



PURNABRAHMA



“WASTE MANAGEMENT WASTE TO WEALTH”

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CASMB MEMBER'S ACHIEVEMENT



Mansi Kulkarni of Dough Adventures LLP had a chance meeting with Reliance Retail CEO Damodar Mall at Smart Bazaar, Mumbai, marking the placement of their products with Reliance Retail. This milestone strengthens the brand's retail footprint and consumer reach.



Glad to announce, Prollets is awarded "Best Startup – Innovative Branding and Packaging" of Poshak Anaaj Awards – Special Edition 2025.

This recognition is part of Millet Stakeholders Summit 2025 – Sustaining and Celebrating the Millet Momentum, organized by Nutrihub, ICAR-IIMR, on 15th May 2025, at T-Hub, Hyderabad.



Was invited by CMPL asia's biggest contract mfg expo to conduct a session 'Savore' on 9th July for food startups successfully guided more than 90 entrepreneurs



SS Pro showcased at the CAIT event in Navi Mumbai, earning praise from 120+ entrepreneurs and securing 8 onboardings with 5 more trials. A new partnership with a leading LinkedIn influencer (80K+ followers) is set to boost global MSME outreach. Recently, a Mumbai-based rubber manufacturer used SS Pro to recover dues, improve follow-ups, and enhance monthly closures—now expanding into sales process consulting with SS Pro.



CASMB ACTIVITIES



We are proud to share that our Chairman, Dr. Prabodh Halde, led a delegation to meet the Hon'ble Chief Minister of Odisha, Shri Mohan Charan Majhi, during his recent visit to Mumbai. The meeting was held at Hotel Trident, BKC, and focused on collaborative opportunities in the Food Processing and AYUSH sectors in Odisha.



CASMB marked its 5th Foundation Day with 'Sankalp 2025' at Mumbai's Jio World Convention Centre – a landmark event highlighting innovation, MSME growth, and export-ready breakthroughs in food, nutraceuticals, and spices!



CASMB successfully led a vibrant delegation to ProPak Asia 2025, and what an incredible experience it was! From engaging with global leaders to exploring cutting-edge innovations in food processing and packaging.



The CASMB booth saw incredible interest, meaningful conversations, and a strong presence of India's rising MSMEs. Excited for what the next days have in store!



Dr. Prabodh Halde, Chairman, CASMB, had a fruitful meeting with Hon. Shri Avinash Joshi, IAS, Secretary, Ministry of Food Processing Industries, Government of India.



CASMB, in collaboration with Chetana Institute, hosted a Member Meet that turned simple introductions into meaningful connections and future collaborations.

Dr. Prabodh Halde

Chairman
Chamber for Advancement of
Small and Medium Businesses,
CASMB



Congratulations to Purnabrahma for raising awareness on such a vital issue. This edition beautifully blends our ancient wisdom with modern sustainability efforts.

In India, the concept of “waste to wealth” is not new—it is deeply rooted in our cultural consciousness. For centuries, we have lived by the principle of minimal waste and maximum utility. This issue of Purnabrahma reminds us of that very ethos.

Let me begin with a timeless Sanskrit subhāṣita that reflects this idea:

“अमन्त्रं अक्षरं नास्ति, नास्ति मूलम् अनौषधम् ।
अयोग्यः पुरुषो नास्ति, योजकस्तत्र दुर्लभः ॥”

Meaning:

There is no syllable (word) that cannot be a mantra, no root that is not a medicine, and no person who is unfit.

What is rare is someone who can recognize and apply the right potential in the right way.

This ancient wisdom teaches us that everything has value—whether it is a syllable, a herb, or a human being. The same is true for waste. With the right vision and effort, even waste can become a source of wealth, health, and sustainability.

India's culture was built on this frugal mindset. In earlier generations, hand-me-down clothes from elder siblings were worn proudly, and textbooks were passed on joyfully. Toilets were water-saving by design—there were no flush systems. Food was treated as sacred—Annam Brahma—and any leftover were fed to cows, never thrown away.

Such practices weren't just about scarcity; they reflected respect for resources and reverence for nature.

But with the advent of the industrial revolution, this delicate balance began to shift. Mass production led to mass consumption, and with it came industrial and agricultural waste.

Today, we face a two-fold challenge: managing the sheer volume of waste and reducing its environmental impact.

One major issue is the burning of agricultural residue (parali), especially in Delhi and Punjab. This not only wastes potential biomass energy but contributes significantly to air pollution, causing respiratory issues.

Doctors have warned of the rise in cases of black lungs due to carbon-loaded air.

However, every challenge carries within it the seed of a solution.

Many NGOs, start-ups, industries, and innovators are stepping up with solutions that convert waste into wealth. Here are a few notable examples:

- 1) Biomass pellets from crop stubble are now being used in boilers and crematoriums.
- 2) Rice bran, once discarded, is today a valuable source of Rice Bran Oil, rich in nutrients.
- 3) De-oiled soy cake is now used to produce protein-rich foods like soymeal and soy protein isolate.
- 4) Bio-diesel is being produced from broken grains and waste edible oils.
- 5) Ethylene and fuel are derived from sugar factory waste, biomass, and discarded materials.
- 6) Unused lands are being transformed into bamboo plantations, offering carbon credits and livelihood the technology exists. The intent is growing. What is required now is a cultural shift.

Another Sanskrit verse that echoes this transition is:

“परोपकाराय फलन्ति वृक्षाः, परोपकाराय वहन्ति नद्यः ।
परोपकाराय दुहन्ति गावः, परोपकारार्थमिदं शरीरम् ॥”

Meaning:

Trees bear fruit for others, rivers flow for others, cows give milk for others—this body, too, is meant for the service of others.

We must begin service to our planet by shifting our everyday habits.

Segregating wet and dry waste at home, reducing plastic usage, reusing what we can, and being conscious consumers are small but powerful steps.

Encouragingly, government initiatives like FSSAI's RUCO (Repurpose Used Cooking Oil) and the Indian Food Sharing Alliance are enabling large-scale solutions. Corporate ESG targets, policies on plastic reuse, and clean fuel are gaining momentum.

Yet, the true transformation must begin from school, in our children's minds. Awareness campaigns and education can spark the change that lasts generations.

We must act now for saving our next generations

Let us commit to this new creation—where waste is not discarded but respected and transformed. Let our collective efforts leave behind a better Earth than the one we inherited.

Once again, heartfelt congratulations to Purnabrahma for highlighting this noble mission.

May this edition inspire minds, ignite innovation, and invoke action.

Thank you.

Dr. Prabodh Halde

Chairman, (CASMB)



**CHAMBER FOR ADVANCEMENT
OF SMALL & MEDIUM BUSINESSES**

Nilesh Lele

President,
Chamber for Advancement
of Small & Medium
Business (CASMB)



Transforming Waste into Wellness: Leadership in Circular Thinking

Dear Members,

As we turn the pages of this edition, themed “*Waste to Health*”, we are reminded that waste is not just a by-product—it is an untapped opportunity. From biodegradable kitchen waste becoming rich compost to bio-medical waste being responsibly neutralized, we stand at a crossroads where informed choices can transform health outcomes for individuals, communities, and our planet.

In a world increasingly defined by its consumption patterns, our greatest strength lies in our ability to rethink and reimagine. The future of waste management is not just

about disposal; it is about **designing circular systems**—where every output has a purpose and every stakeholder plays a part.

Our small and medium enterprises are uniquely positioned to lead in this area. With the right innovation, collaboration, and policy alignment, we can convert food waste into nutrition, agricultural residue into bio-energy, and packaging waste into sustainable solutions.

As a Chamber, we remain committed to facilitating dialogue, encouraging innovation, and recognizing efforts that bridge the gap between waste and wellness. Let us continue to lead with purpose—where economic growth aligns with environmental and public health priorities.

Together, let's turn waste into wealth, and more importantly, into **well-being**.

Warm regards,

Nilesh Lele

President,
**Chamber for Advancement of Small &
Medium Business (CASMB)**



PURNABRAHMA

**Nidhi Godbole
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In today's fast-paced world, the way we manage our waste will define the health of our planet and the quality of life for future generations. Waste management is not just about keeping our surroundings clean—it is about conserving resources, protecting the environment, and creating opportunities. Every item we discard has a story: the energy used to make it, the materials extracted from nature, and the potential it still holds. By segregating, recycling, and reusing, we prevent valuable resources from ending up in landfills and reduce the strain on our natural ecosystems.

Forward-thinking communities and industries have already shown that “waste” can be a

powerful economic resource. Organic waste becomes compost or bio-energy, plastics transform into building materials, and scrap metals return to the production cycle—turning what was once a liability into a source of income and innovation. This is the very essence of “wealth from waste.”

The future belongs to those who see possibilities where others see problems. If we treat waste as a raw material rather than rubbish, we can create green jobs, support circular economies, and leave a cleaner, more resource-rich world for generations to come. The choice is ours—let us be the generation that turns waste into wealth and responsibility into opportunity.

Nidhi Godbole Deshpande

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PURNABRAHMA

Dr. Umesh Kamble

Secretary
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Small & Medium Businesses
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Fostering a Culture of Responsibility: Waste Segregation Starts With Us

Dear Readers,

As we explore the powerful theme of “Waste to Health” in this issue, I am reminded that meaningful change often begins with small, consistent actions—many of which start right at our homes, workplaces, and communities.

Waste management is no longer just about disposal—it is about accountability, innovation, and health. At the heart of effective waste transformation lies segregation at source, a simple practice that holds the key to unlocking the potential of waste. When we separate biodegradable from non-

biodegradable, recyclable from hazardous, we're not just sorting garbage—we're enabling a healthier planet and a safer tomorrow.

This quarter, our focus as a collective has been on sensitizing our stakeholders about these crucial first steps. From awareness drives to community clean-ups, from promoting composting to discouraging single-use plastic, every initiative is a testimony to the fact that waste is not the enemy—our habits are.

Let us continue to champion the cause of responsible waste practices. When we treat waste not as something to discard, but as something to transform, we move closer to a vision of wellness—for ourselves, and for the generations that follow.

Warm regards,

Dr. Umesh Kamble

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Save the Planet with Waste to Wealth

Waste accumulation and pollution is one of four major environmental crises identified as critical threats to humanity, the other three being biodiversity loss, climate change and land degradation. These interconnected crises result from profound human activities.

Although consumers are increasingly aware of the environmental damage from polymeric (plastic) packaging, there remains a substantial, yet less visible, ecological impact of wasted food inside the packaging. Most recent estimates of global annual greenhouse gas generate 2.5 to 5 grams of CO₂ emissions.

Food waste and insecurity are two major challenges facing the food industry and society at large. According to the Food and Agriculture Organization, about one-third of the food produced for human consumption is lost or wasted every year, while about 690 million people suffer from chronic hunger. How can the food industry address these issues and contribute to a more sustainable and equitable food system? Strategies and practices that can help the food industry reduce food waste, improve food security and enhance its corporate social responsibility (CSR) will have important role to play.

Reducing food waste is essential for businesses not only from a moral standpoint but also in terms of economic losses, environmental impact and social inequalities. To prevent, reduce and recover food waste along the supply chain, the food industry can implement efficient inventory management and distribution systems, educate consumers and employees on proper food handling and disposal, donate surplus food to charities and food banks,

compost organic waste or convert it into biogas or animal feed and collaborate with other stakeholders to develop standards, policies and initiatives to tackle food waste. The most effective mechanism of action will depend on the company's proximity to food waste generation. Food companies involved in production and processing have various proven ways to reduce food waste, including via donating safe, fresh food items that do not meet retailer standards, composting or generating biogas from others, just to mention a few. Other companies also have tested ways to reduce food waste within their own organization and they can look at best practices in many corporates like that of Toyota North America and like. Toyota Company is directly sourcing food products, especially at scale, can make waste minimization a criteria when selecting suppliers, creating a powerful waste reduction incentive in its supply chain.

Many factories, discharges millions of gallons of wastewater daily—sewage, industrial waste and runoff, into the rivers leading to sea, making it the dominant source of coastal pollution in the region. The study conducted examines how such wastewater influences coastal aerosols by tracking spatial gradients from near the border. Using benzoylecgonine (a nonvolatile cocaine metabolite) as a sewage tracer, it found that wastewater compounds—including a mixture of illicit drugs, drug metabolites and chemicals from tyres and personal care products—become aerosolized and are detectable in both water and air. Spatial analyses confirm that most measured chemicals concentrate in aerosols near the various rivers, potentially exposing local populations to tens of nanograms per hour via inhalation of octinoxate and methamphetamine. This airborne pathway highlights a largely overlooked source of atmospheric pollution, emphasizing the need to reassess health risks in coastal regions as global water contamination continues to escalate.

Our CASMB family members will have to work in the direction of Zero waste and if not at least for Waste to Wealth, enabling not only fulfilling the social obligation but also to enhance their profitably. Further advocating for policies that support the reduction of food waste and enhance food security is a supportive measure in the direction of "Save the Planet". ■

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Biological Waste and Wealth

Nikita Kansara

**Microbiologist &
Nutritionist**

(Mumbai)



India is a big country with a large population. Every day, we create huge amounts of waste from our homes, farms, factories, and markets. Much of this waste is biological waste, which means it comes from plants, animals, or food. For example, vegetable peels, fruit skins, leftover food, crop stalks, cow dung, and even dead leaves are all biological waste.

As a microbiologist, I study tiny living organisms called microbes such as bacteria and fungi. These tiny creatures are nature's cleaners. They help break down biological waste into useful materials. In India, if we use these microbes wisely, we can turn waste into wealth like compost, fuel, electricity, and even plastic alternatives!

Let me take you through how India can solve its waste problems and also make money from it using the power of microbes.

What is Biological Waste?

Biological waste is anything that comes from living things and can rot or decompose naturally. This includes:

- **Kitchen waste** – vegetable peels, tea leaves, leftover food
- **Agricultural waste** – wheat straw, rice husk, sugarcane bagasse
- **Animal waste** – cow dung, chicken litter, fish market waste
- **Human waste** – sewage and toilet waste
- **Plant waste** – fallen leaves, grass cuttings, etc.

In India, we generate millions of tons of biological waste every year. Sadly, much of this waste is not managed properly. It ends up in landfills or is burnt in the open, causing pollution and health problems.

But here's the good news, this waste can be turned

into something valuable with the help of microbes! Microbes: Nature's Little Helpers

Microbes are tiny living things you cannot see without a microscope. They are found everywhere in soil, water, air, and even inside our bodies. Certain microbes can eat and break down biological waste. They change it into useful things like:

- **Compost (organic fertilizer)**
- **Biogas (a clean fuel)**
- **Bio-plastic (eco-friendly plastic)**
- **Bio-enzyme (natural cleaner)**
- **Protein for animals and fish**

Let's explore how this works in India.



1. Composting: Turning Kitchen and Garden Waste into Soil Food

In many Indian cities and villages, people throw away food scraps and garden waste. But these can be turned into compost a natural fertilizer using microbes. In compost bins, bacteria and fungi break down the waste into a dark, earthy material. This compost is full of nutrients and makes plants grow better. It reduces the need for chemical fertilizers. Many households in India now use composting bins. Cities like Pune, Mysore, and Indore have large composting centers that use market and kitchen waste.

2. Biogas: Clean Cooking Fuel from Waste

In rural India, cow dung is often used as fuel. But we can use microbes to make this process better. In biogas plants, bacteria break down cow dung and food waste without oxygen (anaerobic digestion). This produces biogas mainly methane which can be used for cooking or lighting. The leftover material, called slurry, is a great fertilizer. Thousands of biogas plants run in Indian villages. Even cities like

Bengaluru and Bhopal are using big biogas plants to manage market and kitchen waste.

3. Agricultural Waste to Biofuels

In states like Punjab and Haryana, farmers burn crop leftovers (like wheat straw) after harvest. This causes severe air pollution, especially in Delhi. But this waste can be turned into bioethanol, a clean fuel for vehicles. Microbes like fungi and bacteria break down plant fibers and turn them into sugar, which is then fermented into alcohol. India is now building biofuel plants to use this crop waste. A big plant in Panipat, Haryana, is already converting stubble into fuel reducing pollution and giving farmers extra income.

4. Animal and Fish Market Waste to Fertilizer and Enzymes

Fish markets, meat shops, and poultry farms create smelly, rotting waste. If left open, it causes disease and pollution. But microbes can convert this waste into bio fertilizers or enzymes used in soaps, medicines, and the food industry. For example, in Kerala and Tamil Nadu, small plants use fish waste to make liquid fertilizer for farms. This not only solves the waste problem but also creates new products.

5. Single Cell Protein: Food from Waste

Did you know that certain microbes can be grown on food waste or molasses to produce high-protein food for animals and fish? These are called single-cell proteins (SCP). Microbes like Spirulina and Fusarium grow fast and have lots of protein. They can help reduce the cost of fish feed and poultry feed. India is now exploring this in aquaculture (fish farming) and poultry farms.

6. Bio plastics: Microbes Making Plastic from Waste

Plastic is a big problem in India. It does not break down easily and pollutes rivers and soil. But scientists have found microbes that can make biodegradable plastic from food waste and sugar waste. This plastic breaks down naturally and is safe for the environment. Startups in India are now making bags and packaging from bio-based materials, thanks to microbes.



Benefits of Turning Biological Waste into Wealth

- **Reduces Pollution** – Less burning, less landfill, cleaner air and water
- **Creates Jobs** – In composting units, biofuel plants, recycling centers
- **Improves Soil** – Compost and bio fertilizer make land more fertile
- **Saves Energy** – Biogas and biofuel are renewable sources
- Promotes Clean Cities and Villages – Better hygiene, fewer diseases

Even though we have the science, there are some problems:

- Waste is not separated – Wet and dry waste get mixed in homes
- People lack awareness – Many still throw waste on the road or burn it
- Poor infrastructure – Some compost or biogas units are not maintained well
- Lack of support – Small businesses working in this area need more help

But with the right education, support from government, and use of science, these problems can be solved.

What Can You Do?

- Segregate waste – Keep kitchen waste separate from plastic and paper
- Compost at home – Use a small bin to compost your food waste
- Support local recycling – Buy compost or biogas from local units
- Say no to single-use plastic – Choose bio-based alternatives
- Spread awareness – Teach others about microbes and waste recycling

Conclusion

Biological waste is not a problem; it is a gift if handled properly. In India, we have millions of tons of waste, but we also have millions of microbes ready to help us.

As a microbiologist, I truly believe that microbes are India's silent soldiers. They can clean our cities, protect our environment, and create wealth from waste. We just need to work with them, not against them.

Let us build a cleaner, greener India using science, microbes, and a little bit of care from every one of us.

— Written by a Microbiologist — turning rot into resource, one microbe at a time. 

Waste Management – “Waste to Wealth”

**Chef Sumit
Ghadiyali**

Brand Consultant and
Executive Chef, (Pune)



“Waste to Wealth: In easy words, it is transforming discarded materials into valuable resources”

The "Waste to Wealth" concept is a brilliant approach that:

1. Reduces waste disposal
2. Conserves natural resources
3. Promotes sustainability
4. Generates economic opportunities
5. Mitigates environmental pollution



COCONUT SHELL

By converting discarded materials into valuable products or resources, we can create a more circular and regenerative economy. This approach has the potential to transform waste management and create new opportunities for innovation and growth.

The benefits of Waste to Wealth are multifaceted:

1. **Environmental Conservation:** By reducing landfill waste, conserving natural resources, and decreasing greenhouse gas emissions, we can protect the planet.

2. **Economic Opportunities:** Creating new industries, jobs, and revenue streams from waste materials can boost local economies.



ALUMINIUM TIN

3. **Resource Efficiency:** Encouraging efficient resource use reduces waste generation, saving resources for future generations.

4. **Innovation:** Fostering innovation in waste management, product design, and manufacturing can lead to new technologies and sustainable solutions.



WATER BOTTLE

These benefits highlight the potential of Waste to Wealth initiatives to drive positive change.

Waste to Wealth initiatives can take many forms, including:

1. **Recycling:** Converting waste materials like plastics, metals, and paper into new products.
2. **Composting:** Turning organic waste into nutrient-rich fertilizers.
3. **Energy Generation:** Producing energy from waste through waste-to-energy plants or biogas generation.
4. **Up cycling:** Transforming waste materials into new products of higher value or quality.

These examples demonstrate the potential for waste materials to become valuable resources, reducing waste disposal and promoting sustainability.



WASTE SEGREGATION

Key Waste-to-Wealth Initiatives

- 1. **Circular Economy:** Encourages businesses to adopt circular economy models, designing products for reuse and recyclability.
- 2. **Waste Segregation:** Implementing effective waste segregation systems to facilitate recycling and proper disposal.
- 3. **Product Design:** Designing products with recyclability, reusability, and sustainability in mind.
- 4. **Community Engagement:** Educating communities about the importance of waste reduction, segregation, and recycling.

These initiatives work together to reduce waste, conserve resources, and create a more sustainable future.

Challenges and Opportunities

- 1. **Infrastructure:** Developing adequate infrastructure for waste collection, segregation, and processing.
- 2. **Public Awareness:** Raising public awareness about the importance of waste reduction and proper disposal.
- 3. **Technological Innovations:**
Developing innovative technologies for waste management and conversion.
- 4. **Policy Frameworks:** Establishing supportive policy frameworks to encourage

Waste-to-wealth initiatives.



PAPERCUPS

Conclusion

The waste-to-wealth concept offers a promising solution to environmental and economic challenges. By adopting sustainable waste management practices, encouraging innovation, and promoting community engagement, we can transform discarded materials into valuable resources. As we move forward, it's essential to prioritize waste reduction, recycling, and sustainable practices to create a more circular and regenerative economy.

Future Directions

- 1. **Investing in Waste Management Infrastructure:** Developing modern waste management facilities and technologies.
- 2. **Promoting Circular Economy:** Encouraging businesses to adopt circular economy models and design sustainable products.
- 3. **Raising Public Awareness:** Educating communities about the importance of waste reduction and proper disposal.
- 4. **Fostering Innovation:** Supporting research and development of new waste-to-wealth technologies and initiatives.

By working together, we can unlock the potential of waste-to-wealth initiatives and create a more sustainable future for generations to come.



NEWSPAPER



Meet our new friend from MIT USA

It was my fruitful day when I had a special occasion to meet personally Dr Sanjay Basu on 3rd August 2025. His Oracle Blog is...<https://sanjaysays.com>.



Dr. Sanjay Basu

Dr. Prakash Kondekar with Dr. Basu

A Technical Deep Dive

Dr. Sanjay Basu is Senior Director of AI/ML Oracle Cloud Engineering. He is a distinguished technology leader with over 30 years of experience in the industry. He is an industry-recognized subject matter expert in Artificial Intelligence, Machine Learning and Quantum Computing. He has double masters in Computer Science and Systems Design. His PhD was in Organizational Behaviour and Applied Neuroscience. Currently, he is pursuing his second PhD in AI. His focus of research is Retentive Networks. Dr. Basu is also the author and editor of Ethics in AI collection, author of Web 3 books. One can check out Dr. Basu's technical deep dive about Augmenting Prompt OPS with Partner Products: A Comprehensive Framework for Input-Output Guardrails in Large Language Models.

Dr Sanjay focuses on the advanced services like Generative AI, Machine-Learning, GPU Engineering, Block chain, Micro services, Industrial IoT, 5G core along with Cloud Security and Compliance. He has double masters in Computer Science and Systems Design. His PhD was in Organizational Behaviour and Applied Neuroscience. Currently, he is pursuing his second PhD in AI. His focus of research is Retentive Networks.

As a recognized expert in the field, Dr. Basu is a Life Member of prestigious professional organizations, including the Association for Computing Machinery (ACM), the Association for the Advancement of Artificial Intelligence (AAAI), the American Association for the

Advancement of Science (AAAS), and the Institute of Electrical and Electronics Engineers (IEEE). He is also a Fellow of the Institution of Electronics and Telecommunication Engineers (IETE).

Beyond his leadership roles, Dr. Basu is a prolific writer, having authored five technical books and numerous insightful blog articles. His contributions to technological advancements are further underscored by his six U.S. patents. His thought leadership and expertise in AI, cloud computing, and technology infrastructure are widely recognized in the academic and professional communities.

A few books authored by Dr Basu...

- Responsible Leadership... Bite-sized articles on various management topics leading to a blueprint for Responsible Leadership.
- Unravelling QBism for the Uninitiated... A Deep Dive into Quantum Bayesianism: With One Math Equation.
- Digital Haunts & Other Disturbances.

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Waste Management: Waste to Wealth - A need of the hour

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Introduction

“Waste management” involves the collection, transport, treatment, and disposal of waste. It also includes efforts to reduce waste generation and encourage recycling and reuse. The rapid pace of industrialization and urbanization has led to an exponential increase in waste generation worldwide. However, modern waste management is no longer about merely collecting and disposing of waste, it is about recognizing waste as a resource. The concept of “Waste to Wealth” refers to converting waste materials into useful products, energy, or income. This sustainable approach not only addresses environmental challenges but also creates economic opportunities and jobs.

The world is generating more waste than ever, driven by population growth, urbanization, and consumption patterns. According to one estimate, India produces over 150,000 tonnes of municipal solid waste (MSW) daily, with less than 30 percent treated. Globally, waste is projected to rise by 70% by 2050. Traditional disposal methods. Open dumping and poorly managed landfills harm the environment, pollute water and soil and contribute to greenhouse gas emissions.

However, now the concept is shifting. Earlier, what was considered garbage is increasingly seen as a resource...a potential source of energy, materials, jobs, and innovation. The concept of “Waste to Wealth” reframes waste management: it's not just about disposal, but about recovery, transformation, and value creation.

Why Waste-to-Wealth Matters

1. Environmental Protection: Proper waste processing prevents air, water and soil contamination.
2. Public Health: Decentralized, clean management reduces carriers for diseases and limits exposure to hazardous waste.
3. Climate Action: Composting and waste-to-energy systems cut methane gas emissions from landfills.
4. Economic Opportunity: Circular economy models generate new industries, jobs, and revenue streams, turning challenges into growth.

Key Waste-to-Wealth Strategies

A. Source Segregation & Recycling

Segregating waste at origin is a foundation for downstream recovery.

for example..

SWaCH Cooperative (Pune):Kerala's Zero-Waste Cities:Recykal (Hyderabad):

B. Organic Waste Valorization

Food and green waste are processed into compost, biogas, and biofuel.

Village Composting (Uttar Pradesh): Over 22,000 gram panchayats implement door-to-door organic waste collection for sales of compost.

Biogas/CNG Plants: BPCL's, CBG plant in Bilaspur will treats 100 tonnes of solid waste, yielding clean-fuel CBG, creating many jobs.

Muttathara Sewage STP (Kerala): Using Gates Foundation-backed Omni processor technology, it will convert sludge into electricity and potable water.

C. Waste-to-Energy & Biomining

Advanced treatments convert waste into energy and recover resources from legacy dumps. e.g. Trichy Bio mining:

Timarpur-Okhla WtE (Delhi): Industrial Fuel from Waste

D. Upcycling & Circular Entrepreneurship

Turning discarded items into value-added products.

Plastic Weaving (Dharavi, Mumbai): Artisans,

especially women, make woven bags and décor from plastic scraps, exported globally...empowering hundreds of women.

Iro Iro (Jaipur):

Converts fabric scraps into handcrafted apparel, diverting tonnes of material and aiding local artisans

Phool / HelpUsGreen (Kanpur): Collecting temple flower waste, processed into incense and vermicompost, recycling it.

E. Tech-Enabled Formalization

Digital platforms bring transparency and scale to informal sectors.

Nepra (Ahmedabad): Builds dry-waste value chains

Recykal: Offers an EPR-compliant platform serving brands and aggregators across 30+ states.

Protoprint (Pune): Uses plastics from SWACH to produce 3D-printing filaments .

● Policy Framework & Mission-Driven Initiatives

Waste to Wealth Mission (Office of PSA, GOI): Promotes zero-waste urban centers through innovation, community engagement, and technology validation .

Swachh Bharat & Solid Waste Management Rules (2016): These national guidelines have catalyzed institutional support: composting pits, decentralized recovery units in many villages and ULB-led initiatives .

Case Studies: Impact & Lessons

● Indore – Cleanest Indian City

From 25th rank in 2017 to 1st for eight consecutive years, Indore's transformation is driven by: 100% waste segregation

GPS-tracked garbage van fleet Compost and fuel facilities for green waste Thousands of sweepers, color-coded bins, CCTV enforcement: Community engagement: pledges, school programs, and public pride

● Nashik – Slump to Revamp

After scrapping underused waste-to-energy machinery, Nashik repurposed a plant into a CNG-from-waste facility, showcasing flexibility in tech adoption.

● Tribal & Village Models

Borchila (Assam): Transforms aquatic weeds into handicrafts

Garden Estate (Gurgaon): Showcases 5–10% landfill output through meticulous segregation into 22 categories .

Challenges on the Path

Despite progress, several hurdles remain:

- Weak Segregation Systems:** Many cities fail at source separation, impeding downstream treatment .
- Informality:** Fragmented supply chains and exploitation of waste pickers persist; platforms like Nepra and Recykal seek to formalize .
- Economic Constraints:** Innovative technologies (e.g. gasification) often demand high capital and energy.
- Behavior & Awareness:** Public apathy requires sustained education, enforcement, and pride-building.
- Tech Failures:** As with Nashik's waste-to-energy plant, technology must be appropriate and feedstock consistent .

To scale “Waste to Wealth,” several actions are essential:

- **Enable community engagement:** Empower cooperatives and village task forces.
- **Promote modular technology:** Biogas/CNG units for communities and institutional generators.
- **Strengthen decentralized infrastructure:** 100% coverage by regional recovery centers.
- **Regulatory clarity:** Expand EPR, incentivize compost sales, and standardize recovery
- **Support public-private partnerships:** Encourage

TECHNICAL ARTICLE

investment in scalable facilities via mission programs.

- Awareness campaigns: Education in schools, civic media and celebrations, awards for cleanliness milestones.

Conclusion

“Waste to Wealth” is not just a slogan; it is a powerful approach to transforming environmental liabilities into economic assets. By reimagining waste as a resource, societies can drive sustainability, create jobs, and build resilient economies. The future lies in adopting a circular model where nothing is wasted and everything has value. “Waste to Wealth” is a systemic thought. From Pune's waste-pickers to Indore's cleanliness leadership, from CNG plants to floral upcycling, India is charting a path where garbage becomes resource, livelihood and pride. The journey demands technological touch, policy coherence, behavioural

change, and inclusive economy. But the reward...clean environments, vibrant communities and sustainable growth are profound. As the country and world move toward zero-landfill visions, “Waste to Wealth” shines as a transformative principle for both people and planet.

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Green Chemistry: The Path to Sustainable Innovation

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Green chemistry not merely as a scientific discipline but as an ethical imperative, it represents a transformative approach to how one thinks about chemistry—moving from a focus on yield and efficiency alone, to a broader consideration of environmental responsibility by waste reduction, sustainability and human health. It challenges one to reimagine the role of chemists: not just as creators of new compounds but as stewards of the Earth. The twelve principles of green chemistry serve as a blueprint for innovation that minimizes waste, reduces toxicity, and conserves energy and resources. These are not just academic ideals—they are essential practices that must become second nature to the next generation of chemists.

Green chemistry is not a limitation on creativity but a powerful framework that drives innovation. Whether through developing biodegradable polymers, designing safer solvents or creating more efficient catalytic systems, green chemistry fosters smarter, cleaner and more sustainable solutions.

Principles of Green Chemistry

Paul Anastas and John Warner in 1998, coined words, Green Chemistry. Principles of Green Chemistry serve as a foundation for scientists and industries

Prevention of Waste: It is more efficient and **cost-effective to prevent waste** from being produced in the first place than to deal with waste after it has been generated.

- **Atom Economy:** Chemical processes designed such to maximize incorporation of all materials used in the process into final product, minimizing waste and improving efficiency.

- **Less Hazardous Chemical Syntheses:** Avoid using substances that are toxic to humans or environment.
- **Designing Safer Chemicals:** Chemical products should be designed to be effective yet non-toxic, reducing any potential harm to human health and the environment.
- **Safer Solvents and Auxiliaries:** Wherever possible, hazardous solvents or reagents should be eliminated or replaced with safer alternatives.
- **Energy Efficiency:** Chemical processes should be designed to minimize energy consumption, ideally operating at room
- **Renewable Feedstocks:** Chemicals should be derived from renewable resources rather than finite fossil fuels, reducing the depletion of natural resources.
- **Reduce Derivatives:** The use of unnecessary chemical derivatives (such as protecting groups) should be minimized, as they often generate waste and require additional resources.
- **Catalysis:** Catalytic reactions, which require fewer reagents and energy, should be preferred over stoichiometric reactions, as they are more efficient and produce less waste.
- **Design for Degradation:** Chemical products should be designed to degrade into harmless substances after their useful life cycle to prevent long-term pollution.
- **Real-Time Analysis for Pollution Prevention:** Analytical tools should be used to monitor chemical processes in real-time, allowing for the detection and prevention of pollutants before they are produced.
- **Inherently Safer Chemistry for Accident Prevention:** The chemical process should be designed to minimize the potential for accidents, such as explosions, fires, or toxic exposures.

Applications of Green Chemistry

Green chemistry has had a profound impact on a variety of industries, from pharmaceuticals to materials science. Below are some key examples of how green chemistry principles have been applied in real-world scenarios

- **Pharmaceutical Industry**

The pharmaceutical industry is one of the most important sectors where green chemistry principles are being applied. Drug synthesis typically involves numerous chemical reactions, often requiring toxic solvents and generating waste. By utilizing green chemistry techniques, pharmaceutical companies can reduce the environmental footprint of drug manufacturing.

For example, the use of solvent-free reactions or supercritical fluids (like supercritical carbon dioxide) has reduced the need for organic solvents, which are often volatile and hazardous. Additionally, green catalysts are being explored as alternatives to traditional metal catalysts, which can be toxic and expensive.

- **Renewable Energy**

Green chemistry is at the forefront of developing cleaner energy solutions. One of the major areas of focus is the development of biofuels derived from renewable sources such as algae, corn, and even agricultural waste. These biofuels offer a more sustainable alternative to fossil fuels, which contribute significantly to climate change.

In addition to biofuels, green chemistry is also being used to develop photovoltaic cells and batteries that are more energy-efficient and less harmful to the environment. For example, the development of organic solar cells, which use carbon-based materials, presents a promising alternative to traditional silicon-based solar cells, offering lower costs and potentially more sustainable production methods.

- **Green Synthesis of Nanomaterials**

Green chemistry has played a significant role in the development of sustainable methods for the synthesis of nanomaterials. Traditional methods for synthesizing nanoparticles often require toxic chemicals or high energy inputs. However, green chemistry encourages the use of biological routes (such as plant-based synthesis) or low-energy methods to reduce the environmental impact.

- **Agricultural Chemicals**

Pesticides and herbicides are essential in modern agriculture but often come with significant environmental and health risks. Green chemistry aims to develop eco-friendly pesticides that are

less toxic to humans, animals, and the environment. Techniques such as targeted delivery systems and bio-based pesticides are being explored as safer alternatives to traditional chemical pesticides.

Challenges in Green Chemistry

Despite its many advantages, the widespread adoption of green chemistry faces several challenges.

- **Economic Viability:** Many green chemistry processes, especially those involving renewable feedstocks or alternative solvents, can be more expensive than conventional methods. This creates a barrier for industries to transition to greener practices, particularly in sectors where profit margins are tight.
- **Scalability:** While laboratory-scale green chemistry experiments are often successful, scaling up these processes to industrial levels is not always straightforward. The challenges of maintaining cost-effectiveness, efficiency, and sustainability at a larger scale can be significant.
- **Public Awareness and Education:** Green chemistry is still a relatively niche field, and there is a lack of widespread understanding about its principles and benefits. Education and outreach efforts are necessary to increase awareness among consumers, policymakers, and industries.
- **Regulatory Aspect:** The regulatory framework for green chemistry is still evolving. In some cases, existing regulations do not account for the specific benefits or challenges posed by green chemistry innovations. This can slow down the adoption of greener processes or make it difficult for new green products to enter the market.

The Future of Green Chemistry

The future of green chemistry is promising, with ongoing research and development paving the way for new sustainable practices. Key areas of focus for the future include:

- **Biomaterials and Biodegradable Products:** The demand for environmentally friendly alternatives to petrochemical-based products is expected to continue growing. Green chemistry will play a crucial role in developing new materials that are biodegradable, renewable, and non-toxic.
- **Circular Economy:** Green chemistry aligns with

the concept of a circular economy, where products are designed to be reused, recycled, or biodegraded. The focus will be on designing products and materials that are part of a closed-loop system, reducing waste and the need for virgin resources.

- **Carbon Capture and Utilization:** Green chemistry may hold the key to developing technologies for capturing and utilizing carbon dioxide (CO₂), a major greenhouse gas. By transforming CO₂ into useful products, such as chemicals or fuels, green chemistry could provide a way to mitigate climate change while creating valuable resources.
- **AI and Green Chemistry:** AI can be used to predict the best chemical reactions, identify new catalysts, and design greener products more efficiently.

Conclusion

By focusing on waste reduction, renewable resources, and safer products, green chemistry is helping to create a more sustainable future in doing so **we also contribute meaningfully to the health of our planet.**

While challenges remain, the growing recognition of its importance and the continuous advancements in research and technology suggest that green chemistry will play an increasingly central role in shaping the industries of tomorrow.

The principles of green chemistry offer a pathway to a more sustainable, cleaner, and healthier world. As industries continue to embrace green chemistry, we can look forward to a future where chemistry works in harmony with nature, fostering innovations that benefit both people and the planet.

Note: The article was written under guidance of CASMB Advisor **Dr Prakash Kondekar.** 



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DECLARATION



- The contents of this issue is referred and compiled from various sources and Purnabrahma doesn't claim it's authenticity.
- The contents given in the article are the views of the respective authors.

Waste to Wealth for Health

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It is disheartening to see so much effort goes into producing food-from Farmers and growers, to manufacturing and selling, go in the bin many times. It is a terrifying situation.

It is important to note that improving nutrition in the early years of a child's life can enhance the health and reduce the food inequalities and have long-term benefits for economic growth. However, many parents across the globe struggle to access or afford nutritious food for their children and themselves. Waste to wealth for Health will be important step from the point of reducing waste to zero and improving the Health of a nation.

Food companies involved in production and processing have various proven ways to reduce food waste, including via donating safe, fresh food items that do not meet retailer standards, composting or generating biogas from others, just to mention a few.

One of the example is Grape pomace is, what's left after the juice has been squeezed out of a grape—skin, seeds, stems and pulp. Some of the pomace can be repurposed in applications like fertilizer or compost but most of it is wasted. Given that 20% to 25% of grapes' weight ends up as pomace after wine is made and global wine production is around 244 million hectoliters that's a lot of waste Grape pomace contains catechin, quercetin, kaempferol, trans-cinamic acid, rutin, malvidin and delphinidin also showed cardioprotective role at concentration between, 0.25 and 2mg/100 gm of phenolic compounds. Resveratrol impacts obesity is commonly found in food and drinks, including red wine and grapes. Grape extracts have a potent antimicrobial activity in vitro. The antimicrobial activity of plant

extracts is the base of their potential application in food preservation agents, pharmaceuticals, cosmetics, alternative drugs and natural therapies. Pure resveratrol and grape pomace extracts of red variety are useful. Resveratrol and red grape pomace extract have a very good antimicrobial activity against Gram-positive bacteria when compared with bacteria in yeasts.

Reducing food waste is essential for businesses not only from a moral standpoint but also in terms of economic losses, environmental impacts and social inequalities and improvement of the society. Surplus food to charities and food banks, compost organic waste or convert it into biogas or animal feed and collaborate with other stakeholders to develop standards, policies and initiatives to tackle food waste.

The most effective mechanism of action will depend on the company's proximity to food waste generation. Many companies have tested ways to reduce food waste within their own organization and they can look at best practices in many corporates like that of Toyota North America and like. Toyota Company is directly sourcing food products, especially at scale, can make waste minimization a criteria when selecting suppliers, creating a powerful waste reduction incentive in its supply chain.

Many factories, discharges millions of gallons of wastewater daily—sewage, industrial waste and runoff—into the rivers leading to sea, making it the dominant source of coastal pollution in the region. The study conducted examines how such wastewater influences coastal aerosols by tracking spatial gradients from near the border. Using benzoylecgonine as a sewage tracer, it found that wastewater compounds—including a mixture of illicit drugs, drug metabolites and chemicals from tyres and personal care products—become aerosolized and are detectable in both water and air which are threats to human health. Spatial analyses confirm that most measured chemicals concentrate in aerosols near the various rivers, potentially exposing local populations to tens of nanograms per hour (e.g., octinoxate and methamphetamine) via inhalation. This airborne pathway highlights a largely overlooked source of atmospheric pollution, emphasizing the need to reassess health risks in coastal regions as global water contamination continues to escalate.

Advocating for policies that support the reduction of food waste and enhance food security is a supportive measure in the direction of "Save the Planet".

It is important to focus on few chemicals for which standards are available that represent different common categories expected in sewage, wastewater and runoff, including personal care products, tires, illicit drugs, pharmaceuticals, metabolites and biocides which are chemical or biological substances designed to control or eliminate harmful bacteria, viruses, fungi and algae for prevention of health hazards.

Green chemistry discusses the engineering concept of pollution prevention and [zero waste](#) both at laboratory and industrial scales. It encourages the use of economical and ecocompatible techniques that not only improve the yield but also bring down the cost of disposal of wastes at the end of a chemical process which is the need of the people at large. It also helps in maintaining health of a society and planet.

The field of Waste management is undergoing a major transformation thanks to a range of innovations that address efficiency, environmental impact and scalability.

Now, Smart Waste Management Systems use IoT (Internet of Things), sensors and data analytics to optimize collection and sorting with sensors to monitor fill levels, using real-time data to streamline waste collection routes, cutting emissions and costs. AI-based analytics, helps municipalities and companies track waste generation patterns and improve recycling rates. Automated systems using AI-powered robots and machine vision are revolutionizing material recovery facilities.

Advanced Thermal Treatment (ATT) for incineration are cleaner and more efficient for lower emissions than traditional incineration. Biological processes and organisms are being used to degrade or transform waste. Blockchain for Waste Tracking ensures transparency and traceability in the waste lifecycle.

Autonomous vehicles can handle collection in fixed routes or private facilities

“Waste to Wealth” is a powerful concept that reimagines waste as a resource rather than a burden. It's central to the circular economy where materials are kept in use for as long as possible through reuse, repair, recycling and recovery. They could be in turn good for human health. It is important to see how waste is being turned into wealth across sectors saving materials and energy and creating jobs. Converts non-recyclable waste into biogas and electricity for heat or fuel. Reduces methane emissions.

“Waste to Wealth to health” is not just an environmental solution—it's an economic opportunity. By leveraging technology, innovation and sustainable development. It improves the Environmental Health in turn of the people. Municipalities adopting decentralized composting and stricter solid waste rules will be a part of Swachh Bharat Abhiyan.

Hospital waste or healthcare waste or medical waste, refers to all waste materials generated by healthcare institutions, including hospitals, clinics, laboratories and research facilities. Proper disposal is critical for preventing the spread of infections, protecting public health, and safeguarding the environment.

Hospital waste is categorized into several types, like, Infectious waste, pathological waste, sharps waste, pharma waste, chemical waste, radioactive waste and general waste.

Best Practices for Hospital Waste Management are necessary.

Environmental & Health Risks of Improper Disposal can spread Hepatitis B/C and other diseases. Environmental pollution: toxic chemicals, air emissions, contaminated water. Injury to waste workers and public. Antibiotic resistance due to pharmaceutical residues.

Countries typically have laws and standards, such as: Biomedical Waste Management Rules (India).WHO Guidelines on Safe Management of Wastes from Healthcare Activities

The waste to wealth mission of Govt of India, aims at the strengthening the waste management system in India by identifying and validating innovative technology solutions and model to achieve a zero landfill and zero waste nation.

The wealth created from waste recycling can be reinvested in: Clean technologies, Public health infrastructure, Nutrition and food security programs, Reduced pollution directly improves environmental and human health, Cleaner air and water from reduced landfill and incineration. Organic agriculture, using compost boosts food quality. Employment and income from green jobs support mental and physical health. Reduced disease burden from improper waste disposal.

Thus “Waste to Wealth for Health” can be ideal concept for India as a sustainable development goal. 

Turning Food Waste into Wealth: Sustainable Food Waste Management in India

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1. Introduction

Food waste is not merely a logistical inefficiency but a multi-dimensional challenge that affects nutrition security, resource conservation, climate action, and economic equity. India must treat food waste management as a strategic priority to build a sustainable, resilient, and just food future. The concept of “Turning Food Waste into Wealth” aligns with India's goals for sustainable development, inclusive growth, and ecological responsibility. Through technology, innovation, policy support, and community engagement, food waste can be converted into a driver of nutrition, employment, and environmental resilience.

2. Food Waste: Definition and Its Global and Indian Context

2.1 Definition of Food Waste

Food waste refers to the edible parts of food that are discarded, lost, or uneaten, typically along the food supply chain—from production and processing to retail, hospitality, and households. It is a subset of food loss, which also includes unintentional losses during agricultural production and post-harvest handling.

2.2 Global Definitions

The Food and Agriculture Organization (FAO) defines food waste as: “The discarding or

alternative (non-food) use of food that is safe and nutritious for human consumption along the entire food supply chain, from primary production to end household consumer level.”

The United Nations Environment Programme (UNEP) differentiates:

Food loss: Occurs during production, post-harvest, and processing stages.

Food waste: Occurs at the retail and consumer levels due to behavioral or logistical issues.

2.3 Global Context of Food Waste



(Source: UNEP Food Waste Index Report 2021)

According to the UNEP Food Waste Index Report (2021), an estimated 931 million tonnes of food is wasted globally each year, amounting to approximately 17% of total

global food production. Of this, 61% occurs at the household level, 26% in food service, and 13% at the retail stage. The environmental consequences are severe, as food waste contributes to 8–10% of global greenhouse gas emissions and leads to the inefficient use of land, water, labor, and energy resources. Economically, it represents an annual loss of nearly \$1 trillion in value. This widespread wastage stands in stark contrast to the reality that nearly 800 million people around the world suffer from chronic undernourishment, highlighting a profound imbalance in the global food system.

2.4 Indian Context of Food Waste

India generates approximately 68.8 million tonnes of food waste annually, with estimates from the Ministry of Food Processing Industries and FSSAI indicating that 30–40% of food produced in the country is either lost or wasted. Key contributors to this waste include post-harvest losses resulting from inadequate cold chain systems and poor infrastructure, as well as significant plate waste in households, weddings, hotels, and religious gatherings. This situation is particularly troubling given the country's high rates of undernutrition—over one-third of Indian children are stunted, as reported in NFHS-5—reflecting the stark contradiction of widespread food waste in a food-insecure nation. The issue directly undermines India's progress toward Sustainable Development Goals, particularly SDG 2 (Zero Hunger) and SDG 12 (Sustainable Consumption and Production).

3. Waste to Wealth Concept in Food

'Waste to Wealth' in the context of food refers to the strategic transformation of food waste—whether it occurs during production, processing, distribution, or consumption—into valuable resources such as compost, bioenergy, animal feed, or even new food products. It is a practical and sustainable solution to address both the problem of food wastage and the pressing need for environmental conservation, economic efficiency, and food security.

4. Approaches to Food Waste Management

4.1 Reduction at Source

- Consumer awareness campaigns (portion control, meal planning).
- Food labelling awareness (e.g., 'Best Before' vs. 'Use By').

4.2 Redistribution

- Food recovery networks (e.g., Feeding India, Robin Hood Army).
- Role of FBOs (Food Business Operators) in redistribution.

4.3 Recycling and Valorization

- Composting and vermicomposting at household/institutional level.
- Anaerobic digestion and biogas production.
- Conversion into animal feed, biofertilizers, or industrial inputs.

4.4 Innovations in Circular Economy

- Startups and social enterprises turning waste into packaged products, bioplastics, etc.
- Role of food tech and blockchain in managing inventory and reducing loss.

5. Exemplars of Promising Value-Added Products

5.1 Isolation of Prebiotics from Horticultural Waste

Prebiotics are non-digestible food ingredients (primarily oligosaccharides or fibers) that beneficially affect the host by selectively stimulating the growth of beneficial gut microbiota.

Sources include banana peel, citrus peel, mango seed kernel, apple pomace, orange peel, and sugarcane bagasse. Techniques such as enzymatic hydrolysis, membrane filtration, ultrafiltration, and fermentation are used to extract oligosaccharides like FOS and GOS.

Applications include functional foods, nutraceuticals, and symbiotic formulations. The global prebiotics market is projected to

surpass USD 8 billion by 2030, offering scope for rural biotech clusters and ingredient-focused startups.

5.2 Enzyme Production from Agro-Horticultural Waste

Enzymes are essential in food, pharmaceutical, textile, and biofuel industries. Suitable substrates include apple pomace, grape marc, wheat bran, sugarcane bagasse, and potato peel.

Using solid-state fermentation with microbial strains like *Aspergillus* and *Bacillus*, enzymes like amylases, cellulases, proteases, and pectinases can be extracted.

These enzymes serve purposes like fruit juice clarification, bakery applications, animal feed enhancement, and detergent formulation.

5.3 Use of Bagasse and Spent Food Products

Sugarcane bagasse, composed of cellulose, hemicellulose, and lignin, is used to produce biodegradable packaging, bioethanol, biochar, and pulp products.

Spent grain, tea waste, and coffee grounds are valuable for animal feed, mushroom substrate, and high-fiber food products. They can also yield antioxidants and bioactive pigments.

Entrepreneurial use cases include startups producing eco-packaging (e.g., from bagasse), snack products from spent grain, and biofertilizers from composted food residues.

6. Opportunity for Job Creation and Entrepreneurship in Waste-to-Wealth Models

India's food waste management sector presents a significant untapped potential for generating employment and fostering entrepreneurship, particularly within the framework of the circular economy. As the country grapples with mounting food waste—estimated at 68 million tonnes annually—transformative solutions not only mitigate environmental harm but also create avenues for livelihood generation across rural and urban settings.

6.1 Entrepreneurial Opportunities

Food Recovery and Redistribution Startups: Social enterprises and NGOs such as Feeding India, No Food Waste, and Robin Hood Army have demonstrated scalable models of collecting surplus food and redistributing it to the needy.

Composting and Organic Fertilizer Units: Micro-enterprises can be established to produce compost or vermicompost from segregated food waste.

Biogas and Bioenergy Generation Plants: Entrepreneurs can establish small-scale biogas units using kitchen waste from hostels, hospitals, and temples.

Manufacturing from Upcycled Food Waste: Startups are converting food waste into bioplastics, textiles, or packaged products.

6.2 Job Creation across the Value Chain

- Collection and Segregation Workers
- Trainers and Awareness Campaign Staff
- Tech-Enabled Roles

6.3 Empowering Women and Youth

Women's self-help groups (SHGs) and youth-led cooperatives can be capacitated to run compost units, manage food banks, or lead awareness campaigns.

6.4 Government and Policy Support

Schemes such as Startup India, PM Formalization of Micro Food Processing Enterprises (PMFME), and Swachh Bharat Mission can be leveraged to access seed capital, technical support, and market linkages.

7. Policy and Regulatory Landscape in India for Food Waste Management

India faces a dual challenge of widespread food insecurity and substantial food waste. Addressing this requires a coherent policy and regulatory framework involving multiple stakeholders at the central, state, and local levels.

7.1 Food Safety and Standards Authority of India (FSSAI)

Established under the Food Safety and

Standards Act, 2006, FSSAI is the apex regulatory body for food safety and quality in India.

Key Initiatives by FSSAI:

1. 'Save Food, Share Food, Share Joy' campaign
2. Draft Regulation on Surplus Food Distribution (2019)
3. EAT RIGHT INDIA movement
4. Facilitation of food recovery networks and food banks

7.2 Ministry of Consumer Affairs, Food & Public Distribution

This ministry manages food security through the Public Distribution System (PDS) and food grain buffer stocks.

7.3 Ministry of Environment, Forest and Climate Change (MoEFCC)

MoEFCC regulates the environmental aspects of food and organic waste through:

1. Solid Waste Management Rules, 2016
2. Plastic Waste Management Rules, 2016
3. National Action Plan on Climate Change (NAPCC)

7.4 Ministry of Agriculture & Farmers Welfare

This ministry focuses on minimizing post-harvest losses and improving agri-logistics through schemes like MIDH, NFSM, and PMKSY.

7.5 Ministry of Housing and Urban Affairs (MoHUA)

MoHUA promotes urban waste management via Swachh Bharat Mission – Urban (SBM-U), Model Solid Waste Bylaws, and city-based cleanliness rankings.

7.6 Policy Coherence and Integration Challenges

Despite multiple agencies, policy coherence remains a challenge due to fragmented responsibilities, limited enforcement, and inadequate incentives.

8. Conclusion

Food waste management, when strategically harnessed, presents a powerful tool for inclusive and sustainable wealth generation in India. By turning waste into compost, energy, feed, or products, India can not only reduce environmental degradation but also empower entrepreneurs, farmers, and marginalized communities. A well-designed waste-to-wealth ecosystem supports not just economic growth, but also nutrition security, climate resilience, and social equity. □

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Waste Management: From Ritual Residue to Regenerative Resource – A Case Study on Om Sai Nirmalya Nirmulan Kendra in Mumbai, India

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Urban waste management, in developing nations, is a big civic issue. It is witnessing a paradigm shift towards sustainable and decentralized practices, with Nirmalya Nirmulan Kendra, Mumbai. Among India's overlooked huge waste streams is nirmalya floral offerings used in religious rituals. This study examines a Mumbai-based NGO's initiative which transforms sacred organic refuse into nutrient-rich compost through community engagement and spiritual stewardship. Using a qualitative case-study approach, this paper presents the environmental, cultural, and policy-level implications of ritual waste disposal in a socially and economically useful way. Findings underscore the role of faith-aligned ecological models in creating scalable waste-to-wealth solutions.

Urban Solid waste mismanagement poses escalating challenges in crowded urban spaces in India. One of the big sources of such wastes; Ritual Waste (nirmalya) in temples/during festivals; despite being biodegradable, often contaminates water bodies during religious immersions (Gupta & Arora, 2020). The symbolic offerings of devotion become agents of ecological degradation when unmanaged/mismanaged. Yet, culturally integrated waste models remain underexplored. This paper assesses a novel

framework led by social worker and environmentalist, Sanjeev Said that effectively converts nirmalya into organic wealth.

A qualitative, single-case design was employed to examine the operational ecosystem of Nirmalya Nirmulan Kendra (Patton, 2015). Secondary data from vernacular and national newspapers, media recognitions, and NGO documentation were analyzed thematically. Supplementary observations from public interviews and local community coverage added depth to the narrative. The interview conducted with the Proprietors provided firsthand in-depth analysis of the actual process being followed.

Religious waste remains marginal in formal waste literature. The value of spiritual waste is not well documented in urban policy around the world (Wilson, Velis, & Cheeseman, 2006). Studies within Indian contexts (Sharma & Singh, 2019) suggest religious leaders and NGOs can play transformative roles in urban ecological movements. The concept of circular economy has increasingly permeated solid waste discourse, offering promising intersections between culture, spirituality, and sustainability.

Welingkar Institute of Management Development and Research, Mumbai alumnus (MBA, 1997), transitioned from accounting into environmental social work in 2004. Witnessing the post-festival waste crisis prompted his founding of Om Sai Nirmalya Nirmulan Kendra. The NGO was formally registered in 2014, with the BMC from 2015-2021 at Malad East, Mumbai on Nirmalya Mukti - a Project dedicated towards holy flowers waste management of Ganesh festivals.

The symbolic transformation of nirmalya into compost reflects a harmony between seva (service) and prakriti (nature). Unlike industrial composting, this model taps spiritual behavioral anchors, enhancing voluntary citizen engagement (Sarkar & Debnath, 2021). The waste-to-wealth framework acquires a unique dimension when culture is positioned as a co-driver of sustainability. It not only cleans the environment but also enhances spirituality by converting offerings to deities into nutrients for mother earth, thereby maintaining the sacred nature of the whole cycle intact. This provides innovative ways of civic waste disposal, serving as a model to look at urban waste as a source of wealth instead of a burden.

Yet, despite its potential, religious waste management has long remained on the periphery of public discourse. The NGO driving this initiative faces two

significant challenges: limited funding support, and low levels of public involvement and enrollment. This underscores the need for collective action. Citizens, institutions, and donors must come forward to strengthen this movement, especially given its unique role in addressing a niche yet vital dimension of sustainability. Through shared responsibility and conscious participation, this model offers an inspiring pathway—one that merges tradition with transformation and faith with environmental stewardship.

To conclude, the efforts of Om Sai Nirmalya Nirmulan Kendra illuminate the potential of aligning environmental stewardship with cultural traditions. By rechanneling devotional remnants into regenerative assets, the initiative paves a path for future-ready, eco-conscious cities. It shows a way to look at solid waste as a potential resource rather than a municipal burden. It provides just a model and opens doors for many other possible models such as fragrance production from flower wastes, using them as fuel in power generation, etc. Waste, when processed with wisdom and reverence, becomes a blessing, not a burden.

Declaration... The authors declare that the case study is based on publicly available records, media citations, and secondary data. No human subjects were involved in the primary research.

Acknowledgement... The author(s) extend heartfelt gratitude to Prin. L. N. Welingkar Institute of Management Development and Research, Mumbai, for their continued encouragement and nurturing of socially responsive scholarship and practice-based learning. The author(s) further extend heartfelt gratitude to Founder of Om Sai Nirmalya Nirmulan Kendra, Mumbai, for sharing valuable insights into the process of waste-to-wealth enterprise.

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Waste to Wealth: Empowering Communities through Clean Solutions

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One Man Trash Is Another Man Treasure-

This ancient insight beautifully expresses the transforming potential of the waste to movement. Communities all across the world are showing that what was once rejected can be reused to provide income, respect, and sustainability.

Waste refers to materials that are no longer suitable for use. It is any substance that is discarded after fulfilling its primary purpose or is considered worthless or defective (World Bank, 2018; OECD, 2001). In contrast, a byproduct is a secondary output of lesser economic value, generated alongside the main product during production processes (Britannica, n.d.; UNEP, 2013). While waste is commonly seen as a burden or a problem to be managed, a growing paradigm shift now views it as a valuable resource, a raw material, and even a catalyst for community development.

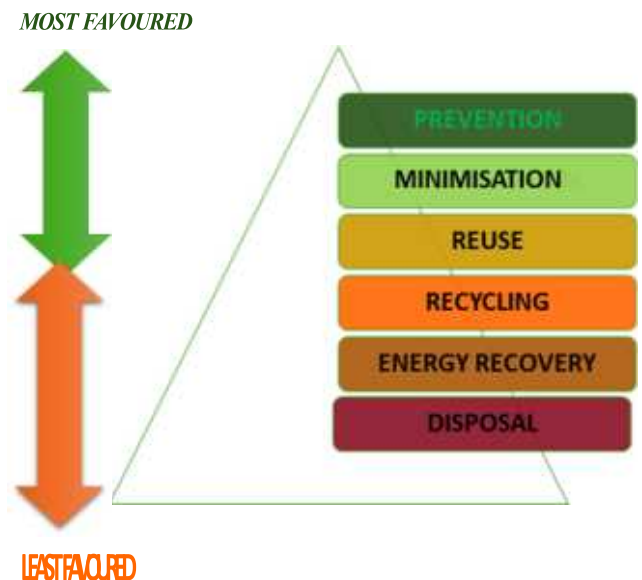
In an increasingly urbanized and environmentally degraded world, waste is often considered one of the

biggest dangers to sustainability. Plastic pollution, toxic pollutants, overflowing landfills, and poorly managed garbage are commonplace in many regions of the world, particularly in low- and middle-income nations (World Bank, 2018; UNEP, 2013). Waste to riches is a fascinating idea that is receiving international attention amid this worsening crisis. This strategy goes beyond recycling. It places a strong emphasis on using innovative, inclusive, and sustainable solutions to empower communities. The objective is to turn garbage into a useful resource that protects the environment, boosts local economies, and helps people (Ellen MacArthur Foundation, 2020; OECD, 2001).

What Does “Waste to Wealth” Really Mean?

Waste is redefined as a productive input in the waste to wealth model. Reusing, recycling, upcycling, composting, or energy recovery are methods of obtaining value from trash. This strategy encourages the circular economy, which minimizes waste through clever design and effective recovery methods and keeps things in use for as long as practicable. Most importantly, waste to wealth is a social and economic opportunity that strengthens communities, generates employment, and advances climate action. It is not merely a technological or industrial solution.

Fig 1: Waste Hierarchy Pyramid



Communities in the Heart of Waste Transformation:

Across the globe, communities are taking the lead in transforming trash into money, often in creative and inspirational ways. People power is at the heart of the

movement, which includes self-help organizations, waste pickers cooperatives, green entrepreneurs, and local startups.

What Can Be Done With Different Types of Waste?

1. Pune, India: The Swachh Model- One of the most significant examples is Pune's Swachh cooperative. Swachh, founded in collaboration with the Pune Municipal Corporation, empowers nearly 3,000 waste pickers, the majority of whom are women from communities with limited resources. These workers gather, separate, and recycle domestic junk, making a decent living while keeping the city clean. The model is decentralized, inexpensive, and repeatable. It saves the city crores in waste management costs while decreasing landfill consumption. Workers benefit from higher wages, social security, and communal recognition.
2. Hasiru Dala, Bengaluru- What it does: It is a social enterprise that educates, organizes, and employs informal waste pickers to help with solid waste management. Impact: Over 10,000 rubbish pickers have received formal recognition, safety equipment, ID cards, and a consistent wage. They provide door-to-door collection, composting, and dry trash recycling. Significance: It empowers marginalized workers and promotes circular waste practices.

Communities into Transformation:



Advantages beyond Hygiene:

Environmental Gains-

Clean Air, Water, Soil

Encourages Entrepreneurship in local

Economic Value- Recycled materials reduce production costs

Educates Citizens about Sustainable Living

The road is not without obstacles, despite the promising vision:

The majority of families continue to mix wet and dry garbage, proving inadequate waste segregation methods at the home level. Furthermore, there is a lack of support for informal workers, as waste pickers frequently work in hazardous and unclean situations without proper safety precautions or recognition. Technological gaps also restrict effective waste management, with many locations missing even basic waste treatment equipment and infrastructure. Furthermore, social behaviour resistance remains a big challenge, as changing the public's understanding of waste takes time, and implementation of policies, particularly in smaller communities, is disorganized and poor.

Overcoming the Roadblocks: Practical Solutions

EMPOWER INFORMAL WASTE WORKERS

BETTER POLICY MANAGEMENT

AWARENESS CAMPAIGN

BRIDGE THE TECHNOLOGICAL GAP

Conclusion: If we handle waste properly, it can be a source of wealth.

Waste presents a social and economic opportunity that has yet to be realized, making it more than just an

environmental issue. Communities may take the lead in creating a cleaner, greener, and more just society if they are equipped with the right information, resources, and assistance.

The waste-to-wealth path is full of joy, from compost piles in villages to plastic upcycling in cities, from the dignity of ragpickers to the inventiveness of startups. It demonstrates that real sustainability starts at the local level, where individuals change not only trash but also their own prospects.

The next time you discard anything, consider whether it is a waste or a disguised kind of riches.

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Waste Management: Waste to Wealth

Dr. Rachana Patil

Associate Professor &
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S. P. Mandali's Prin. L. N.
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Waste to Wealth: Transforming Trash into Treasure

In today's fast-paced world driven by consumption, convenience, and relentless urbanization, one undeniable truth confronts us all — **waste is everywhere**.

From landfills overflowing with garbage to oceans choked with plastic, our throwaway culture has reached alarming levels. Yet, within this grim reality lies a powerful and hopeful idea: **waste doesn't have to be the end of the story, it can be the beginning of something valuable**.

Welcome to the era of “**Waste to Wealth**”, where garbage is no longer just rubbish but a **resource** a raw material that, with a bit of creativity and innovation, can be turned into energy, food, and even economic opportunity.

The Global Waste Crisis: A Growing Concern

Globally, we generate a staggering 2.3 billion tonnes of municipal solid waste (MSW) every year. That number is expected to balloon to 3.8 billion tonnes by 2050, driven by population growth, consumerism, and urban expansion. Shockingly, only about 25% of this waste is currently managed in an environmentally responsible manner.

And it's not just household trash we're talking about. Each year:

- 275 million tonnes of plastic waste is produced.
- 57 million tonnes of e-waste is generated loaded with toxic metals and chemicals.

This unmanaged waste has a domino effect, triggering

land, air, and water pollution, hurting biodiversity, and significantly contributing to climate change.

India's Waste Landscape: A Nation at the Crossroads

India finds itself grappling with this global crisis on a national scale. Currently, the country generates about 62 million tonnes of waste per year, translating to roughly 170,000 tonnes every single day. By 2030, that number could more than double to 165 million tonnes, and by 2050, potentially reach an astonishing 435 million tonnes per year.

While collection efforts have improved almost all waste is collected, only about half is treated. The rest ends up in landfills, open fields, or water bodies, leading to a cascade of health and environmental issues.

Take plastic waste, for example. India generates 9.3 million tonnes annually, much of it ending up in waterways and soil, slowly breaking down into harmful microplastics.

The writing is on the wall: India must shift from linear “use-and-throw” models to circular, regenerative systems that prioritize reduction, reuse, recycling, and resource recovery.

The Environmental Impact of Waste: More Than Just an Eyesore



Improper waste management doesn't just create messy streets or smelly landfills. It creates a toxic chain reaction:

The Role of Responsible Citizens: Small Actions, Big Impact While policies and infrastructure are crucial, citizens play a vital role in reversing the tide of waste mismanagement. Here are meaningful steps we can all take: 1. Reduce, Reuse, Recycle (3Rs) Be mindful about what you consume. Buy only what you need. Reuse items. Recycle responsibly through formal channels. 2. Segregate Waste at Source Separate wet (biodegradable) waste, dry (non-biodegradable) waste, and hazardous items. Follow color-coded bin guidelines provided by local municipalities. 3. Compost Organic Waste Home composting can significantly reduce the burden on landfills while producing nutrient-rich soil for plants. 4. Say No to Single-Use Plastic Carry reusable bags, water bottles, and containers. Choose alternatives like jute, cloth, steel, and glass. 5. Dispose of E-Waste Properly Use e-waste collection centers. Never throw old gadgets, batteries, or cables into general trash. 6. Participate in Clean-Up Drives Join local or community-led clean-up efforts in your neighborhood, parks, or beaches. 7. Spread Awareness Educate children, staff, and neighbors about waste segregation and eco-friendly practices. Use social media as a tool for change. 8. Avoid Littering Carry your waste if bins aren't available. Teach others to do the same. Every small action adds up. Collectively, we can change the culture from careless disposal to conscious living. Turning Trash into Food: An Innovative Experiment of Mushroom Farming. Now, let's look at a real-world example of the “waste to wealth” philosophy in action right in the heart of Mumbai.	In an innovative urban farming initiative, PGDM- Rural Management program of WeSchool in collaboration with the Consulate of the Kingdom of the Netherlands, established a Mushroom Lab using coffee grounds a common urban waste product mixed it with paddy straw to grow oyster mushrooms. The Concept: Circular Economy in Action In line with the circular economy model, the project repurposes coffee waste often dumped into the garbage to cultivate mushrooms, a highly nutritious food. Coffee grounds, when mixed with paddy straw, provide an excellent growing medium for mushrooms. This approach does three things at once: 1. Reduces organic waste in cities. 2. Produces healthy food in small urban spaces. 3. Creates business opportunities for entrepreneurs. From Research to Reality: How the Lab Works Indoor lab was set up at the WeSchool campus in Mumbai, marking the first such initiative in a B-school setting in India. Students were trained in oyster mushroom cultivation, gaining practical and entrepreneurial skills. Key insights: • Mushrooms grew successfully on the coffee ground + straw mixture. • Fresh mushrooms sell for ₹600–₹700 per kg. • Dried mushrooms (easier to store and transport) sell for ₹4000 per kg highlighting significant value addition. This project doesn't just stop at the lab. It envisions a full value chain from waste collection to market-ready, high-value food products. Mushrooms: Smart Food for Smart Cities In the quest for sustainable, nutritious, and easily cultivable food sources, mushrooms emerge as a clear winner. Packed with protein, dietary fiber, B-vitamins, and powerful antioxidants, mushrooms are a nutritional powerhouse—ideal for meeting the dietary needs of urban populations. Beyond their health benefits, mushrooms can be cultivated in compact, low-tech spaces using agricultural waste, making them a perfect fit for urban farming. Promoting mushroom consumption not only supports
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health and immunity but also addresses food security, livelihood creation, and waste recycling. It's time we recognized mushrooms not just as a delicacy but as a **smart food solution** for today's health-conscious, resource-stretched urban world.

Scalable Impact: A Business Opportunity for the Future

The implications of this model are far-reaching:

- Urban homes can set up small mushroom farms using kitchen waste.
- Startups can build supply chains for waste collection and mushroom retail.
- Municipalities can incorporate this into their waste-to-resource programs.
- Schools and colleges can introduce practical sustainability education.

By turning something as mundane as coffee waste into a high-value food product, this initiative bridges environmental sustainability with entrepreneurship.

Conclusion: Future Worth Cultivating

The transformation from waste to wealth is not just an idea, it's a necessity. As population and consumption rise, the pressure on natural resources and ecosystems will only grow. But with the right mindset, policies, and citizen action, we can flip the narrative.

The Mushroom Lab is a shining example of how even small spaces and simple materials can create big change. It's not just about mushrooms or coffee it's about rethinking our relationship with waste.

As individuals, we must **reduce, reuse, recycle, and reimagine**. As communities, we must collaborate. And as a country, we must invest in models that close the loop where waste becomes food, pollution becomes profit, and problems become possibilities.

After all, in the right hands, even **trash can become treasure**.

Acknowledgement

The author extends heartfelt gratitude to Prin. L. N. Welingkar Institute of Management Development and Research, Mumbai, and the Consulate of the Kingdom of the Netherlands for their invaluable infrastructure and financial support, and for their continued encouragement of practice-based learning. □



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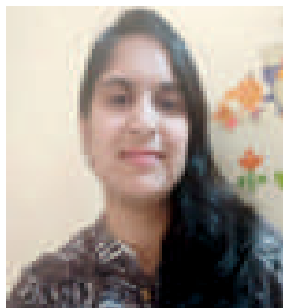


With Purnima Niranjan Karhade, owner of Soul Food India, in Frisco Texas, who sales only Maharashtrian Foods(फक्त मराठी खाद्य पदार्थ). २१-०६-२०२५, International Yoga Day.

Zero-Waste on Your Plate: How Kitchens Can Heal the Planet

Ms. Asha S Byahatti

Proprietrix- Login Health Services



Introduction:

Let's talk food—not just the delicious dishes we eat, but what we throw away in the process. Ever peeled a potato and tossed the skin straight into the bin? Or cut off the stalk of a bunch of coriander without thinking twice? You're not alone. We've all done it. But here's the thing: our kitchens are powerful places, and if we just shift our thinking a bit, they can actually help heal the planet.

The idea I'm talking about is called **zero-waste cooking**—and it's exactly what it sounds like. It's about using up as much of your ingredients as possible, from peel to stem; so that we're not letting valuable food (and nutrients!) goes to waste. And honestly, it's not as complicated as it sounds.

Why Should We Even Care?

We're living in a time where food waste is a serious problem. Across the world, millions of tons of perfectly usable food get dumped into landfills every year. **Average Food Waste in India:** Indian households waste approximately **50–55 kg of food per person annually**, amounting to over **68 million tonnes** of food waste each year.

Wasted food = wasted water, energy, labor, and packaging. And when it ends up in a landfill, it breaks down and releases methane—a greenhouse gas that's even more harmful than carbon dioxide. A study by Anna University's CCCDM finds that **biodegradable waste** in Chennai's landfill sites produces **28,870 tonnes of methane annually**, accounting for **52% of total methane emissions** in Tamil Nadu.

So, imagine if each of us simply used more of what we already buy? Not only would our dustbins stay emptier, but our grocery bills might shrink too. Plus, the Earth would thank us.

So, what's This “Peel-to-Stem” Thing?

It's simple: Instead of tossing out the parts of vegetables and fruits we usually discard, we use them creatively in cooking. Think of ridge gourd tops in chutneys, pumpkin peels in sabzi, or watermelon rinds in subzi/stir fry/soups.



The use of watermelon rind in various dishes

Yep, that stuff you've been trashing? Turns out it's totally edible and often loaded with nutrition.



Ridge gourd peels chutney is an amazing idea to enhance nutritionally

I know, I know. It may sound strange at first. But this isn't some new-age fad. Our grandmothers have been doing this forever—making chutneys with ridge gourd peels or using banana stems in traditional recipes. Somewhere along the way, convenience and packaged food made us forget these little hacks.



Beetroot pulp after extracting juice & steamed banana peels for subzi

It's Not Just About Waste—it's About Wellness:

Let's not forget that a lot of those “unwanted” bits we throw away are nutrient-dense. For example:

- Banana peels are great for digestion and rich in fiber.
- Coriander stems have the same vitamins and antioxidants as the leaves.
- Vegetable peels often have more nutrients than the inside pulp.



Vegetable stem/peel herb crisps, don't throw them away!

So, by going zero-waste, we're not only saving food but also adding health boosters to our meals. It's a win-win.

Can It Be Achieved in Everyday Life?

Of course! You don't need a fancy kitchen or new recipes. It only takes a little planning and curiosity.

Achieving Zero Waste in Cooking



This is a good starting point, even once a week. You'll be astonished at how fulfilling and imaginative it is.

From Home Kitchens to Home Businesses:

What's so exciting is the potential for this concept to

become a movement. Schools can host cooking competitions with no waste. It can be a wonderful weekend activity for families.

Local communities can share peel-to-stem recipes in the same way that they do Diwali food. When children learn early on that no part of the food should be wasted, they become more conscious and mindful. And let's be honest: this world could use more of that.

However, it's not always simple. Let's face it, changing habits requires work. At initially, not every member of your family might be on board. You might worry about taste, hygiene, or even what others will think.

That's okay. Start small. Try one idea at a time. And keep the conversation going. The more we talk about sustainable cooking, the more normal it becomes.

But Hey, It's Not Always Easy:

Let's be real—it takes effort to change habits. Not everyone in your family may be on board at first. You might worry about taste, hygiene, or even what others will think.

That's okay. Start small. Try one idea at a time. And keep the conversation going. The more we talk about sustainable cooking, the more normal it becomes.

Here's My Tiny Unit:

You don't need to be flawless. However, each time you decide to repurpose a portion of your food rather than discarding it, you're making a greater impact. An atmosphere that is cleaner, a more nutritious dinner, a smarter lifestyle.

Therefore, take a moment the next time you are holding that bottle gourd peel or carrot top in your hand. "Can I use this?" you ask. The response may surprise you.

"Our kitchens are where change begins, not factories."

Let's make cooking with zero waste a way of life rather than just a challenge. Peel by peel, let's cook, share and inspire.

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Fruit Processing Waste - Potential Source of Wealth and Health

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Indian Scenario of the Fruit processing Industry

India is the third largest producer of fruits in the world, next to Brazil and USA with an annual production of 33 million tonnes... It is world's largest producer of bananas, papaya, mangoes and guavas. Fruit spectrum also includes exotic fruits like jackfruit, sapota, custard apple, litchi, pomegranate and pineapples. Per capita Fruit consumption in India is around 30-31 kg per annum, as against the recommended intake of 146 kg per annum. Although India is reported to produce 227 kg of fruits and vegetables per capita per annum, a significant quantity (4.6-15.9%) is wasted during harvesting, storage, and transport due to the inherent perishable nature of the produce. This causes economic loss to the producer, wastage of valuable nutrients, and also leads to environmental pollution. At present, major consumption is as fresh fruits and hardly 2% goes for processing. Processing waste has high pollution index with high BOD load (0.85-10 Kg/ton) and COD (1.4-14.3 Kg/Ton). Except for recovery of citrus peel oil and mango kernel fat in some units, most of the waste is used as cattle feed, or is left for natural degradation,

In near future, production of fruits is expected to increase by more than 4 times, and fruit processing sector is marked for rapid growth in domestic, as well as export market. MOFPI offers incentives to support investments to reduce wastage levels with adequate infrastructure (cold chain, processing infrastructure), innovative on farm preservation systems, new technology for food processing and packaging, and skill development.

Waste is generated at two major stages.

1. **Pre-processing waste** is generated during harvesting, handling, transport, storage and marketing. Fruits fallen due to storm, unexpected rains are not marketable. It also includes the spoilage during storage and transport, before it reaches the consumer. Pre-processing losses account for almost 30% of the total loss. This is attributed to seasonal fluctuations, lack of proper infrastructure like on farm storage and transport, and unorganised marketing.
2. **Waste during processing** is generated at various stages like sorting, cutting, peeling, pulping, etc. and mainly includes peels, seeds, kernels and pomace. Fruits differ in the structure, and the quantum and nature of waste processing produced during is highly variable (Table 1)

Wealth from Waste concept --It is obvious from Table 1, that the fruit processing waste contains valuable components like cellulose, hemicellulose, lignin, pectin, sugars, proteins, essential oils, pigments and flavouring substances. Hence, this waste can be considered as a resource for recovery of these nutrients and chemicals, and reduce pollution load. This calls for application of 3R strategy as follows -

1. **Reduce**, 2.**Recover** 3. **Regenerate**

The aim is holistic eco-friendly process to maximise recovery of nutrients, minimise losses, and reduce pollution index

Table 1:- Waste generation during processing of different fruits

S.No	Fruit	% on wet basis	Type of Waste	Composition
1	Mango	35-45	Peel Kernel	Fiber, pectin, carotenes Starch and fat and proteins
2	Citrus fruits	45-60	Peel Pomace Seeds	Fiber, Pectin, essential oil, Fiber, sugars, pigments Fiber and oil
3	Apple	20-30	Peel Pomace Seeds	Fiber and Pectin Pectin, sugars Fiber and oil
4	Pineapple	50-60	Crown, Peel and eyes Core and Pomace	Fiber Fiber and pectin Fiber pectin, sugars , enzymes
5	Guava	15-25	Pomace Seed	Pectin Fiber
6	Papaya	15-22	Peel Seeds	Fiber Fiber
7	Jack fruit	60-70	Rind, core Seeds	Cellulose, fiber, pectin, phenolics Starch, protein, saponins phenolics

1. **Reduce** – Considering the factors influencing pre-processing losses, this can be reduced to a substantial extent by creating infrastructures like on farm low cost zero energy cooling chambers, Controlled and Modified Atmosphere storage, digital marketing and proper transport facilities. Pretreatments like individual packing and wax coating can reduce wilting and infestation. Dried orange and lemon peel powder finds use in cosmetic preparations. Excess produce can be dehydrated in solar dryers.

2. **Recover** - Value added marketable by-products can be recovered from processing waste, depending on its source and composition. Some important byproducts are – Pectin - **Pectin** is partially methoxylated poly galacturonic acid, which forms gel with sugar and pectin under suitable conditions. It acts as colloidal stabiliser in foods like ice cream, and finds use in pharmaceutical products. Best source is Citrus peels, but non citrus sources including mango peels, jackfruit peels/core, guava, papaya, can also be exploited.

- **Essential oils** - Citrus peels, especially orange and lemon peels contain limonene, and other flavour compounds, that find use in food, cosmetic and perfume industry. Cold press oil has higher market value, compared to steam distilled oil.
- **Fat/oil** – Many fruit seeds contain fats/oils, which can be extracted by solvent extraction. They are utilised as edible fats, or find applications in cosmetic/ paint industry. Consistency of Mango kernel fat is similar to coco butter, and can be used in confectionary.
- **Starch** – Mango kernel, jackfruit seeds and banana pseudo stem contain starch, which can be extracted and used for edible purpose or in textile, paper and adhesive industry.
- **Food colours** – Fat soluble carotenes can be extracted from mango and orange peel, tomato pomace contains lycopene, whereas water soluble anthocyanins can be extracted from grape skin, phalsa, and jamun waste.
- **Antioxidants and phenolics**- Isoflavones, hesperidines, phenolics obtained from orange and banana peels, apple etc. are

antioxidants, and find use in health foods and pharmaceuticals.

- **Sugars** – Pomace left after juice extraction contains residual sugars. It can be extracted as fruit molasses, and used in animal feed, or for further bioconversions.
- **Cellulosic waste** – Cellulosic waste remaining after extraction of valuable chemicals can be incorporated in animal feed. After refining, it can also find use in food for fiber enrichment, or in pharmaceutical preparations.
- **Enzymes**- Enzymes Papain and Bromelain are extracted from papaya and pineapple pulp respectively. They are traditional meat tenderisers, but can find new applications in cosmetic and detergent industry products.

3. **Regenerate** –Waste can be used as a starting material to generate alternative products, through bioconversion.

Ethanol and organic acids - Fruit molasses obtained from waste pomace can be utilised for production of alcohol, vinegar, citric acid, etc. and also for cultivation of yeast and mushrooms.

Enzymes – there is ample opportunity to utilise lignocellulosic and pectin rich solid waste as substrate for production of hydrolytic enzymes (cellulase, pectinase, amylase,) by Solid State Fermentation with fungi eg *Aspergillus*, *Penicillium*, *Sporotrichum* and *Fusarium*. Residue after extraction of extracellular enzymes can be utilised for bio methanation or composting.

Bio methanation– Direct utilisation of fruit processing waste for bio methanation by anaerobic digestion poses some problems. Unlike cattle dung, where lignocellulosic matter is partially hydrolysed in cattle rumen, these wastes are rich in cellulose hemicellulose, lignin, and pectins, and relatively low in nitrogen, with prolonged digestion. Essential oils present in citrus peels inhibit the growth of methanogenic and nonmethanogenic organisms. Pre-treatment with fungi eg *Aspergillus*, *Penicillium*, *Sporotrichum* and *Fusarium*, and supplementation with organic/inorganic Nitrogen source leads to improved rate and yield of biogas. Apart from methane, watery effluent goes for aqua culture, and spent solids are used as soil conditioners. Biogas generation potential varies between 0.4-0.72 m³/Kg added waste.

Compost- Compost is ideal organic fertiliser and soil conditioner. Fruit processing waste is a valuable compost material for conventional windrow composting or vermicomposting, after adjusting C/N ratio, pH, moisture content and redox potential.

Animal feed- Cellulosic residue, along with dry seeds are utilised in manufacture of animal feed.

Figure 1 is a model of holistic approach for orange processing, with maximum recovery of by products, and minimum waste generation.

Present scenario -Considerations for generation of wealth from waste

1. Quantum of waste generation.
2. Composition of waste.
3. Technology for recovery of valuable components.
4. Value addition based on market potential of by-products.
5. Nature of new waste generated in the process.
6. Over all economics.

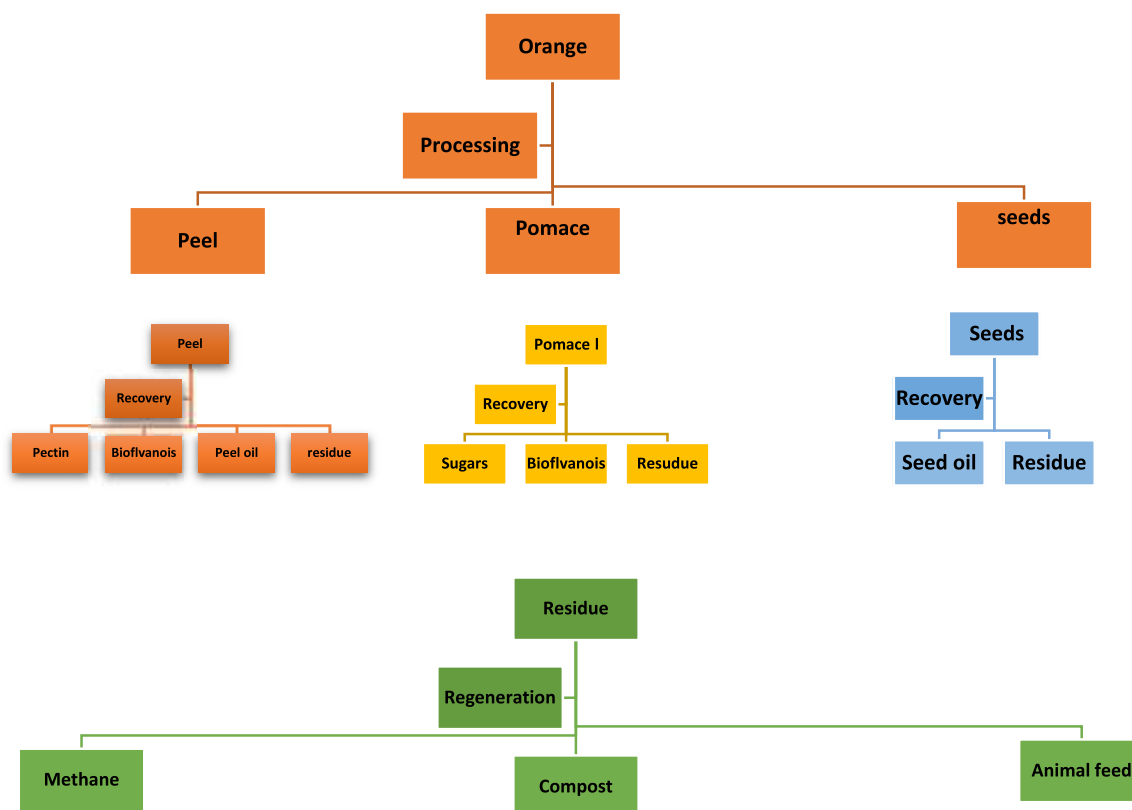
Constraints for proper utilisation of fruit processing waste-

- Nature and quantum of waste varies widely in different seasons.
- In spite of large variety, and high production of fruits, hardly 2% is processed.
- Major (4-16%) loss is during storage and transportation.
- Small entrepreneurs, situated at distant places, prepare semi processed products, where the waste is generated. There is no organised attempt for waste collection and disposal at this point.

Conclusion- Impact of food processing on environment is related to the technology to protect the food material, allow maximum recovery of valuable byproducts, and improve environment and public health. Treating waste as a resource will definitely lead to generation of wealth as well as health for everybody.

अमंत्रमक्षरं नास्ति , नास्ति मूलमौषधिम्,
अयोग्यो पुरुषो नास्ति , योजकस्तत्र दुर्लभः ॥

Figure 1- Scheme for holistic processing of orange, with maximum utilisation of waste



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