Original Article

Composition, Application And Recycling Of RHA To Value-Added Products: A Review

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Abstract

Leveraging waste products and by-products is essential for addressing current fiscal woes. The primary agricultural by-product from rice production is rice husk that results from rice milling. A total of 741 million tons of rice were produced globally each year, and 148 million tons of husks are also produced that corresponds to 20% of the grain weight. Rice husk ash (RHA), which is dispersed widely throughout the rice milling process, is the main waste product that results from burning rice husks. Burnt rice husk poses a challenging disposal issue and adds to further environmental deterioration; as a result, recycling of rice husk to value added products hold importance. RHA is a thin, fragile, and incredibly permeable substance. RHA typically contains 90% amorphous silica. The study discusses the chemical composition as well as characterization of RHA, its use as an adsorption material the making of silica and biochar, and also provides an insight into the purification of wastewater produced by various sources, including iron and steel plants, dye factories, and rice mills, by RHA and RHA as a catalyst and biomedical applications of rice husks and ash from rice Husks across multiple industries and products with value.

Keywords: Silica, Biochar, RHA, Ash, Biomedical, Rice Husk.

INTRODUCTION

Around fifty percent of mankind eats rice as an important everyday food. The Food and Agricultural Organization of the United Nations reports that around 996 million Tonnes of rice, as well as paddy, were produced globally in 2018. The countries with the greatest amounts of rice and wheat farming are all in Asia. (China, India, Indonesia, Bangladesh, Vietnam, and Thailand). Typically, the husk of rice, an outcome of the milling of rice process, makes up approximately twenty percent of the paddy generated. In multiple nations, rice husks are utilized to produce power. The heating value per kilogram of rice husk is 15 MJ, and its annual energy potential is 2985 PJ.

Most Asian nations currently use the energy from burning rice husks in simple incinerators, thermal power plants, and industrial streams. Many Asian countries, including Thailand, China, and India, operate rice husk gasification power facilities. Although they are still in the demonstration stage, rice husk gasification power plants can produce 20 to 400 Kwa of electricity. One ton of rice husk creates around 0.195 tons of rice husk ash because of generating power. 800 kWh of power is generated from one tone of rice husk. Due to the high ash concentration of rice husks, thermal conversion is challenging and costly. Therefore, it is essential to assess rice husk ash for uses that call for value-added components.

As a result, it is critical to value-add applications for rice husk ash to increase the process's overall economic return. To lessen the load of the energy production process, it may also be beneficial to extract inorganic substances from rice husks prior to energy creation. Rice husk is mostly composed of cellulose, hemicellulose, along with lignin. A cellulose-based fiber made of amorphous silica, rice husk has a mineral content of 20%. About 40% of it is cellulose, 30% lignin, and 20% is silica. Rice husk's concentration (in wt. percent) is 41.92 percent C, 6.34 percent H, 1.85 percent N, and 0.47 percent S. They can be used as a source of energy, but their co-firing utilization is restricted by their high ash content when compared to other biomass materials. A significant amount of rice husk is produced annually throughout the world as a byproduct of the milling of paddy rice. Rice husk contains substantial amounts of amorphous silica.

As a result, rice husk provides a natural and sustainable biomass source for silica extraction and subsequently for making silicon-based products with added value. Nowadays, the majority of rice husk is burned directly to create electricity or power, which results in the generation of a lot of rice husk ash. On an industrial basis, silica is only extracted from a small portion of rice husk. The ash from rice husks is used in the making of concrete as a complement to cement. Due to the accelerating rate of ecosystem deterioration plus the demand for sustainability, the idea for employing the husks of rice has come to light. Over a hundred million tons of by-products are generated worldwide from the growing of paddies of rice. Their bulk density was just [90] (Figure 1).

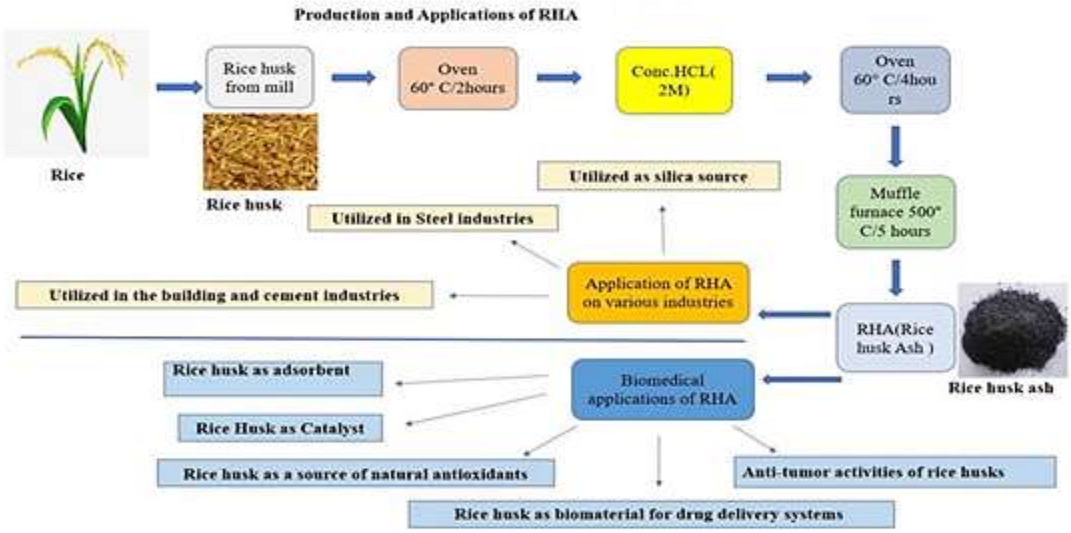

Figure 1: Schematization of the production of RHA and its various applications in biomedical and industrial fields.

CHARACTERIZATION AND COMPOSITION OF RHA

RHA is a thin, fragile, and incredibly permeable substance. It makes up about 4% of the weight of the rice paddy and 20% of the husk [1]. RHA is greyish-black, with a hint of unburned carbon. Burning temperatures between 550 and 800 °C are necessary to make amorphous silica, but higher temperatures are required to produce crystalline silica. 90% amorphous silica, 5% carbon, and 2% K_2O are typical compositions of well-burnt RHA. RHA has several uses, including in the building industry where it is used as a pozzolan, also filler, additive, abrasion factor, oil adsorbent, sweeping agent, and suspension. RHA has a specific gravity ranging from 2.11 to 2.27, is very porous, light, and has a remarkably high specific surface area. The remaining 75–90% of the weight is made up of the other minerals found in rice husk, including silica, alkalis, and trace minerals [2]. The advantages of rice husk over other biomass fuels include. The ash has an extremely high exterior outer layer area, is very porous, and contains 87-97% silica. It is an important substance for use in industrial applications because of the large amount of silica present [3]. Less than 1% of rice husk ash (RHA) contains other ingredients such K_2O, Al_2O_3, Cao, MgO, Na_2O, and Fe_2O_3. Bulk density of 96–160 kg/m3; oxygen content of 31-37%; nitrogen material of 0.23–0.32%; and Sulphur material of 0.04–0.08% (Table 1).

Table 1: Shows the rice husk chemical components and organic constituents [16][17]

Organic Constituents and Chemical Components in RHA	Weight percentage
D-Galactose	2.37

L-Arabinose	6.53
Lignin	22.00
Alpha-cellulose	43.30
D-Xylose	17.52
Methyl glucuronic acid	3.27
Al trace	0.21
Ca as CaO	0.48
Mg as MgO	0.23
Fe trace	0.62
Mn	0.11
Si as SiO_2	94.5
K as K2O	Trace
P as $P2O_5$	Trace
S as SO_4	Trace

Table 1: Shows the rice husk chemical components and organic constituents [16][17]

3. CONVERSION OF RHA TO VALUE ADDED PRODUCTS

3.1 The Growth of RHA as A Raw Material for Numerous Additional Value-Added Products

A 2005 estimate placed the annual production of RHA at 21 million tons worldwide [4]. The production and release of RHA into the ecosystem has come under heavy fire over the past ten years, mostly because of its cancer-causing and bio accumulative qualities. The effects of this RHA discharge include lack of appetite, exhaustion, the silicosis syndrome, respiratory diseases, and even death [5]. There developed a widespread interest in converting this garbage into some type of usable material, both to reduce the cost of properly disposing of it and to produce goods with commercial worth on the global market [6][9]. RHA finds use as a pozzolanic material to produce high strength concrete and refractory bricks under such an ideology to produce valuable products [7], a feedstock for the silicon chip processing sector [8].

It is used as a filler in the manufacturing of polymers, as an agent for clarifying beer, as a refractory powder, for vulcanizing rubber, and as an oil adsorbent [9][6]. RHA has worked as a thermal conductor in the field of steel and as a pozzolan in the construction industry. [9][6]. RHA offers good insulating qualities thanks to its high melting point, low bulk density, and low thermal conductivity. Due to its insulating qualities, it can be used as a superb "tundish powder"—powder that insulates the tundish to stop steel from cooling too quickly and provide consistent solidification in continuous casting processes [10]. As a by-product of the milling process, rice hulls (also known as rice husks) are the tough protective coverings that preserve the rice grains. However, its yearly output results in enormous amounts of husks 1011 kg [11] The silica content, silica's crystalline condition, the rice husk particles' size and surface area are what give RHA its pozzolan qualities [12]. The method for extracting high purity silica from RHA for use in the production of silicon chips in industry has been successfully developed by the Indian Space Research Organization. Rubber vulcanization uses RHA [13].

High-Performance Phosphors are made using rice husk as a catalyst. Additional applications for rice husk (RH) include the prevention of insect pests in stored food products. The usage of RHA as flame retardants, waterproofing chemicals, and as a pesticide and insecticide carrier has all been found to be effective [14]. Hydraulic cement plus silicone ashes there from, prepared. the United States. By employing rice husk, the issue of trash disposal may be handled, and the cost of waste treatment may be minimized. New materials are directly produced and synthesized using rice husk and ash. Bricks, fertilizer, substrate, silica plus silicon substances, carbonized carbon, pet food fibre, and other items are all made using it. Ash from rice husks is utilized in the steel, cement, and building industries. For the removal of heavy metals from wastewater, rice husk serves as an absorbent. An additional advantage of using this material is the simple availability and affordable pricing of rice husk in nations that produce rice.

RHA with these qualities can be made by using the right incineration procedure at a regulated temperature in an appropriately built furnace and the right grinding procedure [15]. Rice husk's ability to absorb heavy metals, in terms of q max (mg. g-1) RHA can be used as a catalytic material to produce biodiesel. It can also be used as a fertilizer or soil conditioner. Additionally, RHA has been used to produce ceramics, to produce activated carbon, and to produce nanomaterials. Further research should be conducted to better understand the potential applications of RHA and to develop effective strategies for its use in different scenarios. With further research and development, RHA is likely to be a workable and inexpensive material for a range of uses. Moreover, RHA has been found to be effective in the removal of many pollutants from wastewater and industrial effluents.

3.2 Silica and catalyst preparation using RHA

Rice husk a distinctive agricultural waste with a consistent shape and a high quantity of ash 1425 is a by-product of the milling of rice industry the silica concentration of rice husk ash RHA may vary from 90 to 97 [18][19][20] amorphous silica is well known and commonly used as a support material because of its enormous surface area which offers ample surface area for any metal to disperse [24]in recent years there has been a lot of interest in the use of techniques to chemically change both inorganic and organic catalytic surfaces in order to increase their effectiveness in processes involving catalysis the potential for these chemically modified materials to replace conventional heterogeneous as well as homogeneous catalysts is enormous.

Immobilizing transitional metal complexes and clusters of transition metals might be utilized to create a specific sort of mixed catalyst whose nature and function may be more clearly understood and potentially give ways to adjust metal particulate and crystallite sizes to produce unique types of catalysts [22]. Ruthenium catalysts have gained a lot of attention recently. They involve both solid catalysts and soluble complexes. Recently created Ru-Co-Al hydrotalite, Ru hydroxyapatite, and Ru/Al_2O_3 are the most effective Ru-based hetero mixed systems for the aerobic breakdown of alcohols. in a liquid phase. Ruthenium catalysts are known to be highly tolerable towards many functional groups that may be present in the alcohol molecules and to be sufficiently identified to stop over-oxidation aromatic compounds to acid [25]. The ruthenium oxides that are utilized to make the heterogeneous catalysts can be very pricey.

If the metal or its oxide can be spread in an inert matrix with a wide surface area, the cost of the catalyst can be decreased. By using less metal, the catalyst's price will be reduced, and the metal can be disseminated across a larger surface area for more effective and efficient catalytic activity. All over the globe, 120 million tons of rice husks are generated annually as agricultural litter [23]. Silicon dioxide (20 wt.%) makes up the majority of rice husk ash in comparison to other biomasses [27]. It may be obtained and has a variety of uses, including filler [28] catalytic support [29] component for batteries made with lithium-ion [31], and more. A well-known green fuel is hydrogen. A particular way of generating hydrogen utilizes the bio-oil steam distillation method. Rice husk may be used to extract nano-silica, which is then utilized to support catalysts.

There are several techniques used to eliminate SiO_2 using rice husk notably sol-gel, precipitation, lye, and heat treatment methods. The Sol-gel technique comprises polycondensation and low-temperature hydrolysis. SiO_2 atoms with stable molecule size distribution are produced using this method [26]. Although the method has an extended production cycle, elevated amounts of pollutants, and high expenses, making it unsuitable for industrial production. In the lye method, rice husk is dissolved in silicon dioxide by uniting basic solution and lye, in which a lot of dye is consumed. Two frequently used lye's are Sodium hydroxide (NaOH) and Potassium carbonate

(K_2CO_3) solutions. [21] created absorbent silica using a sol-gel technique and NaOH extraction. The heat treatment process is straightforward, efficient, and good for the environment because it often uses fewer chemical reagents. It involved pre-treatment to remove metal impurities from the rice husk, followed by creating a high-purity, ultra-fine silica material by calcining in an oxygen-rich atmosphere. [27] studied the effects of temperature and speed on the structure of rice husk-derived nano-SiO_2.

When heated at a rate of 5 °C per minute, nano-SiO_2 had a particular surface area of 235 square meters g1, a mean pore diameter and size of particles of 5.4 and 60 nano meter, and a purity of 99.7%. Prior to being burnt in an air environment at 1073–1273 K to create SiO_2 with a purity of 99.5–99.8%, rice husks were treated with citric acid to remove metal impurities. [50]. The purity and structure of SiO_2 may be impacted by the pyrolysis temperature. [51] Investigated the impact of rice husk particle size and pyrolysis temperature on the purity of SiO_2 produced during heat treatment. It was discovered that under ideal circumstances, the purity of SiO_2 can reach 99.9%. To compare the pyrolysis behaviour of silicon-containing agricultural wastes, such as rice husks, wheat husks, and bagasse, [52] undertook thermogravimetric tests. It was discovered that the types of raw materials had a direct impact on the SiO_2 production. Using rice husk, [53] isolated nano-SiO_2 that they used as substrates for creating nano-Au catalysts. To produce 60-70 nm SiO_2, the husk of rice was heated at a temperature of 700 degrees Celsius for two hours after being refluxed with five percent hydrogen chloride (HCl). These materials' Si-O-Si bonds exhibited a variety of infrared spectrum distinctive peaks, according to [54] analysis of the structure of SiO_2 produced at various heat treatment temperatures.

Oil to generate hydrogen include those based on nickel [32-38] noble metals [39,40] etc. One of them, a Nickle-based catalyst [41], which is a good bio-oil steaming reform catalyst, can break C-C bonds and improve water gas transfer processes. Carriers are typically added to boost the catalytic activities and the area of surface of the active components. The carriers must be able to endure the high temperatures involved in steam reforming. It consists of Al_2O_3 [42-44] CeO_2, and [45,46] SiO_2. [47-49] Al_2O_3 has a significant amount of acid sites and a big specific surface area, both of which can aid in the dehydration of acetic acid. There have been numerous studies on it. The amount of Ni added to the catalyst had a significant impact on how well it performed, according to [42] research on how well the Ni/Al_2O_3 catalyst performs when reforming acetic acid. Metal Ni and carrier Al_2O_3 interacted with one another. The Ce-Zr-O carrier also performed well during steam reforming and had an oxygen storage capacity.

Co-precipitation was used by [55] to create a Ni/Ce_2-ZrO_2 ethanol reforming catalyst. 100% of the reaction's ethanol was converted at GHSV = 345 h1, S/C = 9.2, and T = 825 °C. SiO_2 is a highly specific surface area acidic oxide that is used in the steam reforming of bio-oil. [48] put a Ni/La_2O_3-SiO_2-catalyst in the steam reforming of glycerol which helped in discovering that the addition of La_2O_3 to the Ni/SiO_2 catalyst may prevent carbon deposition from developing. Nano-Ni/SiO_2 catalyst for ethanol reformation was created by [49]. H_2 yield was 0.24 g per hour when catalyst mass was set at 0.3 g and Ni loading at 20% (Figure 2)

Figure 2: Illustrates the methods to produce silica using the ash of rice husks (RHA)

4. USING RHA AS AN ADSORBENT

Rice husk ash (RHA) is a waste material generated from burning rice plant husks. Environmentalists throughout the globe have grown increasingly interested in the issues that come to severe soil, air, and water contamination during the past few decades. [58]. It has been used for many years as an adsorbent material in many applications. RHA is an attractive adsorbent material given its high price and high porosity, and high surface area. It is currently being utilized to absorb organic molecules from the air and remove a wide range of pollutants from sewage and industrial wastewater. The two basic methods for activation are physisorption and chemical activation. So, because the carbonization method takes less power and produces activated carbon with fewer pores than physical activation, chemical induction is preferable [59]. The principal substances that are utilized as activation agents are $ZnCl_2$, H_3PO_4, H_2SO_4, K_2CO_3, and KOH. [59] RHA is composed of amorphous silica, which is formed from the burning of rice husks and contains several other minerals and compounds.

RHA has Si-OH, Si-O-Si, and Si-O-C groups on its surface, which makes it highly favorable for adsorption. RHA generally has a surface area of 300 m2/g and a pore volume of 1 cm3/g, which makes it highly suitable for adsorption applications. RHA has been used for the removal of many different pollutants, such as heavy metals, dyes, and organic compounds. RHA has been found to be effective in removing lead, cadmium, copper, and zinc from wastewater. RHA has recently been utilized to remove organic volatile compounds (VOCs) from the air. It has been found to be effective for the removal of benzene, toluene, ethylbenzene, xylene, and other VOCs. RHA has also been used for the absorption of polychlorinated biphenyls (PCBs) from water. Many aspects, notably pH, temperature, and the existence of additional ions in the fluid, have an effect on the contaminants that are absorbed in RHA. The adsorption capacity of RHA is typically higher at higher pH values and lower temperatures.

The adsorption capacity of RHA is also affected by the presence of other ions in the solution, such as calcium and magnesium. On the other hand, more research needs to be out to comprehend its precise procedure for adsorption on RHA and to create efficient ways for its application in different scenarios. Additionally, RHA needs to be evaluated for its potential for use in other applications, such as for the removal of dyes from wastewater and the adsorption of organic compounds from the air. Further research should be conducted to better understand the adsorption mechanism of RHA and to develop effective strategies for its application in different scenarios. With further research and development, RHA does have the ability to be a cost-effective adsorbent material for the elimination of contaminants in sewage and commercial wastewaters and from the air. To fully grasp the adsorption characteristics of RHA, more research is needed. and to develop effective strategies for its application in different scenarios. With further research and development, RHA has the potential to be a viable and cost-effective adsorbent material for the removal of pollutants from wastewater and industrial effluents, as well as from the air (Figure 3).

Figure 3: Illustrates the way RHA is being utilized as an adsorbent.

5. REPARATION OF BIOCHAR

A solid organic by-product of wood pyrolysis is called biochar. When used as a soil amendment, biochar alters the soil's chemical, biological, and physical properties, which has a major impact on soil fertility [60]. Biochar is defined as biomass that has been carbonized and buried in the soil from renewable sources. This makes it different from charcoal that is burned for heating purposes. Biochar can help enhance the soil quality and productivity for agriculture and the environment in the present and future. A porous substance called biochar can assist in keeping moisture and micronutrients within topsoil that plants might take up as they develop. Heavy metal ions, pesticides, herbicides, and hormones can all be immobilized by some types of biochar. thanks to their adsorption abilities. They can also stop nitrate leaching and faecal bacteria from entering streams, as well as soil emissions of N2O and CH4.

Using a cooking stove or a biochar may be made in little or large quantities using the pyrolysis technique. Biomass is transformed into biochar, bio-oil, and syngas by the thermochemical process of pyrolysis in the absence of air. at temperatures between 350 and 700 °C [63]. However, pyrolysis and gasification are the thermochemical reactions that result in the solid form of biochar [61][62]. Forest by-products, Typical biochar feedstocks include organic industrial waste, manure, and agricultural residue. A variety of pyrolysis techniques have been used to create biochar from biomass. Choosing the right approach is essential if you want to maximize the yield amount of the intended by-product during pyrolysis. All process variations are carried out in an oxygen-free environment, which reduces the number of greenhouse gases released during the combustion of biomass. Wet pyrolysis, pyrolysis, torrefaction, slow pyrolysis, quick pyrolysis, flash pyrolysis, and microwave-assisted pyrolysis are a few examples of pyrolysis procedure types of dependent on the heating rate (Figure 4)

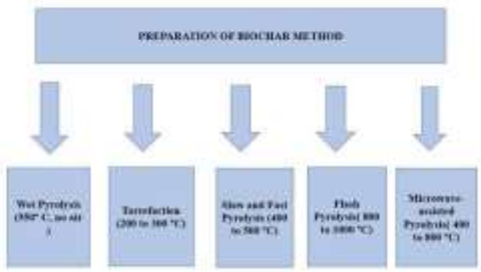

Figure 4: Illustrates the methods of biochar preparation

5.1 Wet Pyrolysis

For the thermochemical conversion of biomass into hydrocar or hydrothermal biochar, wet pyrolysis is one option. In wet pyrolysis, the feedstock is pyrolyzed in a pressurized vessel without any pre-drying steps despite having a high moisture content of up to 75–90%. The dehydro carboxylation of the biomass ingredients and its transformation into a carbon-densified product were caused by the high temperature of between 180 and 250 °C and high moisture content. The procedure produced biochar with a relatively low H/C and O/C ratio and a high concentration of oxygen-containing functional groups after just partial carbonization of the biomass.

5.2 Pyrolysis

Heat-induced breakdown of biofuel happens in a biomass pyrolysis technique it starts at 350-550 c and progresses to 700-800 c the method produces bio char bio-oils or gases that are not condensable like carbon monoxide carbon dioxide methane hydrogen higher moisture content waste streams like muck and meats industry garbage are processed prior to combustion to lower moisture levels rice husk material on other side having little water in it and may be pyrolyzed right soon by bringing the organic matter to its steady-state temperatures and leaving the surrounding region inert more stable by-products are produced volatiles created throughout each stage may be condensed in order to obtain biological oil pyrolysis comprises two stages. The first stage involves the cleaving up and devolatilization of biomass. By cleaving biomass, carboxyl, carbonyl, and hydroxyl groups are formed in addition to lignin, cellulose, and hemicellulose becoming the primary components of biomass. Decarboxylation, dehydration, and dehydrogenation of the biomass are effects of devolatilization. At the second step, bigger molecules and heavy chemicals in biomass are converted, resulting in the synthesis biochar biooil or gases that cannot condense the second step of the procedure can be accelerated by speeding up the heating rate and employing a catalyst.

5.3 Torrefaction

Torrefaction occurs at low pyrolysis temp of 200 to 300 c this process involves progressively heating the input materials at a rate of 60cmin for hours or days by gradually releasing volatiles and moisture content from the biomass stiff structures like those seen it at carbonaceous biogas are preserved hemicellulose cellulose and lignin. are partially decomposed because of the process. It frequently yields a larger proportion of solids as compared to fluid and semi gases. The resultant solid cannot be referred to be biochar since it has a high O/C ratio. Torrefaction is therefore regarded as a pre-treatment for removing moisture.

5.4 Slow and the Rapid Pyrolysis

Gradual creation of biochar is a substantial consequence of gradual pyrolysis which its name implies calls for a lengthy residence period greater than an hour 89 traditional or gradual pyrolysis includes warming up biomass at a pace of 5-7cmin keeping the temp between 300 600c 9091 the subsequent reactions can advance through the assistance of favourable environment and sufficient time offered by a longer residence time for vapour and a slower pace of heating to change solid materials into high-energy liquid bio-oil a direct thermochemical technique as quick pyrolysis is utilized biofuels obtained from biomass perhaps created with less particulates and gas utilizing a high-efficiency thermochemical technique 9293 quick pyrolysis happens whenever temperature exceed 500 °C and heat rates exceed 300.

5.5 Flash Pyrolysis

This improved and updated variant is referred to as rapid quick pyrolysis at temps of 1000 c or above bioenergy material decomposes swiftly usually in less than a minute on rare occasions the warming intensity has approached 1000csec in quick pyrolysis materials undergo warming to temperature within 900 and 1200c in a relatively short amount of time often between 01 and 1 s or less 8788 high heat a quick gas holding time and a quick heat transfer rate are all necessary for a high bio-oil output.

5.6 Pyrolysis by Microwave

Pyrolysis using by oven instead of comparing or standard strategies for raising the pyrolysis heat selectively by voluminously heats biogas by conduct, convective, and radiation, that restricts their capacity for maintaining thermostat. When a substance is heated by a microwave, electromagnetic radiation penetrates it and interacts with its dipoles to create thermal energy throughout the depth of its penetration by dielectric heating, that results in convection heating from inside. In most cases, microwave heating calls for a substance that has a substantial dielectric constant. The microwave filters used in combination with biogas to improve programmable throughout the pyrolysis using a microwave to warm assistance is takes place at heat at 400 to 800 c and it is regarded to be an superior to typical pyrolysis.

6. APPLICATIONS OF RHA ON VARIOUS INDUSTRIES:

RHA is an important raw material for many industrial and synthetic uses, including production of polymers, adsorption and heterogeneous catalysts, refractory materials, ceramics, cement, rubber fillers, and plastic composites [64]. Here is a discussion of some further significant RHA industrial and home applications.

6.1 Utilized as Silica Source

It has been highlighted that silica has been found in rice husk for a very long time and is well known around the world [56]. A fundamental substance called silica was extensively used in a variety of products, including ceramics, adhesives, chromatography columns, and pharmaceuticals. Rice husk ash (RHA), a commercially feasible raw material to produce silica gels and powder, contains around 60% silica by weight. Since rice husk ash contains a significant amount of silica, using it as a source of silica results in reduced extraction costs. Silica is utilized as an anti-caking compound in toothpaste, cosmetics, rubber, and or the food sector [57]. RHA is appropriate for use as a natural pozzolana in the cement industry and to be employed in the formulation of zeolite due to the high amorphous silica content that results from suspension-fired technology [95]. It was considered that RHA can help to reduce environmental consequences when utilised as a cement alternative [96, 97]. Many researchers have showed an interest in using RH silica in a variety of domains during the last few decades.

6.2 Utilized in Cement Industries

There is a rising need for fine amorphous silica to produce high performance cement and concrete for usage in bridges, marine environments, nuclear power plants, etc. Super thermal insulators, catalyst supports, and dielectric materials all utilize silica aerogels produced from rice husk ash (RHA). And it might be a commercially feasible raw material for silicate and silica manufacturing [65]. Concrete is a primary material consumed in the continually increasing building sector. Utilising a by-product of agriculture like RHA in the building industry may significantly minimise RHA disposal, which in turn reduces eventual land contamination. Furthermore, the utilization of natural resources as fine aggregate, such as river sand, has a direct influence on river bank erosion caused by excessive sand mining. River sand is in short supply and there is a rising need for fine aggregate. Since the manufacture of cement generates considerable amounts of CO_2 and depletes the earth's finite natural resources, alkali activated binder (AAB), a binder without cement, is a potential replacement for cement. As a result, using RHA-based AAB reduces pollutants associated with cement manufacturing and enhances the utilization of agricultural by-products as value-added source materials.

In addition, rice straw ash [98] makes them suitable substitute materials in various construction products. The use of RHA can reduce the total porosity of concrete by improving the interfacial transition zone (ITZ) between the cement matrix and aggregate and increasing packing density [95]. Furthermore, AAB is a higher-grade binder than standard Portland cement. Bricks are an ancient and widely used masonry construction material in many regions of the world. Burned clay bricks are quite popular today because of their toughness and fire resistance. The most important features of bricks are compressive strength, water absorption, density, and efflorescence. Each of these features defines the bricks' durability and strength. The elimination of ash dumps through the use of RHA would enhance environmental protection and the micro-filling structure of concrete when compared to concrete made solely from ordinary Portland cement (OPC) [99].

6.3 Utilized in Steel Industries

Owing to its excellent insulating qualities such as low heat conductivity high melting point low bulk density and high porosity rice husk is utilized in the manufacture of high-quality steel and employed over the molten metal as layer in the ladle as well as tundish which serves as a very effective insulator and prevents the metal from cooling quickly [66].

6.4 Utilized in the Building and Refractory Industries and Ceramics

To meet the growing need for construction materials is made utilizing RHA. Pozzolan made from RHA is very reactive. Used in production of inexpensive cement blocks, rice husk ash is mostly utilized as a substitute for silica fume or as an additive [67]. Due to its insulating qualities, rice husk ash is utilised in the production of refractory bricks. It has been utilised to create inexpensive, lightweight insulating boards. RHA has been employed as a silica source in the synthesis of cordierite. Higher cordierites are produced with a lower crystallisation temperature and a decrease in crystallisation activation energy when rice husk silica replaces kaolinite in the mixture composition (Figure 5).

Figure 5: Illustrates the rice husk ash applications

6.5 RHA Application and Upcoming Research Projects

The economic backbone is said to be the effective utilization of commodities. The environmentally friendly handling of earth's resources must be included into any industrial activity that strives to protect the environment. A complete framework with cleaner production paths is advised for the effective utilization of by-products obtained from rice husk as a consequence of the chosen literature analysis. There are several pathways connecting the construction and energy industries with the agricultural economy. The possibility of increasing residual soil qualities by combining RHA and cement as stabilizing agents in appropriate amounts.

The Indian Space Research Organization has successfully developed a process for synthesizing high purity silica from RHA, which may be utilised in the fabrication of silicon chips in industry (cf. the prospect of employing RHA in water purification usage of Rice Husk to synthesis High-Performance Phosphors). RH is also used to purify water, vulcanize rubber, control insect pests in stored food products, and as flue gas desulfurization absorbents. The usage of RHA as flame retardants, waterproofing agents, and as a pesticide and insecticide carrier has all been proven to be successful. Many industrial applications benefit from its insulating and absorbing characteristics.

7. BIOMEDICAL APPLICATIONS OF RICE HUSK

7.1 Rice Husk as Adsorbent

Numerous activation techniques have been devised and tested to make inexpensive adsorbents from different agricultural wastes, such RH, for the removal of aqueous pollutants. The low cost, high efficiency, and regenerate of biosorbents of biomaterial-based adsorbents above conventional treatment methods. Aside from their availability, renewability, and high efficiency, agricultural waste is also cost-effective and environmentally benign. To use them in heavy metal absorption, they would be a viable choice. Agricultural wastes, especially those that contain cellulose, exhibit potential metal biosorption ability. It is found that RHA produced using moving grate technology is suitable for use as an adsorbent because of its large surface area [100]. As a contrast, fluidized bed ash may be used as a filler in innovative ceramic mixes as well as polymeric composites [101].

7.2 The Utilization of Rice Husk as a Biomaterial in Drug Delivery Systems

The delivery of drugs relates to the delivery of pharmacologic chemical substances with a therapeutic impact upon people or animal [68]. SiO_2-rice is silica that has been extracted from RH and has been used in medication delivery systems [69]. These SiO_2-related substrates, also known as biological silicon or bio-silica, are exceptionally low in toxicity and may be employed in a variety of applications in biomedical science, include systems for delivering drugs. Among several potential uses for nanoparticles of silica are the generation of biogas and biofuel by anaerobic digestion and lipid extraction, respectively. Surprisingly, silica offers a potential toolbox as a fundamental material for a wide range of applications due to its bioactivity and biocompatibility. Its varied structure, density, and content of biogenic silica makes it a superior substitute for manufactured silica.

7.3 Using Rice Husk as a Natural Antioxidant Resource

The oxidative stress is a complicated process triggered when the production of reactive oxygen species is out of equilibrium in biological mechanisms. Utilizing both endogenous and exogenous antioxidants, such harmful chemical compounds are eliminated from the body. [70] Naturally occurring antioxidant defense mechanisms exist in humans and can be either enzymatic or non-enzymatic (products of body metabolism). Exogenous antioxidants, on the other hand, enter the human body through diet and are present in some foods or dietary supplements that include antioxidant formulations, and co-factors like copper [71]. A highly reactive, unstable molecule with the capacity for autonomy is referred to as the free radical. It is also highly reactive and a risk factor for several chronic human illnesses since it possesses an electron that is unpaired in its atomic orbital, for example tumors, neurological disorders, and heart problems (CVD) [72].

By donating or absorbing an electron from various atoms, free radicals can behave as oxidizing agents or reductants. [73] It was suggested that using antioxidants—substances that delay or prevent the oxidation of a substrate—can minimize the severity of the condition via scavenging radicals that are harmful and reducing cell destruction [74][75]. Furthermore, to their detrimental effects on wellness, reactive oxygen species can induce peroxidation of lipids, which is a major factor in the breakdown of pharmaceutical and food items during their manufacture and storage [76]. This is because antioxidant components like tocopherols work as free radical scavengers, potentially extending the shelf life of such products [70]. RH frequently contains polyphenols, bioactive secondary plant compounds with anti-inflammatory and antioxidant activities [77][78][79]. Additionally, the existence of aromatic phenolic rings in RH allows for the presence of a variety of phenol substances, like phytic acid, the acid vanillic, & syringic acid, along with iso vitexin.

7.4 Rice Husk as Catalyst

In comparison to other biocatalysts, researchers discovered found, in terms of result yield, solvent, and time to reaction, rice husk ash SO3H had the greatest catalytic activity. The resulting product was effectively evaluated for its herbicidal and antifungal activities at various doses; it demonstrated delayed development when interacting with imidazole. RH is so cheap and easily accessible as a catalyst for generating an antiviral medication due to its availability. The amount of every one of these distinct components varies depending on the type of rice grown, the climate, and the growing region. For instance, RH samples from cities like Trivandrum and Hyderabad in southern India have considerably higher Mg, Al, and Fe contents than those from other nations, according to research [94]. The catalyst can be recycled, which makes it a highly useful resource for green chemistry, according to scientists. Silica is used as a drug delivery vehicle for cancer cells in addition to being a biocatalyst. The prevalence of cancers such breast, lung, intestinal, uterine, brain, and others has increased recently.

7.5 RH is Used to Removal of HMs from Aqueous Medium

Risky excessive metal pollution of wastewater is currently posing serious environmental concerns due to increased urbanization and industrialization; for example, wastewater-contained Pb2+, Cd2+, Zn2+, Hg+/Hg2+, Ni+, Cr3+/Cr6+, As3+/AS5+, Cu2+, and Co2+ are gradually being legitimately or indirectly released into water bodies, especially in developing countries [102]. Additionally, certain toxic metals may be present in the soil surrounding military sites, which might endanger both groundwater and surface water [103]. Similar research was conducted by[104], who amended soil samples from an e-waste dumpsite in Accra, Ghana, for 21 days utilizing RH at rates of 20%, 40%, and 60% w/w in separate rubber containers. The RH treatment, according to the authors, reduced the amounts of Cu, Fe, and Zn in the soil at the e-waste dumpsite. Additionally, it was discovered that 97% RH amendment demonstrated significant adsorption for Cu in comparison to Zn and Fe and that the higher the RH dosage, the greater the adsorption capacity.

7.6 Anti-Tumor Activities of Rice Husks

Cancer is any uncontrolled, malignant development of bodily tissues or cells that develops anywhere on the human body. [80] The WHO has (WHO) says cancer constitutes the [81] most common cause of sickness and death globally. It led to over 8 million cancer-related fatalities and over 14 million new cases in just 2012, and during the twenty years that follow, the incidence is expected to increase to more than 70%. [82] A correct medical diagnosis is necessary for prescribing a specific reliable method for treatment since each kind of disease needs a distinct approach to therapy. [83]As a result, cancer therapy & prevention have been the main areas of focus in biomedicine.[84] showed the antitumor effect of cells of the body's cancer [84] demonstrated the anticancer effect of In cancer cells of the human colon (HT-29 and SW620), Momilactone B from methanolic extract of RH may have been implicated additionally to in Fischer 344 (F334) rat throughout their separate in vitro and in vivo experiments. Rice's weed resistance is facilitated by the allopathic phytoalexin momilactone B.

Their findings shown that the methanolic extract of RH decreased the frequency of preneoplastic aberrant crypt foci in the colon of F334 rats by 35% when compared to controls and dose-dependently inhibited the development of HT-29 and SW620 cells. To shed light on a potential mechanism for how momilactone B isolated from RH from Korea could stimulate apoptosis, [85] employed two distinct breast cancer cell lines (MCF-7 and T47D) under hypoxic circumstances. They demonstrate the potential of Iso vitexin extracted from RH as a strong antioxidant that inhibits tumor necrosis factor (TNF-) and cyclooxygenase-2 (COX-2) in a dose-dependent manner using the Lipopolysaccharide (LPS) induced murine monocyte-macrophage cell line RAW 264.7. Using both in vivo and in vitro models, [86] investigated the cancer-chemo preventive abilities of two different colours of RH.

8. CONCLUSION

Both rice husk (RH) and rice husk ash (RHA) are employed as resources with added value in the manufacture and creation of new substances, and as inexpensive replacements for certain present-day goods with altered qualities. Husk (RH) and husk ash from rice (RHA) are agricultural wastes that can be acquired for free or at a minimal cost. With the advancements in research methods, it is found that the systematic and potential application of RH and RHA for the manufacture of new materials could solve many problems associated with their disposal and burning in fields, which causes pollution. This method could improve the economic feasibility of waste treatment. The effective use of RH in fuel/electricity generation, as well as bioethanol production, provides an opportunity to convert agricultural waste into a valuable/renewable energy source for a variety of industries.

Rice husk ash (RHA) is thought to be promising as a Pozzolanic material as well as an adsorbent. Because of the synthesis of silica nanoparticles and their applications in various fields and industries, it is an important raw material for nanotechnology. Rice husks have a variety of other biotechnological and biomedical applications too. Some of the biotechnological applications include liquid fuel, bioplastics, butanediol production, biochar, biocatalyst media, biogas, compost, and food packaging. Rice husk and its derivatives are used in the manufacture of SiO_2 for glass apparatus, extraction of cellulose, protein extraction, and other medical uses. Rice husk is also used as a substrate and in the production of activated carbon, pet food fiber, bricks, and other products. The metals cement along with building industries additionally use the husks of rice ash metals such as mercury are eliminated off wastewater utilizing husks of rice as an absorbent. A systematic treatment of this substance can create a new industrial branch for rice husk. Rice husks and rice husk materials are less expensive and easier to obtain when compared to other food wastes. Rice husks are really a popular and commonly used material towards overcoming problems associated with biotechnology along with medicine, particular ones associated with the cure for cancer.

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CONFLICT OF INTEREST

Authors declare that there is no conflict of interest.

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