Title of research project: Comprehensive monitoring of pharmaceuticals and personal care products (PPCPs) and artificial sweeteners in surface water and fish in northern Vietnam: Contamination status, bioaccumulation potentials, and risk assessment

Project members:

1. Dr. Hoang Quoc Anh, University of Science, Vietnam National University, Hanoi, Vietnam.
2. Assoc. Prof. Rumi Tanoue, Ehime University, Japan.
3. Prof. Tatsuya Kunisue, Ehime University, Japan.

Purposes:

Information about contamination status, sources and fate, and potential adverse effects of PPCPs in aquatic environments of emerging and developing countries like Vietnam is relatively limited. Comprehensive and updated investigations on concentrations and profiles of multiple PPCPs in surface water and aquatic biota are needed in this country to characterize current contamination status, potential sources, and risks. The aims of this research include: (1) conducting field survey and collection of surface water and plasma fish samples from urban areas of Hanoi Capital City, northern Vietnam; (2) validation and application of analytical methods for simultaneous determination of pharmaceuticals, personal care products, bisphenols, and artificial sweeteners in water and fish plasma samples by using liquid chromatography tandem mass spectrometry (LC-MS/MS) method; (3) evaluation and providing updated information on contamination levels, spatiotemporal trends, water and biota profiles, bioaccumulation potentials, and emission sources of PPCPs in urban surface water of Hanoi; and (4) assessment of potential risks of PPCPs for fish, aquatic ecosystem, human health, and antibiotic resistance development by using concentrations measured in water and fish plasma samples.

Methods:

The target compounds include 70 pharmaceuticals, 10 personal care products, 5 bisphenols, and 3 artificial sweeteners. The surface water and fish plasma samples were collected from several locations in Hanoi urban areas (e.g., Nhue River, To Lich River, and Yen So WWTP) and one wastewater discharge point in in 2019 and stored in CMES. The liquid samples will be processed by using solid phase extraction (SPE) to extract target compounds and to eliminate interferences. The clean extracts will be analyzed by using a LC-MS/MS system operating in the electrospray ionization (ESI) positive and negative modes with multiple reaction monitoring (MRM). Concentrations of target compounds were calculated by internal standard method. Analytical results of PPCPs in water and fish plasma samples will be further evaluated to understand contamination degree, accumulation profiles, distribution trends, and potential emission sources by using statistical methods. Accumulation characteristics of PPCPs in biota were evaluated by estimation of bioaccumulation factors (BAF) and predicted bioconcentration factors (BCF). Risk quotients of PPCPs were estimated based on the comparison between measured levels and reference values.

Results:

Water samples. A total of 63 substances was detected at least once in the water samples of this study, including 48 pharmaceuticals, 8 personal care products, 4 bisphenols, and 3 artificial sweeteners. Concentrations of total pollutants ranged from 4200 to 63,700 (median 27,700) ng/L. Concentrations (median and range) of pollutant groups decreased in the order of artificial sweeteners (19,200; 1800–33,000 ng/L), pharmaceuticals (5300; 1600–12,900 ng/L), personal care products (780; 12–2200 ng/L), and bisphenols (660; 290–53,700 ng/L) (Fig. 1). A significant decrease in pollutant concentrations was found in influent, effluent, and downstream water samples from the Yen So wastewater treatment plant (WWTP), indicating pollutant removal efficiency of the WWTP. An increasing trend of pollutant concentrations from upstream to downstream of Nhue River was observed. The highest level of pollutants (63,700 ng/L) was measured in a wastewater sample collected from Bui Dau plastic recycling area, which was mainly contributed by bisphenols (53,700 ng/L).

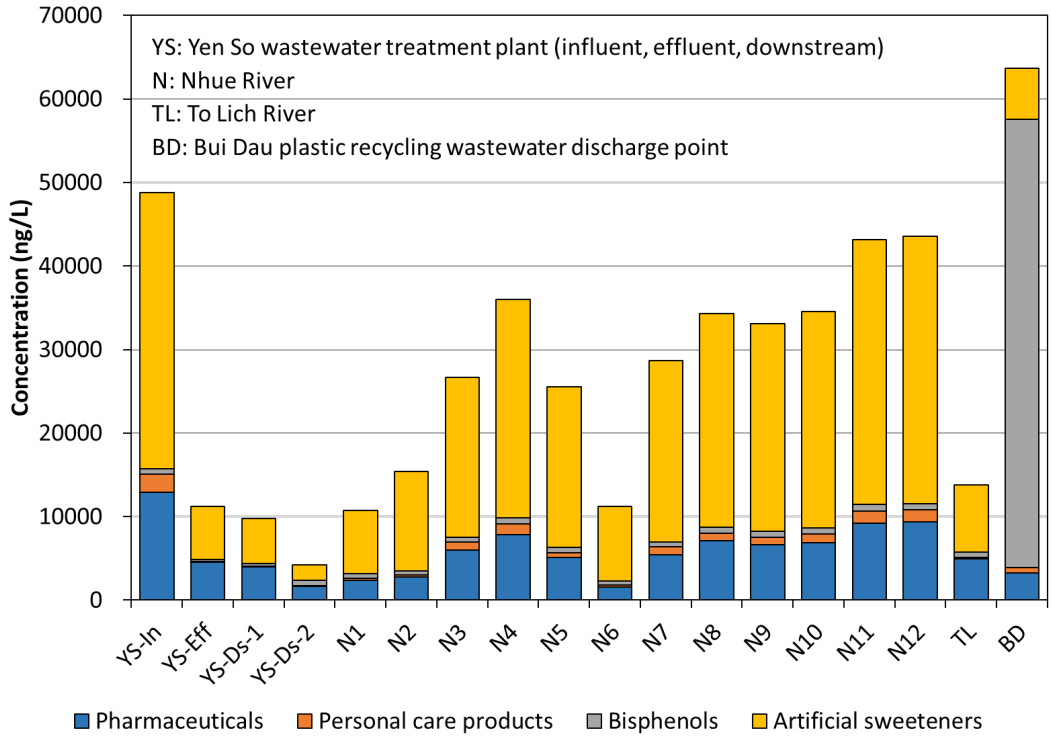

Fig. 1. Concentrations of pharmaceuticals, personal care products, bisphenols, and artificial sweeteners in surface water samples from Hanoi and Bui Dau, northern Vietnam.

There were 28 substances detected in all the samples, including 23 pharmaceuticals (i.e., diclofenac, mefenamic acid, ibuprofen, fenofibric acid, gemfibrozil, losartan, telmisartan, irbesartan, valsartan, rebamipide, sulpiride, metformin, diphenhydramine, certirizine, fexofenadine, tramadol, carbamazepine, sulfamethoxazole, trimethoprim, lincomycin, clarithromycin, florfenicol, and fluconazole), bisphenol A, and 3 artificial sweeteners (i.e., acesulfame, saccharin, and sucralose). The most predominant compounds were acesulfame (median 11,300 ng/L), saccharin (4800 ng/L), sucralose (3400 ng/L), metformin (1800 ng/L), sulfamethoxazole (650 ng/L), fexofenadine (590 ng/L), lincomycin (520 ng/L), bisphenol A (420 ng/L), and *N*,*N*-diethyl-*m*-toluamide (350 ng/L).

Fish plasma samples. A total of 16 substances was detected at least once in the fish plasma samples of this study, including 13 pharmaceuticals (i.e., diclofenac, telmisartan, irbesartan, sulpiride, diphenhydramine, chlorpheniramine, cetirizine, tramadol, quetiapine, carbamazepine, phenytoin, sulfamethazine, and sulfamethoxazole), 1 personal care product (benzophenone-1), and 2 bisphenols (bisphenol A and tetrabromobisphenol A). Concentrations of total pollutants ranged from 0.61 to 380 (median 3.2) ng/mL (Fig. 2). The most frequently detected compounds were carbamazepine (8/8 samples), chlorpheniramine (6/8), cetirizine (6/8), and telmisartan (5/8). Some compounds were only detected in fish plasma samples from Bui Dau plastic recycling area, including phenytoin, benzophenol-1, bisphenol A, and tetrabromobisphenol A. Bisphenol A was the most predominant compound measured in the Nile tilapia plasma samples from Bui Dau, with concentrations ranging from 37 to 380 ng/mL. Significant BAF values were estimated for telmisartan, chlorpheniramine, carbamazepine, and tetrabromobisphenol A.

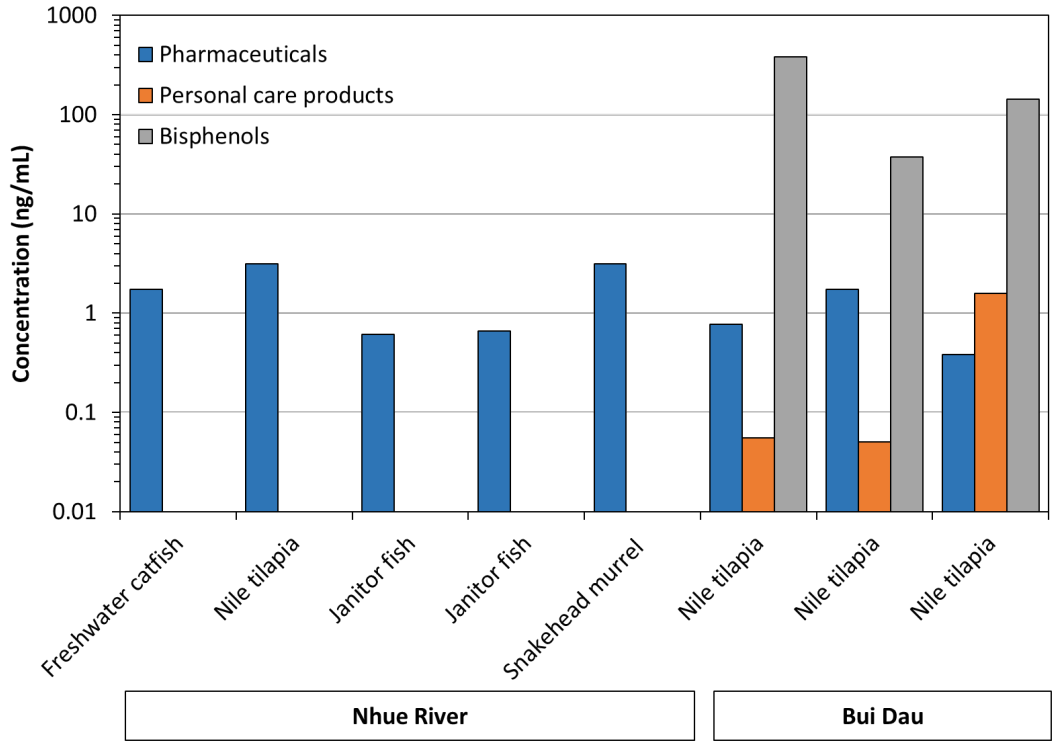

Fig. 2. Concentrations of pharmaceuticals, personal care products, and bisphenols in fish plasma samples from Hanoi and Bui Dau, northern Vietnam.

Conclusion:

This study provides a comprehensive picture of the occurrence and bioaccumulation of pharmaceuticals, personal care products, bisphenols, and artificial sweeteners in surface water and fish plasma samples collected from Hanoi and Bui Dau, northern Vietnam. Concentrations of pharmaceuticals and artificial sweeteners were generally higher in the urban water samples, while bisphenols were more abundant in the wastewater sample from plastic recycling area. Numbers of pollutants detected in fish plasma samples were markedly lower than those found in water samples, implying effects of metabolism in fish. Considerable ecological risks were estimated for several compounds, such as ibuprofen, sulfamethoxazole, clarithromycin, triclosan, and bisphenol S.

Future challenges:

Further studies are needed to characterize the contamination status, emission sources, environmental behaviors, and ecological risks of organic micro-pollutants in water environment from urbanized and industrialized areas in developing and emerging countries like Vietnam. Besides target analysis, screening and non-target analysis should also be applied.

Publication:

Anh Quoc Hoang, Rumi Tanoue, Tatsuya Kunisue, et al. Comprehensive monitoring of pharmaceuticals and personal care products (PPCPs) and artificial sweeteners in surface water and fish in northern Vietnam: Contamination status, bioaccumulation potentials, and risk assessment. Manuscript in preparation.