Abstract

Urban canals play a major socio-economic role in many tropical countries and, particularly, Thailand. One of the overlooked functions that they perform is a significant attenuation of waste-related pathogens posing considerable health risk, as well as nutrient pollution attenuation in general. The study dealt with a comparison of three canals receiving: (i) municipal (canal One), (ii) mainly industrial (canal Prem) and (iii) mainly agricultural (canal Four) wastewater, listed in order of progressively decreasing organic loading. The canals were situated in the Pathumthani province, Klong Luang district. The occurrence and fate of waterborne *Cryptosporidium parvum*, *Giardia lamblia* and *Escherichia coli* were monitored in the canals by both real-time PCR and conventionally for 12 months.

The geographic information system (GIS) was used to evaluate and map the point and, particularly, non-point pollution sources which allowed differentiating the canal sections in terms of predominant pathogen sources. The flowthrough canals, which can be viewed as self-purifying system, were found to be efficiently removing the pathogens at the following generalized specific rates: 0.3 (*C. parvum*), 1.2 (*G. lamblia*), 1.8 (*E. coli*) $\log_{10}$/km.d in the dry season. In the canals Four and Prem which were less organically loaded (compared to the canal One) the rates of removal decreased in the rainy season for all the pathogens and the organic pollution, while in the heavily loaded canal One, the removal rates decreased in the rainy season for *G. lamblia* and BOD_5 but increased for *C. parvum* and *E. coli* indicating different removal mechanisms. Data suggested that *E. coli* and *G. lamblia* were mainly removed through sedimentation and sunlight irradiation (UV), while the likely mechanism for *C. parvum* was predation by larger organisms. Overall, the specific pathogen removal rates positively correlated with the canal organic loading rates in the rainy season. A calculated extent of the municipal pollution mitigation by over 2,280 km canals in the Greater Bangkok suggested that concomitant to the pathogen removal, at least 36-95 tons of BOD_5 was removed daily, thereby saving the receiving Chao Phraya River and Bight of Bangkok from major eutrophication, by far exceeding current extent of pollution.

However the residual concentrations of the pathogens still remained a threat for the surrounding population. A Quantitative Microbial Risk Assessment (QMRA) involving *C.parvum*, *G.lamblia* and diarreogenic *E.coli* was performed using 10,000-trial Monte Carlo risk simulations to estimate the human health risks associated with the use of canal water (i) for recreational purposes, (ii) for unrestricted and (iii) restricted irrigation in Thailand.

Genotyping has been performed which revealed the predominant presence of the human infectious *C.hominis* and *Giardia* assemblages A and B. The highest individual health risk from a single exposure was found to be from *Giardia* (6×10^{-1}) and through swimming in the rainy season, particularly in the most polluted section downstream of a large wholesale market. The risks of diarrhoel disease from the protozoan parasites were up to 120-fold greater than the reported prevalence of diarrhea in the Klong Luang district and Thailand as a whole. The annual risk of *E.coli* and *Cryptosporidium* were at least 6,000-fold greater than the acceptable risk while the risk of *Giardia* was 10,000-fold higher in all the canals with a maximum in Canal One. The obtained results would be useful for the public health protection and establishing an integrated pathogens management in Thailand.

Key words: canal network*, Cryptosporidium parvum,* diarrhea, *Escherichia coli,* geographic information systems, *Giardia lamblia,* health risks, QMRA, removal mechanisms