred back to other offices or agencies before continuation of a project. Interruptions of days or weeks are common, especially if the requested person is not available.

Poor decisions: Due to a difference in background knowledge, different project managers can come to different conclusions or solutions for the same problem.

## Data Availability

When trying to make a large body of data and information generally accessible and interpretable, a conceptual data base is an indispensable tool. Data modeling as the process leading to a general data base requires that the model is not only a tool of limited applicability and life time, but is laid out as a permanent and durable collection of knowledge. Long-term storage, permanent use and continuing development are critical elements in this process. EAWAG is developing this conceptual data base for water management issues in close cooperation with government and private offices involved in the field.

[1] VSA, "Datenstruktur Siedlungsentwässerung", Verein Schweiz. Abwasser- und Gewässerschutzfachleute, 1999.

[2] Wille, R., "Concept lattices and conceptual knowledge systems", Computer and Mathematics with Applications 23, 1992.

Daniel Bernasconi
Civil Engineer, Practical experience in the area of information technology with Emch and Berger, doctoral dissertation at EAWAG (Diss. ETHZ 12963).

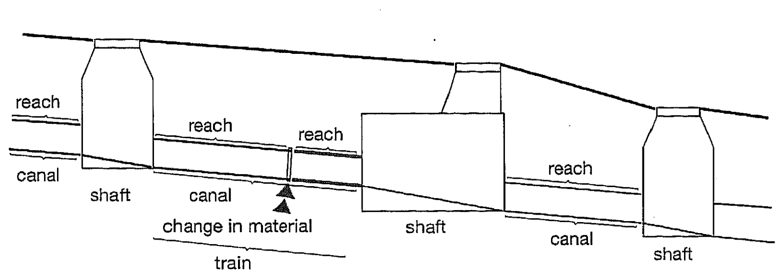
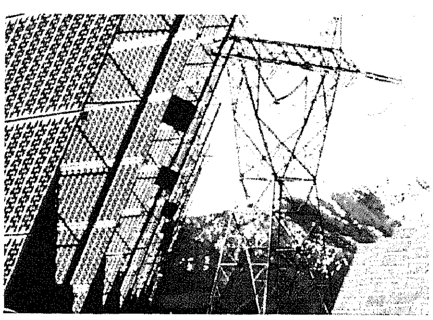


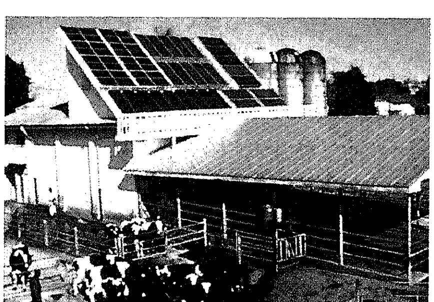

**Fig. 1**
**Data modeling in the planning of urban drainage systems. The term "Haltung" or "reach" has a different meaning depending on the context (see text). In the process of data modeling, the term has to be given a unique and clear definition. The data base will facilitate a more efficient project planning process.**

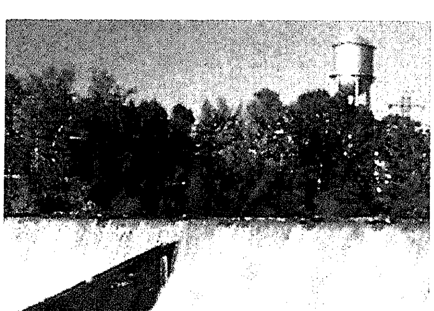
# Environmental policy: Good or bad for economic growth?

**About a year ago, EAWAG embarked on economic modeling. In collaboration with the Tellus Institute in Boston, U.S.A., we constructed a model of the U.S. economy for estimating the economic impacts of a number of energy policies. The aim of this exercise was to highlight the influence of structural model features on model results. We plan to continue this effort, investigating additional model assumptions and extending the focus of the analysis on natural resources other than energy.**

There are literally hundreds of economic models for policy evaluation. Our interest is to take a critical look at current modeling practice and try out new modeling approaches, especially as they pertain to technological change and the impact of economic activities on the natural environment. This is because the type of economy-wide models that have come to dominate policy analysis – Computable General Equilibrium (CGE) models – contain a number of problematic assumptions. They fail to represent a number of phenomena that affect the way in which technological change unfolds. For example:







- When facing decisions, individuals cannot process all the relevant information that exists. They often use "rule-of-thumb" strategies to guide their behavior. This can make their purchasing decisions seemingly irrational, say, when they fail to realize the savings they can obtain from buying energy-efficient appliances.
- Information spreads over time and space; it is not available instantaneously to everyone, everywhere.
- There are positive feedback effects between the diffusion of new technologies and their costs; the costs of a technology tend to fall as users gain experience in handling it and as it matures.

Due to these phenomena, it is not always the best and most efficient technologies that come to dominate in a market, as mainstream economics would have it. These phenomena can indeed call for targeted policy interventions on behalf of certain technologies, if only to compensate for past policy interventions on behalf of others.

Taking explicit account of the above phenomena in economy-wide models such as CGEs may drastically change the results of a modeling analysis. It is possible that policy measures which, according to traditional models, would decrease economic output and employment, are now shown to have positive economic impacts.

Our model is not comparable, neither in detail nor in scope, with many of the current models used for policy evaluation that have been developed and refined over a number of years; however, we have introduced two novel modeling features:

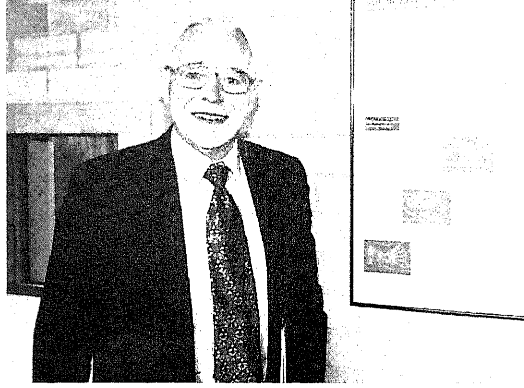
- First, we explicitly represent public infrastructure. In our model, this infrastructure constitutes an input into private production activities and provides a policy lever; i.e., it can be the target of government policies. Most current policy evaluation models treat government expenditures as "consumption".
- Second, investment in energy-efficient technologies yields unexpected side-benefits in the form of productivity increases. This, too, is a phenomenon that is all too well known in the real world, but that is excluded, by assumption, in traditional models.

Both modeling innovations have the same effect: for the policies that we investigated, the model with these new features exhibits a positive impact on overall economic production, whereas the traditional model predicts a negative or, in some cases, a less positive impact of those same policies.

**Irene Peters** is an economist and deals with economic aspects of urban water management and economic modeling in general. Before joining EAWAG in 1997, she worked for many years in the U.S.A., as a consultant on environmental policy issues pertaining to solid waste management, energy, and transportation.

Bernow, S., Peters, S., Rudkevich A., Ruth, M.: A Pragmatic CGE Model for Assessing the Influence of Model Structure and Assumptions in Climate Change Policy Analysis. Tellus Institute/ EAWAG Report, November 1998.

# The Future Lies in a "Spacecraft Economy"



**"I have been shaped by something I recall from my youth. We used to have a dirt road on a slope in front of our house. It was always exciting to watch how the water found its way through the dust."**

## An Interview with Dr. Ernst Basler, Retiring President of the EAWAG Advisory Committee

The environment and the biosphere are central concepts for you. How did you come upon the idea of a "spacecraft economy"?
The concept is meant to draw attention to the growing over-exploitation of finite resources.
In 1969, man first landed on the moon. Many realized at the time that the biosphere is only the thin skin of the earth and that life only functions there. I then decided to make my thoughts known to the public. So the main message of my book is: we are expanding exponentially, but because the earth is a finite system, there is only one option – we must learn to live in a so-called sustainable way. Twenty eight years later, our office had the opportunity to write the draft paper on "Sustainable Development, Action Plan for Switzerland" for the Swiss Federal Council. Today these ideas are becoming general knowledge. And now it is a matter of implementing them...
What has been most important to you in your professional life?
In my everyday working life, I have stepped beyond the bounds of classical civil engineering to include other disciplines; this has led to tensions. We primarily concentrated on whether or not we were solving the right problem – not whether a problem was being solved in the right way. Put another way: "It's better to be roughly right, than exactly wrong". This realization was a turning point in our company.
I would like to allay the ETH's biggest fear by stating that it is better to start approaching neglected problems with modest resources than to pursue irrelevant questions that seem to be in vogue at any one time. In the early 1970s, we formulated many new questions, for example, in the area of traffic planning: What environmental effects does a person or a ton of goods exert when it is transported by road, by rail, by air or water? From an ecological point of view, what is the impact of fragmentation of the landscape through highway construction?
EAWAG has always had a special mission, which was embraced very early on by Werner Stumm and which, in my opinion, is still important to both the ETHZ and EAWAG.
Being on the advisory committee, you supported EAWAG for a decade. What characterizes our institute?
What is so typical of EAWAG is its broad point of view and spectrum of activities. Its narrowly defined mission of the 1950s, the purification of wastewater, has been dramatically expanded to consideration of the water balance of the biosphere and its sustainable management.
In education, EAWAG offers its students interdisciplinarity and the opportunity to work on case studies. EAWAG needed to develop this interdisciplinary approach since the basic sciences alone were unable to solve the urgent, practical problems of the time. EAWAG, in fact, pioneered this approach and created today's arsenal of methods for solving complex environmental problems. This approach has attained a high level of sophistication, though there is still room for expansion and improvement.
What does EAWAG need in the future?
Like any other research institute, I think that EAWAG should have its own profile. But, in my opinion, research is often directed too strongly by popular trends. This imparts the advantage of constant competition, but means that research directions are left to the whims of others who determine what is the newest and hottest area of work.
EAWAG should be guided by the democratic process, which is what the citizens also expect. And it would be wonderful if EAWAG, as well as other other institutions, would serve as an "early warning system", a "lookout station" and sound the alert about danger zones towards which Mankind is moving. We are producing new chemical compounds in increasing amounts, and are developing more new processes.
Society as a whole must undergo a learning process; it needs to dialogue with scientists since they are the first link between science and society. Every piece of scientific work should be scrutinized for its relevance: who can use this information, and how does it contribute to the big picture? Otherwise, the work is incomplete!

**"For one to succeed, it is important to be open to experimentation".**

**Upon completion of his first degree at the ETHZ in 1955, the young civil engineer was invited by the Massachusetts Institute of Technology (MIT) to participate in its Master's degree program. After four intense years in the USA, he returned to Switzerland to continue his education and begin his work in the private sector. He completed his doctorate at the ETHZ in 1960. During a subsequent sabbatical leave at MIT, he focused on questions concerning the biosphere. His work resulted in a book entitled "Strategie des Fortschritts" ("The Strategy of Progress") published by Huber Frauenfeld (1972). The approaches articulated in the book have significantly influenced his work as a civil engineer. In 1980, he established his own company in Zollikon (Ernst Basler + Partners AG). In 1995, he received an honorary doctorate from the ETHZ to acknowledge his many professional achievements.**

Do we still have time for discussion with such rapid changes occurring?
Yes, society can react faster nowadays, thanks to the various means of communication. We live in a very fast-paced time; fortunately, it has become easier to diagnose and solve problems more rapidly.
... even when sacrifices have to be made?
There will always be sacrifices! Unfortunately, something dramatic has to happen for human behavior to change. In my opinion, it is better to reach a limit sooner in order to gain the time needed to change course, rather than gaining time by "building up the rim of the bathtub" and then running into even greater problems.
It is amazing what can be modeled today using information technology. Previously, we were dependent on experimental data or other direct observations. I see it as a powerful new type of x-ray machine that allows us to both see better and see more.
It is up to the succeeding generations to implement the "spacecraft economy" in the next century – feeling their way forward, humanely and step-by-step.
Thank you for this conversation, Dr. Basler!

**(Diana Hornung asked the questions.)**

# Letter to the Editor

## Nutrient Cycles in Urban Water Management

Based on its value as fertilizer, sewage sludge from wastewater treatment plants is by far the most important waste product usable in agriculture. It is the predominant domestic resource for phosphorus and contains significant amounts of nitrogen, calcium and magnesium. Heavy metal concentrations in sewage sludge have dropped significantly over the past 20 years; however, it still contains pollutants at levels that are too high for long-term application. The quality of sewage sludge must improve dramatically before the mandate of sustainability can be satisfied: to protect resources without compromising soil fertility There is always a need for new approaches in the utilization of resources in wastewater. It has been almost 20 years ago since the separate collection of bio-organic fractions for composting was introduced in the processing of household waste, which brought about a fundamental change in direction, demonstrating that even solutions which seem to be right out of Utopia at the time can be realized. Important only is the end result: valuable nutrients, which are currently released into the wastewater stream, need to be used as completely as possible. The pollutant load, which is introduced to soils along with the nutrients, should, however, not exceed the normal export from soils (removal with harvested material, leaching and erosion, degradation).

What measures are most appropriate to reach this goal? Of course, water protection has to have equal weight, and economic and sociopolitical aspects have to be considered. Is it the dry toilet proposed by Tove Larsen, the exclusive use of sewage sludge from wastewater treatment plants, and/or the systematic de-coupling of all major industrial contributors of pollutants? Or does the solution lie somewhere different altogether?

**T. Candinas Anton, Candinas@IUL.admin.ch, Institute for Environmental Protection and Agriculture (IUL), 3003 Bern**

# Network Declining Fish Yields, Switzerland

**EAWAG and SAEFL (Swiss Agency for the Environment, Forests and Landscape) have jointly launched the project "Fischnetz" (Fishing Net) "Netzwerk Fischrückgang Schweiz" (Network Declining Fish Yields, Switzerland). This project examines the causes of the dramatic decline in fish catch in Switzerland's water systems over the past 10 years. Research institutions are jointly investigating with the public and private sector not only the causes and consequences for this decline, but are also developing measures for improvement.**

Parallel to the growing concern of those involved in fisheries over the decline in catch, anomalies in the sexual development of fish, amphibians, reptiles, and other wildlife are increasingly reported worldwide. Effects on humans have also been observed, such as for example a decline in sperm count in men. Evidence suggests that these effects are related to the chronic pollution of the environment with trace elements. This correlation has to be studied in order to establish a basis for developing specific and acceptable measures for improvement.

In particular the effects of the so-called "endocrine disruptors" (pollutants with hormone-like effects or synthetic hormones from medicine) have attracted international attention. This triggered various research projects, such as the EU Project COMPREHEND, in which Switzerland also takes part. It was primarily the decline in fish catch that induced the Swiss fisheries centres and Offices for water pollution control to conduct investigations in various waters.

To accelerate, coordinate and network the Swiss effort, EAWAG and SAEFL have decided to launch a joint project with the cantons and research institutes. In December 1998, an interim directorate in charge of the project officially initiated the project "Fischnetz". An information bulletin, which appears every three to four months, informs on the activities of the project. The first issue of "fischnetz-info" was sent to over 300 interested parties.

The direction of the project "Fischnetz" (professionals from research, the public and private sector) is responsible for its professional management. This executive body is assisted by the managers of the sub-projects, and is itself subordinate to the Steering Committee (Directorates of EAWAG and SAEFL, local governments, Industrial Board for Fisheries, and the chemical industry). The cantons, universities, the private sector and other offices or institutions are requested to report any current or planned projects pertaining to the decline in fish yields to the direction of the project "Fischnetz".

Members of the project's direction:
Karl Fent, Walter Giger, Herbert Guettinger, Patricia Holm (EAWAG Duebendorf), Ueli Ochsenbein (GSA/GBL Berne), Armin Peter (EAWAG Kastanienbaum), Erich Staub (SAEFL Berne), Peter Dollenmeier (CibaSC Basel)

## Questions and Aims of the Project

**Investigation on the Decline in Fish Yields**

- How can the decline in fish catch and fish stock be clearly documented?
- How important is the decrease in fish populations?
- How can health effects on fish best be measured?
- What are the causes for the decline in fish catch? Are chemical substances or other factors, such as temperature, diseases, morphology of waters, stocking practices, responsible for the decline? How do these factors interact?
- Can single compounds or groups of compounds be identified as the most important causes ? Are point sources, such as wastewater treatment plant effluents or diffuse inputs, responsible for the damage?

**Investigation on the Effects of Trace Compounds**

- How do the potential pollutants impair the fish ? Which organs are affected? What is the dose-response relation?
- What importance do endocrine modulating compounds have on fish?
- How do entire populations react to the health impairment of single fish ? How can laboratory results be transferred to natural systems?

**Procedural Guidelines**

- Identification of a comprehensive approach to eliminate the most important causes for the decline in fish, development of various procedural options adapted to the parties concerned.
- Introduction of specific measures to improve the situation in collaboration with the parties concerned.

**Patricia Holm, director of the project**

Address:
Projekt Fischnetz, Helga Reutimann
Phone 01-823 55 94, Fax 01-823 53 75
helga.reutimann@eawag.ch

**Herbert Guettinger, EAWAG**

# Personnel

## Habilitations

Mark Gessner completed his undegraduate studies in Biology at the University of Dusseldorf (Germany), received a B.Sc. Honours degree from Trent University (Ontario, Canada) and an M.Sc. degree in Biology from the University of Freiburg (Germany). The research leading, in 1991, to a Ph.D. degree from the University of Freiburg was conducted at the Centre d'Écologie des Ressources Renouvelables of the National Research Center (CNRS) in Toulouse, France. These studies focused on changes in litter chemistry and microbial litter

Mark Gessner

colonization during the breakdown of leaf litter in streams. Later work addressed microbial decomposition processes in the littoral zone of lakes. These investigations were conducted as part of an interdisciplinary research project at the University of Kiel (Germany). This is also where, in 1996, Mark Gessner earned his habilitation in Limnology. Following his affiliation with the Department of Limnology at EAWAG, he renewed his habilitation at the ETH Zurich; his inaugural lecture held on 18 January 1999 was entitled "Biofilms in Running Waters". Mark Gessner offers lectures and excursions on wetland ecology together with Klement Tockner. His current research activities are primarily directed towards organic matter dynamics in aquatic ecosystems and the productivity of aquatic fungi and bacteria in benthic limnetic habitats.

Stefan Haderlein

Stefan Haderlein held his initiation lecture on January 28, 1999 at ETHZ on the topic "Chemical Concepts to Evaluate the Environmental Behavior of Groundwater Pollutants". His presentation demonstrated how reactive tracer compounds can be used to characterise transport and transformation processes as well as environmental conditions prevailling in the subsurfaces.

Stefan Haderlein obtained his undergraduate education at the University of Bayreuth in the area of Environmental Sciences with a major in Hydrology. At ETH Zürich, he participated in the postgraduate course in Urban Water Management and Water Protection, and finished his doctoral studies in the Department of Environmental Sciences. Since 1993, Stefan Haderlein has been assistant professor and lecturer and built up a research group dealing with sorption and chemical transformation of organic chemicals in heterogeneous aqueous systems. On April 1, 1998, Stefan Haderlein obtained the "Venia Legendi" in the area of Environmental Chemistry at ETHZ.

## In Memory of Professor Rudolf Braun

Professor Dr. Rudolf Braun passed away shortly after his 79th birthday following a long illness. His colleagues, friends and students, and certainly the field of environmental protection as a whole, have lost an outstanding scientist. During his professional career, Rudolf Braun put all of his energy into his work to protect the environment.

His interest in aquatic sciences was first kindled by his mentors, Professors Gäumann and Jaag. At the age of 26, Braun received a scholarship to attend the University of São Paulo where he worked on issues involved with the settling of Brazil and the development of water resources in the Amazon basin. He later undertook extensive botanical-biological expeditions in various countries on the African continent. His travels not only increased his general knowledge, but helped him develop a global perspective.

In 1952, Professor Braun was offered a Professorship at the "Institute for Qualitative Water Management and Hydrobiology" at the Technical University of Karlsruhe which he refused in favor of returning to his hometown of Aarau, where he built the first cantonal agency for water protection. Foaming streams, fish kills and reeking landfills were a certain sign that there was a serious lack of environmental protection. In 1955, Professor Jaag brought Dr. Braun to EAWAG and charged him with forming a group for "Management of Solid Waste".

Until his retirement in 1983, Rudolf Braun focused all of his energy on this task. He approached the problem on a very broad front: he was engaged in basic research and put technical solutions to their practical test. But Professor Braun was not one to combat the ever-increasing pile of waste with ever-newer technology; he was one of the early proponents of recycling. "Waste is raw materials in the wrong place", was one of his favorite sayings.

Professor Braun was an expert who was sought after in Switzerland and abroad. He vigorously promoted international cooperation. His winning and very human character let him easily interact with agencies and regulators at all levels. He was the president of the International Association of Waste Disposal and Urban Sanitation, secretary of the International Solid Waste Association, president of the European Federation for Water Protection, president of the Swiss Association for Water Protection and Air Hygiene, and a member of the Swiss Federal Commission on Waste Management. The German Federal Government nominated him to the prestigious Council of Experts on Environmental Problems. In that function, Professor Braun had a significant influence on the legislation of the European Union regarding resource management.

At the Swiss Federal Institute of Technology, Rudolf Braun was nominated Associate Professor in 1970 and promoted to Full Professor in 1973. At the same time, he continued to head the Department for Waste Management at EAWAG. His achievements were extremely diverse: education of well-trained experts, new concepts in waste management, new systems and technologies for waste treatment. In addition to his obvious achievements, he was also involved in the legislative groundwork and establishment of a new value system in environmental management. EAWAG, ETHZ and society as a whole owe Professor Rudolf Braun a tremendous debt of thanks for the healthy environment we enjoy today. Hans Wasmer

# Publications

**Can be ordered separately from the EAWAG library (please use the order form).**

Corrigenda

2510 **Biermann, P.R., Albrecht, A., Bothner, M.H., Brown, E.T., Bullen, T.D., Gray, L.B., Turpin, L.**
Erosion, weathering, and sedimentation. In: «Isotope tracers in catchment hydrology», C. Kendall, J.J. McDonnell (Eds.). Elsevier Science B.V., Amsterdam 1998, pp. 647–678.

Nouvelles publications

2521 **Bucheli, T.D., Müller, S.R., Heberle, S., Schwarzenbach, R.P.**
Occurrence and behavior of pesticides in rainwater, roof runoff and artificial stormwater infiltration. Environ. Sci. & Technol., *32*, 3457–3464 (1998).

2522 **Bucheli, T.D., Müller, S.R., Voegelin, A., Schwarzenbach, R.P.**
Bituminous roof sealing membranes as major sources of the herbicide *(R,S)*-mecoprop in roof runoff waters: potential contamination of groundwater and surface waters. Environ. Sci. & Technol. *32*, 3465–3471 (1998).

2523 **Perlinger, J.A., Buschmann, J., Angst, W., Schwarzenbach, R.P.**
Iron porphyrin and mercaptjuglone mediated reduction of polyhalogenated methanes and ethanes in homogeneous aqueous solutions. Environ. Sci. & Technol. *32*, 2431–2437 (1998).

2524 **Gächter, R., Wehrli, B.**
Ten years of artificial mixing and oxygenation: No effect on the internal phosphorus loading of two eutrophic lakes. Environ. Sci. & Technol. *32*, 3659–3665 (1998).

2525 **Knauer, K., Ahner, B., Xue, H.B., Sigg, L.**
Metal and phytochelatin content in phytoplankton from freshwater lakes with different metal concentrations. Environ. Toxicol. & Chem. *17*, No. 12, 2444–2452 (1998).

2526 **Schäfer, A., Harms, H., Zehnder, A.J.B.**
Bacterial accumulation at the air-water interference. Environ Sci. & Technol. *32*, No. 23, 3704–3712 (1998).

2527 **Bichsel, Y., von Gunten, U.**
Determination of iodide omd iodate by ion chromatography with postcolumn reaction and UV/visible detection. Anal. Chem. *71*, No., 1, 34–38 (1999).

2528 **van der Meer, J.R., Zepp, K., Eggen, R.**
Modern methods for detection of microorganisms and their activity. Bio World *3*, No. 5, 3–8 (1998).

2529 **Boller, M., Mottier, V.**
Wasserwirtschaftliche Bedeutung der Regenwasserversickerung am Beispiel einer Region. Z. für Kulturtechnik und Landentwicklung *39*, 247–254 (1998).

2530 **Güttinger, H.**
Auf dem Weg zu einer Bildung nach Mass. Erfahrungen und Visionen aus der Umwelt-Weiterbildung. Neue Zürcher Ztg. Nr. 243, 20.10.1998, Beilage «Studium und Beruf».

2531 **Güttinger, H.**
Probleme früher erkennen, besser kommunizieren und verhindern. Tagung «Macht uns die Umwelt krank?», 28. Mai 1998. VGL Information Nr. 3, 4–5 (1998).

2532 **van der Meer, J.R.**
Bakterien: die unsichtbaren Helfer. Schweiz. Tech. Z., Technik Aktuell *5*, 44–47 (1998).

2533 **Ravatn, R., Studer, D., Zehnder, A.J.B., van der Meer, J.R.**
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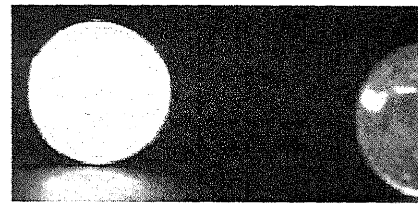

Over the past few years, so-called "dialogue methods" or "discourse methods" have been developed as a new tool for conflict resolution in the areas of environmental and technological politics. Some of these methods include mediation, planning groups, consensus-conferences, deliberative surveys, and focus groups. While these methods hold much potential, their application in the democratization of these hotly debated political areas is still poorly understood.
This book provides a survey of the various methods for promoting discourse. Particular emphasis is placed on questions of how to run and analyze such discourses. The principles are exemplified in a case study where the public discusses the use of economic tools in energy politics ($CO_2$-tax, energy tax, energy permits) and produces a public recommendation which is based on consensus. The whole discussion process is evaluated in detail, with particular attention paid to how opinions are formed and which arguments have the greatest weight. Results indicate that these new economic tools have public support, although the reasons for their support vary greatly between experts and lay people.
The use of discourse methods for conflict resolution is only in its infancy. The final chapter of the book is dedicated to a few suggestions for the further development of the theory and practical application of such methods.

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## 100th License for AQUASIM

The computer program AQUASIM was developed in the Department for Computer and Systems Sciences as a tool for simulation and data analysis of aquatic systems. AQUASIM allows the user to describe the spatial configuration of a system with the use of pre-defined compartments, to define links between the compartments, and to introduce any number of chemical components and processes. Once a system is defined, the program will perform simulations and sensitivity analyses, or model parameters can be estimated by providing the program with measured data. Currently, predefined compartments include mixed reactors, biofilm reactors, advective-diffusive reactors, soil columns, rivers and lakes.

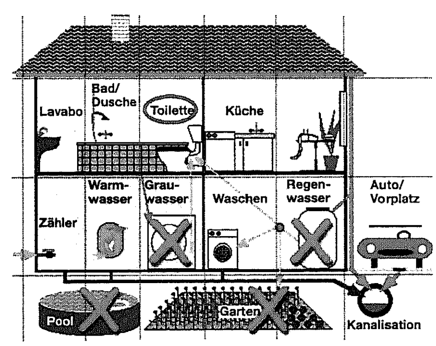
The program was originally developed for inhouse use and has been used on a number of projects. Because of growing interest, the program has been sold outside EAWAG starting in 1994, reaching the 100th license sold in December of 1998. AQUASIM is now being used at over 100 universities and consulting companies in 30 countries, including Australia, Belgium, Denmark, Germany, Finland, France, Great Britain, Ireland, Israel, Italy, Japan, Canada, Korea, Malaysia, The Netherlands, Norway, Austria, Portugal, Russia, Sweden, Switzerland, Singapore, Spain, Sri Lanka, South Africa, Thailand, Turkey, Hungary, Uruguay and USA.

For more information visit the AQUASIM home page at http://www.aquasim.eawag.ch

## The Personal Water Calculator

A large portion of the Swiss population does not know how much they are currently paying for their water. Clean water is cheap and appears to be available in abundance. Conservation still is a topic one hardly thinks about. People who want to learn more, usually do not get straight-forward answers from the water supply experts, despite the fact that the cost for drinking water in general, and the fees for wastewater treatment in particular, are expected to rise dramatically over the next few years. The personal water calculator is an Internet tool developed to raise the awareness of the general population. It lets the user calculate water usage, the volume of wastewater created, and warm water consumption, both in terms of volume and energy used, as well as the associated costs. The user can interactively explore how changes in lifestyle and technical measures affect water consumption. In addition to being a serious technical tool, the program has been designed to be user-friendly, colorful and humorous.

**Andreas Schönborn**

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Thank you very much in advance

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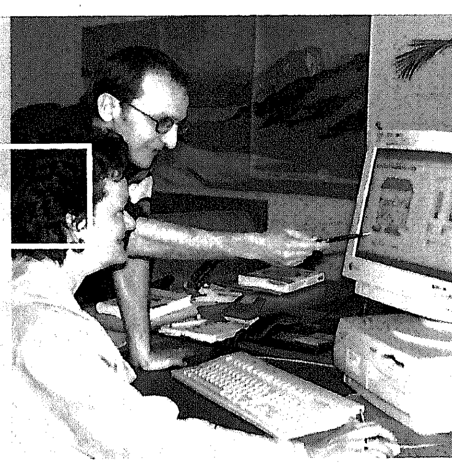

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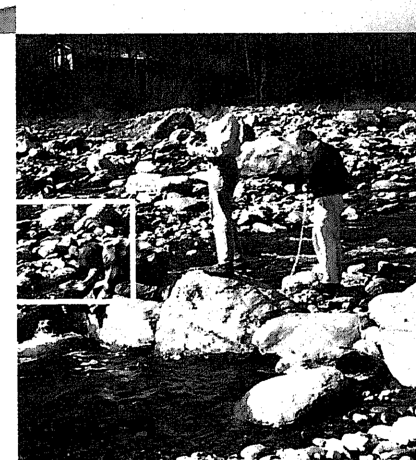

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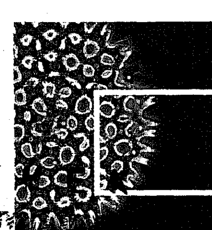

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