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Monitoring of endocrine disruptors in surface water of agro-ecosystems in the Mekong Delta, Vietnam

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Introduction

Endocrine Disruptors (EDs) are pollutant that may be hormonally active at low concentrations and are emerging as a major concern for water quality. Estrogenic EDs (e-EDs) are a subclass of EDs that can negatively affect humans and wildlife (Cambell et al., 2006). Young et al. (2002) proposed the Predicted No Effect Concentration (PNEC) of 1 ng/L for the case of 17β-estradiol (E2) to protect the aquatic animals. There is a variety of e-EDs, they can be either natural chemicals such as estrogens or industrial chemicals such as bisphenol A, nonylphenol, pesticides, etc (Cambell et al., 2006; Lavado et al., 2009). The sources of these chemicals to the environment may vary differently from point sources such as municipal and industrial effluent to non-point sources such as agricultural runoff (Campell et al., 2006). Due to different e-EDs possess different estrogenic potency in addition to the co-occurrence of these chemicals in the environment, the activity of these chemicals in an environmental sample is usually reported as total estrogenic activity, and usually relative to E2 equivalent (EEQ). Among a variety of e-EDs, estrogens are usually the major contributors to the total estrogenic activity in the environment (Snyder et al., 2001), and these compounds are mainly excreted by humans and livestock (Cambell et al., 2006).

The Mekong Delta in Vietnam, one of the most intensive agricultural areas in the world, has increasingly polluted its surface waters by agrochemicals (Dasgupta et al., 2007) and the direct discharges of human and livestock wastes into water bodies (Loan, 2010). The objective of this study was to monitor the concentration of estrogenic activity in surface waters of some agro-ecosystems including agricultural runoff, fishponds and irrigation canals in two representative areas in the Mekong Delta, Vietnam (Can Tho city and Dong Thap province).

Materials and Methods

Tam Nong district in Dong Thap Province (DTP) and Cai Rang district in Can Tho City (CTC) were selected as a representative for an agricultural and suburban area in the Mekong Delta, respectively (Fig. 1). Different surface water categories including irrigation canals, agricultural fields and fishponds in both areas were sampled. We monitored these surface water categories for about one year, from the end of 2008 to the end of 2009. Sampling was conducted every three weeks in Can Tho city and very six weeks in Dong Thap province.

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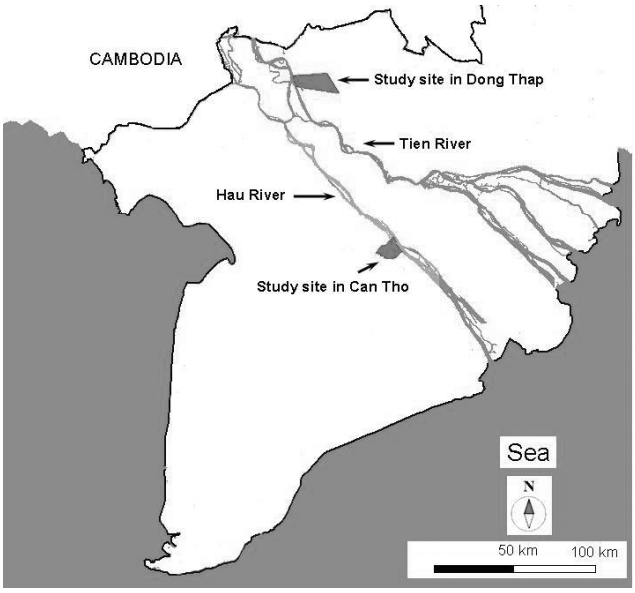

Figure 1: Locations of two representative sampling areas in the Mekong Delta in Vietnam

Water samples were collected as grab samples using 1-litre, pre-cleaned glass bottles with Teflon caps. Samples were taken during the day between 6 am and 8 pm. The samples were then kept on ice, protected from the light, and transported to the laboratory within a maximum 36 hours, where they were stored at 4^{o}C before extraction, which was normally performed within a week. The samples were finally analyzed by the Yeast Estrogen Screen (YES) assay. The analytical procedure was adopted from Roultedge and Sumpter (1996), and thoroughly described in Hong's dissertation (in preparation).

Results and Discussion

In Dong Thap province (DTP) estrogenic activity occurred in all the sampling events and ranged from under the detection limit (ND = 0.015 ng EEQ/L) to 2 ng EEQ/L (median 0.19 ng EEQ/L) for the irrigation canals; from 0.02 to 0.58 ng EEQ/L (median 0.16 ng EEQ/L) for the agricultural fields and from ND to 0.75 ng EEQ/L (median 0.14 ng EEQ/L) for the fishponds (Fig. 2). In general, estrogenic activity was observed higher in the irrigation canals and followed by the agricultural fields and the fishpond. Only a few samples from the irrigation canals exceeded the PNEC value of 1 ng EEQ/L. The higher estrogenic activity recorded in the irrigation canals, on the one hand, could be explained by the fact that in addition to local households are mainly located along the irrigation canals, domestic wastewater including human and animal wastes from these households are mainly and directly discharged into these irrigation canals without properly treatment in the Mekong Delta in Vietnam. On the other hand, more stable water in the agricultural fields and the fish ponds as compared to the canals could enhance the sedimentation of estrogenic activity in these two categories. In Can Tho city (CTC) estrogenic activity occurred in all the sampling events. Except in the canals (range: ND to 2.99 ng EEQ/L; median: 0.26 ng EEQ/L), the estrogenic activity in the agricultural fields (range: ND to 3.6 ng EEQ/L; median: 0.3 ng EEQ/L) and the fishponds (range: 0.05 to 2.66 ng EEQ/L; median: 0.69 ng EEQ/L; Fig. 3) in CTC were significantly higher than those in their respective sampling categories in the more rural DTP, an upstream area of CTC. In total, about 17% of the samples from CTC had a higher estrogenic activity than the PNEC value, and these samples were observed in all the sampling categories indicating estrogenic risk for local aquatic fauna. This could be explained by the higher population density of CTC, the most urbanized and industrialized city in the region. Therefore, households in CTC are not only located along the canals, but also directly on the fields

or adjacent to the fishponds. As a consequence, wastewaters from these households are mainly discharged into the canals, the fields or the fishponds without properly treatment.

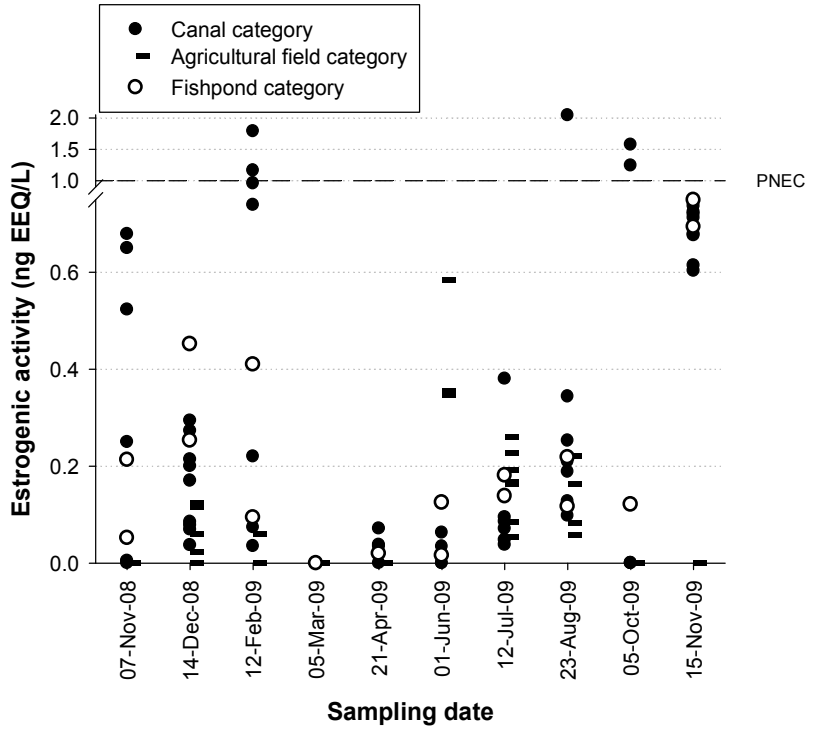

Figure 2: Estrogenic activity in different sampling categories in Dong Thap province

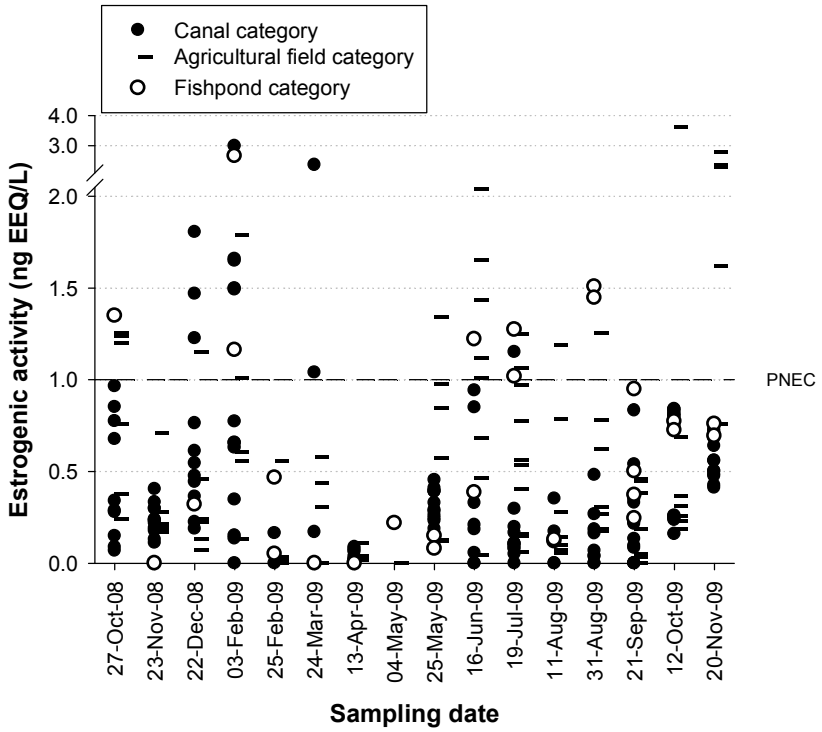

Figure 3: Estrogenic activity in different sampling categories in Dong Thap province

The estrogenic activity in this study are in line with studies from other countries such as ND to 8.64 ng EEQ/L in Taiwan, 2.2 to 12.1 ng EEQ/L in China, ND to 7.4 ng EEQ/L in Korea, 0.3 to

4.5 ng EEQ/L in France (Shue et al., 2010), 0.7 to 4.0 ng EEQ/L in Japan (Hashimoto et al., 2005). A comparison of estrogenic activity is limited because the concentration depends on the water discharge in the rivers. The sites in this study were hydrologically connected to the Mekong River that has a rather high discharge (average discharge of about 14000 m^3/s; Cenci and Martin, 2004).

Conclusions and Outlook

The estrogenic activity in the agro-ecosystems of CTC is significantly higher than that in DTP. In many cases the concentration in CTC exceeded the PNEC value of 1 ng/L, indicating an estrogenically potential risk to the local aquatic fauna. The direct discharge of domestic wastewater including human and animal wastes are the source of estrogenic activity in these areas. If the human and animal wastes are collected, treated and used as organic fertilizers, then the estrogenic activity in surface water could be reduced. However, this will require a change in the local waste management system.

This topic certainly deserves further studies to further identify the sources, to elucidate the composition of total estrogenic activity, and to understand the risk of these chemicals to local aquatic fauna and people.

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