

# The Thirty-Third International Conference on Solid Waste Technology and Management

Annapolis, MD (Washington, DC), USA

March 11-14, 2018

## AGENDA

(updated March 6, 2018)

Department of Civil Engineering  
Widener University  
1 University Place  
Chester, PA 19013-5792 USA  
Phone: 610-499-4042  
Fax: 610-499-4461  
email: [solid.waste@widener.edu](mailto:solid.waste@widener.edu)  
<http://solid-waste.org>

Founder: Iraj Zandi  
University of Pennsylvania

Chair: Ronald L. Mersky  
Widener University

Manager: Joy Foster  
Widener University

## Sponsors



## Partners

[The Journal of Solid Waste Technology and Management](#)



**Environmental Research & Education Foundation**  
*Lighting a path to sustainable waste management practices*



## Scientific Committee:

- Haluk Akgun, Middle East Technical University (METU), Turkey
- Professor Joseph Akunna, Abertay University, Dundee, UK
- Prof. Ofira Ayalon, University of Haifa and Samuel Neaman Institute, Technion, Israel
- Giuseppe Bonifazi, Sapienza – Università di Roma – La Sapienza, Italy
- Prof. Mervat El-Hoz, University of Balamand, Lebanon
- Prof. Dr. Sadhan Kumar Ghosh, President, International Society of Waste Management, Air and Water (ISWMAW-IconSWM) and Professor, Mechanical Engineering, Jadavpur University, Kolkata, India
- Serpil Guran, Rutgers EcoComplex, USA
- Nissim Ilan, Ministry Energy, Israel
- Maria Liubarskaia, Saint-Petersburg State University of Economics, Baltic Academy of Tourism and Entrepreneurship, Russia
- Masato R. Nakamura, New York City Tech, CUNY, USA
- Sara Ojeda Benitez, Instituto de Ingeniería Universidad Autónoma de Baja California, México
- Dr. Chukwu Onu, Southern University and A & M College, Baton Rouge, Louisiana, USA
- Genxing Pan, Nanjing Agricultural University, China
- Dr. Mary Purcell, Cork Institute of Technology, Ireland
- Dr. Lakshmi Raghupathy, TERI University, India
- Prof. Krishna R. Reddy, University of Illinois, Chicago, USA
- Dr. Masafumi Tateda, Toyama Prefectural University, Japan
- Jerry E. Uhuo, Ph. D., University of Nigeria, Nsukka and National Assembly, Abuja, Nigeria
- Anita Závodská, Ph.D., Barry University, USA

# CONFERENCE SUMMARY

## SUNDAY, MARCH 11, 2018

- Pre-Conference Tour of Annapolis
- Opening Reception

## MONDAY, MARCH 12, 2018

Opening Plenary

### Oral Presentations

- 1A Economic Analyses
- 1B Use of Wastes in Construction 1
- 1C Composting and Biological Treatment 1
- 1D Landfill 1
  
- 2A Community Education and Participation
- 2B Construction and Demolition Wastes
- 2C Environmental Assessment
- 2D Recycling 1
- 2E Case Studies 1
  
- 3A Special Session: Emerging Contaminants Found in Landfill Leachate
- 3B Waste Collection
- 3C Agricultural and Food Wastes 1
- 3D Medical Wastes
- 3E Landfill 2
  
- 4A Waste to Energy 1
- 4B Integrated Management and Policy 1
- 4C Shell Wastes
- 4D Ash Utilization
- 4E Innovative Technologies

Poster Session 1

## TUESDAY, MARCH 13, 2018

### Oral Presentations

- 5A Use of Wastes in Construction 2
- 5B Contaminated Sites
- 5C Mining Wastes
- 5D Composting and Biological Treatment 2
- 5E Integrated Management and Policy 2
  
- 6A Agricultural and Food Wastes 2
- 6B Landfill 3
- 6C Sludge Management
- 6D Special Wastes

Poster Session 2

- 7A Sludge and Wastewater Management
- 7B Waste to Energy 2
- 7C Research Advances
- 7D Case Studies 2
- 7E Recycling 2
- 7F Agricultural and Food Wastes 3

Closing Reception

## WEDNESDAY, MARCH 14, 2018

Technical Field Trips

# DETAILED AGENDA

## SUNDAY, MARCH 11

12:00 p.m. - 6:00 p.m.

Conference check-in and registration

1:00 p.m. - 5:00 p.m.

Guided Tour of Annapolis  
(additional fee)

1:00 p.m. - 5:00 p.m.

Professional Education Course: *Recycled Materials in Construction Applications*

Instructor: Magdy Abdelrahman, Ph.D., Missouri Asphalt Pavement Association (MAPA) Endowed Professor, Civil, Architectural and Environmental Engineering, Missouri University of Science and Technology

Recycled materials have been used in construction applications for years throughout the United States and in other countries. The use of recycled materials also has the added benefit of responsible disposal of waste materials in a manner that provides engineering benefits to infrastructures. Such products have indicated potential for improved performance by delaying infrastructure deterioration. This course will focus on the challenges facing the use of recycled materials as an aspect of the civil infrastructure sustainability. One challenge is adopting current specifications or developing new specifications for recycled materials in infrastructure applications. The course will present the widespread use of recycled materials in construction but will focus on pavement applications, such as crumb rubber modifier (CRM), and recycled asphalt pavement (RAP); both materials have significant effects on delaying cracking and improving rut resistance. Techniques of how recycled materials are engineered and used successfully in pavement applications will be presented. The course will also provide up-to-date information on fundamentally characterizing the materials and process variables responsible for property development in pavement applications. Both laboratory testing and field performance data will be presented.

5:00 p.m. - 6:00 p.m.

Welcome Reception

## MONDAY, MARCH 12

8:00 a.m. - 5:30 p.m.

Conference check-in and registration

8:00 a.m. - 8:45 a.m.

Coffee

8:45 a.m. - 10:00 a.m.

Opening Plenary

### Welcome:

Roy McGrath, Director/CEO, Maryland Environmental Service

Cecil Rodrigues, Deputy Regional Administrator, Mid-Atlantic Region, US EPA

**Keynote Address:** A Strategic Overview of Research Needs and Problems in North America and Abroad, Bryan Staley, Environmental Research & Education Foundation (EREF), USA

**Plenary Presentations:**

Zero Landfill Zero Waste - Connecting People to Nature, *Sadhan Kumar Ghosh*, President, International Society of Waste Management, Air and Water, & Mechanical Engineering Dept., Jadavpur University, **India**

In Search of Secondary Resource - Research Potential in Waste, *Lakshmi Raghupathy*, TERI University, **India**

10:05 a.m. – 11:30 a.m.

**Sessions 1**

**SESSION 1A**  
*Economic Analyses*

Who Should Really Pay for Waste Management?, *Anita Zavodska*, Barry University, *Anne Morrissey*, Dublin City University, **USA**

Evaluation of the Performance and Profitability of Waste Businesses Using Diversion Indices, *Conglian Pan*, University of Regina, *Kelvin T.W. Ng*, University of Regina, *Amy Richter*, University of Regina, **Canada**

Modeling Economic Aspects of Food Waste-to-Energy Systems, *Matthew Franchetti*, The University of Toledo, *Somik Ghose*, The University of Toledo, **USA**

Synthetic Wood Generation through the Reuse of Solid Waste: An Environmentally Sustainable Product, *Marisa S. Borges*, Federal University of Parana, *Jonathan Cocker*, Baker & McKenzie LLP, *Douglas Santos*, INPI, **Brazil**

**SESSION 1B**  
*Use of Wastes in Construction 1*

Ceramic Ware Waste Potential as Co-Ballast in Dense Masonry Unit Production, *Ajayi-Banji Ademola*, University of Ilorin, *David Jenyo Adewale*, University of Ilorin, *Michael Adegbile*, **Nigeria**

Experimental Investigation of the Compressive Strength of Hair Fiber Reinforced Concrete with Superplasticizer, *Manny Anthony Taguba*, National University, *Franz Santos*, National University, *Allan Alzona*, National University, *Gabriel L. Nones*, **Philippines**

Study on the Shrinkage of Concrete with Pre-Wetting Recycled Aggregate, *Fei Li*, Beijing University of Civil Engineering and Architecture, *Li'an Zhou*, Beijing University of Civil Engineering and Architecture, **China**

Waste Material Recovery Rates, Incomes, and Challenges Facing Informal Waste Reclaimers in the Ekurhuleni Metropolitan Municipality in the Gauteng Province of South Africa - An Exploratory Study, *Isaac Tebogo Rampedi*, University of Johannesburg, *Sibongile Euphemia Gumbi*, University of South Africa, **South Africa**

## SESSION 1C

### *Composting and Biological Treatment 1*

Methane Production from Restaurant Food Waste in Batch Systems at Mesophilic Conditions, *Ivan Moreno-Andrade*, Institute of Engineering, Universidad Nacional Autónoma de México, *Maria Jose Berrocal-Bravo*, Institute of Engineering, Universidad Nacional Autónoma de México, *Beatriz Pérez-Aragón*, Institute of Engineering, Universidad Nacional Autónoma de México, **Mexico**

Rice-Straw Lining on Inner Walls of Composting Boxes to Regulate Heat Storage for Thermophilic Microorganism Functions in Digesting Organic Garbage, *Chulabut Chanthasoon*, The King's Royally Initiated Laem Phak Bia Environmental Research and Development Project, Chaipattana Foundation, *Kasem Chunkao*, Kasetsart University, *Noppawan Semvimol*, Kasetsart University, *Jeerasak Phermsin*, **Thailand**

Flexible Energy Production through Combined Hydrogen and Methane Production at a Municipal Sewage Treatment Plant, *Marco Küppers*, University Duisburg-Essen, *Jens Schoth*, University Duisburg-Essen, *Ruth Brunstermann*, University Duisburg-Essen, **Germany**

Enhancement of Biogas Production from Organic Fraction of Municipal Solid Waste (OFMSW) Using Acid Pretreatment, *Arpita Dasgupta*, Indian Institute of Technology Bombay, *Munish Kumar Chandel*, Indian Institute of Technology Bombay, **India**

## SESSION 1D

### *Landfill 1*

Using Synthetic Biogas to Evaluate Adsorbents for Removing Siloxane Contaminants from Biogas Streams under Varying Conditions, *Clara Eichler*, Virginia Tech, *Steven Cox*, Virginia Tech, *Gregory Boardman*, **USA**

Utilization of Selected Fungal Strains to Treat Old Landfill Leachate, *Mofizul Islam*, University of Manitoba, *Qiuyan Yuan*, University of Manitoba, **Canada**

Estimation of Half-Life of Municipal Solid Waste, *Dorairaja Raghu*, NJIT, *Swamy Basim*, Central Connecticut State University, **USA**

Assessment of Ammonia Removal from Landfill Leachate Using Ultrasonic Irradiation, *Majid Sartaj*, University of Ottawa, *Andrew Tobalt*, Environment Canada, **Canada**

11:30 a.m. – 11:50 a.m.

Break

11:50 a.m. – 1:10 p.m.

**Sessions 2**

## SESSION 2A

### *Community Education and Participation*

Evaluation of Waste Recycling Practices of Primary School Learners in Mamelodi Township of South Africa, *Isaac Tebogo Rampedi*, University of Johannesburg, *Gilani Muriel Makhubele*, University of Johannesburg, **South Africa**

The 'Real Nappies for London' Scheme - Waste Prevention and Wider Social Benefits - 2012-2017, *Charles Warner*, University of Northampton, **United Kingdom**

Solid Waste Management in a University Campus in Brazil, *Liseane Padilha Thives*, Federal University of Santa Catarina, *Enedir Ghisi*, Federal University of Santa Catarina, **Brazil**

## SESSION 2B

### *Construction and Demolition Wastes*

Assessment of Human Health and Environmental Risks in Construction and Demolition Waste Use in the Czech Republic, *Anita Zavodska*, Barry University, *M. Zimová*, Charles University, *Libuse Benesova*, Charles University, **Czech Republic**

Clean Aggregates and Minerals from CDW: The VEEP Project, *Francesco Di Maio*, Delft University of Technology, *S. Lofti*, Delft University of Technology, *A. Gebremariam*, Delft University of Technology, *P. Rem*, Delft University of Technology, *I. Vegas*, Fundacion Tecnalia Research & Innovation, Spain, *J. M. Juez*, Fundacion Tecnalia Research & Innovation, Spain, *M. Hu*, Leiden University, *E. van Roekel*, Strukton Civiel, **The Netherlands**

## SESSION 2C

### *Environmental Assessment*

Multivariate Analysis and Hydrochemical Assessment of Groundwater at Regina Landfill Site, *Conglian Pan*, University of Regina, *Kelvin T.W. Ng*, University of Regina, **Canada**

Sanitation Markets and Urban Climate Decisions Asymmetry: Lessons from Trend in CH<sub>4</sub> Emissions from Solid Waste Disposal Subsector in Rwandan Cities after Private Sector Involvement in Solid Waste Collection, *Pius Nishimwe*, Water for People, *Elisee Gashugi*, University of Rwanda, *Paulin Buregeya*, COPED Group, **Rwanda**

Numerical Modeling of Migration of Landfill Gas and Odors to Nearby Homes, *Ray Kapahi*, NCM Environmental Solution, *Jesse Levin*, NCM Environmental Solution, **USA**

From Process to Practice: Generating Sustainable Waste Streams for Fun and Profit, *Eileen Straughan*, Straughan Environmental, Inc., *Diana Gutierrez*, Straughan Environmental, Inc., *Christine Wysocki*, Straughan Environmental, Inc., **USA**

Energy Audits in Small Water Treatment Facilities, *Michael Conway*, Pennoni, *David Reault*, Environmental Chemical Corporation, **USA**

## SESSION 2D

### *Recycling 1*

Single Stream is Not Always the Single Answer, *Walt Davenport*, MSW Consultants, LLC, *Joanne Shafer*, Centre County Recycling & Refuse Authority, **USA**

Utilization of Post-Consumer Plastic Bottles in Construction, *Pranshoo Solanki*, Illinois State University, *Samikaran Bhattarai*, Illinois State University, **USA**

Improve Efficiencies to Get to the Next Level: What Do the Numbers and Models Say?, *Lisa Skumatz*, SERA Skumatz Economic Research Associates, Inc., **USA**

Wow! Recycling Delivers GHG More Cheaply than Energy Programs – Really?, *Lisa Skumatz*, SERA Skumatz Economic Research Associates, Inc., **USA**

## SESSION 2E

### *Case Studies 1*

Urban Solid Waste Management in Techiman Municipality (Ghana), *Gloria Ametepey*, Zoomlion Ghana Limited (B/A), **Ghana**

Development of an Integrated Solid Waste Management System in Guatemala, *Sean O'Donnell*, Geosyntec Consultants, *Jeremy Morris*, Geosyntec Consultants, *David Espinoza*, Geosyntec Consultants, *Bill Gaffigan*, *Manuel Basterrechea*, *Javier Rojo*, **USA**

Municipal Solid Waste Management in the City of Polokwane: Current Situation, Problems and Challenges, *Mpho Godwin Morudu*, University of Johannesburg, *Isaac Tebogo Rampedi*, University of Johannesburg, **South Africa**

Best Practices of Community Based Solid Waste Management in Panga, Kirtipur, Kathmandu, Nepal, *Nabin Bikash Maharjan*, Blue Waste to Value, **Nepal**

The Role of Waste Segregation in Effective Management of Domestic Solid Wastes in Nairobi, Kenya, *Philip Nyongesa Wangia*, Kenyatta University, *Michael Koech*, Kenyatta University, **Kenya**

1:10 p.m. - 2:05 p.m.

**Awards Luncheon**

**Presentation of the Russell Ackoff Award, Roy F. Weston Award, Iraj Zandi Award and Student Paper Award**

2:05 p.m. – 3:55 p.m.

**Sessions 3**



## SESSION 3A

### *Special Session: Emerging Contaminants Found in Landfill Leachate*

Introduction: *Ivan Cooper*, Civil & Environmental Consultants, Inc.

Regulatory and Litigation Updates, *Matthew Thurlow*, BakerHostetler

Technology Panel:

*Francis Boodoo* – Purolite Ion Exchange

*John Matthis* – Calgon Carbon Corporation

*Pat Stanford* – Rochem

*Steve Koenigsberg*, CEC - ARC Technology

Wrap Up: *Steve Zemba* – Sanborn Head, Risks

## SESSION 3B

### *Waste Collection*

Monopolistic Private Sector Involvement in Solid Waste Collection in Kigali, A Success Story or a Flog: Social, Economic and Environmental Outcome, *Pius Nishimwe*, Water for People, *Jaap Evers*, IHE Institute for Water Education, *Paulin Buregeya*, COPED Group, **Rwanda**

Customer Satisfaction of Solid Waste Collection Services: A Measure towards Effective Waste Management, *Alhassan Sulemana*, Kwame Nkrumah University of Science and Technology, *Emmanuel A. Donkor*, Kwame Nkrumah University of Science and Technology, *Kofi S. Boateng*, Zoomlion Ghana Limited, *Kodwo Miezah*, *George N. Rockson*, *Ebenezer O. Turkson*, *Franklin O. Akuffo*, *Roland Darko*, **Ghana**

Route Optimization for Municipal Solid Waste Collection in Sunyani, Ghana, *Alhassan Sulemana*, Kwame Nkrumah University of Science and Technology, *Emmanuel A. Donkor*, Kwame Nkrumah University of Science and Technology, *Eric K. Forkuo*, Kwame Nkrumah University of Science and Technology, *Sampson Oduro-Kwarteng*, **Ghana**

Incidence of Human Labor in Waste Collection, *Francesco Di Maria*, Dipartimento di Ingegneria - Università di Perugia, *Federico Sisani*, Dipartimento di Ingegneria - Università di Perugia, **Italy**

The Art of Invisible Waste, *Jay Wheeler*, Underground Refuse Systems Inc., **USA**

## SESSION 3C

### *Agricultural and Food Wastes 1*

Study of Slow Release of Urea Supported on Coconut and Straw Biochars, *Marco Antonio Gaya de Figueiredo*, Universidade do Estado do Rio de Janeiro, *Luana Ventura Bais*, Universidade do Estado do Rio de Janeiro, *Wallace Souza*, Universidade do Estado do Rio de Janeiro, *Fabio Antônio Cavalcante da Silva*, *Ana Paula Carvalho*, **Brasil**

Enhanced Biogas Production from Alkali-Pretreatment Giant Reed as a Potential Wild Reproductive Crop, *Zainab Ziad Ismail*, University of Baghdad, *Nazik Adnan Noori*, University of Baghdad, **Iraq**

A Study on Functioning of the Dry Waste Collection Centers In Bangalore City, *Prakash Gowdra*, M.S. Ramaiah Institute of Technology, *Vivekanand Venkataraman*, M.S. Ramaiah Institute of Technology, *Judith Anthony*, PGDM, Great Lakes Institute of Management, *Mohammed Sharukh*, **India**

Modeling the Life Cycle Greenhouse Gas Emission Benefits of Sodium Bisulfate for Poultry Litter Treatment, *Matthew Franchetti*, The University of Toledo, *Somik Ghose*, The University of Toledo, **USA**

### **SESSION 3D** ***Medical Wastes***

A Review of Medical Waste Management: A Case Study of South Africa, *Foluke Comfort Olaniyi*, University of Venda, *Jason S. Ogola*, University of Venda, *Augustine K. Tugli*, University of Venda, **South Africa**

### **SESSION 3E** ***Landfill 2***

The Effect of Using Prefabricated Vertical Drains on Secondary Settlement, *Mohammad Al-Quraan*, Geosyntec Consultants, *Andrew Stallings*, Geosyntec Consultants, *David Espinoza*, Geosyntec Consultants, **USA**

Redevelopment of Landfill Site Eysels, Turnhout, Belgium, *Bart Nevejans*, Aertssen Group, **Belgium**

An Innovative Passive Approach to Remediation at a Closed Landfill, *Laura Oakes*, EA Engineering, Science, and Technology, Inc., PBC, *Michael Hertz*, EA Engineering, Science, and Technology, Inc., PBC, *Michael Phillips*, EA Engineering, Science, and Technology, Inc., PBC, *Kari Hodgson*, **USA**

Case Studies of Landfills of Indochina Peninsula, Deep Pit Disposal on Geological Barrier and Its Effects on Leachate Quality and Groundwater, *Phetyasone Xaypanya*, Tokyo Institute of Technology, *Jiro Takemura*, Tokyo Institute of Technology, *Chart Chiemchaisri*, Kasetsart University, *Hul Seingheng*, *Maria N. Tanchuling*, **Japan**

A Sustainable and Integrated Design of a Bioreactor Landfill Operation, Gas Separation, and Utilization: A Step towards Waste Management, *Anaya Ghosh*, National Institute of Technology, Durgapur, *Sadhan Kumar Ghosh*, Jadavpur University, Kolkata, *Bimal Das*, National Institute of Technology, Durgapur, *Jyoti Prakash Sarkar*, **India**

Circular Economy, *Sadhan Kumar Ghosh*, Jadavpur University, Kolkata, *Francesco Di Maria*, Dipartimento di Ingegneria - Università di Perugia, *Ofira Ayalon*, The University of Haifa and Samuel Neaman Institute, **India, Italy, Israel**

3:55 p.m. – 4:15 p.m.

**Break**

4:15 p.m. – 5:55 p.m.

**Sessions 4**

**SESSION 4A**  
***Waste to Energy 1***

Combustion Characteristics of Selected Tropical Wood Residues in Relation to Their Particle Sizes, *Abdulkarim Baba Rabi*, University of Ilorin, *Olumuyiwa Ajani Lasode*, University of Ilorin, *Habeeb A. Ajimotokan*, University of Ilorin, *V.A. Afolayan*, **Nigeria**

Power/Water Solutions: Using Thermal Energy from CHP Plants to Treat Challenging Waste Waters, *Earl Jones*, Heartland Water Technology, Inc., *Ben Laurent*, Heartland Water Technology, Inc., **USA**

The Feasibility Study on Municipal Solid Waste to F-T Derived, *Wei Wu*, Northeastern University, *Yijie Zhong*, Northeastern University, *Gang Fan*, Northeastern University, **P.R. China**

Co-Combustion of Solid Recovered Fuel as Sustainable Tool in an Advanced Waste Management System, *Eva Miller*, University of Stuttgart - IFK, *Aaron Fuller*, University of Stuttgart - IFK, *Jörg Maier*, University of Stuttgart - IFK, *Günter Scheffknecht*, *Thomas Glorius*, **Germany**

**SESSION 4B**  
***Integrated Management and Policy 1***

LCA towards Optimizing the Environmental Performance of ISWM in a Developing Context, *Amani Maalouf*, American University of Beirut, *Mutasem El-Fadel*, American University of Beirut, **Lebanon**

An Overview of Municipal Solid Waste Indicators: Towards the Efficiency, Efficacy, and Effectiveness, *Rafael Deus*, UNESP, *Rosane Battistelle*, UNESP, *Barbara Bezerra*, UNESP, *Karina Rabelo Ogasawara Vieira*, *Edvaldo José Scoton*, **Brazil**

Challenges for Implementing Public Private Partnership Scheme on Solid Waste to Energy in Indonesia, *Erwin Sondang Siagian*, Universitas Padjadjaran, *Asep Sumaryana*, Universitas Padjadjaran, *Ida Widianingsih*, Universitas Padjadjaran, *Heru Nurasa*, **Indonesia**

Integrated PET Bottle Life Cycle System: A Comparative Study of Nigeria, Sweden and Japan, *Nkonyeasua Kingsley Egun*, Greenspring Consulting, **Nigeria**

Policy Direction for Management of Waste Lithium Batteries in Electric Vehicles, *Ji Hye Jo*, Korea Environment Institute, **South Korea**

Policy Implications for Sustainable Consumption and Production in India, *Lakshmi Raghupathy*, TERI University, **India**

Municipal Solid Waste Trends in the US, *David Iacono*, US EPA Mid-Atlantic Region, **USA**

## SESSION 4C

### *Shell Wastes*

The Influence of Utilizing Seashell Waste Materials and Fly Ash on Binding Time for Geopolymer, *Ridho Bayuaji*, Institut Teknologi Sepuluh Nopember, *M. Sigit Darmawan*, Institut Teknologi Sepuluh Nopember, *Nur Ahmad Husin*, Institut Teknologi Sepuluh Nopember, *R. Buyung Anugraha*, *S. Subekti*, *S.E. Santoso*, **Indonesia**

## SESSION 4D

### *Ash Utilization*

New Zeolite Catalyst from Waste Coal Ash for Bio-Diesel Synthesis, *Omotola Babajide*, Cape Peninsula University of Technology, *Roland Missengue*, AgriProtein, *Juvet Shabani*, Cape Peninsula University of Technology, **South Africa**

Zero Solid Waste for Fly Ash: Policies, Mind-Sets, Standardization, and Technologies, *Jinder Jow*, National Institute of Clean-and-Low-Carbon Energy, *Yang Dong*, National Institute of Clean-and-Low-Carbon Energy, *Ke Wang*, National Institute of Clean-and-Low-Carbon Energy, **China**

## SESSION 4E

### *Innovative Technologies*

Potential Constructed Technosols Eco-System Services, *Maha Deeb*, CUNY Advanced Science Research Center, *Peter Groffman*, CUNY Advanced Science Research Center, *Sara Perl Egendorf*, *Daniel Walsh*, *Tatiana Morin*, *Manuel Blouin*, *Geoffroy Séré*, **USA**

Physico-Chemical and Biological Characterization of Mixed Fruit Peels Waste, *Gajraj Singh Rajput*, Indian Institute of Technology, Kharagpur, *Sudha Goel*, Indian Institute of Technology, Kharagpur, **India**

Use of Nano-Silica from Rice Husk as a Drug Delivery Vehicle in Drug Delivery System, *Ryoko Sekifuji*, Toyama Prefectural University, *Masafumi Tateda*, Toyama Prefectural University, **Japan**

Optimization and Prediction of the Compressive Strength of Superplasticized Hair Fiber Reinforced Concrete Using Central Composite Design and Artificial Neural Network, *Manny Anthony Taguba*, National University, *Jan Michael Elbit*, National University, *Romel Carl Basada*, National University, *Keanu Patrick Orido*, *Epphram G. Ramos*, **Philippines**

Recovering of Metals from the Surface of Wasted Printed Circuit Board by Alkaline Electrochemical Leaching and Stripping Foil, *Chenglong Zhang*, Shanghai Polytechnic University, *Feilong Zheng*, Shanghai Polytechnic University, *Jianfeng Bai*, Shanghai Polytechnic University, *Jingwei Wang*, *Wenyi Yuan*, *Weihua Gu*, **China**

## POSTER SESSION 1

A Novel Design of a Solar-Assisted Accelerated Composting Unit, *Kurabachew Duba*, East Carolina University, *Praveen Malali*, East Carolina University, *Faete Filho*, East Carolina University, **USA**

Problem of Utilization of Municipal Solid Waste in the Republic of Uzbekistan in City Samarkand, *Shodi Kholikulov*, Samarkand State University, *Sindor Pardaev*, Samarkand Agricultural University, **Uzbekistan**

Redevelopment of Landfill Site Eysels, Turnhout, Belgium, *Bart Nevejans*, Aertssen Group, **Belgium**

Urban Solid Waste Management in Techiman Municipality (Ghana), *Gloria Ametepey*, Zoomlion Ghana Limited (B/A), **Ghana**

Flexible Energy Production through Combined Hydrogen and Methane Production at a Municipal Sewage Treatment Plant, *Marco Küppers*, University Duisburg-Essen, *Jens Schoth*, University Duisburg-Essen, *Ruth Brunstermann*, University Duisburg-Essen, **Germany**

The Role of Waste Segregation in Effective Management of Domestic Solid Wastes in Nairobi, Kenya, *Philip Nyongesa Wangia*, Kenyatta University, *Michael Koech*, Kenyatta University, **Kenya**

The Effect of Using Prefabricated Vertical Drains on Secondary Settlement, *Mohammad Al-Quraan*, Geosyntec Consultants, *Andrew Stallings*, Geosyntec Consultants, *David Espinoza*, Geosyntec Consultants, **USA**

The Role of Environmental Education and Awareness in Application of the 7R Approach of Sustainable Solid Waste Management in Nairobi County, Kenya, *Philip Nyongesa Wangia*, Kenyatta University, *Michael Koech*, Kenyatta University, **Kenya**

Sustainable Energy Generation through Wastewater: A Situation in the Urban City of Lagos, Nigeria, *Timothy Oluwagbenga Ajayi*, Ogun State Institute of Technology, **Nigeria**

Best Practices of Community Based Solid Waste Management in Panga, Kirtipur, Kathmandu, Nepal, *Nabin Bikash Maharjan*, Blue Waste to Value, **Nepal**

Effect of the Incorporation of Biomass Wastes on the Properties of Fired Clay Bricks, *Gisela Pelozo*, Facultad Regional San Nicolás - Universidad Tecnológica Nacional, *Nancy Quaranta*, Facultad Regional San Nicolás - Universidad Tecnológica Nacional, *Marta Caligaris*, Facultad Regional San Nicolás - Universidad Tecnológica Nacional, *Melisa Romano*, *Adrián Cristóbal*, **Argentina**

Life Cycle Assessment for High Solids Anaerobic Digestion of Food Waste, Yard Waste, and Biosolids, *Luiza Stolte Bezerra Lisboa Oliveira*, University of South Florida, *Deborah Stolte Bezerra Lisboa Oliveira*, University of South Florida, *Eunyoung Lee*, University of South Florida, *Eduardo Jimenez*, *Qiong Zhang*, *Sarina Ergas*, **USA**

Utilization of Selected Fungal Strains to Treat Old Landfill Leachate, *Mofizul Islam*, University of Manitoba, *Qiuyan Yuan*, University of Manitoba, **Canada**

Organic Wastes Management from Low-Cost Meals: The Educator Role of the Universities, *Liseane Thives*, Federal University of Santa Catarina (UFSC), *Gabriel Dibe Andrade*, *Ricardo Henrique Nunes*, *Pâmela Betiatto*, *Mariana Fornara Nohatto*, *Cláudio Cesar Zimmermann*, **Brasil**

Emerging Contaminants: Perfluorinated Alkylated Substances PFAS, *Harry Behzadi*, SGS, **USA**

Sustainability Improvements for the USACE Navigation Mission: Dredging Sediments LCA, *Catherine Fox-Lent*, USACE, *Matthew Bates*, USACE, *Avi Mersky*, ORISE/USACE, **USA**

Effects of Chlortetracycline on the Adsorption of 17 $\beta$ -estradiol to Natural Sorbents, *Baiyang Hu*, Beijing Normal University, *Kefeng Liu*, Beijing University of Agriculture, *Xieyang Xu*, Beijing Normal University, *Xinyi Li*, *Xuelian Zhang*, *Chengda Gao*, *Xin Tong*, **China**

An Innovative Passive Approach to Remediation at a Closed Landfill, *Laura Oakes*, EA Engineering, Science, and Technology, Inc., PBC, *Michael Hertz*, EA Engineering, Science, and Technology, Inc., PBC, *Michael Phillips*, EA Engineering, Science, and Technology, Inc., PBC, *Kari Hodgson*, **USA**

## **TUESDAY, MARCH 13**

8:00 a.m. - 5:30 p.m.

Conference check-in and registration

8:00 a.m. – 8:30 a.m.

Coffee

8:30 a.m. - 10:20 a.m.

**Sessions 5**

### **SESSION 5A**

#### ***Use of Wastes in Construction 2***

Risks and Opportunities of RDF Fuel Replacement in Cement Kilns, *Hanan Hassan El-Sersy*, Cairo University, *Mai Mohamed Kamal Fouad*, Cairo University, *Shakinaz El Sheltawy*, Cairo University, **Egypt**

Potential Use of a Local Municipal Sewage Sludge Ash as Cementitious Additives, *Ian Nordfors*, Widener University, *Xiaochao Tang*, Widener University, **USA**

Key Factors Affecting Construction Waste Recycling in China, *J. Hao*, Xi'an Jiaotong-Liverpool University, *Z. Bao*, University of Hong Kong, *Z. Chen*, Xi'an Jiaotong-Liverpool University, *W. Lu*, *K. Sikora*, *I. Galobardes*, **China**

**SESSION 5B**  
***Contaminated Sites***

Comparative Study of Environmental Parameters at Two Construction Sites under Controlled and Uncontrolled Conditions, *Khalid Iqbal*, University of Gujrat, *Muhammad Waseem Mumtaz*, University of Gujrat, *Muhammad Sohaib Ejaz*, University of Gujrat, **Pakistan**

Prediction of 1,4-Dioxane Contamination Distribution during Countermeasures at an Illegal Dumping Site by Numerical Simulation, *Kazuei Ishii*, Hokkaido University, *Atsushi Fujiyama*, Hokkaido University, *Masahiro Sato*, Hokkaido University, *Toru Furuichi*, **Japan**

Impact of Soil Texture on Contaminants around Degraded Waste Dumpsite: Case of College Road, Kaduna North-Nigeria, *Ahmed Mohammed*, Federal College of Education (Technical), *Sadiq Umar*, Ahmadu Bello University, *Zakari Ibrahim*, Ahmadu Bello University, **Nigeria**

Emerging Contaminants: Perfluorinated Alkylated Substances PFAS, *Harry Behzadi*, SGS, **USA**

**SESSION 5C**  
***Mining Wastes***

Evaluation of Economic Mineral in Gold Tailings Dams: A Case Study of the Louis Moore Tailings Dam, Limpopo Province, South Africa, *Ndivhuwo Nemapate*, University of Venda, *J.S. Ogola*, *G.E Ekosse*, **South Africa**

Mine Waste as a Resource: A Case Study of South Africa, *Humbulani Rejune Mundalamo*, University of Venda, *Jason Sammuuel Ogola*, University of Venda, **South Africa**

Resource Efficiency through Recycling Mining Wastes, *Lakshmi Raghupathy*, TERI University, **India**

Short-Term Prediction of Acid Rock Drainage from Mine Waste in the Klersksdorp Gold Field, North-West Province, South Africa, *Kawawa Banda*, University of Venda, *Jason Ogola*, University of Venda, **South Africa**

**SESSION 5D**  
***Composting and Biological Treatment 2***

A Feasibility Study on Treatment of Solid Waste Generated from Religious Places Using Vermicomposting Technique, *Nirav Shah*, The Maharaja Sayajirao University of Baroda, *Ketan Patel*, **India**

**SESSION 5E**  
***Integrated Management and Policy 2***

Household Hazardous Waste Management, *Chukwu Onu*, Southern University, **USA**

Waste Management Intervention Evaluation Using System Dynamics and Field Survey: A Case Study in a Low-Income Neighborhood in Baltimore, MD, USA, *Fengwei Hung*, Johns Hopkins University, *Benjamin Hobbs*, Johns Hopkins University, *Molly Lasater*, Johns Hopkins University, *Peter Winch*, **USA**

Enhancing Local Capacity for Solid Waste Management in Ethiopia and Worldwide, *Ranjith Annepu*, Be Waste Wise, **USA**

Model for Prediction of MSW Generation in India Using Artificial Neural Network (ANN), *Tirthankar Mukherjee*, Jadavpur University, *Rahul Baidya*, Jadavpur University, *Sadhan Ghosh*, Jadavpur University, **India**

Barriers to Implementation of Solid Waste Management Policies of Small Island Nations of the Pacific, *Ajantha Perera*, University of Fiji, *Manavi Perera*, University of Essex/ University of Cape Town, **Fiji**

Municipal Solid Waste Management in Urban Cities: Challenges and Perspectives, *Mervat El-Hoz*, The University of Balamand, **Lebanon**

10:20 a.m. – 10:50 a.m.

**Break**

10:50 a.m. – 12:35 p.m.

**Sessions 6**

## **SESSION 6A**

### ***Agricultural and Food Wastes 2***

The Brazilian Experience in the Valorization of Agro-Livestock By-Products and Production of Biofertilizers, *Marisa S. Borges*, Federal University of Parana, *Thiago Gonzales*, CIBIOGAS, *Douglas Santos*, INPI, **Brazil**

King Bhumibol's Royally Initiative Nature-by-Nature Process for Activating Digestion Period in Municipal Garbage Composting, *Kasem Chunkao*, Kasetsart University, *Thanit Pattamapitoon*, Kasetsart University, *Chulabut Chanthasoon*, The King's Royally Initiated Laem Phak Bia Environmental Research and Development Project, Chaipattana Foundation, *Surat Bualert*, *Aphichaya Taychitkunanon*, *Narumon Vongsawan*, *Sakonwan Mokatip*, **Thailand**

Phenolic Aqueous Solution Treatment Using Crude Enzyme Peroxidases from Waste Cabbage (*Brassica oleracea capitata* var. *alba* L.) Leaves, *Allan Alzona*, National University, *Joanna Clarisse Velasco*, National University, *Manny Anthony Taguba*, National University, *Thea Rodriguez*, *Mary Rose De Leon*, *Josh Evans Cariño*, *Lebbie Anne Valeriano*, *Virginia Rocabo*, **Philippines**

Potential of Campus Food Waste for Biodigestion or Direct Combustion, *Patrick Caton*, US Naval Academy, *Scotty Davids*, US Naval Academy (Formerly), **USA**

Organic Wastes Management from Low-Cost Meals: The Educator Role of the Universities, *Liseane Thives*, Federal University of Santa Catarina (UFSC), *Gabriel Dibe Andrade*, *Ricardo Henrique Nunes*, *Pâmela Betiatto*, *Mariana Fornara Nohatto*, *Cláudio Cesar Zimmermann*, **Brasil**



## SESSION 6B

### *Landfill 3*

Analysis on Potentials of Waste to Energy by Landfill Mining and Resource Recovery in Korea, *Sora Yi*, Korea Environment Institute, *YoungJoon Rhee*, Korea Environment Institute, **Korea**

Multivariate Factor Analysis as a Tool for Evaluation of Complex Groundwater Datasets for Waste Management Facilities, *Wayne Pearce*, SCS Engineers, **USA**

## SESSION 6C

### *Sludge Management*

Sewage Sludge Treated by Pyrolysis to Be Used as an Adsorbent, *Luciane Lemos do Prado*, Parana Federal University, *Vander de Freitas Melo*, Parana Federal University, *Maria Cristina Borba Braga*, Parana Federal University, *Edson Costa Jr.*, **Brazil**

## SESSION 6D

### *Special Wastes*

Cigarette Butt as Non-Biodegradable Wastes: Cause of Environmental Concern, *Shamim Ahsan*, Metropolitan State University of Denver, **USA**

Environmental Friendlier Magnesium Fuel from Liquid Waste Bittern, *Rania Ramadan*, National Research Centre, *Marwa Saied Shalaby*, National Research Centre, *Shakinaz Ali El-Sherbiny*, Cairo University, *Hanem Abdel Rahman Sibak*, **Egypt**

The “Ins” and “Outs” of EPR and Product Stewardship: Hazardous Waste & Mercury Thermostats Examples, *Lisa Skumatz*, SERA Skumatz Economic Research Associates, Inc., **USA**

12:35 p.m. – 1:35 p.m.

**Poster Session 2**

## POSTER SESSION 2

Utilization of Coal Bottom Ash as Aggregate in Clayey Mixtures, *Miguel Unsen*, Facultad Regional San Nicolás - Universidad Tecnológica Nacional, *Gisela Pelozo*, Facultad Regional San Nicolás - Universidad Tecnológica Nacional, *Marta Caligaris*, Facultad Regional San Nicolás - Universidad Tecnológica Nacional, *Nancy Quaranta*, **Argentina**

The Use of Municipal Tree Pruning and Bamboo Wastes in Bricks Production, *Barbara Bezerra*, UNESP, *Manuel Silva*, UNESP, *Rosane Battistelle*, UNESP, *Paulo Roberto O. Carvalho*, **Brazil**

An Economic, Technical and Environmental Feasibility Study for Slurry Injection for Biosolids Management in the Dallas Fort Worth Metroplex, *Yashesh Panchal*, Advantek Waste Management Services, *Ibrahim Mohamed*, Advantek Waste Management Services, *Omar Abou-Sayed*, Advantek Waste Management Services, *Nihal Mounir*, **USA**

New Zeolite Catalyst from Waste Coal Ash for Bio-Diesel Synthesis, *Omotola Babajide*, Cape Peninsula University of Technology, *Roland Missengue*, AgriProtein, *Juvet Shabani*, Cape Peninsula University of Technology, **South Africa**

Policy Implications for Sustainable Consumption and Production in India, *Lakshmi Raghupathy*, TERI University, **India**

Study of Incorporation of Gravel Drilling and the Ashes of Marc Cane Sugar in Formulations for Manufacture of Bricks Cement-Soil, *Sheyla Marques*, IFAL, *Wilson Acchar*, UFRN, **Brazil**

Energy Utilization of Municipal Solid Waste in Brazil: Technologies, Economic Viability, Barriers and Policy Proposal, *Fabio Rubens Soares*, Instituto de Energia e Ambiente da Universidade de São Paulo, *Suani Teixeira Coelho*, Universidade de São Paulo, *Javier Escobar*, Universidade de São Paulo, **Brazil**

Investigation on Workability and Strength of Geo-Polymer Concrete, *Najeb Sawsi*, Wayne State University, *Hwai Wu*, Wayne State University, **USA**

1:35 p.m. – 2:35 p.m.

**Luncheon**

2:35 p.m. – 4:25 p.m.

**Sessions 7**

## **SESSION 7A**

### ***Sludge and Wastewater Management***

An Economic, Technical and Environmental Feasibility Study for Slurry Injection for Biosolids Management in the Dallas Fort Worth Metroplex, *Yashesh Panchal*, Advantek Waste Management Services, *Ibrahim Mohamed*, Advantek Waste Management Services, *Omar Abou-Sayed*, Advantek Waste Management Services, *Nihal Mounir*, **USA**

Feasibility of Sewage Water Treatment in Skaka City Using Up-Flow Anaerobic Sludge Blanket (UASB) Reactor, *Abdalla Zakey Albahrawy*, Aljouf University, *Mohamed El-Khateeb*, Aljouf University, *Maher Al-Enazi*, Sattam bin Abdulaziz University, **Saudi Arabia**

Applicable Granule Sludge from Wastewater Treatment Process of Cassava Starch Factory for Energy Generating and Construction Materials, *Noppawan Semvimol*, Kasetsart University, *Kasem Chunkao*, Kasetsart University, *Surat Bualert*, Kasetsart University, *Siwanat Thaipakdee*, *Chulabut Chanthasoon*, *Donyarat Subwongrod*, **Thailand**

Utilization of Community Wastewater and Sewage Sludge for Economic Cropping in Phetchaburi Province, Thailand, *Onanong Phewnil*, Kasetsart University, *Noppawan Semvimol*, Kasetsart University, *Watcharapong Wararam*, Kasetsart University, *Kittichai*

*Duangmal, Nawee Chanwong, Pavin Wichittrakarn, Worakai Usa, Nontaporn Prasertkul, Wiroon Sumleeraj, Thailand*

**SESSION 7B**  
***Waste to Energy 2***

A New Approach in Dioxins and Furans Emissions by Accumulation of Precursor Compounds at Incinerators Post Fire Zone, *Marcelo Pestana Vieira, Cetrel S.A., Brazil*

Identification of Waste Potential and Location(s) for Waste-to-Value-Added Facility to Generate Heat and Electricity in the Province of Alberta, *Prashant Patel, University of Alberta, Mahdi Vaezi, University of Alberta, Amit Kumar, University of Alberta, Canada*

Evaluating Anaerobic Digestion of Source Separated Organic Solid Wastes in Hennepin County, Minnesota, USA, *Shunchang Yang, University of Florida, Jaime V. Chávez-León, University of Florida, Cesar Miguel Moreira, ESPOL, Polytechnic University, John Jaimez, Paul M. Kroening, Pratap Pullammanappallil, USA*

Assessment of Food Waste to Energy and GHG Reductions in New Jersey, *Serpil Guran, Rutgers EcoComplex, David Specca, Rutgers EcoComplex, Margaret Brennan-Tonetta, Rutgers University, USA*

**SESSION 7C**  
***Research Advances***

A Comprehensive Characterization of Plastic Waste and Effect of UV Radiation on Bacterial Breakdown of LDPE, *Ved Prakash Ranjan, Indian Institute of Technology, Kharagpur, Sudha Goel, Indian Institute of Technology, Kharagpur, India*

Recovery of Neodymium from Waste Permanent Magnets by Solvent Extraction and Supported Liquid Membrane, *Achmad Chusnun Niam, Chung Yuan Christian University, Yi-Hsien Liu, Chung Yuan Christian University, Sheng-Jie You, Chung Yuan Christian University, Ya-Fen Wang, Taiwan*

**SESSION 7D**  
***Case Studies 2***

Development of a Sustainable Municipal Solid Waste Management for an Urban Area: Case Study from a Developing Country, *Anil Kumar Gupta, IIT Kharagpur, Venkata Sai Praneeth Doranadula, IIT Kharagpur, Brajesh Dubey, IIT Kharagpur, Arundhuti Devi, Suravi Kalita, Khanindra Sharma, India*

Eco-Industrial Parks for Developing Economies, *Lakshmi Raghupathy, TERI University, India*

Material Flow in Informal Sectors – Case Studies from India, *Lakshmi Raghupathy*,  
TERI University, **India**

**SESSION 7E**  
***Recycling 2***

E-Waste Recycling in the Informal Sector of India: Findings from Case Studies,  
*Biswajit Debnath*, Jadavpur University, *Sadhan Ghosh*, Jadavpur University, **India**

Role of Informal Sector Recycling in Reduction of Greenhouse Gas Emission in  
Developing Country Cities: A Case Study in Hanoi, Vietnam, *ThaiHuyen Nguyen*,  
Hanoi Architectural University, *HoaThai Nguyen*, Ritsumeikan University, **Vietnam**

Indian Waste Regulations Amendments 2016, *Lakshmi Raghupathy*, TERI University,  
**India**

**SESSION 7F**  
***Agricultural and Food Wastes 3***

Anaerobic Process Performance Treating Swine Wastewater in Full Scale, *Woong Kim*,  
Kyungpook National University, **Republic of Korea**

Monitoring Urease, Invertase, Phosphatase and Total Enzyme Activity in Soil Amended  
with Municipal Sewage Sludge, *George Antonious*, Kentucky State University, **USA**

5:00 p.m. – 6:00 p.m.  
**Closing Reception**

**WEDNESDAY MARCH 14**

8:00 a.m. – 9:00 a.m.  
Conference check-in and registration

8:00 a.m. – 9:00 a.m.  
Coffee

9:00a.m. – 2:00 p.m.  
Technical Field Trips (choose 1)

**Field Trip 1**

**Prince Georges County Solid Waste Management Facilities:**

This tour will visit three facilities:

The organics composting facility accepts yard waste such as grass clippings, leaves, and small branches from approximately 158,000 households. The waste is ground, placed in windrows and processed into compost. Food scrap composting utilizes the Gore Cover technology which is an in-vessel aerated pile system with oxygen and temperature monitoring devices. This technology is designed to create ideal composting conditions within the pile while efficiently trapping odors and other emissions such as dust and volatile organic compounds (VOCs).

The Brown Station Road Sanitary Landfill accepts material from residents and local businesses. There is leachate pretreatment and biogas recovery.

The Materials Recovery Facility removes contaminants, separates paper by grade, segregates ferrous and aluminum containers, divides plastic by resin type and sorts glass by color. Once separated, the glass, aluminum, steel plastic and paper are baled or crushed and shipped to end markets.

## **Field Trip 2**

### **Millersville Landfill and Recycling Center:**

The Millersville Landfill & Resource Recovery Facility, located on more than 565 acres, is the only active municipal solid waste landfill owned by Anne Arundel County. Opened in September 1975, eight (8) disposal cells have been filled. The County is currently filling the ninth cell.

The active disposal cell Facility (Cell 9) is equipped with a double liner and leachate collection system. The leachate is collected at the bottom of the cell, pumped to storage tanks prior to being discharged into the County's sanitary sewer system. Ultimately, it is treated at the Patuxent Water Reclamation Facility. On average, approximately 5 million gallons of leachate is generated annually in the Cell 8 (recently closed) and Cell 9 (currently active) landfills.

Seven of the eight old disposal cells are closed and capped. The waste from one of the older cells was removed and placed in the new cell to create a stormwater infiltration pond. By regulation, these closed and capped cells are inspected and maintained as part of our post-closure care program. Groundwater monitoring wells are installed to a depth below the groundwater surface so the water can be sampled and tested for the presence of landfill-related chemicals. Ground and surface water is sampled at locations upstream and downstream of the landfill.

Landfill gas is currently captured from all landfill cells and used as fuel for electrical power generation. Electrical power is generated utilizing two Caterpillar Model 3520 engine-generators (configured to operate with methane as the primary fuel component) with a total plant output of 3.2 MW of electricity, the equivalent energy consumption of approximately 2,000 homes. At the Facility a series of blowers, collection pipes, and extraction wells are installed to collect and convey the landfill gas to the landfill gas to energy plant. The landfill gas to energy plant has been in operation since June 2012.

## **Field Trip 3**

## **Oyster Recovery Partnership Shell Recycling & Processing Operation, Horn Point Lab, Cambridge, Maryland:**

Oyster shell is the best, most natural material used to rebuild oyster reefs but it is also in short supply. In an effort to reclaim this ecologically important byproduct, the Oyster Recovery Partnership collects and recycles oyster shells from 340 restaurants in the Maryland/Virginia/Washington DC region through its Shell Recycling Alliance. Since the program's inception in 2010, more than 140,000 bushels of shell have been diverted away from the waste stream and used to build oyster reefs in the Chesapeake Bay. ORP's SRA program operates like many food waste collection companies. Each day SRA staff navigate specific routes to collect shell from participating restaurants. SRA challenges are determining the most efficient routes to collect shell, optimal containers for transport, and also with odors attributed to decomposition. Once shell is collected it's transported in flat-bed trucks or hook and go dumpsters to ORP's shell processing facility outside of Cambridge, Maryland.

### **Aging**

The raw shell is usually mixed with a variety of organic and nonorganic materials – oyster tissue, condiments, napkins, tableware, etc. It is aged in large, outdoor piles for at least one year, exposed to weather and sunlight. Most of the non-shell material is removed naturally during this period.

### **Washing**

After at least one year, loaders and bobcats move the aged shell into a hopper of a custom built, conveyor-based washing system. The shell proceeds through several steps aimed at removing any remaining materials using water and gravity. Approximately 10% of the shell is lost during this phase – brittle shell is crushed or otherwise destroyed.

### **Use**

After washing, the shell is deployed in a number of ways, depending on its ultimate use. Most of the aged, cleaned shell is loaded into large stainless steel cages, each holding approximately 20 bushels of shell. The cages are placed in large tanks situated on a pier on the Choptank River. After filling the tanks with river water, oyster larvae produced at the University of Maryland's adjacent oyster hatchery are added. The larvae attach themselves to the individual shells – on average, 8-10 larvae per shell – and the so-called spat-on-shell are then transported by boat to one of a number of nearby oyster reefs.