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Review Article

AGRICULTURAL WASTES AND THEIR MANAGEMENT

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Abstract: Any unusable materials produced during the process of raising cattle, poultry, fruit crops, aquaculture, or other agricultural activities are considered agricultural wastes. Therefore, items produced as a result of various agricultural activities are referred to as "agricultural waste," such as manure and other waste from farms, livestock harvest waste, fertilizer runoff from fields, pesticides that end up in water, the atmosphere, or soils, and salt and silt drained from fields. Agricultural waste processing can cause enormous financial loss and pose a serious risk to human health through environmental pollution. Agricultural solid wastes are frequently discarded or burned in public in developing nations, which results in the production of air pollution, soil contamination, a poisonous gas, smoke, and muck, as well as the spread of disease. By contributing to the production of greenhouse gases (CO_2, N_2O, CH_4), air pollutants (CO, NH_3, NOx, SO_2, NMHC, volatile organic compounds), particulates, and smoke, burning agricultural crop residue puts human health at risk. The main goal of the current review article is to give readers useful knowledge on agricultural wastes, their harmful effects on the environment, and strategies for reducing waste by using it for societal benefit.

Keywords: *Agricultural waste, Crop residues, Post harvest waste, Residue burning, Environment, Pollution, Human health*

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Introduction

It is not exaggeration to say that agriculture is still a backbone of Indian economy as was in past and will remain in future too. Majority of Indian population right from the Kashmir to the coast of Kanya Kumari and from North eastern states to the desserts of Rajasthan are involved in agriculture activities. Agriculture is a multi-operational profession as it includes several activities related to growing crops, their handling, processing, transportation, marketing, reaching to consumer, utilization and leaving a huge quantum of wasteful unutilized materials. These wasteful unutilized materials remain in environment causing health hazard and environmental pollution or are further recycled in different forms which further goes to various cycle forming different products. The main issue of these activities is generation and degeneration of living bodies which utilizes and release some sort of energy. Thus, lot of resources is used in generation. It is general saying that more and more use of resources more and more pollutes the environment. In the past, most things were not in abundance, and so a core practice of a circular economy was adopted. People easily accept a wasteful and exploitative attitude when things are in abundance. In ancient times, household wastages were enough to be recycled, even now too many villages in India practice dumping household and wastages to decompose in their backyard for further utilization as compost as nutritional supplements for their crops. The real problem of waste generation started in India by the name of modernization and invention of plastics. It can be said that agriculture is one of the biggest biological sectors that produces highest biomass, which can contribute an important input for the bio economy. The overall objective of a present review article is to provide valuable information about agricultural wastes and their negative impact on environment as well as ways to minimize wastages by utilizing them for the advantage of society.

Agricultural waste

There are different types of waste which are generated from our daily or industrial activities such as organic waste, e-waste, hazardous waste, inert waste *etc.* However, agricultural wastes can be defined as any un utilizable materials generated during the process of growing crops, rearing poultry birds, livestock, growing fruit crops, aquaculture [1]. Nothing in world is waste unless and until its further utilization in other form is not understood. Thus 'agricultural waste' are items produced as a result of various agricultural activities including manure and other wastes from farms, poultry houses and slaughterhouses; harvest waste; fertilizer run-off from fields; pesticides that enter water, air or soils; and salt and silt drained from fields.

Losses caused by agricultural waste

Agricultural waste may constitute a significant threat to human health through environmental pollution and handling them may result in huge economic loss. Many of the farmers and household managers who generate these wastes don't know how to effectively manage them. In many parts in developing countries, agricultural solid wastes are indiscriminately dumped or burnt publicly there by leading to the generation of air pollution, soil contamination, a harmful gas, smoke and mud and the residue may be channelled into a water source thereby polluting the water and aquatic environment [2]. If nobody manages the waste, then it not only pollutes water and air but also disrupt the process of farming. According to Jain *et al.* (2014)[3] agricultural crop residue burning contribute towards the emission of greenhouse gases (CO_2, N_2O, CH_4), air pollutants (CO, NH_3, NOx, SO_2, NMHC, volatile organic compounds), particulates matter and smoke thereby posing threat to human health.

Quantum of agricultural waste produced

India is one of the richest countries in agricultural resources. We have been experiencing that there is great contribution of agriculture in bringing food and nutritional security and economic growth of the country. India produced about 93.51 million tons (Mt) of wheat, 105.24 Mt of rice, 22.26 Mt of maize, 16.03 Mt of millets (jowar, bajra, ragi and small millet), 341.20 Mt of sugarcane, 7.79 Mt of fiber crops (jute, mesta, cotton), 18.34 Mt of pulses and 30.94 Mt of oilseed crops [4]. According to an estimate from Ministry of New and Renewable Energy about 500 Mt of crop residues are generated annually.

Quantification Crop residue and its worldwide production

The output of crop wastes is not tracked by any country. However, seldom national or international totals have only ever been calculated as part of studies that evaluate the prospective benefits of enhanced agroecosystem management and the potential contribution of biomass energy. The ratio of straw to grain (S: G) is the most popular unit of measurement for agricultural residual production. The norm is to express residue production as crop yield at field wetness and dry-matter mass (Smil 1983, unpublished report). The residual mass can be calculated using the formula (1 - HI)/HI when given as a multiple of harvested yields. The S: G ratio may not include stubble; thus this total will be a little higher than that. The annual global harvest of crops and crop residues in the mid-1990s, agricultural residues are produced annually at a rate of 3.5 to 4.0 Gt. the mid-1990's the highest estimate, 3.75 GT, is over 1.4 times the amount of the annual aggregate of crop harvest (2.750 GT).

Sugar cane tops and leaves are the second-largest contributors, and cereal stem, leaf, and sheath material make up two-thirds of all residual phytomass. Besides, the inclusion of crop processing residues, such as husks and brans (which comprise about 13% of ripe rice), or sugarcane bagasse (the fibrous residue remaining after the milling of cane stalks, which accounts for 15 to 18% of the fresh weight of the cane plant), would significantly increase any calculated total of residual phytomass. However, regardless of the ratio employed, the variety of environmental and agronomic conditions makes it impossible to determine the production of agricultural residue globally.

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Crop residue in Indian Context

Many leftovers are produced during and after crop harvest, both on and off the farm. Crop residue production is predicted to be 500 Mt per year by the Ministry of New and Renewable Energy. Punjab (51 Mt), Maharashtra (60 Mt), and Uttar Pradesh (60 Mt) produce the most crop leftovers (46 Mt). Cereals provide the most residues (352 Mt) among diverse crops, followed by fibers (66 Mt), oilseeds (29 Mt), pulses (13 Mt), and sugarcane (12 Mt). 70% of the agricultural wastes are from cereal crops (rice, wheat, maize, and millet), with rice accounting for 34% of the total. The top and leaves of sugarcane yield 12 Mt of agricultural residues in India or 2% of all crop residues. Punjab (51 Mt), Maharashtra (46.45 Mt), and Uttar Pradesh (60 Mt) produce the most crop leftovers (46 Mt). Cereals provide the most residues (352 Mt) among diverse crops, followed by fibers (66 Mt), oilseeds (29 Mt), pulses (13 Mt), and sugarcane (12 Mt). Cereal crops (rice, wheat, maize, and millet) account for 58% of the crop residues, with rice accounting for 53% of the total. The top and leaves of sugarcane produce 12 Mt of crop residues in India, or 17% of all crop residues [6-8].

Crop Residue Burning in India and its Impact

According to the Indian Ministry of New and Renewable Energy (MNRE), the country produces 500 million tons annually. The majority of this crop residue is used as fuel for other residential and industrial uses, as well as for fodder. Nevertheless, there is still a 140 Mt surplus, of which 92 Mt has burned annually. It's also important to note that India burns a significantly bigger volume of agricultural waste than any other country in the area does overall [9]. However, only 5% of India's total agricultural leftovers are burned annually; the remaining 80% are used as animal bedding and cattle feed, as soil mulch, to produce biogas, to make bio manure and compost, thatch rural homes, grow mushrooms, and as fuel for residential and industrial purposes. This raises the possibility that effective state intervention, handholding of farmers, and private player involvement in farm waste management will boost its utilization and produce natural resources. Burning crop residue has several negative effects, including the release of greenhouse gases (GHGs) that contribute to global warming, elevated levels of particulate matter (PM) and smog that pose health risks, the loss of agricultural lands' biodiversity, and deterioration in soil fertility [10].

The heat produced by burning wastes increases soil temperature and decreases bacterial and fungal populations. The burning of residue raises soil temperatures below the surface to roughly 33.8-42.2°C at a depth of 10 mm [11], and long-term impacts may extend up to 15 cm into the top 15 cm of soil. Frequent burning destroys the soil's beneficial microflora and fauna lowers the soil's potential for retaining nitrogen and carbon and loss of a significant amount of organic matter. Crop burning destroys the soil's carbon-nitrogen balance [12]. According to NPMCR, 2019, burning one ton of straw results in the loss of 25 kg of carbon, 5.5 kg of nitrogen, 2.3 kg of phosphorous, and 5.5 kg of organic carbon, 5.5 kg of nitrogen, 2.3 kg of phosphorous, 25 kg of potassium and 1.2 kg of sulfur. Crop residue from various crops typically contains around 80% nitrogen (N), 25% phosphorus (P), 50% sulfur (S), and 20% potassium (K). The soil can also be enriched with C, N, P, and K if the crop residue is left in the soil. Burning crop leftovers is a significant problem across the country. According to Jain et. al.2014, the percentage of crop residue burned in rice paddies across the states ranged from 8 to 80%. Harvesters in Punjab, Haryana, and Himachal Pradesh burned 80% of the rice straw on-site, followed by those in Karnataka (50%) and Uttar Pradesh (25%).

Types of Agricultural Waste Resources

Agricultural wastes are the leftovers from producing and processing agricultural products, including grains, fruits, vegetables, meat, poultry, dairy, and other raw agricultural items. They are the by-products of agricultural product production and processing that may contain elements that are useful to people but whose economic worth is less than the expense of gathering, transporting, and processing them for such purposes. They can take the shape of liquids, slurries, or solids, relying on the system and type of agricultural activity. Today's agricultural output exceeds that of the previous five decades by more than three times [13]. Productivity may rise in the horticultural industries as a result of technical improvement. On the other hand, increased productivity also results in increased trash production. They come in both recyclable solid waste and green waste varieties. Animal waste (manure, animal carcasses), food processing waste (only 20% of maize is canned, and 80% of it is wasted), crop waste (corn stalks, sugarcane bagasse, drops and culls from fruits and vegetables, prunings), and hazardous and toxic agricultural waste are all included in the term "agricultural waste" also called as Agro-Waste (pesticides, insecticides, and herbicides, *etc*). Chemical wastes during cultivation are produced as a result of the ongoing use of pesticides, insecticides, and herbicides in farming. These are primarily solid wastes like bottles and pesticide containers. The majority of these forms of chemical use activities are carried out by rural, illiterate farmers in developing nations. Therefore, producers or consumers frequently lack knowledge regarding the disposal of these forms of solid waste. Such forms of ignorance lead to the environmental equilibrium being compromised. About 2% of pesticides are typically left unused in their containers before being thrown into nearby ponds or open fields for disposal. Due to this ignorance, serious environmental problems such as food poisoning, water pollution, air pollution, *etc*. may result [14].

Livestock waste

The livestock comprises three types of farm animals namely cattle, pig, and poultry. The wastes produced from livestock are not only useful in making manures but are also helpful in generating biogas as an energy source. Considering collection efficiency of 80 per cent and organic part of municipal solid waste to be 50 per cent, total organic waste generated per day in India comes to around 65,000 tons per day. Even if half of this is diverted to the biogas industry, the government can leverage this by reduction in import of fossils and fertilizers [15].

If properly stored and used, manure from animal feeding operations may be a valuable resource. The addition of manures in crop fields improves soil physical conditions like water infiltration, bulk density, and cation exchange capacity, besides supplementing nutrient supplementation. The addition of manure also brings out the increase in microbial population thereby making the soil more fertile. However, a serious issue is represented by the presence of pathogens. The latter may affect soil and water quality with a consequent serious risk to human health.

Food borne diseases introduced by animal waste may occur when raw or improperly treated manure is employed as a soil amendment or organic fertilizer to grow fruits and vegetables. These compounds pose a threat to both human health and environmental safety. The consumption of vegetables grown in manure-amended soils may end in widespread resistance to antibiotics [16] and the consequent strengthening of pathogens and other bacteria. Animal manure is seen as a feasible source for the creation of biogas, heat, power, and soil amendment through aerobic and anaerobic bio stabilization or thermal conversion such as gasification or pyrolysis considering new technologies and increased environmental effect concerns [17,18].

Utilization of Post - Harvest Agricultural Waste

These are in the category of secondary agricultural residuals produced after processing crops into various bio-product forms. These can be used in fodder and the rest is decomposed or burnt. These residues are rich in cellulosic fibers. Making use of extra harvest as animal feeds is an effective way to reduce post-harvest waste. Cattle, goats, and sheep can eat vegetables, while birds can eat grains that have been damaged. This is a useful way to put waste to use. Some examples of using post-harvest/ processing of agricultural produce are as below. India's food processing industry generates a lot of solid waste. Additionally, the food business produces waste water as well, however in far greater quantities than solid waste. Different kinds of microorganisms that are connected to the solid waste from the food industry produce metabolic byproducts, which lead to chemical and biological environmental pollution [19]. Fruit processing produces large volumes of trash, including peels, seeds, stones, pomace, rags, kernels, and oilseed meals [20,21]. The processing of fruits and vegetables generates enormous amounts of liquid and solid waste, which, if not used or disposed of properly, can lead to pollution issues. Due to the usage of a wide variety of fruits and vegetables, a wide range of processing techniques, and the multiplicity of the product, the waste produced by the fruit processing sector is quite different [21]. Due to the usage of a wide variety of fruits and vegetables, a wide range of processing techniques, and the multiplicity of the product, the waste produced by the fruit processing sector is quite different. Various fruits and vegetables have varying levels of waste. The waste from fruits and vegetables has a high nutritious content, as seen by its chemical makeup. Therefore, tossing garbage from food processing facilities into a river is equivalent to tossing money into the ocean. Some of these fruit and vegetable wastes are a rich source of essential nutrients like sugars, proteins, lipids, minerals, fiber, and others. The waste from processing industries can be turned into a variety of value-added products, including essential oils, starch, pectin, dietary fibers, acids, wine, ethanol, vinegar, microbial pigments, flavors, and gums, enzymes, single cell proteins, amino acids, vitamins, organic compounds, colors, and animal feed [22].

Preparation of Handmade Paper from Jute Waste

About 40,000 ton of processing trash, or caddies, are produced as a byproduct by the jute industry [23]. The main component of this waste is short, unspinnable jute fiber. This waste was historically utilized by the jute industry, along with coal, as fuel for the boiler that produced the steam necessary to drive the size and calendering machinery. Caddies are a difficult fuel to use because of their low bulk density and poor thermal efficiency [24]. The strong characteristics of hand-made paper created from cleaned and scrubbed jute caddies indicate its potential for use in the production of paper bags for groceries and shopping. Given the growing restrictions on the use of non-biodegradable plastic carry bags due to their detrimental environmental and ecological impact, these eco-friendly paper bags have significant market potential. Particularly in the rural sector, the technology is practical and easily adopted, requiring minimal investment and having the potential to create jobs.

Lac Dye from Effluent of Stick Lac Washing

Lac dye is a red-colored natural dye, which is present in the body fluid of the lac insect, Kerria lacca (Kerr) as the alkali salt. It is obtained during the washing of sticklac for preparing seedlac. India is the leading producer of Lac in the world. in terms of production of raw lac with an annual production of 18,537tons [25]. About 80% of the world's production is in India, and 75% of it is exported to over 100 countries, mainly in processed and semi-processed forms. Among lac-growing states, Jharkhand ranks first followed by Chhatisgarh, Madhya Pradesh, Orissa, Uttar Pradesh, and, Maharashtra. About 200 ton of lac dye is produced during the processing of this raw lac; most of this dye is lost as a byproduct. Some processors utilize the technically graded, somewhat pure form for indeterminate amounts of textile dye while the other processing industries provide the sludge of washing to the peasants as manure. Thus, there is a huge potential for using this by-product of lac factories, and even if only half of it is realized, it will be possible to transform the trade-in lac dye into a successful specialized product business with a secure international market [26].

Lac Mud as Organic Manure

Lac mud is the waste product of lac processing industries which is obtained to a tune of about 2.5 to 4.5% on a dry and wet weight basis, respectively, Lac mud produced is mostly dumped due to lack of a proper method of disposal which may create pollution hazards. As such can be used as manure. Application of decomposed enriched lac mud in vegetables has recorded 22.0, 22.5, and 18.3 percent higher yields of brinjal, tomato, and spinach, respectively, over 100% N through inorganic sources as farmers' practice [27]. Singh et.al. (2021) [28] observed that lac mud was ground in fine particles and treated with lime (@ 25 g per kg of lac mud) followed by enrichment with each of N, P and K as per treatments, azotobacter and PSB each @ 25 g/kg of lac mud. Experimental results revealed that lac mud enriched with 0.2% N + 0.2% P_2O_5 + 0.2% K_2O produced the highest number and weight of chrysanthemum and rose flowers. The increase in number and weight of flowers with an application of lac mud enriched with 0.2% N + 0.2% P_2O_5 + 0.2% K_2O was 47.4 and 38.5 percent in chrysanthemum and 25.5 and 31.7 percent in rose over the conventional method of manuring (application of vermicompost), respectively.

Protein Isolates/Concentrates from De-Oiled Cakes/Meals

Cattle feed, compost additives, or plant conditioners are the three main uses for oil-seed cakes that are still available after oil extraction for other uses. These cakes made from oilseed are a good source of minerals, nitrogenous chemicals, and protein. Efforts have been done to use these protein-rich resources for human consumption in addition to their customary use. India is the world's greatest producer of oilseeds, according to the FAO Statistics Division (2010) [29], producing approximately 25 million tonnes of oilseed cakes per year. The largest by-product in the world in terms of production is soybean seed cake, followed by canola seed cake. Oilseed cakes were utilized in the past as soil compost and animal feed since they were a great source of advantages and were inexpensive. Oilseed cakes include a lot of minerals, energy, and carbohydrates. The weight of the newborn calves increased due to the oilseed cake [30]. Diets strong in plant protein have various health advantages, including decreasing blood pressure and cholesterol levels as well as body weight. This is the main reason why these are preferred over animal protein. Groundnut cake has the highest protein level (45–50%), followed by soybean, cottonseed, rapeseed, sesame, sunflower, palm oil, and olive oil cake.

Microbial Protein using Corn Cob

Corn cobs [CC] are a common cereal crop by-product. At the moment, the majority of these materials are wasteful uses of natural resources and environmental pollutants. Several nations have already passed legislation outlawing the burning of CC. Because of their high cellulose and hemicellulose content, corn cobs may be an excellent source of roughage for ruminants.

In the tropics, crossbred dairy cows are typically fed low-quality roughages, primarily agricultural crop leftovers like rice straw (RS) [31]. However, rice straw has low nutritional value due to its low protein content (2% to 5% DM), high fiber content, and low dry matter digestibility, which leads to low voluntary feed intake [32]. Corn cobs are a by-product of one of the most common cereals farmed globally. Since the ratio of Corn cob to maize grain may approach 100:18, a lot of CC can be produced [33].

Utilization of Corn Cob Powder for Kulhad(Cup) Making

Mud is combined in various ratios with corn cob powder, and then cups are made by baking the molded cups over an open flame. To turn waste into a product with additional value, corn cobs, which would otherwise be a waste product, are used to make mud cups. Advantages Part of the agricultural biomass waste can be utilized to make cups with mud; this method of biomass use offers an alternative method for getting rid of corn cob waste.

Biochar from Agricultural Waste Material

One effort to manage agricultural waste is by making biochar. Biochar utilization opportunities for agricultural land are tremendous, both in terms of the availability of raw materials and their functions. Biochar is a carbon-rich material produced by the incomplete combustion of biological materials in the absence of oxygen or with a limited amount of oxygen [34]. Biochar can improve the soil's physiochemical properties to accommodate cultivation [35]. Saowanee (2022) [36] reported that cassava rhizome biochar had the highest pH and EC, while krachid (*Streblus ilicifolius* (Vidal) Corner.) biochar had the lowest pH value. Rice husk biochar had the lowest EC and CEC values. Cassava rhizome biochar and corncob biochar were very strongly alkaline. The highest CEC was found in the krachid biochar, significantly higher than in the other biochar types. The results showed that all types of biochar had high stability and could remain in the soil for a long time.

Uses of Sugar Industry Residue

The crop known as sugarcane provides humans with food in the form of sucrose and syrups as well as animal feed in the form of green leaves, fertilizer in the form of SCB and PMC, fiber in the form of cellulitis materials, fuel in the form of residue/waste materials, chemicals in the form of alcohol, and binding material [37]. Bagasse is high in nutrients and can be fed to ruminants as bran when food is in short supply [38]. Additionally, SCB can be used to create goods based on fermentation, pulp, and paper manufacture, as well as enzymes that are enhanced with protein and cow feed [39]. Byproducts of the sugar industry also benefit agriculture, as they lower the need for mineral fertilizers, increase soil organic matter, and increase crop production. In addition to producing sugar and beverages, sugarcane processing industries also produce ecologically hazardous byproducts, and disposing of them is a significant problem [40]. The two main byproducts of sugar production are sugarcane bagasse (SCB; 25–30%) and press mud cake (PMC; 3.4%).

The use of SCB as fuel in the sugar industries is its most cost-effective application. A tiny fraction of the SCB produced in the sugar industry is utilized to make other goods, but the entire amount is used as boilers (enzymatic products, drugs, *etc*.). The solid waste left over from filtering sugarcane juice is known as sugarcane press mud. According to studies by Gaikwad *et al*. (1996)[41], the purifying process divides the juice into a clear juice that rises to the top and is used to make sugar and mud that settles at the bottom. It has physical characteristics comparable to soil and offers good anchoring to plant roots in addition to providing nutrients for plants if composted properly. It is rich in nitrogen, phosphorous, potassium, organic carbon, and other micronutrients [42].

Utilizing Groundnut Shell as Substrate to produce Enzymes Cellulases

One of the most widely grown plants in India is the groundnut. Its waste utilization is still quite low, though. According to Statista, (2022) [43], India produced 9.86 million tonnes of groundnuts, with the shell accounting for about 29% of the overall weight of the pod. Therefore, it is projected that 2.86 million metric tonnes of groundnut shells are produced in India each year but are not valued. The percentages of cellulose (35.7%), hemicellulose (18.7%), lignin (30.2%), and ash (5.9%) in groundnut shells are all relatively high. Naidu *et al* (2016) [44]. In addition to serving as a source of antioxidants, groundnut shells are also used as a raw material to make fertilizers and the enzymes cellulase and hemicellulose [45]. Additionally, groundnut shells have uses in the manufacture of enzymes and hydrogen, dyes, and the breakdown of heavy metals, among other bio-products like biodiesel, bioethanol, nano-sheet, *etc*. To achieve a zero-waste production system, an effective management approach must be used to transform what would otherwise be deemed garbage into useful bioproducts.

Conclusion

Agricultural wastes pose a threat to both human and environmental health, including waste feed, animal faeces, urine, and manure. These wastes pollute the environment by releasing dangerous gases such carbon dioxide, methane, nitrous oxide, and hydrogen sulphide. These make the climate unpredictable and affect the environment.

Application of research: The amount of agricultural wastes produced on farms and released into the environment will be reduced if efficient methods for managing agricultural wastes identified in the study are properly implemented.

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