**Agriculture: Waste to Wealth**

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

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

**Abstract**

India annually produces 450 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 becomes a source of income. Agricultural waste is produced from agricultural products, agro-industries, animal feed, horticulture, aquaculture, etc. With the vast 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 sustains the environment and is 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**

Despite being one of the most agriculturally dependent economies, India came in at number 107 on the 2022 Global Hunger Index. India's economy is heavily reliant on agriculture. According to the Census of 2011, 54.6% of all workers are employed in agriculture and related sectors, which are expected to contribute 18.8% to the nation's Gross Value Added (GVA) in the years 2021–22. (at current prices). There aren't many studies on agricultural losses, but two have been done by the Central Institute of Post Harvest Engineering and Technology in Ludhiana (CIPHET), a division of the Indian Council of Agricultural Research (ICAR). On the proposal of the parliamentary standing committee of the ministry of agriculture, the initial investigation was carried out between October 2005 and February 2007. The committee received the report in 2010, and it was released in August 2012.

The ministry of food processing industries supported the second study. It was based on information about the production of 43 different crops and animals in 2012–2013 and 2014 wholesale prices. carried out in 120 districts in 14 agroclimatic zones, and the report was released in March 2015. At various phases of production and transportation, the losses experienced in cereals, pulses, oilseeds, plantation crops, spices, vegetables, fruits, milk, fisheries, poultry, and meat were examined. CIPHET also conducted studies on other farm-level processes, such as harvesting, gathering, sorting, grading, drying, packaging, and shipping. Farm-level cold storage, wholesaler, retailer, and processing units were among the entities that suffered losses in the storage channel..

It was discovered that the overall losses in the study of 2012–2013 were significantly lower, changing the notion that losses accounted for around one-third of production. Losses in the case of grains ranged from 4.65% (maize) to 5.99%. (sorghum). The losses were 4.93% in wheat and 5.53% in paddy, respectively. It was shown that losses at the level of agriculture operations were larger. In the cases of paddy and wheat, respectively, about 4.67% and 4.07%. The storage loss for both paddy and wheat was only 0.86%. The perishable crops reportedly experienced s ubstantially worse losses. Mangoes were reported to have lost 9.16% of their value. Compared to the loss in storage, which was only 2.24%, the loss during farm operations was substantially larger at 6.92%. Guava suffered a loss of 15.88% while apples suffered a loss of 10.39%.

In terms of vegetables, the loss in the case of potatoes was 7.32%, of which 6.54% was at the level of farm operations and only 0.78% was at the level of storage as a result of the extensive cold storage of potatoes. They discovered that the loss rate for tomatoes was 12.44 percent, which broke down to 9.41 percent at the farm operation level and 3.03 percent in storage at the wholesale, retail, and processing levels.

Only 1.05% of the inland fish lost overall—5.23%—was in the storage channel. For poultry meat, the overall loss was 6.74%, but in this case, a high rate of 4% loss in the storage channel was discovered. There was only a 0.92% loss of milk. The storage channel only csontributed 0.21% of this.

**TYPES OF AGRICULTURAL WASTE**

Although India has high levels of food production, India ranks 107 out of 121 countries on the 2022 Global Hunger Index , published by Concern Worldwide and Welthungerhilfe. 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 when our soils are less fertile, Pollution is drastically increasing, we nee d 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 described as "the residue from the production and processing of raw agricultural products" such as grains, fruits, vegetables, meat, poultry, and dairy products. It covers wastes generated by a variety of farming endeavours, including dairy farming, horticulture, seed producing, 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's critical to distinguish between valuable resources and garbage that can be turned into a range of goods. Generally speaking, creating money involves turning waste into a useful commodity. Thus, the expression "Waste to Wealth." By shifting the conventional perspective of waste as an unwanted byproduct that needs to be disposed of and turning it into a useful product, the waste-to-wealth concept has been applied to alleviate the environmental problem. Innovative waste conversion techniques have the potenti al to significantly increase micro-entrepreneurship fortuity given the volume of garbage produced. Waste may be turned into wealth quite well in India. Increasing the company's chances could bring a variety of benefits.

It can relieve environmental pressure produced by garbage, create opportunities for livelihood generation in a relatively new location, increase fiscal activity, and have an impact on quality of life. It can also bring back useless and discarded waste goods into economic usage

Depending on the type of agriculture, there are several sorts of agricultural waste as 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 table1-

|  |  |  |
| --- | --- | --- |
| **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 |

**Table 1: Agricultural activity and waste created**

**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**

Cultivation is the tiling or unsettling and refining of soil by digging the soil to prepare a better soil bed for plantation. Various methods and techniques have been deployed for the cultivation of crops such as terrace cultivation, crop rotation, agro-forestry, shifting agriculture etc. With increasing cultivation activities and farmers using variety of pesticides and fertilizers to increase the annual growth of the crops, it leads to different waste being produced from different activities and different crops, such as –

* **Groundnut**: It produces oil cake as a waste which can be used as a feed for cattle and other farm animals. It can also be used for human consumption as protein rich food supplement. Its residues also maintains nitrogen availability in soil when left in the field after harvesting.
* **Paddy**: Waste produced such as paddy husk can be used as fuel and as raw material for alcohol and furfural, paddy straw can be used in soil mulch , as fodder and making baskets , ropes etc. Bran can be used for making edible fatty oil and cattle feed .
* **Wheat**: The waste produced by the wheat crop is straw, it is used as bedding of cattle , thatching , packaging and straw pulp produced as waste is used in furfuryl alcohol as well as biogas production and straw pulp is used in making paper , building material.
* **Cotton**: The waste produced by cotton crop is cotton sticks and seeds. The sticks are used in power plants, plywood industries, and can also be used in composting as well. Cotton seeds are rich in vitamin B and are used as cattle feed. Cotton seed oil is also used as a substitute of olive oil in pharmaceutical industry.

1. **AQUACULTURE**

Aquaculture growth depends totally on feeds, therefore excess amount of feed is a major source of waste. The primary source of waste in aquaculture is feed, chemicals, and pathogens. All the factors contribute to the generation of waste.

1. **LIVESTOCK PRODUCTION**

Livestock waste is any waste that comes from the excreta of animals and birds, including bedding materials, wastewater from animal bathing, cage water, urine, manure, and feathers, as well as feed and fodder. Agricultural runoff results from improper management of livestock excrement. Livestock manure has a lot of useful by-products that farmers may employ to manufacture dung cake and make it a better option for making fuels like biogas and composting.

1. **HORTICULTURE WASTE**:

The term "horticulture wastes" relates to the term "spoiled, unwanted, and unsold vegetables and fruits," as well as "branches, leaves, and dead plants." Compost, animal feed, a biogas plant, and other materials can be made from this trash (Zhang et al. 2011).

1. **AGRO-INDUSTRIAL WASTE (SUGAR PROCESSING)**:

One of the largest sectors that employs agricultural waste bagasse, which is produced in significant quantities each year and used in wall panels, insulating boards, and paper production, is the sugar industry. Wheat bran, rice bran, and corn bob are further agro-industrial wastes. It greatly benefits the circular economy (Sen 2002; BMTPC 2005).

6 . **FOOD PROCESSING WASTE**:

Food waste occurs throughout the food supply chain. In low-income nations, the majority of losses occur during manufacturing, whereas in rich nations, approximately 100 kilograms per person per year are lost during consumption. The food industry generates a lot of solid and liquid waste from the production, preparation, and consumption of food. Pollution and depletion of nutrients are brought on by the generated trash. In addition to the waste that is generated, waste from food processing can be utilized and transformed into valuable goods...

**UTILIZATION OF AGRICULTURAL WASTE**

The utilization of leftover residues, proper storage system, and converting waste into the desired product such that it helps in reducing and reusing the waste (Komnitsas 2012) is called the utilization of agricultural waste . There are a lot of applications of agro-wastes shown in fig5. Some useful approaches of utilizing agro-wastes-

1. **MANURE / VERMICOMPOSTING**:

With tons of waste being generated from all the sectors of developing nations, should always look for sustainable and economic approaches to minimize the waste and get the best out of it. One such way is vermicomposting. In India for ages, the best way to manage the waste has been dumping it in the landfill, we need to step up, and rather than dumping the waste in the landfill, we should utilize it as vermicompost. Vermicomposting is a natural decomposition of waste in synergy with earthworms and microorganisms and converts it into organic manure in table 2 (Pramanik P, 2011). It helps in maintaining soil health by improving the physical and chemical properties of soil . Apart from industrial and domestic waste, agricultural waste can also be used for vermicomposting. Agricultural waste including crop residue, rice straw, wheat waste along with livestock waste is a preferable choice for the process of vermicomposting.  Manures from agricultural waste are utilized as they provide nitrogen, phosphorus, and potassium. (Pratt 1975). It is possible to transform it into organic manure, which reduces costs, increases crop yields, and has a number of health benefits—a serious issue brought on by many inorganic manures. Vermicomposting increases soil fertility, maintains its capacity for nutrients, stabilizes soil texture, and improves the soil's capacity to hold water. (CAST Report No. 41. 1975).

**ADVANTAGES OF VERMICOMPOSTING**

* It is an eco-friendly and is a zero-waste method for the management of waste.
* It is cheaper than the traditional method of composting.
* It produces uses compounds that help in reducing waste.
* It releases fewer greenhouse gases as it consumes less energy.
* Its use is multidimensional as it is economical and produces energy.
* It takes less time as compared to traditional ways.

|  |  |  |  |
| --- | --- | --- | --- |
| **S.NO** | **AGRICULTURAL WASTE** | **DURATION** | **REFERENCE** |
| 1 | Coconut husk poultry manure, pig slurry | 21 Days | Swarnam *et al* 2016 |
| 2 | Wheat straw, pig ,poultry, rabbit, cattle and sheep dung, and vegetal compost | 90 Days | Vodounnou *et al.* 2016 |
| 3 | Sawdust, boxwood leaves, and cardboard compost (MSW) | 100 Days | Alidadi *et al*.2016 |
| 4 | Pig manure and rice straw | 40 Days | Zhu *et al* 2018 |
| 5 | Cow manure and wheat residues | 60 Days | Sudkolai and Nourbakhsh2017 |

**Table 2: Waste and its duration of decomping**

1. **PAPER INDUSTRY :**

The Paper industry is among one of the biggest industries utilizing agricultural waste such as sugarcane bagasse, paddy straw, and wheat straw shown in fig2. Using agricultural wastes, around 22% of paper is produced by the paper industry. Paper produced is recyclable, biodegradable, and is a sustainable and environment-friendly process.

**Fig 2: Agricultural waste utilization in paper industry**

1. **MUSHROOM PRODUCTION** :

Mushroom production ishighly profitable and eco- friendly method of utilization of agricultural waste . The waste such as rice straw , wheat straw , cotton straw , sawdust, coffee pulp , tea leaves and banana leaves are used for the production of mushroom. *Pleurotus sp*. can be made using rice and wheat straw , *Ganoderma sp.* from sawdust and *Lentinula edodes* from coffee pulp are some of the examples (Elahe et al., 2016). Mushroom production+ is one the best methods to utilize the agricultural waste produce for wealth as well as for health as it combats malnutrition and environmental pollution in a eco-friendly and sustainable manner.

1. **PYROLYSIS**:

Heating agricultural waste at a temperature of 400-600 0 C in anaerobic condition is called pyrolysis, which yields char, oil, and low-heating-value gas.

1. **ANIMAL FEED**:

Postharvest processes like threshing and milling produce waste that can be used directly to feed various animals and make a variety of valuable products. A few creatures, like goats, steers, and others, can be offered rice and wheat grain straightforwardly.

1. **ENERGY FROM AGRICULTURAL WASTE**:

An environmentally friendly and long-lasting method is the biochemical conversion of agricultural biomass waste to bioenergy, as indicated in table 3. Waste-to-energy programmes not only generate income but also provide an alternate, ecologically responsible method of disposing of waste. A high-quality, odourless agricultural fertiliser is another useful by-product that it produces. India is a developing nation with an economy that is mostly built on agriculture. As future energy shortages and rising fuel and electricity prices loom over us, we must stick to the waste-to-energy philosophy. As shown in table 3, agricultural waste can be used to generate energy from biomass.

1. **BIOETHANOL PRODUCTION FROM AGRICULTURAL WASTE** :

Fuel sources are limited and we are dependent on non-renewable sources for fulfilling our needs such as fossil fuels. However, the production of fuel from non-renewable sources leads to environmental pollution by the emission of greenhouse gases causing global warming. We are living in a world where sustainable development is of utmost importance. The usage of agricultural waste is one of the ways to produce a fuel that not only is environmentally friendly but also reduces the loss of by-products. Bio-fuel is an alternative source to reduce dependence on fossil fuels. Production of bio-ethanol from agricultural waste is a widely explored area shown in Fig3.

First-generation bioethanol is produced from natural resources like sugar cane, wheat, and corn, among others. Bioethanol of the second generation is made from agricultural waste. The best method for making bioethanol is to use the Second Generation because it not only produces valuable fuel but also reduces waste. Additionally, they produce more energy and release less carbon. Second-generation bioethanol is made from agricultural waste like wheat straw, barley husks, corn cobs, paper pulp, sugar cane bagasse, banana peel, orange peel, and pineapple peel.

In 2014, Meenakshi and Kumaresan produced ethanol from potato peel and corn waste. Similarly, groundnut shell waste was used to make ethanol by Bhatt and Shilpa (2014). Producing ethanol from squander is a method for getting a better and more feasible climate.

**ADVANTAGES OF BIO-ETHANOL**

* Lower emission of carbon.
* Since, bio-ethanol is made from waste, it is a renewable source of energy .
* They are bio-degradable.
* They are safer to use and does not harm the environment.

1. **BIOGAS PRODUCTION FROM AGRICULTURAL WASTE**

Under conditions known as anaerobic conditions, the biological breakdown of organic matter results in the production of biogas. It is a biofuel that produces a lot of methane gas (fig. 4). Biogas is made from animal waste like silage effluent, dead stock, waste forage, cow dung, and milk house waste. It saves plant nutrients and results in the production of biofuel and bio-fertilizers.

**ADVANTAGES OF BIOGAS**

* Large amount of methane gas is produced
* It can be used as a vehicle biofuel.
* It is also used in generating power.
* Produces odourless sludge which can be used as a biofertilizer.

**Agricultural waste**

**Pretreatment**

**Breaks hemicelluloses and removes lignin barrier from agricultural materials**

**Enzymatic hydrolysis**

**Hydrolysis of cellulose and hemicelluloses by enzyme**

**Fermentation**

**fermentation of sugar to ethanol to ethanol by bacteria/yeast**

**Recovery**

**using Distillation**

**Ethanol**

Physical

Physio-chemical

Chemical

Biological

**Fig 3: Production of ethanol from agricultural waste**

**Fig 4 : Bio – Gas production from agricultural waste**.

|  |  |  |  |
| --- | --- | --- | --- |
| **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 3: Waste Biomass Conversion To Energy**

Compost

Paper & Pulp

Fuel

Alcohol Production

Leather Industries

Bio-fertilizer

Biogas

Industrial Material

**Fig 5: Uses of agricultural waste**

**Agricultural Waste In India under Public Private Partnership**

As India enters a new era of creating wealth from waste, all sectors of the Indian economy are coming together such as start-ups, and public-private companies are implementing new technologies and creating new useful products. Some examples are as follows –

1. A Bangalore-based company called carbon masters working on converting food and agriculture waste meant for landfill through the process of bio-methanation creating a carbon neutral fuel called Carbonlites – Bio CNG which can be used for power generation, cooking, and heating. It has proven to have better fuel quality and less cost than LPG.

With the use of digest slurry, they are also making Carbonlites Bio enriched organic manure. It helps farmers reduce the use of chemical fertilizers and pesticides improving soil health, the water holding capacity of the soil, and increasing the soil carbon.

1. A Tamil Nadu-based company called crysops biocontrol provides pest management and agricultural waste management through insects.
2. Using soil biotechnology to minimize nitrogen emissions, with only green biomass, and bio-mineral fertilizer, as byproducts, Life connections, provides cost-effective and pollution-free treatment to natural soil plant approaches.
3. Manufacturing bricks and blocks from foundry sand and bio-gas from food waste, The Mahindra group is working on reducing waste and using by-products to create environmentally friendly products.
4. Fermentech Labs Pvt Ltd, a Roorke-based company provides circular bio-economy solutions by producing enzymes that find a wide range of applications in the pulp and paper industry, bio-fuel production, textile industry, pharmaceuticals and animal feed etc.
5. A Chennai-based startup, developing mycelium bio-composites based protective packaging that can replace Styrofoam using mushroom waste, with the help of farmers, such that it also helps farmers boost their income.
6. In 2020, the Andhra Pradesh government signed an MOU with the Netherlands, naming the program Waste to worth and establishing agricultural biomass-based industries to generate income for farmers and reduces the environmental pollution which is caused basically by the burning of agricultural biomass.
7. BIO-LUTIONS India , a Hamburg based company in Bangalore is utilizing the agricultural waste and converting it into biodegradable packaging and tableware providing farmers with not only an extra source of income but also an eco-friendly way of reducing agricultural waste and plastic pollution.
8. Kriya labs is using agro waste such as rice straw which does not have market as big as compared to wheat straw. It utilized rice straw and convert it into pulp which can be used as an intermediary product for paper industry , bio-fuel , fabric etc.
9. Farm2Energy , a punjab based startup , processes paddy straw, sugarcane trash , corn strover etc and make and supplies products such as bio-pellets , bio-char and torrefied pellet such that in the coming time they become a sustainable replacement of fossil fuels.

**AGRICULTURAL WASTE MANAGEMENT SYSTEM (AWMS)**

Six basic functions :

• Production

• Collection

• Transfer

• Storage

• Treatment

• Utilization

For a particular framework, these capabilities might be joined, rehashed, disposed of, or improved as required. The Integrated Agricultural Waste Management System is yet another approach to waste management.

**INTEGRATED AGRICULTURAL WASTE MANAGEMENT (IAWM)**

IWMS is a combination of several processes such as waste collection, treatment, and disposal, creating a method of practical waste management. IWMS combines both the management and reduction of waste strategies that aim to provide sustainability, a pollution-free environment, and economic affordability.

The main objective of the integrated waste management system is the minimum waste production, the creation of new products from waste, a sustainable environment, and providing income to farmers with many employment opportunities.

**ADVANTAGES OF IAWM**

* Minimum use of fertilizers
* Reducing the waste
* Improved soil fertility
* Improved income
* Recycling of resources
* Environmental friendly

Even though we study the management of agricultural waste but many developing countries are not able to manage it due to various issues. Waste management differs from one country to another and one typical solution will not solve the problem of waste management. As waste management is a localized problem, it requires a multidimensional solution sustainably with a combination of different aspects assessed together to reach a solution.

We need to combine all the different aspects as per the requirement of the particular place. For example, a developing nation like India is not technologically developed and we as a country are not aware of waste management.

Technology plays an important part in waste management as well-developed nations like Japan have access to world-class technology and the developing nations still follow the conventional method of waste management which has less scope in today’s world. New age technologies can sort out waste and the country as a whole need to be made aware of the benefits of recycling and reusing,  by making them aware of the waste collection system. With adequate education and training programs, we can learn the importance of waste management.

One of the main issues with waste management is economic feasibility. All the new age technologies and techniques of waste management are not economically viable to a developing nation unless they are subsidized by the government, which is the reason that most countries are still opting for the landfill as a method of waste management. The technologies need to be made cost-effective so that companies could expand.

Policies and government support are the key drivers for any management to work. For  Sustainable development to work, besides policies, other aspects such as transparency, reduced corruption, etc are also important factors for it. For example, the Indian government has National Mission for Sustainable Development (NMSD).

As much as all the other factors are important for the system to work, waste management is a societal issue. In developed nations, children from a very young are made aware of waste segregation and management, such that when they become adults they pass on these values to the younger generation, but this is not the case in developing nations, the waste management knowledge and awareness is minimal and require am adequate roadman to overcome the barrier of lack of awareness.

**Conclusion:**

The true meaning of the phrase waste to wealth can only be realized if we are aware of every one of the 5R principles of waste management. Agricultural waste is a value whose utilization can be maximized if we are aware of its 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 bring out environmentally 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 create a new world based on proper waste management techniques. Not only will it be environmentally friendly but will also generate income, especially for the farmers.

**5R PRINCIPLE OF WASTE MANAGEMENT**

**People must be made aware of the 5 R's and put them into practice in order to reduce waste and create a sustainable environment.**

1. **REFUSE**

The first part of the 5 R's hierarchy Although it may take some practice to learn to refuse waste, including this step is the most efficient way to reduce waste**.**

1. **REDUCE**

In order to produce less waste, use less harmful, wasteful, and non-recyclable products.

1. **REUSE**

It includes utilization of currently delivered material again and again to such an extent that no new expense of work, natural substance or apparatus is required.

1. **REPURPOSE**

Repurpose, also known as upcycling, should be done for every item that cannot be reduced, reused, or rejected. The utilization of an item can't fill its need can be used as normal/other use for something different.

1. **RECYCLE**

It is the most eco-friendly method of disposal. It is the transformation of an old product into a new one by using it as an input.

Farmers and the general public ought to be educated on a variety of waste management strategies in order to develop effective waste management strategies for agricultural waste. We will get off to a great start by entering a new era of development by creating new campaigns, raising awareness of the uses of agro-waste and recycling it into a useful product with the assistance of NGOs and government policies. New concepts and education about old and new waste management methods are made possible by a proper framework that integrates technology, society, and policy. Reduce agricultural waste and discover new methods for a cleaner and brighter India with a holistic approach to the situation are the only ways to develop a healthy and sustainable environment.

**REFERENCES**

1. A.Meenakshi, R. Kumaresan, “Ethanol Production from Corn, Potato Peel Waste and its Process Development”, International Journal of ChemTech Research, Vol.6, No.5, pp 2843-2853, Aug-Sept 2014
2. Ajmal M, Rao RAK, Siddiqui BA (1996) Studies on removal and recovery of Cr (VI) from electroplating wastes. Water Res 30(6):1478–1482
3. Alidadi H, Hosseinzadeh A, Najafpoor AA, Esmaili H, Zanganeh J, Takabi MD, Piranloo FG. Waste recycling by vermicomposting: maturity and quality assessment via dehydrogenase enzyme activity, lignin, water soluble carbon, nitrogen, phosphorous and other indicators. Journal of Environmental Management 2016;182: 134e40.
4. Anon (2015). https://en.wikipedia.org/wiki/Food\_waste
5. Anonymous (2000). Environmental Standards for Ambient Air, Automobiles, Fuels, Industries and Noise. Central pollution control board ministry of environment & forests .
6. BMTPC (2005) Home page. <http://www.bmtpc.org/fibre.pdf>
7. Chattopadhyay, S. C. & Chattopadhyay, D. B. (2010). Waste from Food Industry and their Disposal: Some Facts. Proc. of Int. Conf. on Advances in Civil Engineering.
8. Elahe KJ, Mehrdad J, Shahin E (2016) King oyster mushroom production using various sources of agricultural wastes in Iran. International J Rec Org Waste Agr, 5: 17-24.
9. FAO(2015). The potential use of wood residues for energy generation. <http://www.fao.org/docrep/t0269e/t0269e08.htm>
10. Gustavson, Jenny; Cederberg, Christel; Sonesson, Ulf; van Otterdijk, Robert; Meybeck, Alexandre (2011). Global Food Losses and Food Waste (PDF). FAO. [7].
11. [How Much of India's Agricultural Produce Is Wasted Annually?](https://thewire.in/agriculture/india-agricultural-produce-wasted) The wire article.
12. <http://kvkernakulam.org.in/uploads_en/files/KVK%20Newsletter%202017%20APril%20to%20March%202018.pdf>
13. <http://www.nirjaft.res.in/admin/uploads/Publication/219118303293438_publication_pdf_NINFETAR2020compressedpdf.pdf>
14. <https://cdn.cseindia.org/attachments/0.89229900_1635734110_jalopchar.pdf> https://naip.icar.gov.in/download/c2-209001.pdf
15. <https://cift.res.in/annual_reports/english/2014-15/Annual-Report_2014-15.pdf>
16. <https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=31493.wba>
17. https://ediary.foe.org.in/index.php/2019/04/15/agricultural-waste-to-wealth-approaches-forvaluation-of-agricultural-waste/
18. https://fptaindia.in/paper-is green .
19. https://scroll.in/article/909699/startups-are-helping-north-indias-farmers-to-dispose-of-crop-residue-cleanly-and-reduce-pollution
20. <https://www.f6s.com/companies/agricultural-waste-management/india/co>
21. https://www.roadrunnerwm.com/blog/the-5-rs-of-waste-recycling
22. <https://www.thehindu.com/news/national/andhra-pradesh/turning-waste-into-wealth-by-salvaging-crop-residue/article32538011.ece>
23. Joshi, B., Bhatt, M. R., Sharma, D., Joshi, J., Malla, R., & Sreerama, L. (2011). Lignocellulosic ethanol production: Current practices and recent developments. Biotechnology & Molecular Biology Review, 6(8), 172–182.
24. Joshi, V. K. & Sharma, S.K. (2011). Food Processing Waste Management: Treatment and Utilization Technology, 11-15.
25. KARTHIK RAJENDRAN, PHD • RICHEN LIN, PHD • DAVID M. WALL, PHD • JERRY D. MURPHY, PHD , Influential Aspects in Waste Management PracticesSustainable Resource Recovery and Zero Waste Approaches. https://doi.org/10.1016/B978-0-444-64200-4.00005-0 Copyright © 2019 Elsevier B.V. All rights reserved.
26. KAVITA SHARMA, PHD • V.K. GARG, PHD Vermicomposting of Waste: A Zero-Waste Approach for Waste Management Sustainable Resource Recovery and Zero Waste Approaches. https://doi.org/10.1016/B978-0-444-64200-4.00010-4 Copyright © 2019 Elsevier B.V. All rights reserved.
27. Khan NA, Shaaban MG, Hassan MH (2003) Removal of heavy metal using an inexpensive adsorbent. In: Proceedings of UM research seminar 2003 organized by Institute of Research Management and Consultancy (IPPP), University of Malaya, Kuala Lumpur
28. Komnitsas K (2012) Best practices for agricultural wastes (AW) treatment and reuse in the Mediterranean countries, Project Number: LIFE10 ENV/GR/594
29. Lim SF, Matu SU (2015) Utilization of agro-wastes to produce biofertilizer. Int J Energy Environ Eng 6(1):31–35
30. Mishra, Surabhi (2013). Value addition and processing of agri-products. <http://www.slideshare.net/surabhimishra1/value-addition-and-processing-of-agriproducts>
31. Mohan D, Singh KP (2002) Single and multi-component adsorption of cadmium and zinc using activated carbon derived from bagasse – an agricultural waste. Water Res 36:2304–2318
32. Obil FO, Ugwuishiwu BO, Nwakaire JN (2016) Agricultural waste concept, generation, utilization and management. Niger J Technol 35(4):957–964
33. Pappu, M. Saxena, and S. R. Asolekar, “Solid wastes generation in India and their recycling potential in building materials,” Build. Environ., 2007, doi: 10.1016/j.buildenv.2006.04.015.
34. Pappua A, Saxenaa M, Asolekar SR (2007) Solid wastes generation in India and their recycling potential in building materials. Build Environ 42:2311–2320
35. Paulson, L.D. (2014). How Is Waste Converted to Energy? https://www.rwlwater.com/wasteconverted-energy.
36. Petit-Boix A, Leipold S. Circular economy in cities: reviewing how environmental research aligns with local practices. Journal of Cleaner Production 2018;195: 1270e81.
37. Pramanik P, Chung YR. Changes in fungal population of fly ash and vinasse mixture during vermicomposting by Eudrilus eugeniae and Eisenia fetida: documentation of cellulase isozymes in vermicompost. Waste Management 2011;31:1169e75
38. Prasad, Mrinalini & Ranjan, Rajiv & Ali, Dr. Akbar & Goyal, Deepika & Yadav, Arti & Singh, Teg & Shrivastav, Preksha & Dantu, Prem. (2020). Efficient Transformation of Agricultural Waste in India. 10.1007/978-3-030-41552-5\_13.
39. Pratt PF CAST Report (1975) Utilization of animal manures and sewage sludges in food and fiber production. Report No. 41 of the Council for Agricultural Science and Technology. Ames, Iowa: Headquarters Office: Department of Agronomy, Iowa State University. 50010
40. Sarmah, A.K., 2009. Agricultural Wastes, Chapter 1. Potential risk and environmental benefits of waste derived from animal agriculture; Editors: G. S. Ashworth and P. Azevedo Nova Publishers, p.p. 1-17.
41. Sengupta J (2002) Recycling of agro-industrial wastes for manufacturing of building materials and components in India. An over view. Civil Eng Constr Rev 15(2):23–33
42. Sheelendra Mangal Bhatt and Shilpa, “Bioethanol Production from Economical Agro Waste (Groundnut Shell) in SSF Mode”, Research Journal of Pharmaceutical, Biological and Chemical Sciences, Vol.5, No.6, pp.1210-1219, 2014.
43. Sindhu NP, Seharawat SP, Malik JS (2015) Strategies of agricultural waste management for better employment and environment. Int J Curr Res 7(12):24604–24608
44. Sow, Sumit & Ranjan, Shivani. (2021). Bioconversion of Agricultural Wastes for Mushroom Production.
45. SS Parihar, KPS Saini, GP Lakhani, A Jain, B Roy, S Ghosh and Bhavna Aharwal “Livestock waste management: A review” Journal of Entomology and Zoology Studies 2019; 7(3): 384-393
46. Sudkolai ST, Nourbakhsh F. Urease activity as an index for assessing the maturity of cow manure and wheat residue vermicomposts. Waste Management 2017;64: 63e6
47. Sun, Y., & Cheng, J. (2002). Hydrolysis of lignocellulosic materials for ethanol production: A review. Bioresource Technology, 83(1). doi:10.1016/S0960-8524(01)00212-7 PMID:12058826
48. Swarnam TP, Velmurugan A, Pandey SK, Roy SD. Enhancing nutrient recovery and compost maturity of coconut husk by vermicomposting technology. Bioresource Technology 2016;207:76e84
49. Taherzadeh, M. J., & Karimi, K. (2008). Pretreatment of lignocellulosic wastes to improve ethanol and biogas production: A review. International Journal of Molecular Sciences, 9(9), 1621–1651. doi:10.3390/ ijms9091621 PMID:19325822
50. Tan WT, Ooi ST, Lee CK (1993) Removal of chromium (VI) from solution by coconut husk and palm pressed fibre. Environ Technol 14:277–282
51. Ungureanu G, Ignat G, Vintu CR, Diaconu CD, Sandu IG (2017) Study of utilization of agricultural waste as environmental issue in Romania. Rev Chim 1(3):570–575
52. Vodounnou DSJV, Kpogue DNS, Tossavi CE, Mennsah GA, Fiogbe ED. Effect of animal waste and vegetable compost on production and growth of earthworm (Eisenia fetida) during vermiculture. International Journal of Recycling of Organic Waste in Agriculture 2016;5:87e92.
53. Zhang F, Gu W, Xu P, Tang S, Xie K, Huang X, Huang Q (2011) Effects of alkyl polyglycoside (APG) on composting of agricultural wastes. Waste Manag 31:1333–1338
54. Zhu W, Yao W, Shen X, Zhang W, Xu H. Heavy metal and d 13 C value variations and characterization of dissolved organic matter (DOM) during vermicomposting of pig manure amended with 13C-labeled rice straw. Environmental Science and Pollution Research 2018: 1e10