Guest Editorial

Natural Wetlands Treatment of Sewage Discharges from Phnom Penh, Cambodia: Successes and Future Challenges

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Access to clean drinking water and adequate sanitation are vital to protect human health but most countries in Southeast Asia cannot afford the centralized, secondary or tertiary wastewater treatment plant approach conventionally used in the West for sewage treatment. What are the alternatives? Constructed wetlands are regarded as a promising treatment option worldwide since they are easy to operate, cost-effective, and a technically feasible approach for treatment of stormwater runoff; municipal, industrial and agricultural wastewater; landfill leachate and faecal sludge. However, barriers remain to adopting innovative, sustainable approaches to wastewater management including lack of managerial capacity and availability of technical skills; ineffective transfer of knowledge from research institutions to decision-makers and practitioners; and a lack of success stories and guidance. Furthermore, technical advisors from donor countries frequently promote conventional treatment approaches practiced in their countries rather than adjusting to the realities and cultures of developing nations.

Although there is increasing research on optimizing designs and the benefits of constructed wetlands, there is little information on the efficiency of natural wetlands in treating wastewater discharges. Yet, many Southeast Asian countries have an abundance of naturally-occurring wetlands. To address some of these basic sanitation issues in Cambodia, the International Foundation for Science (IFS) and Swedish International Development cooperation Agency (SIDA) funded a team project, *The Role of Phnom Penh's Wetlands in Sustainably Treating Sewage Discharges to the Mekong/Bassac River System*. The overarching objective of this project was to determine the effectiveness of Phnom Penh, Cambodia's current wetland configuration in sustainably treating sewage discharge, with a specific focus on Boeng Cheung Ek, the 1300-2000 ha natural wetland to the south of the city. Boeng Cheung Ek also is a significant agriculture and aquaculture resource, home to a peri-urban community, and has a role in flood mitigation for Phnom Penh. Because Boeng Cheung Ek receives wastewater, the potential health risk to those living on the wetland and those consuming food stuffs from the wetland must be considered. In addressing the overarching research objective, five interconnected sub-projects were carried out and these are summarized in the first four papers of this special section. A separate project done collaboratively by the Chemistry Department at the Royal University of Phnom Penh (RUPP) and the World Wildlife Fund also is included because its theme and timeframe of study complement the IFS/SIDA work.

Following more than 25 years (~1970-1996) of political instability, civil war, and the tragic Khmer Rouge period, Cambodia's economy, education system (including universities), urban infrastructure, and government agency capacity were severely impaired. Cambodia ranked 137th amongst 182 countries based on the United Nations Human Development Index for 2007 (http://hdrstats.undp.org/en/countries/country_fact_sheets/cty_fs_KHM.html) and there remains a great need for technical capacity building both at the university level and within government line agencies. Against these challenges, however, the Cambodian economy grew steadily over the past decade (prior to the recent global downturn) with the textile and garment industry becoming the leading source of manufacturing jobs.

New construction—both within the main city of Phnom Penh and in the outer suburban areas and new satellite cities—has continued at an aggressive pace over the past 10 years. The current population of Phnom Penh is 1.4 million with projection that by 2020 the population of the city will be about two million. Phnom Penh is serviced by a combined sewer system consisting of underground pipes that discharge into several main open interceptor sewers. The interceptor sewers subsequently discharge into the natural treatment wetlands that ring the city. Major drainage improvement projects were funded by the Asian Development Bank, OPEC Fund, and Japan International Cooperation Agency (JICA) between 1998 and 2004 to clear and reconstruct the Trabek and Meanchey interceptor sewers and rehabilitate the pump stations. Over the past two years, underground stormwater holding tanks have been installed along the city's waterfront to reduce surface flooding in this downtown area.

The work outlined in the following five papers showed that Boeng Cheung Ek is effective in treating the waste discharge from central and south Phnom Penh and that levels of Zn, Cu and Cr in the vegetables and fish taken from the wetland generally do not pose a high health risk (with the exception of Cr for children eating fish at one sample site). Risk of Cr intake also is higher for children eating snails. Risk management related to certain aspects of food stuff consumption (e.g. education on proper cooking of fish to avoid liver fluke infection, filtering or boiling water, limiting children's consumption of snails) could be developed through a community outreach programme. Routine testing of the food stuffs (including pesticides, given the level of *p,p'*-DDT and *p,p'*-DDE in sediment) should be conducted to confirm results from this study and ensure future health safety. Boeng Cheung Ek receives stormwater discharge during rainfall events and, as such, helps to reduce flooding in Phnom Penh. Parts of Boeng Cheung Ek are being filled-in to provide land for new development in the city and in-filling of the natural treatment wetlands north of the city (e.g. Boeng Kak, Boeng Poung Peay) also has begun. The current plan for Boeng Kak shows a reduction in area from 90 ha to approximately 10 ha and there is ongoing debate regarding how this in-filling will affect local flooding and water quality.

As important as the research results in this study were, the outcomes of capacity-building also were impressive. A total of 12 undergraduates from RUPP, two undergraduates and two graduate students from Buffalo State, one undergraduate student from Eastern Mennonite University, one undergraduate from University at Buffalo, and an exchange student from Asian Institute of Technology (AIT) worked collaboratively as research assistants on this project. In addition, three Ph.D. students from Chiang Mai University, Thailand, travelled to Cambodia for the first time to conduct the parasite sub-study. This cross-cultural, multidisciplinary interaction truly was rewarding. Three undergraduate theses were completed at RUPP in relation to this study and three of the 12 RUPP students have now entered a Bridge Programme to prepare them for graduate school in the West. One of the RUPP students obtained a scholarship through the CALIBRE (Cambodia and Laos Initiative for Building Human Resources for the Environment – EU Asialink) programme to pursue a Masters degree at the University of Manchester. Two of the RUPP faculty are now pursuing Ph.Ds (one at the University of Warwick, UK and one at the University of Hawaii) and one is pursuing a second Masters degree at Okayama University, Japan. The project also has established ongoing relations between the universities involved.

The city of Phnom Penh is approaching a development cross-road. As it expands, it is reducing its capability of sustainably treating waste through its existing system of natural wetlands. This study represents a success story; it has shown that the natural wetlands can be effective in treating waste and RUPP and AIT now have the modelling capability to explore future directions to optimize the wetland treatment. But what is the future? Certainly, there is concern from downstream Vietnam regarding any reduction in Phnom Penh's wastewater treatment capacity. Can an optimized wetland continue to fully serve Phnom Penh's needs? How long can the natural wetlands receive wastewater from a fast growing city like Phnom Penh and continue to be effective in treatment? Can the use of natural wetlands, or constructed wetlands, be successfully replicated for other growing municipalities in Cambodia? At this stage in the development path it is unlikely that Cambodian communities can afford conventional wastewater treatment approaches used in the West and innovative use of multi-functions wetlands seems a viable alternative as an integral element of sustainable sanitation.