Some thoughts about future perspectives of water and wastewater management

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Abstract The ideals of sustainability have a longer history than is sometimes realised, as they can be traced back to the insights of Von Carlowitz in 1713. However in the intervening centuries early successes in sanitation based on the "flushing sewer" led engineers to focus too much on sewerage-based solutions that are increasingly uneconomic and unequal to the challenges arising from population growth and urbanisation. The future strategy for globally sustainable sanitation will surely involve source separation and recycling and reuse: these are the technologies that environmental scientists and engineers should now be addressing.
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Urban water management in the light of the concept of sustainable development

Measures to protect the environment from over-exploitation of resources were taken at the end of medieval times already, when Hanns Carl von Carlowitz in 1713 published an article in the scientific journal "Sylviculture Economica." Much later, in the 1980s, this article became the corner stone of the concept of sustainable development, proposed by the Brundtland Commission, and eventually adopted by the delegates of the World Summit on Environmental Protection that took place in Rio de Janeiro in 1992.

In the 16th century mining of copper and iron ore became big business in Central Europe. An enormous amount of logs were needed to secure mining shafts. Von Carlowitz became greatly concerned about deforestation of large parts of the country resulting from excessive cutting of trees for mining purposes. In order to meet the long-term needs of the mining companies he concluded that the number of trees allowed to be cut should stay below the number of trees that grow, per unit of time. In essence that means that growth of economy had to be limited by a biological factor: the growth rate of trees in this particular case. Von Carlowitz called this concept "nachhaltige Entwicklung." The Brundtland Commission translated this term into "sustainable development."

Since Rio de Janeiro, sustainability and sustainable development are rated by the majority of States as guiding principle, although it is all but clear how to measure the factors that govern sustainability, and progress of sustainable development. Without measures, engineers have problems to come up with reasonable solutions.

Sustainability is assumed to comprise an economic, a social and an environmental dimension. It is assumed that a society lives in prosperity, if economic, social and environmental affairs are kept in balance.

Prosperity, however, also has something to do with sentiments of people, pride, religious beliefs, customs, heritage, with the "cultural background," in summary. The cultural background of people living in different regions of the world is different, and will be different in future. Therefore, the culture of a region must be respected when decisions have to be made on actions to be taken to satisfy our generation, but not on the account of future generations.

A wide variety of actions must urgently be taken to secure the existence of mankind.

Supply of the world's population with safe drinking water and efficient sanitation is a most important, even crucial task of our generation and of the generations to come.

When we interpret "sustainable development" as a concept to secure mankind, and when we agree that water is a key element in securing the existence of mankind than we also must agree that water supply and sanitation needs not only advanced technology. One must also take into account metaphysical aspects associated with water and with other resources as well (air, soil, flora, and fauna). The cultural dimension certainly plays a major role in the attempt to implement sustainability measures in our societies and to develop reasonable technologies that foster sustainable development.

Paradigm shift from "flushing" to "reuse"

From a historical point of view, the investigations made by the British Royal Commission in the middle of the 19th century, and the conclusions drawn by this Commission are often considered as the advent of modern environmental technology. The Royal Commission investigated the reasons for the outbreak of mass diseases, and finally concluded that the direct contact of humans with their own faeces is the main cause for the outbreak of mass diseases like cholera, typhus, diarrhoea and others. One may add SARS, nowadays.

Something had to be done to avoid direct contact of humans with their own faeces. The method of choice was installation of flushing sewers. In retrospect, one may consider the invention of flushing sewers as one of the greatest sins of engineers, although one also must admit that at that time no other method was available, not even an idea of an alternative solution.

In essence, the "flushing sewer" concept implies the use of high quality tap water as a means to transport faeces and other waste substances away from homes, enterprises, office buildings and industries towards rivers, lakes and to the open sea.

In the decades that followed, flushing sewers were installed in the cities and also in rural areas of the industrialized countries. In Germany for instance, more than 96% of the population is served by sewers. One may consider this as a success.

It took 150 years to raise the money needed to cover the investment costs for sewer installation. As a result, the annual financial load of the tax payer remained at a reasonable level. Today, we simply no longer have that much time to install flushing sewers throughout the rest of the world. People need proper water supply and sanitation very quickly, in particular in the rapidly growing metropolitan areas around the world. The annual load of the tax payers would rise into an order of magnitude hardly affordable by any economy, if the flushing sewers would be chosen as the only acceptable means, and installed within the time frame dictated by the current growth rate of the human population in general, and by the ever increasing rate of urbanisation in particular.

In conclusion, alternative solutions must be found to serve mankind, and to secure its long-term existence. Obviously, we as environmental scientists and engineers are facing a major challenge.

Using drinking water as transportation means, although convenient, does not at all meet sustainability criteria. What we actually do in practice is: we withdraw water from ground or surface water reservoirs, treat the water and make drinking water out of it, pollute it, send it to a wastewater treatment plant (in the best case), and discharge the treated wastewater, eventually. One should realize that most of the water in the industrialized countries is used just for flushing, and only a fraction is used for drinking, washing, cleaning and as process water in industry.

A second aspect has to be taken into account, when evaluating our current urban water management practices. In the past, we spent billions of US dollars to improve methods of (bio-)degradation. Proudly we announce that we are able, nowadays, to destruct in the

wastewater treatment plants the majority of organic substances, and turn even high concentrations of organic nitrogen into nitrogen gas, i.e., the focus of this conference. Our modern wastewater treatment facilities are perfect in destructing materials. But why do we want to destruct materials? Wouldn't it be wise to recover materials and return them directly and on a short pass into the cycle of materials?

Recovery of valuable materials from our normal municipal wastewater is certainly difficult because the materials are present in a very dilute form. Wastewater is a heterogeneous mixture of all kinds of materials since we mix a wide variety of wastewater fractions together, in households, in enterprises, in industry. Mixing and dilution are the major characteristics of our urban sanitation.

If we would source separate distinct wastewater fractions and if we would provide treatment close to the source we could possibly minimize the heterogeneity of materials in the various wastewater streams, and dilution effects. In many industrial plants, source separation, treatment of the individual wastewater fractions, and re-use at least of the treated water are already common practice. Why not apply source separation in private homes, hotels, office buildings etc. as well?

Urine, for instance, and the liquid fraction of manure could be used as raw material for fertilizer production, making nitrification and denitrification in wastewater treatment plants unnecessary.

Wastewater from showers and washing machines could be easily converted into water to be returned to the house, and re-used for washing, cleaning and for flushing toilets. By doing so, the amount of water to be delivered and discharged could be drastically reduced.

The message

- We do have a well developed technology to manage water supply and wastewater treatment, but this technology needs a more than critical review and evaluation.
- We need novel concepts of water supply and sanitation that serve the ever growing world population and industry, particularly in the urban areas of developing countries.
- We should take any efforts to supplement the current mixing–dilution–discharge approach prevailing in environmental technology by a rather material re-use oriented approach (direct re-use of water, and of valuable constituents of wastewater including nutrients).
- We need novel technology which provides high efficiency with respect to costs and hygienic safety, applicable also in countries where the financial capacity of the economy is still comparably low.
- We need novel technology which people of different cultural and educational backgrounds are ready to use.
- Engineers are called upon to develop such technologies.
- Research is urgently needed to provide the scientific basis for such technologies.
- Young researchers and engineers should realize that the challenges we are facing are extremely complex in nature. Working in teams, listening to partners from other disciplines, and exploring the unknown at the interface between disciplines and cultures are an important key of success.