UN water action decade: a unique challenge and chance for water engineers

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Abstract In the year 2000, the UN General Assembly resolved the Millennium Development Goals (MDGs), and all the Member States of the UN pledged to take any measures to get the MDGs achieved. Concerning water supply and sanitation, a rough calculation clearly tells that it is impossible to meet the MDGs by just copying and pasting the traditional technology as it has been developed in the industrialized countries. Novel concepts and technologies have to be developed, tested and made available which allow fast implementation for a reasonable price, and which provide high treatment efficiency, reliability and robustness. Based on the latest estimates on population growth and migration rates it appears that top priority should be given to investments in the water infrastructure of municipalities. Introduction of water re-use systems should be favoured to avoid over-exploitation of local water resources. Suggested are step changes of the infrastructural system components with emphasis on technology innovation. Many small steps are often more effective than a single big one. In the attempt to quickly improve local situations specific attention should be paid to modern physico-chemical methods based on membrane technology. Decentralized wastewater treatment and re-use methods should be installed simultaneously to the construction of new houses. Further development of methods for separate collection and treatment of particularly composed waste streams should be encouraged. Wastewater should be rated as a source of valuable materials rather than a nuisance. Technology development should proceed hand-in-hand with the development of the societal, economical and political framework. Concerted actions are necessary to make novel technology function. Otherwise, meeting of the MDGs will remain an illusion.

Keywords Millennium development goals; source control; sustainability; wastewater treatment; water re-use; water supply

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Background

On 8 September 2000, the General Assembly of the United Nations resolved unanimously a document containing among other important statements the so called Millennium Development Goals (MDGs). The 191 Member States of the UN promised to take all measures to halve by the year 2015 the number of people who live in deep poverty, who suffer from extreme hunger, who lack reasonable basic education, who are threatened by gender disparity, who die of major, often waterborne diseases, who do not have access to safe drinking water and basic sanitation. In general, unsustainable exploitation of natural resources should be stopped, and a global partnership for development should be established.

Water plays a dominant role in most, if not all of the above mentioned areas of concern. Water is needed to grow crops, and crops are needed to quench hunger. Water is needed to be able to run a proliferating economy, a most important prerequisite in the attempt to win the war against poverty. Safe drinking water and a reasonable level of sanitation is required to eliminate waterborne diseases, one of the major causes of the high child and maternal mortality in many developing countries. With respect to the goal to enhance primary education and to foster gender equality it should be understood that sustainable development is an intellectual challenge which requires educated actors in

general, and educated women in particular. In many respect, women are prominent users of water. Wise and sustainable use of water can only be promoted when the specific concerns of women, local traditions and habits are satisfied. Who could better address what is locally required and acceptable than the well educated women of all ages.

During the years that followed, the MDGs were repeatedly confirmed, but the chances to actually meet the goals within the narrow timeframe given are considered rather low. "Pessimists" claim that the goals are way too ambitious to be met in time. On the other hand, it is agreed that setting tough goals is absolutely necessary to drive the development into the right direction. Anyhow, it appears that with all the disputes between pessimists, realists and optimists, not much materialized. And the problems which led to the formulation of the MDGs kept increasing rather than decreasing: "word-smithing" dominated over "black-smithing". Therefore, and to get things on track, in December 2003 the UN General Assembly proclaimed the World Water Action Decade which is supposed to start on 22 March 2005.

In the context of the upcoming World Water Action Decade, "action" stands for "doing", and doing should be understood as the generic field of engineers. The World Water Action Decade will be the decade of the engineers. Engineers are called upon developing and implementing technical solutions required to achieve the MDGs. Solutions are to be developed which serve the specific needs prevailing in the many different regions of the world, each characterized by specific local conditions such as climate, quantity and quality of fresh water available, economic capacity, cultural heritage, and technical skills to operate technical devices.

In Europe, the challenges and chances which evolved in context with the proclamation of the World Water Action Decade encouraged the EU Commission to initiate the establishment of a unique technology oriented forum, the Water Supply and Sanitation Technology Platform (WSSTP). This platform is based on the Environmental Technology Action Plan (ETAP) resolved by the EU Commission on 28 January 2004. Within the WSSTP professionals work together representing, in particular,

- the European water industry and services,
- professional and academic associations,
- academia,
- financial institutions,
- EU agencies,
- Commission services, and
- EU Member States.

By mid-2005, the members of the platform are supposed to come up with three key documents,

- a vision document in which it should be clearly stated where Europe should be positioned in the very near future, in medium terms and on the long run,
- a research agenda in which the steps are described which the various stakeholders consider important in order to meet the envisioned milestones,
- an implementation plan which describes the actions to be taken to get the short, medium and long term goals accomplished.

Detailed information about the WSSTP can be found on the web-site of the platform (URL: www.wsstp.org).

Scale and dimension of the problems to be solved

As mentioned above, a very ambitious deadline was set by the UN to meet the MDGs. By the year 2015 the number of people not having access to safe drinking water and to

proper sanitation should have been cut to a half. The following rough calculation may help realizing the dimension of this goal.

It is estimated that currently some 1.2 billion of people do not have access to safe drinking water. Cutting this number to a half within the next 10 years means that every year 60 million people must be connected to advanced water supply systems. Considering 300 working days per year, *every day* waterworks plus distribution systems have to be built and brought into service serving 200,000 people.

Sanitation is a term encompassing in-house wastewater collection, transportation of wastewater by means of sewers, and treatment of the wastewater prior to discharge into any open water body (river, lake, open sea). It is estimated that currently less than 10 percent of the world population is connected to any reasonably working sanitation system. In order to meet the MDGs within the next 10 years, considering again 300 working days per year, *every day* wastewater treatment facilities must be built serving 900,000 people.

Considering the order of magnitude of manpower and the investment money needed to establish the required capacity of waterworks, water distribution systems, sewers and wastewater treatment plants it is easy to comprehend that meeting the MDGs is impossible as long as the traditional concept of urban water supply and sanitation is considered the only method applicable. Certainly, the technology which has been developed and implemented over the past 150 years in the industrialized countries has merits which are indisputable. Nevertheless, the inherited concept is not universally applicable for three reasons. The time frame within which water technology is to be implemented exceeds the economic carrying capacity of most of the municipalities in need of water infrastructure (in the industrialized countries the financial burden could be distributed on the shoulders of many generations!). The climatic conditions are different (dry in contrast to the countries where the existing technology comes from). Availability of skilled operators and the readiness of the customers to pay for the service they get remain under-developed (very much in contrast to the situation in the industrialized countries). Subsequently, meeting the MDGs requires efforts into invention, development and implementation of methods tailored to the specific needs of the individual regions to be served. Most probably, a wide variety of inherited as well as novel methods are required. And it should be realized that technology serves its assignation only when it gets accepted by the users. Participation of the local users in the process of development of water technology is important to gain progress with respect to the MDGs. The many treatment facilities which were built in developing countries but never used tell a story to be learnt.

There is another aspect to be considered in the attempt to meet the MDGs. According to recent estimates it must be assumed that migration of people towards municipal areas will continue, even increase in intensity. The reasons for this are manifold. Advances in the educational status of people living in rural areas (one of the MDGs) will virtually drive people into migration unless attractive jobs are made available in rural areas. Subsequently, metropolitan areas will keep growing at an ever increasing speed, and so does the demand for water. On the other hand, the amount of water applicable for domestic or industrial purposes remains more or less constant. By the year 2035, about 65 percent of the world population is expected to live in metropolitan areas, but only 10 percent of them will live in mega-cities. Most of the people on earth will concentrate in relatively small or medium-size cities. These numbers suggest that major efforts have to be made to satisfy the specific demands of people living in cities. Here, it appears feasible to apply high-tech solutions, in contrast to rural areas, where the level of sophistication of technical appliances and systems must be kept low compared to municipal applications.

In summary, the World Water Action Decade should be understood as a great chance to re-consider approaches to water supply and sanitation. Required are novel water

management concepts, and we should develop innovative technology tailored to the needs and capacities of the very local situation as it appears in rural or in municipal environments, respectively, in developed or in developing countries. In particular, solutions are required which can be readily implemented within a reasonable period of time. Solutions are required which are effective, affordable, reliable and robust.

Envisioned solutions

Water re-use in municipal areas

In an attempt to solve the water shortages in the rapidly growing cities around the world various options are currently discussed (Larsen and Gujer, 1996b; Venhuizen, 1997; Wilderer and Schreff, 2000, and many more). Both modified central and decentralized systems are taken into consideration and investigated. In this context, the term "central system" describes the traditional way of producing and distributing high quality drinking water in municipal areas. The wastewater generated in the municipal area is sent, mostly by means of gravity sewers, to a treatment plant, purified and discharged to a river, lake or to the open sea (Figure 1).

In contrast, decentralized sanitation stands for an approach where the wastewater generated in single households, apartment buildings, residential areas, office buildings or in industrial sites is treated close to the point of origin (Figure 2).

Traditionally, the treated wastewater is not commonly considered as a source from which useable water or other valuable substances can be directly obtained. As depicted in Figure 3, however, rivers having received the treated wastewater upstream are actually used as a source of drinking water in many industrialized countries. Indirect re-use of wastewater is apparently common practice but not commonly realized along the Rhine river in Germany and in The Netherlands, for instance.

As indirect water re-use in populated areas has proven applicable and acceptable by the customers, why should direct water re-use not be applicable or acceptable? Direct water re-use could be a very attractive way of quenching the thirst of the rapidly growing cities, especially those located close to the sea where discharge of the treated water into a river for subsequent use downstream is not available as an option. Re-use of water is also to be understood as an important contribution to the sustainable development of the region because it reduced excessive withdrawal of water from the natural water cycle, and subsequent impacts on natural habitats. The City of Singapore already adopted this concept. Ultra-pure water is produced at the North-East Water (NEW) Plant, sent to a reservoir, mixed there with rain water, and used for drinking water production (Figure 4). By inserting a close-to-nature element into the recycling path it can be expected that acceptability of the re-used water by the customers significantly improves.

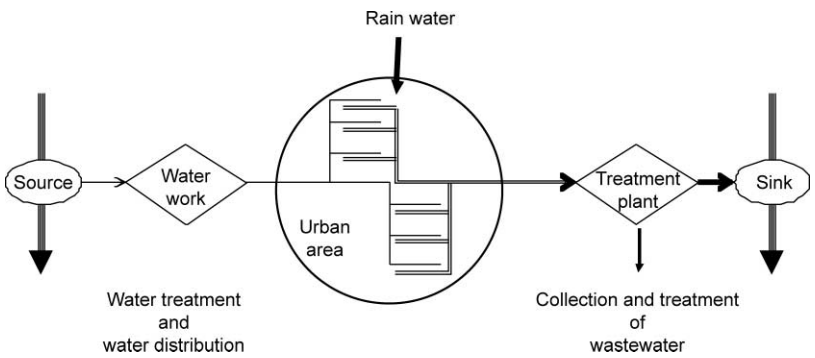

Figure 1 Schematic representation of a "central" water/wastewater management system

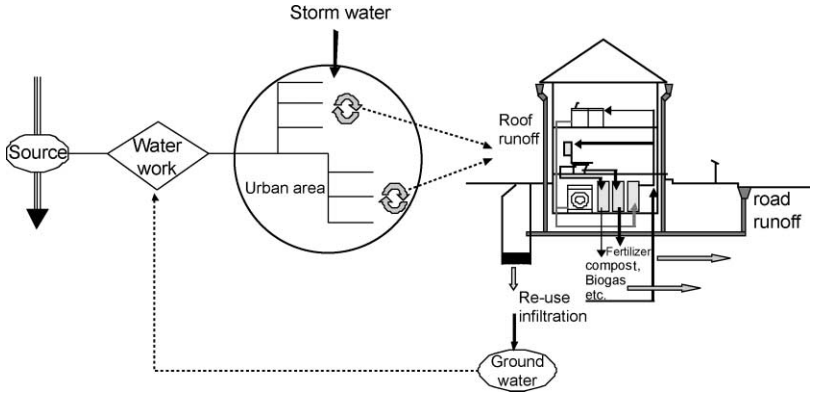

Figure 2 Schematic representation of a "decentralized" system where the wastewater is treated close to the point of origin

As depicted in Figure 4, rain water collected from roofs and roads can also be considered a valuable source of water. Certainly, the collected water needs to be properly treated before it can be used for any domestic purpose (Athanasiadis *et al.*, 2004; Boller and Steiner, 2002; Matsui and Lee, 2003). Infiltration of the well treated water into the groundwater, wherever possible, is to be considered as a contribution to sustainability in favour of man and nature.

Step changes

As mentioned above, advanced water supply and sanitation must be made available to a large fraction of the world population within a narrow time frame. The MDGs call for halving the number of people not yet served with safe drinking water and proper sanitation within 10 years, counted from the moment in time this article has been written. It was also mentioned that meeting this goal is impossible when only those methods are considered applicable which were developed and applied during the past 150 years. Neither the investment money nor the manpower is available to cover within the remaining 10 years the "rest of the world" with centralized systems as depicted in Figure 1. And it has been mentioned that the traditional centralized systems do not readily contribute to the sustainable development of urban regions. Not only does once-only use of water

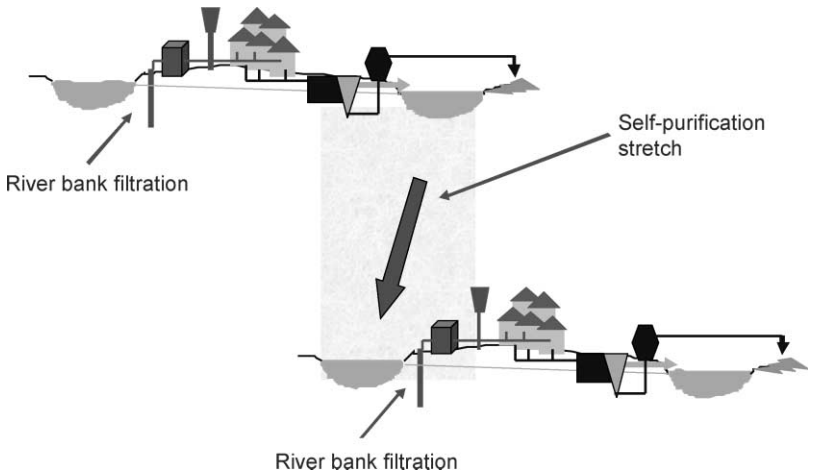

Figure 3 Consecutive re-use of water along rivers: common practice in many countries since decades

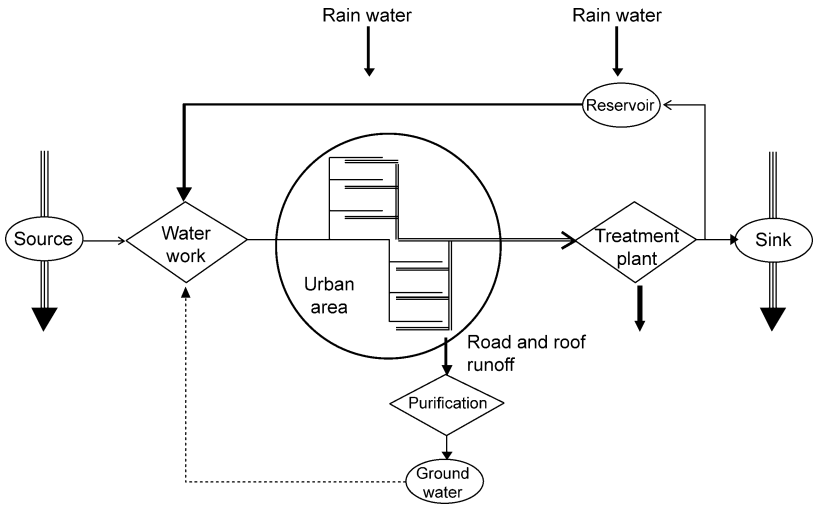

Figure 4 Direct water re-use, taking water reservoirs and groundwater as close-to-nature holding facilities, and as means to enhance acceptability of the re-used water by the customers

significantly impair the local water cycle and the related resilience of the environment, the traditional concept also causes significant loss of other valuable substances, nutrients for instance. But what are the alternatives?

To be able to quickly improve the local situation on the wastewater management side, implementation of advanced physico-chemical treatment is considered a promising first step (Figure 5). Mechanical pre-treatment consisting of screens, grit chamber and primary clarification using gravity sedimentation has traditionally been the first step in the process of wastewater treatment. Nowadays, a wide variety of membranes is available allowing advanced solid-liquid separation. By replacing the primary clarifier by membrane separation modules an effluent can be produced which is not only low in concentration of suspended solids but also low in the concentration of microorganisms including pathogens. Produced is a type of water which can be directly used, not as drinking water of course but for many other purposes, flushing and cleaning for instance. By dosing precipitants or inexpensive ion exchangers in front of the membrane, the concentration of dissolved substances could be reduced making the effluent even more attractive for domestic uses. Subsequently in time, the pre-treatment units could be supplemented with biological treatment units as has been common practice in the industrial countries. But for the time being, a significant progress could be made with a reasonable effort, particularly if considered that membrane modules can be mass produced with the advantage that through mass production costs can normally be significantly lowered.

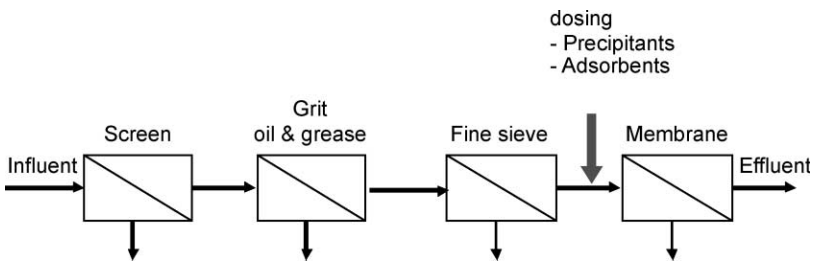

Figure 5 Schematic of an advanced physico-chemical treatment train

Favourable step changes can also be achieved by implementation of decentralized wastewater treatment and re-use systems in conjunction with the construction of apartment buildings, residential complexes, condominiums, recreational facilities, industrial parks and so forth. In all these cases, money is obviously available for getting building built. This includes installation of in-house water infrastructure. Wouldn't it be just logical to build, simultaneously, a water plant to which the wastewater is sent for removal of pollutants and pathogens, and thus for the generation of reusable water for flushing, cleaning or for watering gardens? Approaches of this kind are already common practice in some parts of Japan, in Tokyo specifically. Step by step and in a reasonable period of time an integrated water management system could be built up in contribution to the MDGs as well as to sustainable development of the region.

As a further step in the direction of sustainability of municipal areas, decentralized sanitation systems could be designed so that the various waste streams generated in households or in industrial plants, respectively, are collected and treated separately with the aim not only to recover clean water for further use but also to recover other valuable substances as well, nutrients in the first place. Respective proposals were made by a wide variety of authors (e.g., Larsen and Gujer, 1996a; Otterpohl *et al.*, 1997; Wilderer, 2004; Zeeman *et al.*, 2000), and a number of development and demonstration plants are already in operation. By limiting mixing and dilution effects recovery of valuable substances can be achieved much easier and by far more cost effective compared to the common practice when all the waste streams generated in municipal areas are mixed together, and diluted by large quantities of flushing water. Operation and control of such sophisticated decentralized re-use systems requires specific technical means. Remote control is to be executed by specifically trained personnel. Required are specifically designs legal frameworks and effective enforcement of laws and regulations, and last but not least specifically educated users. Experience with source separation of solid waste shows that motivation of the users to use those systems properly is relatively easy, especially when modern participatory approaches are used and intensive education is provided from the kindergarten level on. Experience also shows that technology by itself is an important but not the only important prerequisite in the process to creating a world where people can live in the long run in harmony with each other and as part of the larger ecosystem. The MDGs are challenge for engineers. Progress, however, can only be made when engineers and all the other sectors of our society get ready to work together in respect to nature we are a part of, and with respect to the right future generations possess to sustain themselves on earth.

Conclusions

Meeting the Millennium Development Goals is impossible unless engineers in concert with all the other sectors of our global society develop and accept novel methods of urban water management. Key factors to be considered in the process of development and implementation of novel technical solutions are as follows.

- Major focus has to be placed on urban areas. Because of the continuing and even increasing rate of migration installation of proper water supply and sanitation within cities, small alike big ones, is of critical importance in order to save human life and in order to maintain the societal stability and resilience which is a crucial factor in the war against poverty and hunger.
- Because of the limited amount of fresh water available in a municipal area, and because of the rapid increase of the water demand correlated with the population growth of the city, major emphasis has to be placed on development, implementation and build-up of acceptance of advanced methods for municipal water re-use. Extensive re-use of water within cities helps not only covering increasing water demands but

must be understood as well as an important contribution to the sustainable development of metropolitan areas.

- It will be impossible to supply in an instant all the municipal areas on earth with advanced wastewater treatment technology. But the water situation in the cities and villages can be significantly improved within a short period of time and for a relatively low amount of investment money, if the concept of step changes is adopted.
- As a most promising first step the author proposes development and subsequent implementation of pre-fabricated, mass produced and highly advanced physico-chemical treatment methods for the generation of hygienically safe water usable for flushing, cleaning and watering gardens.
- Installation of wastewater treatment plants in the course of the building of apartment houses, residential complexes, condominiums, recreational facilities, industrial plants and parks, and production of hygienically safe water for further use within the neighbourhood of the plant appears to be another important step in the attempt to meet the MDGs.
- As a further step towards sustainability of metropolitan and rural areas separate collection and treatment of the various waste streams from households and from industrial operations should be considered. Wastewater as well as the content of wastewater should be understood as valuable resources rather than a nuisance.
- The methods described above will not contribute to the development of a safe urban ecology unless the various technical units which are proposed are properly operated and controlled, and unless the urban population is ready to accept the technology with all its consequences. Implementation of technology must go hand in hand with education, build up of public awareness and readiness to pay for the service received. Application of the whole spectrum of information technology is necessary to be able to remote control the decentralized units. Also necessary are build up of operator expertise and establishment of a functioning system of law enforcement.
- The MDGs provide great opportunities for engineers. Engineers, however, can only be successful when supported by the readiness of the population to accept the technical solutions proposed. There must be established a two way traffic between engineers and any other sectors of science and society as well as with economical and political decision making to get the development proceeding into a direction man and nature, economy and ecology can profit alike.

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