RÉSEAU BIOFUELNET CANADA

FROM WASTE TO WEALTH

Given a choice, **wealth** beats **waste** every time.

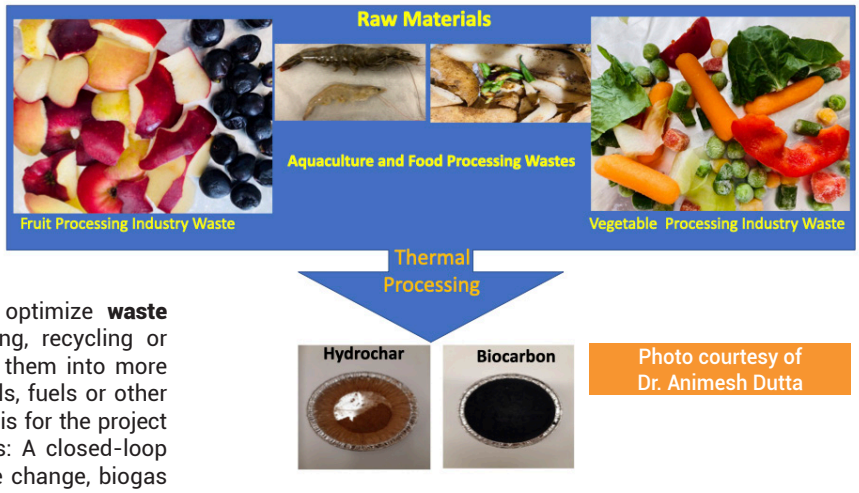

Photo courtesy of Dr. Animesh Dutta

With that in mind, researchers sought to optimize **waste valorization**, which is the process of reusing, recycling or composting waste materials and converting them into more useful products including materials, chemicals, fuels or other sources of energy. Their quest formed the basis for the project "Valorization of agricultural and food wastes: A closed-loop circular economy concept to address climate change, biogas production, wastewater management, and soil health".

"The three major challenges in the 21st century are **ensuring food security**, **adapting to and mitigating climate change**, and **finding alternate and sustainable sources of energy**." said Dr. Animesh Dutta, Professor and Director, Bio-Renewable Innovation Lab (BRIL), School of Engineering at the University of Guelph.

One promising solution is to intensify sustainable horticulture in a new generation of closed greenhouses that integrate water, energy and nutrient cycles. In Canada, the greenhouse industry generated a farm gate **value of $2.82 billion in 2015**. The challenges identified by the greenhouse industry include high energy and labor costs for heating, cooling and lighting, and waste management, especially of wastewater which is loaded with useful nutrients and sometimes harmful pesticides.

Wasting away

"Roughly **40 per cent of food is wasted in Canada every year**, which is worth about **$31 billion annually** or about 2 per cent of our GDP," said Dr. Dutta. "In addition, commercial sea and freshwater fishery production was 866,811 tons in Canada in 2015, producing a considerable amount of waste in the process."

Because food and fishery wastes, as well as closed greenhouse residues, are high in moisture, they are not suitable for other renewable energy systems. Presently, most food waste is disposed to landfill or composted, which emits harmful greenhouse gases including methane or CH_4. Consequently, the development of a sustainable and cleaner organic waste conversion technology is vital to promoting local use of biomass/waste in Canada.

To that end, this project used a **hybrid thermochemical** and **biochemical approach** (much like a pressure cooker) to produce hydrochar/activated carbon, bio-methane, and bio-fertilizer from wet biomass to simultaneously contribute to the circular economy concept. A **circular economy** is an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, **extract the maximum value** from them while in use, and recover and regenerate products and materials at the end of each service life.

"The production and use of hydrochar, bio-methane and bio-fertilizer are promising renewable resources with **low net CO_2 emissions**." said Dr. Dutta. "These resources can be economically sustainable as well if the financial, environmental and social impacts are properly managed."

In this approach, biomass first undergoes **hydrothermal carbonization** (HTC) (a process where biomass is heated at a temperature range of 200–300°C in the presence of water), **producing hydrochar and process water** (HTCPW). The HTCPW can be digested or co-digested with food waste to enhance bio-methane and bio-fertilizer production. On the other hand, hydrochar can be used either for treating the effluent from closed greenhouses, which is rich in nutrients, and used as a soil supplement, or for bioenergy.

"The wastewater can be passed through hydrochar packed columns to produce clean water and nutrient enriched hydro-char," said Dr. Dutta. "This hydrochar is then employed as a bed material in closed greenhouses, thereby reducing the use of chemical fertilizers, **lowering greenhouse gas emissions** and **enhancing economic benefits**."

Double barreled approach

A unique aspect of this envisioned approach is **polygeneration** [producing two or more marketable products from the same input] using an energy-efficient technology. This technology would **simultaneously generate heat and power**, as well as other energy products, in a single integrated process to target the **maximum recovery of bioenergy** and other potential products.

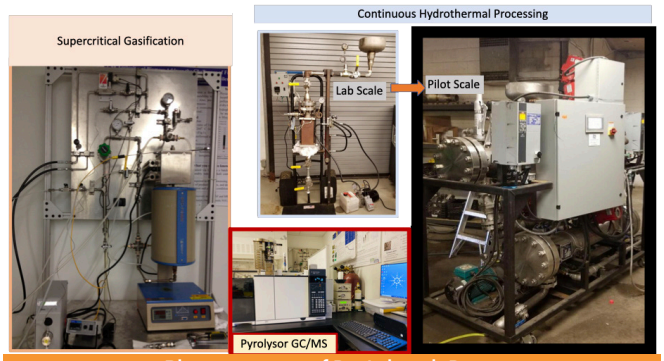

Photo courtesy of Dr. Animesh Dutta

"One of the **primary objectives** of greenhouse and aquaculture is recycling of water, which stands to benefit the most from the application of biochar in water treatment and reuse," said Dr. Ranjan Pradhan, Visiting Professor, School of Engineering, University of Guelph.

While this project would be beneficial in a variety of settings, Canada has significant advantages in bioenergy and biochemicals, based on the extent of arable land and forested areas available. Canada's waste biomass supply, which is produced from the forestry and agriculture industries, as well as municipal wastes, can be converted into bioenergy and commercially relevant biochemicals.

Timing is everything

"With the **current global scenario** of COVID-19, this processing technology can be a significant addition to all the measures taken in the new world that emerges after the pandemic." said Dr. Pradhan. "The process itself inherently heat kills all waste and effectively sterilizes any biological contaminant that may be present in the system. The co-products of the system offer added confidence for their application compared to traditional compost."

Overall, Canada's bioeconomy is estimated at **$80 billion** or **more than 6.4 per cent of GDP,** and supports more than **a million jobs**. Ontario's bioeconomy contributes **$34 billion** to Canada's GDP, and forms 41 per cent of Canada's bioeconomy. This country's bioproduct revenue reached **$1.33 billion in 2009**, with over 68 per cent of bioproduct industry revenue coming from **ethanol**, and 63 per cent of the ethanol revenue in Ontario.

In spite of those numbers, Canada's vast resources have yet to translate into a significant source of export revenue for Canadian firms. To address that disparity, this research hopes to generate **new potential revenue streams**, economic development, enhanced environmental sustainability of Canada's bioeconomy sector, and a number of highly skilled workers for a growing labour market.

"The outcome of this study will be an economic stream that ensures **agri-business sustainability**," said Dr. Dutta. "Our focus includes resource and energy conservation, soil heath and water management. Ultimately, we hope to **improve Canada's productivity and competitiveness**, advancing the agri-food sector in a transformative way by using waste from the sector to generate byproducts and use them in the production system."

The aim is to achieve **global leadership** in the field of bioprocessing and establish successful collaborations among national and international institutes, as well as with industrial partners in Ontario, for the effective transfer of HQP [Highly Qualified Personnel] to the work force. The research and engineering undertaken in this project will be specific to the kinds of inputs abundantly available from Ontario farms and food manufacturing industries.

Perhaps most importantly, this project is about something that impacts everyone: **the environment.**

"Climate change and pandemics are not regional problems; they are global issues, so making a change in one area will impact the planet as a whole," said Dr. Dutta. "Waste can be used safely as a resource to minimize the burden on landfills, create more green jobs, make companies more competitive, and position **Canada as a leader in high tech expertise**."

If it comes down to wealth versus waste, the choice is clear. As with any successful research, this project relies on a host of collaborators to make it possible, Dr. Dutta is grateful to all of them: **Biomass Canada Cluster** (www.biofuelnet.ca), **Agriculture and Agri-Food Canada**, and industry partner **(Shrimp Canada, Custom steam solutions Inc., Cindar Power Developments Inc., and IGPC Ethanol Inc)**. The total value of the Biomass Canada Cluster is **$8.3 million over 5 years** (2018-2023), with funds from both AAFC and industry partners (about $4 million).

For more information on this project, please contact:

Dr. Animesh Dutta
Ph: 824-4120 Ext 52441
Email: adutta@uoguelph.ca

Dr. Ranjan Pradhan
Email: rpradhan@uoguelph.ca

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