Quantifying Diarrhoea Infection Risks

Quantitative microbial risk assessment (QMRA) was used to determine the risks of diarrhoea caused by human interactions with untreated wastewater and contaminated surface water in a peri-urban area of Thailand. Aleix Ferrer Duch, Hung Nguyen Viet, Antoine Morel, and Jakob Zinsstag

This study assesses diarrhoea infection risks by wastewater use in Klong Luang municipality, northern Bangkok, Thailand. Bangkok numbers 1165 man-made drainage and irrigation canals of 2280 km total length and 45.6 million m^3 total water volume [1]. Use of this water for agricultural and recreational purposes has a very long tradition in peri-urban areas such as Klong Luang; however, the suitability of such practices is increasingly questioned. Indeed, as a result of rapid urbanisation and industrialisation, the quality of the canal water has deteriorated considerably over the last decade, mainly due to the discharge of untreated domestic and industrial wastewaters (Photo 1).

QMRA, Real-Time PCR

The Quantitative Microbial Risk Assessment (QMRA) method was used to determine the risks caused by human exposure to protozoa [2]. The QMRA methodology follows a four-step approach as described in Table 1.

Diarrhoea infection caused by the two protozoa *Entamoeba histolytica* and *Giardia lamblia* have been identified as relevant hazards in the study area (step 1). Dose-response models for the two protozoa were based on international literature (step 2). Population exposure to the hazards (step 3) was characterised and quantified by a household survey (i. e. frequency and intensity of exposure, reuse practices, eating habits, personal hygiene, behaviours etc.). Wastewater samples were collected in sewers, wastewater treatment plants, canals, and irrigation water. Samples of vegetables traditionally eaten raw (i.e. morning glory (*Ipomoea aquatica*), Thai basil (*Ocimum basilicum*) and Tulsi (*Ocimum tenuiflorum*) were collected from agricultural fields. Protozoa concentrations, at the most relevant exposure points in the environmental sanitation system, were quantified using *Real Time PCR* (totally 54 samples). Integration of steps 1 to 3 enabled to characterise the risks of infection in the study area (step 4). The risk of diarrhoea was calculated using estimated probability density functions, randomly sampled by Monte Carlo simulation. Finally, the quantified risks were converted into DALYs (disability adjusted life years). DALYs represent the time lost through disability or death caused by a disease as compared to a life free of disability in the absence of the disease.

Morning glory, hand washing

The results obtained reveal high concentrations of *G. lamblia* and *E. histolytica* in canal water and on vegetables (morning glory, Thai basil and Tulsi). The highest infection risks (*G. lamblia* = 1.00 & *E. histolytica* = 0.48) and highest load of *G. lamblia* = 2631 and *E. histolytica* = 37431 cysts/100 g^{-1} on vegetables were caused by consumption of morning glory; a highly appreciated vegetable growing in the canal and partly eaten raw. Among the human behaviour studied, current hand washing practices also resulted in high infection risks (*E. histolytica* = 5.2 E^{-2}). Other exposure routes studied here, like fishing or collecting vegetable in the canal, resulted in comparatively low risks. Calculated health risks and reported occurrence of diarrhoeal diseases in the project area were extrapolated to DALYs. According to this estimate, diarrhoea infection caused a loss of almost 1.5 years of healthy life in Klong Luang municipality in 2005 (total population: 49296).

Photo 1: Sampling morning glory in the canal.

Main observations

The methodology applied allows to identify the main transmission routes of protozoa-related diseases in an environmental sanitation system and to quantify the infection probability for main exposure scenarios. An improved understanding of the interrelation between hazard, exposure to hazard and resulting health risks enables to quantify the impact of potential interventions on public health and to assess their suitability in reaching (locally defined) acceptable risks. In the context of Klong Luang, we are convinced that awareness-raising among the population is the intervention with the highest potential in reducing health risks caused by direct or indirect exposure to untreated wastewater.

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Steps	Description
Hazard identification	Describe acute and chronic human health effects associated with any particular hazard.
Dose-response analysis	Characterise the relationship between various doses administered and incidence of the health effect.
Exposure assessment	Determine size and nature of the population exposed and route, amount and duration of exposure.
Risk characterisation	Integrate the information from the different identification steps to assess the magnitude of the public health problem, variability and uncertainty.

Table 1. Procedural steps in QMRA [3].

[1] Diallo, M.B.C., et al., (2009): GIS-based analysis of the fate of waste-related pathogens Cryptosporidium parvum, Giardia lamblia and Escherichia coli in a tropical canal network. Journal of Water and Health 7(1): p. 133–143.

[2] Haas, C.N., Rose, J.B. and Gerba, C.P. (1999): Quantitative Microbial Risk Assessment. New York: John Wiley & Sons, INC. 449.

[3] World Health Organisation (2006): WHO guidelines for the safe use of wastewater, excreta and greywater. Volume 2: wastewater use in agriculture. Geneva, World Health Organisation. 191.