



# Program INEF 2019

International Network of Environmental Forensics

EAST-WEST Center, Honolulu, HI, USA

June 10-12, 2019

[www.rsc.org/inef](http://www.rsc.org/inef)



# INEF 2019

Welcome to the International Network of Environmental Forensics (INEF) 2019 conference. INEF was founded in 2008 for the purpose of providing a forum for scientists, environmental consultants, regulators and attorneys to share the latest information, methods and findings regarding the use of environmental forensics. The conference will consist of plenary presentations, and oral and poster technical sessions.

The conference will be a combination of plenary presentations, and oral and poster technical sessions and will provide an opportunity for people of all experiences to learn from environmental forensic experts practicing and/or studying in this field. We have a very strong program this year with presentation of environmental topics that are uniquely focused on the use of scientific techniques to identify the source, age and timing of contaminant release to the environment (air, surface water, soil, groundwater, and marine).

We hope this 3-day conference provides you with a cordial opportunity to meet and interact with your environmental forensic colleagues and to learn about the latest scientific findings and achievements of experts in the field of environmental forensics. The conference is designed to provide formal and informal setting for you to engage with other scientists, working in this field, all to allow opportunities for in-depth discussion and questioning.

The organizing committee thanks the sponsors for generously supporting this event and to all of the speakers and presenters for volunteering their time and effort to make this a successful conference.

Kind Regards,

**Gwen O'Sullivan**  
INEF 2019 Chair  
Mount Royal University

---

## INEF Committee

Gwen O'Sullivan .....	Mount Royal University, Calgary, Alberta, Canada
David Megson .....	Manchester Metropolitan University, Manchester, England, UK
Steve Mudge .....	Norwegian Institute for Air Research (NILU)
Mike Fowler .....	University of Portsmouth, Portsmouth, England, UK

## Conference Organizing Committee

Gwen O'Sullivan .....	Mount Royal University, Calgary, Alberta, Canada
Robert Morrison .....	The Godfather
David Megson .....	Manchester Metropolitan University, Manchester, England, UK
Ben Williams .....	University of the West of England, Bristol, England, UK
Sri Chaudhuri.....	Conservation Ontario, Toronto, Ontario, Canada
Mike Fowler .....	University of Portsmouth, Portsmouth, England, UK

## TABLE OF CONTENTS

<b>TABLE OF CONTENTS</b>	<b>2</b>
<b>Conference Sponsors</b>	<b>3</b>
<b>General Information</b>	<b>4</b>
Venue and Overview	4
Registration Desk	5
Speaker Information	5
Keep in Contact	5
Student Paper Competition	5
Meals and Receptions	5
Social Activities	5
<b>Plenary abstracts</b>	<b>9</b>
<b>Oral abstracts</b>	<b>13</b>
SESSION 1: ANALYTICAL TECHNIQUES	13
SESSION 2: AIR	14
SESSION 3: PERSISTENT ORGANIC POLLUTANTS	15
SESSION 4: METALS	17
SESSION 5: PANEL DISCUSSION	18
SESSION 6: PETROLEUM HYDROCARBONS	19
SESSION 7: LEGAL	20
SESSION 8: POLYCYCLIC AROMATIC HYDROCARBONS	21
SESSION 9: WASTEWATER	23
SESSION 10: MULTIVARIATE & SPATIAL ANALYSIS	25
<b>Posters</b>	<b>27</b>

## CONFERENCE SPONSORS



**Waters Corporation** creates business advantages for laboratory-dependent organizations by delivering scientific innovation to enable customers to make significant advancements. Waters helps customers make profound discoveries, optimize laboratory operations, deliver product performance, and ensure regulatory compliance with a connected portfolio of separations and analytical science, laboratory informatics, mass spectrometry, as well as thermal analysis. Waters will be hosting a reception at the Natural History Museum of Utah (pictured above) on Monday June 25.



**Eurofins.** A clean and safe environment is a pre-requisite for health and quality of life. Eurofins contributes to this by providing market-leading laboratory testing, monitoring and consultancy services to a wide range of industrial companies, environmental consultants, contractors, retailers and government authorities. Our services comprise testing of water, air, soil, waste and other products to assess their quality and impact on health and the environment.



**Cambridge Isotope Laboratories, Inc. (CIL)** is the world's leading producer of stable isotopes and stable isotope-labeled compounds. Cambridge Isotope Laboratories, Inc. (CIL) is the world leader in the separation and manufacture of stable isotopes and stable isotope-labeled compounds. With over 400 employees and laboratories in four countries, CIL specializes in the process of labeling biochemical and organic compounds with highly enriched, stable (non-radioactive) isotopes of carbon, hydrogen, nitrogen and oxygen. Our chemists substitute a common atom for a rare, highly valued isotopic component so that the final product can be readily measured or traced using mass spectrometry (mass spec) or nuclear magnetic resonance (NMR). CIL's products are utilized in laboratories, medical, government and academic research centers and health care facilities worldwide.



**The Royal Society of Chemistry (RSC)** is an international learned society for advancing the chemical sciences and also the UK's professional body for chemical scientists. Supported by over 47,500 members worldwide and by an internationally acclaimed publishing business, our activities span education and training, contributing to national and international science policy, conference organisation and promotion of the chemical sciences to the wider public. The RSC's headquarters are in London.



## GENERAL INFORMATION

### Venue and Overview

The East-West Centre's 21-acre campus is situated in a lush, quiet area adjacent to the University of Hawaii's Manoa campus. It is located midway between Asia and the U.S. mainland and features research, residential, and international conference facilities. It is convenient to all of Honolulu's resources, yet feels a world away from the bustle of Waikiki and downtown.

The East-West Center was established by the United States Congress in 1960 as a national educational institution to foster better relations and understanding among the peoples of the United States, Asia, and the Pacific islands through programs of cooperative study, training, and research. In early 1959, as Hawaii's statehood was approaching, John A. Burns, Hawaii's Territorial Delegate to Congress, and the then- Senate Majority Leader Lyndon Johnson, both agreed that the East-West Center was an idea whose time had come. Senator Johnson first publicly suggested the concept of an international center during a speech at the American Society of Newspaper Editors in Washington, D.C. on April 16, 1959. He proposed that the nation establish an international university in Hawaii "as a meeting place for intellectuals of the East and West."



*EWC groundbreaking ceremony, May 1961. Left to right: University of Hawai'i President Laurence Snyder, UH Board of Regents Chairman Herbert Cornuelle, first Center chief executive Murray Turnbull, future Hawaii Gov. John A. Burns, then-Vice President Lyndon B. Johnson.*

The conference will take place in the The Hawai'i Imin International Conference Center. The keynote presentations will take place in the KEONI Auditorium and the break ot sessions will be held in either the ASIA or PACIFIC rooms. Lunch and dinner will be in the banquet rooms located in the lower level of IMIN Conference Center.



- A. Abraham Lincoln Hall
- B. Hale Kuahine
- C. Thai Pavilion
- D. Conference Parking
- E. Japanese Tea House
- F. Japanese Garden
- G. **Hawaii Imin International Conference Center at Jefferson Hall**
- H. Hale Manoa
- I. Hale Halawai
- J. John A. Burns Hall
- K. East-West Center Gallery



## Registration Desk

On Monday, June 10, registration will open at 8:00am. Each day of the conference opens with plenary talks at 9:00am followed by concurrent technical sessions.

Poster will be displayed in the West Conference Room on Monday June 10 and Tuesday June 11, and authors will be at their posters during afternoon coffee breaks on Monday and Tuesday (15:00 – 15:30). For more INEF 2019 Program details, please see pages 7-8.

The INEF 2019 registration desk will be open during the following hours:

Monday .....	08:00 to 17:00
Tuesday .....	08:00 to 12:00
Wednesday .....	08:00 to 12:00

## Speaker Information

Presenters in oral sessions are asked to provide their presentations in Microsoft PowerPoint format to the Audio Visual assistants within the session room at least 30 minutes prior to the beginning of their presentation session. Presentation should be approximately 25 minutes with 5 minutes for questions. Each speaker will be provided with a laptop, projector and microphone for their presentation.

Poster presenters are asked to hang their posters at the commencement of the conference and removed them on the final day. Poster board allocation will be provided upon check in at the conference registration desk. Material for hanging poster will be made available at each poster stand. Poster dimensions will be 3 feet tall by 6 feet wide. Authors of posters should be available to discuss content during the scheduled poster sessions.

## Keep in Contact

You can keep up with INEF on social media via Facebook, Twitter (@INEF\_net), and through our website. We invite you to share your experiences of the conference.

You will get several emails from us over the next few months related to conference follow-up matters. You may also get an announcement / call for papers for INEF 2020 and subsequent INEF conferences. You can opt out of this at any time by emailing David Megson at [d.megson@mmu.ac.uk](mailto:d.megson@mmu.ac.uk) and he will remove your details from the INEF database.

In accordance with new May 2018 RSC policy, we will not distribute personal data (names, email addresses, etc.) without your permission, and your contact information will be destroyed after 2 years.

## Student Paper Competition

INEF has an active student outreach program with the express purpose of encouraging students to pursue studies in environmental forensics.

A committee will review submitted student oral and poster presentations during the conference. The committee will select the three best student presentations and present them with an reward on the last day of the conference.

<b>1<sup>st</sup> Prize:</b>	<b>\$500 (Inaugural Robert Morrison Scholarship)</b>
<b>2<sup>nd</sup> Prize:</b>	<b>\$300</b>
<b>3<sup>rd</sup> Prize:</b>	<b>\$250</b>

## Meals and Receptions

The following meals and receptions will be held, and are included as part of your INEF registration. Breakfast is not provided by INEF, but if you are staying at the University Guest House, they offer a free breakfast for guests of the hotel.

### MONDAY, JUNE 10, 2019

10:30 - 11:00	Morning Coffee/Tea
12:30 - 13:30	Lunch
15:00 - 15:30	Afternoon Break/Poster Sessions
17:00 – 18:00	Dinner & AGM
19:00 - 21:00	Pub crawl Social

### TUESDAY, JUNE 12, 2019

10:30 - 11:00	Morning Coffee/Tea
12:30 - 13:30	Lunch
15:00 - 15:30	Afternoon Break/Poster Sessions
17:00 – 18:00	Dinner
18:30 - 21:30	Waters Event

### JUNE 12, 2019

10:30-11:00	Morning Coffee/Tea
12:30-13:30	Lunch

## Social Activities

The committee has arranged a number of social activities to provide delegates with an opportunity to interact in an informal setting on a professional and personal level. The following activities have been planned:

### MONDAY, JUNE 10, 2019: Pub Crawl.

On Monday night delegates can part-take in a pub crawl with a scavenger hunt. The evening will begin at Mai Tai Bar (Ala Moana Center) at 19:30.

### TUESDAY 11<sup>th</sup> June 2019 (Bus Leaving 18:00, Returing 20:45)

### **WATERS INC SPONSORED EVENT**

Join us on the evening of Tuesday June 11th 2019, for a private reception at the Bernice Pauahi Bishop Museum. The Bernice Pauahi Bishop Museum, designated the Hawai'i State Museum of

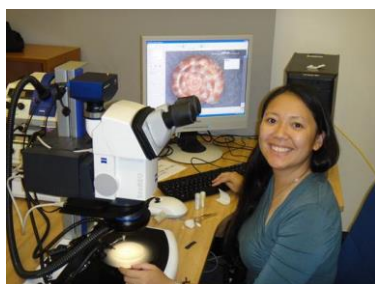
Natural and Cultural History, is a museum of history and science in the historic Kalihi district of Honolulu on the Hawaiian island of O'ahu.

The reception will take place in the great hall and will include light snacks, desserts, and beverages. Delegates will get an opportunity to visit the planetarium and partake in a guided tour through the primary exhibits of the museum. In addition, we are thrilled that we will have two of the Museum's top scientist Ken Hayes and Norine Yeung, who will talk with us about their research in invasion biology and biodiversity conservation.

**Ken Hayes** is the Director of the Pacific Center for Molecular Biodiversity (PCMB) at Bishop Museum, Honolulu, and a Research Collaborator at the Smithsonian Institution in Washington, D.C. Ken did his Ph.D. at



the University of Hawaii Manoa, followed by postdoctoral research at the Smithsonian Institution. Prior to joining the Bishop Museum, he was an Assistant Professor of invertebrate evolutionary biology at Howard University in Washington, D.C. While his research is global in scope, the bulk of his work is carried out in Hawaii and South America, primarily involving aquatic and terrestrial snails. His research foci span the topics of invasion biology, evolution on tropical islands, biodiversity conservation, and evolutionary and ecological genomics. His taxonomic expertise is in Hawaiian land snails and apple snails, which includes the notorious invasive pests *Pomacea canaliculata* and *Pomacea maculata*.



**Norine Yeung** is the Malacology Researcher at the Bishop Museum and is interested in understanding patterns of tropical diversity, focused on phylogeography, systematics and conservation. She is using historic and recently

collected museum specimens to assess the systematics of native and non-native Hawaiian land snails. Prior to her current research in malacology, Nori received her PhD at the University of Hawaii studying the systematics, population genetic structure, and feeding ecology (using stable isotopes) of a pantropical seabird, *Gygis alba*. She also holds affiliate positions at the University of Hawaii and National Museum of Natural History.



**Delivering fast, accurate results with innovative sample preparation, column, and instrument solutions.**

With a wide range of environmental analysis products, advanced applications and dedicated technical support, we work with environmental testing laboratories around the world to implement the most effective analytical innovations to detect and identify chemical contaminants.

**Stop by and visit us at our booth**

**Waters**  
E SCIENCE OF WHAT'S POSSIBLE.™

MONDAY, June 10, 2019	
8:00-9:00	<b>REGISTRATION</b>
9:00-9:05	<b>Welcome and Introduction (Room: Keoni)</b> Gwen O'Sullivan, Mount Royal University, Canada
9:05-9:10	<b>Keynote Speaker Introduction</b> Gwen O'Sullivan, Mount Royal University, Canada
9:10-09:50	<b>Taphonomy and the Terroir: The impact of the Environment on Human Decomposition</b> Shari Forbes, Université du Québec à Trois-Rivières, Canada
09:50-10:30	<b>Keeping our Air Pollution policies on Track</b> Dr Gary Fuller, Kings College, UK
10:30-11:00	<b>COFFEE/REFRESHMENT BREAK</b>
<b>BREAK OUT PLENARY SESSIONS</b>	
	<div> <b>Room: Asia</b>  <b>Analytical Techniques</b>  Moderator – Gwen O'Sullivan </div> <div> <b>Room: Pacific</b>  <b>Air</b>  Moderator – Steven Mudge </div>
11:00-11:30	<div> <b>Monitoring Microbial VOCs using SPME Arrow Combined with GC-MS and GC*GC FID/qMS</b>  Katelynn Perrault, Charminade University of Honolulu, USA </div> <div> <b>Temporal and Geospatial Source Identification of Atmospheric Contaminants using Full Scan Mass Spectra Collected from a Mobile Lab</b>  Larissa Richards, University of Victoria, Canada </div>
11:30-12:00	<div> <b>Retention Indices in Comprehensive Multidimensional Gas Chromatography</b>  Nadin Boegelsack, Mount Royal University, Canada </div> <div> <b>Why Can't I See a Gradient in my Mosses? Spatial Requirements for Sample Collection</b>  Stephen Mudge, Nilu, Norway </div>
12:00-12:30	<div> <b>Advancements in the Development of Nuclear Magnetic Resonance as a Forensic Tool</b>  Julie Konzuk, University of Guelph, Canada </div> <div> <b>Air Monitoring and Health Effects of Volcanic Emissions and Vog: a Review of the 2018 Kilauea Lower East Rift Zone Eruption and Planning for the Future</b>  Diana Felton, Hawai'i Department of Health </div>
12:30-13:30	<b>LUNCH</b>
	<div> <b>Room: Asia</b>  <b>Persistent Organic Pollutants</b>  Moderator – David Megson </div> <div> <b>Room: Pacific</b>  <b>Metals</b>  Moderator – Jun Lu </div>
13:30-13:30	<div> <b>LC-MS/MS Analysis of Emerging and Legacy Polyfluoroalkyl Substances (PFAS) in Environmental Water Samples</b>  Ken Rosnack, Waters Corporations, Canada </div> <div> <b>Recovering Metals from e-Waste is a Risky Business</b>  Stephen Mudge, Nilu, Norway </div>
13:30-14:00	<div> <b>Investigating the State of POPs in Ghana- a Focus on Dioxin Like Compounds in Humans</b>  David Megson, Manchester Metropolitan University, UK </div> <div> <b>Source Identification of Heavy Metals in the Sediments from a Rvier in Anhui, China</b>  Jun Lu, Guozhen Environmental Remediation Co, China </div>
14:00-14:30	<div> <b>Data Visualization of Dioxin/Furan Congener Profiles</b>  Glenn Johnson, EGI, Utah, USA </div> <div> <b>Environmental Forensic Applications for Metal Isotopes Systems</b>  Carol Cheyne, Geosyntec Consultants, USA </div>
14:30-15:00	<div> <b>PCB Signatures and its Application for Source Identification and Differentiation of Colonies of Storm Petrels</b>  Gwen O'Sullivan, Mount Royal University, Canada </div> <div> <b>Exploring Trace Metals in Urban Air Using Biomonitoring</b>  Kevin Hayes, Mount Royal University, Canada </div>
15:00-15:30	<b>COFFEE/REFRESHMENT BREAK</b>
15:30-17:00	<b>Room: Asia</b> <b>PFAS: Scientific, Regulatory and Legal Challenges</b> Leo Rebele, Steve Luis – Ramboll Michael Jacapraro – Allied World Insurance Bret A. Stone - Paladin Law Group, LLP Brenda A. Jensen - Hawaii Pacific University
17:00-18:00	<b>RSC INEF AGM &amp; DINNER</b>
18:30-20:30	<b>ADJOURN &amp; SOCIAL</b>



TUESDAY, June 11, 2019	
8:00-9:00	REGISTRATION
9:05-9:10	Keynote Speaker Introduction (Room: Keoni) Stephen Mudge, Nilu, Norway
9:10-09:50	Best Practices for Scientific Experts in Environmental Litigation: A Canadian Perspective Ms Michelle Jones, Lawson Lundell LLP
09:50-10:30	Integrated Environmental Forensics Ileana Rhodes, GSI Environmental, USA
10:30-11:00	COFFEE/REFRESHMENT BREAK
BREAK OUT PLENARY SESSIONS	
	<div> <b>Room: Asia</b>            Petroleum Hydrocarbons            Moderator – Ken Scally         </div> <div> <b>Room: Pacific</b>            Legal            Moderator – Steven Mudge         </div>
11:00-11:30	<div>Environmental Forensics – Could it be Magic? Ken Scally, Chemtest, Ireland</div> <div>Environmental Stable Isotope Applications in Legal Matters Carol Cheyne, Geosyntec Consultants</div>
11:30-12:00	<div>Expediting Site Closure Using Dissolved Phase PIANO Analysis- A Case Study Jun Lu, Guozhen Environmental Remediation Co, China</div> <div>ELISA and Quality Management in Environmental Forensics. Lauren Horn, Neogen Europe, UK</div>
12:00-12:30	<div>Environmental Damage Assessment in China - Progress and Practice Ji Qi, China Ministry Planning Institute, China</div> <div>Scientific Rigor and Accountability: Quality Assurance in the Forensic Context Hannah Dibner, SNA International for Defense POW/MIA Accounting Agency</div>
12:30-13:30	LUNCH
	<div> <b>Room: Asia</b>            Polycyclic Aromatic Hydrocarbons            Moderator – Glenn Johnson         </div> <div> <b>Room: Pacific</b>            Wastewater            Moderator – Katelynn Perrault         </div>
13:30-13:55	<div>The Future of Environmental Forensics Paul Philp, University of Oklahoma, USA</div> <div>Chemical Tracers of Wastewater Contamination in Sources of Drinking Water Chris Metcalfe, Trent University, Canada</div>
13:55-14:20	<div>PAH Source Evaluation of Sediments in the vicinity of Pier 39, San Francisco Bay Randy Jordan, Natural Spectrum, USA</div> <div>When Less is More: Leveraging Less-Selective Detection for the Non-Targeted Analysis of Wastewater Brendon Parsons, Los Alamos National Laboratory, USA</div>
14:20-14:45	<div>A Tangled Web: Case Study of the Misuse of Environmental Forensics Anne LeHuray, Pavement Coatings Technology Council, USA</div> <div>Factors Affecting Data on Cannabis Obtained by Wastewater-based Epidemiology Viviane Yargeau, McGill University, Canada</div>
14:45-15:10	<div>Chemical Marker Strategy for Evaluating Future Contamination at a Wood preserving Facility James Mc Ateer, QA/QC Solutions, LLC, USA</div> <div>Wastewater Analysis Tai Khan, FQLabs, Honolulu</div>
15:10-15:30	COFFEE/REFRESHMENT BREAK
	<b>Room: ASIA</b> Data Analysis Moderator – Gwen O'Sullivan
15:30-16:00	Applying Multivariate Methods to Source Apportionment for Commingled Groundwater Plumes Cathy CREA, Geosyntec Consultants, USA
16:00-16:30	Studying Antibiotics in Complex Environments Through A Spatial Multimedia Modeling Approach Jinxin Dong, Concordia University, Canada
16:30-17:00	Systematic Planning: How to Make Correct Decisions (or Do I Really Want to Get Fined or Penalized for Making the Wrong Decision?) James Mc Ateer, QA/QC Solutions, LLC, USA
17:00	DINNER
18:30-21:00	SOCIAL: BISHOP MUSEUM ( SPONSORED BY WATERS INC.)

WEDNESDAY, June 12, 2019 ASIA ROOM	
09:00-09:45	Design of Air Monitoring Network Workshop Moderator – Gary Fuller (Kings College, UK)
09:45- 10:30	Aerotoxins & Wipe Sampling Workshop Moderator – David Megson (Manchester Metropolitan University), Kevin Hayes & Gwen O'Sullivan (Mount Royal University)
10:30-10:45	COFFEE/REFRESHMENT BREAK
10:45-11:30	Using Technology to Create an Immersive Data Narrative Workshop Moderator –Nadin Boegelslack (Mount Royal University, Canada)
11:30-12:00	CONFERENCE CLOSING REMARKS & AWARD PRESENTATION
12:00	LUNCH & ADJOURN

## PLENARY ABSTRACTS

MONDAY, JUNE 10, 2019 - KEONI ROOM

9:10 – 9:50

### TAPHONOMY AND THE TERROIR: IMPACT OF THE ENVIRONMENT ON HUMAN DECOMPOSITION

**Shari Forbes**

Universit  du Qu bec   Trois-Rivi res, Canada

[shari.forbes@uqtr.ca](mailto:shari.forbes@uqtr.ca)

Taphonomy is the study of the processes that impact an organism from the time of death to the time of recovery. Research in the field of forensic taphonomy aims to understand the physical, chemical, and biological processes of soft and hard tissue decomposition. Decomposition is inherently impacted by the surrounding environment including, the climate,

geology and ecology. Until recently, the only facilities that conducted human decomposition research were based in the continental USA and much of their data could not be extrapolated to other parts of the world due to different environmental variables. A greater understanding of the decomposition process is necessary to assist police and forensic investigators search for, locate, recover, and identify victim remains. However, where environmental conditions vary, accurate advice may not be possible.

This presentation will contrast the opening of two taphonomy facilities in distinctly different environments, namely Australia and Canada, and highlight the challenges of each. One of the unknown concerns at these outdoor laboratories is the potential for environmental contamination to soil, groundwater and air. Ongoing research at both taphonomic facilities intends to assess these concerns and provide guidelines for establishing future sites on a global scale. The presentation will provide an overview of the need for these facilities elsewhere in the world, the research and training being conducted, as well as examples of how they benefit the scientific and law enforcement community.

*Prof. Shari Forbes is a Professor and Canada 150 Research Chair in Forensic Thanatology at the Universit  du Qu bec   Trois-Rivi res (UQTR). She was formerly an Australian Research Council Future Fellow in the Centre for Forensic*



*Science at the University of Technology Sydney (UTS) in Australia. She established and directed the Australian Facility for Taphonomic Experimental Research (AFTER), the only forensic taphonomy facility in Australia dedicated to the study of human decomposition. Prior to this, she was the founding Director of the Forensic Science program at the University of Ontario Institute of Technology (UOIT) where she also held a Tier II Canada Research Chair in Decomposition Chemistry.*

*Prof. Forbes' research investigates the chemical processes that occur in soft tissue decomposition. She has studied these processes in terrestrial, aquatic, and atmospheric environments throughout Australia, Canada and the USA. Her current research focuses on identifying an accurate chemical profile of decomposition odour using comprehensive two-dimensional gas chromatography – time-of-flight mass spectrometry (GC GC-TOFMS). The research will assist police canine units to improve their training protocols for cadaver-detection dogs deployed to forensic and mass disaster investigations. Her expertise is regularly requested to assist police with locating and recovering buried or concealed evidence, including human remains, drugs, weapons, and currency.*

9:50 – 10:30

## KEEPING OUR AIR POLLUTION POLICIES ON TRACK

**Gary Fuller**

1 MRC PHE Centre for Environment and Health, King's College London, London SE1 9NH, UK

[gary.fuller@kcl.ac.uk](mailto:gary.fuller@kcl.ac.uk)

Right now, around the world thousands of instruments are measuring air pollution. The World Air Quality website (<https://waqi.info/>) is festooned with coloured dots announcing the near-real time air pollution. Although these measurements are used for public information their main purpose is to determine compliance with legal limits. However, a focus on attaining regulatory thresholds can lead to isolated actions in the worst affected places and can incentivise polluting up to the threshold in compliant areas. With little or no evidence of zero-effect thresholds for air pollutants it would be better to focus on reducing concentrations and exposure across the whole population. This would switch the emphasis to rate of change and link better to the effectiveness of control policies. The need for better feedback into policy, was strikingly illustrated by the recent diesel car emissions scandal. Increases in NO<sub>2</sub> concentrations were widely reported but feedback mechanisms were insufficient and almost a decade after the required date, most European countries have yet to meet legal limits. Font et al (2019) showed that policies were not working well everywhere and, if rates of progress between 2010 and 2016 continue, it will take 20 years for compliance in Paris and 193 years in London.

A redesign of our measurement networks would allow them to not only determine compliance and track trends but also to explain them. Changes include the measurement of source tracers also meta data such as traffic flows.

Outside the developed world, in many places it is not network design that restricts analysis but a complete lack of measurements. In 2015 Paris had three times more monitoring sites than the whole of Africa. One approach to may be to use satellite remote sensing in combination with modelling and ground measurements.

With an estimated 4.9 million deaths annually (HEI, 2019), the global impacts of air pollution demand urgent action. In tandem with taking action we must clearly make better use of the air pollution measurement and develop feedback

loops to ensure that our policies remain on track and bring benefits for everyone.

- Font, A et al (2019) *Environmental Pollution*, 248, 1-12.
- Heath Effects Institute (HEI), 2019. *State of Global Air 2018*. HEI, Boston, USA.

**Dr Gary Fuller** is an academic at King's College London. He led the development of the London Air Quality Network to become the most advanced and largest in Europe. His research interests focus on understanding urban sources of air pollution and how they are changing in response to policies. As a member of the MRC PHE Centre for



Environment and Health he works closely with epidemiologists to investigate the health impacts of air pollution. He is a member of the UK government's Air Quality Expert Group, a contributor to the Guardian newspaper and has recently published articles in the Daily Mail, Irish Times, Wired and the Geographical Magazine. His air pollution book *the Invisible Killer* was published by Melville House Books in November 2018.



**Cambridge Isotope  
Laboratories, Inc.**  
**isotope.com**



Environment Testing

## TUESDAY, JUNE 11, 2019 - KEONI ROOM

9:10 – 9:50

### BEST PRACTICES FOR SCIENTIFIC EXPERTS IN ENVIRONMENTAL LITIGATION: A CANADIAN PERSPECTIVES

**Ms Michelle Jones**

<sup>1</sup> Lawson Lundell LLP

[mjones@lawsonlundell.com](mailto:mjones@lawsonlundell.com)

The use of forensic science is often determinative of the key issues in environmental legal proceedings and can be invaluable to assist the parties and their counsel in understanding the issues and potential outcomes. But, being an effective expert involves not only the laws of science, but the science of law. Part of being an effective expert, is understanding the purpose to which your research and conclusions are being put. To do so, experts must have an understanding of the nature of the legal proceedings, the precise legal forum, the applicable evidentiary standard, and the expertise (of lack thereof) of the decision-maker.

Experts must also appreciate the uniqueness of their role. They must act "independently" and avoid advocating for one party over the other. Unlike lay witnesses, experts are permitted, and in fact relied upon, to provide opinion evidence in their respective field. An effective expert is one that appreciates the legal context in which they give evidence and the role they play within it. A lack of appreciation for legal context or a deviation outside the role of an expert can be detrimental to legal counsel's position and the outcome of the case.

This presentation will provide best practices for scientific experts in environmental litigation using the Canadian perspective. It will start with an overview of Canada's environmental law framework with a focus on the type of legal proceeding in which scientific evidence is relied upon, the standard that such evidence is measured by, and the individual expertise of the decision-maker. It will then discuss the unique role that experts play in legal proceedings and the typical challenges faced by experts during cross examination. Finally, it will review past court decisions illustrating successful and unsuccessful expert evidence.

**Ms Michelle Jones.** Michelle's practice is focused on indigenous law and environmental law. Michelle's practice primarily involves administrative and regulatory proceedings, and associated litigation proceedings.



Michelle's experience in Environmental law, includes assisting clients through the environmental assessment process and defending permits and approvals once obtained. Michelle also advises clients respecting compliance with environmental laws and regulations, due diligence, and environmental auditing. She assists clients in reviewing, developing and implementing corporate environmental policies, operating manuals, and standard operating procedures.

In the area of Indigenous law, Michelle counsels government, Crown corporations and private sector clients on the extent of the duty to consult and, if necessary, accommodate potentially affected Indigenous interests. In so doing, Michelle assists clients in identifying potentially affected Indigenous groups, assessing the requisite level of consultation, developing and implementing adequate consultation processes, and where appropriate, negotiating impact and benefit agreements. Michelle has successfully defended the adequacy of consultation processes before regulatory tribunals and courts and on appeal.

Michelle is also a regular contributor to the Project Law Blog, a resource that updates proponents on developments in the law and policy that applies to the development of major projects in Canada. Prior to joining Lawson Lundell LLP, Michelle clerked for the Federal Court of Canada, Trial Division in Ottawa. Prior to becoming a lawyer, Michelle worked on Parliament Hill and for the federal public service. She has firsthand knowledge of the workings of governments and advises clients on policy matters.



9:50 – 10:30

## INETGRATED ENVIRONMETAL FORENSICS

**Dr. Ileana Rhodes**

GSI Environmental, USA

[ileana.rhodes@gmail.com](mailto:ileana.rhodes@gmail.com)

Integrated environmental forensics includes the use of forensics tools along with geology, hydrogeology, fate and transport considerations as well as investigations of site history. Chemical fingerprinting is typically thought to be for the determination of what has been released to the environment and who might be responsible and support to potential litigation. The investigation can include analysis of petroleum, fuels and chemicals ranging from reference materials, LNAPL, soil, water and air. The ability to identify potential sources becomes more challenging in environmental media as compound types and of different sizes partition and degrade at different rates even within the same spill depending on spatial location from source areas and site conditions. Comingled and chronic releases make the job of the forensic scientist more challenging. Furthermore, determination of time of release is not possible based on compositional changes alone. Numerical estimation of residual material in the environment are obtained from variable analytical methods that report “total petroleum hydrocarbons” (TPH). In reality, the results are defined by the method used and may not be “total” or “petroleum hydrocarbons” as anything that is detected by the method get labeled as “TPH”, thus it is essential that “TPH” be investigated the same way as LNAPLs and not simply defined by the label as TPH-diesel, for instance.

Other important applications of environmental forensics include

- use of regulatory limits regarding sulfur, lead, additives in fuels can be useful in “dating” releases
- assistance in CSM development using multiple lines of evidence in relation to LNAPL source and mobility
- selection of remedial system and evaluation of remediation effectiveness, timing and end points
- provide input to regulatory processes

This keynote is intended to highlight challenges and misconception of environmental forensics and to raise awareness of other useful applications.

**Dr. Ileana Rhodes** is an internationally recognized expert in environmental chemistry and forensics. She is currently a Principal Consultant with GSI Environmental Inc. Prior to joining GSI, during her 36-year career with Shell Oil, she was the company's subject matter expert for



environmental chemistry, analysis and forensics supporting the company's exploration, production, downstream operations, and litigation/arbitration matters. Ileana's early chemistry work provided the foundation for her expertise in characterization and fingerprinting of petroleum in free phase products and environmental samples, the historical development of fuels and additives chemistry, regulations related to fuel properties, and characterization of shale gas and shallow gas related to hydraulic fracturing. She previously served as a member of the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG), the American Petroleum Institute (API) Soil and Groundwater Technical Task Force & Clean Water Issues Task Force and led a team in the recently completed ITRC effort to improve understanding of TPH risk.



Environment Testing

## ORAL ABSTRACTS

MONDAY, JUNE 10, 2019

11:00 – 12:30

ASIA ROOM:

SESSION 1: ANALYTICAL TECHNIQUES

### MONITORING MICROBIAL VOCS USING SPME ARROW COMBINED WITH GC-MS AND GC-FID/qMS

Terezie Cernosek<sup>1</sup>, Julianne M. Byrne<sup>1</sup>, Kevin E. Eckert<sup>1</sup>, David O. Carter<sup>2</sup>, and **Katelynn A. Perrault<sup>1\*</sup>**

<sup>1</sup> Laboratory of Forensic and Bioanalytical Chemistry, Forensic Sciences Unit, Chaminade University of Honolulu, 3140 Waiialae Ave, Honolulu HI 96816, USA

<sup>2</sup> Laboratory of Forensic Taphonomy, Forensic Sciences Unit, Chaminade University of Honolulu, 3140 Waiialae Ave, Honolulu HI 96816, USA

\* Presenting Author: Telephone: 808-440-4209,  
[katelynn.perrault@chaminade.edu](mailto:katelynn.perrault@chaminade.edu)

Monitoring volatile organic compounds (VOCs) has many applications in the forensic sciences, including the investigation of environmental exposure. VOCs can be introduced into environmental air through the incorporation of building materials containing volatile chemicals. These VOCs are also a main by-product of microbial metabolism. In forensic taphonomy, the focus of monitoring VOCs is concerned with identifying the odor evolved during human decomposition, which is also a microbial-driven process. The accurate collection and characterization of microbial VOCs (mVOCs) can provide insight into taphonomic status and identify available targets for biological detectors to sense when performing search and recovery.

This study aimed to optimize and apply solid-phase microextraction Arrow (SPME Arrow) and gas chromatographic techniques to mVOCs. There are few published studies on the use of SPME Arrow for VOC applications. Optimized parameters were developed including fiber type, extraction time, desorption temperature, desorption time, and split ratio. This was then applied to three postmortem microbes of interest (*Bacillus subtilis*, *Ignatzschineria indica*, *I. ureiclastica*) using gas chromatography – mass spectrometry (GC-MS). Each bacterial species exhibited different mVOCs when monitored longitudinally over a five-day period. *B. subtilis* exhibited compounds associated with advanced decomposition, while both *Ignatzschineria* species produced VOCs associated with the active decay stage of decomposition. Preliminary results using comprehensive two-dimensional gas chromatography coupled to dual detection with flame ionization detection and quadrupole mass spectrometry (GCxGC-FID/qMS) demonstrated the need for improved chromatographic resolution to uncover additional components in the mVOC profile that could not be identified using GC-MS. Further development of a GCxGC-FID/qMS method will aid in the future characterization of mVOCs in forensic applications.

### RETENTION INDICES IN COMPREHENSIVE MULTIDIMENSIONAL GAS CHROMATOGRAPHY

**Nadin Boegelsack<sup>1,2\*</sup>**, Dena McMartin<sup>2</sup>, Jonathan Withey<sup>1</sup>, Court Sandau<sup>3</sup>, and Gwen O'Sullivan<sup>1</sup>

<sup>1</sup> Mount Royal University, 4825 Mt Royal Gate SW, Calgary, AB T3E 6K6, Canada

<sup>2</sup> University of Saskatchewan, 110 Science Place, Saskatoon, SK S7N 5C9, Canada

<sup>3</sup> Chemistry Matters Inc., 104-1240 Kensington Rd NW Suite 405, Calgary, AB T2N 3P7, Canada

\* Presenting Author: Telephone: +1 403 440 6558, Fax: n/a,  
[nboegelsack@mtroyal.ca](mailto:nboegelsack@mtroyal.ca)

Retention indices (RI) are the roadside markers of chromatography, which have been transforming system-dependent absolute retention times into system-independent relative retention times in one-dimensional GC since 1958. To this day, identifying unknown compounds in complex matrices often requires approximation via RI systems, as opposed to retention time comparisons to pure standards or mass spectral matches.

An exponential increase of unidentified peaks consequentially follows the improved separation potential of GCxGC-TOFMS. To facilitate identification in GCxGC, a robust RI system would be highly desirable. Several studies have been concerned with adapting standard RI methods to incorporate the second dimension in GCxGC and succeeded. Yet, a universally applicable method has not been established. Several factors, such as complexity of the method, the requirement of a thermally modulated system, high error rates or cost are impeding currently published methods.

This presentation will concentrate on a brief historical overview of RI systems in conjunction with their advantages and disadvantages. Further, a new model will be proposed to address the respective drawbacks for GCxGC and to formulate a robust method that is comparable to GC, universally applicable regardless of modulator used, and utilizes readily available standards.

### ADVANCEMENTS IN THE DEVELOPMENT OF NUCLEAR MAGNETIC RESONANCES AS A FORENSICS TOOL

Darcy Fallaise<sup>1</sup>, **Julie Konzuk<sup>\*,2</sup>**, James Longstaffe<sup>1</sup>, Carol Cheyne<sup>2</sup> and Erin Mack<sup>3</sup>

<sup>1</sup> University of Guelph, School of Environmental Sciences, Guelph, Ontario, CANADA;

<sup>2</sup> Geosyntec Consultants International, Toronto, Ontario, CANADA,

<sup>3</sup> DuPont Corporate Remediation Group, Newark, Delaware, USA

\* Presenting Author: Telephone: 416-637-8746,  
[jkonzuk@geosyntec.com](mailto:jkonzuk@geosyntec.com)

Nuclear magnetic resonance (NMR) spectroscopy is a primary analytical tool for the elucidation of unknown chemical structures; however, its application in the area of environmental chemistry is relatively limited to date. Uses of NMR as a tool for environmental characterization to date have included the use of 19-fluorine (19F)

NMR to characterize organofluorine compounds, the use of liquid chromatography-NMR to characterize munitions contamination, and the use of 31-phosphorus (31P) NMR to detect chemical weapons residue. For the past several years, research has been underway at the University of Guelph and Geosyntec Consultants to explore the applications of NMR in fingerprinting complex chemical mixtures found at environmental sites (e.g., non-aqueous phase liquids [NAPLs] released to the subsurface at chemical manufacturing facilities, coal tars and polycyclic aromatic hydrocarbons, and poly- and perfluorinated alkyl substances [PFAS]).

This presentation will cover advancements in method development, including assessment of the advantages and limitations of 1D spectroscopy and various multi-dimensional NMR methods including 2D correlation spectroscopy (COSY), diffusion-ordered spectroscopy (DOSY), heteronuclear single quantum correlation (HSQC), and others. Different methods were also explored for both high-field and low-field (benchtop) NMR applications. Other factors considered included investigating the ability to identify individual components in complex mixtures, understanding limitations associated with detection limits and different types of environmental samples, developing solid-phase extraction techniques to significantly lower detection limits (a common limitation with using NMR on many environmental samples), and differentiating fingerprints of mixtures of knowns (i.e., identified compounds) and unknowns (e.g., unidentified compounds differentiated using DOSY, which can differentiate compounds with distinct differences in molecular size and shape, or using COSY, which can provide at least partial information on the molecular structure of different compounds).

---

## PACIFIC ROOM: SESSION 2: AIR

---

### TEMPORAL AND GEOSPATIAL SOURCE IDENTIFICATION OF ATMOSPHERIC CONTAMINANTS USING FULL SCAN SPECTRA COLLECTED FROM A MOBILE LAB

Larissa Richards<sup>1,2\*</sup>, Nicholas Davey<sup>2</sup>, Jon Davidson<sup>1,2</sup>, Trevor Michalchuk<sup>2</sup>, Chris Gill<sup>1,2</sup>, and Erik Krough<sup>1,2</sup>

<sup>1</sup> University of Victoria, Department of Chemistry, 3800 Finnerty Road, Victoria B.C., Canada, V8P 5C2

<sup>2</sup> Applied Environmental Research Labs, Department of Chemistry, Vancouver Island University, 900 Fifth Street, Nanaimo B.C., Canada, V9R 5S5

\* Presenting Author: Telephone: 1-250-753-3245. Email: [larissa.richards@viu.ca](mailto:larissa.richards@viu.ca)

Volatile organic compounds (VOCs) are important atmospheric pollutants affecting both human and environmental health. VOCs are emitted from a wide variety of point and non-point sources, both

natural and anthropogenic, with atmospheric distributions that vary widely over time and space. Membrane introduction mass spectrometry (MIMS) and proton-transfer reaction time-of-flight mass spectrometry (PTR-ToF-MS) are direct mass spectrometry techniques that can be used to continuously measure VOCs as unresolved mixtures without chromatographic separation at the parts-per-trillion to parts-per-billion level. Direct mass spectrometry techniques can sample at a high frequency (1 Hz), allowing changes in ambient VOC composition to be detected with high temporal resolution. Operating inside a moving vehicle alongside additional air quality and meteorological sensors, both MIMS and PTR-ToF-MS are employed to yield spatially resolved mass spectral data. We report multivariate analysis of full scan mass spectra to fingerprint ambient VOCs and map distributions at regional and neighbourhood scales.

Principal component analysis (PCA) and multivariate curve resolution-alternating least squares (MCR-ALS) were employed to analyze the mass spectral data collected in a mobile mass spectrometry lab. On-road atmospheric data collected on Vancouver Island, BC (Canada), were used to discriminate hydrocarbons from fugitive emissions and incomplete combustion sources, oxygenated compounds associated with composting odours, and reduced sulfur compounds associated with wastewater treatment facilities and pulp mills operations. PCA has been applied to sources of real-world VOCs to discriminate air masses impacted by anthropogenic activities and biogenic processes. In addition, MCR-ALS has been applied to continuous, full scan PTR-ToF-MS data to extract VOC source profiles, and estimate and map source contributions. Work is currently underway to incorporate additional sensor data including carbon dioxide, methane, ozone, nitrogen oxides, and particulate matter to further discriminate sources. This work has applications in environmental forensics, including source identification and apportionment of atmospheric pollutants.

### WHY CAN'T I SEE A GRADIENT IN MY MOSSES? SPATIAL REQUIREMENTS FOR SAMPLE COLLECTION

Steven M Mudge

Environmental effects and sustainability at NILU - Norwegian Institute for Air Research

\*Presenting Author: Telephone: +47 63 89 81 73, Email: [smm@nilu.no](mailto:smm@nilu.no)

Moss samples have been collected every five years in Norway as part of a programme to assess the magnitude of the long range transport of metals. The data from samples collected in the 1980's and 1990's clearly showed trends in selected metals originating from further south in Europe. The reduction in emissions has led to a reduction in these effects in more recent years. However, Norway also has a number of extractive industries that effect the local environment. Inspection of the data indicates measureable enhancement close to the sites but no trends or gradients. This is

due to the distance between samples and the range of the effects. This presentation will consider the metals in mosses again but from the perspective of short range effects and the lack of gradients in the data. Different approaches may be taken to interpolate between irregularly spaced samples and the effect each of these geostatistical methods has will be considered.

# AIR MONITORING AND HEALTH EFFECTS OF VOLCANIC EMISSIONS AND VOG: A REVIEW OF THE 2018 KĪLAUEA LOWER EAST RIFT ZONE ERUPTION AND PLANNING FOR THE FUTURE

**Diana Felton<sup>1</sup>,**

<sup>1</sup> State Toxicologist, Hawai'i Department of Health, Hazard Evaluation and Emergency Response Office (HEER)

\* Presenting Author: Telephone: 808 586 0963, Email: [diana.felton@doh.hawaii.gov](mailto:diana.felton@doh.hawaii.gov)

Abstract unavailable at the time of printing



Cambridge Isotope  
Laboratories, Inc.  
**isotope.com**

**MONDAY, JUNE 10, 2019**

**13:30 – 15:00**

**ASIA ROOM:**  
SESSION 3: PERSISTENT ORGANIC  
POLLUTANTS

## LC-MS/MS ANALYSIS OF EMERGING AND LEGACY POLYFLUOROALKYL SUBSTANCES (PFAS) IN ENVIRONMENTAL WATER SAMPLES

**Ken Rosnack**<sup>1\*</sup>, Kari Organtini<sup>1</sup>, Gareth Cleland<sup>2</sup>, and Doug Stevens<sup>1</sup>

<sup>1</sup> Waters Corporation, 34 Maple St., Milford, MA 01757

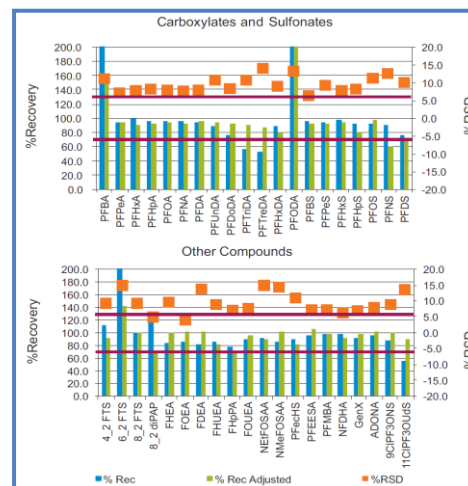
<sup>2</sup> Waters Corporation, 100 Cummings Center, Ste 407N, Beverly, MA 01915

\* Presenting Author: Telephone: +1 508 482 4639, Email: [ken\\_rosnack@waters.com](mailto:ken_rosnack@waters.com)

Currently, there are two main LC-MS/MS approaches for the analysis of PFAS in water. The first involves SPE enrichment, as in EPA Method 537, or for non-drinking water samples, as in ISO method 25101. A weak anion exchange SPE cartridge was selected for this approach. The second approach for PFAS analysis uses direct injection of a large volume of water with very little sample preparation. This is the approach used in ASTM 7979.

The focus of this presentation will be to highlight both approaches discussing observations on the benefits of each method and workflow. Both options were assessed using surface, ground, and waste waters and were found to be robust for all types of matrices tested. Detection limits were in the low to sub parts per trillion (ppt) range which are within compliance of regulatory guidelines. Typically, percent recoveries were within the prescribed range of 70 - 130%. The methods used for both approaches cover a list of approximately 40 PFAS compounds including well characterized legacy PFAS compounds as well as emerging compounds of interest, such as GenX, A DONA, and F53B.

### PFAS covered in SPE method



Method recovery  
(blue bars / left axis  
label)

Method  
reproducibility  
(orange squares /  
right axis label).

Adjusted recovery (green bars / left axis label) represents compound's response corrected to its associated internal standard.



## INVESTIGATING THE STATE OF POPS IN GHANA – A FOCUS ON DIOXIN LIKE COMPOUNDS IN HUMANS

Pennante Bruce-Vanderpuije<sup>1</sup> and **David Megson**<sup>2,3</sup>

<sup>1</sup> Department of Chemistry, University at Buffalo, NY, USA

<sup>2</sup> Ecology and Environment Research Centre, Manchester Metropolitan University, Manchester UK

<sup>3</sup> Chemistry Matters inc, Calgary, AB Canada

\* Presenting Author: [d.megson@mmu.ac.uk](mailto:d.megson@mmu.ac.uk)

The protection of human health and the environment, from persistent organic pollutants (POPs), is the major objective of the Stockholm Convention. However, in developing countries such as Ghana there is limited information on how POP concentrations have changed since the convention was ratified. Ghana is one of highest POP emitters in sub-saharan Africa, with significant inputs from legacy POPs (from pesticides) and emerging POPs (from e-waste sites), making it a key place to understand developing risks from POPs.

This presentation will outline findings of a recent review by Bruce-Vanderpuije et al. (2019a) that identify existing knowledge gaps on the state of POP pollution in Ghana. The research highlighted a large knowledge gap in human biomonitoring data, specifically for dioxin like compounds. These can be unintentionally produced from a variety of different combustion processes making source identification a challenge. To address this knowledge gap we present the findings of two case studies (Bruce-Vanderpuije et al. 2019b & c). The first study (Bruce-Vanderpuije et al. 2019b) determined background concentrations of DLCs in sera of pregnant women in Accra; it showed that whilst levels were lower in comparison to developed countries, they still posed a significant risk. The data also revealed that mixed halogenated dioxins may be a diagnostic tool for source identification studies. The second study (Bruce-Vanderpuije et al. 2019c) determined the levels of DLCs in breast milk from recent mothers in Accra. The results of a detailed quantitative risk assessment identified a risk to children who were breastfed.

## DATA VISUALIZATION OF DIOXIN/FURAN CONGENER PROFILES

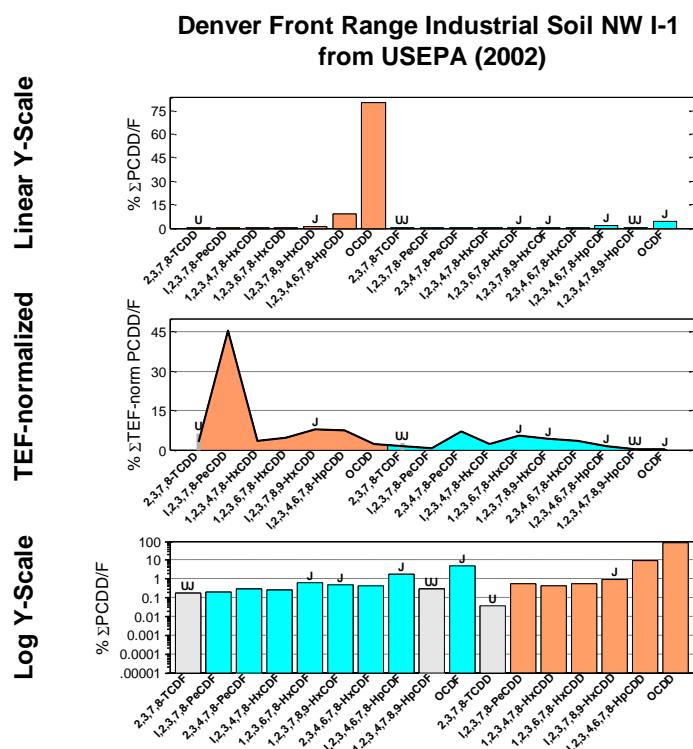
**Glenn Johnson**<sup>1\*</sup>

<sup>1</sup>University of Utah, Salt Lake City, UT USA

\*Presenting Author: Telephone: 01-801-581-6151 Fax: 01-801-585-3540 Email: [gjohnson@egi.utah.edu](mailto:gjohnson@egi.utah.edu)

Visual comparison of congener profiles has been used for decades as a simple, effective method for inferring polychlorinated dibenzo-p-dioxin and dibenzofuran (PCDD/F) sources. With the advent of routine quantitative PCDD/F analysis and large data set, analysis using sophisticated multivariate methods has become routine in dioxin forensics investigations. But the ultimate interpretation process has not appreciably changed. It is a process of comparing either individual samples, or statistically-derived end-member

fingerprints from the field to a library of putative source profiles. However, PCDD/F congener profile comparisons present a unique challenge in that source-diagnostic information often lies within ratios and relative proportions of lower chlorinated congeners present in vanishingly small (but accurately quantitated) proportions. In contrast, the octachlorinated PCDD (OCDD) is often the most abundant congener in a study, but dominant OCDD is not diagnostic of a single source. As a result, there are three main congener profile graphical formats typically applied in PCDD/F forensics studies: linear y-scale, TEF-normalized, and log y-scale (Figure 1). Each of these formats has advantages and drawbacks, and are discussed in this paper.



**Figure 1.** A soil sample PCDD/F congener profile plotted in each of three formats. Light blue bars: PCDFs. Orange bars: PCDDs. Gray bars: Congener reported as non-detect.

# Waters

THE SCIENCE OF WHAT'S POSSIBLE.™

---

## PACIFIC ROOM: SESSION 4: METALS

---

### RECOVERING METALS FROM E-WASTE IS A RISKY BUSINESS

**Stephen M Mudge**, Katrine Aspmo Pfaffhuber, Evert A Bouman,  
Hilde Uggerud, Rebecca J Thorne, and Julius Fobil

Environmental effects and sustainability at NILU - Norwegian Institute  
for Air Research

\*Presenting Author: Telephone: +47 63 89 81 73, Email:  
[smm@nilu.no](mailto:smm@nilu.no)

Waste electronic and electrical equipment is being generated at a significant rate across the globe. The export of such waste from developed to less developed nations is restricted under the Basel Convention. Despite this, there is a significant transfer of such waste to locations like Agbogbloshie in Accra, Ghana where the metals are recovered by informal processes for future use. As part of a study to determine the fate of rare earth elements (REEs) in the environment, a series of dust and soil samples were collected from the city and region around this waste recycling site. It was hypothesised that the wide range of micro-electronics that incorporate the REEs would lead to increased emissions during recycling and recovery. Samples were acid digested and analyses by ICP-HRMS for 69 elements. The results were examined by several approaches:

- Classed postings of the elemental concentrations on city maps highlighted the geographical distributions of each element. It was clear that the highest concentrations for many elements occurred at or near the burn sites.
- Principal components analysis (PCA) divided the elements into three major groups that coincided with three different sampling regions; the e-waste burn sites were characterised by elements associated with solder and circuit boards (tin, lead, antimony, indium), the beach sites were enriched in calcium and strontium, and the city was typified by many elements including those normally associated with soils (iron and aluminium). The REEs were also associated with this source group rather than the burn site.
- The projection to latent structures by means of partial least squares (PLS) using the e-waste burn site samples to develop the elemental signature indicated a small dispersion profile into the neighbouring sites with a path length of less than 2 km.
- Polytopic vector analysis (PVA) suggested three major sources; the city baseline soils, the beaches and the burn site. The chemical profiles of the signatures matched those generated by the PCA.

It might be concluded that the burn residue is only contributing to urban dust samples up to ~1500 m from the source location with a principal axis of dispersion to the east in line with the prevailing wind direction. Observations and analyses suggest that only low

technology items (e.g. wiring looms and simple electronic components) are processed at this site and few high technology items (e.g. mobile telephones) are present in the e-waste. The coastal signature was only measurable at the coast implying very little sea to land transport. The bulk of the signature across this part of Accra was that of the local soils indicating that the contamination due to the burning of the e-waste was confined to a small area around the site. Risk maps based on ratios between the maximum permissible concentration and measured concentrations highlighted the hazardous nature of the dusts at the burn site. Hazard quotients based on uptake factors confirmed these results and copper is the most important element in this system. Relatively simple improvements to the reclamation methods may reduce the hazard to the workers but may shift the problem further into the city of Accra.

---

### SOURCE IDENTIFICATION OF HEAVY METALS IN THE SEDIMENTS FROM A RIVER IN ANHUI CHINA

**Jun Lu\***, Junjie Song, Yunyun Li

Guozhen Environmental Remediation Co., Hefei 230009, China

\*Presenting Author: Telephone: +1 562-355-3442,  
[junlu21@yahoo.com](mailto:junlu21@yahoo.com)

Mineral resources (such as sulfur, iron, lead, and zinc) are abundant in one of the watersheds in Anhui Province, China. However, excessive mining has impacted the surrounding ecosystems and human health. To facilitate planning of the dredging project for the main river in the watershed, identification of the contaminant source(s) of sediments in the river course is critical. This study focuses on the investigation of seven mines and related businesses. Soil samples were collected from tailings piles and sewage outlets from the mines, sediments in the river course, surrounding croplands, and background areas. The pH and the concentrations of eight heavy metals (cadmium, mercury, lead, arsenic, chromium, copper, zinc, and nickel) were analyzed. Multivariate statistical analyses, combined with the specific site information, were conducted to evaluate the potential sources of heavy metals in river sediments. The results indicated that the concentrations of copper, cadmium, and arsenic exceeded the thresholds in most parts of the river course. The degree of pollution was highest for copper, moderate for cadmium and arsenic, and lowest for lead, zinc, mercury, and nickel. Based on pollutant characteristics of different samples, the hydrology and hydrogeology in the watershed, and the operational history of the businesses, the primary source(s) of the contamination of heavy metals in river sediments was determined to be the effluents discharged from mine operations. When the effluents containing large amounts of heavy metals-laden suspensions entered the watershed, the suspensions precipitated gradually, leading to the high concentrations of heavy metals in the river sediments.

---

## ENVIRONMENTAL FORENSIC APPLICATIONS FOR METAL ISOTOPES SYSTEMS

**Carol Cheyne**, M.A.Sc., C.Chem.<sup>1</sup>, Silvia Manchini, Ph.D., P.Geo.<sup>1</sup>, and Bridget Bergquist, Ph.D.<sup>2</sup>

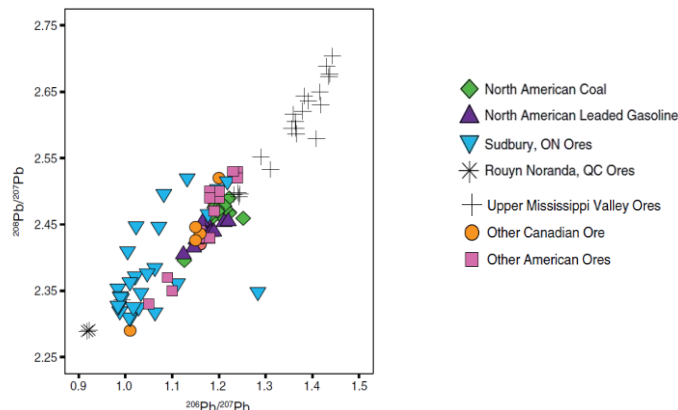
<sup>1</sup> Geosyntec Consultants, 1243 Islington Avenue Suite 1201, Toronto, Ontario, M8X 1Y9

<sup>2</sup> University of Toronto Department of Earth Sciences, 22 Russel Street, Toronto, Ontario, M5S 3B1

\* Presenting Author: Telephone: 416-306-8310 Fax: 888.635.3470  
[ccheyne@geosyntec.com](mailto:ccheyne@geosyntec.com)

Several metal isotope systems have been identified in recent years as powerful tools for tracing the fate and behavior of metal contaminants in the environment. In radiogenic isotope systems such as lead, the isotopes do not fractionate significantly in environmental processes, providing an isotopic fingerprint for the environmental source (e.g. Cheyne et al., 2018, Figure 1). In stable isotope systems such as chromium, the isotopes may fractionate predictably during environmental transformations, providing an isotopic mass balance between source signature and background. In stable isotope systems with several isotopes such as mercury, different isotopic ratios can be applied to detect dominance from key environmental sources. These isotope systems are well studied in the literature but often go under-utilized in environmental forensics investigations.

This presentation will provide the technical background for different metal isotope systems, including applications for stable and radiogenic isotope systems, analytical considerations, and isotopic fractionation documented in the different isotope systems. It will discuss key considerations for determining whether metal isotopes should be applied to a project, and will present case studies where metal isotope systems have been successfully applied to solve forensics problems.



Cheyne et al. 2018. Lead Isotopes as Particulate Contaminant Tracers and Chronostratigraphic Markers in Lake Sediments in Northeastern North America. *Chemical Geology* 477: 47-57.

## EXPLORING TRACE METALS IN URBAN AIR USING BIOMONITORING

**Kevin Hayes\***, Emily Hart, Rachel Hettinga, Gwen O'Sullivan

Department of Earth & Environmental Science, Mount Royal University, Calgary AB, Canada

Presenting Author: Email: [khaye222@mtroyal.ca](mailto:khaye222@mtroyal.ca)

Air pollution has been recognized as a problem throughout history. The concentration of people in urban environments and the associated increase in traffic emissions has led to a decrease in air quality in the urban environment. Air pollution research today is examining the linkage between air pollutants and health implications and refining our understanding of risk from a general population scale to a community level. Our ability to study a finer scale has been limited by our monitoring programs. This study looks at the collection and analysis of foliar samples (proxy indicators of air quality) to examine variation in urban air quality at the community level and explore the linkage, if any, with socioeconomic status of a community.

Biomonitoring of trees, in particular needles, has commonly been used to examine the impacts of air quality on forest ecosystems and more recently urban environments. We will present the findings from a study in which foliar samples were collected at the community level within an urban setting. The concentration of trace metals were determined using ICP-MS. Multivariate statistical analysis, including principal component analysis, was completed to determine trends and relationships within the data. The presentation will highlight the potential, and limitations, of biomonitoring using pine needles, to assist with our understandings of baseline environmental conditions and the environmental impacts of urban air pollution.

**MONDAY, JUNE 10, 2019**

**15:30 – 17:00**

**ASIA ROOM:**

**SESSION 5: PANEL DISCUSSION**

## EMERGING ISSUE FOR EMERGING CONTAMINANTS

**Leo Rebele<sup>1</sup>, Steve Luis<sup>1</sup>, Michael Jacapraro<sup>2</sup>, Bret A. Stone<sup>3</sup>,  
Brenda A. Jensen<sup>4</sup>**

<sup>1</sup> Ramboll

<sup>2</sup> Allied World Insurance

<sup>3</sup> Paladin Law Group, LLP

<sup>4</sup> Hawaii Pacific University

Per- and Polyfluoroalkyl substances or PFAS are rapidly emerging as an area of increased scrutiny by regulatory bodies throughout the world. While facilities involved in the production and use of PFAS and military bases using aqueous film-forming foam (AFFF) have been at the forefront of PFAS investigation and remediation efforts over the past several years, regulatory agencies and drinking water purveyors are increasingly turning to broader investigations of PFAS in local water supplies and development of

effective risk management approaches to reduce potential exposures to PFAS. It is evident that the concern over PFAS in groundwater and sediments is outpacing the state of the science and published regulatory thresholds. As a result, investigations and response actions are being undertaken without clearly established objectives and remedial endpoints. Consequently, there are substantial environmental liability and cost recovery allocation issues that need to be resolved.

At heart of the challenge represented by PFAS in groundwater is the state of the science. To date, our understanding of PFAS impacts to aquifers remains limited despite mounting evidence that potential sources are more widespread than previously understood. Current analytical methods account for only a few of the thousands of chemicals that constitute the class of PFAS and, although those methods are evolving, significant methodological challenges remain. Data quality concerns have also emerged as routine approaches to sampling have, in some cases, proven inadequate. Finally, the understanding of PFAS toxicity and potential effects on human health and the environment remains in its infancy.

This panel will explore the intersection of the scientific, regulatory and legal uncertainties and how the state of the science will need to advance quickly to advance our understanding of the nature and extent of PFAS impacts in the environment, identify sources of those PFAS impacts, and effectively remediate those sources.



**TUESDAY, JUNE 11, 2019**

**11:00 – 12:30**

**ASIA ROOM:**

**SESSION 6: PETROLEUM HYDROCARBONS**

**ENVIRONMENTAL FORENSICS – COULD IT BE MAGIC!**

**Ken Scally**

Chemtest, Ireland

\* Presenting Author: Telephone: +44 (0)1638 606070, Email:  
Ken.Scally@chemtest.com

Abstract unavailable at the time of printing

**EXPEDITING SITE CLOSURE USING DISSOLVED  
PHASE PIANO ANALYSIS- A CASE STUDY**

**Jun Lu\***, Kangping Cui, and Qianli Huang

<sup>1</sup> School of Resources and Environment, Hefei University of  
Technology, Hefei 230009, China

\*Presenting Author: Telephone: +1 562-355-3442,  
[junlu21@yahoo.com](mailto:junlu21@yahoo.com)

Groundwater at a UST site on the west coast of California was impacted by petroleum hydrocarbons. Per California Low Threat Closure Policy, the site meets criteria for closure except for an uncertainty of the source of an "orphan" groundwater plume in the vicinity of the site. Based on the distribution and concentrations of the contaminants of concern, operational history of the site and upgradient sites, and site hydrogeology, the "orphan" plume was interpreted to be from an upgradient source(s). However, because the existing data were believed to be insufficiently specific, the regulator was hesitant to provide a no further action letter. This study employed ratio analysis with dissolved phase PIANO results to provide a line of more diagnostic evidence to enhance source differentiation.

Five samples were collected from the site and vicinity. Three groundwater samples and one NAPL sample were from existing monitoring wells and one grab groundwater sample was from a soil boring. From the PIANO analyses, eleven pairs of ratios are selected for chemical fingerprinting. The compounds of interest included C3- and C4-alkylbenzenes and methyl-naphthalenes. Comparative ratios of these compounds reveal that the fingerprints of the petroleum hydrocarbons in the "orphan" plume are diagnostically different from those at the site. In combination with findings from previous investigation, the analysis has provided a critical line of evidence to rule out the source connection of the "orphan" plume with the site plume, and has provided a clear path to obtain site closure from the regulatory agency for this UST site.



## ENVIRONMENTAL DAMAGE ASSESSMENT IN CHINA- PROGRESS AND PRACTICE

**Ji Qi\***, Fang Yu, Dan Zhao, Zhang Yanshen

Chinese Academy for Environmental planning, Beijing, 100012

\*Presenting Author: Telephone: 86-18618136117, Email:  
[qijicaep@126.com](mailto:qijicaep@126.com)

This study provides a summary of the practice of Environmental Damage Assessment in China (EDA). We describe in detail each step of the EDA procedures developed in China, doing comprehensive analysis on the operational procedures from environmental forensics, compensation judgment, selection and implementation of remediation measures, and public participation. We summarize relevant phases of the procedure, criteria used to select among alternative actions and methods, and approaches and methods available in scaling the environmental damages.

We have found that the EDA system in China has obtained certain progress since 2015. The Ministry of Environmental Protection has issued a series of policies and technical guidelines to build the EDA system in China. In the last 5 Years, over 1000 environmental damage cases have conducted the EDA process and more than 1.5 billion RMB have been compensated by the responsible parties. However, the EDA system in China still has many problems, such as lack of basis in special law, funding shortages, lack of compensation standards, an incomplete technical standard system, weak supervision, and poor incorporation of EDA into the judicial system.

We have also analyzed an EDA case of soil and groundwater damages at a coking facility in Beijing, in order to illustrate the key parts of Chinese EDA system in China, such as identifying responsible parties, different types of damages that can occur, authorities involved in the process, different steps to be undertaken to evaluate damages, liability rules for environmental damage, and financial mechanisms. Using the alternative equivalency analysis approaches, we assessed the damage of soil and groundwater of the coking facility site contaminated by Polycyclic Aromatic Hydrocarbons (PAHs). Our results show two things:

- 1) The social discount rate influences the soil contamination damage assessment result the most
- 2) With regards to groundwater, the most important factors are thickness of contaminated groundwater layer, porosity of aquifer, social discount rate, and remediation cost per unit groundwater.

### PACIFIC ROOM: SESSION 7: LEGAL

#### ENVIRONMENTAL STABLE ISOTOPE APPLICATIONS IN LEGAL MATTERS

**Carol CHEYNE**, M.A.Sc., C.Chem.\*<sup>1</sup> and Silvia MANCINI, Ph.D.,  
P.Geo<sup>1</sup>

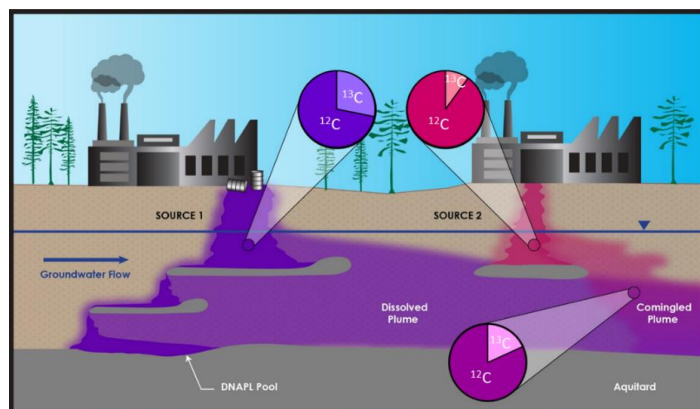
<sup>1</sup> Geosyntec Consultants, 1243 Islington Avenue Suite 1201, Toronto,  
Ontario, M8X 1Y9

\* Presenting Author: Telephone: 416-306-8310 Fax: 888.635.3470  
[ccheyne@geosyntec.com](mailto:ccheyne@geosyntec.com)

Compound specific isotope analysis (CSIA) can be used as a powerful line of evidence to answer questions about contaminant

source apportionment and contaminant degradation through the measurement of naturally occurring ratios of heavy to light isotopes of an element (i.e., the ratio of carbon-13 to carbon-12) of a specific contaminant (e.g., TCE). Multiple sources of the same contaminant may have different isotopic signatures depending on how they were formed or manufactured, providing a valuable line of evidence for evaluating mingled plumes and assessing liability (Figure 1). As a contaminant degrades, chemical bonds involving lighter isotopes are preferentially broken, leaving the remaining contaminant pool enriched in the heavy isotope, providing direct evidence of remedial success to stakeholders and regulators.

To ensure appropriate use of CSIA as scientific evidence in legal matters, technical practitioners must understand the technical limitations and error analysis relevant to isotopic evidence, as outlined in Mancini et al., 2017. This presentation will discuss CSIA principles in the context of the criteria for assessing the reliability of scientific evidence and for admitting expert evidence in the courtroom (The Daubert principle [United States Supreme Court] and the Mohan Criteria [Supreme Court of Canada]). Case studies will be presented to demonstrate where challenges to isotopic evidence may be made, and where CSIA has been successfully applied as defensible data in legal matters.



**Figure 1:** Isotopic fingerprints distinguish contaminant sources

Mancini et al. 2017. The "CSI" in Environmental Forensics: Using Compound Specific Isotope Analysis in Legal Matters. *Natural Resources & Environment* 31 (4).

#### ELISA AND QUALITY MANAGEMENT IN ENVIRONMENTAL FORENSICS

**Lauren Horn**, MChem. AMRSC.,

Neogen Europe, 1-4 Sandfield Industrial Park, Dodgson Street,  
Rochdale, UK, OL16 5SJ

\*Presenting Author: Telephone: +447802 496 864,  
[laurenhorn@hotmail.co.uk](mailto:laurenhorn@hotmail.co.uk)

Enzyme-linked immunosorbent assays (ELISAs) test kits are qualitative, one-step kits designed as screening devices in forensic samples. They are proven to be a powerful tool for reliable sample analysis, with a one to three-minute turnaround time. Most assays are now available for use with a range of different analytical fluids,

including serum, plasma or urine. However, few ELISAs have been validated or their validation is often incomplete for forensic investigations.

Numerous studies have been carried out in their detection. However, commonly used mass-spectrometry-based analytical methods are expensive and time-consuming. The enzyme-linked immunosorbent assay (ELISA) method offers an inexpensive analytical alternative that provides semi-quantitative results in a relatively quick timeframe. For example, the use of ELISA has been shown to perform well for two commonly detected pollutants in groundwater, namely sulfamethoxazole and carbamazepine. The ELISA results were validated with one of two mass-spectrometry-based methods: HPLC and SPE LC. The results indicated that ELISA for organic pollutants is a reliable and cost-effective screening-tool alternative to more commonly used mass spectrometry-based analytical methods.

Quality management systems utilise the robust application of scientific principles, ensuring both accurate interpretation and reporting of results. Currently, there is a growing concern that forensic evidence standards are falling below expectations. A lack of scrutiny may impose a false sense of security with regards to the reliability of evidence provided. Therefore, it is perhaps unsurprising that forensic science in support of criminal justice, certainly in the first instance, is made fit for the purpose of securing convictions thereby meeting customer needs.

The Forensic Science Regulator has published Codes of Practice and Conduct (CoPC) with the aim to establish/identify the quality level required within forensic investigations, along with The United Kingdom Accreditation Service (UKAS®). However, the standards do not specify how investigations should be undertaken - the methods used can be provider specific as long as they are appropriately validated according to these standards. Lessons can, therefore, be learnt from differing disciplines' peer review/verification processes which could be more widely applied.

This work will first examine the quality management systems, both quality control and quality assurance, utilised for the examination and analysis of pollutants detected by ELISA kits for screening purposes. Proposals are then provided identifying what processes are employed and establish some 'best practice' guidelines for implementation, drawing on the experiences of well-established practices in environmental forensic disciplines.

## SCIENTIFIC RIGOR AND ACCOUNTABILITY: QUALITY ASSURANCE IN THE FORENSIC CONTEXT

**Hannah Dibner**

Quality Support Specialist, for DPAA Hawaii, SNA International

\*Presenting Author: Telephone: 808-448-4500 x3780, Email:  
[hdibner@sna-intl.com](mailto:hdibner@sna-intl.com)

Abstract unavailable at the time of printing

**TUESDAY, JUNE 11, 2019**

**13:30 – 15:00**

## **ASIA ROOM: SESSION 8: POLYCYCLIC AROMATIC HYDROCARBONS**

### **THE FUTURE OF ENVIRONMENTAL FORENSICS**

**R. Paul Philp**<sup>1</sup>

<sup>1</sup> School of Geology and Geophysics, University of Oklahoma,  
Norman, OK. 73019

\* Presenting Author: [pphilp@ou.edu](mailto:pphilp@ou.edu)

Environmental forensics as it is known today is now a multidisciplinary subject encompassing a wide variety of scientific techniques. These may range from a wide variety of analytical techniques to historical site investigations, aerial and satellite photography, geology, microbiology, reactive transport models and many others. The key to success is of course the multidisciplinary approach. In terms of building a successful case to determine who was responsible for a release, evidence from a variety of sources will generally provide the most successful result. It is important at the outset of a presentation such as this to point out the basic difference between the environmental forensic approach and the EPA approach in environmental investigations. The EPA approach is basically a monitoring approach to determine changes in concentrations of certain target compounds to determine whether these concentrations are decreasing over time. However that approach will not determine who was responsible for the release of any contaminants and that is where the environmental forensic approach becomes invaluable. Whilst the analytical techniques in the two approaches may be similar the in which the data are acquired and interpreted are different as discussed in this presentation.

The development of gas chromatography with isotope ratio mass spectrometry (GCIRMS) in the mid-1980s lead to an exponential growth in applications of stable isotopes to a wide variety of scientific investigations. It is noteworthy that this occurred some 20 years after the commercial availability of combined gas chromatography-mass spectrometry (GCMS). Analytical tools such as GC and GCMS have been widely used in environmental studies for many years, including the period prior to the availability of the GCIRMS. Any successful investigation will of course utilize data from all these techniques but in this presentation, I will focus on the role that stable isotopes have played in such investigations. We have gone from simply utilizing bulk isotopes for distinguishing sources to having the capability to determine C, H, Cl, Br, S and N stable isotope compositions of individual compounds in complex mixtures. The purpose of this talk will be to review applications of stable isotopes to a variety of environmental problems over time and demonstrate the increasing utility of the approach. This will include early uses of bulk isotopes and passing on to examples of the isotopic composition of individual compounds and their use in a variety of studies including ground water studies and more

recently vapor intrusion studies. If time permits discussion of the limitations and pitfalls of utilizing stable isotopes in these studies will also be discussed towards the end of the presentation.

## PAH SOURCE EVALUATION OF SEDIMENTS IN THE VICINITY OF PIER 39, SAN FRANCISCO BAY

**Randy Jordan**

Natural Spectrum, Poulsbo, Washington

\* Presenting Author: Telephone: 206.866.8661, [rjordan@natural-spectrum.com](mailto:rjordan@natural-spectrum.com)

A forensic evaluation was undertaken to determine the apparent source and nature of PAHs in sediments from a study area in the vicinity of Pier 39 in San Francisco Bay. The study focused on total PAHs greater than ambient concentrations in sediments, and potential pyrogenic source relationships with respect to PAH compounds typically associated with point and nonpoint pyrogenic source types. PAHs potentially associated with manufactured gas plant (MGP) operations were of consideration, due to the historical presence of MGP facilities in the general vicinity. Study objectives included identification of potential nonpoint pyrogenic source signatures that may suggest significant contribution to "nonpoint urban influence", which is distinguished from identified high-concentration point source pyrogenic signatures.

The forensic evaluation considered sediment sample data generated from multiple sampling events during 2016 – 2018, from over 150 station locations. This evaluation also included upland soil samples from the shoreline between Pier 39 and Pier 45, and adjacent to the former Beach Street MGP facility footprint. Additional information included creosote-treated piling samples from the vicinity of Pier 39 to Pier 45.

The forensic approach used diagnostic source ratio analysis for determination of potential source relationships for PAHs. Specific PAH ratios were selected on the basis of being representative of a potential source material and exhibiting environmental stability with respect to weathering influences on relative PAH concentrations. The forensic approach used a two-step process to: (1) identify potential source signatures and define a source model(s); and (2) apply the source model(s) to sediment samples in order to identify the presence of these signatures, and to characterize nonpoint urban influence with respect to PAH composition. In addition, samples from creosote pilings, shoreline soils, and upland soil samples were evaluated with respect to the potential source signatures for sediments.

Initial evaluations of higher PAH concentration sediments supported the use of a two-model approach, consisting of benzo(b+k)fluoranthene/benzo(a)pyrene versus fluoranthene/pyrene and C1-chrysenes/C1-fluoranthenes+pyrenes versus fluoranthene/pyrene. Application of the two-models indicated the presence of distinct potential source signatures, as identified from the distributions of the higher PAH concentration

sediments. Some signatures exhibited pyrogenic character likely consistent with historical MGP sources and one signature was related to a creosote source, such as creosote-treated pilings. A fifth source of PAHs to the study area sediment consists of ubiquitous nonpoint and potential unidentified point sources, which is distinguished from the point source signatures and is termed "urban influence".

## A TANGLED WEB: CASE STUDY OF THE MISUSE OF ENVIRONMENTAL FORENSICS

**Anne Lehuray**

<sup>1</sup> Pavement Coatings Technology Council, 2308 Mt. Vernon Ave., Ste. 134, Alexandria, VA 22301 USA

\* Presenting Author: +1 (703) 299-8470, [alehuray@pavementcouncil.org](mailto:alehuray@pavementcouncil.org)

Evaluating specific uses of environmental forensic methods can, themselves, rise to the level of forensic investigations. Such has been the case in determining how non-forensic scientists have applied forensic methods reported in the literature to conclude that the use of refined coal tar-based pavement sealants (RTS) is a significant, if not the predominant, source of polycyclic aromatic hydrocarbons (PAHs) in urban sediments in parts of the United States (US).

The first challenge encountered in determining how RTS was identified as the most important source of sediment PAHs was attempting to replicate results presented in publications. In their first two publications on the topic of RTS as a PAH source, the authorship group visually compared the clustering of PAH data collected from parking lot runoff to PAH data from "urban stream sediment" on a specific PAH double-ratio plot: Fluoranthene:Pyrene vs. Indeno[1,2,3-cd]pyrene:benzo[ghi]perylene. The published plots could not be reproduced. As such, this raised the question of the identity of the data used to create the plots in the publication. The published papers were unclear about the data used to represent PAH concentrations in urban stream sediment. The authors were not forthcoming about the identity of the data. But using a combination of information received in a response triggered by a letter to the Committee on Ethics of the professional society that published the papers and subsequent responses to a Freedom of Information Act (FOIA) request, strong evidence of selective use of urban stream sediment data was discovered.

In later publications, the authorship group abandoned double ratio methods in favor of a configuration of the US Environmental Protection Agency's (EPA) Chemical Mass Balance (CMB) model. Multiple fatal flaws evident in the CMB configuration developed by the authorship group have been documented, and inputs used to represent varied PAH sources have been reverse-engineered. That said, obtaining inputs and outputs of the CMB model from the authorship group has continued to be a challenge and has led to a FOIA lawsuit filed against the government agency that employs



key members of the authorship group. The problematic CMB model configuration has proliferated as other non-forensic scientists use it as a plug-and-play method of PAH source identification. By these means, environmental forensics is a tool used to embed advocacy research in the scientific literature.

### **CHEMICAL MARKERS STRATEGY FOR EVALUATING FUTURE CONTAMINATION AT A WOOD PRESERVING FACILITY**

**James Mc Ateer**

QA/QC Solutions, LLC, USA

\*Presenting Author: Telephone: 503.763.6948, Email:  
[jimcateer@msn.com](mailto:jimcateer@msn.com)

Operations for over 50 years at a wood treatment facility (formerly the Taylor Lumber and Treating facility in Sheridan, Oregon) used creosote, pentachlorophenol (PCP) enriched P-9 base oil, and Chemonite® (a solution of arsenic, copper, zinc, and ammonia) which resulted in contamination of soil and groundwater. Constituents of concern (COCs) included PCP, DNAPL (primarily creosote), PAHs associated with creosote, PCDD/Fs, arsenic, and other constituents. In 2001, this site was added to the National Priorities List (Superfund) and cleanup included (in part) removal of approximately 5 acres of contaminated soil, a low permeability asphalt cap was put in place, and an underground barrier wall was installed. In 2008 site cleanup was "deemed" complete.

Wood preserving was allowed to continue under new ownership and in 2002 an Agreement and Covenant Not To Sue was signed by applicable parties restricting the use of historical COCs. A copper- and borate-based mixture was then used as the wood treating solution. In 2010 the owners met with USEPA and Oregon DEQ to be allowed to use PCP again as part of the wood treating solution. Subsequently PCP dissolved with a co-solvent (initially butylbenzyl phthalate, then EP-204) and mixed with diesel #2 was used to treat white wood poles. To protect the remedy in place, limit future liabilities, and meet all requirements of two regulatory agencies, legal firms, the insurance agency, and realtors, the current owner needed to reliably distinguish historic site contamination from a potential future release of the current wood treatment solution.

The client is a small firm in a very competitive market and the challenge was to develop a cost effective approach to meet the project data quality objectives (DQOs). A chemical Marker Strategy using routine as well as petroleum hydrocarbon fingerprinting methodologies was used to acquire multiple lines-of-evidence to distinguish historic site contamination from a potential future release of the current wood treatment solution. After evaluation of historical data and the completion of a comprehensive baseline study, the use of an inexpensive C8-C40 hydrocarbon characterization method using GC/MS operated in the full scan mode met the DQOs. The results of this work will be presented.

---

## **PACIFIC ROOM: SESSION 9: WASTEWATER**

---

### **CHEMICAL TRACERS OF WASTEWATER CONTAMINATION IN SOURCES OF DRINKING WATER**

**Chris Metcalfe**<sup>1\*</sup>, Marsha Serville<sup>1</sup>, Quincy Edwards<sup>2</sup>  
and Tamanna Sultana<sup>1</sup>

<sup>1</sup> Water Quality Centre, Trent University, Peterborough, ON, Canada

<sup>2</sup> University of West Indies at Cavehill, Barbados, West Indies

\* Presenting Author: Telephone: 705-748-1011, Email:  
[cmecalf@trentu.ca](mailto:cmecalf@trentu.ca)

We have used residues of caffeine and artificial sweeteners in sources of drinking water as chemical tracers of contamination by domestic wastewater. These compounds can only enter water resources as a result of excretion into sewage by humans. Therefore, there is potential for these chemical tracers to also be used as an indicator of contamination from fecal bacteria of human origin. Our studies in the Caribbean where caffeine and the artificial sweetener, sucralose were detected in groundwater have shown that regions with karst geology are particularly susceptible to contamination as a result of leakage from septic systems and/or direct deposition of sewage into the porous substrate. Our monitoring of caffeine and sucralose in surface waters in Canada show that many sources of drinking water are impacted by upstream discharges from wastewater treatment plants. However, when we simultaneously measured concentrations of caffeine, sucralose and levels of fecal coliform bacteria in sources of drinking water, there was no correlation between the levels of coliforms and the concentrations of the chemical tracers. This can be attributed to microbiological contamination of drinking water from multiple sources, including domestic animals and wildlife, in addition to domestic sewage. In addition, chemical tracers are more persistent in water than coliform bacteria.

---

### **WHEN LESS IS MORE: LEVERAGING LESS SELECTIVE DETECTION FOR THE NON-TARGETED ANALYSIS OF WASTEWATER**

**Brendon Parsons**

Los Alamos National Laboratory, P.O. Box 1663, Los Alamos, NM  
87545

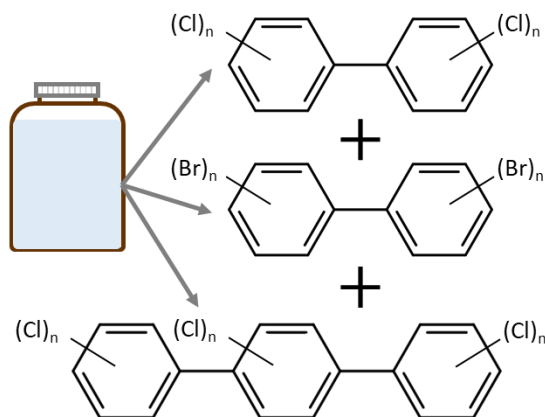
\* Presenting Author: [bparsons@lanl.gov](mailto:bparsons@lanl.gov)

In efforts to locate legacy sources of polychlorinated biphenyls (PCBs) in the combined industrial/sanitary sewer system at Los Alamos National Laboratory (LANL), we developed a novel analytical strategy for sample extraction, cleanup, and analysis. In order to better understand legacy contributions to the LANL sewer, we desired to also detect other halogenated components similar to PCBs. While mass spectrometry detection has become a preferred platform for environmental analysis, it is sometimes too selective as implemented and is difficult to observe unexpected compounds in the samples. By using the less selective but highly sensitive electron capture detector (ECD), we successfully detected



unexpected species present at some locations in the sewer system.

Two unique non-PCB classes of compounds were observed in GC–ECD chromatograms, each appearing in different sampling areas. The identities of the peaks were later confirmed in subsequent analyses by high resolution time-of-flight mass spectrometry (GC–HRT) as polybrominated biphenyls (PBBs) and polychlorinated terphenyls (PCTs). In some samples, the PBB or PCT content of the samples exceeded that of the PCBs. I will discuss the significance of these PCB-like compounds for understanding legacy contributions to the LANL sewer system. I will also cover improvements to the bottle liquid-liquid extraction (BLLE) and extract cleanup procedures necessary to prepare wastewater samples for GC–ECD analysis.



## FACTORS AFFECTING DATA N CANNABIS OBTAINED BY WASTEWATER BASED EPIDEMIOLOGY

**Vivane Yargeau**

<sup>1</sup> Department of Chemical Engineering, McGill, University, Montreal, Canada, H3A 0C5

<sup>2</sup> Statistics Canada, Ottawa, Canada, K1A 0T6

\* Presenting Author: Telephone: 514-398-2273, Fax: 514-398-6678, [viviane.yargeau@mcgill.ca](mailto:viviane.yargeau@mcgill.ca)

The legalization of cannabis production, sale, and use in Canada in 2018 triggered the design and implementation of a country-wide WBE pilot-test to monitor drug consumption of 8.4M people using wastewater-based epidemiology. Best practices developed over more than a decade in the scientific community were used to inform the design of the project. However, some aspects of the design were not well supported by the literature considering that within the research community, research tended to be conducted under fairly well controlled conditions, mostly applied in a single wastewater catchment area of limited population and relatively short periods of time (several days or weeks) and emphasis was generally placed on the science of chemical detection in wastewater, with less attention given to matters of inference and representativity. Knowledge gaps identified at the design phase and some counter-intuitive findings observed during the first months of the project, led to the development of research questions which have been

addressed in parallel to the pilot project. Some of the key questions and findings obtained so far are summarized in the figure below. These results demonstrate that further research is essential in some priority areas in order for WBE to meet expectations of agencies such as Statistics Canada relying on coherent, replicable, and sufficiently accurate estimates of cannabis use.

Sampling strategy	<ul style="list-style-type: none"> <li>Sub-monthly patterns exist and must be taken into account while developing the sampling strategy</li> <li>Results based on daily samples and week aggregates differ</li> <li>The type of sampling (flow- or time-proportional) can impact results</li> </ul>
Sampling material & storage	<ul style="list-style-type: none"> <li>The use of HDPE and PET bottles did not impact results</li> <li>Short term storage at 4°C (&lt; 3 days) seems acceptable</li> </ul>
Measuring the metabolite or the parent compound	<ul style="list-style-type: none"> <li>Unexpectedly, temporal variations of the metabolite benzoylecgonine did not correlate with the temporal variations of cocaine</li> </ul>

**Figure 1.** Few key research questions and results

**Waters**  
THE SCIENCE OF WHAT'S POSSIBLE.™



 **eurofins**

Environment Testing

TUESDAY, JUNE 11, 2019

15:30 – 17:00

ASIA ROOM:

SESSION 10: MULTIVARIATE & SPATIAL  
ANALYSIS

**STUDYING ANTIBIOTICS IN COMPLEX  
ENVIRONMENTS THROUGH A SPATIAL MULTIMEDIA  
MODELING APPROACH**

Jinxin DONG<sup>1</sup>, **Zhi CHEN<sup>1\*</sup>**, Zhenhui GAO<sup>2</sup>, Yi HAN<sup>3</sup>, Jianbo GUO<sup>3</sup>,  
Junhua SONG<sup>4</sup>

<sup>1</sup> Department of Building, Civil, & Environmental Engineering,  
Concordia University, Montreal, Canada

<sup>2</sup> First institute of oceanography, Ministry of Natural Resources of the  
People's Republic of China, Qindao, China

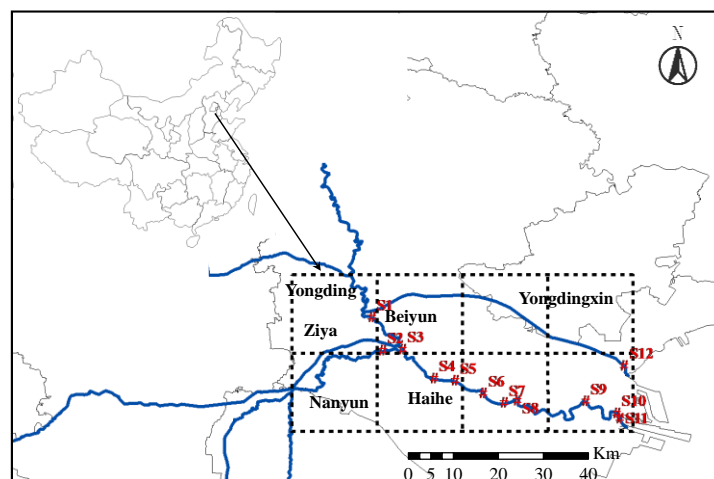
<sup>3</sup> School of Environmental and Municipal Engineering, Tianjin  
Chengjian University, Tianjin, China

<sup>4</sup> Environmental Forensics Section, Chinese Society for  
Environmental Sciences, Beijing, China

\* Presenting/Corresponding Author: Telephone: +1 514 688 0679 E-  
mail: [zhichen@bcee.concordia.ca](mailto:zhichen@bcee.concordia.ca)

Antibiotics disposed into the environment has become a threat to public health and ecosystem. In this study, we introduce a spatial environmental multimedia modeling (SEMM) approach to examine antibiotics emission sources and their transport and exposure risks to the fresh water systems, where risks to the affected water, sediment, soil, and biota are quantified. The SEMM method is based on a numerical river basin model coupled with environmental multimedia chemical fate analysis. The SEMM approach is applied to the Beijing-Tianjin area in China where there are many antibiotics emission sources over a large river basin including six streams as showed in Fig. 1. The SEMM is tested through studying the sulfadiazine (SDZ) as the target antibiotic in the region. Based on the measured and reported data, SDZ concentration in water and sediment zone are considerably higher than those in soil and air of the study region, which agree with the SEMM results. The modeling results show that SDZ concentrations in water and sediment compartments are close to measured values, with most of the average relative errors are less than 40% as shown in Table 1. Further sensitivity analysis shows that flow rate is the most influential parameter for SDZ, which significantly affect the distribution of SDZ in both water and sediment. Therefore the quantitative relation between the SDZ emission and risk has been established, which is employed to examine SDZ control measures. It shows that the SDZ concentrations and risks in the impacted environmental media could be reduced corresponding to antibiotics mitigation actions. The SEMM approach can be also applied to find the source-response relation for controlling other emerging contaminants in a complicated environmental multimedia site.

**Keywords:** spatial multimedia risk analysis, emission source and response relation, antibiotics, river basin, uncertainty analysis



**Figure. 1** The study area

**Table. 1** Comparison of simulation results and measured data

Sampling No	River	Measured results		Simulated Results		Relative error (%)	
		Water (ng/L)	Sediment (ng/g)	Water (ng/L)	Sediment (ng/g)	Water	Sediment
S01	Beiyun	5.9	n.d	8.8	1.3	33.0	-
S02	Nanyun	2.5	1.2	3.9	0.6	35.9	51.7
S03	Beiyun	31.9	n.d	25.4	3.5	20.4	-
S04	Haihe	100	5.4	137.4	9.0	27.2	40.0
S05	Haihe	150	26	121.7	13.7	18.9	47.3
S06	Haihe	78	16	79.6	12.0	2.0	25.0
S07	Haihe	180	20	130.4	18.0	27.6	10.3
S08	Haihe	270	30	270	28.9	0.0	3.7
S09	Haihe	n.d	8.1	61.8	8.8	-	8.1
S10	Haihe	17.2	n.d	31.7	4.8	45.7	-
S11	Haihe	n.d	3.4	30	4.3	-	20.6
S12	Yongdingxin	21	n.d	14.9	2.1	29.0	-

**APPLYING MULTIVARIATE METHODS TO SOURCE  
APPORTIONMENT FOR COMMINGLED  
GROUNDWATER PLUMES**

**Cathy Crea, Ph.D.<sup>1</sup>**, Julie Konzuk, Ph.D., P.Eng., <sup>2</sup> Carol Cheyne, M.A.Sc., C.Chem. <sup>2</sup> Cory Repta, M.Sc. <sup>1</sup>, and James Rayner, M.Sc.<sup>1</sup>

<sup>1</sup> Geosyntec Consultants, 130 Stone Road, Guelph, ON, N1G3Z2

<sup>2</sup> Geosyntec Consultants, 1243 Islington Avenue Suite 1201,  
Toronto, Ontario, M8X 1Y9

\* Presenting Author: Cathy Crea Telephone: +1 (519) 515 0847  
[ccrea@geosyntec.com](mailto:ccrea@geosyntec.com)

Multivariate chemical fingerprinting methods, such as principal component analysis (PCA) and positive matrix factorization (PMF), are routinely used to determine chemical differences in the source

profiles of immobile, recalcitrant chemicals, e.g. PCBs, PAHs, dioxins and furans, in sediments. These methods have also been applied to groundwater contaminated with mobile, degradable chlorinated solvents, e.g. PCE, TCE, to elucidate plume commingling and determine contributions from multiple sources. However, this application requires that these methods are able to account for the spatial and temporal correlations inherent in groundwater data.

The information contained in groundwater concentration data is often confounded by spatial and temporal inconsistencies. Therefore, applying multivariate methods to concentration data alone do not provide sufficient insights into source and plume dynamics. Forensic data from compound specific isotope analysis (CSIA) and molecular biological tools (MBTs) can indicate the occurrence and rates of biological processes that have influenced the distribution of chlorinated solvents in groundwater over time.

In this presentation we apply multivariate methods to groundwater concentration, CSIA and MBT time series data collected at an industrial site to provide insights into the relative contributions of chlorinated solvent sources to a commingled plume, identify likely flowpaths from each source area, and better quantify natural attenuation rates. This information was used to inform remedial strategy optimization to more effectively reach remedial goals.

## **SYSTEMATIC PLANNING – HOW TO MAKE CORRECT DECISIONS (DO I REALLY WANT TO GET FINED OR PENALIZED FOR MAKING THE WRONG DECISIONS)**

**James Mc Ateer**

QA/QC Solutions, LLC, USA

\*Presenting Author: Telephone: 503.763.6948, Email: [jjmcateer@msn.com](mailto:jjmcateer@msn.com)

How do you know if the decision(s) you are making using your data are scientifically valid, meaningful, and legally defensible? Making the wrong decision(s) can be very costly to all parties involved not only in dollars, but also in time and can have adverse effects to ecological and human health. Often times, it can take months or even years before you find out you made a wrong decision; however, making the right decision by using the right data will save time and money in the long run. Proper use of systematic planning (and documentation) are necessary in order to achieve this goal. This should be simple, but how often do we hear, "We don't have enough money to plan or do it right the first time!" Then why do we always have enough money to repeat the sampling and testing again and again? So why not just do it right the first time?

Chemical data, for example, are used to make critical decisions such as identifying the nature and extent of contamination at a site,

verifying cleanup of a site, and identifying and quantifying potential risks to the environment and/or human health. Decisions made can support litigation, toxics tort issues, and a plethora of other end uses. In order to make appropriate decisions based on sound science, it is necessary to know the overall quality of the data set(s) being used. If any of the steps that make up systematic planning and/or QA/QC processes are incomplete, the resulting mistake(s) can be very costly and result in the incorrect use(s) of the data.

This presentation will provide an overview of how using systematic planning; following the 7-Step data quality objective process; selecting appropriate sampling and analysis methodologies; completing data verification and data validation; conducting a data quality assessment and usability evaluation (e.g., using appropriate statistical analyses); and, preparing a data usability report documenting the findings is necessary in both the consulting and academic worlds and how this can be important during litigation. A few real-world examples will be presented to illustrate the importance of using systematic planning and how mistakes in completing one, or more, of the parts of this process can result in incorrect decisions.



## POSTERS

### WEST CONFERENCE ROOM

#### MONITORING VOLATILE ORGANIC COMPOUNDS FROM KAVA USING GC×GC-QMS/FID

Julianne M. BYRNE<sup>1\*</sup>, Jonathan BAKER, and Katelynn A. PERRAULT<sup>1\*</sup>

<sup>1</sup> Laboratory of Forensic and Bioanalytical Chemistry, Forensic Sciences Unit, Chaminade University of Honolulu, 3140 Waiālae Ave, Honolulu HI 96816, USA

<sup>2</sup> Division of Natural Sciences and Mathematics, Chaminade University of Honolulu, 3140 Waiālae Ave, Honolulu HI 96816, USA

\* Presenting Author: Telephone: (650) 678 7544, julianne.byrne@student.chaminade.edu

The kava plant (*Piper methysticum* G. Forst.) is native to the Pacific and has great social significance in many Pacific Island cultures, especially as a social/ceremonial drink and medicine. Outside Oceania, kava is used therapeutically to treat anxiety; demand for kava as a beverage is also increasing in the US and elsewhere. Currently, kava is harvested in several major regions of the Pacific. However, there are minimal regulations on the labeling of product region and minimal regulations regarding quality control to inform consumers who purchase such products. In addition, enforcement of product labelling is challenging in the regions where kava is produced. More research is needed to characterize the chemical profile of kava and understand its safety and efficacy as a plant-based therapy. As kava grows in demand, tracing geographical origin in a "food forensics" scenario may also be necessary.

This study investigated volatile organic compound (VOC) profiling to identify aroma compounds from kava grown in different regions (Vanuatu, Fiji, Tonga). Kava samples were extracted using headspace solid phase microextraction (SPME) Arrow and analyzed using comprehensive two-dimensional gas chromatography coupled with quadrupole mass spectrometry and flame ionization detection (GC×GC-qMS/FID). Tentative analyte identification was achieved using qMS data, while FID data were used for statistical purposes. All samples contained high levels of caryophyllene and humulene, in addition to many alcohols, aldehydes, ketones, terpenes, and aromatics. While some samples could be differentiated based on chemical profile, samples grouped based on brand rather than by geographic origin. While previous research has focused primarily on kavalactones and flavokawains in kava, VOCs may rather provide a means of monitoring product treatment and quality. This is valuable due to the increasing global market of kava. Most of the world's population (~87%) lives in developing countries, where the majority rely on traditional medicines for primary medical care. Comprehensive profiling of accessible, affordable, and culturally acceptable medicines like

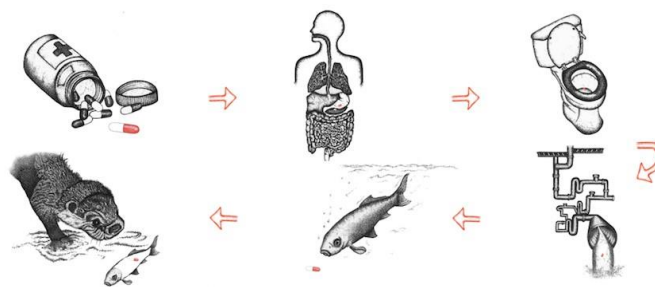
kava may help to provide safe, efficacious therapies for populations who depend primarily on traditional medicines.

#### DEVELOPING METHODS TO QUANTIFY PHARMACEUTICALS IN EURASIAN OTTERS (*LUTRA LUTRA*)

Emmelianna Kumar<sup>1,2</sup>, David Megson<sup>1</sup> and Mark Slevin<sup>1</sup>

<sup>1</sup> Manchester Metropolitan University, UK  
2+44 (0) 161 247 1446, [e.kumar@mmu.ac.uk](mailto:e.kumar@mmu.ac.uk)

Several recent studies have detected pharmaceuticals in free-living fish, but few attempts have been made to look for them in organisms that exist at higher trophic levels. Eurasian otters present an excellent opportunity for investigating potential biomagnification of pharmaceuticals in the food chain, as they are mammalian apex predators that inhabit freshwater ecosystems and consume a diet composed predominantly of fish. Using samples derived from an existing environmental specimen bank, we are developing methods for the analysis of ~50 pharmaceuticals in otter blood, bile and tissues. Several methods of extraction and purification, including Solid Phase Extraction (SPE), Pressurized Liquid Extraction (PLE) and QuEChERS, will be compared, prior to analysis using liquid chromatography tandem mass spectrometry (LC-MS/MS). We will subsequently apply our methods to determine concentrations of these compounds in free-living otters and establish the potential risks through biomagnification.



**Figure 1:** Potential route of entry of pharmaceuticals into Eurasian otters



## Source identification of bottom oil spill by diagnostic ratio analysis: A case study

Te-Kun, HUANG<sup>1\*</sup>, Chi-Wei, WANG<sup>1\*</sup>, Sun-Long, LIN<sup>1</sup>, and Jien-Yu, LIN<sup>1</sup>

<sup>1</sup> Exploration and Development Research Institute, CPC, Corporation, Miaoli 36042, Taiwan

\* Presenting Author: [155667@cpc.com.tw](mailto:155667@cpc.com.tw)

Bottom oil, upon release into a freshwater environment, separates at the surface of the water by density into LNAPL and DNAPL fractions. The LNAPL fraction is dispersed by tidal action, while the DNAPL migrates downward under the force of gravity, and sorbs onto sediments. Consequently, obtaining a representative sample to fingerprint the spilled oil is difficult. This case study performed an environmental forensic investigation focused on source identification of a bottom oil spill using diagnostic ratio analysis.

An oil tanker truck carrying bottom oil overturned on a highway spilling around 6,000 liters of oil into an adjacent ditch. Oil supply company employees took several days to pump out and recover the oil from the water. Five days after the accident, a significant quantity of oil was reported in the harbor water. The Environmental Protection Bureau traced the source, and found that the oil came from a ditch in the north of the site. The company was strongly suspected of illegally dumping the recovered oil into the ditch. In order to determine the legal liability, we were asked to characterize the samples collected by the Environmental Protection Bureau staff to identify the source.

The analytical results showed that the spilled bottom oil mainly contained PAH and a very small amount of diesel as a solvent. The GC/MS total ion chromatogram of the water sample from the harbor indicated that the hydrocarbon had undergone serious weathering. Therefore, fingerprinting was performed with diagnostic ratios of PAH with similar weathering rates to the hydrocarbon. The identical ratios suggested that the hydrocarbon in the three samples were from the same source. The data were used to support litigation against the responsible party.



INEF is a non-profit, interest group within the Royal Society of Chemistry (RSC), join us at <http://www.rsc.org/Membership/Networking/InterestGroups/INEF/>

The International Network of Environmental Forensics (INEF) was founded in 2008 to provide a forum for scientists, environmental consultants, regulators and lawyers to share information regarding the use of environmental forensics. Environmental forensics is the use of scientific techniques to identify the source, age and timing of a contaminant into the environment.

INEF is involved with the design and delivery of a number of outreach programs, including conferences and workshops, to interested parties throughout the world. Information shared through these outreach programs provide investigators employing environmental forensic techniques with the most current scientific information available to identify the source, age and timing of contaminant release to the environment.