**Waste to Wealth**

**Monika Chaudhary, Amar P.Garg\* and Neha Bisht**

School of Biological Engineering & Life Sciences, Shobhit Institute of Engineering & Technology (Deemed-to-be-University) Modipuram, NH-58, Meerut 250110, India

[monika.lm1020@gmail.com, amarprakashgarg@yahoo.com\*, bishtneha1993a@gmail.com](mailto:%20monika.lm1020@gmail.com,%20amarprakashgarg@yahoo.com*,%20bishtneha1993a@gmail.com)

**Abstract**

India annually produces 350 million tonnes of agricultural waste. Between 2020 to 2025 India will undergo a drastic change wherein, we will see a rise in plastics, metals, etc by two folds. As more than half of the Indian population is dependent on agriculture, we need to find ways to utilize agricultural waste such that it doesn’t impact our environment and also provides income. Agricultural waste is produced from agricultural products, agro-industries, animal feed, horticulture, aquaculture, etc. With the huge quantity of waste being produced. In India, we still use the same old methods of waste treatment such as burning, draining the waste, etc. With new technologies around, we need to create a new era of agricultural waste management that not only sustains the environment but is also worth more. We need to find ways to implement the mission of waste to wealth under Swachh Bharat Unnat Bharat.  A new institutional mechanism is needed to address the issue of agricultural waste and achieve India's goal of a zero waste nation.

Keywords: agricultural waste, AWMS

**Introduction**

India ranks only 94th out of 107 countries on the 2020 Global Hunger Index, despite the fact that India is one of the largest agricultural-dependent economies. Agriculture plays a vital role in India's economy. 54.6 of the total workforce is engaged in agriculture and allied sector activities (Census 2011) and accounts for 18.8% (First Advance Estimates) of the country's Gross Value Added (GVA) for the year 2021-22 (at current prices) . Studies on agricultural losses are not many but the Central Institute of Post Harvest Engineering and Technology, Ludhiana (CIPHET), an institution of the Indian Council of Agricultural Research (ICAR) has conducted two studies. The first study was conducted between October 2005 and February 2007 on the recommendation of the parliamentary standing committee of the ministry of agriculture. The report was submitted to the committee in 2010 and was published in August 2012.

The second study was sponsored by the ministry of food processing industries. It was based on production data of 43 crops and livestock produced in 2012-13 and wholesale prices of 2014. Conducted in 120 districts in 14 agro-climatic zones and the report was published in March 2015. The losses incurred in cereals, pulses, oilseeds, plantation crops, spices, vegetables, fruits, milk, fisheries, poultry, and meat at various stages of production and movement were studied. The studies of farm-level operations included harvesting, collection, sorting, grading, drying, packaging, and transportation were also conducted. The losses in the storage channel included storage at farm level and cold storage, wholesaler, retailer, and processing unit were also conducted by CIPHET.

The perception that the losses were about one-third of the production was changed and it was found that the overall losses were much lower in the study of 2012-2013. In the case of cereals, losses ranged between 4.65% (maize) and 5.99% (sorghum). In wheat and paddy, the losses were 4.93% and 5.53% respectively. It was found that the losses were higher at the level of farm operations. About 4.67% in the case of paddy and 4.07% in the case of wheat. For both wheat and paddy, the loss in storage was only 0.86%. It was reported that the perishable crops suffered much higher losses. Loss of 9.16% reported in the case of mango. The loss at farm operations was much higher at 6.92% than the loss in storage at 2.24%. The loss in guava was 15.88% while the same in the case of apple was 10.39%.

When it came down to vegetables, the loss in the case of potatoes was 7.32% out of which 6.54% was at the level of farm operations while the loss in the storage was only 0.78%, due to the large-scale storage of potatoes in cold stores. They found that the loss in tomatoes was 12.44% which was 9.41% at the level of farm operations and 3.03% in the storage at wholesale, retail, and processing levels.

The total loss of inland fish was 5.23%, out of which only 1.05% was in the storage channel. For poultry meat, the total loss was 6.74% but here the loss in the storage channel was found at a high rate of 4%. The milk loss was only 0.92%. Of this, only 0.21% was contributed by the storage channel.

**TYPES OF AGRICULTURAL WASTE**

Although India has high levels of food production, it ranks only 94th out of 107 countries on the 2020 Global Hunger Index. Food is a basic human need and feeding the ever growing population is becoming a challenge. Developing countries rely mostly on agriculture but in times where our soils are less fertile , pollultion is drastically increasing , we need to find ways to increase agricultural produce without degrading the environment .Therefore , there needs to be an intervention in the form of environmental friendly technology. One of these inventions is the management of agro based waste and food processing waste , also called as agricultural waste. Agricultural wastes are defined as “the remaining from the growing and processing of raw agricultural products” like fruits, vegetables, meat, poultry, dairy products, and crops. It includes both natural and non-natural wastes produced through various farming activities such as dairy farming, horticulture, seed growing, livestock breeding, grazing land, market gardens, nursery plots and even woodlands.. Agricultural and food industry residues and wastes constitute a significant proportion of worldwide agricultural productivity (estimated at over 30%) (Sarmah, 2009).

The term Agricultural Wastes relates to all left-overs and residuals of the agriculture production which do not have economical value and are meant for disposal. Special processes are needed to convert these wastes into valuable product. In most cases (and mainly in field crops and vegetables) it is difficult to remove the waste product considering the costs of removal, transport and processing of these wastes. The opportunity and feasibility for recycling these wastes comes for the care for environment and the potential to add value to these wastes by adding positive elements.

It is important to view a valuable ‘resource’ from ‘waste’ that can be converted into a variety of products. This process of conversion of waste to a product that can be put to primary use can be viewed as a process of generating wealth. Hence the phrase ‘Waste to Wealth’. Waste-to-wealth has been used as the concept to address the environmental problem by changing the traditional view of waste as an end product to be disposed off and turning it into a valuable product. Given the amount of waste generated, innovative waste conversion processes can create micro-entrepreneurship fortuity on an enormous scale. In India, the potential to convert waste to wealth is very high. Increasing opportunities for this enterprise can have eclectic advantages.

It can bring back useless and discarded waste products into economic use and lead to:

a) Release of pressure caused by waste on the environment;

b) Creation of opportunities for livelihood generation in a relatively new area thereby enhance fiscal activity; and

c) Impact quality of life

Agricultural waste can be of various types depending on the type of agricultural activity shown in fig1. It can be liquid , slurry or solid form which can be soluble/insoluble, combustible/incombustible, toxic/nontoxic. The type of agricultural waste produced depends on the agro- activity and are as follows-

|  |  |  |
| --- | --- | --- |
| **S.NO** | **AGRICULTURAL ACTIVITY** | **WASTE** |
| 1 | Crop production and harvest | Straw, stover |
| 2 | Fruit and vegetable processing | Biological sludges, trimmings, peels, leaves, stems, soil, seeds, and pits |
| 3 | Sugar processing | Biological sludges, pulp, lime mud |
| 4 | Animal production | Blood, bones, feather, litter, manures, liquid effluents |
| 5 | Dairy product processing | Biological sludges |
| 6 | Leather tanning | Fleshings, hair, raw and tanned trimmings, lime and chrome sludge, grease |
| 7 | Rice production | Bran, straw, hull |
| 8 | Coconut production | Stover, cobs, husk, leaves, coco meal |

**Agricultural Waste**

**Crop residue**

* Rice straw
* Wheat straw
* Corn stover
* Barley straw
* Oat straw

**Industrial processing waste**

**Food waste**

* Sugarcane bagasse
* Rice bran
* Rice husk
* Orange peel
* Apple
* Mango
* Cabbage
* Tomato
* lettuce

**Livestock waste**

* Animal fat
* Cattle manure
* Swine manure

**Fig1: Types of agricultural waste**

**AGRICULTURAL WASTE FROM DIFFERENT SOURCES**

1. **CULTIVATION ACTIVITIES**

(a) **Rice hulls**: It is used as a fuel or as an abrasive character.

(b) **Paddy waste**: It is produced from paddy crop and its by-products are paddy husk, paddy straw, etc. It can be used as animal feed, animal bed and shelter, mulching purpose, composting, and fuel purpose.

(c) **Wheat waste**: The by-product of wheat crop is straw, and it can be used as animal feed, particle board, dry flowers, briquettes, mats, hats, carpets, and many more handcrafts.

(d) **Cotton waste**: The by-product of cotton crop are cotton sticks. Utilization of sticks in power plant, plywood industries, particle board industries, and also in composting.

(e) **Jute stalks and sugarcane tops**: These by-products are utilized in chipboard, soft board, fabric, and matrices for acoustic purposes.

(f) **Mustard waste**: Two major leftovers of mustard crop are mustard sticks and husk. They can be sold to brick industries.

**2. AQUACULTURE**

Aquaculture growth depends totally on feeds , but when excess amount of feed becomes solid waste. The water flow pattern reduces the fragmentation of fish feces and also allows rapid settling.

**3. LIVESTOCK PRODUCTION**

They can be used by farmers to make dung cake and it becomes a better option for fuel generation such as biogas, composting etc.

**4.PLANT WASTE (FRUIT AND VEGETABLE PROCESSING)**

(a) **Banana stalks and leaves**: They are used as painting and waterproofing agent. Boiling banana stalks with water and then mixing with lateritic clay has been used a as a waterproofing agent. This mixture can also used as painting, and it protects from heavy rains.

(b) **Coconut production**: The byproducts of coconuts include husks, coir fiber, unretted and retted pith, coconut shell, straw, etc. They can be used for board making, fiber making, wood particles, roof, roads, mats, etc.

(c) **Sugarcane waste**: The by- product of this crop is sugarcane trash, growing green fodder, and bagasse. Sugarcane waste is mainly used in ethanol production, sugar manufacture, etc.

(d) **Jute products**: The main by-product of the crop are Jute stalks, and are utilized in soft board making, matrices, etc.

**5. AGRO-INDUSTRIAL WASTE (SUGAR PROCESSING)**: Sugar industry produces a large amount of bagasse per year that can be used in wall panels, insulation boards, printing paper, and also corrugating medium (Sen 2002; BMTPC 2005).

**6. HORTICULTURE WASTE**: Unused and spoiled vegetables and fruits, branches, leaves, and dead plants are the types of horticulture wastes (Zhang et al. 2011). Converted into compost, animal feed. The fruits and vegetables that go unsold can also be used as waste.

**UTILIZATION OF AGRICULTURAL WASTE**

Agricultural Waste utilization means reuse of leftover residues, proper storage system, and conversion of the waste into desired product (Komnitsas 2012). There are a lot of applications of agro-wastes shown in fig2. Useful approaches from the agro-wastes -

**A . RICE HULLS** : They can be utilized for the production Portland cement , porous silicate structural material and water glass from heating value and silica content of rice hulls.

(i) Portland cement: Combination of the heating value and silica content of the rice hulls are used in manufacture of Portland cement.

(ii) Water glass (sodium silicate): To manufacture water glass, rice hulls are used as a source of silica and use the process of complete combustion. Another way for the production is wet-air oxidation called as Zimmerman process.

(iii) Porous silicate materials: Good bonding quality of rice hull ash can be used for the production of a wide range of materials like building blocks, pipe lagging, and architectural insulating slabs, etc.

**B COCONUT WASTE PRODUCTS**: A large amount of waste is produced by the coconut, with huge quantity of products being manufactured by these wastes.

**(i) Particle boards**: Particle boards made by coconut husks which are more resistant to termites and wood-rotting fungi and are marginally resistant to burning. The manufacturing of particle board by coconut husks is comparatively of low cost than wood.

**(ii) Coir fiber**: The combination of coconut husks, coir fiber, and Portland cement is used as strong building panel and corrugated roofing sheet, etc. The sheets can be used in partition, walling, roofing, and many more.

**(iii) Coconut fiber boards**: These boards bonded with cashew nut glue are used for waterproofing. They are mostly used for temporary kind of construction.

**(iv) Layered particle board**: Usage of adhesive mixed with wood particle and coconut husks make a cost-effective board.

**(v) Retted pith**: Coconut pith combined with cashew nutshell and liquid resin is used as filler in between roads, runways, and concrete slabs. termites, fungi, and moisture all are resistant.

**(vi) Coir-shearing waste**: Coir fiber can be used in preparation of mats and with the combination of pith and dust, it can be converted into particle boards.

**(vii) Coconut shell**: Building boards can also be manufactured by the combination of coconut shell and urea or phenol formaldehyde glue.

**(viii) Reeds, stalks, and straw:**A low-cost house can be made by the assembly of dry reeds, stalks, and straw.

**(ix) Straw and paper boards**: The straw, vegetable fibers, and cereal straws are compressed under heat and pressure and converted into boards and craft paper.

**(x) Reed boards:** These boards are produced for commercial building boards and wall making. They are very strong, lightweight, and less in cost.

**C. MANURE**: Manures are utilized as they provide 19% nitrogen, 38% phosphorus, and 61% potassium. (Pratt 1975).It can be converted into organic manure which boosts the crop production and lower the cost and offers various health’s benefits, which is a serious problem caused byvarious inorganic manures . Manure combined with soil increases its fertility, nutrient maintenance capacity, soil texture stability, and water-holding capacity (CAST Report No. 41. 1975).

**D. ADSORBENTS IN THE REMOVAL OF HEAVY METALS**: A large amount of heavy metals are produced due to industrialization and urbanization which are toxic to all life forms. Agricultural wastes are cost-effective alternative for the treatment of heavy metals through the process of adsorption . Some examples of agricultural wastes that have been used for elimination of heavy metals are bagasse (Mohan and Singh 2002), rice husk (Ayub et  al. 2002), sawdust (Ajmal et  al. 1996), coconut husk (Tan et al. 1993), oil palm shell (Khan et al. 2003), neem bark (Ayub et al. 2001), etc

**E. PYROLYSIS**:Heating up of agricultural waste at a temperature of 400-600 \* C in the absence of oxygen is called pyrolysis , which yield in char ,oil, and low-heating-value gas.

**F.ANIMAL FEED**: Waste generated from postharvest operations like threshing and the milling process can be used directly for the feeding of various animals and for the development of various value-added products. Rice and wheat bran can directly be served to some animals such as goat, cattle etc.

**G. FOOD PROCESSING WASTE** : Food Wastage occurs at all stages of the food supply chain. In low-income countries, most loss occurs during production, while in developed countries ,about 100 kilograms per person per year is wasted at the consumption stage. Food industry produces large amount of wastes, both solid and liquid, resulting from the production, preparation and consumption of food. These wastes cause severe pollution and a loss of valuable biomass and nutrients. Beside their pollution and hazard aspects, in many cases, food processing wastes might have potential for conversion into useful products of higher value as by-product.

**H. ENERGY FROM AGRICULTURAL WASTE**: Biochemical conversion of agricultural biomass waste to bio energy is an environmental friendly and sustainable technique shown in table1. Besides generating revenue , waste-to-energy schemes offer an alternative and environmental friendly a means of waste disposal. Additionally, it also provide a valuable by-product: a good quality agricultural fertilizer that is odourless. India is a developing country whose economy is largely based on agriculture and the concern over future energy shortages and increasing costs of fuels and electricity looming over us , we need to adhere to the concept of waste –to- energy .Agricultural waste can be utilized to produce energy from biomass as mentioned in the table1

**ETHANOL PRODUCTION FROM AGRICULTURAL WASTE** :

Production ethanol from agricultural waste is a widely explored area.Meenakshi and Kumaresan 2014, carried out production of ethanol fromcorn and potato peel waste. Similarly Bhatt and Shilpa (2014) prepared ethanol from groundnut shell waste. Manufacturing ethanol from the waste is a way to get healthier and sustainable environment .

**BIOGAS PRODUCTION FROM AGRICULTURAL WASTE**

Animal waste such as cow dung ,dead stock, waste forage, and milk house waste and silage effluentare used to produce biogas . It results in the production of bio fertilizers , bio fuel and save plant nutrients.

|  |  |  |  |
| --- | --- | --- | --- |
| TECHNOLOGY | CONVERSION PROCESS | BIOMASS WASTE | FUEL PRODUCED |
| Biodiesel Production | Chemical | rapeseed soy beans waste vegetable oil | Biodiesel |
| Direct Combustion | Thermochemical | agricultural waste mixed waste heat | steam electricity |
| Ethanol Production | Biochemical (aerobic) | sugar or starch crops wood waste pulp sludge rice and corn straw | Ethanol |
| Gasification | Thermochemical | agricultural waste mixed waste | low or medium Btu producer gas |
| Methanol Production | Thermochemical | agricultural waste mixed waste | Methanol |
| Pyrolysis | Thermochemical | agricultural waste municipal solid waste | synthetic fuel oil (biocrude) charcoal |

**Table 1: Waste Biomass Conversion To Energy**

Compost

Paper & Pulp

Fuel

Alcohol

Production

Leather Industries

Bio-fertilizer

Biogas

Industrial Material

**Fig 2: Uses of agricultural waste**

**Utilization of Agricultural Waste In India**

1. **Biochar From Agricultural Waste Material**

**Developer: Division of Agricultural Engineering**

FEATURES

* Biochar are produced from the agricultural waste(maize stalk, pine needle) and weed by using pyrolysis method.
* Agricultural biomass can be converted into biochar within two hours ϖ Improve soil fertility and crop yield.
* Increased fertilizer use efficiency. ϖ Improve water retention, aeration and soil tilth.
* Higher cation exchange capacity and less nutrient runoff.
* Application of biochar improved soil pH by 0.26 to 0.30 units within two months

1. **Preparation of Handmade Paper from Jute Waste**

**Developer: S N Chattopadhyay, ICAR-NINFET, Kolkata**

Features:

* Handmade paper from jute fiber made from jute residue of thrown away jute waste
* Most of the properties are same as normal handmade paper , but have diversified uses of it such as in Files, Folders, Greetings Card, Shopping bags, Visiting Card, Posters, writing grade paper, paper boards, file covers, greeting card etc.
* Handmade paper products conserve resources and generate less pollution.
* Producing handmade paper uses much less total energy than producing virgin paper.

1. **Soil less Planting Media using Sugar Industry Residue**

**Developer: F. Pushparaj Anjelo and Shinoj Subramannian, KVK, Ernakulam**

FEATURES

* The press mud, a residual product in Sugar Industry that is available abundantly at the rate of 2 percent of the cane crushed
* Better moisture retention and less frequent irrigation requirement. ϖBetter root anchorage and reduced plant lodging.
* Enhanced nutrient value and no need of basal manure dose.
* Can be re-used for more than 3 plantings.
* Commercial scale planting media production from press mud is a promising enterprise for youngsters while ensuring nutritionally rich planting solution to urban farmers

1. **Foliar Spray from Fish Waste**

**Developer: A.A. Zynudheen and Binsi Pillai, ICAR-CIFT, Kochi**

Features:

* Foliar spray is a fish waste-derived liquid product that contains peptides and amino acids.
* Stable product under room temperature.
* Can be directly applied after dilution on a wide variety of plants.
* It can be fortified with the deficient components if required
* Enhances the productivity of the plants immediately and possess pest repellent properties.
* High demand for the product and is gainful employment with a high return of margin.

1. **Eco-friendly and sustainable wastewater treatment for safe reuse in agriculture**

**Developer: Ravinder Kaur, Water Technology Centre, ICAR-IARI, New Delhi**

Features:

* The technology has zero energy, zero-chemical and zero-skilled man power demand and it take care of multi-pollutant and pathogen loads, along with salt – remediation
* Compared to conventional wastewater treatment technologies it requires about 80-85% lower capital expenditure demand, and extremely low.
* The technology is at least 1500 times more sustainable and causes at least 33 times lesser environmental stress.
* This technology has the capacity to add a good value to land (metal & pathogen free) reuse in aquaculture/ agriculture.

1. **Biomass based Decentralized ElectricitymGeneration System Biomass**

**Developer: AK Dubey, Sandip Gangil, CR Mehta and KC Pandey, ICAR-CIAE, Bhopal.**

The Biomaterial is powdered and briquetted before feeding to downdraft gasifiers. The gasifier generates the producer gas which after conditioning is sent to gas genset for generation of electricity.

Features:

* Economic gain to farmers producing crop residues. ϖ Development of agro residues market giving opportunity for traders and labours. Leading to employment generation.
* From 1.5 kg biomass 1 unit of electricity can be produced and the cost of electricity is nearly 7-8 Rs per kWh .

**AGRICULTURAL WASTE MANAGEMENT SYSTEM (AWMS)**

An AWMS consists of six basic functions :

• Production

• Collection

• Transfer

• Storage

• Treatment

• Utilization

For a specific system, these functions may be combined, repeated, eliminated, or rearranged as necessary.

**Production**

**Collection**

**Transfer**

**Treatment**

**Storage**

**Utilization**

1. **PRODUCTION**

It is the amount of waste generated and depends on the nature of the agro- waste. Unnecessary waste should be kept at a minimum .If the quantity of product is sufficiently formed for user, then no wastes are left.

1. **COLLECTION**

It is the gathering and collection of waste from the site of origin or from disposal site. A system is to be prepared for the collection , its method , location , scheduling of collection , labor and equipment requirement etc.

1. **TRANSFER**

It is the movement of waste from collection site , to storage site and then to the utilization site. It may involve several movement before the waste lands to the utilization site.The waste can be solid , liquid , slurry depending upon the type of method.

1. **STORAGE**

It is the containment of the waste temporarily. In the mean time , the scheduling and the timing of the utilization of the waste can be decided. It has storage volume, type, estimated quantity, site, period, and cost of the facility.

1. **TREATMENT**

It is the removal of pollution or toxic materials from the waste using physical, chemical, and biological treatments. It specifies the type of treatment , size, site, cost, and process etc.

1. **UTILIZATION**

It is the conversion of agricultural waste into usable and recycled products such as bioenergy , manure, organic matter, or plant nutrients. They are properly treated, so that they can be marketed.

**Conclusion:** The true meaning of the phrase waste to wealth can only be realized if we aware everyone of the 5R principle of waste management. Agricultural waste is a valuable whose utilization can be maximized if we are aware of the uses. It is a promising solution for the world as it will help in creating more opportunities for humans. It will help in the development of agriculture and also bringing out environmental friendly methods to meet our fuel and energy needs .With the help of new technologies we can find new ways to maximize the utilization of agricultural waste and can create a new world based on proper waste management .Not only will it be environmental friendly but will also generate income especially for the farmers.

**5R PRINCIPLE OF WASTE MANAGEMENT**

**To reduce the waste generated and create a sustainable environment , there is a need to make people aware of the 5R’s and implementing them**

1. **REFUSE**

The first element of the 5 R's hierarchy. Learning to refuse waste can take some practice, but incorporating this step is the most effective way to minimize waste.

1. **REDUCE**

Reduce the use of harmful, wasteful, and non-recyclable products , so that less waste is produced.

1. **REUSE**

It involves usage of already produced material over and over again such that no new cost of labor , raw material or machinery is required.

1. **REPURPOSE**

For every item that can't be refused, reduced, or reused, repurpose , also called upcycling. It is the use of a product that cannot serve its purpose can be utilized as common/other use for something else.

1. **RECYCLE**

Recycling is the most environmentally friendly waste disposal method. It is the transformation of used product as an input to form a new product.

To develop a smart and proper management of agricultural wastes, farmers and public at large should be made aware of various practices of waste management. With the help of NGOs, private companies creating new campaigns for the awareness and wakefulness of agro-waste uses and recycling as a useful product, will be a great start to the new era of development. A healthy and sustainable environment can only be developed if reduce the agricultural waste and find new ways for a cleaner and brighter india .

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