Water Supply and Sanitation Facilities in a Human-Centered Management Concept for Fast Growing Megacities
- Waterhouse -

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Abstract

Migrants from rural areas often live in areas with insufficient infrastructure and difficult living conditions. The improvement of these circumstances starts with the basic need for a supply of water for drinking and domestic use in sufficient quality and quantity, as well as the prevention of water related diseases. The establishment of an appropriate distribution network takes a long time and is very costly. However, the lack of access to potable and domestic water and the lack of adequate infrastructure and sanitation facilities require to be prevented without time delay. In these informal settlements water supply is quite unusual, people have to spend more money to get their water from non-authorized dealers than the people in districts with a well-established infrastructure. In an area where increasing population causes water deficit, the water distribution network is often inadequate and unreliable. In many cases the sanitation systems and the pipes for potable water are in a bad condition (development of encrustation, weed growth, blocked by stones). The absence of an adequate water management system causes worsening conditions for the water resource, mainly because of illegal connections and tapping into the resource.

Facing overexploitation and thus deterioration of aquifers means emphasising water conservation, water recharge and reuse depending on the water balance in the region based on technical aspects and possible applications. Every possibility of treatment and reuse depending on necessary water quality standards must be initiated and realized in a sustainable way. In the scope of these problems an alternative concept for fresh water supply has been developed that considers the relevant macro-factors and can be considered as a central point of a sustainable and integrated water management conception. The technical part of the concept envisages the construction of local self-sustaining “waterhouses”. These facilities could accomplish the supply for independent suburb districts with water for drinking and domestic use as well as the water treatment by using mechanical, biological or electrokinetic methods. The energy required for this process could be produced from organic waste material (biogas) and also from other renewable energies (for example solar energy).

Predominately, water deficiencies are met by solutions which focus on technical, economical and regulatory aspects like above introduced. But to achieve long-term effects, the mere focus on these aspects has to be supported by accounting for human and cultural factors. Sustainable and successful water-management solutions require consideration of cognitive, affective and social factors as well as the impact of cultural and religious determinants. This will be the base to derive culturally susceptible best-practise recommendations for human-centred water management strategies and to develop educational concepts that are sensitively balanced with individual factors and cultural diversity.

Keywords

potable water, groundwater contamination, infrastructure, megacities, water quality standards, water resources, human-centered water management strategy

Introduction

Sufficient water supply is one of the most exigent global challenges of the 21st century. At present, a large portion of the world population does not have barrier free access to freshwater and lacks of a vital integral part of daily living. Problems regarding reliable water supply include quantitative and qualitative shortcomings as well as contaminations, salinasation, and overexploitation through agricultural and industrial misuse. Meanwhile water deficit situations are getting worse due to the increasing population, particularly in fast growing megacities, where the water distribution network is often inadequate regarding water leakage and reliability. Problems occur also by virtue of intermittence of supply in form of causing costs for compensatory strategies and unhygienic effects in the pipes. In many cases the sanitation systems as the pipes for potable water are in really bad condition, which also leads to contamination at every

point of leakage. Even the absence of an adequate water management system causes worsening of the scarcity of the water resource, because every illegal connection and tapping will keep undetected and not counteracted.
Dealing with these problems solely facilitating technical solutions leads to failure, because of the complexity of the water/ human-related system, which consists also of hydrogeological, climatic, technical and socio-cultural aspects and all conceivable interactions. If focussing e.g. on the specific standard of knowledge regarding the public perception of grey-water usage, the successful implementation of any reuse project hinges on public awareness and acceptance. The positive attitude towards the usage of recycled water (people see the logic of using grey water) does not necessarily imply the behavioural acceptability (people still remain reluctant), showing once more the complex interaction between cognitions on the one hand and behaviours on the other (PO ET AL., 2003). In the scope of the problems an alternative concept for fresh water supply and sanitation facilities has been developed that considers the relevant macro-factors (water balance, water demand regarding quality standard, technical possibilities and applicabilities…), but focuses also on the specific standard of knowledge regarding the public perception of grey-water usage (e.g. ASANO, 2001). This concept is situated in-between the underprivileged districts. The location has to be chosen by the community and the operation is in its own authority. This is possible due to the aligned technology with practical operation and maintenance tools and the provision is accompaigned by enlightened and educational measurements.

1 Megacities - an Introduction

The third millennium will be the millennium of vast urbanisation and huge megacities. Estimations suggest that by the year 2025, 85% of the population of the industrialised countries and 55% of the population of the third world will be living in urban environments (FELDBAUER & PARNREITER 2001). So for the first time in the history of man more people will be living in agglomerations than in rural areas. The process of urbanisation will most likely continue in the industrialised nations, although the extreme dynamics growth has already decreased in the megacities of the north during the middle of the 20th century. In contrast to this the cities of the third world are currently still undergoing a process of ongoing expansion. This means that the number of megacities worldwide is still going to increase. As it is demonstrated in Figure 1, today there are 39 megacities worldwide of which 28 are located in countries of the third world.

Due to the "functional primacy" the megacities appeal an enormous attractiveness, so that megacities are centres of migration. The tremendous attraction of the third world megacities is to be justified by the hope for a better life for the rural population. In the 1990s the growth of the urban population in developing countries was counted with up to 160.000 persons per day. Although the migration into the megacities of the third world is gradually decreasing, rising population in the megacities is increasingly caused by natural population growth. This implies that even if the, at the moment unimaginable case of radically decreasing migration from rural areas would take place, the increase of urban population would continue. The growth of these megacities which is difficult to control implies great problems for these cities, which will be discussed in the following chapter.

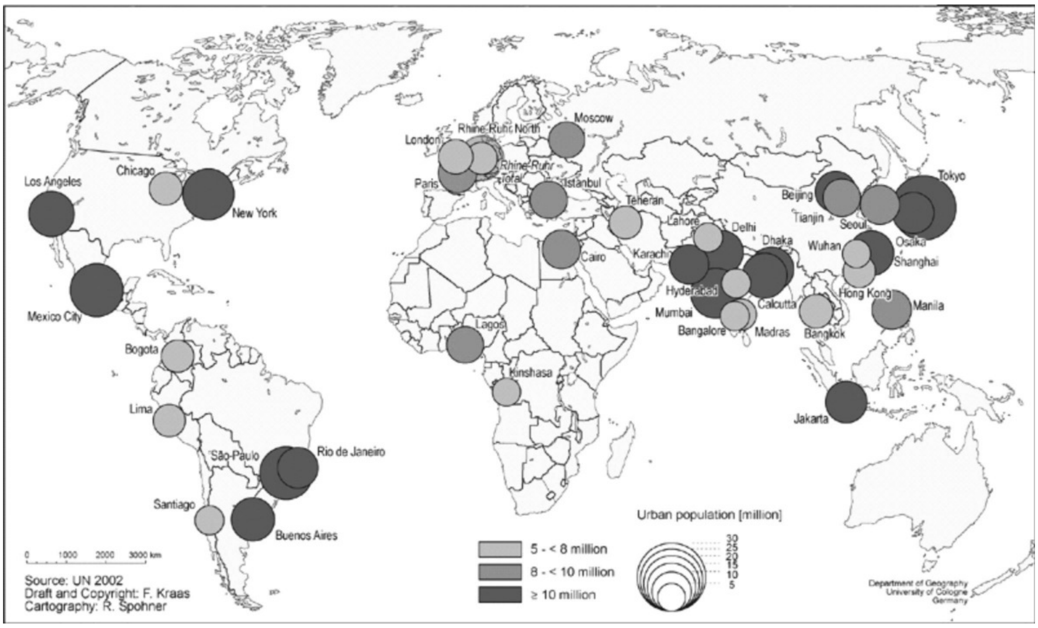

Figure 1: Allocation of megacities; (KRAAS, 2003)

Megacities face great problems as well as in first and in third world countries. The main issues are structural, ecological and socio-economical problems. Naturally the problems in the megacities of the third world are boosted by lacking financial and economic resources and are thus even more difficult to solve. Nevertheless, many of these problems are also faced by megacities in first world countries.

Problems of megacities are versatile and associated with each other. This implies that it is very difficult to solve these challenges individually. It is thus more important to recognise coherences and to develop solutions. Due to the diverse cultural, social and economic preconditions of the different regions in which megacities are located, solutions most certainly have to be modified to fit the regional circumstances.
Structural problems of megacities are often characterised by lacking land use planning and regulation. This frequently results in growth beyond national and civic control. On the one hand this causes unregulated special expansion and a strong increase in informal building. On the other hand this leads to a direct coexistence of diverse forms of utilisation, just as agricultural, industrial utilisation and housing. As a result of this unregulated development, disturbances like spatial wastage, industrial emissions and ecological problems occur. Due to this, megacities often suffer serious infrastructural, ecologic and congestion problems.

Resuming these facts it is very obvious that especially the megacities in the third world are facing a further dilemma, which is to supply the population with water in adequate quality and quantity. Especially the quality of water supply for large parts of the population is a severe problem for many megacities. The water supply for urban population, the disposal of sewage and the dehydration of large sealed areas is a challenge, to which no clear solution has been found up to now. By now it is obvious that the systems that have been developed in the megacities of the first world countries are not sustainable for the challenges implied in the megacities of the developing countries. Attempts are bound to fail due to the enormous technical dimensions and the total lack of financial potential. How is the infrastructure of cities that grow by the size of Frankfurt every year going to manage this development? The European and American infrastructures are far too expensive to establish them globally. By the ongoing growth of these cities the water problem is going to increase, not only for the environment surrounding these cities, but also for the urban population itself (GRAW & MAGGIO 2001).

2 Management strategies

Environmental problems today are very complex, which requires a wide spectrum of solutions. Interdisciplinary approaches nowadays allow the assessment at different levels, working at the same time, integrating site-specific aspects. Master plans have to be developed and proposed, which take the technical, financial and political constrains into account. In India for instance, agriculture interests have been able to frustrate reforms on power pricing and groundwater regulations that are economically and environmentally “rational” (MORRIS ET AL. 2003). Technical and scientific specialists, which gain their acknowledgement from the aquifer system, its balances and the relevant water amounts from precipitation, storage, recharge and consumption, are requested to include economic and social aspects in their considerations. Awareness from the users’ side and participation from all parts of stakeholders and decision makers are just as important as any form or possibility of water treatment or reuse. Nevertheless, the legal framework has to define water conservatory and protective basics, which involves

- pumping permits;
- definition of allowed uses;
- delineation of protection areas;
- identification of polluters and
- monitoring.

Monitoring of water quality and water levels in an aquifer is the foundation on which groundwater resource management is based (JÖRGENSEN 2000). This means that the precondition of all possible measurements is the understanding of the flow system and the baseline of water quality before identifying emerging problems such as over abstraction or water pollution.
Any implementation of management strategies is very sensitive to the status of the country and the characteristics of the city source of water (VÁZQUEZ-SUNÉ et al. 2005).

But these management strategies only make sense, if there is public or municipal distribution of fresh water. In most megacities, where the expansions of the informal settlements represent the augmentation of population, there is no connection to the municipal water supply and the drainage network. Any outcome of a management master plan would fail, because the people have no choice even to decide if they want to participate and behave in an environmental friendly way. They have to take care to satisfy their elementary needs- no matter if there is any contamination due to on-site sanitation or lowering the water table due to tapping the municipal pipelines. In connection with an immediate approach, which is presented in the following chapter, a long-term concept should be aspired to solve the problems that are described in Figure 2 concerning the water supply in fast growing cities. But the first step of any strategy has to make potable water available for slum dwellers and the setup of sanitation facilities in the informal areas through “waterhouses”.

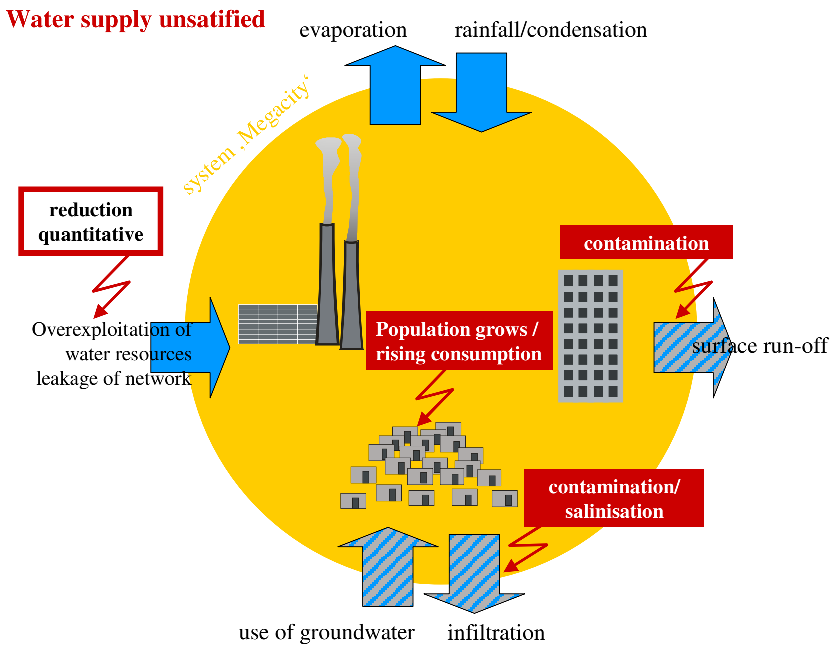

Figure 2: Unsatisfied water supply; own concept

3 Sustainability in urban groundwater management in consideration to satisfy basic needs for water supply

In order to provide basic water supply in a good quality and in a sufficient quantity for great parts of the population in the fast growing megacities of the third world, small scale, integrated, decentralised supply and disposal systems have to be established next to the already described water management concepts.

Such a small scale supply and disposal system is going to be described by the following example. In such a system the water supply for inhabitants, according to the local situation, could be established by a “waterhouse”.

The primary idea of the “waterhouse” derived from the several centuries’ old bagnio or bath houses in the Greek or Arabian culture (Cisterns, Hamams). Issues of sanitation or personal hygiene were central organised and provided for the community in acceptable distance to everyone of the district. The bath houses were also places for conversation and exchange and therefore they fulfilled additionally a social need of the population. The “waterhouses” in a modern sense serve the same way, but are adapted to actual conditions in that manner, that they have to fulfil beneath the social needs primary the basic needs as the allocation of potable water, water for sanitation and laundry for a lot of people. It is just one step forward to integrate the directive of sustainability by treating the waste water or give the possibility to reuse less polluted water within a cycle.
The functionality of the “waterhouse” cycle serves the intention to make water available for this part of population, which is not connected with the municipal network. The supply of potable water in these districts can’t wait until the municipal administration starts to install or advance existing sewerage. Basic needs have to be satisfied immediately, which means the availability of potable water, water for personal hygiene and water for laundry. To enforce a sustainable development in the informal areas of fast growing cities, the water resources have to be used carefully and any possibility to save water has to be taken into account, which leads to the methods of reuse, treatment with adapted technologies and to the idea of different quality sensitive uses.

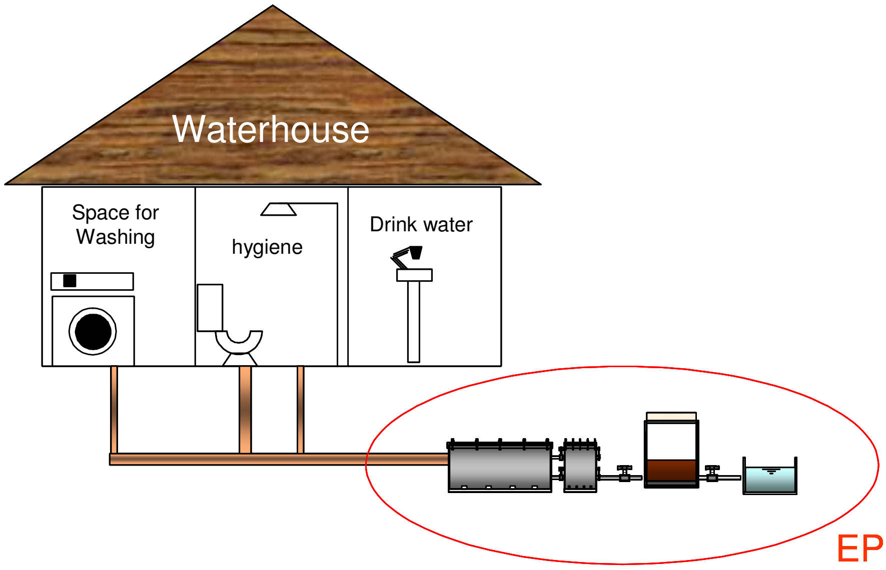

Figure 3: Waterhouse; own concept

In a “waterhouse” (Figure 3) potable water, sanitary facilities for personal hygiene and laundry facilities can be provided. The “waterhouse” is equipped with a well, because complete recycling of used water is actually not yet realizable. For the system of wastewater treatment in the “waterhouse”, we use the concept of appropriate technology which is innovative, easy to implement, environment-friendly and economically feasible.
A system as the “waterhouse” requires functionality and this can be achieved with a decentralized technology; a simple system with greater ease of operation, maintenance and better results. The treatment of wastewater in the house can for example be done by electrochemical processes comprising Electrokinetic Phenomena (EP).
This electrochemical advanced oxidation process represents a feasible technology for separation and removal of organic and inorganic substances present in sewage. By the help of an integrated electrochemical process harmful substances present in sewage can be controlled through a phase interception and can then be removed. The process has several phases in which wastewater can be prepared, pre-treated and treated.
Through a system of cells working in series the flow passes through different conditions of the physical and electrical type of material for treatment. Water can be subjected to conditions of electric charges, time of application and temperature variation. With the EP precipitation takes place at the same time as the destabilization of colloids; unlike conventional coagulation.
A monitoring system can identify the initial conditions of water, for example: the amount of electric charge that has to be applied is determined by the conductivity of water. Voltages can be programmed between the cells in such a way as to optimize the use of electricity. With these parameters it is possible to apply electrical charges to the heterogeneous fluid and create a separation and sedimentation of substances that are suspended.

This process can ensure high efficiency in the oxidation solution as hydroxides that are generated remove the organic pollutants, in turn generating disinfection and stability in the process. Depending on the material of the electrodes a high production of oxygen can be generated in any phase, which is optimal for the treatment itself.

The most important benefits may include:

- harmful substances can be removed,
- the treatment is optimal concerning hygienic aspects and the control of gas emissions,
- by means of the recycling process, opportunities to reuse treated water are given,
- the infrastructure required is minimal,
- no need for the use of chemical additives,
- remove metals that could be present in water, such as oxides,
- destroy and remove bacteria, viruses and organisms,
- low operating and maintenance costs.

Within such a concept the three aspects of sustainability can be reached. Ecologically, the efficient use of the scarce water resource can be increased and the emission of pollutants is reduced. Economically, jobs are created, regular costs can be optimised and an adequate pricing system can be established. In a social context the living standards of the affected people can be improved and conflicts about water can be released.

4 Summary

This presentation discusses the problems of water supply in fast growing megacities from different points of view in order to follow the directive of sustainability. The described concept of a waterhouse provides an ecological, economical and social positioned approach, which immediately tries to improve the drastic water deficit situation in urban border areas and informal settlements. Facing overexploitation and thus deterioration of aquifers in the megacities means emphasising water conservation, water recharge and reuse depending on the regional water balance. In this context the conception of the waterhouse is hung in, integrating adapted technologies for waste water treatment like mechanical/biological treatment and the application of solar distillation and electrolytic methods depending on hydrological and -chemical conditions. Different technologies are adjusted to optimise the idea of reuse and conservation of the scare water resource, but are integrated in a self-sustaining treatment cycle, which has to be operated by the dwellers themselves. While adding new jobs the community is required to take care of the waterhouse and the consciousness for saving water and the awareness to prevent water pollution is awaken. The intention of the waterhouse is to make potable water immediately available within an economically rational price system for the disconnected parts of the megacity but is not able to compensate a drastic lack of landuse planning nor to reduce the responsibility of the municipal administration to water and sanitate their population. But these structural problems need time and the basic needs have to be satisfied without any delay.

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