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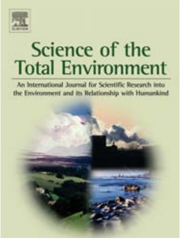

# Underground sources of nutrient contamination to surface waters in Bangkok, Thailand

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## ABSTRACT

Radon-222 is very concentrated in groundwater relative to surface waters and thus serves as an effective groundwater discharge tracer. We observed spikes in radon data from an earlier (2004) survey of the Chao Phraya River that appeared to correspond to locations where major canals ("klongs") enter the river. We returned in 2006 and conducted more detailed surveys along some of the main klongs on the western (Thonburi) side of the Chao Phraya to evaluate this possibility.

Our results show that both radon and conductivity are enriched in some areas of the klongs with 3 apparent "end-members," two of which are likely related to groundwater seepage. Furthermore, nutrient analyses conducted during a time-series experiment at a site of suspected high discharge (Wat Intharam, Klong Bangkok Yai) showed that dissolved inorganic nitrogen (DIN) and phosphate correlated significantly to the groundwater tracer, radon. Rough estimates of the nutrient fluxes in this area are orders of magnitude higher than those measured in coastal settings and may represent a significant fraction of the riverine flux. It thus appears very likely that seepage of shallow groundwater is an important pathway for nutrient contamination of the klongs, and thus to the river, and ultimately to the Gulf of Thailand.

## 1. Introduction

Urban centers in many parts of the world experienced significant declines of groundwater levels as a consequence of increased pumping to meet demands for water resources. In order to correct problems associated with the resulting land subsidence, many Asian megacities (including Bangkok) imposed regulations restricting groundwater withdrawals from urban areas (Phien-wej et al., 2006). This has resulted in a more recent rebound back towards "normal" groundwater levels. Such dramatic variations over relatively short time scales present new challenges. One of these issues concerns the effect on interactions between the subsurface environment and surrounding surface waters (Taniguchi et al., 2009-this issue).

In 1950, the world contained only one "megacity" (a city with more than 10 million people), New York City. However, the speed of urbanization has accelerated tremendously over the past several decades, especially in the developing world. There are now 17 megacities around the globe, 14 located in coastal areas, and 11 in Asia. The greater speed and numbers of the Asian urban transition impose a much greater sense of urgency to identify and address the problems the transition is bringing. While these problems include the many social, and

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economic concerns that result from urban overcrowding, we address here an overlooked environmental issue — subterranean urban pathways of contaminants to surface environments.

We are investigating how groundwater becomes an important vector for distributing contamination to surface environments. While groundwater has become an increasingly important aspect of human life, its role as part of the urban environment has not as yet been fully evaluated. This is especially true in Asian coastal cities where population numbers and density have expanded very rapidly and uses of the subsurface environment have increased correspondingly.

Perhaps the most dramatic and obvious subsurface environmental problem occurring in Asian coastal cities is the subsidence and related problems due to excessive pumping of groundwater. This has occurred repeatedly in major cities throughout Asia with a timing corresponding to the developmental stage of urbanization. Subsidence not only results in dangerous structural problems within cities but has also resulted in a serious danger of flooding in many low-lying coastal cities. Entire sections of Bangkok, for example, now flood during each spring tide. Government-mandated changes in reliable water resources from groundwater to surface water supplies have typically been initiated to address the subsidence problem. On the other hand, even when land subsidence has ceased due to regulation of groundwater pumping (e.g., Tokyo, Osaka), the associated more recent *increase* in groundwater level has caused other types of damage by flooding and exerting buoyant forces to underground infrastructures (e.g., subways) that were constructed during the drawdown period. This scenario has been repeated at different times in nearly every Asian megacity (Taniguchi et al., 2009-this issue).

Another important aspect of the subsurface environment, and the one specifically addressed here, concerns material (contaminant) transport to surface waters. Research over the last few years has shown that direct groundwater discharge to the coastal zone is a significant water and material pathway from land to sea (Moore, 1996, 1999; Taniguchi et al., 2002; Slomp and Van Cappellen, 2004; Burnett et al., 2003a, 2006). While coastal scientists now recognize that groundwater can often be a major contributor to coastal nutrient budgets, most studies to date have been performed in rural, in many cases, pristine environments. This is an understandable desire to deal with "natural" environmental systems. The few investigations that have examined urban groundwater–surface water interactions include: Charette and Buesseler (2004; urban area of Chesapeake

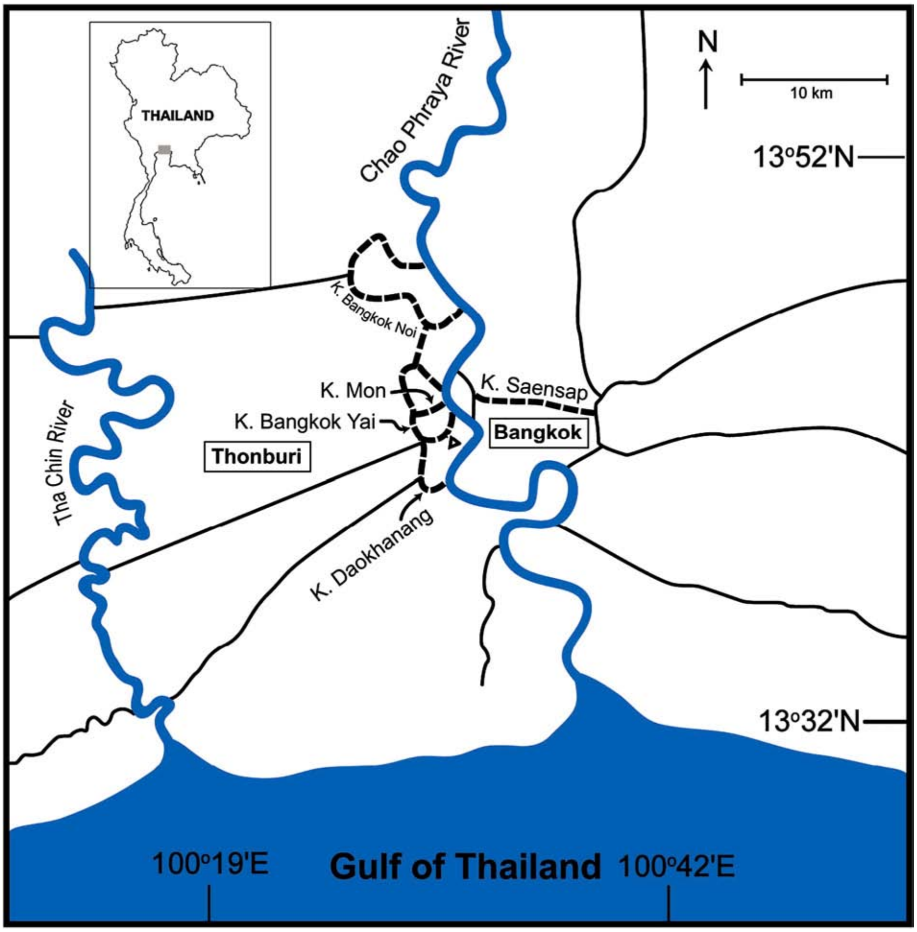

**Fig. 1 – Index map showing the Chao Phraya River and some of the major canals ("klongs") that are found in the Bangkok area. We present data here from the K. Bangkok Yai–K. Bangkok Noi loop on the Thonburi side of the river and from K. Saensap on the Bangkok side (shown as dashed lines). The triangle on K. Bangkok Yai marks the location of Wat Intharam.**