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Sustainable Efficacy of Agriculture Waste Materials and the Value of Indigenous Knowledge

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Abstract-

India has been an agriculturally important country contributing 19.9 1% in GDP (2020-2021) which has surged when compared to last year. Wheat, paddy, maize, millets, sugarcane, pulses, and a range of other crops are cultivated in India's varied agro climates. The large amount of crop production is not solitary, it creates large quantity of residues with them. Earlier the residues from the harvested grains were burned or either disposed which had its own adverse effects on the environment. The waste materials from the agriculture can be used effectively in sustainable manner for various objectives like fuel and energy generation, bio-based fertilizers, materials used in construction, synthesis of nanomaterial's, remediation of heavy metals, waste water treatment, synthesis of bio plastics, activated carbon and so on. India produces more than 400 million tonnes (MT) of agricultural waste each year. Paddy straw produces 130 MT in which mainly it is use as fodder and rest goes waste in landfills Agriculture waste products are not useless; they can be used to manage the ecosystem and human existence without harming the environment. Aim of the review article is to highlight the sustainable benefits of the waste materials generated from Agriculture. Crop burning, along with other sources of pollution, is a serious problem in India. As particulate matter and greenhouse gases in the air increases it poses health risks to humans and animals, as well as global warming and climate change.

Keywords: Agriculture waste, Crop residues, Agriculture biomass, Energy generation, Indigenous knowledge

Introduction

"The term "agricultural waste"are the by-products of agricultural activities. Crop leftovers are mostly residual stalks, straw, leaves, roots, husks, shells etc. It can be used to make heat, biodiesel, steam, methanol, ethanol, charcoal, biodiesel, raw materials, animal

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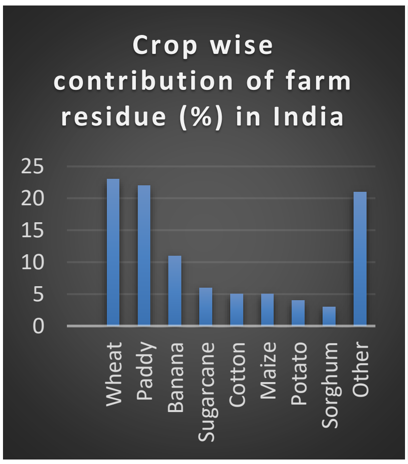
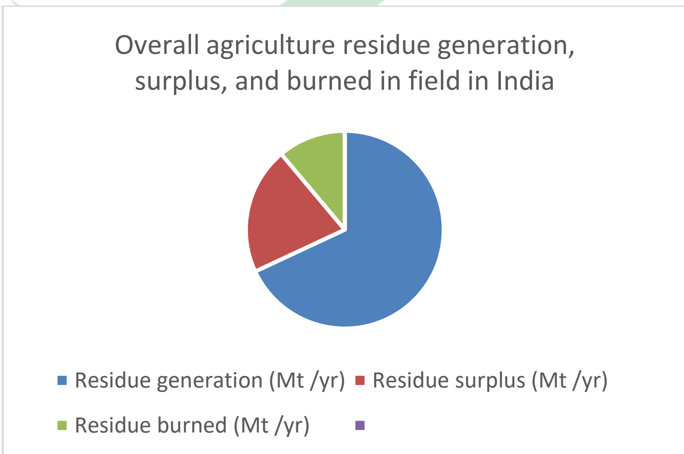
feed, composting, energy, and biogas construction, among other things.Many agricultural wastes, especially in developing nations, are still generally unused and are left to rot or are publicly burned in the field (Sabiti, 2011). The annual lignocellulose biomass produced by the primary agriculture sector is estimated to be around 200 billion tons around the world (Ren et al, 2019).

India produces more than 400 million tonnes (MT) of agricultural waste each year. Paddy straw produces 130 MT in which mainly it is use as fodder and rest goes waste in landfills (Rautray *et al*, 2019).Agriculture waste is a significant portion of global rice husk, bagasse, jute, stalk, and coconut fiber. India is the world's greatest sugar cane producer, producing 285.4 MT of cane, or slightly more than 20% of global sugar cane production. It have been analyzed that baggase makes up one-third of the waste product generated following sugar extraction, according to research (Raghuvanshi *et al*, 2004).

Stubble burning following the grain harvest from crops such as wheat, paddy is a popular practice in several Indian states. Farmers do this over time in order to save money on the cost of clearing the field of agricultural remains. This result in significant environmental pollution as particulate matter and greenhouse gases in the air increase, posing health risks to humans and animals, as well as global warming and climate change. It also has a negative impact on soil health, causing direct losses of macro- and micronutrients from the soil as well as a reduction in soil microbial population and diversity, which are responsible for the principal pathway of nutrient transformation in soil (Guo *et al*, 2010).

Agricultural biomass waste is expected to be produced at a rate of 140 Pg each year, which is comparable to about 50 billion tons of oil.





Source : Cradon *et al*., 2015)Source : Chandal *et al*., 2015

Agricultural wastes can be used to improve food security in a variety of ways, including as a bio-fertilizer and soil amendment, as animal feed, and as a source of energy. They have a lot of organic stuff in them and many of them can be applied to the soil without concern (Sabiti, 2011). Crop burning, along with other sources of pollution, is a serious problem in India, particularly in the Indo Gangetic plains. Burning crop leftovers poses a serious threat to one's health. It impairs lung function, potentially posing an epidemiological risk. (Rautray *et al*, 2019).

Values of Traditional Knowledge For Agriculture Waste Management

Traditional ecological knowledge plays an important role in the long-term relationships between indigenous peoples and vast ecosystems in the circumpolar north, it can also aid our understanding of the long-term composition, structure, and function of ecosystems as a result of management decisions and human-use consequences. Watson et al, 2003. Over generations, the indigenous system develops its knowledge by utilizing common property resources. These resources are safeguarded by public involvement, societal participation beyond self-interest, and market potential grasp (Raju *et al.*, 2006).The increased expectation of people's aspirations, the gap between haves & have-nots, food security have all been challenges for public and private organizations to overcome. Farm income must be sustained by effective, cost-effective, and environmentally friendly technology, especially in tropical nations (Ravikumar *et al*, 2015).

2.1 Storage practices

Straw of wheat are mixed with the grains to store the grain up to one year along with the prevention of grains form pests. To store paddy, wheat straw or paddy straw is used in capacity with braided ropes like buildings known as "Kacheri." The structures created from paddy straw promote air circulation, which helps to keep the seeds appropriately. Paddy grains are stored in large mud-pots that can reach three feet in height. Clay and paddy straw are used to make these airtight jars. Paddy cultivated in these containers does not absorb water from the air.

Cotton (*Gossypiumhirsutum*) stalks and Indian elm (*Holarrhenaantidysenterica*) were used to build a basket to preserve onions and keep them from rotting for a year. The Indian elm is placed at rock bottom of basket before placing the onion by which, the method of

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turning is not recommended. Soaked paddy straw are placed around the basket in circular type in which coating of cow dung is applied. These is used to store the pulses (which is mixed with ash). Before storing grainy, a mixture of gramme (*Cicer arietinum*) husk, neem leaves, and ash is put to the grains to prevent the wheat from exiguous holes and to improve grain keeping quality.. To store the wheat grains for a long time the wheat husk and wheat straw. 4-5 straws of wheat are used for one granary to store the seed/grains of wheat. Place sorghum and wheat stalks in each of the storage area's four corners. In chickpeas and wheat, it helps to protect the grains from pests up to 1 year **(**Grassroots Innovation Database [GRID]N. D).

2.2 Seedling Mixture

Tyagi *et al*., (2019), studied that 90-98% silica as a raw material is found in husk of rice. Because of its large specific surface area, silica gel is an excellent drying agent. Silica has antifungal properties, making it a possible antifungal agent. In 2018, Ratnayake *et al*, discovered that adding rice husk to the soil boosts some chemical defense responses against fungal infections while simultaneously promoting Bitter Gourd development. Ahaiwe *et al*, in 2016 used rice husk, straw, corn cobs and wood chips as mulching material for Ginger production. After six week of planting 50.0% more sprouting was observed in ginger where rice husk was used as mulching material.

Paddy straw with dry leaves are used in nursery bed as seedling mixture. The covered layer of leaves and straw should be removed after 6 days of sowing the onion seed **(**Grassroots Innovation Database [GRID]N. D)

2.3 Pest and weed control

Narayanasamy 2002, reviewed traditional way to control pest. The rice husk, neem along with other plant ingredients are known to control pest in traditional way. The husk of *Indian beans (Dolichos lablab*) is broadcasted in field and burnt to create smokes in order to control aphids in Indian beans crop. Harvested dried cumin stalks should be put in the affected area to reduce Bermuda grass growth. The stalk will absorb water and disintegrate with the soil during the monsoon. It should be left in the soil for a year to prevent grass from germinating. To manage the nut grass (*Cypeus rotundus*) weed in field crops, the shells of cotton (*Gossypium hirsutum*) should be scattered over nut grass-infested soil after cotton is extracted from cotton bolls. The cotton shell should be mixed with soil evenly once for two year.

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Cluster bean straws, wheat husks, and other dry plant matter form a layer that is put as a mulch between 2 cm rows of ground nut to replenish moisture and inhibit weed growth. To avoid spoilage of stored grain and seeds are places in pits with sorghum stalk **(** Grassroots Innovation Database [GRID]N. D).

2.4 To promote growth and higher yield

In 2016, Nwite *et al* investigated the response of cocoyam (*Colocasia esuclenta* (L.) and soil chemical characteristics to several manure sources, including Rice Husk Ash (RHA) and Rice Husk Dust (RHD). Prepare a soil bed through bio compost mixing, then potato seeds lay on the soil surface. Seeds covered with paddy straw 3.5 - 4 cm straw mulching. In this technique paddy straw mulching creates vapor and its help to substitute of water.

Sarangi *et al*., 2020 studied different composition of paddy straw mulching with zero tillage along withfoliar spray of nutrients. They recorded highest yield between 37.9–41.5 t ha in first year and 21.5–32.3 t ha^{-1} in second year. Wheat stalks are used as a fertiliser to boost cotton crop yields. It also aids in the deep rooting of the ground nut by increasing the number of spikes and clusters per pod. The fine husk of fenugreek (*Foeniculum vulgare*) is applied to the field to improve the soil texture and increase paddy production. To increase the rooted cuttings of pepper from the mother plant, coconut husks filled with cow dung powder, sand and soil should applied on every third runner shoots. The grafted plant is resistance to disease like quick wilt in pepper **(**Grassroots Innovation Database [GRID]N. D). The empty castor pods broadcasted into saline part of soil as part of reclamation which help to neutralize the soil pH within 1 to 2 year. Oyster mushroom cultivation is done with wheat straw. A composition (bundles of wheat straw+ organic debris) and kept in a wet location for 20 to 25 days to develop the mushrooms **(**Grassroots Innovation Database [GRID]N. D).

Table 1: List of efficient agriculture waste materials used in traditional practices

S.no	Traditional practices	Agriculture waste materials	Crop
1	Storage practices	Straw	Wheat
2		Straw	Paddy
3		Stalk	Cotton
4		Stalk	Wheat
5		Stalk	Sorghum

6	Seedling Mixture	Husk	Paddy
7		Husk	Paddy
8	Pest control	Husk	Paddy
9		Husk	Indian bean
10	Weed control	Straws	Cluster bean
11		Dried stalks	Cumin
12		Shells	Cotton
13		Husk	Wheat

3. Utilization of Agriculture waste materials

3.1 Alternative of Synthesis plastic: Bio Plastic

Polyethylene, polyvinylchloride, and polystyrene are commonly utilized in the production of plastics that survive for hundreds of years. There are no microorganisms in it, so it took thousands of years to degrade the plastic. It is projected that between 4.8 and 12.7 million tons of plastic garbage reach the oceans each year from land, with a major increase expected by 2025 if waste management is not improved (Sabapathy, 2020). Biopolymers reduce carbon dioxide emissions during production and breakdown to organic matter after disposal, although this does not imply that all biopolymers are fully biodegradable. In 2009, Momani stated that non-biodegradable materials have grown increasingly essential in recent decades as a result of unavoidable population growth and the necessity to adopt more cost-effective alternatives.

Babalola & Olorunnisola , 2019 studiedCoconut husk fibre with five different % of bio plastic compositions (0% , 5%, 10%,15) as reinforcing material in the production of bio plastics. Tensile strength ranged from 0.36 to 0.68 MPa, with elasticity ranging from 2.7 to 4.9 x106N/m2. With water absorption (27.3 - 42.9 %), the impact energy rose up to 15% with an increase in fibre content, where optium fibre reinforcement was found to be 10%. Within one month of the graveyard test, the bio plastics were biodegraded. Polyhydroxyalkanoates (PHAs) are bio plastics that can be used in place of petroleum-based products in a variety of applications. On a dry weight basis, wheat straw (WS) contains around 25% (w/w) hemicellulose, of which approximately 80% is pentose. The microorganisms can devour hexoses and pentose and convert them to PHA with excellent conversion yields and consumption rates.The hydrolyzed sugarcane bagasse, corn cob, teff straw, and banana peel were used for the production of PHB (polyhydroxybutyrate). PHB and fructose were found in 56 % of sugarcane bagasse (54 %). Corn cob and sugar cane produced PHB of 52 and 49 %, respectively PHB was produced in 39 % of the time using teff straw.

3.2 Green synthesis of Nano particle

Nanoparticles (NPs) can be made in a variety of ways, including physically, chemically, and biologically. The most essential physical procedures are evaporation, condensation, and laser ablation, although they all require a lot of energy to keep pressure and temperature constant. Chemical and physical approaches are costly and inappropriate for long-term ecosystem sustainability. The alternative methods for synthesizing NPs are much safe, clean, and environmentally friendly Vaibhav *et al*, 2015. Green nanoparticles are more stable than chemically generated nanoparticles, and they don't produce any harmful by-products, making them suitable for therapeutic application. For the production of NPs, extracts of food by products, crop residues were employed (Sinsinwar *et al*, 2018).

3.2.1 Synthesis of Silver Nano particles (AgNPs) using agriculture wastes

Due to its unique physical and chemical features, (AgNPs) are increasingly used in a variety of industries, including medical, food, textiles, keyboards, wound dressings, biomedical devices, and industrial uses. Optical, electrical, and thermal properties, as well as strong electrical conductivity and biological qualities, are among them. Several synthesis methods have been used to address the need for AgNPs (Zhang *et al.*, 2016). For the green synthesis of AgNPs, a phenolic-rich methanolic extract of coconut shell was used. Extract of coconut shell (ESC) for the production and stability of CSE-AgNPs with good nano-characteristics, CSE works as a reducing and capping agent. The efficacy of CSE-AgNPs as an antibacterial agent was demonstrated against a number of human infections, with cell wall breakdown as the mechanism of action agians *S. aureus.)* (Sinsinwar *et al*, 2018)

Mandal & Ghosh (2018) analyzed concentrates on employing rice husk extract as a reducing agent in the green production of poly (vinyl alcohol) (PVA) - silver nanoparticles (PVA-AgNPs) hybrids. The characterization of AgNPs produced is supported by UV–vis spectrum and transmission electron microscopy (TEM) data. Antibacterial activity of a PVA-AgNPs combination was discovered against *Escherichia coli* and *Bacillus subtilis.*Wheat straw biomass under light radiation was used for synthesis of silver nanoparticle. AgNPs

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characterized using X –ray diffusion, FTIR, TEM, UV vis spectroscopy and zeta potential. (Ma *et al*, 2016). In the production of silver nanoparticles, wheat straw extracted lignin was used by Sinsinwar et al, 2019. AgNPs shows antimicrobial properties against *E. coli andBacillus subtilis* strains.

Corn cob was used as an environmentally acceptable synthesis technique for silver nanoparticles containing xylan (nanoxylan). Chemical and NMR tests both verified the presence of AgNPs. Candida albicans, Candida parapsilosis, and Cryptococcus neoformans all showed antifungal activity at a minimum inhibitor concentration of 7.5 g/mL. Bagasse was employed as a reducing and capping agent in the microwave production of silver nanoparticles with sizes ranging from 50 to 150 nm. UV Visible spectroscopy, DLS, TEM, and XRD were used to characterize the nanoparticles. FTIR was used to examine the biomolecules bound to the nanoparticles (Silva *et al*, 2020).

3.2.2 Synthesis of Gold Nano Particles using Agriculture Wastes

In recent years, there has been a lot of interest in using gold (Au) nanoparticles as a platform technology in a variety of biomedical applications such as biosensors, fluorescent immunoassays, cancer treatment, targeted delivery of medications, and antibacterial agents. Gold nanoparticles produced from leftover macadamia nut shells have antimicrobial action against Escherichia coli and Staphylococcus epidermis.. The scattering of laser light indicated the existence of nanoparticles (Dang *et al*, 2019).After processing the grapes gold nanoparticles was obtained using the skin, stalk, and seeds. UV-Vis spectrophotometer, high resolution transmission electron microscope (HR-TEM), and energy-dispersive X-ray spectroscopy were used to evaluate the AuNP generated (EDX). The green produced gold nanoparticles from grape waste had an average particle size of 20 -25 nm (Krishnaswamy *et al*.,2014).

3.2.3 Synthesis of Silica Nano particles using agriculture wastes

Silica nanoparticles have a diverse set of applications in a variety of industries. The distinctive qualities of SiNPs are biocompatibility, stability, variable pore size, large surface area, and surface reactivity etc. Green and sustainable approaches have unique advantages for producing nanomaterial’s with desired qualities (Karande et al., 2021). Vaibhav et al, 2015 analyzed the extraction of silica from natural sources including rice husk and sugarcane

Agriculture waste	Synthesis of Nanoparticle	Reference
Coconut-coir	Silver nanoparticle (AgNP)	Roopan et al., 2013

bagasse. After acidic extraction, SiO_2 was purified to a high purity of 98 % (wt%), with yields of 78 % from rice husk and 71 % from sugarcane bagasse.

Coconut shell	Silver nanoparticle (AgNP)	Sinsinwar et al., 2018
Rice husk	Poly(Vinyl Alcohol)- Silver nanoparticle (PVA-AgNP)	Mandal & Ghosh, 2020
Corn silky hair	Silver nanoparticle (AgNP)	Patra & Baek, 2016
Corn cob	Silver nanoparticle (AgNP)	Viana et al., 2020
Wheat straw	Silver nanoparticle (AgNP)	Ma et al., 2016;
	Lignin-Silver nanoparticle (Li-AgNP)	Saratale et al., 2019
Sugarcane bagasse	Silver nanoparticle (AgNP)	Gonçalves al., 2016; Mishra & Sardar, 2013
Macadamia nut shell	Gold nanoparticle (AuNP)	Dang H et al., 2019
Grapes seed, skin and stalk	Gold nanoparticle (AuNP)	Krishnaswamy et al., 2014
Rice Husk	Silica nanoparticle (SiNP)	V. Vaibhav et al., 2014; Karande et al., 2021; Snehal & Lohani, 2018; W Soemphol et al., 2020; Patel et al., 2017
Sugarcane bagasse	Silica nanoparticle (SiNP)	V. Vaibhav et al., 2014; Karande et al., 2021; N. K. Mohd et al., 2017
Bamboo Leaves	Silica nanoparticle (SiNP)	V. Vaibhav et al., 2014; Karande et al., 2021
Groundnut Shell	Silica nanoparticle (SiNP)	V. Vaibhav et al., 2014; Karande et al., 2021
Sugar beet bagasse	Silica nanoparticle (SiNP)	Snehal & Lohani, 2018
Bamboo Culms	Silica nanoparticle (SiNP)	Snehal & Lohani, 2018
Wheat straw	Silica nanoparticle (SiNP)	Patel et al., 2017
Barley grain waste	Silica nanoparticle (SiNP)	Akhayere et al., 2018

Table 2 : List of Synthesized Nanoparticles from Agriculture Waste

3.3 Remediation of heavy metals

Heavy metals are transported from the abiotic environment to living species, where they accumulate in biota at various trophic levels, contaminating food chains and webs. Hazardous heavy metals in food chains undergo trophic transfer, bioaccumulation, and bio magnification, all of which have serious consequences for animal and human health (Ali & Khan, 2018).Heavy metals mainly chromium (Cr), selenium (Se), iron (Fe), vanadium (V), copper (Cu), nickel (Ni), cobalt (Co), mercury (Hg), cadmium (Cd),), lead (Pb), arsenic (As), and zinc (Zn) are introduce them to aquatic streams. Due to industrial activities mining, ores refining, fertilizer companies, tanneries, batteries, paper businesses, and pesticides all (Hegazi, 2013). Natural occurrences such as weathering and volcanic eruptions have also been documented to contribute significantly to heavy metal contamination (Tchounwou et al.,2012).

Heavy metal pollution of the natural environment is a growing problem around the world. We face a technological difficulty in removing these toxins from our surroundings.Bioremediation is a novel approach to heavy metal elimination in which metal toxicants are removed in an environmentally acceptable manner Gaur *et al.*, 2014. Agricultural wastes, such as fruit peels, straw, coconut coir, and other agricultural wastes, are attached to mediums to generate bio sorbents for the remediation of heavy metal toxicants in the solution (Reddy *et al.*, 2011). Because non-living biomass requires no particular storage or application care, it is preferred over living biomass and is more cost-effective in the bio sorption process. Agricultural waste bio sorbents can be easily created by a simple pretreatment process, and they often include certain functional groups that can generate adsorption affinity for heavy metal ions (Saxena et al, 2017).

Table 3 : List of Agriculture waste used for heavy metals remediation

Heavy metal remediated	**Agriculture waste**	**Reference**
Cadium (II)	Sugarcane bagasse & Maize corncob; Cashew nut shell,;Corn stalk; Coconut shell, walnut shell, and almond shell; Barley Hull and Barley Hull Ash; Sunflower stalk	Garg et al., 2008 ; Kumar et al., 2012; Zheng et al, 2010; Ayuba et al, 2019; Maleki et al, 2011; Jalali & Aboulghazi 2013

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Chromium (VI)	Apricot stone and almond shell; Rice husk; Sugarcane bagasse	Namasivayam & Sureshkumar 2008; Bansal et al 2009; Garg et al, 2009
Chromium (III)	Coconut shell fibers	Mohan et al, 2006
Copper(II)	Peanut shells; Grape stalks; Hazelnut husks; Corn cob and corn stalk; Rice hulls; Cashew nut shell; Sugarcane bagasse	Hansen et al, 2010; Villaescusa , 2004; Imamoglu & Tekir, 2008; Vafakhah et al,2014; Vafakhah et al,2014;Jeon et al., 2011; Kumar et al., 2011; Jiang et al., 2009
Nickel (II)	Sugarcane bagasse, Peanut hulls, Corn cob; Grape stalks	Alomá et al 2012; Periasamy et al.,1995; Muthusamy, et al 2012; Villaescusa , 2004
Lead (II)	Sunflower stalk; Rice husk	Jalali & Aboulghazi 2013; Sarma et al, 2015
Mercury (II)	Mung bean hull; Rice husk;Soybean Stalk; Walnut shell; Coconut husk	Rao et al,2009; Khoramzadeh et al, 2013; Kong et al, 2011; Zabihi et al, 2009; Johari et al., 2015;
Arsenic(VI)	Sugarcane Bagasse; Rice husk; Wheat straw;	Nasernejad & Ghafori 2014; Asif &Chen 2017; Shakoor et al., 2016
Arsenic (III)	Peanut shell	Sattar et al., 2019
Uranium (VI)	Wheat straw; Apricot shell	Bagherifam et al., 2010; Yi et al., 2013
Uranium (II)	Walnut shell	Yaman, & Demirel, 2020

3.4 Alternative of Fuels

Bio-energy is a key component for reducing greenhouse gas emissions and replacing fossil fuels. It is one of the more efficient energy sources. The need for energy is always increasing as a result of increased industrialization and population. Ethanol yield Petroleum, natural gas, coal, hydropower, and nuclear power are the primary sources of this energy. The

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most significant downside of utilizing petroleum-based fuels is the pollution (greenhouse gas (GHG)) that is produced by using petroleum diesel. Biomass is one of the more efficient energy sources. Biomass energy could play a role in sustainable development on numerous levels, including environmental, social, and economic (Hossain *et al*, 2008).

3.4.1 Bio hydrogen

The production of bio hydrogen from cornstalks treated with NaOH (0.5 %) was 57 mL, based on the initial value of the raw material (3 mL). After an acidification and heat pre-treatment, bio hydrogen can be produced from cornstalk waste. After a 0.2 % HCl treatment, a maximum cumulative H2 yield of 150 mL was produced, which was 50 times the initial value of raw materials (Zhang et al, 2007). Kongjan & Angelidaki 2010 used wheat straw hydrolysate for the production of hydrogen using mixed culture fermentation. The highest yield was achieved with the up-flow anaerobic sludge bed reactor 212.0 ± 6.6 mL-H2/g-sugars , corresponding to a hydrogen production rate of 821.4 ± 25.5 mL-H2/d L was achieved with the UASB reactor. Microwaves and alkali together can significantly boost hydrogen yields by rice straw hydrolysate, which produced 155 ml H 2 (Chen et al. 2012).

3.4.2 Bio ethanol

Ethanol is a widely utilized chemical with applications ranging from the food sector to the petroleum industry. Various agricultural raw materials can be used for ethanol production.Both scarification and fermentation was used simultaneous for production of ethanol from ground nut shell by using potassium dichromate method. 35 percent cellulose, 32.10 percent lignin, 4.3 percent miscellaneous compounds, 27.7 percent organic carbon, and 23.4 percent nitrogen were found in groundnut shell (Bhatt & Shilpa 2014).

Comparative investigations on bio-ethanol generation from diverse agricultural organic waste residues were conducted by Singh et al 2015. They discovered that after fermentation and various procedures, 41% to 46% alcohol was produced. For conversion, they looked at potato peel, banana peel, rice straw, and corn cob. In potato peel and corn cob, the most sugar to alcohol conversion was feasible. Several extracellular enzymes are produced by edible mushrooms. Alcohol can be made from the residual substrate left over after mushroom growing with Paddy straw. By using this procedure 5.5 times more ethanol can be produced than using raw paddy straw (Koshy and Nambisan 2012). Guinea maize husk and millet husk were investigated as alternative and cost-effective feedstock's for the production of

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bioethanol. The guinea corn husk give 26.83 g/l of ethanol yield and millet husk (18.31 g/l) was highest at 120th hour, with ethanol concentrations of 67.7 and 63.8 %, respectively by using acid hydrolysis with 2.5 M H_2SO_4 (Oyeleke & Jibrin 2009).

3.4.3 Biogas

Anaerobic digestion of energy crops, residues, and wastes is gaining popularity as a way to reduce greenhouse gas emissions and allow long-term energy supply development. Biogas production provides a versatile renewable energy carrier, as methane may be utilized to replace fossil fuels in both heat and power generation, as well as as a vehicle fuel (Weiland, 2010).

Biogas produced by anaerobic digestion contains 50–70 % methane, 25–40 % carbon dioxide, 2–8% water vapors, and traces of N_2, O_2, NH_3, and H_2S. Biogas can be utilized for a variety of applications, including heating and power generation. The rice straw and coconut shell biomass act as a biogas substrate, a sequential combination of ultra-sonication, hot water, and alkali hydrolysis treatment at (4 % and 5 % w/v) concentrations was assessed. Cattle Manure + Rice Straw Biogas yielded 18.18 % and Cattle Manure + Coconut Shell Biogas yielded 23.12 percent when 3 percent NaOH was added (Magomnang & Capareda 2020).Anaerobic treatment method was used for biogas production from coconut husk liquor where biogas production was found to be 20m3 using upflow Anaerobic Sludge Blanket (UASB) reactor (Leitão et al.,2009).Corn straw was pretreated naturally for 15 days with new complex microbial 0.01 percent (w/w) bacteria at ambient temperature (20 C), yielding 33.07 % anaerobic biogas. (Zhong et al., 2011). In anaerobic co-digestion of Swine Manure with Cotton stalk when prepared with NaOH, the biogas yield was 449 mL/g with a production rate of 0.65 L/day, which was 24-25 percent higher than the control (Cheng & Zhong 2014).

3.5 Building materials and handcrafts

Agricultural waste materials like rice husk ash have been used as partial cement and aggregate replacement in concrete in a number of studies. Green concrete are made from agricultural waste materials such as waste coconut shell, coconut fibers and waste rice husk (M o *et al*, 2017). Zeidabadi *et al*, 2018 evaluate the effect of two substitutes (rice husk and bagasse) which at 700 C (in the absence of oxygen), in order to produce biochar, on

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the mechanical properties of concrete samples containing variable amounts of those substitutes. According to the findings based on the XRD, SEM and BET methods synthesized materials can be employed as pozzolanic materials.

Bio-brick is a sustainable alternative and solution to meet the increase demand of construction materials in the industry. Brick made from agriculture waste materials are cost effective and act as carbon sinker, it also reduce the load in high rise structure due to its low density.The agro waste like Sugarcane bagasee and wheat husk with slurry lime, stone dust and binder was used to prepare the biobricks (Rautray *et al*, 2019). Murmu & Patel reviewed sustainable bricks production in 2018. Rice husk ash was used for production of bio bricks at Firing/curing temperature between 250 -1000. By apply the Compaction Pressure of 20 MPa bio bricks was prepared using Sugarcane bagasse. The moulding water content was 25–32 when lime was utilised as a binder. Paddy straw can be used as a packing material and in the production of handicrafts such as mats, bags, shoes, ropes, and toys. Clay and concrete are also bound using paddy straw. Cob is a clay-straw mixture which is used as a building material (K Shruti *et al*, 2020).

3.7 Remediation of textile industry effluents

Waste water decolorization has now become a serious issue for water treatment plants in the industries. Textiles, rubber, paper, plastics, leather, cosmetics, and food are the few industries that employ synthetic dyes to color their goods. Synthetic dye use has increased in recent decades, with more than 7105 metric tonnes of different shades produced globally each year. (Pearce *et al*., 2003).

A dye is a coloured substance with a high affinity for attaching to the substrate to which it is applied. A mordant, which is usually administered in an aqueous solution, may be necessary to increase the dye's fastness on the fibres. Because they absorb some light, both dyes and pigments appear to be coloured. (Sharma et al, 2012). The effluent from the dyeing industry is vividly coloured and can be detrimental to aquatic life. Dyes are persistent in nature and absorb a lot of light, lowering the amount of light absorbed by water plants and phytoplankton, reducing photosynthesis and dissolved oxygen in the aquatic ecosystem, and increasing COD. Furthermore, dye effluents are very dispersible, difficult to treat, large in volume, and include dangerous organic and inorganic compounds that have toxic and carcinogenic impacts on microbial populations, humans, and animals. The adsorption

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approach is widely regarded as an excellent way for rapidly reducing the content of dissolved colors in waste water (Reife *et al*, 1996). The use of activated carbon made from rice husk was assessed as a potential adsorbed for the removal of Malachite green and found to have a high adsorption capacity when compared to activated carbon made from banana peel and orange peel (Annadurai *et al*, 2002). The adsorbent groundnut shell, an agricultural solid waste, was employed to get rid of Malachite green from solution. Due to their physico-chemical properties and cheap cost, the fabric is widely available and may be used as possible sorbents. Nut shell is a carbonaceous, fibrous solid waste that poses a disposal issue and is commonly utilized for fuel. It was tested for the potential of the adsorbents by treating it with ZnCl2 WHERE effect of contact time, adsorbent dose and initial dye concentration were also studied. Groundnut shell powder activated carbon removed 94.5 percent of the dye in 30 minutes at a dosage of 0.5 g L-1 and an initial concentration of 100 mg L-1, while commercially available powdered activated carbon removed 96 percent of the dye in 15 minutes(Malik *et al*, 2007).

Robinson *et al*, 2002 proved the sorption efficiency of corncob and barley husk with varying particle sizes and weights for various colors. In the first five hours, it had been discovered that 2gm of barley husk and corn cob was more efficient than 5gm, leading to 92 % dye removal, with the particle size of 600 µm, for both substrates, which had a greater rate of removal than 14mm particle size. It's possible that this is because smaller particles have a larger specific surface area. Decolorization is not a precise procedure that is influenced by a number of factors. The low cost, extensive availability, organic in nature and having great affinity for certain colors, are all aspects that favor the use of agricultural adsorbents (Sharma *et al*, 2012). Methylene blue adsorption occurs via a film diffusion mechanism at low and high concentrations, and methyl orange adsorption occurs via a film diffusion mechanism at low concentrations and particle diffusion at high concentrations from activated carbon of 2 g/L made from coconut shell fibres. (Singh et al, 2003). The multilayer adsorption method was used to for the removal of methylene blue dye from pumpkin seed hull in aqueous solutions, in which the initial concentration, agitation time and solution pH were studied at 30 ◦C. Film diffusion controls the rate of adsorption for a short period of time, whereas pore diffusion controls the rate of adsorption for a longer length of time (Hamid & Khaiary 2008). The bio sorption of three anionic dyes, amaranth, sunset yellow, and quick green, was achieved using peanut hull powder. Three dyes may be efficiently removed at the initial pH of 2.0. The Langmuir and Freundlich models are used for the isothermal data with rate kinetics of pseudo-first-order (Gong, 2005).

The seed hull of the sunflower (Helianthus annuus L.) was used to remove methyl violet from aqueous solutions. The Freundlich isotherm model accurately describes the equilibrium process. At 30°C, the highest Sunflower seed husk sorption capacity was discovered to be 92.59 mg L 1.The sorption process was best represented by the pseudo-second-order model (Hamid, 2008).Wheat straw components were carboxymethylated for Methylene Blue adsorption The effects of pH on adsorption demonstrated that the adsorbents function better under neutral and alkaline conditions. The Langmuir equation was used to describe adsorption isotherms, whereas the pseudo-second order equation and the Elovich equation were used to describe adsorption kinetics. The Methylene Blue-loaded adsorbents were stable at pH > 6.0 and effective in secondary methylene orange adsorption due to changed surface structures of the straw-based adsorbents following Methylene Blue adsorption (Zhang et al, 2011).

Raghuvanshi *et al*. (2004) investigated sugarcane bagasse's adsorption capability.. Under the varied conditions the removal of Methylene Blue dye, with different parameters like dye contact time, concentration, temperature andadsorbent dose. Chemically activated bagasse performed better than raw bagasse in terms of elimination.Using Congo Red as a model system, the powder form of rice husk carbon (RHCAS) was examined for dye removal. With agitation times ranging from 20 to 200 minutes, a quantity of 0.08 g/l RHCAS could remove 10 to 99 % of the dye from a 25 ppm aqueous solution. The interactions were investigated for both pseudo first-order and second-order kinetics, and it was discovered that first-order kinetics could better describe the interactions (Sharma & Janjevan 2008).

3. 8 Pulp production

The world's forests are being decimated for the production of paper products. Every year, around 4 billion trees are harvested and used to produce paper products. In the previous forty years, the global consumption of paper has increased by 400%. Because all of these plant materials contain cellulose in the form of fibers, they could be more environment

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friendly sources of pulp than wood, which has traditionally been the most widely used ligno-cellulosic material in the production of pulp, furniture, and various types of boards, as well as a source of energy (Ekhuemelo and Tor, 2013). Non-wood plants have various advantages, including short growth cycles, low lignin content, and minimal watering and fertilization requirements, which reduce the amount of energy and chemicals necessary in pulp production (Taiwo, 2014).

Soda pulping was used to produce pulp from corn husks and banana stalks, which was then tested for chemical composition. The surface morphological structure of the pulps was further studied using scanning electron microscopy (SEM). The pulp obtained was found 23% for corn husk and 35.96 % for banana stalk. Where the tensile index was 0.30 mm and 0.08 mm for corn husk and banana stalk (Aremu et al, 2015). Corn stalk was valorized for the production of cellulose nanofibers (CNF) were tested for improving recycled paper properties. The tensile index of CNF made from carbon organosolv pulp to recycled paper has risen by 20%. (Balea et al, 2016).

Groundnut shells were utilized in paper production as reported for kraft's pulping and soda pulping using different chemicals. Then, the pulp was washed, bleached, dried and compressed to supply paper. Paper produced from kraft's process was of higher quality as compared to the soda pulping process (Upendra et al., 2018). Kaur et al.,2017 reviewed the effective need of eco-friendly, economically reliable pulping and bleaching sequences within the case of rice straw to eliminate the issues of chlorinated compounds in wastewater of paper mills. The cellulose content of agro-waste like rice husk, maize cub, sorghum stalk and groundnut shell was experimentally determined by defattening, scouring and alpha cellulose test. The alpha cellulose content obtained for the varied agro-wastes were rice husk 43.33%, maize cub 62.96%, sorghum stalk 47.36% and groundnut shell 65.20% as against the alpha cellulose content of wood which is 63%. Where the ash contents of rice husk, maize cub, sorghum stalk and groundnut shell was 0.3%. 1.5%, 0.09%, 0.149%, 0.3% respectively (Lawal et al., 2010).

3.9 Activated carbon

Activated carbons are highly flexible adsorbents with significant industrial use. The global consumption of activated carbons is continually expanding with new uses, particularly in the field of environmental pollution remediation, are constantly emerging, which should help to keep demand for them high. Their usage in water treatment for the elimination of flavor, color, odor, and other unpleasant organic pollutants is one of their most important uses (Zhao *et al*, 2020). Due to the need for environmental protection as well as material recovery, activated carbon is also employed in industrial wastewater and gas treatment (Soleimani &Kaghazch, 2017).

The coconut husks were carbonated and used to make activated carbon, which was activated using Zinc Chloride. The hexamine cobalt reduction was accelerated using the activated carbon that produced, retrofitting the simulation with hexamine cobalt removal of SO2 and NO from flue gases generated by power plants (II).The particle size distribution of 150-200 mesh size of activated carbon was found the best conditions for conversion of the reduction reaction with pH of 2.6 and stirring speed of 400rpm (Sodeinde 2012).

The use of low-cost activated carbon generated from bagasse, an agricultural waste material, as a replacement for present expensive methods of heavy metal removal from wastewater has been examined by Mohan& Singh 2002. According to preliminary study on the rate of Cd(II) and Zn(II) absorption on activated carbon, the processes are quite rapid, with 40–50 percent of total adsorption occurring within the first hour of contact. Agricultural wastes such as bagasse, apricot stone hard shells, almond, walnut, and hazelnut shells were employed as raw materials in the production of activated carbons.Sugarcane bagasse, Hazel nut, Wal nut, Almond shell, and Apricot stone had activated carbon adsorption capacities of 387, 440, 420, 412, and 450 (mg I2/g C), respectively. (Soleimani &Kaghazch, 2017).

Wheat husk conversion to activated carbon with a large surface area for energy storage in high-performance super capacitors.The electrodes were characterised and electrochemically tested using Fourier-transform infrared spectroscopy, X-ray powder diffraction, scanning electron microscope, cyclic voltammetry, galvanostatic charge-discharge, and electrical impedance spectroscopy. AC-800, activated at 800 C, has the highest capacitance (271.5 F g 1 at a current density of 0.5 A g 1) (Baig 2021). Microwave treatment is used to produce activated carbon from rice and cotton stalks. One of the most important physical properties that can affect the reactivity and combustion behavior of carbon is the BET surface area (SBET) with pore size. Rice husk in KOH medium recorded with 752 (m^2/g) SBET with 34.14 A and 1165 (m^2/g) with 26.89 A. Cotton stalk in $ZNCL_2$ medium has surface area (SBET) 794.84 m^2/g and pore size 32 A (Hesas et al, 2013). The agricultural waste of maize

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stalks was processed to manufacture activated carbon (ACs) with micro-meso pores using a simple activation procedure including treatment with KOH solution. The ACs exhibited excellent Cr(VI) adsorption capability, with the maximum adsorption ability of the ACs generated by activation with 4 % KOH solution reaching 89.5 mg g 1 at a dose of 2.5 g L 1 and a pH of 4.5.(Zhao et al, 2020).

Conclusion

Agriculture waste materials can be developed as new source of energy, food security and income. The commercial use of biomass generated from crops can motivate the famers to grow more such crops with knowledge of utility which can be economical beneficial to the farmers. Waste agricultural biomass reduction GHG emission from biomass when left in the field to rot and replaces the fossil fuel with fuels derived. With recent considerations over the dependableness of oil the country has to increase its energy security by enhancing domesticenergy provides. This waste can be turnedinto a valuable biological product to achieve zero waste production.

Western science and traditional knowledge despite their variation in different form of knowledge can learn from each other. Indigenous knowledge can also play a key role for sustainable utilization of agriculture waste materials. This knowledge embodies the rich natural wisdom and experience gained from direct observation over thousands of years, and is passed down from generation to generation. Traditional or indigenous knowledge has been rediscovered as a model for healthy interaction with the environment andthe use of the environment, and as a wealthof resourcesforgaining new perspectives on the relationship between man and nature. In the Northwest Territories of Canada, governments, industrial companies, and other organizations have tried many strategies to promote meaningful consideration of traditional knowledge in environmental decision-making,recognizing that such considerations can promote greaterequality and social equality between human society and nature

Improving change of squander agrarian biomass into vitality will moreover offer assistance to attain other natural goals, such as making strides to discuss quality (e.g. lessening smoke and particulates outflow especially brief lived climate poisons), biodiversity preservation.The fetched of vitality delivered from squander rural biomass is impressively lower than that from fossil powers especially oil and gas.

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