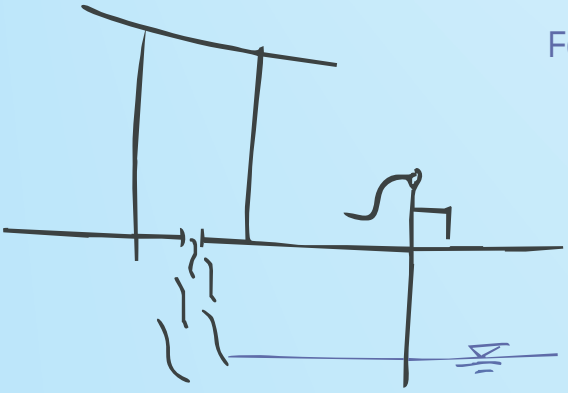
INTERNATIONAL YEAR OF SANITATION 2008

BGR Bundesanstalt für Geowissenschaften und Rohstoffe

Symposium Booklet
International Symposium

Coupling Sustainable Sanitation & Groundwater Protection

14. - 17. October 2008
Geozentrum Hannover, Germany



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Technology-Transfer-Centre

Welcome to BGR!

Honorable speakers, distinguished guests, dear participants and colleagues,

I warmly welcome you here in the Federal Institute for Geosciences and Natural Resources (BGR) in Hannover. BGR is committed to sustainable use of natural resources and to the protection of the human habitat. As an independent institution, belonging to the Federal Ministry of Economy and Technology, we feel responsible for the future, advise ministries and the European Community, and act as partners in industry and science. In the development cooperation sector BGR is a partner of the Federal Ministry for Economic Cooperation and Development (BMZ), in particular for projects in the geology and mining sector including soil and groundwater.

In the last 100 years, the world population has grown by a factor of four, while international water demand has increased ten times. More and more humans are migrating into cities, often mega-cities, and are in need of infrastructure for drinking water and sanitation facilities. Today, nearly 900 million people are lacking access to clean drinking water and more than 2.5 billions are without improved sanitation facilities.

Worldwide, 46% of the population have no access to piped water on premises. Furthermore, it is not unusual that the poor have to buy drinking water in bottles to a very high price as the only alternative would be to spend hours of valuable working time to withdraw clean water from distant places. Human excreta are often discharged without treatment into rivers or remain in open drains, creating high risks for human health. In addition, pit latrines pollute local groundwater resources which provide drinking water for the poor. Such conditions lead to a vicious circle of diarrhoea related diseases like Cholera and Typhoid.

Every 20 seconds a child dies due to water born diseases (according to Unicef), that is equivalent to 15 fully booked 747 passenger Boeings per day. 80% of the diseases in developing countries are due to contaminated drinking water and unimproved or lacking sanitation facilities, estimated by the World Health Organisation.

Knowing these shocking figures, it is high time to act! Among the indicators that should remind us to act are the Millennium Development Goals, the MDGs.

During the Millennium Summit in New York in 2000 and the World Summit on Sustainable Development in Johannesburg in 2002, the United Nations developed a series of Millennium Development Goals aiming to achieve poverty eradication and sustainable development. The Water and Sanitation targets are to halve the proportion of people without access to safe drinking water and

adequate sanitation by the year 2015. Many developing countries are off track for achievement, especially on the sanitation target.

The UN Secretary General's Advisory Board (UNSGAB) therefore has set up a plan describing how breakthroughs for water and sanitation can be achieved. The UNSGAB Hashimoto Action Plan recommends actions on all important aspects of water and sanitation. The call for the United Nations to declare 2008 the "International Year of Sanitation" was one of the recommendations of the Hashimoto Plan. In December 2007, the United Nations followed this recommendation, aiming to raise awareness for the global sanitation crisis which presents one of the main obstacles to human development.

BGR has decided to organize and host this important symposium in order to take up the momentum the United Nations General Assembly has created by declaring 2008 the International Year of Sanitation.

For us lacking of improved sanitation is the greatest obstacle to protected, clean groundwater. Groundwater accounts for 70% of drinking water supply resources in the world; in arid areas people fully depend on this resource.

The latest Joint Monitoring Programme report on drinking water and sanitation shows that, without considering sanitation and groundwater protection for drinking water, the world will dramatically fail to meet the Millennium Development Goals. Decision makers including political leaders often fatally lack interest and awareness of this problem. Improved sanitation and groundwater protection can save the lives of several millions of children and adults each year. It is fundamental to gender equity as it protects women's dignity. Investing in sustainable sanitation results in development and pays back economically. According to a study by the Swiss Tropical Institute and WHO, every dollar invested in sanitation in developing regions returns 5 to 46 US$, depending on the intervention. The main contributor to economic benefits was time savings associated with better access to water and sanitation services, contributing at least 80% to overall economic benefits.

Worldwide, a lot of activities are ongoing in the field of water and sanitation, but little attention is given to the important interaction between non-treated wastewater and groundwater. We need to rethink on this aspect and put our efforts on fostering sustainable sanitation and groundwater protection.

I am looking forward to an inspiring symposium. Let us share our experiences from the technical and the policy side and address the gap between technical approaches and political challenges.

Sincerely

Prof. Dr. Hans-Joachim-Kümpel
President of BGR

Introduction

Looking back on more than 40 years of groundwater quality assessments in developing countries, we recognize that massive pollution of groundwater bodies underneath urban settlements are in most cases due to lacking or inadequate sanitation techniques. A rapid increase in worldwide population along with evolving mega cities turns untreated sewage into a massive threat to valuable groundwater resources. Since groundwater resources are in arid areas very often the only source for drinking water, the poorest in developing societies face severe drinking water scarcity. Microbiological pollution as a consequence of untreated faeces and wastewater of other origins, causes water born diseases and leads to 2.2 million deaths every year. In most developing countries child mortality still reaches terrifying figures. It can't be stressed enough, that the only way out of this dilemma lies in the implementation of sustainable sanitation and thus also in adequate measures for groundwater protection. Both solutions must be regarded as essential prerequisite for further human development.

Natural groundwater, unaffected by human activities, is free of pathogenic germs. Once such germs have infiltrated into the groundwater it takes about 50 days until 99% have vanished. In cases where drinking water wells are located in direct neighborhood to a pollution source, travel times of the groundwater are much shorter. Next to reducing health risks, appropriate sanitation solutions also reduce the transfer of most unwanted dissolved organic and inorganic substances into the groundwater body. As natural groundwater is usually of good quality when extracted from aquifers, it can be fed into the local water supply system without any further treatment. This makes groundwater an inexpensive drinking water source, available especially to the poor. Well protected groundwater resources can be tapped close to human settlements and thus makes distance water supply and expensive surface water treatment unnecessary. Thus, every precaution in form of sustainable sanitation and appropriate groundwater protection is much more cost-effective than any subsequent and costly treatment of spoiled water resources or distance water supply.

Our chemical analyses of groundwater samples often prove that even simple but effective first steps in enhanced sanitation pays off within a relative short time in a better groundwater quality. With regard to general health concerns the reduction of the microbiological load gains highest priority. Any further avoidance of uncontrolled seepage of dissolved nutrients into groundwater bodies contributes to a better long term groundwater quality. It has to be stressed that excreta and greywater represent valuable resources in most settings. They support agricultural production and help to sustain food security. BGR does not prefer certain sanitation technologies over others, but rather supports all approaches which prove economically and ecologically sustainable, socially acceptable and groundwater friendly in the local context.

Dr. Thomas Himmelsbach
Head of Section Groundwater Protection

General information

Venue

Federal Institute for Geosciences and Natural Resources (BGR)
Geozentrum Hannover
Stilleweg 2
30655 Hannover, Germany
E-Mail: symposium2008@bgr.de
Website: www.bgr.bund.de/EN/symposium2008

Registration

The Registration Desk is located in Room A14 and will be open from
5pm to 7pm on Tuesday, October 14,
8am on Wednesday, October 15 and
8am Thursday, October 16th.

Badge Identification

Every participant will be required to wear their symposium badge at all times.

Opening Ice Breaker

An Opening Ice Breaker will be held in the Foyer from 7pm on Tuesday 14 October

Tee & Coffee, Lunch

Tea, coffee and lunch will be served at the symposium venue, on Friday 17 lunch will be provided during the field trip.

Social Event

18:30pm on Wednesday 15 October
Departure to Restaurant Meyershof from Geozentrum by bus
All badge-wearing participants are invited to dinner.

Field Trip

08:30am on Friday 17 October
Sanitation technologies and groundwater protection near Braunschweig
Departure from Geozentrum by bus
16:30pm on Friday October 17: Arrival at Hannover, Geozentrum

Contents

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Symposium Rationale

Presently, 1.1 billion people lack access to improved water supply and 2.6 billion to improved sanitation. Inadequate water supply and sanitation are responsible for the vicious circle of poverty and ill-health.

The United Nations have declared 2008 as the International Year of Sanitation (IYS) to raise awareness for the global sanitation crisis which presents one of the major obstacles to human development in many developing countries.

BGR, as the German implementation agency for development cooperation in the groundwater sector, addresses sanitation issues in many projects from the perspective of groundwater protection. Lacking or insufficient sanitation facilities threaten the quality of groundwater resources which provide drinking water to many people. The IYS offers a unique opportunity to highlight the immense problems of groundwater pollution due to lacking or inadequate sanitation facilities in developing countries. As groundwater is worldwide the major source of drinking water supply, especially in arid regions, the protection of groundwater resources from pollution is a key element of sustainable human development.

The symposium will focus on applicable solutions for the protection of groundwater against anthropogenic domestic effluents in the context of developing countries. It will address the gap between technical approaches and political challenges and provide a forum for exchange between practitioners of development cooperation, technical and scientific specialists and representatives of political institutions who are committed to substantive support for improved sanitation and groundwater protection. This will contribute to the international efforts for improving sustainable sanitation and groundwater protection practises in future.

The symposium will therefore discuss technical and scientific approaches to improved sanitation and groundwater protection within a political framework.

Programme

Tue 14.10.2008

17:00 Registration

19:00 Ice breaker

Wed 15.10.2008

08:00 Registration

09:00 **Welcome by the hosts**

Hans-Joachim Kümpel, Thomas Himmelsbach (BGR)

Christoph Merdes (BMZ)

Bernd Strauch (City of Hannover)

09:30 **Keynotes: Links between groundwater protection and sanitation**

- Stephen Foster (World Bank GW-MATE & IAH)

  Urban water supply security in the developing world – groundwater use trends and the sanitation nexus
- Perry McCarty (Stanford University)

  The insidious nature of groundwater contamination – the great need for protection

10:30 Coffee break

11:00 **Statements: International efforts for sustainable sanitation and groundwater protection.**

- Patrick Mmayi (UNEP)

  Sanitation and groundwater protection: a UNEP perspective
- Susanne Herbst (WHO)

  Sanitation and groundwater protection: a WHO perspective
- Darren Saywell (IWA / SuSanA)

  Better planning for better sanitation

12:30 Lunch

13:30 Opening of poster exhibition and coffee

14:30 **Session I: Sanitation concepts and their relevance for groundwater protection**

- Elisabeth von Münch (GTZ)

  Overview of anaerobic treatment options for sustainable sanitation systems
- Arno Rosemarin (SEI)

  Overview on dry sanitation concepts including handling and storage of urine

- Thomas Levin (GTZ)

  Groundwater protection through improved wastewater management in Kafr El Sheikh, Egypt
- Mirko Hänel (TTZ)

  Sustainable and safe application of sludge and wastewater in short-rotation-plantations
- Ralf Otterpohl (TUHH)

  Constructed wetlands for greywater handling
- Stefan Reuter (BORDA)

  DEWAT systems and stakeholder involvement: Lessons learnt from a national community based sanitation programme

16:30 Coffee break

17:00 Panel discussion with the presenters of Session I

18:00 End of day 1

18:30 Departure to restaurant Meyershof by bus

Thu 16.10.2008

08:00 Registration

09:00 **Session II: Approaches covering sustainable sanitation and groundwater protection**

- Ali Subah (MWI) & Ariane Borgstedt (BGR)

  Groundwater protection and sanitation – practical experiences in Jordan
- Thomas Nuber (University of Bochum)

  Challenges of groundwater management in the Mekong Delta, Vietnam
- Ridha Béji and Khaled Mehrez (DGRE/ONAS; KfW)

  Contribution of wastewater treatment to groundwater protection - experiences in Tunesia
- Bernard Keraita (IWMI)

  Protecting groundwater through safe agricultural reuse of wastewater
- Bassim Abbassi (Al-Balqua Uni) & Leif Wolf (University of Karlsruhe)

  Integrated assessment of sanitation aspects and groundwater management at the Lower Jordan River within the SMART-research project
- Chris Shisanya (Kenyatta University)

  Mainstreaming sanitation into planning and implementation of integrated watershed management measures in Kenya

11:00 Coffee break

11:30	Panel discussion with the presenters of Session II
12:30	Lunch
13:30	Poster exhibition and coffee
14:00	(parallel to Poster Exhibition) SuSanA working group meeting WG03: Sustainable sanitation, renewable energies, groundwater protection and climate change
15:30	Coffee break
16:00	**High level panel: Coupling sustainable sanitation and groundwater protection: What is done to make progress in this field?** Patrick Mmayi (UNEP) Susanne Herbst (WHO) Uschi Eid (UNSGAB) Christoph Merdes (BMZ) Mahesh Mishra (WaterAid Zambia) Wilhelm Struckmeier (BGR & IAH)
18:00	**Closing procedure** Michael Kosinowski (BGR) and Gerd Förch (moderator)
18:30	End of day 2

Fri 17.10.2008

08:30	Field trip (sanitation technologies and groundwater protection near Braunschweig), departure from Geozentrum by bus
16:30	Arrival at Geozentrum Hannover

Poster Abstracts

The current status of sanitation and groundwater linkage in the city of Addis Ababa, Ethiopia

Tamiru Alemayehu Abiye

School of Geosciences, University of the Witwatersrand, Johannesburg, South-Africa

Addis Ababa was established as the capital city of Ethiopia in 1886 and has grown to become the largest urban and commercial center in the country, hosting over 4.5 million residents. It is located in the central part of the country at the edge of the Ethiopian Rift. Addis Ababa is the seat of the African Union and other many international organizations.

Fast population growth and rapid industrialization, on one hand, and poor sanitation, on the other, have led to the deterioration of the ground water quality in the city of Addis Ababa due to direct linkage with the streams of the city.

The urban wastewater is discharged largely into streams that drain the city. Only less than 3% join the wastewater treatment facilities. Since sanitation is one of the most basic services in human life, public toilets have been introduced with charge system in the city. However, most of the residents discharge directly into the nearby streams where over 35% uses septic tanks. The Kaliti Treatment Plant receives about 7,500 m3/d of sewage from the city which is negligible amount for the city. This reaches a peak value of 10, 000 m3/d at rainy seasons. The sewage collected using vacuum trucks from septic tanks is being discharged into drying beds that are constructed near the Kaliti waste stabilization pond and in Kotebe Yerer Ber.

The exponential population growth in the city has lead to further groundwater exploration in different localities. It has been estimated that per capita consumption of water will approximately be doubled over the next 15 years as a result of several factors including improved living conditions with a greater proportion of backyard plantation and sanitary facilities; good personal hygiene; increase in commercial and industrial demand. Hence, the current demand has created a supply shortfall of over 50%. There are also continuous efforts by the municipality to establish new well fields to fill the existing water demand gap.

The spatial water sampling has been carried out in the streams that drain the city. Random sampling on boreholes has also been performed. The analytical results from major ions and bacteriology indicate that the impact of poor sanitation is high on groundwater. In the areas where sanitation is improved,

the groundwater quality is relatively good. The groundwater vulnerability for pollution mapping performed has been done using DRASTIC nodel. The result indicates that over 95% of the volcanic aquifer fall under highly vulnerable category that corresponds to the aquifer that contain large number of Faecal colifoms and E. Coli bacteria. The plots from physical and chemical analyses results show slight variation in the quality of surface water due to poor sanitation is being reflected on shallow groundwater. The monitoring results show the presence of quality variation based on the infiltrated water. The provision of communal sanitary facility and construction of individual septic tanks could help to protect the vital water supply aquifer of the city.

Integrated groundwater modeling and hydogeochemical study in Addis Ababa area: Towards the protection of wellheads and developing decision support system for sustainable groundwater utilization

Tenalem Ayenew, Stefan Wohnlich & Molla Demlie

Addis Ababa University, Department of Earth Sciences, Addis Ababa, Ethiopia

A detailed groundwater flow system analysis was made using numerical flow model (Modflow) along with conventional hydrogeochemical surveying in a highly fractured volcanic area. Converging evidence approach was employed to integrate the model simulation results with the extensive water quality data. The main focuses are to delineate wellhead protection areas and analyzing groundwater-surface water interactions. The result indicates that the groundwater flows regionally to the south converging to the major well field supplying a quarter of the water supply of the city of Addis Ababa. Reservoirs and rivers play important role in recharging the fractured volcanic aquifers. Model simulations made under different pumping scenarios indicate that an increase in pumping rate results in substantial regional groundwater level decline, which will lead to the drying of springs, and shallow hand dug wells. This causes reversal of flow from contaminated rivers in to productive shallow aquifers close to highly polluted rivers draining through the city. The comprehensive hydrochemical survey revealed that most of shallow wells, springs and rivers are extremely polluted by heavy metals and nitrate. In places coli bacteria has been detected. Excessive pumping and luck of considerations on issues of wellhead (recharge area) protection will likely lead to large-scale groundwater pollution. The study clearly indicates the importance of model-based decision support tool for sustainable groundwater management practice. By converging the hydrochemical data and flow simulation results, focal areas to be protected were identified. The work is believed to have far-reaching impactions for many urbanized areas established on fractured volcanic aquifers that can easily be polluted by contaminated rivers and springs elsewhere in the East African rift system.

Environmental sanitation and groundwater resources of the developing economy of southeastern Nigeria: Implications and sustainable containment approches

Elizabeth Okoro, B.C.E. Egboka, A.G. Onwuemesi & Anike

Department of Geological Sciences, Nnamdi Azikiwe University, Awka, Nigeria

Pollution and contamination of water resources are parts of the negative consequences of urbanization and population growth in many developing economies. The numerous commercial and urban centers of southeastern, Nigeria such as Onitsha, Awka, Nnewi, Ekwulobia, and Ihiala lacked functional water supply and adequate sewage systems. Improper waste disposal practices with attendant poor condition of the total environment abound. One is confronted by heaps of refuse that form ugly scenario on entry into the rural, commercial and urban areas. Lack of waste disposal and management facilities is common place and impairs the quality of groundwater especially during the rainy season as human and environmental sanitation received very low attention. The resultant public health is the associated consequences of this environmental menace.Lack of adequate toilet facilities is commonplace. The use of open spaces, bushes and shallow pits for toilet purpose have negative impacts on groundwater quality. The improper disposal and management of industrial and domestic wastes are not without implications on groundwater quality. The impact of the climate change on water resources and the environment is on the increase and has resulted in the increased dependence on unprotected groundwater resources. Most biological parameters of the groundwater resources occur in objectional values. Water from contaminated shallow hand dug wells are sold to the public at exorbitant prices without treatment encouraging the spread of water borne diseases as witnessed in the recent cholera outbreak in five communities in the area. The cities and commercial centers are faced with acute water and environmental problems that exacerbate the standard of living of the people. Ignorance and self indiscipline results in the loss of sustainable socioeconomic benefits of the natural environments. For sustainable socioeconomic development of the developing economy, functional water and efficient waste management schemes are prerequisite. It is in line with these that the government made accesses to potable water supply in schools, hospitals urban and peri-urban areas a priority. Monitoring of private sector participation in water supply ventures to ensure provision of water of good quality has been adopted. Considering the numerous benefits of a healthy total environment, Department of Environment and Water Resources was created and adequately equipped with relevant expertise, facilities and manpower to ensure environmental protection and enforcement of environmental laws and polices. Sustainable water projects in the commercial cities of the state for adequate water supply are in progress. Waste disposal facilities located at strategic places now

abound with the inauguration of environmental protection agency to ensure regular evacuation of wastes. The Institution of new sanitary inspectors to ensure adequate household and environmental sanitation has received mass commendation. Provision of toilet facilities in schools and market places has also improved the sanitation condition of the area. The above measures have positive impact on the sustainable health and economic development of the area for improved total environmental condition and for the achievement of the millennium development goals.

Jordan experience in watershed management (Qairwan Spring at Jarrash Governorate case)

Ahmed Ali Uleimat

Quality Resources Protection Department, Water Authority of Jordan, Amman, Jordan

In this poster, the Jordanian experience as a developing country in watershed management will be presented. Jordan has very limited renewable water resources and water is becoming an increasingly scarce resource. Planners are forced to consider any source of water which might be used economically and effectively to promote further development. One of the major challenges facing the government is the protection of precious water resources by introducing sound principles of watershed management. The water resources dilemma in Jordan is two-dimensional. A growing population requires more water. However, more human activities result in increasing ground water pollution. Jordan's water resources quality is deteriorating as evidenced by: elevated nitrate levels, salinity in the ground water and microbiological contamination. Deteriorating water quality requires sophisticated treatment technology. This increases the need for capital investment to build new water treatment facilities. Protection of water quality at the source through watershed management can reduce the requirements and costs of building and operating drinking water treatment systems throughout the kingdom. MWI/WAJ has highlighted the severe water scarcity with the international donors to balance the goals of providing services and source protection and regulatory enforcement. One of these agencies is the U.S. Agency for International Development (USAID) through the project entitled Pollution Prevention for Environmental Health Protection (Jordan's Water Quality Management Program).

Jordan water quality management program funded by USAID has begun in 2002. CDM, Inc has been implementing this program in partnership with several national agencies including the Ministry of Water and Irrigation (MWI)/Water Authority of Jordan (WAJ). Together these agencies work to improve water resources management and thereby protect public health and the environment.

This poster will show the different stages of the program (2002-2008) including the main activities.

Phase I (2000):

- Development of preliminary watershed management plans for catchments supplying treatment facilities at Wadi Es-sir,Qairawan,Qantara,Deek and Saltl;
- Improvement of water quality monitoring by building partnerships between WAJ and MOH.

Phase II(2003-2005):

- Implementation of the watershed management concept on a pilot scale in the Qairwan watershed.

Phase III (2006-2009):

- To implement the solutions building on the first two phases and the best management practices previously identified.

Sanitation practices and their potential influence on groundwater quality in Lusaka

Daniel C.W. Nkhuwa, Roland Bäumle, Theresa Kafula, Ahmed H. Ahmed, Oscar Silembo & Levy Museteka

School of Mines, University of Zambia, Lusaka, Zambia

Problem Statement

Water forms one of the most important natural resource, and is the basis of life and an essential pre-requisite for all living organisms, major ecosystems, human health, and socio-economic development. To this end, most population growth and distribution centres appear to be intimately linked to the availability of freshwater. However, the potability of this water is threatened by disposal of different forms of different forms of waste – solid, human excreta, wastewater, etc. Of the city's 1.5 million inhabitants, 55%, 25% and 20% of the population depend on pit latrines, sewer and septic tank systems, respectively, to disposal of their excreta and wastewater. Since the city is predominantly underlain by karstified, marble in which the water table is shallow, such practices pose great threats to the quality of groundwater in the underlying aquifer(s). Several research activities so far undertaken in this aquifer have revealed impairment of groundwater quality to different levels. The objective of this poster is present data from research carried out by the author and from the Groundwater Resources for Southern Province project, which is supported by the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) of Hannover, Germany.

Objectives

i) To map some water points and potential pollution sources in their vicinities.
ii) To collect water samples for analysis of physico-chemical and faecal parameters.

Methodology

i) Desk study to collect and synthesize baseline information and to integrate it in a GIS.
ii) Mapping of water points and potential pollution sources in their vicinities using a hand-held Global Positioning System (GPS).
iii) Water sampling and analysis for physico-chemical and faecal parameters associated with the mapped potential sources of pollution.

Results

Except for a few sampled locations, most parameters did not meet the WHO Guidelines for domestic water. Especially the presence of faecal coliforms, which constitute an important primary guideline parameter for drinking water in most water sources, made it unsafe for domestic use.

Conclusions and Recommendations

Improper management of waste is harmful to the quality of groundwater and poses threats of transmitting waterborne diseases to the population that consumes this water. Therefore, this paper recommends that the Ministry of Health and the Environmental Council of Zambia work in unison to enforce appropriate pieces of legislation and disseminate/implement the Zambia Infection Prevention Guidelines in order to ensure a city with a protected natural environment, in which people will live a healthy and productive life.

Nitrate pollution in groundwater in the Pearl River delta

Jianyao Chen & Xinfeng Zhao

School of Geographical Science and Planning,Sun Yatsen University, Guangzhou, China

The Pearl River delta, with population more than 40 millions, is one of the most developed regions in China with extremely rapid expansion of urban area in the last 30 years. Groundwater pollution is becoming an important issue because of its unique role for water supply in the emergent situation. Water samples from Zhuhai were collected during the dry season (March) and wet season (July) for isotopic and chemical analyses in 2006 and 2007. The percent of samples exceeding the WHO nitrate standard (45 NO_3- mg/l) in dry and wet seasons were 33.3% and 28.9% respectively, indicating the dilution effect of

rainfall in water quality. Stable isotopes of 18O and deuterium (D) confirm that modern rainfall predominate as a source of aquifer recharge. The age of groundwater in the discharge area is older than that of recharge area, and horizontal transport rate of approximately 110-132 m/y was obtained by using CFCs. The calculation by Darcy's law gave a rate in a similar order of magnitude. The high level of nitrate concentration in groundwater occurred in suburb residential area, for which poor condition of local sewage system and leakage of septic tank were blamed based on the evidences of 15N and 18O in nitrate. Comparison of nitrate in groundwater between suburb residential area and city center, where sewage system was well constructed was carried out, showing a low level of nitrate in the city center. By classifying the type of residential area, groundwater pollution area can thus be delineated. In order to sustain groundwater use, especially in the case of emergency, the policy and/or counter measurements should be proposed to deal with nitrate pollution, e.g., water source planning and protection, development and use of sound technique to build septic tank.

WASH in schools
Scaling up water, sanitation and hygiene education for schools

Roy Kunajppy

Centre for Community Health Research (CCHR), India

Description of the project: It was pointed out that globally, 2600 million people defecate in the open while in India, 700 million people lack access to sanitation facilities and resort to defecate in the open. Diarrhoea claims the lives of 2 million children around the world every year while one million children in India die of diarrhoeal diseases each year directly as a result of drinking unsafe water and living in unhygienic conditions. Children suffer from preventable diseases such as diarrhoea and dysentery. Environmental degradation and growing populations threaten water for other critical purposes such as food production and adequate livelihoods.

The health profile of Kerala State in India is said to be low mortality-high morbidity syndrome. Poor sanitation and hygiene are the most critical routes of transmission of infectious diseases. Lack of basic amenities compels people to resort to practices such as open-air defection. Acute poverty, poor hygiene, and inadequate garbage disposal and drainage facilities have further aggravated the matter.

WASH Coalition in Kerala State (South India) has launched a programme in certain selected schools in the southern districts of Kerala called „WASH in Schools" with an objective for better hygiene behavior and healthy environ-

ment in schools. The basic concept of this initiative was that schools are considered as ideal places of learning for children and they have a crucial role in the process of community development. Schools can be able to stimulate children for a better behavior change. If there is adequate facilities on enough safe drinking water, sanitation and hygiene facilities in schools, children as well as teachers can act as role models of the society. This will definitely influence the communities for a better change in their attitude and approach.

Stakeholders of the programme: Basically, WASH in Schools is a collective effort by the stakeholders of the sector including Parent-Teachers Associations (PTAs), School directors, Local self-governments (Panchayats), CBOs, NGOs, self-help groups and other grass-root organisations. Further, State and National Governments, International Organisations like WaterAid and Water Supply & Sanitation Collaborative Council (WSSCC) will be active stakeholders of WASH in schools. WASH in Schools is a mass movement as part of the Global WASH Campaign. Hence, the programme is a sustainable model for better hygiene behaviour and healthy environment in schools. WASH-coalition (net-work of organisations) in the State of Kerala have a crucial role in the implementation process.

Area of coverage and target population: Schools in 4 districts of Kerala State in South India have been selected for the implementation of this initiative. A total of 100 schools were selected for this programme as Phase-1.

Key activities: Awareness camps, symposia, seminars, children congress, water quiz, competitions, rallies, will be conducted in all selected schools as part of the programme. Selected children will be sent to State and National level competitions and incentives will be given to those selected. WASH posters will exhibit and display in all selected schools. Further, to constitute „WASH school committees“ and „Eco-clubs“ with the co-operation and participation of pupils, teachers, parent-teachers association (PTA) and school directors. Intense awareness will be given to mosquito eradication and school children will be part of this drive against mosquito eradication programme. Adequate steps will be taken to propagate various rainwater harvesting techniques and other methods of water conservation. Parent-teachers associations (PTAs), school directors, panchayats (PRIs) and other local stakeholders of the programme will be responsible for the construction of water supply and sanitary facilities in the respective schools. Building the capacity of local stakeholders considered as one of the most important element for the successful implementation of the programme. Training modules on safe use of drinking water, decent sanitation, safe disposal of solid and liquid waste, and best hygiene practices will be provided to the stakeholders of the programme. Try to implement environmental awareness/school sanitation/ hygiene education in school syllabus for a healthy school environment. Medical camps will be conducted during rainy season in rural and semi-urban schools as part of the WASH Campaign in association with the stakeholders.

Social and economic relevance of the project: The environmental health interventions are regulatory in nature, and benefit accrued are indirect. They are exclusively preventive and benefits can be realised over a long period. The environmental health interventions also potentially convey considerable non-health socio-economic benefits. Apart from other conventional initiatives, „WASH in Schools“ will be a sustainable model with sectoral co-operation and children to be agents of change.

A sustainable sanitation for internally displaced persons in Sri Lanka

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Sri Lanka is an island in the Indian Ocean extending about 65000 sq km and having a population of about 19 million. There are three major communities in the country namely Sinhalese, Tamils & Muslims. The country has been undergoing a series of clashes between government forces & Tamil rebels who demand a separate state for Tamil people. As a result of on going fighting many Sinhalese & Muslims had been displaced and settled down in southern parts of the country. A large number of Muslims who lived in Mannar district of Northern Province had to flee from the area, due to the pressure from Tamil rebels in the year 1992. Most of them settled in the district of “Puttalam” about 150 km away from Mannar.

As many IDP had some money when they were fled from their houses, they purchased a small plot of land about 25 square metres and some philanthropists also purchased lands and distributed among IDP. They started their new life in small temporary houses constructed with the assistance of government and non governmental organizations. There were about 50 to 100 houses closed to each other in a settlement normally called as an “IDP Camp”. They are spread in a large area in the Puttalam district. As at April 2006, there were total of 15760 IDP families living in 146 IDP camps, as per the survey carried out by UNHCR.

The above IDP families lack basic infrastructure facilities such as water, roads, electricity and sanitation. They managed to obtain roads & electricity with the assistance of many organizations. However the problem of water & sanitation has not still been solved. Marjory of them lives in “Kalpitiya” area bounded by sea from two sides and lagoon from another side. Although ground water is available in the area, that is unsuitable for drinking due to high salinity. Farmers in the area use pesticides and fertilizer for cultivation heavily. This has further deteriorated the quality of ground water. Therefore people are used to buy water from water vendors. In the case of sanitation situation is worst. Due

to the high water table, they cannot use normal toilets. There is a danger of pollution of the ground water when they use water sealed latrines with soakage pits. A project has been planned to implement in this area under the assistance of World Bank to provide better water supply & sanitation facilities.

The sanitation issue in the project area has to be attended with due consideration into the possible environmental effects. As the protection of ground water is utmost important, following three possible alternatives were considered for provision of sanitation facilities.

(1) Properly sealed septic tanks connected to anaerobic filter.

(2) Dry compost or eco-sanitation toilets

(3) Small bore sewer systems.

In selecting a most appropriate option, demographical aspects, cultural and social nature of people, water consumption and user habits, climatic parameters, financial constraints, donor's interest, geology of the area, protection of ground water and sustainability and acceptability of the sanitation options were considered.

The situation of groundwater and sanitation in the city of Kabul

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The water supply situation in Afghanistan is still in a much deteriorated state (consumption is 20 l/d/capita, UNDP 2007) and sanitation does not provide a better picture. Kabul is the capital of Afghanistan and one of the world's poorest cities. It is faced with two big challenges: water scarcity and groundwater contamination.

Kabul is home to 4.5 million people but has no public sewer system. Only 172,000 of inhabitants are connected to a central sewer system. The Kabul River is the main source of groundwater recharge inside Kabul city, however, during the dry period of the year all liquid waste flows inside the river bed.

The quality of groundwater in the Kabul city varies widely. In some limited areas, groundwater quality is excellent, with low concentration of dissolved solids and no hazardous constituents. In most areas, however, high concentrations of dissolved solids and of certain contaminants present a harm to humans. Untreated groundwater from production wells inside the city is unsuitable for public supply and agricultural use.

Because of the drought that has continued for several years and the destruction of the infrastructure as a result of the war, as well as the population increase in

the Kabul basin in recent years, the dependence on groundwater for drinking water supply and irrigation is very high.

About 20% of the inhabitants receive piped water, the rest (80 %) of the population use hand pump wells, dug wells and surface water. Some 100,000-120,000 shallow wells; dug wells, hand pump wells, and deep wells are situated all over the city. The lack of efficient waste disposal and sewage collection system leads to the contamination of shallow groundwater. Microbiological analysis shows high levels of coli bacteria in approximately 50-60 % of the shallow wells in the urban area. As shallow groundwater and surface water are the main water supply sources used for direct consumption, the population is frequently affected by water related diseases, and the children are the most vulnerable with a high death rate.

Sewage is largely disposed of in countless domestic drainage pits and open traditional latrines.

In some minor areas of the Kabul basin the disposal of domestic wastewater is accomplished through the use of septic tanks and cesspits and most of them pose a risk on groundwater.

Because of the negative balance between low annual precipitation, low recharge in groundwater, and high discharge, groundwater resources in the Kabul basin will be continuously threatened by the scarcity and shortage as well as by pollution from household wastewater in future.

Safeguarding the water supply of Beirut Protection of the Jeita Spring

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The Caza of Kesrouan situated directly to the north of the City of Beirut is a densely populated area consisting of many small localities spread across its mountainous terrains. The region is bound from the north by the Ibrahim River and from the south by Al Kalb River. It is characterized by its steep gorges and seasonal water courses. Melting snow and surface water infiltrates into the underlying highly permeable Karstic rock formation, recharging the groundwater aquifer which feeds the Jeita Spring; the main source of drinking water for the 1,5 million inhabitants of the City of Beirut.

In recent years, the entire area underwent serious environmental pollution due to the absence of adequate wastewater collection and treatment infrastructure. Municipalities have not been able to cope with the growing population and to

develop the necessary sanitary services. Most households do not have a proper sewer system. The wastewater resulting from different localities is either disposed off in septic tanks, or inappropriately diverted into ditches, boreholes, and water courses without treatment. As a result, the groundwater aquifer is being polluted. This is evident from the increasing coliform count in the Jeita source water.

In light of the existing situation, a wastewater collection and treatment project is envisaged for localities directly influencing the water quality of the Jeita Spring source, in particular those discharging their untreated effluent wastewater into Al Kalb River gorge.

The project aims at the protection of water resources in the area from contamination with sewage water, and in particular, those feeding the Jeita Springs water.

The target group are the inhabitants of the City of Beirut whose drinking water supply is at risk of becoming more frequently and severely contaminated, and the residents of the localities situated across the region who suffer from nuisances related to improper sewage discharge, such as bad odours in ditches, overflowing sewage from septic tanks, polluted water streams, etc.

Once implemented, it is expected that the project would reduce adverse health impacts resulting from the contamination of drinking water supply for residents of the City of Beirut, and would enhance the environmental conditions of the project area as water courses for Al Kalb River and its tributaries will flow again with non-polluted water, which enhances developmental activities and increases touristic attraction for the area.

Living organisms, cysts and gastrointestinal parasites eggs, living in wells and spring water used by the populations in Dschang city

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A study on biological quality of the wells and spring water used by the population was conducted from June to October 2006 in Dschang - Cameroun. The aim of the study was to contribute to the knowledge of sanitation pratices and the reduction of health risks associated with difficulties in access to potable water. Inventory of water sources was carried out with the assistance of population and their geographical coordinates obtained using the Global Positioning System. The influence of the quality of water sources on the population‘s health was investigated through a questionnaire. Of 1461 water sources censored, 1431 were wells and 30 natural springs. 14 wells, 5 springs and a tap sup-

plied with water from the national water distribution system were selected for the biological control analysis.

Privately constructed wells and natural springs were the most commonly used water sources. The percentages of the populations using these two sources were 33 % and 31.40 % respectively, while 31 % were found connected to the public distribution network. From the investigation, it was noticed that 24.32 % of persons who use water from wells complain of itching, against 11 % and 6 % for those who use pipe borne water and spring water respectively. For water related diseases, the high prevalences were observed from the consumers of pipe borne water (18.95 %, 11.15 % and 10.11 % for typhoid, gastroenteritis and dysentries respectively). Biological analysis revealed the presence of insect larvae, plant phytoplankton and zooplankton in some water sources.

The consumption of water from springs and wells in Dschang without prior treatment exposes the population to serious health risks. Several cost-effective methods for water treatment particularly groundwater, as well as the good maintenance practices for wells and springs used as domestic water sourcesare proposed in this study.

Accessible water and sanitation facilities by and for disabled people

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Making WATSAN facilities accessible for disabled people is not complicated. It is well within the technical capacity of the average WATSAN service provider. Very simple adjustments and additions can make a tremendous difference to a disabled person and their family.

People in rural and urban areas all over Bangladesh face a serious problem of access to safe water and sanitary latrine facilities, which is even more serious for people with disabilities, because the inadequate existing facilities are inaccessible for them. Under this circumstance, the program for "Accessible Water and sanitation facilities by and for Disabled people" has been initiated by Bangladesh Protibandhi Kallyan Somity (BPKS) as one component of its overall programme entitled "Persons with disabilities Self-Initiative to Development (PSID)".

Objectives of the WATSAN program:

- To ensure people's participatory, cost effective, sustainable and accessible sanitary latrine and safe water for persons with disabilities, and their family and community members.

- To improve the health conditions of the people in these area.
- To increase personal dignity of PWDs , reduced work-load and increased earning capacity of family members
- To demonstrate to policy- makers of government and non-government agencies the feasibility of replicating such program in other areas.

Primary beneficiaries are people with disabilities, Secondary beneficiaries are parents and family members and Tertiary beneficiaries are the community as whole.

Implementation process:

- *Need Assessment:* At their regular weekly meeting, DPO self-help group members discuss their problems on sanitation and decide among themselves who would most benefit from an accessible latrine and hand-pump facilities.
- *DPOs envelopment:* The decision is discussed with representative of Bangladesh Protibandhi Kallyan Somity (BPKS). Then BPKS expertise and local DPO self-help group members install accessible sanitary latrine and tube well with direct support of BPKS and PWDs provide voluntary labour for the installation and recruit voluntary labour from family and friends.

Further developments to make accessible: A basic design for both tube well and latrine was formulated during the planning stages of the program, with modifications to be undertaken on a needs basis on the specific requirements of disabled people. Some modifications could be adapted are as follows:

Using clay from nearby ponds to build ramps to facilities, Stringing rope between the house of a visually impaired persons and his or her latrine/ tube well which can be followed the facility, Installing a simple handrail beside the latrine, or suspending a rope from the selling, Establishing a non- slip environment between the facilities and the PWDs home would be providing improved independence.

Sustainability: The project activity will be supervised and managed by the grassroots disabled people organization to development(GDPOD). The members of the GDPODs are the owner of the project by receiving its services . So that by these process BPKS strongly believe that project is sustaining.

Low-cost technologies based on heterogeneous photocatalysis and zero-valent iron for arsenic removal in the Chacopampean plain, Argentina

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The Chacopampean Plain in Argentina constitutes one of the most extended areas in the world with very high arsenic concentrations in groundwater, amply surpassing the standard requirements for drinking water (Argentine and WHO limit 10 μg L^{-1}). The situation is more se-rious in rural areas, where low water quality, poverty and malnutrition cause a high incidence of HACRE (Chronic Endemic Regional Hydroarsenicism, Hidroarsenicismo Crónico Regional Endémico in Spanish).

In this work, results of application of simple and low-cost technologies based on heterogeneous photocatalysis (HP) and zerovalent ion (ZVI) to remove As (III, V or both) from groundwater are presented.

HP is an advanced oxidation technology that uses semiconductors such as TiO_2 for water detoxification. Under UV irradiation (e.g. solar light), active oxidizing species are formed, able to transform organic and inorganic pollutants in less harmful compounds.

For HP tests, PET bottles covered internally with a TiO_2 layer were exposed to solar or artificial UV light. Arsenic-containing synthetic waters (around 1 mg L^{-1}), irradiated 6 h under artificial light, followed by the addition of iron packing wire, yielded 86% of As removal. Real well waters with As concentrations from 900 to 1800 mg L^{-1} (Santiago del Estero, NW Argentina) under solar light irradiation, with further addition of a ferric salt, yielded 95% As removal.

The zerovalent iron technology (ZVI) has been extensively applied to remediation of contaminants, especially toxic metallic pollutants. The primary advantages of ZVI include low cost, simplicity in handling and scalability. Different iron materials such as packing wire, iron powder and iron nanoparticles have been tested. Arsenic removal using iron nanoparticles was found to be much more efficient than the other materials, due to the higher contact area between phases.

For ZVI tests, water was introduced in plastic bottles with iron packing wire, iron wool or iron nanoparticles (NanoFe®) and were kept in the dark or irradiated under artificial UV or solar light. An enhancement of As removal was observed under UV light in synthetic samples, especially at low Fe concentrations. This enhancement was even higher in samples containing humic acids and in real well waters of the Tucumán Province (NW Argentina).

Water point hygiene and good sanitary practices – Key to groundwater protection

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In 2006 Water Aid undertook a rigorous testing of ground water quality involving 58 water points (WPs) in its operational area in Zambia where sanitation facilities entirely consist of on-site dry pit latrines of varying depths but up to a maximum of 3 meters. Open defecation was also quite common. The study brought some interesting findings.

A large number of WPs (41%) showed faecal coli form (FC) contamination of varying degrees but higher than the acceptable range <=15FC/100 ml. A detailed analysis was done of the sanitary risks in the water points that showed FC contamination.

A number of sanitary risks were identified that can be broken up into two categories: Social and Technical. Social risks can be attributed to lack of motivation/will power of the community to act on issues like stagnant water, inadequate fences and soak-aways, solid waste and rope and bucket contamination. Technical risks comprised issues around poor design and/or construction, namely: apron cracks, inadequate apron diameter, inadequate/cracked parapet, latrines nearby, and hand pump loose at point of attachment to apron.

The following sanitation risks can be considered technical risks but are exacerbated by social risks.

Details of WAZ supported WPs with Identified Sanitation Risks

Rank of risk	No of WPs affected	Sanitation Risk
1	29	Inadequate fence, allowing animals to use WP and threaten water quality
2	33	Inadequate soak-away, either non-existent or insufficient to drain water in a hygienic manner
3	18	Stagnant water at or surrounding the WP, within 20m radius
3	18	Solid waste (animal excreta/rubbish) within 10m that could act as a source of pollution
5	8	Cracks in apron that potentially threaten the water quality or integrity of the system
5	8	Inadequate apron diameter (<1m)

7	6	Rope and bucket exposed to contamination (i.e. lying on ground)
8	4	Latrines within 30m and/or uphill
9	3	Height of parapet inadequate or parapet cracked
10	0	HP loose at point of attachment to apron

The social sanitation risks were evident in many cases where FC contamination was prevalent. Where a community felt that water point protection was important and took measures to protect their safe water supply, FC contamination was within limits. In cases where WP hygiene was seen as a low priority most social sanitary issues were neglected. The lesson is that if a community doesn't openly display enthusiasm for WP hygiene, it is likely that most categories of sanitary risks will be neglected on an on-going basis affecting ground water quality. WPs with low daily yield and limited recharging were found with FC contamination. Many of those dry up at critical times.

Significant changes in water quality was noticed after Water Aid made technical changes by installing hand pumps on hand dug wells and focused more on hygiene education and better point - of - use water handing practices. This ensured better care of the WPs. WaterAid is planning to undertake activities such as small dams, rainwater harvesting closer to WPs to enhance ground water recharge in order to achieve water quality and security.

Managed aquifer recharge in Jordan
Infiltration test sites, water quality monitoring and large scale potential map

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The Lower Jordan River Valley is a place of extreme water scarcity and constitutes an overexploited closed river basin. The water level of the Dead Sea as the final sink has already dropped in thirty years by more than 20 m as a result. This demonstrates, that apart from water quality considerations, the quantitative water balance is negative. The only means of introducing additional volumes of water to the area are water imports or reduction of evaporation. Increasing the amount of artificial groundwater recharge, now internationally termed "managed aquifer recharge (MAR)", would be beneficial to the water availability of the region by reducing evaporation. In this background setting, the research initiative SMART (**S**ustainable **M**anagement of **A**vailable **R**esources

with Innovative **T**echnologies) has now been launched to include all available water resources of the Lower Jordan River Valley, namely ground water, waste water, saline water, and flood water into an integrated management concept.

At first, the construction of a managed aquifer recharge test site in Wadi Kafrein is presented. The test site investigates the possibility to infiltrate surface water comprising a mixture of treated wastewater and fresh water with special regard to clogging problems. After 90 days of operation, the infiltration rate still exceeded 1.8 m^3/m^2*d or 1800 mm/d, demonstrating the excellent infiltration capacity of the unconsolidated gravel sediments in the Wadi. Online monitoring of the water quality showed a strong diurnal cycle of the electrical conductivity. This is a result of the treated wastewater inflow as well as varying usage of fresh water from the springs upstream.

A site for managed aquifer recharge by flood water is currently planned at Wadi ed Dardur, approx. 45 km southwest of Amman. Detailed geological mapping of the area has been completed. Within the approx. 20 m wide Wadi, a rockfill dam will be constructed to store water from flash floods and infiltrate it into the fractured sandstone and basaltic aquifer.

Further on, a large scale map (1:200 000) covering 9800 km^2 of NW Jordan was established to provide a first indication of potential for managed aquifer recharge by surface infiltration. The potential map is based on following criteria: (i) presence of an aquifer directly below the surface (ii) slope, i.e. in very hilly terrain there is no suitable space to allow for infiltration ponds (iii) availability of a water to be infiltrated (iv) land use.

The results give a first preliminary overview. They do not cover all types of managed aquifer recharge (such as recharge via injection wells) and can not replace more detailed feasibility studies.

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Impact of two different on-site sanitation solutions on human health risks associated with the aquifer pathway and exposure to pathogens from shallow water supply wells

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In a residential setting where households are extracting water from shallow supply wells for drinking and domestic purposes, the health risks associated with faecal contamination from a dense pattern of simple/unsafe on-site sanitation solutions is a critical issue, particularly where the water table is high.

The health risks related to the aquifer pathway may be reduced to an acceptable level by the application of appropriate control measures such as choice of on-site sanitation (OSS) system, depth of the pit/collection chamber, pumping rates and distances to nearby wells.

This study focus on a hazardous event scenario where residents connected to an OSS system are infected by a pathogenic microorganism under a period of high water table. Hence, polluted effluents are introduced directly to a shallow aquifer. The daily/yearly health risk posed to the user of a nearby water supply well is quantitatively assessed for two different types of OSS systems and for different source-receptor setback distances. The pour flush latrine connected to a "wet" collection chamber, a representative on-site sanitation solution in the developing world and a compact greywater filtration system are the two studied systems.

The assessment includes quantification of pathogen input for the given hazardous event, reduction in the technical- (OSS unit) and natural barrier (groundwater transport). Enterohaemorrhagic E.coli (EHEC) and Rotavirus are selected as model pathogens. The data from a two-year survey of a full scale compact greywater filtration system form the basis for the description of the technical barrier efficiency. Water was analyzed for the reduction of the naturally occurring E coli, chosen to represent bacteria, and Salmonella typhimurium phage 28 B was spiked to the system to study the virus attenuation. Reduction in the blackwater system is described by a simple model with representative residence times and inactivation data from literature. The microbial contamination of the nearby water supply well from the OSS-unit effluent is quantitatively assessed by the application of a groundwater flow- and transport model combined with microbial risk calculations. The pathogen attenuation from inactivation in the natural barrier is related to the residence time in the aquifer, governed by hydrogeological factors such as the hydraulic gradient, spatial variability of hydraulic conductivity and retarding effects from sorption processes. With the daily average pathogen exposure estimated from water con-

sumption patterns and the modelled concentration in the well, dose response models accounting for the infectious dose of the model pathogens are applied to calculate the probability of infection. Typical hydrogeological conditions found in the south Indian state Kerala is applied in the groundwater transport modelling.

Refined, this quantitative approach may aid in the implementation of "safe" and cost effective small scale OSS-solutions. A comparison of the assessed health risk with a tolerable level will give recommendations on safe setback distance, given the type of OSS system and site specific hydrogeological conditions. Further, it may give recommendations on where investments in e.g. improved OSS-systems are best needed to assure the safety of the exposed population.

Impacts of low sanitation on groundwater resources in selected parts of Dar Es Salaam region - Tanzania

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The present study focuses on the investigation of the contribution of domestic sewage effluents to groundwater pollution and characterization of physicochemical conditions of groundwater in some selected parts of Dar es Salaam Region. Water samples were taken from both shallow wells and boreholes during the weekly monitoring campaign conducted throughout the year for determining selected bacteriological and physicochemical indicators using appropriate gears. The results of FC and FS are found to range from 3 – 312 counts/100 ml of water sample as detected by membrane filtration procedure in 67 to 73 % of the wells sampled from the two wards. The data also show a positive correlation between FC, FS and NO_3^- in places lacking poor sanitation facilities indicating that bacteriological groundwater pollution is predominantly caused by uncontrolled domestic sewage effluents in a localized fashion. However, the specific faecal pollution of groundwater is both of animal and human origin at Ukonga and only human origin at Kigamboni as implied by high NO_3-correlation with SO_4^{2-}. Poor and unsustainable sanitation systems in the study area seem to be the main contributors to the observed findings. This is indicated by the use of on-site sanitation facilities encompassing pit latrines (79 %) compared to that of septic tanks (9 %). It was then observed that not all the wells were polluted and that pollution appeared to be localized consequent to the levels of sanitation, the locations of the wells and population density and where sanitation was improved, groundwater was consequently protected from pollution. However, FC counts were high in the wells with poor sanitary design and improper handling of domestic sewage. The highest positive correlation was

found between FC and FS in Ukonga compared to Kigamboni indicating faecal pollution in the area. FC, FS, NO_3^- and K+ showed better correlation in Ukonga than Kigamboni implying that both human and animal are potential sources of groundwater pollution in the area while in Kigamboni sources of faecal pollution could be human only as shown by high NO_3^- correlation with SO_4^{2}.

It is therefore recommended that improvement in handling domestic waste by installation of sanitary sewage systems and remediation of polluted sites and/or abandoned polluted wells should be undertaken in order to protect groundwater resources.

Behaviour of three pharmaceuticals in soil applied by urine fertilization

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Urine is a valuable plant fertiliser. But aside of high loads of N, P, and K, it also contains pharmaceutical residues. In the case of its application as fertilizer, knowledge is required for the expected behaviour of pharmaceuticals in soil. Within a greenhouse pot experiment, rye grass planted in luvisol was fertilized with urine spiked with carbamazepine (CZ), ibuprofen (IBU), and ethinylestradiol (EE2) in concentrations expected (conc.) in an average German urine (AGU). Pharmaceuticals were added alone as well as in combinations. After three months growth period, only CZ was detected in soil by GC/MS analysis. LOQ of CZ was 1 µg kg-1 DM. Concentrations found in soil samples correlated clearly with the applied CZ concentration of 3.2 µg kg-1 DM (conc. in AGU) and 32 µg kg-1 DM (10 x conc. in AGU) according one-way ANOVA ($P < 0.05$). 49 % of the applied CZ was discovered in average regardless if contained alone or in combination with IBU and/or EE2. Disappearance of EE2 was expected as applied concentrations were rather low (highest dose: 0.1 µg kg-1 DM; 40 x conc. in AGU) and EE2 is well biodegradable. While complete disappearance of IBU was surprising. Although, it was known to be biodegrading as EE2, at least in case of the artificial dosing (940 µg IBU kg-1 DM soil; 10 x conc. in AGU) traces of IBU were expected (LOD of 1 µg kg-1 DM). It can be concluded that the biodegradation potential is a good indicator to determine causes and effects of pharmaceuticals for agricultural fields in case of urine application. Focus for future research should lay on highly persistent pharmaceuticals as they have the potential to accumulate over longer time spans and to reach deeper soil layers, maybe even groundwater.

Retention of *Escherichia coli* and *Salmonella* sp by two soil layers closely topping groundwater table in equatorial region in Cameroon (Central Africa)

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Bacterial movement in soil is important in the pollution follow-up of the surface and underground waters. These movements and bacterial transportation in soil and in underground water can occur by adsorption-desorption mechanisms, by filtration or by advection-scattering. In many regions of the world, groundwater is still the main source of drinking water supply. Most studies have indicated the pollution of this resource by many bacterial species. In most African countries, wastewaters containing faecal and non faecal bacteria are often discharged to the environment without any pre-treatment, and therefore, can potentially pollute soil and groundwater. Knowledge of the adsorption capacity and kinetics of bacterial retention in soil could contribute to the scientific understanding of the microbiological quality of groundwater in specific soil types. The main purpose of this laboratory research was to assess the sorption kinetics of *Escherichia coli* and *Salmonella* sp on two soil layers (H_X and H_Y) collected closely above a groundwater table in Yaounde, Cameroon (Central Africa). HX is located above H_Y which is located in close proximity of the water table.

For both soil layers, bacterial sorption on soil particles occurred rapidly during the first 30 minutes of incubation of bacteria and soil particles in aqueous media, and increased gradually with incubation time up to 300 min. Sorption data of *E. coli* and *Salmonella* sp on soil particles were analysed with Freundlich isotherms (non-linear) model to evaluate the kinetics parameters in the sorption process. It is described by equation:

$$C_s = K_f.C^{1/n}$$

where C_s is the amount of adsorbate adsorbed by adsorbent, C is the equilibrium concentration of non adsorbed, K_f is the Freundlich adsorption coefficient and it is related to adsorption capacity, *1/n* is the linearity exponent and n is related to adsorption intensity. Here, C_s is expressed as number of cells.mg^{-1} of soil and C as number of cells.ml^{-1}. When logC_s was plotted against logC, a straight line with slope *1/n* and intercepting logK_f was obtained.

Results showed for both soil layers, bacterial sorption on soil particles occurred rapidly during the first 30 minutes of incubation of bacteria and soil particles in aqueous media, and increased gradually with incubation time up to

300 min. It was noted hat adsorption coefficient related to adsorption capacity varied from 19 to 4026 *E. coli*.mg^{-1} of soil, and from 506 to 847 *Salmonella* sp.mg^{-1} of soil. For both bacterial species, the adsorption coefficient of layer H_Y was greater than that of H_X and seemed to positively correlate with the pH values and N/P ratios, and to negatively correlate with the values of C/N and C/P ratios. The linearity coefficient related to adsorption intensity varied from 0.5841 to 1.0023 for *E. coli*, and from 0.7068 to 1.5236 for *Salmonella* sp. The physico-chemical characteristics of soil particles seemed to influence the sorption kinetics of bacteria on soil.

(In the name of God)

Water safety plan & protection for sustainable underground water resources

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Water scarcity or water shortage is the global concern and it affects the entire world particular in arid and semi-arid climates with low raining rate such Africa and Asia.

For hundred years in these **area underground water resource**s "wells, springs and fountain, Qantas* or kareez "are the main water supplies because of an absence of larger rivers with year-round flows sufficient to support drinking water and irrigation.

A **qanat** (from Arabic: قناة) or **kareez** (from Persian: كاريز) is a water management system used to provide a reliable supply of water to human settlements or for irrigation in hot, arid and semi-arid climates.

The Qanats technology was used most extensively in areas with the following characteristics:

- An absence of larger rivers with year-round flows sufficient to support irrigation.
- Proximity of potentially fertile areas to precipitation-rich mountains or mountain ranges.
- Arid climate with its high surface evaporation rates so that surface reservoirs and canals would result in high losses
- An aquifer at the potentially fertile area which is too deep for convenient use of simple wells.

Without any energy consumption (for water transferring from aquifers to surface level) The water is freshest, cleanest, and coolest in the upper reaches

and more prosperous people live at the outlet or immediately upstream of the outlet.

Population growth, urbanization and industrialization bring great risk “Danger pollutants “to these ancient water supplies.

Continuing traditional water management make wasting these critical water resources particular in arid semiarid climates.

Washing household utensils, clothes, vehicles, farm irrigation, cause exposure these vital sources hazard chemical substances such as heavy metals, such as lead, cadmium, mercury organic substances fertilizer, herbicides, Pesticides, non biodegradable reagents in washing and cleaning powdered, industrial Solid waste discharge such various batteries (vehicles, electronic devices).

The great concern for underground water resources are the first wasting theses invaluable fresh water resources by mismanagement ways in the critical arid and semi arid zones, the second environment consequences pollutions risk for public health, the third as the most danger event accumulation non biodegradable hazard substances in the ecosystem and the food chains finally biodiversity degradation.

Lacking of modern analytic equipments, skilled analyst for quality and quantity determining water pollution in developing countries makes situation worse which bring for the next generation poor productivity, illness and poverty in societies without water safety plan and protection strategy.

Conclusion:

Water scarcity and shortage will be great challenge for the world and next generations Integrated Water safety plan must be applied for underground water resources along with lunch new legislations, taught exist regulations along permanent public educations encourage and develop NGOs, women, and young involvement in water protection movement.

Water sanitation without integrated protection not only nver brings sufficient health guarantee but also will be very expensive and even useless.

Elimination of emerging pollutants in membrane bioreactors (MBR) and soil-aquifer-treatment (SAT)

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Pharmaceuticals, endocrine disrupting compounds and x-ray contrast agents are a broad and diverse group of biologically active compounds that are used in large quantities in both human and veterinary medicine around the world. These emerging pollutants already have been detected in wastewater, surface water, and groundwater. In regions where there is a lack of fresh water resources the reuse of wastewater becomes an important issue. As part of the SMART Jordan Valley project, new integrated approaches for water management, aquifer recharge, and wastewater reuse are developed. As reuse of wastewater may result in the accumulation of persistent organic pollutants it is necessary to eliminate such compounds during suitable treatment processes. Decentralized MBR technologies combined with consecutive subsoil conditioning are studied within the research project with respect to the removal of emerging pollutants and pathogenic organisms.

Samples from a conventional wastewater treatment plant (WWTP) and a MBR have been analysed for approx. 190 organic micro-pollutants. Trace pollutants such as ibuprofen and bezafibrate are almost entirely removed in the conventional WWTP, whereas others (e.g. diclofenac) show only moderate removal rates (53 %). Gemfibrozil, fenofibric acid and naproxen showed lower elimination rates (52 %, 66 % and 80 %) in the conventional WWTP, whereas with the MBR process elimination rates of > 95 % have been measured for these pollutants. The increased removal is thought to be the result of the higher sludge age in MBRs as compared to conventional WWTPs.

Additionally, batch tests are performed in order to identify the most efficient degradation processes, e.g. depending on the presence of auxiliary substrates (co-metabolic degradation) and redox conditions (e.g. aerobic/anoxic degradation). In first aerobic batch tests all endocrine disrupting compounds (e.g. estriol, bisphenol A) are eliminated by 100% and the pharmaceuticals diclofenac, bezafibrate and ibuprofen show removal rates of 82 %, 72 % and 100%, respectively. However the x-ray contrast agents (eg. diatrizoic acid, iopamidol) do not show significant elimination rates. Emphasis in further experiments will be put on the optimization of pollutant removal in a wastewater reuse concept integrating MBR and SAT, to be applied in the Jordan Valley area.

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Origin of nitrate in shallow groundwater in Teungku Dilaweueng

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On 26th December 2004 a tsunami wave damaged hundreds of wells along the eastern coast of Sumatra. In September 2005 German Agro Action (GAA) started cleaning and rehabilitating almost 300 dug wells in this region. Water samples taken by GAA were analysed in the hydrochemical laboratory of Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) in Hannover, Germany. Fifteen percent of the water samples from dug wells exceed the national guideline value for nitrate. Almost all of these wells are located in one of the three villages Cot, Teungku Dilaweueng and Blang Raya in the sub-district Muaratiga, north-west of Sigli. In March 2007, Dinas Pertambangan dan Energi (DISTAMBEN) and BGR started a joint field campaign in the village Teungku Dilaweueng to find out the source of the high nitrate concentration. Within this investigation further 25 dug wells were tested. The concentration of nitrate ranges from 0.07 to 241 mg/L. 14 of the 25 tested wells tap water with nitrate concentration above the guideline value of 50 mg/L. The lowest concentrations of nitrate were found in dug wells upstream of the village and the highest in the centre of the village. Possible sources of nitrate in shallow groundwater are: excessive application of fertiliser in agriculture, inadequate sanitation facilities and livestock farming. Herein groundwater contamination from field fertiliser is ruled out as high nitrate concentrations are found in the centre of the village, while nitrate concentrations in agricultural environments are low. Effluent from latrines is directly infiltrated into the groundwater via cesspits. This is definitely a major hazard for the quality of shallow groundwater. Livestock farming, especially poultry is likely to represent a further source for contamination. The situation concerning sanitation techniques and the hazard of groundwater contamination is almost the same along the eastern coast of Sumatra, but the high nitrate concentration in shallow groundwater only occurs in Teungku Dilaweueng and the two surrounding villages. The reason for this circumstance is probably found in the topography. The centre of Teungku Dilaweueng is located in a narrow local basin. The diversion of the village from the hinterland has great influence on the groundwater balance: The reason for the high nitrate concentration is an accumulation in groundwater, because nitrate is not diluted by an adequate amount of fresh water. The special topographical setup is similar to the neighbouring villages Cot and Blang Raya. In opposition to the

above described morphology, most of the settlements along the eastern coast of Sumatra are located in flat areas. It is supposed that nitrate influx into shallow groundwater along the whole inhabited coast is in the same range as in the study area, but nitrate concentration is reduced particularly by dilution with fresh water. Considering the spatial distribution of nitrate concentrations, it is eye-catching how great the influence of the geomorphologic and hydro geologic setup is. On this basis it is clearly, that its survey must play a major role in the implementation of sanitation programmes.

Impact of untreated sewage infiltration to metalloid content in groundwater: A case study from West Bengal

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Worldwide, elevated concentrations of anorganic contaminants, especially of arsenic and to a lesser extent other metalloids have been found to be widespread in shallow groundwater, despite of low content in the ambient sedimentary host rocks. During the two passed decades, numerous examples were published, particularly from rural areas of Southeast Asian countries, such as India, Bangladesh, Vietnam and Cambodia. In the affected areas, chronic diseases pattern are widespread due to continuous consumption of contaminated groundwater. Multiple causes have been discussed to understand the metalloids release processes. The frame conditions are similar in the affected areas, such as sedimentary aquifers of young (Holocene) age, shallow groundwater with low hydraulic gradient and a dominating rural land use without any sewage treatment and canalisation systems. Still then, the complex interacting processes which are responsible for the contaminants release are not understood in detail. The presented study focuses on the link between geogene release processes and anthropogenic sewage infiltration into groundwater. A detailed geochemical case study has been carried out in a rural area in Malda district, West Bengal (India). In shallow groundwater of the 35 km² area, several hot-spots with enriched concentrations of arsenic (up to 50-fold of the max. level recommended by WHO) and other constituents such as ammonia, sulphate and phosphate have been identified. These hot spots are linked with geologic features such as oxbow channels and fine grained sediments, but also with densely populated village areas where untreated sewage is allowed to infiltrate from pit latrines into subsurface, sometimes in immediate vicinity of a drinking water well. In summary, the release of geogene metalloids from the aquifer sediments is a redox-sensitive process, which is - amongst others - triggered by the geo- and hydrochemical environment, such as the available content of natural organic carbon. Uncontrolled infiltrating sewage fluids which meet the

groundwater just a few meters below subsurface add a multiple of the natural organic carbon content to the aquifer system. As a consequence, activity of microorganisms which obtain their energy from the degradation of organic matter and consume oxygen and other electron acceptors is accelerated. This changes the redox-environment and possibly leads to the release of redox-sensitive constituents from the sediment. The anthropogenic input of organic matter has the potential to accelerate this process. The presented case study indicates that sewage infiltration not only leads to direct contamination of groundwater, such as pathogen germs, nitrate/ammonia, but may also indirectly accelerate the release of other contaminants. Sewage infiltration and metalloid-release is ongoing so that appropriate monitoring and remediation strategies are urgent and essential.

Development of molecular tools to monitor virus elimination in waste water reuse

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As part of the SMART Jordan Valley project, new integrated approaches for water management, aquifer recharge, and waste water reuse are developed. Decentralized membrane bioreactor technologies combined with consecutive subsoil conditioning are studied with respect to the removal of persistent organic pollutants (POPs) and pathogenic organisms. The presence of microbial pathogens in reclaimed water can pose a considerable health risk, and monitoring the elimination of pathogenic organisms is a pre-requisite for developing sustainable waste water reuse approaches. While current cultivation methods for the detection of pathogens are time consuming and expensive, the polymerase chain reaction (PCR) has been shown to be a rapid alternative method. Furthermore, the PCR method makes sample conservation possible, a significant advantage as compared to cultivation methods. However, excisting PCR laboratory protocols often are not applicable to environmental samples due to interactions with co-pollutants or high detection limits. In our study an advanced cation-coated filter method is developed to concentrate pathogens in large volumes of water, followed by PCR. In first experiments, MS2 bacteriophages were added to waste water treatment plant (WWTP) effluents, and the detection limits were determined. MS2 recovery was additionally determined in drinking water. The method proved to be suitable for virus detection in WWTP effluents. The recovery of MS2 phage was 76 to 93 % and a calculated detection limit of 288 pfu/mL was determined. For this purpose WWTP effluent was spiked with MS2 phages of a defined concentration before ascertained via cultivation method. A dilution series was performed and the concentration still able to detect by PCR indi-

cated the detection limit. The detection of the MS2 phage, used as a model to proof the method, indicates that other viral contaminants also will be detectable. The method will be applied to monitor virus elimination in laboratory studies and in field samples taken at Jordan waste water infiltration test sites. Acknowledgement: The authors gratefully acknowledge funding by the German Federal Ministry of Education and Research (02WM0803). The study is associated with the joint research project "Sustainable Management of Available Water Resources with Innovative Technologies (SMART: http://www.iwrm-smart.org/)".

Water quality asessment of the Benig River: Implication to environment

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The problem of climate change and scarcity of water supply is currently experienced globally and in the Philippines particularly in Regions I, II, and III. Thus, in response to this problem, the Tarlac City Environment and Natural Resources Council (TCENRC), Tarlac City, Philippines launched a project for the adoption of Benig River into a protected watershed. Benig River is one of the 4 river systems in the area. This can serve as an alternative water source for the people of Tarlac. It could be used for irrigation of rice lands and for day to day uses.

However, effluent wastes are continuously discharged to the Benig River by piggery farms at the vicinity. To check its present condition and adverse effects to health and in the environment, water samples were drawn at three sampling points: the upstream, downstream, and the effluent. The samples were analyzed for oil and grease (O/G), chemical oxygen demand (COD), biochemical oxygen demand (BOD), and dissolved oxygen (DO) as test parameters. The data obtained in the laboratory tests were compared, correlated, and interpreted based on existing laws and standards of the Department of Environment and Natural Resources of the Philippines. The results were used as an initial base data for the conduct of continuous monitoring of the Benig River for its improvement or reclassification. Generally, the water quality of the upstream portion is within the permissible level based on the standards of DENR Administrative Order 34 of 1990. However, it was found out that the effluent discharge from the piggery farms is a source of pollution. The oil and grease content in the effluent does not contribute much to the oil and grease found in the water sample collected from the downstream. The COD and BOD levels increased as it approaches the downstream. Currently, the river is on its second phase monitoring. Hence, this study. It was the end in view of the TCENRC not only to maintain the quality of the river but at the same time implement policies for its protection through a joint community based effort with the residents of the area.

Assessment of sustainable sanitation and protection of the groundwater aquifers

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Water is fundamental to human well - being, socio-economic development and the health evolution of the ecosystem.

Water is basic to production, and therefore clearly a factor in poverty reduction. The productivity of irrigated agriculture is particularly dependent on rational and wise water resources management. Growth in population, increased economic activity and improved standards of living lead to increased competition for, and conflicts over, the limited freshwater resource. A combination of social inequity an economic marginalization forces people living in extreme poverty to overexploit soil and forestry resources, with damaging impacts on water resources.

Poor water management and water shortage can lead to disease, malnutrition, reduced economic growth, social instability, and confilict and environemntal disaster. Water related diseases are among the worst killers in sub-region and the poorest segments of the population are often hit hardest, not least the women who carry the daily responsibility of the health of their families.

In many countries the challenges to be dealt with comprise issues such as securing access to safe drinking water and basic sanitation for the presently unsaved; the challenge of rapidly growing urban water demands and wastewater discharges; securing water for increased food production; reducing vulnerability to floods and droughts (including considerations of possible impact of climate change); reducing risk to human health and production from diseases and hazards; meeting increased demands from irrigated agriculture, industry and other economic activities; protecting the resource base and vital ecosystems; and the prioritization among these often conflicting demands. Providing equal opportunity for men and women in dealing with these issues is an important challenge.

The trends to water resources, in particular is the twin issues of over-exploitation and degradation. I agree that solid and liquid waste streams are inadequately managed, and I propose a solid waste management strategy to be built so as to minimize waste separation, recyling and disposal. In order to minimise the risks associated with contaninant migration from point sources, therefore that land fill/dumpsites, and on-site sanitation systems should be constructed according to industry standard, and the choice of facility location subject to a minimum separation distance criterion with respect to aquifers/water courses and water intakes e.g well used for public supplies). For instance community

wells should be at least 50 m from dump/latrines and other known sources of pollutant.

Regarding the risk of diffuse pollution from agrochemicals, organic farming is touted as an attractive alternative. The connection between environmental sustainability and poverty is made through irreversible loss/decline of productivity of individuals and environmental systems.

New sanitation concepts for condominium housing: Urine-diverting dry toilets in multi-storey buildings in Ethiopia

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Ethiopia is one of the countries with the lowest sanitation coverage worldwide with less than 15 % of the population having access to improved sanitation. Although the situation is slightly better in urban areas than in rural areas, it is the fast growing cities where the most pressing problems with regard to sustainable sanitation exist. The majority of the existing toilets are simple pit latrines which face a variety of problems like pit collapsing, entering of excreta into the soil, flooding as well as rapid filling. The lack of desludging possibilities and missing sludge management concepts are factors that are restricting the use of septic tanks. In addition, due to the missing lining of the septic tanks, wastewater is allowed to infiltrate into the soil and, thus, risking groundwater quality. Water-based sanitation systems such as flush toilets connected to sewerage are often creating nuisances due to water shortages and low water consumption rates. Moreover, these conventional technologies neglect the need for safe recycling of plant nutrients to agriculture. Prices for mineral fertilisers are skyrocketing at present making it difficult for Ethiopian farmers to supply the required nutrients to their fields. Therefore, new sanitation approaches and concepts are required, taking into account hygienic excreta management, protection of natural resources and the value that human excreta represent in terms of plant nutrients and organic matter. Currently, a wide range of activities are carried out in several Ethiopian cities aiming at the dissemination of sanitation concepts that save water, protect the groundwater and recycle nutrients. One of the main targets of our activities are large-scale housing programmes implemented by the Ethiopian government. The integration of a dry toilet system into multi-storey houses presented a special challenge, which was addressed by the adaptation of the double-vault urine-diverting system. Urine-separating toilets were installed for testing and demonstration purposes. First experiences with the reuse of human excreta products in agriculture were gained. These tests showed very good results in terms of crop yield and social acceptance. Farmers as well as consumers have not raised any objections, but appreciated the value of the fer-

tiliser in the form of urine and composted excreta. In order to be able to separate the urine at source, the production of urine-separating toilets by Ethiopian companies has been supported. Different models (sitting and squatting) are produced locally out of fibreglass and also a ceramic urine-diverting toilet is available. The projected implementation of water-less, urine-separating toilets in the governmental housing programs is showing an alternative approach for resource-efficient and non-polluting sanitation even in multi-storey buildings. This strategy creates a strong link between sanitation and agriculture and contributes to employment generation with regard to micro and small enterprises operating and managing the sanitation system. We acknowledge the support of GTZ within the PPP project "Introduction of ecological sanitation for large scale housing programs" and the EU within the ROSA project ("Resource-oriented sanitation concepts for peri-urban areas in Africa").

Anthropogenic pollution characteristics and impacts on shallow groundwater quality in a peri-urban settlement in Kampala and solutions for prevention

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Kampala, the capital of Uganda is located near the shores of Lake Victoria. Thirty six percent of the population in peri-urban settlements and slums in/around Kampala draws shallow groundwater for domestic consumption from protected and 11% from unprotected springs. The quality of the shallow groundwater is a major concern due to poor environmental sanitation. This study presents the characteristics and impact of anthropogenic pollution on shallow groundwater in a typical peri-urban settlement, Bwaise III Parish in Kampala. The latter is densely populated with a high water table (<0.5-1.5 m) and lacks basic social infrastructural services. Field surveys were undertaken to identify and locate pollutant sources and to obtain information that can be used to design interventions. Water quality monitoring was carried out over a period of 19 months for 16 installed monitoring wells and one protected spring to ascertain the seasonal variation. To characterise the wastewater carried by the open storm/grey water drains, samples were collected monthly from 3 drains over a period of 6 months. To assess the effect of the rain on the groundwater quality, spring discharge and water table levels in the wells, for short rains (48 h prior to the sampling) were used. Findings show that pit latrines are a major source of pollution giving pathogenic bacteria and nutrient loads of 14.5 x 1020 cfu TTC /yr, 1,775kg Nitrogen/yr and 6,680 kg Phosphorus/yr. Drains receive high loads of runoff, solid waste and faecal matter during the rains. The water table responds rapidly to short rains due to the pervious and

shallow nature of the unsaturated zone. There is widespread contamination of the groundwater with high organic (up to 370 mg Total Kjedahl Nitrogen/l and 779 mg NO-3/l), thermotolerant coliforms (TTCs) and faecal streptococci (FS) and total phosphorus (up to 13 mg/l). Multiple sources of contamination were identified as animal rearing, solid waste dumps, pit latrines and grey/storm water. The spring discharge (1.22–1.48 m3/h) had high nitrate levels (median values of 117 and 129 mg/l in the wet and dry seasons respectively) and did not vary significantly with season (p=0.087) suggesting that this source is fed by regional base flow. The deteriorating microbial spring water discharge after rain events (median values of 815TTCs cfu /100 ml and 433 FS cfu/100 ml) was attributed to the poor maintenance of the protection structure. To protect community health in these settlements, calls for an urgent need to identify and select appropriate technical and institutional management solutions that take into account the underlying socio-economic issues. An appropriate technology for excreta disposal is Ecological Sanitation (EcoSan) toilets, which – in comparison to pit latrines- avoids the discharge of nutrients and pathogens into the groundwater. In Uganda EcoSan is considered as urine-diversion dry toilets, which assure proper storage and treatment of faeces, and collection and reuse of urine. The German Development Cooperation is supporting pro-poor approaches in several sanitation projects in Uganda. Ecosan is promoted by the German Development Service (DED) in several major cities for sanitation improvements, groundwater protection, and as solution to ensure food safety.

The impact of anthropogenic activity on groundwater system in the southern Nile Delta, Northern Egypt

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Thirteen piezometers were constructed to indicate water table fluctuation and water quality in southern Nile Delta. Groundwater from the saturated zone and sediment samples from the unsaturated and the saturated systems, were collected within different depths from the ground. Water depth was measured for the unsaturated (aquitard Holocene) and the saturated (Pleistocene aquifer) environments to clarify the leakage direction. The purpose of this research is to obtain a better understanding of groundwater contamination process in an arid environment due to cultivation. Additional aims were to investigate the fate of organic matter along unsaturated environment. The downward leakage from the agricultural wastewater to unsaturated and eventually into saturated zones, was predominant in the study area. The soil salinity increased due the northern part, because of inflow of soil water and agricultural wastewater. The organic matter content in soil is high and decreased with depth indicate

pollution signal. Results indicate that EC, Cl, Mg, and Ca concentrations were increased due the southwestern part of the study area, attributed to agricultural activity, pesticides application, and low thickness of unsaturated zone. Na concentration was increased in the eastern part, enhanced by the base exchange reaction between the wastewater contain high Na and the aquitard clay, which release Ca and Mg into groundwater. Groundwater was suitable for irrigation, while few of them can used for drinking purposes. Multivariate statistical analyses and hydrogeochemical models were used to clarify the water characterization and the different dissolution/precipitation products in unsaturated and saturated environments.

Groundwater pollution in Shantytowns of Cotonou: Which strategies to limit waterborne diseases risks?

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Cotonou is the most densely populated city of the coastal sedimentary basin of Benin and also the most polluted, especially its shantytowns of which 74 % are located in the unsuitable marshy zones. Most of people use water from wells of which the depth varies between 0.5 and 1 m and often drilled less than 5 m distance from septic tanks. However, the rainfall and hydro-geological conditions and inadequate house hygienic sanitation equipment reduce the self-purification capacity of water bodies and pollute groundwater. Thus, the contamination of water from wells affects poor population health in the slum areas of the city.

Water quality deterioration explains the occurrence of waterborne diseases, such as bacillary dysentery, cholera, gastrointestinal and diarrhoea diseases. Safe drinking water would be assured only by promoting adequate house hygienic equipment and sustainable water source management.

To reduce population vulnerability to diseases related to water quality in the slum areas of Cotonou, it is important to control the environmental factors like risk related to extreme climatic event, especially flooding, geology, solid waste and wastewater management which govern groundwater availability (quantity and quality). Sustainable sanitation and groundwater protection also need to take into account the socio-economic factors (poverty, distance to safe water point, etc.) which determine safe water consumption.

Evidence of improper sanitation on groundwater quality in Thiaroye aquifer, Dakar, Senegal: An isotopic approach

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The unconfined sand aquifer lying below the Thiaroye suburban areas bears a considerable groundwater resource which contributes up to 12,000 m^3/d to the Dakar city water supply. Groundwater investigation in the Thiaroye quaternary sandy aquifer was carried out in order to evaluate variation and the anthropogenic influence on water quality. In this respect, long term quality monitoring as well as sources of pollution were investigated using chemical and isotopic data obtained from samples collected from hand dug wells, boreholes and piezometers. Stable isotopes analysis results of the dissolved nitrates were used to identify urban sewage and septic tanks as major source of contamination.

The results of this study reveal a wide variation of groundwater composition, with high concentrations of Na^+, K^+, Ca^{2+}, Cl^-, HCO_3- and NO_3- encountered in the urban area.

Groundwater is particularly dominated by Na-Cl and Ca-Cl_2 type. In most groundwater the chloride concentration may originate from anthropogenic input and agricultural activities. However the groundwater quality is mainly affected by high nitrate content which indicates an important increase during recent decades. Nitrate concentrations of groundwater samples mostly exceed the World Health Organization's recommended limit (50 mg/l) for drinking water in about 61 % of the examined samples. Highest nitrate contents are encountered in the agglomeration zone particularly at the vicinity of the pumping field where septic tanks leakage is believed to be the main source of nitrate. In this part the concentration of nitrate is mostly well above 100 mg/l and reaches a maximum value of 743 mg/l.

Considering the isotopic data obtained from wells in Dakar, three major sources infer the nitrogen isotope values of dissolved nitrate were identified: nitrate derived from animal and human waste for most of the sample with $\delta^{15}N$ (NO_3-) > 10‰ and ranging from 10.2 to 22.2‰, the oxidation of soil organic nitrogen with isotopic signature ranging from 7.3 to 9‰ and the mixture of nitrates derived from human and or animal waste and those derived from the oxidation of soil organic nitrogen [$\delta^{15}N$ (NO_3-) around 10‰]. These results may be confirmed by the lack of sanitation system and sewage in the Dakar suburbs, which concentred the major part of the population.

Pollution and sustainable development of West Bank groundwater Aquifers

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Groundwater is the primary water resource in Palestine. The aquifer system is highly karstic and heterogeneous. It is composed of carbonate rocks, buried in great depths and confined by marl, shale and chalk.

Six aquifers have been identified in the West Bank, ranked from youngest to oldest: Valley Aquifer (Valley Alluvium and Pleistocene Lisan Formation), Beida Aquifer (Neogene age), Eocene, Turon (Subseries of the Upper Aquifer), Upper and Lower aquifers. The alluvium and upper aquifer systems are vulnerable. Sampling data is relatively extensive for chloride and nitrate ions and sampling for major ions has been completed at many locations. However, sampling and laboratory analysis for organic pollutants such as volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), priority pollutant metals, herbicides, pesticides, and polychlorinated biphenyls (PCBs) as well as total and fecal coliform are relatively rare to non-existent. The recent sampling results had indicated pollution from pesticides, herbicides in the wells and springs taping some of the above aquifers.

The aim of the paper is to investigate the vulnerability of West Bank aquifers through water quality sampling programs. This involves linking results from field sampling from old and new-drilled wells including the deep wells (production, and monitoring wells) with sources of contamination and using risk analysis method. The risk analysis is based on identification and mapping the significant potential sources of contamination, and combine this data with evaluation of the vulnerability of the aquifers in the study area.

Impact of land-use on groundwater quality in the unsewered Thiaroye Suburb (Dakar, Senegal): Remote sensing and GIS approach

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Contamination through septic tanks and effluents of the urban groundwater used by local population for agricultural practices and domestic consumption has led water authorities, stakeholders and researchers to develop strategies for water resource management. In this respect a multi-disciplinary approach

which combines Remote Sensing, GIS, hydrogeological and sociological techniques focusing on water quality degradation and devastating urban floods were developed to provide material for future emergency planning and hazard mitigation in the densely populated area in the Dakar suburb area. The long trend analytical data on groundwater quality stretching back to 1966 were considered to evaluate impact resulting from the rapid expansion of the region. Establishment of these impacts was considered to be important, given the rapid expansion of Dakar city and its reliance on groundwater from the unconfined Thiaroye aquifer.

Record of nitrogen, chloride and sulfate compounds were correlated with the multi data land use and other thematic maps from aerial photography (1966), Thematic Mapper (TM) of Landsat (1972, 1988) and Spot imagery (1995, 2006). Spatial information was acquired with different spatial resolution of 2.5 to 30 m. Data from aerial photographs and RS image have been interpreted using ARC GIS 9.2 to provide separate land use distribution for each time periods between 1966 and 2008.

Results on land use distribution from 1966 to 2008 evidence real conversion from uninhabited zone to urban zone with expansion evolving from 2,809 to 12,925 ha. The greatest increase occurred between 1988 and 1995 with 31%. The main changes with time concerning groundwater quality deterioration were derived mainly from nitrate and to lesser extend sulfate and chloride. Lower nitrate concentrations (5 – 32 mg/l) were observed in the pumping field zone (F17, F19, F22, F21, F22) during period prior to 1988. Unsewered urban areas rapidely increase since 1988; it corresponds to high levels of nitrate (116 – 297mg/l) above the drinking-water standard in the pumping area. More recently (1995 – 2008) nitrate level reach 300 – 550mg/l on the pumping zone located in the populated suburb area. The adjusted sanitation system map (2000) confirms the lack of the system on the suburb zone where septic tanks leakage is the main source of pollution.

This approach developed and the resulting maps are useful for development of regional groundwater protection plans, policy analysis tools and pollution source control. The effective awareness of the local population and stakeholders can permit to implement strategies to ensure properly conceived tool for managing this valuable water resource in the urban environment.

Groundwater contamination due to sanitation problems and it's relation to soil characteristics (Case study in Denipitiya, Sri Lanka)

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Availability of well-analyzed safe water plays a vital role in national development. Large amount of water is required for various day to day activities like human consumption, agriculture and industrial purposes. The surface and underground water is being contaminated with various elements, by the untreated discharge of sewage water and poor sanitation measures. The main objective of the present study is to identify groundwater contamination due to depth variations of the latrine pits and its relation to soil characteristics of Denipitiya which is located in southern Sri Lanka. Groundwater is the major water source in the study area, where shallow unconfined groundwater is used for domestic purposes and irrigation. Shallow groundwater aquifer is mainly consisted of sandy-clay, clay, silty-clay and calcified sandstone formations. Thirty dug wells are selected and continues monitoring was conducted with respect to Groundwater levels, Electrical conductivity (EC), Total dissolved solids (TDS), Coli form and E Coli. Three auger holes were drilled within the study area and collected soil samples to identify saturated (aquifer) and unsaturated zone characteristics. From each angering point, soil samples were taken from surface layer and each 50 cm depth until reach water table and also water samples were taken from auger holes. Soil samples were analysis with respect to physical and chemical parameters.

Most of the dug wells distributed in the study area are shallow, at 3 – 5 m depth range and 0.5 – 1.5 m diameter. The average EC, TDS values of the groundwater were observed as 667 micro siemens/ cm and 291 mg/ liter. Within the study area most of the latrines and dug wells are sited within the homestead. In this context the sanitary facilities deposit wastewater into the ground from which groundwater is obtained for domestic purposes. The results significantly reveled that the E coli and Coli form (bacterial) contaminations depend on the well constructions, well water collection method, latrine pit depth (latrine pits are constructed above and below the groundwater level). Bacterial contamination is higher in well water collection using the bucket than electrical water pump installed wells. In dug wells constructed below the groundwater table, bacterial contamination is higher than the wells constructed within the unsaturated zone. The Soil analysis results show that pit latrines aquifer permeability contribute significant affect to contamination of bacterial pollution.

Groundwater protection as important component of an IWRM

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Environmental change and population growth are putting increasing pressure on scarce water resources in central northern Namibia. Almost 50% of Namibia's population live in this region, which experiences a high dependency on transboundary water supplies from the Kunene River. In the framework of the Integrated Water Resources Management (IWRM) concept, the project 'CuveWaters' investigates demand-driven and adapted water supply and waste water treatment technologies. The overall goal of the project is to improve livelihoods by innovative and adapted technological solutions, but also by incorporating groundwater protection into the concept. For the rural sites, sufficient water supply is one of the major challenges. The ephemeral Cuvelai streams, locally known as 'oshanas', represent a traditionally very important water source, despite their only seasonal availability. The water of the shallow oshanas usually evaporates or seeps away, and only in years of abundant water drains into the Etosha Pan. Groundwater is the second most important source of water supply. The shallow groundwater, which is fed by rain and run-off, is traditionally accessed by hand-dug wells up to a depth of approximately 30 m. The water quality varies strongly in the upper groundwater layers and ranges from fresh to salty. Most of the hand-dug wells are not protected from livestock and are therefore very vulnerable to faecal pollution. The locations of the latrines can also negatively influence the hand-dug wells. To achieve groundwater protection by adequate technical solutions as well as education, awareness campaigns and social marketing, is part of the CuveWaters project. The groundwater at greater depths (40 to 80 m) is very saline with values up to 90.000 mg/l TDS. Desalination is seen as a possible solution for drinking water supply. The evolving brine can either be re-infiltrated into the ground or deposited in evaporation ponds. Negative impacts on the environment, including aquifers, have to be avoided by thorough investigations for the adapted implementation of desalination plants. For urban sites, sewer systems currently exist only for the formal areas. Wastewater is often collected in oxidation ponds, where the main part evaporates and another part probably infiltrates into the groundwater. In informal settlements, a sanitation infrastructure is missing. In some places, dry toilets have been installed, but in many cases, people use the bush as a toilet. This leads to hygienic problems as well as to damages to shallow groundwater, especially during the rainy season. Within CuveWaters, a semi-decentralised urban infrastructure system concept is investigated in an informal settlement. It includes both rainwater utilisation and sanitation and waste treatment and reuse. Cleaned waste water, free of pathogens but containing fertiliser from an

anaerobic waste water treatment plant will be re-used for plant production to improve the safety of household food (poverty reduction) and/or to generate alternative income, while biogas will be utilised for cooking or lighting. This concept reduces the exposure of groundwater resources to possible pollution through inadequate sanitation systems.

Pit latrines and their impact on groundwater in small towns in Uganda A case of Bugiri Town Council

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Access to clean and safe water is and will be one of the greatest challenges for sustainable development in Sub Saharan Africa. In order to reduce by half the proportion of people without sustainable access to safe drinking water under Millennium Development Goal 7 by 2015, the government of Uganda is improving water supply by exploiting the potential of groundwater using low cost water supply technologies. The promotion of Pit Latrines to improve household sanitation coupled with the need to improve access to safe drinking water in areas with shallow groundwater is a serious development challenge in Uganda. The promotion of Pit Latrines has traditionally been done with very little knowledge of its impact on the quality of groundwater in Uganda. ECO, a non governmental organization promoting water and sanitation issues in Uganda carried out a survey to establish the impact of pit latrines on groundwater in a small town with shallow ground water aquifer. According to the survey which was carried out between Sept and Nov 2007, the bacterial quality of groundwater drawn from 15 sites (10 shallow boreholes and 5 springs) indicated that 40% (6 sites) of the water samples analyzed had strains of faecal bacterial counts. The microbiological analysis for water samples from the 5 springs 40% (2 sites) confirmed the presence of faecal bacteria. It was also found that over 80% of new latrines dug get filled up with water at between 10-20 metres deep before their completion (i.e. 30 metres). Correlation between water quality and the out break of water bone diseases focusing on diarrhea was made by visiting 10 health centres located in the Bugiri town council. It was confirmed that 60% of the health centres visited had at least 5 cases of diarrhea per month among children below five years. The 40% of health centres had less than 3 cases of diarrhea per month among children below five years. The presence of the bacterial strains in analyzed water points exposes their users to short and long term health risks. ECO came up with the promotion of the use of Ecological Sanitation (ECOSAN) Technology to improve sanitation and hygiene conditions for the urban poor population in small towns in Eastern Uganda using best practices from other parts of the country and Malawi. ECO also mobilized and

sensitized local town council in the area on the merits of utilizing ECOSAN technology to improve sanitation and hygiene conditions of communities while at the same time protecting groundwater in small towns.

Economic waste management system for ecological sanitation

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The Urban population of developing countries is predicted to rise from one third in 1990 to over 50% by 2025. On the basis of the figures and other global trends, it would appear that Africa and Asia will have the highest share of world's urban growth in next 25 years, resulting consideration rise of large number of metropolitan cities. Over the next generation of greatest increase in population, in production and in poverty will occurs in cities causing the social, economic and environmental problems in these cities. The Safe sanitation, water and waste, is the greatest challenge for the cities and towns in developing countries in Asia including India. The Maharashtra state in India has 325 Towns and 33 cities. There are 232 municipal councils including A, B, and C class, and 12 municipal corporations. These local authorities are looking after the civic administration at town or city level. These towns are now facing the acute solid waste management problem causing the environmental pollution. The combined effect of this pollution is responsible for degradation in the soil, water and air quality, which ultimately affect the civic health in these areas. The farmers from the periurban areas are bringing their agricultural products including vegetables in the city market. This creates large amount of the solid waste from vegetables as well as animal excreta especially organic waste, which contain more percentage of moisture content. The Government provided the economic incentives for farmers to reduce the organic waste. However the economic instruments for reduction of solid waste can not be successfully implemented with out pre-existing appropriate standards and effective monitoring and enforcement capacities. Although economic incentives have been viewed as alternative to the traditional approach, they can not be considered as short cuts to the organic solid waste management such as composting, vermin-composting. The source reduction, source separation and producer responsibility- these three factors are critical in developing and designing ecological sanitation model for economic and optimum waste management model using composting system in towns of the Maharashtra. The municipal councils and local authorities are spending large amount of their budget on solid waste management system, which is major constraint in expanding other civic services to citizens. This paper will deals with present scenario in sustainability of ecological sanitation using composting and vermin-composting of the organic

waste such as night soil, animal excreta etc. and its application in agriculture and forestry; past efforts to ensure the economic development of compost process from agriculture waste, kitchen waste, market waste and organic waste. It also discusses history of some of recent successful examples in regards to public - private and peoples partnership in infrastructure provision for ecological sanitation and biotreatment and marketing for the same. The paper emphasizes for extensive capacity building for ecological sanitation using compost process and its application for sustainability at local level for economic use of organic waste.

Vunerability of Shallow Aquifers into Pollution, the Ugandan Case

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Safe water coverage in the rural area in Uganda stood at 63% in June 2007. Low cost technology options for water supply (protected springs and shallow wells) constitute 62, 3% of the technologies used for groundwater abstraction. Shallow wells include hand dug wells, hand augured wells and motorized augured wells typically developed at a depth of 3-8 meters. Despite the increase in safe water coverage, water borne diseases remain a big health challenge. Between July 2006 and June 2007 alone, the cumulative total of cholera cases was 5,194 with 105 deaths. In October 2007, new water related epidemic of Hepatitis E was reported with 4,129 cumulative cases and 67 deaths by June 2008. With annual outbreak of water borne diseases of such magnitude, the quality of water supplies, inadequate sanitation and poor hygiene behaviour have been cited as the main causes of these outbreaks. This paper summarizes reports on water quality from protected springs and shallow wells from various studies undertaken in Uganda between 2002 and 2007. In all studies it was observed that shallow aquifers were vulnerable to intermittent pollution especially during the wet seasons. Although only one study directly correlated water quality with outbreak of diarrheal diseases, in all other studies, either the area or season of outbreak directly corresponded with location of sources with poor water quality or seasonal variation in water quality. It may be concluded that further research is required into the factors that render shallow aquifers (protected springs and shallow wells) vulnerable to pollution but the big question to be answered now is whether this Technology Types should be encouraged for groundwater abstraction considering the water quality concerns and associated health impacts.

Design of low cost water recycle system in a small scale food industry to overcome groundwater shortage

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Industry and commercial activities overuse and deplete groundwater causing adverse impact to the environment, such as decreasing soil surface and intrusion of seawater in some high populated cities in Java, Indonesia. To minimize the use of groundwater, the administration of the capital city, Jakarta, plans to increase groundwater retribution as much as four times to around Rp 12.000 m^3, similar to the price of tap water. If this new regulation is implemented, industries in particular small size companies will face problems related to the supply of clean water for its production line. To maintain production continuity and competition level of the food industry, the government needs to provide technology support particularly for the small scale industry so that the new policy can be realized in practice. Based on economic considerations, this trend will enhance the implementation of water efficiency, water conservation, and water recycle rather than over use of groundwater and discharge of wastewater with considerable environmental expenditures. To provide adequate water quality for recycling purpose, supplemental water purification system is required beyond conventional secondary wastewater treatment. Health safety parameter also needs to be considered because pathogens can exist in partially treated effluents, particularly for specific application such as in a food industry where chlorination is needed. This paper discusses about the design of a water recycle system in a food industry, particularly the development of unit processes to further treat effluent of a secondary treatment system to a sufficient water quality for tray cleaning, a non-food application.

The design of the water recycle system was started by analyzing a water balance and lay outing the existing wastewater treatment system. The main unit in the secondary wastewater treatment system is a biological process involving anaerobic and anoxic conditions known as sequencing batch reactor (SBR). The plant produced treated effluent from the SBR as much as 10 m^3/day with COD, TSS, and total N concentrations of 48.3 ppm, 22 ppm, and 1.43 ppm, respectively. Although these qualities satisfy the discharge standard according to West Java Governor Decree number 6/1999, the effluent discharge permit is limited because the plant is located in an area which is not allowed to dispose wastewater to the environment. The recycle system is therefore designed to further process the effluent into a sufficient quality water. The water recycle system is consisted of three main unit processes, these are the chlorination unit, the 660 L rapid sand filtration, and the 600 L activated carbon filtration. Based on the published design criteria, the quality of recycled water was estimated to meet the class I water according to the government regulation PP 82

year 2001, a standard for raw water for drinking water, requiring COD, TSS, total N and chlorine concentrations of 10 ppm, 50 ppm, 0.25 ppm, and 0.1 ppm, respectively.

Cairo East Bank Effluent Re-Use study 4-monitoring of groundwater contamination as affected by crop irrigation with secondary treated wastewater

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The paper is a part of a large study entitled the „Cairo East Bank Effluent Re-Use Study“ .The aim of this work was to evaluate the effect of treated wastewater on chemical properties of groundwater changes that may occur as a result of wastewater irrigation of field crops in greater Cairo. Large scale field trials were carried out in summer and winter seasons in experimental site about 20 km north east of Cairo and located inside El Berka wastewater treatment plant; the soil is gravelly sand and could be classified as virgin soil. Crop selection included range of food, fodder and industrial (fiber and oil) crops according to WHO (1989).

A comprehensive sampling program included wastewater irrigation and groundwater quality was undertaken. Groundwater monitoring wells were installed in and around the experimental soil site and the samples were analyzed for range of chemical and bacteriological parameters according to the international common procedures and the data were subjected to the proper statistical analysis.

The results showed that the treated wastewater was generally acceptable for reuse, according to the Egyptian decree for wastewater reuse (DecreeECREE 44, 2000). The heavy metal concentrations were very small and was well below the limit values for secondary wastewater reuse according to the Egyptian cod of practice for wastewater reuse. The numbers of faecal coliforms found in the treated wastewater were at 106 MPN/L, far in excess of that permitted by the guidelines of WHO (1989), and salmonella were present in all samples. Nematode ova were found in all samples of treated wastewater in excess of the limit value for reuse (mean 49 ova/L).

The data showed considerable spatial and temporal marked variation in the groundwater. There was no discernible relationship between well location and irrigation of treated wastewater in the trials. The salinity of groundwater was moderate. Heavy metal concentrations in the groundwater were small. The

groundwater samples which have been examined for the presence of pathogenic bacteria (salmonella), faecal coliform bacteria and helminth ova indicated that the groundwater were contaminated by secondary treated wastewater irrigation. There was a seasonal effect of nitrate leaching following the peak irrigation period, with a lag phase before the nitrate reaches the groundwater. 10–57 % of the samples from each well contained salmonella the numbers of faecal coliforms were in the range 102–103 MPN/100mL. Small numbers of parasite ova were also found in the majority of wells. The groundwater under both sites was similar and of poor quality.

It could be concluded from this study that the groundwater was of poor quality, and would be unsuitable for potable or irrigation purposes. Microbial and parasitic levels indicate that chlorination at levels to achieve faecal coliform compliance does not significantly reduce viable nematode numbers. Consequently, additional treatment of this treated wastewater (such as by UV, sand filters or lagooning) would be necessary to achieve compliance.

Contamination of ground water in Bwaise slums - a challenge to the developing parts of Uganda

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Bwaise is one of the slum areas in the suburbs of Kampala, the capital city of Uganda, it is swampy and the ground water always contaminated due to the following number of reasons.

Shallow water table – the acquifers which are the main source of water for domestic use get direct contact with the feaces from pit latrine, hence contamination.

Over population – the population density in this area is quite high.

Ignorance – Most people are illiterate therefore having little knowledge on dangers of poor sanitation and hygien.

Poverty – many are so poor to afford putting in place sanitation facilities

Technology – luck the capacity to make a good choice of the appropriate technology.

Culture – rigidity to keeping their cultural values, which are not hygienic.

The land tenure system – This restrict tenants on the choice of technology to apply.

Alcoholism and drugs abuse – This leads nuisance behavior, which may not be hygienic.

Economic activities – Small-scale industries by products let into the streams of water.

Negligence – I don't care type attitude in inhabitants.

Government policy – luck of an effective policy to eradicate slums.

Mitigation

Participatory implementation – All stake holders must be involved

Institutional and funding option – Must be designed to suit the prevailing condition

Social cultural dimension – The community must adopt a common cultural behaviour

Flexibility of design option – Which is appropriate for the area.

Sufficient hygienic – education should be carried out

Environment concern – programs must be promoted to prevent contamination

Land requirement – use and ownership policies must be transformed

Health aspects must be addressed – understand the consequences of contaminating water sources.

Conclusion

If all stakeholders come on board the contamination of ground water in slums of Uganda can be avoided. It will be a big stride in eradicating water borne and related diseases, which have caused a number of deaths in the areas.

Natural Attenuation of an urban CHC-plume – Prediction results

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Within the framework of a funding priority issued by the German Ministry of Education and Research (BMBF) a CHC-plume of 2 km² extent, located south of the city center of Hannover/Germany has been investigated in detail between 2003 and 2007. The **first** objective was to identify and quantify natural attenuation processes taking place in the aquifer, which consists of quartenary sands and gravels. The plume is detached from the contamination source, which was safeguarded by a slurry wall more than 10 years ago. Metabolites of trichloroethene (cDCE, VC) are the predominant contaminants today, with their highest concentration near the base of the shallow, unconfined aquifer where groundwater flows at approx. 100 m/y. The **further** objective was to provide the local

authority with model-based advice on the future handling of the site, coming up with an estimate of remaining contaminant mass and attenuation rates. From the regulatory viewpoint it is essential, whether the plume is stationary and when permissible levels of contamination will be achieved without further active measures.

Groundwater monitoring with an emphasis on the vertical distribution of CHC-metabolites and electron acceptors was carried out for 3 years. Hydrochemical results were complemented by geochemical and petrographical investigations of aquifer-cores and desorption column experiments. 3D-modeling of monitoring results with Open Source GIS GRASS, PostgreSQL and PARAVIEW provided the current **dissolved mass of contaminants** and allowed to delineate hydrogeochemical reaction zones with reducing and oxidizing degradation pathways in the aquifer in 3D. In spite of only 0.075 wt.% TOC (mean) significant tailing was found in the desorption experiments. Coals in the sand size fraction of the aquifer are responsible for kinetic desorption properties leading to a long term release of CHC-contaminants. Based on a drill-database, 36 new drill holes and results from shear-wave seismic measurements, a 3D-subsurface model has been developed.

The spatial coupling of reducing and oxidizing processes in a numerical reactive transport model allowed to describe transport of metabolites through these zones. Kinetic desorption, combined with thermodynamic desorption from two different types of sorption sites (e.g. Van Genuchten, 1982) was taken to represent interaction between contaminants in solution and the matrix. The degradation rate for dissolved CHC was found to be higher than the release rate from the aquifer. The apparent longterm immobility of the plume can be reproduced well, which therefore is a dynamic equilibrium. CHC-sorption to dispersed coal-type kerogens in the aquifer plays an essential role for the future development of the plume. Several runs of the 3D reactive transport model (FeFLOW) showed, that the characteristic immobility of the plume will persist into the future, while contamination levels will decrease within approx. 30 more years down to permissible regulatory levels. This is due to the fact, that although only 2 tons of metabolites are currently dissolved in the plume, up to 16 tons of contaminants are still sorbed on the matrix (coal particles) of the aquifer.

Sustainable urban drainage system for Barangay Bonbon, Cagayan de Oro, Philippines

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Bonbon is one of the riverine barangays facing the Macajalar Bay in Cagayan de Oro City, Northern Mindanao, Philippines. As a coastal community with rather lower elevation, the residents are frequently experiencing flood caused by heavy rainfall. Rainwater often accumulates because it is not properly discharged to the creeks and to the rivers due to the absence of appropriate drainage systems. Few areas have existing creeks which, however, are often clogged due to improper solid waste disposal, including human excreta. Although many residents have sanitation facilities (water closets, urinals, subterranean septic tanks), groundwater contamination when flooding persist has not been ruled out. This persisting situation is also very unfortunate because Barangay Bonbon has beautiful natural beaches, which are threatened to loss their splendor if the problem of flooding will not be addressed. Furthermore, the threats of water-borne diseases have been speculated, but no formal medical researches have ever yet been conducted. As the city accelerates into urbanization and new areas being rapidly developed, groundwater infiltration and recharge are reduced and surface run-off is increased because of increasing paved roads and lots. In the drainage system master plan of the city's Comprehensive Land Use Plan (CLUP), Barangay Bonbon was not included even though persisting local reports of frequent flooding has been filed. In response to this concern, the Infrastructure Committee of Barangay Bonbon proposed to have a drainage system plan in the affected areas, but unfortunately to date, has not received any actions from the government agency concerned. As a concrete response to the community's concern, the Xavier University Engineering Resource Center (XU ERC) formed a small team of Professors and Students to develop a corresponding engineering approach. Objectives of the project include: (1) identifying the specific areas within Barangay Bonbon where flooding is severe, (2) investigating the specific cause of flooding in these heavily affected areas, (3) aims to offer the best engineering design suitable in eliminating flood in the affected areas, and (4) integrate community-based capacity building initiatives for short-term and long-term operation and maintenance of the facilities and programs. A preliminary consultation with representatives from Barangay Bonbon has been conducted to identify the persisting problems and the proposed courses of actions, solutions and alternatives. The purpose of this on-going project is to generate a sustainable urban drainage system by incorporating ecological sanitation approaches. This includes urine-diversion dehydration toilets (UDDT), elevated sanitation facilities equipped with water-impermeable septic cham-

bers to eliminate groundwater contamination; household rainwater harvesting facilities as well as community-based allotment garden systems where the rainwater and the treated human excreta from the UDDT can be reused to water and fertilize the crops as already successfully demonstrated in other areas of Cagayan de Oro. This will further create and maintain green open spaces in the fast growing city not only to produce food but also to provide necessary space for water infiltration. The researchers are currently conducting engineering surveys of the entire barangay for database collection which will aid in generating a sustainable urban drainage design.

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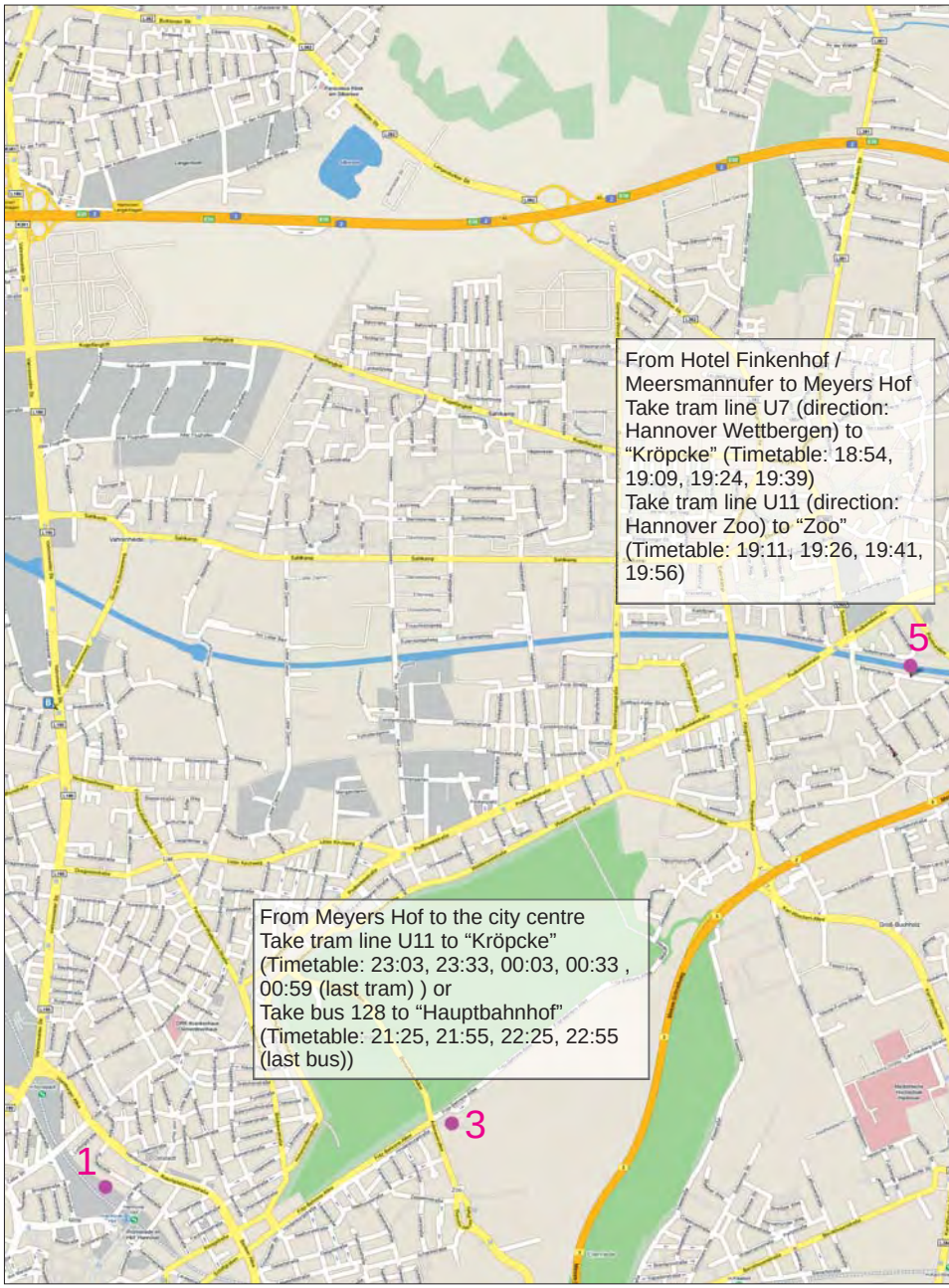
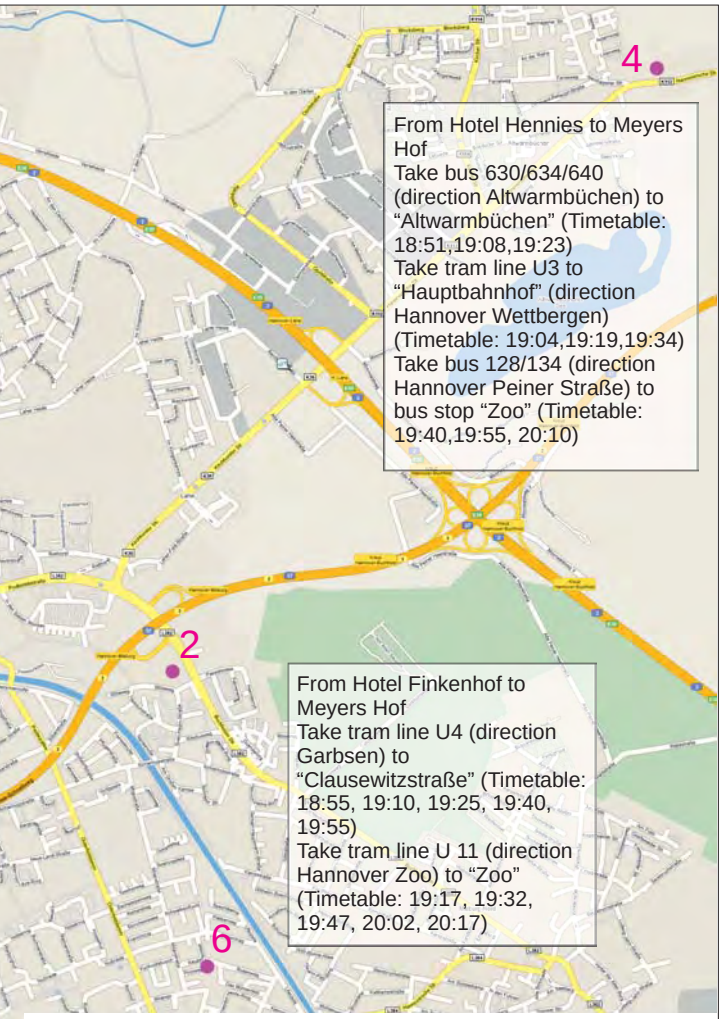

From Hotel Finkenhof / Meersmannufer to Meyers Hof
Take tram line U7 (direction: Hannover Wettbergen) to “Kröpcke” (Timetable: 18:54, 19:09, 19:24, 19:39)
Take tram line U11 (direction: Hannover Zoo) to “Zoo” (Timetable: 19:11, 19:26, 19:41, 19:56)
From Meyers Hof to the city centre
Take tram line U11 to “Kröpcke” (Timetable: 23:03, 23:33, 00:03, 00:33 , 00:59 (last tram)) or
Take bus 128 to “Hauptbahnhof” (Timetable: 21:25, 21:55, 22:25, 22:55 (last bus))
1
3
5



1 Central station (*Hauptbahnhof*)

2 BGR (*Geozentrum/Pappelwiese*)

3 Restaurant Meyers Hof (*Zoo*)
Adenauerallee 3
30175 Hannover

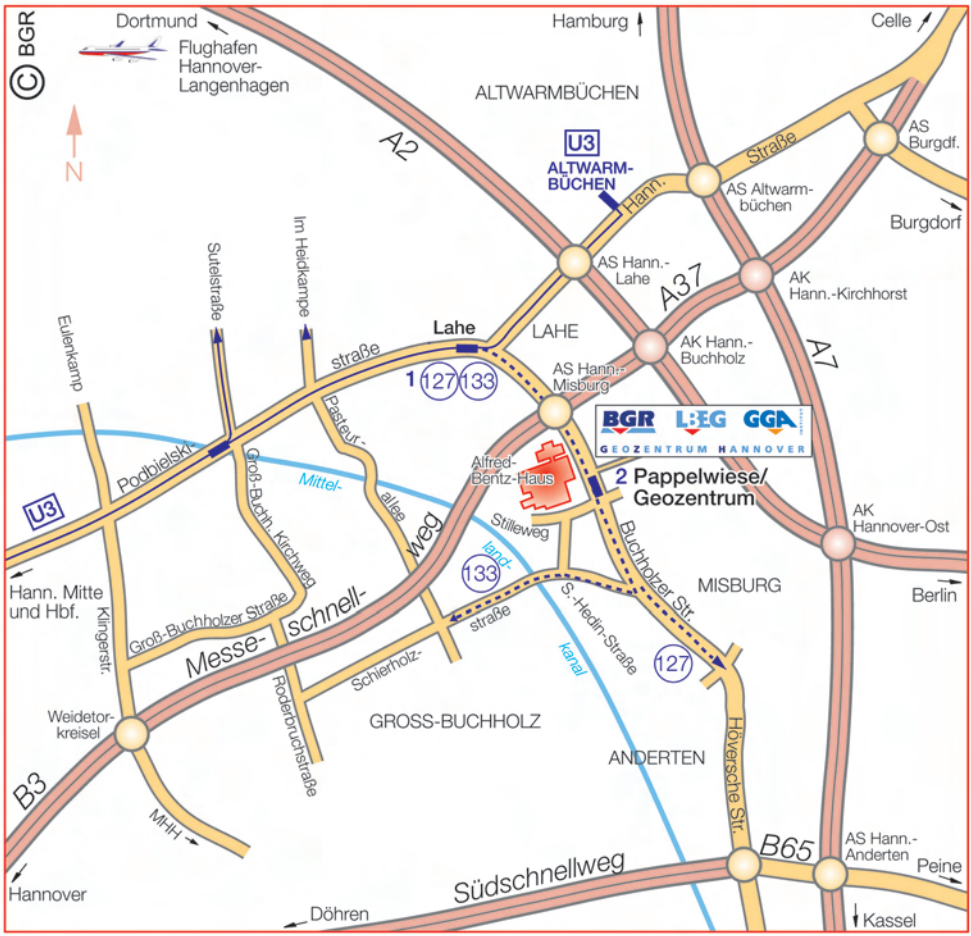
4 Hotel Hennies (*Hennies*)
Hannoversche Straße 40
30916 Isernhagen

5 Hotel Finkenhof / Meersmannufer (*Buchholz/Noltemeyerbrücke*)
Meersmannufer 13
30627 Hannover

6 Hotel Finkenhof (*Roderbruch*)
Pirolweg 2
30627 Hannover

next bus or tram station

Notes



Stadtbahnlinie / Tram line U3

Buslinie / Bus line 127 133

1 Stadtbahn- und Bushaltestelle / Tram and bus stop Lahe

2 Bushaltestelle / Bus stop Pappelwiese/Geozentrum

Ab Hauptbahnhof Stadtbahnlinie **U3** Richtung **Altwarmbüchen** bis Lahe, Buslinie 127 oder 133 bis Haltestelle **Pappelwiese/Geozentrum**

From main railway station, take tram no. **U3** direction **Altwarmbüchen** to Lahe, and then bus 127 or 133, bus stop **Pappelwiese/Geozentrum**

BGR Bundesanstalt für Geowissenschaften und Rohstoffe

partner of sustainable sanitation alliance