DIVISION OF ENVIRONMENTAL CHEMISTRY

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WEDNESDAY AFTERNOON

Emerging Contaminants, Pharmaceuticals and Personal Care Products, and Organohalogens in Wastewater and Municipal Biosolids

A. Sapkota, *Organizer*
R. U. Halden, *Organizer, Presiding*

1:30 —91. Wastewater treatment plants as chemical observatories of persistent and potentially problematic contaminants in the environment. **R. U. Halden**

1:55 —92. Removal of polar pharmaceuticals from wastewater by activated sludge systems, membrane bioreactor, and by granular activated carbon. **D. S. Aga**, M. D. Celiz, S. Y. Baik

2:20 —93. Persistent organic pollutants in Australian biosolids. **B. O. Clarke**, N. Porter, J. Blackbeard, R. Symons, P. Marriot

2:45 —94. Removal of two antibacterial compounds (triclocarban and triclosan) in a wastewater treatment plant. A. Torrents, **N. Lozano**, C. P. Rice, M. Ramirez

3:10 — Intermission.

3:25 —95. Environmental risk assessment of endogenously-produced and exogenously-consumed pharmaceutically active compounds: A Canadian perspective. **U. Khan**, J. Nicell

3:50 —96. Environmental fate and hazards of the pharmaceutical diclofenac. **L. Kronberg**, J. Svanfelt, J -M. Kallio

4:15 —97. Issues, implications, and possible remedies regarding pharmaceutical contaminants in Maryland's environment. **E. W. Berg**

4:40 —98. PBDEs: Persistence in agricultural soils after biosolids application. **N. A. Andrade**, L. L. McConnell, A. Torrents, M. Ramirez

ABSTRACTS

ENVR 91

Wastewater treatment plants as chemical observatories of persistent and potentially problematic contaminants in the environment

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Municipal wastewater treatment plants play a key role in protecting ecosystems and human health. This project explored their potential role as observatories for judging the sustainability of chemicals used by modern society, and for the biodegradability of anthropogenic compounds in engineered and natural systems. Harmful chemicals that travel through the treatment process without undergoing any appreciable degradation are deemed to be of particular concern. They may be discharged into surface waters during reclamation of treated effluent or find their way into terrestrial environments via applications of biosolids. The latter are the semi-solid by-product of wastewater treatment that is routinely applied on land for inexpensive disposal of these abundant materials and as a source of nutrients. Wastewater-borne chemicals of concern include traditional environmental pollutants, such as toxic organohalogens (polychlorinated biphenyls, brominated flame retardants, etc.) as well as the so-called "emerging contaminants." This latter group of compounds includes a large number of pharmaceuticals and personal care products (PPCPs), whose adverse impacts on human and ecosystem health are slowly being recognized. A review will be provided of recent data on the occurrence, removal, biodegradability, persistence, and mass flux of organohalogens and emerging contaminants through wastewater treatment plants. Case studies show that mass balances on chemicals during municipal sewage treatment may serve as a powerful tool for identifying unsustainable chemistry and for studying chemical consumption and disposal patterns. Effective utilization of this information by regulatory agencies can aid in curtailing environmental pollution, thereby limiting adverse ecological and human health effects.

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Removal of polar pharmaceuticals from wastewater by activated sludge systems, membrane bioreactor, and by granular activated carbon

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In this study, conventional activated sludge (CAS) and membrane bioreactor (MBR) treatment systems are compared in eliminating pharmaceuticals in wastewater. The pharmaceuticals investigated include aceclofenac, carbamazepine, diclofenac, enalapril, and trimethoprim. In the influent, the concentration of these compounds ranges from 85 to 1373 ng/L. Diclofenac shows resistance to degradation in the CAS but is amenable to degradation in the MBR. Trimethoprim and enalapril are only slightly eliminated in the CAS but are reduced by more than 95% in the MBR. Carbamazepine removal is negligible, while aceclofenac is only 50% reduced in CAS and MBR. Due to the persistence of carbamazepine in biological treatment systems, the use of granular activated carbon (GAC) in removing carbamazepine and other polar pharmaceuticals from wastewater was examined. It was found that significant removal of biodegradation-resistant pharmaceuticals are achieved by GAC, with observed removal efficiencies of 75% for carbamazepine and 83% for trimethoprim.

ENVR 93

Persistent organic pollutants in Australian biosolids

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The concentrations and trends of some persistent organic pollutants (POPs) in Australian biosolids is presented. The POPs investigated were dioxin-like compounds, polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyls (PBBs), organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs) and phthalate esters. The concentration of these compounds was determined in a number of Australian biosolids surveys, with samples collected from all states of Australia and from urban (pop. >1,000,000) and rural (pop. <300,000) locations. In a survey of Australian biosolids (n=13) conducted in 2006 the concentration of dioxin-like compounds ranged between 1.2 and 15.3 TEQ-WHO05 ng kg^{-1} dw and the concentration of PBDEs ranged between 5 and 4230 µg kg^{-1} dw. Three OCPs were regularly detected in Australian biosolids between 2004 and 2006 and they were dieldrin, chlordane and DDE (a metabolite of DDT) detected in 68%, 27% and 13% of samples (n=829). The concentration of the other OCPs and PCBs was frequently below the detection limit (<0.01 mg kg^{-1} dw) and, when detected, was low.

ENVR 94

Removal of two antibacterial compounds (triclocarban and triclosan) in a wastewater treatment plant

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This study investigates the fate of triclocarban (TCC) and triclosan (TCS) in a wastewater treatment plant (WWTP). Our goal was to identify the most effective removal step and to determine the amount of the solid-phase versus degraded. Our influent contained higher TCS than TCC concentrations (8.06 and 4.65 µg/L respectively) and 82.4% of TCS and 89.9% of TCC on the suspended solids. Primary treatment was most effective in removing the TCS and TCC as suspended soils. TCS concentrations in the primary and secondary sludge were 23.7 and 16.0 mg/Kg dw and for TCC were 14.4 and 9.96 mg/Kg dw, respectively. The most effective steps for reducing dissolved TCC and TCS were activated sludge and nitrification-denitrification processes. Concentrations in the final effluent were 173.8 ng\L for TCS and 129.6 ng\L for TCC. Our data suggest that despite the fact that most TCC and TCS are eliminated from the liquid phase, they are still present at high concentrations in the biosolids.

ENVR 95

Environmental risk assessment of endogenously-produced and exogenously-consumed pharmaceutically active compounds: A Canadian perspective

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One of the fastest emerging concerns in the wastewater treatment industry is the presence of pharmaceutically active compounds (PhACs). Even though typical monitoring studies report their occurrence in the nanogram to microgram per litre range, their mere presence is a cause for concern. The environmental/toxicological threat such presence may possess may be ascertained by conducting an environmental risk assessment (ERA). The study presents ERAs for five endogenously-produced and 307 exogenously-consumed PhACs based on Canadian consumption figures, existing environmental data, population demographics and excretion patterns. ERAs of the selected compounds were performed according to the European Agency for the Evaluation of Medicinal Products guidelines. The results of the ERAs will be the main

focus of the presentation. In particular, those PhACs whose environmental presence is likely to be an environmental risk will be identified. Furthermore, the contribution of hospital effluents to the net environmental load of such contaminants will also be discussed.

ENVR 96

Environmental fate and hazards of the pharmaceutical diclofenac

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The anti-inflammatory drug diclofenac (DCF) is among the most widely used pharmaceuticals worldwide. It is not fully eliminated during the wastewater treatment processes and consequently enters the recipient waters through discharges from sewage treatment plants. Although detected at low concentrations (from ng to µg l^{-1}), the biologically active pharmaceutical may pose a risk to aquatic ecosystems, mainly due to its continuous discharge from the sewage treatments plants. Further, it is known that DCF is not stable in the aquatic environment and phototransformation is one of the major reactions the compound undergoes. The objectives of our work were 1) to study the up-take and biotransformation of DCF in fish and 2) to determine the phototransformation products and their formation pathways. The aims were achieved by exposure of rainbow trout to DCF in aquariums and by the synthesis of major phototransformation products (14 compounds).

ENVR 97

Issues, implications, and possible remedies regarding pharmaceutical contaminants in Maryland's environment

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Pharmaceutical contaminants exist in the environment at the sub-ppb to several ppm levels in water, sediment, and soil most notably where livestock and human waste effluent is present. The emergence of sensitive, accurate analytical techniques by the mid-1990s has enabled the detection of the widespread but more frequently localized presence of pharmaceutical drug pollution in water, soil, and sediment. A potential source for pharmaceutical contamination issues in Maryland are the watershed regions adjacent to concentrated animal feeding operation (CAFO) chicken farms (>2,500 heads), along certain parts of the Eastern Shore. CAFO chicken farms may be able to reduce their pharmaceutical drug footprint by not over-applying manure to fields. The enhanced nutrient removal (ENR) systems being installed to numerous wastewater

treatment plants will likely enhance pharmaceutical contaminant removal from water effluent. Policies affecting disposal mechanisms of certain unused medications may further reduce the risk potential of pharmaceutical contaminants from wastewater plants.

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PBDEs: Persistence in agricultural soils after biosolids application

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In the U.S., biosolids are often used as soil amendments; while this practice is considered a sustainable use of waste, there are concerns with respect to the fate of POPs present in biosolids. Soil samples from commercial farms were collected and analyzed. The hypothesis tested and confirmed in this study is that PBDEs are persistent in soils and concentrations increase after multiple applications. Concentrations observed in soil samples ranged from below quantitation limit to 386 µg/kg d.w. The dominant congeners found in agricultural soils were BDE-47, BDE-99, and BDE-209, at ratios similar to those found in biosolids. This analysis focuses mainly on congener distribution observed in soil. Some parameters that influence concentration - proximity to fields that receive application, required buffer zones, application rate, and soil carbon content were also analyzed. A basic analysis of the data also provides an estimation of half life of these chemicals in agricultural soils.