Tove A. Larsen, chemical engineer and project leader of Novaquatis
Co-autors: H.-P. Bader, H.-J. Mosler, W. Gujer, E. Medilanski, R. Scheidegger,D.-B. Huang, R. Schertenleib

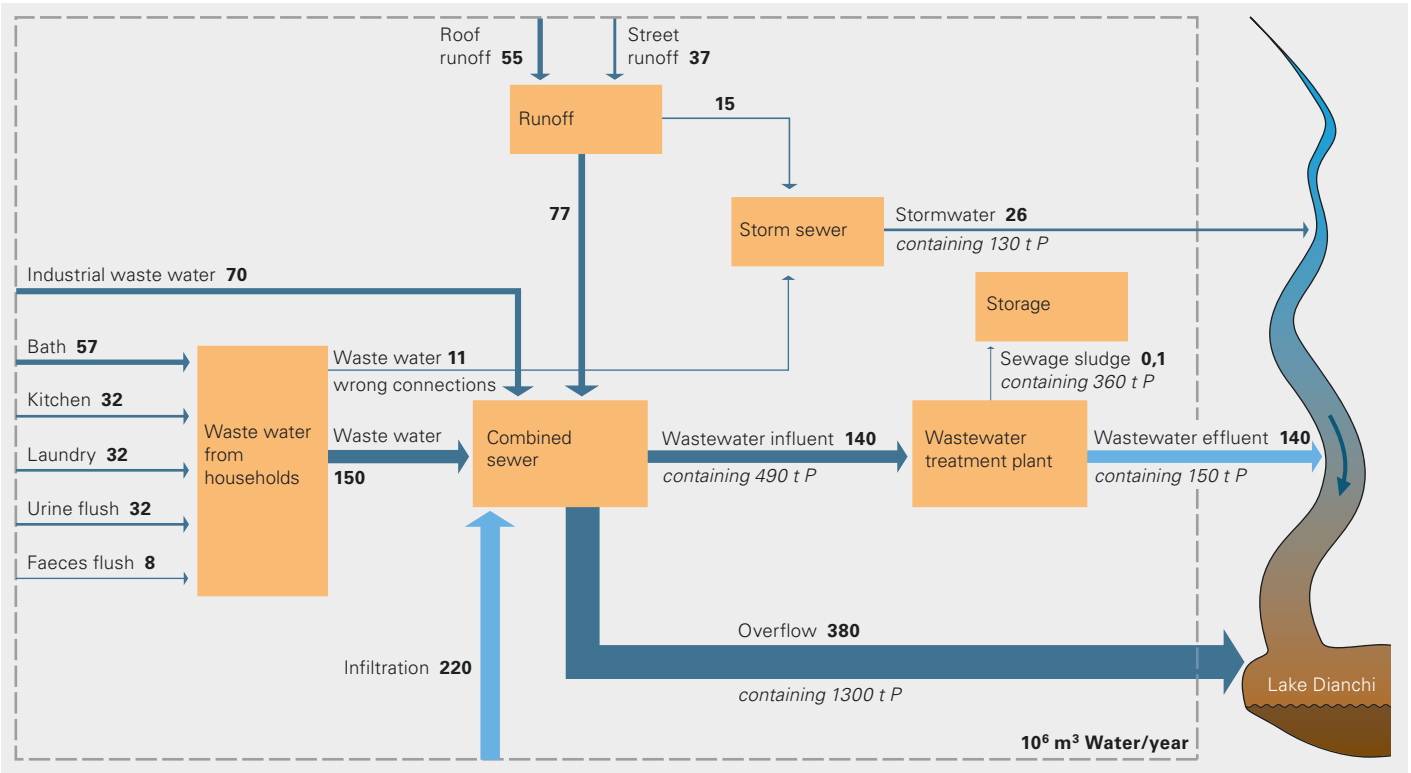
Applying Traditional Chinese Knowledge

Kunming, Zurich's sister city in China, is determined to tackle its wastewater problem. In the development of measures based on nutrient recycling – a long-established principle in China – it is receiving support from Eawag in technical as well as social issues.

Drinking water supplies for Kunming's population of several million are largely drawn from Lake Dianchi. However, this shallow lake is heavily contaminated with phosphorus as a result of wastewater discharges from the city and regional agriculture. For some time now, the abstraction of drinking water from the lake has been steadily reduced, and withdrawals will probably be stopped altogether in the near future. In view of this precarious situation, the authorities have called for efforts to restore the quality of lake water to the 1960 standard. However, the question remaining is how this objective can be achieved, given the complexity of the system and the fact that possible measures need to be effective both technically and socially.

Can Source Control Measures Solve the Problem? Measures taken at source represent important alternatives to conventional treatment technologies. China has a long tradition of nutrient recycling, and in rural areas urine has long been used as a fertilizer. Does this mean that urine separation would be a possible option for improving water quality in Lake Dianchi? To investigate this question, a three-part project financed through the Swiss

Fig. 1: Wastewater flows in Kunming in 2000, expressed in 10^6 m^3 per year. The scant local data were supplemented by literature data and reference data from the city of Zurich.



research programme NCCR North-South [1] was carried out by Eawag in Kunming. It involved:

► analysing wastewater flows in Kunming and simulating the outcome of possible measures;

► surveying the relevant stakeholders on the acceptance of source control measures, the introduction of urine separation, and possible decision-making paths; and

► launching a pilot project to test urine-diverting waterless toilets in a rural area.

Kunming's Urban Drainage System. Using a simple material-flow model developed for the drainage system in Kunming, we sought to establish the quantities of nutrients deriving from various sources [2]. In the model, water, nitrogen and phosphorus flows are represented, together with the main sources of wastewater:

► households (broken down into five categories: bath, kitchen, laundry, urine flush and faeces flush),

► industry,

► street and roof run-off,

► sewer infiltration (including groundwater and river water).

Wastewater flows and phosphorus loads are shown in Figure 1. It became evident that the capacity of the sewerage system and of wastewater treatment plants (WWTP) is inadequate, and that WWTP technology is not sufficiently advanced. Only about 25% of the collected wastewater is treated at one of the six WWTPs, with most of the remainder entering the lake untreated via overflows. The problem is exacerbated by unwanted infiltration water, which dilutes wastewater in a ratio of at least 1:1. As a result, around 1600 of a total of 1960 tonnes of phosphorus from the city flow into Lake Dianchi each year. According to an estimation [3], however, annual inflows of phosphorus into the lake should not exceed 60 tonnes if the water quality of 1960 is to be restored. Allowing for the current ratio of urban/agricultural inputs – approximately 1:1 [4] – the target level would thus be less than 30 tonnes of phosphorus discharged from the city per year. These conclusions are essentially unchanged even if the high level of data uncertainty is taken into account.

Specific Remedial Measures. In order to develop proposals for appropriate remedial measures, various scenarios were simulated using the material-flow model [2]. Of these scenarios, the two most important were:

► BAT (best available technology) – upgrading of Kunming's urban drainage system to up-to-date standards, as complied with, for example, in Zurich: reduction of infiltration, elimination of misconnections, increase in sewerage system capacity and application of best available treatment processes in WWTPs. The required alterations to the sewer system would make this option extremely costly and exceedingly difficult to implement.

► BAT plus urine separation, with two thirds of all households being equipped with urine-diverting toilets.

Under both scenarios, the phosphorus load is substantially reduced. Nevertheless, with the BAT option, 56 tonnes of phosphorus per year would still be discharged from the city into Lake Dianchi. The end-of-pipe approach would thus, in itself, not be sufficient to attain the desired level of water quality. This measure could be supported by diverting part of the treated wastewater into other receiving waters. However, this would produce adverse ecological impacts, as Lake Dianchi would no longer receive sufficient water. Consequently, there is no simple solution; instead, a combination of measures is required. According to the simulation, the amount of phosphorus discharged into the lake under the "BAT plus urine separation" scenario is only 39 tonnes per year. As we consider the BAT option to be somewhat unrealistic, there is a need for additional source control measures – urine separation alone is not enough. Whatever options are chosen, successful implementation depends crucially on a careful assessment of feasibility, with the involvement of all stakeholders.

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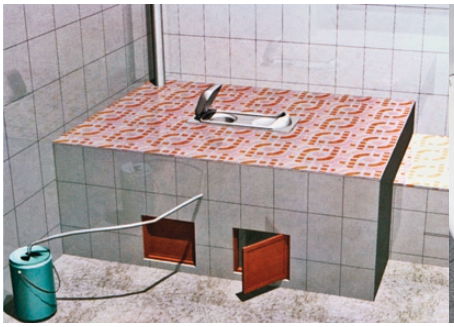

Eawag

Fig. 2: Two urine-separating sanitary systems: waterless toilet (left) and NoMix flush toilet (right).

Stakeholders' Attitudes to Urine Separation. Before new technologies can be introduced on a large scale, it is essential to determine the relevant actors' interests and readiness for action, and to be aware of the relevant decision-making processes. Accordingly, we conducted an in-depth stakeholder analysis [5, 6]. Thirty-five different stakeholders from political, administrative, scientific and business circles were identified and characterized in terms of their interest in urine-diverting toilets and their impact with regard to the introduction of this type of sanitary system. The greatest influence on this process is wielded by the key stakeholders – namely, the Congress, the government, the Communist Party, the Lake Dianchi Protection Authority, and the municipal and national environmental protection agencies, but also real estate companies and the urban planning authority.

The vast majority of stakeholders consider source control measures, especially in the area of industrial and sanitary wastewater, to be necessary and also feasible in the next 20 years. Overall, positive ratings were given to the technical feasibility and environmental effects of urine separation, and also to social acceptance and institutional flexibility in relation to the introduction of this technology. Asked about which of the two urine-diverting systems the stakeholders would prefer (Fig. 2), they favoured the NoMix flush system over the less costly waterless toilet (Fig. 3). It was, however, pointed out that NoMix systems could certainly be produced more cheaply in China than in Western countries.

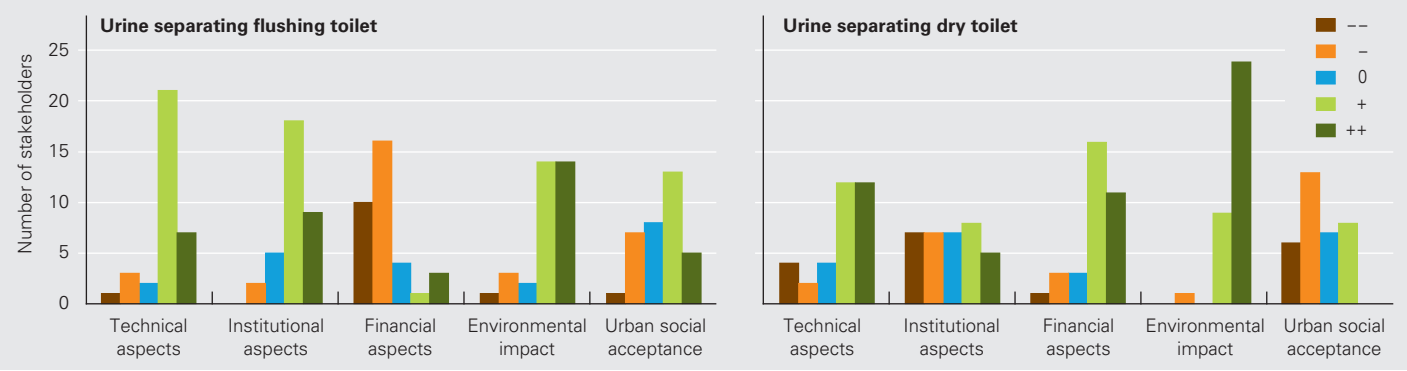

Fig. 3: Stakeholders' views on two different urine-diverting toilet systems. Assessments on a scale from highly negative (−−) to highly positive (++).

Importance of a Smooth Decision-making Process. The stakeholder analysis was also designed to identify the decision-making processes involved in the implementation of urine separation. What form would these take in practice, if urine-diverting toilets were to be widely introduced in Kunming City? A measure of this kind would require a submission to central government and the National People's Congress prepared by the national environmental protection agency in cooperation with the Lake Dianchi Protection Authority. If the submission were approved in principle, the Kunming Institute of Environmental Science would initially be charged with conducting a pilot project to study feasibility on a small scale. Only after successful completion of the pilot project could urine separation be introduced on a large scale by the Lake Dianchi Protection Authority.

One striking finding is the existing institutional flexibility: although the law provides for central wastewater treatment, it is also perfectly possible – under the current five-year plan – to carry out innovative pilot projects in the city.

Pilot Project: Urine-diverting Toilets in a Rural District. In cooperation with Eawag, the Kunming Institute of Environmental Science launched a pilot project involving the installation of over 100 urine-diverting waterless toilets in a rural district on the outskirts of Kunming [7]. While experiences are positive, the results also indicate the objections and problems likely to be encountered in the event of widespread introduction. According to a quantitative study of satisfaction with the technology [8], the waterless toilets are presently only used by about 40% of the residents; the users are, however, largely satisfied. The main problem cited is the question of location: a preference has been expressed for installing the toilets outdoors, if possible even outside the users' own plot. No doubt, this is partly attributable to concerns about odour problems.

Persistence and Courage to Pursue a Sustainable Solution. Overall, it turns out that urine separation can make a significant contribution to solving Kunming's wastewater problems, although different approaches will probably be required for rural and urban areas. It is also obvious that Kunming City is making strong efforts to restore the quality of the lake which has been deteriorating due to intense population pressure. For this extremely challenging task there is no standard solution – neither the modernization of Kunming's sewerage system combined with a diversion of the treated wastewater nor urine separation alone can solve the problems of Lake Dianchi. A combination of measures will be needed, as will persistence and the courage to experiment, so that appropriate solutions can be developed and tested before they are implemented on a large scale. ○ ○ ○

[1] www.nccr-north-south.unibe.ch. The Swiss National Centres of Competence in Research (NCCR) are Swiss National Science Foundation research instruments. The NCCR-North-South is co-financed by the Swiss Agency for Development and Cooperation (SDC).

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