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A critical study on utilization of rice husk and their ash: A review

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Abstract

Due to rapid growth in population and industrialization, some new technologies are made for waste utilization and cost reduction in industrial processing by using rice husk (lignocellulosic biomass) as a valued material. In this paper various industrial and domestic application of rice husk and rice husk ash are discussed. Rice husk act as adsorbent for removing heavy metals from wastewater. In mostly countries of the world, lignocellulosic biomass used for bioethanol production because it is a renewable and environment friendly fuel. With the review, it is hope that researchers concentrate on producing non-food feedstocks.

Keywords: Lignocellulosic biomass, rice husk, bioethanol

Introduction

Rice is the seed of the grass species *Oryza sativa* (Asian rice) or less commonly *Oryza glaberrima* (African rice). The name wild rice is usually used for species of the genera *Zizania* and *Porteresia*, both wild and domesticated, although the term may also be used for primitive or uncultivated varieties of *Oryza*.

As a cereal grain, domesticated rice is the most widely consumed staple food for over half of the world's human population, especially in Asia and Africa. It is the agricultural commodity with the third-highest worldwide production, after sugarcane and maize. Since sizable portions of sugarcane and maize crops are used for purposes other than human consumption, rice is the most important food crop with regard to human nutrition and caloric intake, providing more than one-fifth of the calories consumed worldwide by humans. There are many varieties of rice and culinary preferences tend to vary regionally.

The traditional method for cultivating rice is flooding the fields while, or after, setting the young seedlings. This simple method requires sound irrigation planning but reduces the growth of less robust weed and pest plants that have no submerged growth state, and deters vermin. While flooding is not mandatory for the cultivation of rice, all other methods of irrigation require higher effort in weed and pest control during growth periods and a different approach for fertilizing the soil.

Rice is an important staple food for approximately half of the world population. More than seventy countries mainly China, India, Indonesia produce rice. Rice husk is one of the most widely available agricultural wastes in many rice producing countries of the world. Rice hulls (or rice husks) are the hard protecting coverings of grains of rice and removed from rice seed as a by-product during the milling process. Rice husk used as a valued added raw material for different purposes. It possess various properties that make them suitable for bioethanol production. Rice husk biomass is made up of three polymers like cellulose, hemicelluloses and lignin. Rice husk like other lignocellulosic biomass feedstock has been explored as the cheapest feedstock for bio-ethanol production. It is essentially free as waste product from agriculture sector and forest residues. Utilization of these wastes could solve the disposal problem and reduce the cost of waste treatment. When rice husk incinerated, ash is obtained called rice husk ash. In this review, we are discussing about different applications of rice husk and rice husk ash. Rice hulls that are parboiled (PBH) are used as a substrate or medium for gardening, including certain hydrocultures. It has been shown that rice hulls do not affect plant growth regulation. Rice hulls are used as pillow stuffing. The pillows are loosely stuffed and considered therapeutic as they retain the shape of the head.

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Rice husk has been used as insulating material for cold storage for many years in China, and it is available locally. Rice husk is usually used for wall and roof insulation. Occasionally it is used for floor insulation in small cold storages. On the 'cold side' of the outer wall, the fabricated RC wall panel is used to retain the loosely filled rice husk. Under the roof, a flat slab floor sustains the rice husk and the ceiling coils. In some cases, an overhung fabricated channelled RC panel ceiling is used. The purposes of these arrangements are to save wood. The former gives more convenience for filling, renewal and routine inspection of rice husk. But it costs more money. The latter decreases the dead load of the structure, and seemed to be better for the infiltration of vapour. But the filling and renewal of rice husk seem more stiff than the former. The floor of the freezers, most people appreciate the cork board as their insulations. As the beginning of design the cold storage work, we consider how to carry on the maintenance works as the rice husk will be settled or absorbed water vapour simultaneously. Up to day, some cold storages insulated with rice husk still run as usual, even for twenty years if they are arranged and behaved reasonably. From experiences, it is known a well done preparation will make the refilling of rice husk easier.

Composition of rice husk

Rice husk contains 75-90 % organic matter such as cellulose, lignin etc. and rest mineral components such as silica, alkalis and trace elements. Rice husk is unusually high in ash compared to other biomass fuels in the range 10-20%. The ash is 87-97% silica, highly porous and light-weight, with a very high external surface area. Presence of high amount of silica makes it a valuable material for use in industrial application. Other constituents of Rice Husk Ash (RHA), such as K_2O , Al_2O_3 , CaO , MgO , Na_2O , Fe_2O_3 are available in less than 1 %. Rice husk having bulk density of 96-160 kg/m^3 , oxygen 31-37%, nitrogen 0.23-0.32%, sulphur 0.04-0.08 %.

Utilization of rice husk

Rice husk used for different applications depending upon their physical and chemical properties like ash content, silica content etc. In power plants, rice husk is directly used as a good fuel. It is also used as a raw material for making some compounds like silica and silicon compounds. Rice husk have various application in different industries and domestic fields.

a) As an industrial fuel

For processing paddy and generation of process steam, rice husk used as a fuel. Heat energy is produced by combustion and gasification. In small sector process industries, rice husk used as a fuel in low capacity boilers. For producing 1MWH (million watt hour) electricity, 1 tonne of rice husk is required. It is also used as alternative fuel for household energy.

b) Preparation of activated carbon

Rice husk contain large amount of cellulose and lignin contents, due to this it used as a raw material for preparation of activated carbon. Activated carbon are effective

adsorbents due to their complex microporous structure.

c) Rice husk as a fertilizer and substrate

Due to high lignin content, rice husk composted very slowly, at that time earthworm is used to accelerate this process. Using vermicomposting technique, rice husk can be converted into fertilizer within four months.

Paraboiled rice husk used as a substrate or medium for gardening including certain hydroculture

d) As Pet food fiber

Rice hulls are the outermost covering of the rice and come as organic rice hulls and natural rice hulls. Rice hulls are an inexpensive by-product of human food processing, serving as a source of fiber that is considered a filler ingredient in cheap pet foods.

e) Substrate for silica and silicon compound

Rice husk contain 20% silica due to this reason it is a good raw material for making silicon compounds like silicon nitride, zeolite, silica and pure silicon etc.

f) Used for making bricks

Rice husk used for making bricks. More the percentage of rice husk in brick, more porous would be the brick and better thermal insulation.

g) Other uses

Rice husk are used for production of xylitol, furfural, ethanol, acetic acid, etc. It used as a cleaning and polishing agent in metal and machine industries. It is also used as building material and also used as industrial raw material example-as an insulating board material, filler in plastics, filling material, for making panel board etc.

Rice Husk Ash (RHA) applications

• Used in Steel Industries

Due to fine insulating properties of rice husk like low thermal conductivity, high melting point, low bulk density high porosity, it used for the production of high quality steel. It is also used as a coating over the molten metal in the tundish and in ladle which act as a very good insulator and does not allow quick cooling of metal.

• Used in Cement and Construction Industries

Blended cement are produced by using rice husk ash for fulfilling the increasing need for building material. Rice husk ash is a highly reactive pozzolan. Rice husk ash mainly used a replacement of silica fume or as an admixture in manufacturing of low cost concrete block.

• Use of Rice Husk Ash as Silica Source

Due to large silica content in rice husk ash, extraction of silica is economical. Silica are used in rubber industries as a reinforcing agent, in cosmetics, in toothpastes, in food industries as an anti-caking agent. There is a growing demand for fine amorphous silica in the production of high performance cement and concrete, use in bridges, marine environments, nuclear power plants etc. Silica aerogels prepared from Rice.



Fig 1: Husk Ash (RHA) finds application in super thermal insulators, catalyst supports and dielectric materials. It can be an economically viable raw material for the production of silicates and silica.

Other Uses

Indian Space Research Organization has successfully developed a technology for producing high purity silica from RHA that can be used in manufacturing of silicon chip in industry. RHA used in vulcanizing rubber. Use of Rice Husk to synthesize High-Performance Phosphors. Other uses of Rice Husk (RH) are in control of insect pests in Stored Food Stuffs. RHA has been found to be effective as an oil spill absorbent, and for use in waterproofing chemicals, flame retardants, and as a carrier for pesticides and insecticides.

Rice husk as an adsorbent for heavy metals

Table 1: Adsorption Capacity of Rice Husk on Heavy Metal $q_{max}/(mg.g^{-1})$

Adsorbent	Rice Husk
Copper	10.9
Lead	58.1
Zinc	8.14
Cadmium	20.24
Mercury	66.66
Chromium	0.6
Nickle	0.6
(Reference - 20)	

The rice husk is an agricultural waste substance and it is a good adsorption capacity on adsorption of heavy metals. It can be used to treat heavy metals in the form of either untreated or modified using different modification methods. Hydrochloric acid, sodium hydroxide, sodium carbonate, epichlorohydrin, and tartaric acid are commonly used in the chemical treatment of rice husk. Pretreatment of rice husks can remove lignin, hemicellulose, reduce cellulose crystallinity and increase the porosity or surface area. In general, chemically modified or treated rice husk exhibited higher adsorption capacities on heavy metal ions than unmodified rice husk. Rice husk is insoluble in water, has good chemical stability, has high mechanical strength and possesses a granular structure, making it a good adsorbent material for treating heavy metals from wastewater. By using the rice husk, heavy metals such as Cd, Cu, Hg, Cr, Pb, Zn and Ni are removed.

Rice husk for bioethanol production

Rice husk is a cheap carbon source for industrial production of bioethanol by using cellulolytic microorganisms. From

rice husk highest ethanol concentration in fermentation product using *Saccharomyces cerevisiae* is 1.13% attained at final temperature of 220 °C. Bioethanol is produced from rice husk by using *Zymomonas mobilis* is also reported.

For conversion of lignocellulosic biomass to bioethanol, three processes are involved. First is pretreatment to remove lignin and disrupt/loosen-up the crystalline structure of cellulose and increase the porosity of the biomass. Secondly, hydrolysis of cellulose to produce reducing sugar by chemical and enzymatic process. Thirdly, Fermentation of the sugar to ethanol by yeast.

Conclusion

Utilization of rice husk could solve the disposal problem and reduce the cost of waste treatment. Rice Husk and its ash are used directly for manufacturing and synthesizing new materials. It is used as a fuel, Fertilizer, substrate and it also used in preparation of activated carbon, Pet food fiber, Silica and silicon compounds, bricks etc. Rice husk ash used in steel, cement and construction industries. Rice Husk act as an adsorbent for heavy metal removal from waste water. Easy availability and low price of rice husk in rice producing countries is an extra benefit towards the use of this material. Therefore abundantly and renewability of rice husk represents a real advantage over source of dwindling fossil fuels for bioethanol production. Multiple benefits of rice husk and rice husk ash can be achieved by future critical research efforts to provide new impetus for local and regional sustainable development.

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