Enhancement of natural water systems and treatment methods for safe and sustainable water supply in India

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Saph Pani

Saph Pani is an EU funded collaborative research project which started in October 2011 with duration of three years involving a consortium of 20 partners from India, European Union, Switzerland, Sri Lanka and Australia. Its full name is “Enhancement of natural water systems and treatment methods for safe and sustainable water supply in India” and it addresses the water challenges of the 21th century. Saph Pani builds on already existing Indian projects for natural treatment and storage of water identifying potential for their improvement by applying high-tech measurement equipment and conducting field trials. For more information, visit: www.saphpani.eu

Special Feature WP3

The Work Package 3 of the Saph Pani project is called "Constructed Wetland (CW) and other Natural Treatment System (NTS) for wastewater treatment and reuse". The prime objective of WP3 is to capture the existing experiences with CW and other NTS for wastewater treatment in India and to identify strategies for its enhancement. Based on the experiences gained during the India wide survey IITB along with WP3 partners are developing recommendations on how the potential of CW and other NTS for water reuse can be better utilized in India.

Interview with Professor Shyam R. Asolekar

Shyam R. Asolekar is currently a Professor at the Centre for Environmental Science and Engineering at the Indian Institute of Technology Bombay. He is author of three patents, policy documents, chapters of books and several research papers in international and national journals including three books. Shyam Asolekar has been a member of the “Dahanu Taluka Environmental Protection Authority” since 1997, constituted by the Honorable Supreme Court of India. He was also recruited by the Honorable Planning Commission of India in the “Steering Committee on Environment, Forests & Wildlife” for the 12th Five Year Development Plan for India to be implemented during 2012 and 2017. Shyam Asolekar has been entrusted in Saph Pani Project to lead the activities in WP3.

What do you think is the potential of Constructed Wetlands for water reuse in India?

CW are typically those "engineered" Natural Treatment Systems (NTS) that are designed and constructed to utilize the natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist in treating biodegradable wastewaters. They have been gaining increased international interest and are considered highly applicable in developing countries, due to their characteristics like utilization of natural processes, simple construction, simple operation and mainte-

nance, process stability, and above all their cost effectiveness.

In the light of shortages of water in several parts of the world and especially in India communities are searching for the alternatives that are less power intensive and less expensive in providing primary and secondary treatment. The NTS typically fill the gap in the sense that they need relatively low operation and maintenance costs and far low power to run them when compared with conventional primary, secondary treatment alternatives - especially such as activated sludge process, trickling filter or extended aeration systems. With this specific motivation, several NTS have been proposed to be investigated thoroughly in Saph Pani. Research at IIT Bombay has underscored the fact that among these, especially the CW systems can be effectively combined with advanced tertiary treatment alternatives and the resulting high quality treated effluents can be gainfully recycled into production and sanitation applications.

How is your experience with the project so far?

We seem to be on the right track. The Saph Pani project encompasses different work packages - each having well defined focus area. Our partners in WP3, NGRI, BRGM, IWMI, CEMDS and IHE-UNESCO received cooperation from various communities and municipal authorities during our field work and assessment. It is an enriching experience for all of us to work with each other because we work in a team and we are an interdisciplinary group.

What do you hope to achieve with Saph Pani?

Based on the assessment and in-depth evaluation of a variety of NTS in India; we have been able to propose a classification system for NTS as well as derive system parameters corresponding to the CW systems and other NTS currently operating in India. More importantly, our investigation has articulated limitations and difficulties faced by those NTS - which will enable the practitioners to design new CW systems with greater confidence. One of the gaps in the state-of-art knowledge regarding NTS in general and CW in particular happens to be location-specific and treatment objective-specific elaboration of system components and design parameters. It is our humble hope that we will be able to propose a rational approach to CW designing based on the detailed evaluation of the effectiveness of the various plants species, media alternatives and hydrological choices investigated using laboratory CW reactors in IIT Bombay campus.

Assessment of NTS

Recently under WP3 a study of assessment of natural treatment systems (NTS) has been completed in order to capture the existing experiences with constructed wetlands (CW) and other NTS for wastewater treatment in India. Under this study 41 NTS were visited across India and data were gathered, compiled, and interpreted in order to integrate the various experiences and issues presently associated with NTS in India. Further, representative NTS were subjected for in-depth evaluation of estimation of design parameters and socioeconomic analysis. Based on the experiences gained from extensive field studies across India, a CW-based research station is in progress where the treated effluent generated from various CW will then be subjected to the membrane processing units in the laboratory set-up and investigation of possibilities of combining CW with advanced tertiary treatment unit will be undertaken.

Progress of establishing CW based Research Station named “Water Prospect” on IITB Campus

CWs are most prone to engineering adaptation and modular applications and that is the reason why these natural treatment technologies have been chosen as the technology for the current research project at IIT Bombay. The construction of a pilot scale sewage treatment plant based on CW are in progress at IIT Bombay campus. The steps of land preparation and actual construction have already been finished and the constructed structure (CW bed) has been tested for water leakage. The CW beds will be planted with vegetation in second week of September, 2013.The pilot plant will be stabilized after one month of plantation. On one hand the research station will help IITB to explore potential ways of enhancing performance of constructed wetland-like natural treatment systems that can hopefully provide an economic solution for the problems currently faced while providing sanitation in the remote tribal and rural locations. On the other hand, it is hoped that this approach will demonstrate the significance of constructed wetland as a sustainable and eco-friendly alternative among a plethora of treatment methods that claim to be providing

safe and sustainable technologies to protect water resources in a developing country like India.

CW-1 ready for media filling and plantation

The June 2013 flood in Uttarakhand underlines the need for flood-protection measures at RBF sites in India

Consequent to an extreme high-intensity rainfall event in Uttarakhand from 15 – 17 June 2013, an unprecedented flood event occurred in the rivers Mandakini, Alaknanda and their tributaries. The extremely high water level in the rivers submerged and damaged (washed-away, or deposition of bed load sediment) around 1091 abstraction structures and pump houses for drinking water production that lead to an interruption in the drinking water supply for at least 5 – 15 days. However, the long-term effects of the flood are far-ranging. Even those RBF sites that were built around 7 m above the highest-ever recorded flood level (prior to 2013) and thereby considered sufficiently safe, such as in Srinagar, were inundated by the Alaknanda River. In Srinagar, the flood of the Alaknanda River inundated the Saph Pani RBF case study site as well as most of the neighbouring area with flood water up to a depth of 6 – 7 m (Fig.1). After the energy of the flood subsided, the receding water deposited a 1.5 – 3 m thick fine sand layer over the area around all RBF wells shown in Fig. 1, on the approach road to the RBF site, the adjacent Srinagar-Rishikesh main road and houses (Fig. 2 & Fig. 3). In the immediate aftermath, most of the available mobile construction equipment was deployed to clear the widespread sediment deposition, especially on the main roads and in and around peoples' homes. As this task has priority in Srinagar, access to the RBF site is not possible before the debris is cleared from the roads up to the RBF wells. Although the RBF wells were constructed at an elevation to which no previous flood had reached, the June 2013 flood highlights the risk from the dynamic discharge of the monsoon and consequent floods to RBF sites. In this context one of the major problems is to safeguard RBF sites from extreme water levels and sediment deposition during floods and monsoon in India.

Fig. 1a/b: View of RBF site in Srinagar before and during the flood in June 2013 (HTWD 2011, UJS 2013)

Fig. 2: Production well DST (PW-DST) at Srinagar RBF site before flood in March 2013 (HTWD 2013)

Fig. 3: Sediment deposition at RBF site in Srinagar consequent to June 2013 flood (HTWD 2013)

Water quality sampling of existing and potential bank filtration sites across India

The HTWD and WP1 partners NIH, including its regional centres in Kakinada, Patna and Jammu, as well as IITR and UJS, conducted a sampling campaign of surface and groundwater in June – July 2013 from various potential, but also some existing urban bank filtration sites spread across the states of Gujarat, Andhra Pradesh, Jharkhand, Bihar, Uttar Pradesh, Delhi, Jammu and Kashmir and Uttarakhand including Saph Pani RBF case study sites (Fig. 1 & 2). The focus of the sampling was to determine concentrations of major ions, trace metals, dissolved organic carbon, organic micropollutants (analysed with support from the Institute for Water Chemistry, TU Dresden) and occasionally total coliforms and E.coli. Furthermore, information on the design of some sites and aquifer properties was collected. The sampling was conducted starting from Andhra Pradesh (South-East India) in mid-June and moving towards North India in an at-

tempt to follow the progress of the monsoon and thus to also determine the quality of the initial surface water run-off from the monsoon rains.

Fig. 1: Water sampling at RBF site by North Koel River in Daltonganj, Jharkhand

Fig. 2: Water sampling from Tawi River in Sitlee with the surface water abstraction point of the main drinking water treatment plant for Jammu City in the background

Stakeholder workshop on Musi River in Hyderabad

Scientists from the Saph Pani project participated in a one-day stakeholder workshop held at the Irrigation and Command Area Development Department, Jalasoudha Building, Erramanzil, Hyderabad, India, on August 14, 2013. Over 45 key stakeholders from the departments of irrigation, groundwater, animal husbandry, and watershed development, and Andhra Pradesh Pollution Control Board (APPCB), universities, research institutions and farmers discussed the water quality of the Musi River and its impact on the catchment areas. Of particular interest to the Saph Pani project was the stakeholder view on the establishment of a natural wastewater treatment system to treat the water that enters the irrigation systems in the peri-urban regions. Thus, the workshop was aimed at obtaining the views of various stakeholders on the future development trends for the peri-urban areas, and more specifically about the establishment of a natural wastewater treatment system for treating polluted river water before it is used for irrigation. The workshop was part of the WP6 (Integrated sustainability assessment) work package of the Saph Pani project, and was jointly organized by the Water and Land Management Training and Research Institute (WALAMTARI) and the International Water Management Institute (IWMI), a partner in the Saph Pani project.

Participants of the Stakeholder Workshop in Hyderabad

Stakeholder workshop on MAR in Chennai

A one day stakeholder workshop was held on 20th August 2013 at the Department of Geology, Anna University, Chennai. This workshop aimed at obtaining the views of various stakeholders on the application of the managed aquifer recharge (MAR) for augmenting water supply to the Chennai city and was a part of Saph Pani's WP6 (Integrated sustainability assessment).

About 35 participants comprising officials from various Government organizations including Tamil Nadu Water Supply and Drainage Board (TWAD), Public Works Department (PWD), Chennai Metropolitan Water Supply and Sewage Board (CMWSSB), Central Groundwater Board (CGWB), SMEs, NGOs and about 15 farmers from Arani-Korattalaiyar river basin attended this workshop. The participants very actively participated in the discus-

sions and gave their opinion on the applicability of MAR after the culmination of every session. The audience witnessed an energetic and active discussion between agriculturalists and the government authorities as the pros and cons of implementing the aforementioned practices were thoroughly and systematically debated. The workshop provided a platform to prompt the views of people from different organizations and its outcomes will be an important input to the integrated sustainability assessment.

Participants of the Stakeholder Workshop in Chennai

Sampling campaign at the Yamuna flood plain in Delhi

At the Yamuna flood plain in Delhi, close to the famous Akshardam Temple, another set of surface water samples from the Yamuna River and groundwater samples was taken in July 2013 by M. Gröschke. Heavy rainfall during June 2013 caused severe floods in North India and thus also at the field site in Delhi. Ankush Gupta and Laxmi Das joined to take water samples which were analysed for *E.coli* and total coliforms at IIT Roorkee. Within the study area the Yamuna River has been suffering from increasing degradation of water quality over the last decades. The adjacent flood plain aquifer is used for water production and threatened by various contaminants. The aim of this study is to investigate the fate and transport of nitrogen species during infiltration of surface water into the urban aquifer.

Inundated land at the flood plain in Delhi. (Background: Houses of the Commonwealth Games village, Foreground: water pipe connections) photo taken by M. Gröschke.

Maheshwaram percolation tank

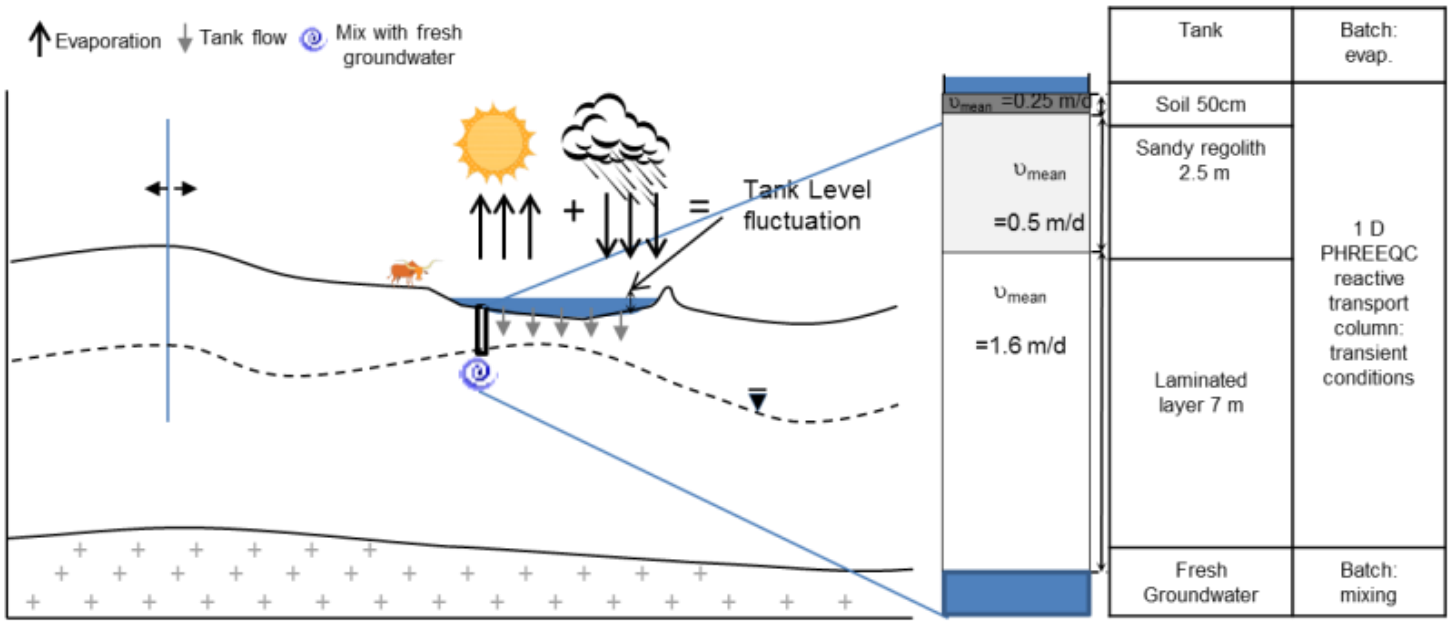
Managed aquifer recharge through percolation tanks is widely used in semi-arid regions of India. In Andhra Pradesh, the Central Ground Water Board estimates to 44'000 the number of these tanks. However despite the common view that MAR is suitable for water recharge, little scientific evidence exist on the efficiency of such structures. In Saph Pani we assess the efficiency of a percolation tank in hard rock aquifer in the Maheshwaram watershed. Using surface and groundwater water balances as well as geochemistry we demonstrate that in the case of average rainfall the increase of water resources remains low and that the tank's impact is limited to a couple of farmers in the surroundings. Further works are on-going to characterize the transport properties and its possible impact on water quality in a fluoride prone area.

The Maheshwaram percolation tank

Geochemical modeling of the Maheshwaram percolation tank

The aim of the geochemical modelling is to quantify the water-rock interactions processes during the recharge and the corresponding impact on water quality at the global scale of the watershed. This study is conducted in parallel with the hydrogeological modelling. Results of hydrogeological modelling, provide mass water budget (Boisson et al., 2013, Picot-Colbeaux et al., 2013) to evaluate the beneficial (or not…) effect of recharge onto soil salinization and fluoride accumulation in weathering zones overlying fractured crystalline basement, a setting widespread in India.. A numerical geochemical model of solute recycling (Pettenati et al., 2013) was adapted on the basis of new data in order to refine the conceptual geochemical model of Managed Aquifer Recharge (Figure).

First results show that tank infiltration effect is favorable to the decrease of aquifer fluoride concentration. But these results are obtained with an effective infiltration 435 times higher than the actual infiltration for the 2012 wet hydrological period.



Conceptual model of regolith-hard-rock aquifers in southern India with Managed Aquifer Recharge (MAR) through infiltration tanks and setup of 1D PHREEQC reactive column transport model. υ is the mean pore flow velocity.

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Dissemination activities

Saph Pani present at the International Symposium for Managed Aquifer Recharge (ISMAR)

The Event will take place in Bejing on October 15-19, 2013. Saph Pani results will be presented in six oral presentations.

Saph Pani at the Third Water Framework Directive International Conference

The topic of the conference is "Climate change impacts on water security and safety" and will be held von 4-6 of November 2013 in Lille, France.

www.WFDLille2013.eu

Two day training course on constructed wetlands for wastewater treatment and reuse

The training course will be held at the Indian Institute of Technology Bombay on 20-21 of November, 2013.

For registration please contact Prof. Shyam Asolekar: asolekar.wp3@fmail.com

Greetings from the Saph Pani Consortium

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