

Title of dissertation			
HUMAN EXPOSURE AND ENVIRONMENTAL FATE OF ENDOCRINE DISRUPTING CHEMICALS (EDCS) IN KLANG VALLEY, MALAYSIA			
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Endocrine disrupting chemicals (EDCs) are ubiquitous in the environment, causing concern for wildlife and human health. Due to this information gap, current risk assessments for EDCs such as per- and polyfluoroalkyl substances (PFAS), bisphenol, and paraben has underestimate indoor exposure pathways such as household dust, foodstuff and alternative sources of drinking water. This thesis is divided into 7 chapters with each of the chapters covers various part as followed: Chapter 1 briefly explained about the background and purpose of this research. The objectives, together with the scope of the studies were also covered in detail in this section.

Chapter 2 mainly focused on the collection of literature on the topics relevant to the research that is being conducted. It starts with the introduction about Endocrine disrupting chemical (EDCs) followed by details on specific EDC such as Paraben, bisphenol and perfluoroalkyl substances (PFAS) related to environmental and human health.

Chapter 3 investigated multiclass of EDC such as nine perfluoroalkyl and polyfluoroalkyl substances (PFAS), five bisphenols, and four parabens in tap water samples from Malaysia's Klang Valley region. All samples were analyzed by liquid chromatography mass tandem spectrometry (LC-MS/MS) with limit of quantitation (LOQ) ranged between 0.5 ng/mL – 5 ng/mL. Fifteen of the 18 EDCs were tested positive in tap water samples, with total EDC concentrations ranging from 0.28 to 5516.57 ng/L for all 61 sampling points locations. In specific area total EDCs ranged from 5.29-5516.57 ng/L (Hulu Langat), 21.99-93.22 ng/L (Petaling), 29.49-123.18 ng/L (Putrajaya), 14.18-312.48 ng/L (Sepang), 12.99-65.92 ng/L (Kuala Lumpur), 7.74-13.36 ng/L (Seremban) and 8.28-8.84 ng/L (Gombak/Klang). PFAS (total: 1.82-194.47 ng/L) and paraben (total: 0.28-15.36 ng/L) were the most found EDCs component in all tap water samples, indicating human exposure to these compounds although their concentrations were lower than bisphenol (total: 1.50–5430.25 ng/L). Meanwhile ethyl paraben (EtP) was detected in 90.16 % of regions despite its low total concentration and mean distribution with the highest detection rate of all EDCs tested. Perfluoro-n-butanoic acid (PFBA), perfluoro-n-hexanoic acid (PFHXA), perfluoro-n-octanoic acid (PFOA), and perfluoro-n-nonanoic acid (PFNA) were detected in more than 70% of the regions while perfluoro-1-octanesulfonate (PFOS) was detected at frequency of 62.3%. Other compounds were detected <40%. The spatial distribution and mean concentrations of EDCs in the Klang Valley regions demonstrated that the higher BPA levels were found in Hulu Langat, Petaling Jaya, and Putrajaya. Meanwhile, Kuala Lumpur and Sepang had the highest mean concentrations of PFBA. The estimated daily intake (EDI) and risk quotient (RQ<1) of all EDCs in this study were within the acceptable limit of the Malaysia Drinking Water Quality Standard and other international standards. The presence of EDCs in tap water is undeniably a growing concern, as health consequences may result from exposure to EDCs

even at low concentrations, implying the need for a standardized approach to assess human populations for EDC exposure and direct health effects.

Chapter 4 assesses the health risks associated with exposure to endocrine disrupting compounds (EDCs) in household dust collected from Klang Valley residences. A total of 57 dust samples representing indoor air were collected. Growing industrialization and urbanization in Malaysia have resulted in increasing air pollution. Indoor air pollution may be worse than outdoor air pollution due to the limited and confined area where dermal contact and ingestion are common exposure pathways. During the COVID-19 pandemic in 2020-2021, many Malaysians were confined to their homes. Prior to analysis, samples were filtered and extracted with methanol. Eighteen (18) EDCs were identified in dust samples using liquid chromatography mass tandem spectrometry (LCMS/MS). These included nine per- and polyfluoroalkyl substances (PFAS), five bisphenol, and four parabens. The analytical method was validated using QC samples to ensure adequate recovery and detection/quantification limits (LOD/LOQ). PFOA, PFOS, BuP, MeP, EtP, and PrP were found in 50-100% of indoor dust samples, indicating that these compounds are common in indoor dust. Other EDCs detected included BPB, BPF, BPAF, BPA, BPS, PFHxA, PFNA, and PFDA, albeit at lower detection frequencies (10- 49%). MeP is the most prevalent in collected indoor dust samples, accounting for 54% of the concentration distribution, followed by BuP and PFOA. Urban areas like Putrajaya, Kuala Lumpur, and Petaling had higher PFAS and paraben levels. There may be regional differences in EDC profiles, but more study with larger sample sizes is needed to confirm this speculation. The estimated daily intake (EDI) of EDCs from indoor dust ingestion for infants, toddlers, children, teenagers, and adults demonstrated that infants had a significantly higher ($p < 0.01$) EDI of EDCs than children and adults. Even though the EDI of certain EDI here is much lower than some regulations, the adverse health effects of exposure to EDCs present in dust cannot be ignored, particularly for infants.

Chapter 5 present the concentration and estimation of dietary exposure of endocrine disrupting chemicals (EDCs) such as per- and polyfluoroalkyl substances (PFAS), bisphenol, and paraben which commonly used in food packaging or as preservatives. This chapter also assess the human health risk of EDC residues which has been linked to cancer based on age group and gender. Malaysia has a scarcity of food EDC data. Thus, we used liquid chromatography mass tandem spectrometry (LCMS/MS) to analyze 18 EDCs from nine different food categories. Bisphenol was the most abundant EDC, followed by PFAS and paraben. Bisphenol levels in canned foods, dairy products, canned drinks, fruits, and vegetables ranged from 1.16 to 183.21 ng/g. PFAS was found in almost every food category, with canned foods having the highest concentrations (0.18 – 34.53 ng/g). PFAS were also found in dairy products, fruits, fish, seafood, and eggs. Only canned foods, fruits, and vegetables contained paraben, with mean concentrations ranging from 0.27 to 26.65 ng/g. The estimated dietary intake (EDI) of EDC demonstrated that adults ingested more EDCs than children. PFAS, bisphenol A, methylparaben, and ethyl paraben all had a hazard quotient (HQ) < 1 indicating that they were safe to consume. Future research into dietary exposure to other foods, as well as potential health consequences, is suggested, with a focus on vulnerable populations such as infants and children.

Chapter 6 explain the characteristic pathway of PFAS, bisphenol, and paraben exposure to 57 Malaysian adults' human serum concentrations via drinking tap water, household dust, and foodstuffs. The concentrations in these matrices were used to calculate the daily intakes of each EDC. Individuals taking part in the study will also be characterized based on the results of the questionnaire. PFAS was found predominant in serum where distribution of PFOS and PFOA were 66% and 12%, respectively from the total concentrations of PFAS in serum. Bisphenol and paraben, on the other hand, were negligible due to unquantifiable serum concentrations. Males were found to be more exposed to PFAS contamination than females. Other variables like BMI and age were not statistically correlated. There is also no statistically direct correlation between individual serum concentration with all the pathway. However based on age group data the EDI for PFAS contaminants in drinking water ranged from 4.85 ng/kg bw/day to 15.14 ng/kg bw/day for the four age groups of infant,

child, adolescent, and adult, with PFOA and PFBA being the most frequently detected PFAS contaminants. In this study, we calculated daily PFAS intakes from foodstuffs with the highest concentrations, which were collected and analyzed from the Malaysian market. The EDI of PFAS ranged from 0.89 ng/kg bw/day to 15.83 ng/kg bw/day for the four age groups, with the EDI of PFAS in foods increasing with age. The daily intakes of emerging contaminants from dust are far lower than those from drinking water and food consumption. For infants, children, teenagers, and adults, the EDI of PFAS was 0.89, 0.45, 0.26, and 0.10, ng/kg bw/day, respectively. The estimated daily PFAS intakes in this study were lower than the health-based guidance values. This study emphasizes the significance of conducting studies that consider multiple exposure pathways on an individual basis.

Chapter 7 brings together the conclusion from each the preceding chapters and suggestion of promising area for future research.

Photos



Degree conferral from academic advisor

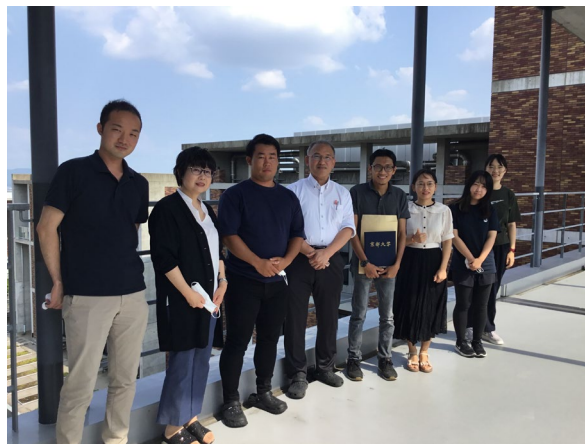


Photo with lab mates on degree day