**Agriculture: Waste to Wealth**

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**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 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**

India ranks only 94th out of 107 countries on the 2020 Global Hunger Index, even though 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. Other studies conducted by CIPHET 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.

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. A loss of 9.16% was 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 when our soils are less fertile, Pollution 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. Generating wealth generally refers to the conversion of waste to product.. 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 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 the waste produced from excreta with bedding material, wastewater such as urine, cage water, wastewater from bathing of animals, hair, dung, feather, feed and fodder, etc from animals and birds. Improper management of livestock waste leads to agricultural runoff. Livestock waste contains many beneficial by-products that can be used by farmers to make dung cake and it becomes a better option for fuel generation such as biogas, composting, etc.

1. **HORTICULTURE WASTE**:

Horticulture wastes refers to the spoiled, unused and the unsold vegetables and fruits including the branches, leaves, and dead plants are the types of horticulture wastes (Zhang et al. 2011). This waste can be  converted into compost, and animal feed , biogas plant etc.

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

Sugar industry is one of the biggest industries that uses agricultural waste bagasse produced at a large amount per year that is used in wall panels, insulation boards, and manufacturing paper. Other agro-industrial wastes include wheat bran, rice bran, and corn bob It is very helpful in the circular economy. (Sen 2002; BMTPC 2005).

6 . **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. The food industry produces large amounts of waste, both solid and liquid, resulting from the production, preparation, and consumption of food. The waste produced cause pollution and a loss of valuable nutrients. Apart from the waste created , food processing waste can be utilized and converted into useful products of high value.

**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, we 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 can be converted into organic manure which boosts crop production and lowers the cost and offers various health benefits, which is a serious problem caused by various inorganic manures. Vermicomposting helps in increasing soil fertility, maintaining nutrient capacity, stabilizing soil texture , and water-holding capacity of soil(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.

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| --- | --- | --- | --- |
| **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**:

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

1. **ENERGY FROM AGRICULTURAL WASTE**:

Biochemically converting agricultural biomass waste to bio-energy is an environmental friendly and sustainable technique as shown in table 3. Besides generating revenue, waste-to-energy schemes offer an alternative and environmentally friendly means of waste disposal. Additionally, it also provides a valuable by-product: a good quality agricultural fertilizer that is odorless. 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 table 3.

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..

Bio-ethanol production from natural resources such as sugar cane, wheat, corn, etc is called first-generation bio-ethanol. Second-generation bio-ethanol is produced from agricultural waste. Producing bio-ethanol using the Second generation is the best option as it not only reduces the waste produced but also generates valuable fuel. They also emit less carbon and produce more energy. Agriculture waste such as wheat straw, barley husks, corn cobs, paper pulp, sugar cane bagasse, banana peel, orange peels, and pineapple peels are used for the production of second generation bio-ethanol.

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

**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**

Biogas is produced by the biological breakdown of organic matter in the absence of oxygen, also called the anaerobic conditions. It is a type of bio-fuel that produces high amounts of methane gas fig4. Animal waste such as, dead stock, waste forage , cow dung , milk house waste, and silage effluent is used to produce biogas. It results in the production of bio-fertilizers, and biofuel and saves plant nutrients.

**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**.

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| --- | --- | --- | --- |
| **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 specific system, these functions may be combined, repeated, eliminated, or rearranged as necessary. One other way of waste management is Integrated Agricultural Waste Management System.

**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**

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

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

To develop smart management of agricultural waste, farmers and the public at large should be made aware of various practices of waste management. With the help of NGOs, and government policies creating new campaigns and generating awareness and wakefulness of agro-waste uses and recycling the waste into a useful product will provide us with a great start by bringing us into a new era of development. A proper framework where policy, technology, and society go hand in hand makes way for new ideas and education of old and new ways of waste management. A healthy and sustainable environment can only be developed if reduce agricultural waste and find new ways for a cleaner and brighter India with a holistic approach to the whole situation.

**REFERENCES**

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

Ajmal M, Rao RAK, Siddiqui BA (1996) Studies on removal and recovery of Cr (VI) from electroplating wastes. Water Res 30(6):1478–1482

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.

Anon (2015). https://en.wikipedia.org/wiki/Food\_waste

Anonymous (2000). Environmental Standards for Ambient Air, Automobiles, Fuels, Industries and Noise. Central pollution control board ministry of environment & forests .

BMTPC (2005) Home page. <http://www.bmtpc.org/fibre.pdf>

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.

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.

FAO(2015). The potential use of wood residues for energy generation. <http://www.fao.org/docrep/t0269e/t0269e08.htm>

Gustavson, Jenny; Cederberg, Christel; Sonesson, Ulf; van Otterdijk, Robert; Meybeck, Alexandre (2011). Global Food Losses and Food Waste (PDF). FAO. [7].

Joshi, V. K. & Sharma, S.K. (2011). Food Processing Waste Management: Treatment and Utilization Technology, 11-15.

[How Much of India's Agricultural Produce Is Wasted Annually?](https://thewire.in/agriculture/india-agricultural-produce-wasted) The wire article.

<http://kvkernakulam.org.in/uploads_en/files/KVK%20Newsletter%202017%20APril%20to%20March%202018.pdf>

<http://www.nirjaft.res.in/admin/uploads/Publication/219118303293438_publication_pdf_NINFETAR2020compressedpdf.pdf>

<https://cdn.cseindia.org/attachments/0.89229900_1635734110_jalopchar.pdf> https://naip.icar.gov.in/download/c2-209001.pdf

<https://cift.res.in/annual_reports/english/2014-15/Annual-Report_2014-15.pdf>

<https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=31493.wba>

https://ediary.foe.org.in/index.php/2019/04/15/agricultural-waste-to-wealth-approaches-forvaluation-of-agricultural-waste/

https://fptaindia.in/paper-is green .

<https://www.f6s.com/companies/agricultural-waste-management/india/co>

https://www.roadrunnerwm.com/blog/the-5-rs-of-waste-recycling

<https://www.thehindu.com/news/national/andhra-pradesh/turning-waste-into-wealth-by-salvaging-crop-residue/article32538011.ece>

https://scroll.in/article/909699/startups-are-helping-north-indias-farmers-to-dispose-of-crop-residue-cleanly-and-reduce-pollution

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.

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.

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.

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

Komnitsas K (2012) Best practices for agricultural wastes (AW) treatment and reuse in the Mediterranean countries, Project Number: LIFE10 ENV/GR/594

Lim SF, Matu SU (2015) Utilization of agro-wastes to produce biofertilizer. Int J Energy Environ Eng 6(1):31–35

Mishra, Surabhi (2013). Value addition and processing of agri-products. <http://www.slideshare.net/surabhimishra1/value-addition-and-processing-of-agriproducts>

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

Obil FO, Ugwuishiwu BO, Nwakaire JN (2016) Agricultural waste concept, generation, utilization and management. Niger J Technol 35(4):957–964

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.

Pappua A, Saxenaa M, Asolekar SR (2007) Solid wastes generation in India and their recycling potential in building materials. Build Environ 42:2311–2320

Paulson, L.D. (2014). How Is Waste Converted to Energy? https://www.rwlwater.com/wasteconverted-energy.

Petit-Boix A, Leipold S. Circular economy in cities: reviewing how environmental research aligns with local practices. Journal of Cleaner Production 2018;195: 1270e81.

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

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.

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

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.

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

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.

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

Sow, Sumit & Ranjan, Shivani. (2021). Bioconversion of Agricultural Wastes for Mushroom Production.

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

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

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

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

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

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

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

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.

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

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