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CROP RESIDUE RECYCLING FOR ECONOMIC AND ENVIRONMENTAL SUSTAINABILITY

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ABSTRACT

India is a major exporter of food grains, oilseeds, sugarcane, and other agricultural commodities. Agricultural crops produce a lot of residual residues, and as food production rises, agricultural leftovers will rise as well. These remaining residues represent not only a waste of resources, but also a lost chance for a farmer to increase his or her revenue. Researchers from all over the globe are investigating the use of agricultural residues in a variety of sectors, including textile composite non-woven manufacturing processes, power generation, biogas production, animal feed, compost and manures, and so on. The growing tendency in the installation of bio-energy cogeneration facilities, the growing need for animal fodder, and the growing trend in organic agriculture all point to crop waste as a competitive potential in agriculture. It's worth noting that the uses for this leftover residue aren't always mutually exclusive, making determining its economic worth more challenging. Straw, for example, may be used as animal bedding before being utilized as a crop fertilizer. As a result, the primary goal of this study was to determine how much agricultural residue is wasted and how well it may be used for other purposes to promote environmental stewardship and sustainability. In this regard, using data from different government sources and a SWOT analysis of potential alternative applications of residue in India, an effort has been made to estimate the total agricultural residue throughout the states and its economic worth. This article also covers successful case studies using agricultural wastes in economic activity in India and at the global level. In all, 516 Mtonnes of agricultural residue were generated in India in 2014-15, with cereals being the biggest contributor, followed by sugarcane. For 2014-15, the energy potential of paddy rice straw crop residue was projected to be 486,955 megawatt, while coarse cereals had a potential of 226,200 megawatt.

KEYWORDS: *Crop Residue, Economic Value, Environmental Sustainability, Composites Making, India.*

1. INTRODUCTION

Agriculture accounts for a significant portion of India's total economy. A broad variety of crops are grown over the great majority of land in India's many agro-ecological zones, with large amounts of crop residue (non-economic plant parts) left in the field after harvest. Nearly 234 million tons per year (or 30%) of gross residue produced in India is accessible as surplus after being utilized in competitive alternatives such as cow feed, animal bedding, cooking fuel, organic manure, and so on. This massive quantity of agricultural waste has monetary worth. Annually, it produces about 500-550 million tons (Mt) of agricultural residue from the production of 110 Mt of wheat, 122 Mt of rice, 71 Mt of maize, 26 Mt of millets, 141 Mt of sugarcane, 8 Mt of fibre crops (jutemesta, cotton), and 28 Mt of pulses on-farm and off-farm(1–3).

Crop waste may be used for a variety of purposes, including animal feed, soil mulching, bio-manure, thatching for rural houses, and household and industrial fuel. Despite the advantages, farmers burn a large part of the crop leftovers on-farm so that the next crop may be planted on a clean area. Mechanized farming, along with a scarcity of low-skilled farm labor and the high costs connected with it, exacerbates the issue of agricultural residue burning on farms. Rice, wheat, cotton, maize, millet, sugarcane, jute, rapeseed-mustard, and groundnut waste were being burned in large quantities in irrigated regions where several crops are produced yearly, as well as areas adjacent to the national capital region and satellite towns. Crop residue demand for cattle feed and industrial purposes has risen in recent years throughout India owing to excessive in-situ burning. As a result, it's critical to put in place regulations that encourage various uses of agricultural residues in the framework of conservation agriculture while also preventing on-farm burning. In this review article, we wanted to focus on

1. Yearly crop residue generation and on-farm burning, as well as their environmental effect.
2. The scope and difficulties of utilizing agricultural leftovers in conservation agriculture,
3. A local and regional crop residue management strategy, and
4. Identifying crop residue management research and policy for productive, economic, and sustainable agriculture.

Agriculture alone produces 140 billion tons of biomass per year, which is equal to around 50 billion tons of oil. Agricultural biomass waste energy may significantly replace fossil fuels, decrease greenhouse gas emissions, and offer renewable energy to approximately 1.6 billion people in poor countries who do not have access to electricity. Similarly, partly green crop waste with a low carbon: nitrogen ratio (30:1), which makes composting easier, may be used as an alternative to high-energy-derived fertilizer and is a feasible choice for environmentally friendly organic farming. Biomass wastes have a lot of promise as raw materials for large-scale businesses and communities. Previous research has shown that lignocellulose byproducts such as maize stover, rice and wheat straw, sorghum stalks and leaves, pineapple and banana leaves may be utilized to extract natural cellulose fibers appropriate for textile, composite, and other industrial uses(4–7).

1.1. Crop residue generation in India:

Crop residue is the leftover plant material, such as leaves, stalks, and roots, after a crop has been harvested. India is expected to produce approximately 500 Mt of agricultural waste each year, with regional variation. Crop residue distribution and usage varies throughout the country, depending on the crops produced, cropping intensity, and productivity. Uttar Pradesh has the highest estimate of agricultural residue (60 Mt). Punjab (51 Mt) and Maharashtra (21 Mt) were two other high-residue-producing states (46 Mt). Cereals, fibers, oilseeds, pulses, and sugarcane, with production estimates of 352 Mt, 66 Mt, 29 Mt, 13 Mt, and 12 Mt, respectively, provided the bulk of crop waste. Rice, wheat, maize, and millets provided 70 percent of crop residue among cereal crops, followed by fiber crops(8–12).

Eurachem provided a method for calculating the estimate's uncertainty using the Eurachem handbook. The main uncertainty sources, such as the residue to crop ratio (RCR), dry matter fraction (DMF), and production average, are first identified in this uncertainty calculation technique, which assumes data to be normally distributed (PA). After that, each uncertainty source's standard uncertainty (u) is calculated. If the range and standard deviation (sd) of crop residue input variables are reported, then 'u' is taken as the mean of the range and sd as it is, respectively. Summing conventional uncertainty sources yields the final combined uncertainty (Ufc) for each crop (Uc).

1.2. Utilization and on-farm burning of crop residues in India:

Crop residue is used in India in a variety of ways, depending on the region's socioeconomic level, kind of farmed crop, number of crops each year, and other factors. Rice stubble, for example, is used for household fuel or in boilers to parboil rice in southern India, while in northern India, a significant proportion is burned on-farm. Similarly, sugarcane waste is either fed to animals or burned on the field for the ratoon crop. Groundnut wastes are similarly burned in brick and lime kilns. Domestic fuel is made from cotton, pulses, oilseed crops, chilies, coconut shells, rapeseed and mustard stalks, sunflower and jute wastes. Growers often utilize agricultural leftovers for feed, firewood, cow barns, packing, and other purposes, or sell them to landless families or middlemen for resale(13–16).

Cereals are the leading source of excess leftovers in India, which are often burned in-situ. Fiber, oilseeds, legumes, and sugarcane are some of the other crops that produce a lot of excess waste. Estimates of total vs. excess crop residue come with a range of prediction ranges and degrees of uncertainty. Interestingly, although the magnitudes may differ, the pattern of crop residue estimates among states remains constant.

1.3. Quantification of economic value of crop residue:

To solve the issue of in-situ burning of agricultural waste, it's crucial to determine its economic value. In India, on the other hand, the vast bulk of agricultural waste is not burnt. Rice residue, for example, comes in the shape of straw and husk. Rice straw is mostly utilized for animal feed, roof thatching, and on-farm burning in southern and northern India, respectively. Husk, on the other hand, is often burned on farms throughout the nation, particularly with the advent of sophisticated combine harvesters. After rice, wheat is the second most eaten crop. Wheat straws (residue) are used for cattle feed, household fuel, paperboard production, and oil extraction.

However, in regions of the Indo-Gangetic plains (IGP) where intensive farming systems are used, such as Punjab, Haryana, Uttarnchal, and Uttar Pradesh, the straw is burned since it is the simplest and most cost-effective way to get rid of it in the short time between harvests. Corn straw and millet stalks, unlike wheat, are rather hard and therefore used less as feed. It is, however, either utilized as cow fodder or left on the field as compost. Mustard stalks are also often burned or utilized as a source of household energy. Sugarcane is a long-term crop, and its waste is swiftly disposed of to make room for the planting of the next crop. Trash, tops, and bagasse are all examples of sugarcane residue. Trash is utilized as a source of energy for jaggery extraction, calf feed, or on-site combustion. Similarly, peanut stems and shells are utilized as both household and industrial fuel(17–20).

Crop residue burning accounts for approximately 2020 Mt globally (approx. 25 percent of total biomass produced). According to the IPCC coefficient, the four states of Uttar Pradesh, Maharastra, Madhya Pradesh, and Punjab account for 47 percent of total burned agricultural residue. This massive quantity of burned agricultural waste represents a significant loss of opportunity for its possible use in a variety of applications, including composite manufacturing and bio-energy production. Advanced biomass cooking stoves can help poor countries increase their clean and cheap energy output. The usage of biofuel for transportation is expected to increase from 2% now to 27% in 2050, according to projections.

1.3. Alternative Uses of Crop Stubble:

Rice is the most widely eaten food in the planet. As a result, rice is cultivated on a massive scale, resulting in a significant quantity of residue in the form of straw. In Asia, a significant quantity of rice straw is burned in the fields. According to the researchers, 668 t of rice residue can produce 708.7 litres of bioethanol. As a consequence, burning rice straw results in an almost total loss of bio-ethanol potential energy. With rising fuel costs, more frequent weather fluctuations (or debate over climate change), air pollution, and greenhouse gas emissions, researchers are looking for new ways to utilize field-based leftovers for energy applications. The way rice residue is disposed of in India is determined by its market value. It's clear that more than 3/4 of the rice straw has been burned in place. Growers often burn agricultural waste in two ways: partly or completely(21–23).

Full burning is mostly used in IGP when there isn't enough time between planting and harvesting the following and preceding crops to dispose of the leftover residue from the previous crop. Pollution has a significant effect on the ecosystem in both burning methods, including decreased soil quality, increased soil erosion, and increased air pollutant and greenhouse gas emissions. As the frequency of agricultural waste burning has risen, central authorities have begun to implement and promote solutions to the issue. Crop leftover (especially cereals) as fodder, bio-thermal power plants and mushroom growth, as cow bedding material, bio-oil, paper manufacturing, bio-gas, rice residue integration in soil, energy technology, and thermal combustion are some of these methods. Only combustion technology is presently marketed among the several methods, while the others are in various phases of development.

2. DISCUSSION

Crop residues are plant components that have been left in the field after harvesting and threshing. Crop residue recycling has the benefit of turning excess agricultural waste into a valuable product that may be used to satisfy the nutritional requirements of following crops. Crop leftovers provide organic C to soil microbes while also providing nutrients to plants. Crop residue retention on the soil surface decreases run-off, soil erosion, and soil evaporation, as well as land preparation expenses. Crop residues are produced in India in quantities ranging from 500 to 550 million tonnes (Mt) each year. The Rice Wheat Cropping System (RWS) is one of India's most commonly used cropping systems, with 90 percent of the country's land located in the Indo-Gangetic Plains (IGP). In the northwestern portions of the IGPs, more than 75 percent of the rice land is harvested mechanically since the advent of combine harvesters. Wheat straw is removed by the majority of farmers for animal feed.

Rice straw, on the other hand, is a significant problem to handle since it is regarded as a poor feed for animals due to its high silica concentration. A swath of loose rice leftovers is left behind by the combine harvester, interfering with the seed drill's operations while planting wheat. Farmers burn agricultural waste to prevent these issues (90-140 Mt annually). From the perspective of the farmers, burning rice straw may be the most appropriate way of disposal. It is not only a cost-effective technique, but it also works as a pest control method. Rice straw burning accounted for 0.05 percent of India's total greenhouse gas (GHG) emissions, resulting in the loss of vast amounts of biomass, such as organic carbon and plant nutrients, as well as negative effects on soil characteristics and flora and fauna. As a result, strategies for managing this important resource must be developed. Crop residue potential, management choices, and soil characteristics related with residue management are all addressed in this article.

Crop Soil physical characteristics such as soil moisture content, aggregate formation, bulk density, and porosity are all affected by residue management methods. Crop residues were incorporated and/or retained in the soils, which decreased bulk density and compaction. The annual application of 16 t ha-1 rice straw for three years reduced bulk density in the 0-5 cm layer on a sandy loam from 1.20 to 0.98 g cm-3. Because of the disintegration of aggregates and the development of a surface seal as a consequence of raindrop contact, the surface soil becomes more compacted, and the pore percentage of the surface soil decreases, resulting in reduced infiltration. This issue is solved via residue retention on the surface. In comparison to the no-residue condition, crop residue incorporation reduced BD and increased infiltration rate, WHC, microbial population, and soil fertility. The greatest production, nitrogen absorption, residual soil fertility, and soil microorganism status were achieved when residue was combined with NPK fertilizer.

Soil microbial biomass (SMB) and microbial activity are both reliant on the availability of organic substrates in the soil. The phyto-biomass contained in soil is positively linked with the population of soil flora and fauna. Crop residue-treated soil had 5-10 times more aerobic bacteria and 1.5-11 times more fungus than soil that had been burned or removed, according to the researchers. Many studies have shown that in the zero till treatments of both rainfed and irrigated long term trials, soil microbial biomass (C and N) reduced as the quantity of residue maintained on the soil surface decreased. The capacity of the soil to retain and cycle nutrients (C, N, P, and S) and organic matter is reflected in its microbial biomass, which plays an essential role in aggregate physical stability. Crop leftovers are also known to help asymbiotic bacteria fix nitrogen in the soil (Azotobacterchrococcum and A. agilis). The activity of soil enzymes responsible for converting inaccessible to available forms of nutrients rises as the microbial population of the soil grows.

The pH of the soil, which is heavily affected by agricultural residues absorbed in the soil, is a deciding element of soil fertility. Long-term straw application will enhance soil organic matter and nitrogen stocks, as well as macro- and micronutrient availability. Researchers found that incorporating leftovers from both crops in the rice wheat system improved total P accessible P and K content in the soil over removing residues in an 11-year field trial performed on loamy sand soil. The inclusion of crop residue over straw burnt enhanced inorganic and organic P, decreased P sorption, and boosted P release, according to a three-year research. Micronutrients (Zn, Fe, Cu, and Mn) taken up by rice and wheat crops may be recycled in the form of integrated residue to the tune of 50-80%. The availability of micronutrients like zinc and iron in rice is influenced by crop waste.

Decomposition is influenced by residue properties as well as soil and crop management variables. N immobilization may last 4-6 weeks under ideal temperature and moisture conditions. Residue management methods have an impact on soil microbial biomass (SMB). When leftovers are burned, many employees notice a decrease in microbial biomass. Microbial activity is higher when residues are incorporated rather than removed or burned.

3. CONCLUSION

Crop leftovers have a high economic value as animal feed, fuel, and a raw resource for industry. Crop residue management problems, on the other hand, vary depending on the area and its socioeconomic requirements. The projected quantity, when combined with typical uncertainties, gives a comprehensive picture of crop residue production each year. A significant portion of it is not commercially utilized and is discarded. To yet, widespread attention to agricultural waste management has been obviously restricted. The lack of enthusiasm and energy on the part of farmers and small industrial stakeholders, as well as the economic challenges in farming, have all contributed to the exclusion of agricultural residue as a commercial commodity in India (and related industries). Imposing a ban on crop residue burning may not be effective unless farmers are educated about the harmful consequences of crop residue burning on human, animal, and soil health, crop biodiversity, the micro and macro-environment, and other factors. Extension education is promoted among farmers and producers to spread information about agricultural residue's use. Talks, speeches, graphics, presentations, and publishing are examples of extension efforts. Alternatives to burning agricultural residues such as collection and transportation of agricultural residues, gasification as a fuel for boilers, converting into briquettes, designing of suitable harvester, composting in situ, and straw mulching while using disc ploughs, disc ploughs, disc ploughs, disc ploughs, disc ploughs, disc ploughs, disc ploughs, disc ploughs, disc ploughs, disc ploughs, disc ploughs, disc ploughs, disc Crop residue use in nontraditional methods has a limited future. However, as shown by the numbers above, the pressure to shift is growing quickly as more companies use agricultural waste as a raw resource. Individual industries' potential, on the other hand, has yet to be prioritized and has to be accelerated. The government's effort to turn these waste materials into electricity has served as a catalyst. This instills the concept of economic gain among various stakeholders even further.

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