Article ID 240204053

Production of Particle Board from Agricultural Residues

Parvathy Nayana N., Ramya C. S. and Prajwal R.
PhD. Scholar, Division of Agricultural Engineering, Indian Agricultural Research Institute, New Delhi, 110012.
*Corresponding Author: nayanapfe@gmail.com

India is one of the key producers of food grain, oilseed, sugarcane, fibre crops and other agricultural products. After crop harvesting, the left-over plant material including straw, leaves, stalk, husk, shell, and roots is known as agriculture residues. India generates around 500 Mt of crop residue annually (GOI, 2016), From total crop-residues production - Wheat produces 20%, Rice- 24%, Maize-12%, Millets- 5%, Sugarcane- 26%, Fibre crops – 3%, and

Pulses- 6%. In India among all agro-residues cereals are the largest producer of crop residue followed by sugarcane. In recent years, across India the demands of crop residue for cattle feed and industrial purpose have increased due to excessive in-situ burning of it. The four states viz. Uttar Pradesh, Maharastra, Madhya Pradesh and Punjab constitute 47% of total burnt crop residue. These agro-residues can be used for different industrial purposes such as bio-energy generation, composite making, particle board and paper board preparation etc. It can be a source of additional income generation for farmers.

Particle board

It is composed of distinct particle or chips of the wood or any other lignocellulosic fibrous substances which are bounded together using any organic binder or glue by the application of heat and pressure. To make the end product water resistant, fire proof and/or insect-proof chemicals are used including wax, dyes, wetting agents, and release agents. Particle boards can be made of different thickness like 8mm, 12mm, 19 mm 25mm etc. The agro residues like saw dust, bagasse, rice straw, wheat straw, ground nut husk, Cotton stalks etc. can be used for preparation of particle boards.

Raw materials used

1. **Bagasse** is the dry pulpy fibrous residue that remains after sugarcane or sorghum stalks are crushed to extract their juice.
2. **Sawdust** is the by-product of woodworking operations such as sawing, milling, routing, drilling and sanding. It is composed of fine particle of wood. Sawdust is the main component of particle board.
3. **Rice Straw:** It is a rice by-product produced when harvesting paddy. Each kg of milled rice produced about 0.7-1.4 kg of rice straw.
4. **Wheat straw:** It is wheat by-product.
5. **Cotton Stalks:** Cotton stalks are produced after harvesting of seed cotton

Basic steps Involved

1. Raw material is chipped into 1.5 to 2.0 cm size
2. Rechipped to 20 to 8 mesh size
3. Dry the materials to bring its moisture content to 2-3% level
4. The dried material is taken to rotary screen unit where it is separated into coarser (≥2.5 mm) and finer (<2.5 mm)
5. Mix with synthetic binders such as urea formaldehyde and phenol formaldehyde
6. Additives are used to make board water proof, fire proof and termite resistant
7. Prepared three layered mat comprising coarser particles at core layer and finer at top and bottom, respectively
8. Press the mat between cold press and heated platens of a hydraulic press for specific time and pressure (18-20 $^{kg}/_{cm^2}$, 140-180℃) to form board. Pre-pressing is done to reduce the thickness of mattress or to increase the bulk density. It gives the mattress some mechanical strength for handling and speed up the hot press process. Hot pressing is used to consolidate the board and cure the adhesive.
9. Cooled to obtain dimensional stability and cut into desired shape and size
10. Thickness may vary from 2.5 to 35 mm

Particle boards based on density

1. Low density particle board: 0.4 g/cc or below
2. Medium density particle board: 0.4-0.9 g/cc
3. High density particle board: Above 0.9 g/cc

Some of the biomaterials used for the production of particle board and their properties as obtained from research is shown in Table 1.

Uses of particle board

Particle boards are being used in door panel inserts, interior decoration, partitions, wall panels, furniture items and floor and ceiling tiles.

Table1: Studies done on production of particle board from waste

Sl. No	Materials	Pre treatments	Properties of board	References
1	Cement, calcium chloride at 3% weight of cement(additive), red iron wood saw dust, palm kernel shell (PKS)	• PKS ground using hammer mill • Hot water treatment at 80°C for one hour to breakdown sugar compounds that can hinder cement hydration. • Process repeated for one hour more in cold water. • Red wood iron undergoes same treatments. Both samples dried to 12% moisture content • Particles with 0.600 mm size chosen	• Properties least affected by PKS. Minimum water absorption for PKS between 26% and 32% • Modulus of rupture and modulus of elasticity affected by cement content	Atoyebi et al., 2018
2	Portland cement, saw dust, periwinkle shell, water, lubricating oil, calcium chloride (additive)	• Size reduction of periwinkle shell done using hammer mill • Hot water treatment for both periwinkle shell and saw dust at 80°C for 24 hours followed by cold water treatment for a day to extract starch, phenolic compounds, oils • Dried to 9% moisture content	• Optimum at 40% cement, 27% saw dust, 33% periwinkle shell. • Density:1644.87 $^{kg}/_{m^2}$ • Water absorption:4.58 • Thickness swelling 1.5 • MOR:3060.38 $^{N}/_{mm^2}$ • MOE:1805 $^{N}/_{mm^2}$	Odeyemi et al., 2020
3	Cotton seed hulls, urea formaldehyde resin as binder, ammonium chloride as catalyst	• Cotton seed hulls reduced to size by beater type mill • Dried at 40°C	• At 15% resin concentration and 15% moisture, the density obtained as 1.28 $^{g}/_{cm^3}$ • Modulus of rupture: 50.29 $^{kg}/_{cm^2}$	Pandey and Gurjar, 1985
4	Mangrove bark, corncob, sugar cane bagasse, wood shavings, resorcinol formaldehyde, urea formaldehyde resin	• Particles sieved through 60 mesh screens • Oven dried to 12% moisture content	• Wood shavings (25%), bagasse (25%), corn cob (50%), 10% RF resin have dry strength 200 psi and wet strength after 5hr immersion 159 psi and water absorption 8.6%	Odozi et al., 1986
5	Jute stick, urea formaldehyde resin	Jute sticks made into 60 mesh size particles at disintegrator.	• Highest flexural strength ($23.08 \times 10\ ^{kg}/_{cm^2}$), highest tensile strength ($9.0 \times 10\ ^{kg}/_{cm^2}$) and impact strength (2.9 kg) obtained at 40% resin concentration	Das et al., 1987
6	Coffee parchment, eucalyptus wood	• Wood and coffee parchment were crushed in mill • Wood particles passing through 6 mm sieve and coffee retained between 20 and 40 mesh were chosen	• Water absorption decreases with an increase in coffee concentration • Thickness swelling doesn't vary significantly	Scatolino et al., 2017

			for after 24-hour immersion • MOR and MOE decrease with an increase in coffee but IB showed increasing trend till 30% coffee. • Optimum at 40% coffee parchment	
7	Rattan waste, corn stalk, coir and wood waste, phenol formaldehyde as additive	• Chopped using ring flaker and sun dried and sieved to 4-14 mesh • Oven drying to reduce moisture content to 5%	• Density: 0.7 $^{g}/_{cm^3}$ • Water absorption high (11.2%) for corn cob and low for wood (7.2%) • MOR high for rattan core • IB more for wood (1.46 MPa)	Astari et al., 2014
8	Corn cob, saw dust, urea formaldehyde resin	• Corn cob crushed using wooden mortar and pestle and further crushed in hammer mill and size chosen at 1.18 mm. • Saw dust dried and same size chosen	• Density ranges from 436 to 413 $^{kg}/_{m^3}$ • Water absorption least at 75% saw dust and 25% corn cob • Highest MOR (82.55 $^{N}/_{mm^2}$) and MOE for 75% corn cob • Optimum at 50% corn cob	Akinyemi et al., 2016
9	Rice husk, starch, wood glue, water	• Rice husk was dried and sieved	• Density: 711.11 $^{kg}/_{m^3}$ • Water absorption:16%	Temitope et al., 2015
10	Coconut mesocarp fiber and *pinus oocarpa*	• Logs were kept in water at 65°C for 24 hours to promote lignin softening • Hammer milled to obtain particles of 6 mm size • Coconut fibres also milled and dried to 5% moisture content	• Reduction in water absorption and thickness swelling on addition of coconut fibre • Decrease in mechanical properties but in acceptable level	Narciso et al., 2020

Problems in utilization of agro-residues by industries

The problem in utilising agro-residues include absence of an established supply chain, industry hesitation to use new raw material, dependence on timber, lack of legislation on ecological considerations, uncertainties in dry land agriculture leading to inconsistent supply of raw material and lack of awareness about market acceptability of composite boards from cotton stalks.

Conclusion

Crop residues have a great economic value as industrial raw material. It is a sustainable alternative source that can replace the use of wood to a large extent. Particle boards from agro-residues could be a great substitute of wood. It can Improve the soil health and environment by preventing the burning of biomass in the field. It Generates employment in rural areas and income enhancement among the rural masses. There is a need of some kind of extension activity (talks, speeches, presentations etc.) to disseminate the knowledge of usefulness of crop residues.

References

Akinyemi, A. B., Afolayan, J. O., & Oluwatobi, E. O. (2016). Some properties of composite corn cob and sawdust particle boards. *Construction and Building Materials*, 127, 436-441.

Astari, L., & Akbar, F. (2019, October). Characteristics of Particleboards Made from Agricultural Wastes. In *IOP Conference Series: Earth and*

Environmental Science (Vol. 359, No. 1, p. 012014). IOP Publishing.

Atoyebi, O. D., Awolusi, T. F., & Davies, I. E. (2018). Artificial neural network evaluation of cement-bonded particle board produced from red iron wood (Lophira alata) sawdust and palm kernel shell residues. *Case Studies in Construction Materials*, 9, e00185.

Das, R. N., Day, A., & Pandey, S. N. (1987). Particle boards from jute stick. *Biological wastes*, 20(4), 309-313.

Narciso, C. R. P., Reis, A. H. S., Mendes, J. F., Nogueira, N. D., & Mendes, R. F. (2021). Potential for the use of coconut husk in the production of medium density particleboard. *Waste and Biomass Valorization*, *12*(3), 1647-1658.

Odeyemi, S. O., Abdulwahab, R., Adeniyi, A. G., & Atoyebi, O. D. (2020). Physical and mechanical properties of cement-bonded particle board produced from African balsam tree (Populous Balsamifera) and periwinkle shell residues. *Results in Engineering*, *6*, 100126.

Odozi, T.O., Akaranta, O. and Ejike, P.N. 1986. Particle boards from agricultural wastes. *Agricultural wastes*. 237-240.

Pandey, S. N., & Gurjar, R. M. (1985). Production of particle boards from cottonseed hulls. *Agricultural wastes*, 13(4), 287-293.

Scatolino, M. V., Costa, A. D. O., Guimarães, J. B., Protásio, T. D. P., Mendes, R. F., & Mendes, L. M. (2017). Eucalyptus wood and coffee parchment for particleboard production: Physical and mechanical properties. *Ciência e Agrotecnologia*, 41, 139-146.

Temitope, A. K., Onaopemipo, A. T., Olawale, A. A., & Abayomi, O. O. (2015). Recycling of rice husk into a locally-made water-resistant particle board. *Ind Eng Manage*, 4(164), 2169-0316.

* * * * * * * *