European Journal of Mechanical Engineering Research (EJMER)

Vol. 8, Issue 1, pp.1-9, 2021

Print ISSN: ISSN 2055-6551(Print)

Online ISSN: ISSN 2055-656X(Online)

A REVIEW OF THE POTENTIAL OF RICE HUSK (RH) AND PERIWINKLE SHELL (PWS) IN THE DEVELOPMENT OF PLASTIC COMPOSITES

Sylvester Gojim Sara
National Water Resources Institute, Kaduna, Nigeria

ABSTRAC: *Rice husk (RH) and Periwinkles shells (PWS) are two agricultural by-products that have been found to constitute to environmental challenges. There is need to research on them for possible potentialities and alternative uses apart from what they used to be in the localities. Therefore, this paper aims at reviewing the characteristic compositions of the two agricultural wastes to identify their potentials in development of renewable composite materials. The chemical composition of RH and PWS have been found to be 94.5% and 33.8% by weight, respectively, of silica content and this is a good quality material for concretes and other composites production. Among other potentials, they are sources of fuel for electricity generation and agents of pozzolanic and polymerization with polypropylene for flame retardation. In conclusion, RH and PWS are organic and degradable materials that are good for renewable energy and composites production thereby controlling environmental degradation*.

KEYWORDS: Rice Husk (RH), Periwinkle Shell (PWS) development, plastic composites

INTRODUCTION

Rice is a stable food in the world consumed by many races as well as grown in many parts of the world. Among the byproducts derived from rice production in the world today is rice husk (RH). RH is classified as an agricultural waste that is available in abundance in most parts of the areas where rice is grown after the farming season. Production of rice is mostly in Asian countries, where rice served as the only stable food crop that can be grown during the rainy season and in waterlogged tropical areas. The continent, Asia, generates over 90 % of world rice production where China and India alone account for over half of the world supply (Sultana *et al.*, 2014). In Nigeria especially around Niger, Kebbi and Ebonyi States, rice is grown in abundance and processed locally. These mentioned states are not alone, as research has shown that Kaduna, Kano, Benue, Cross River, Enugu, Delta, Edo, Bayelsa, Akwa Ibom and Rivers states are among the producers of rice in Nigeria of which their contribution is between 29% and 43% (Orji *et al*., 2017). Rice production has been estimated to be approximately 580 million tons per year and is expected to rise as population increases (Reddy and Marcelina Alvarez, 2006). Investigations have shown that, the disposal of RH has been a huge challenge to both the rice farmers and industrial millers according to a report by Orji *et al* (2017) and a great environmental threats causing damage to land and drainage system (Ghosh and Bhattacherjee, 2013). When frequently disposed by incineration, it produces carbon-monoxide in the environment causing undesirable pollution (Olamide and

Vol. 8, Issue 1, pp.1-9, 2021

Print ISSN: ISSN 2055-6551(Print)

Online ISSN: ISSN 2055-656X(Online)

Oyawale, 2012). The RH ash produced from burning has been found to leach into landfill pits when burnt in close piles where open piles burning is prohibited (Reddy and Marcelina Alvarez, 2006).

Periwinkles are small edible species of medium-sized sea snails of the marine *gastropod mollusks* (Ofem *et al*., 2012). The outer casing which are discarded after consuming the flesh inside which is hard and has a rough protruding surface is the periwinkle shell (Obot *et al*., 2015). The abrasive grits, hard and stiff resistance nature of the shell is expected to play a role in engineering strength of materials. Periwinkles are found in the marine coastal areas, robust intertidal species having dark branded shell, broadly ovate, thick and sharply pointed (Elakhame, *et al*., 2017). The research indicated that about 40.3 tons of periwinkles per year are been harvested from the 35 Mangrove Communities of Delta and Rivers States of Nigeria (Orji *et al*., 2017). The disposal also called for recognition as continuous dumping of the shell as observed by Oyedepo and Olukanni (2015) has resulted in heaps constituting environmental menace in some Rivers and Akwa Ibom villages in Nigeria (Orji *et al*., 2017). The excess periwinkle shells are usually disposed using different ways such as fertilizer which constituted about 26.6 %, livestock feed ingredients 21.1 %, dumpsite waste 26.3 %, while other ways constituted 15.8 % (Shehu *et al*., 2016).

Consequently, this work aims to review these two agricultural wastes by examining their characteristic compositions for the purpose of identification of their potentials in the development of renewable composite materials and minimize their environmental problems.

Characteristics of Rice Husk

The potential material resources of RH for development of plastic composites must possess some certain conditions to be fitted and served the objective purposes. The suitability of this resource depends on its characteristic such as mineralogy, chemical, physical, mechanical and biological properties (Sultana *et al.,* 2014). Composite is a compound that is made by combining two or more physical materials. The composites are multifunctional engineering materials having unprecedented mechanical and physical properties that can be trailed to serve a requirement of application (Doorvasan *et al*., 2014). The reinforcing agent and binder matrix should be compatible to produce a multiphase system with different properties of the starting materials but retains the characteristics of the material (Deepa *et al*., 2011). RH is highly rich with silica and lignin, tough, woody, abrasive in nature, resist to weathering process and has low nutritive contents (Ghosh and Bhattacherjee, 2013). RH by weight has 10 % rice grain and when burn to ashes it becomes about 20 % (Sultana *et al.,* 2014). RH is a good source of fuel for the production of electricity. Reddy and Marcelina Alvarez (2006) reported that RH has estimated energy content of about 13.5 GJ/ton of which it can give a global energy potential of 1.57billion GJ/year. In Maulida and Bukhory (2015) it was reported that RH is one of the biggest silica's producer for complete combustion. It will produce crystalline silica when at higher temperature of over 1000 ^{0}C and silica's ash that can be utilized for chemical processes (Maulida and Bukhory, 2015). RH ash contains between 86 %

- 97 % of silica by dry weight (Fajar *et al*., 2013). The silica found in RH ash support the filler property, catalyst, adsorbent and source for synthesizing high performance property (Ghosh and Bhattacherjee, 2013). Though, there are limitations to the use of RH ash for filler property in thermoplastics due to its purity and particle characteristics as reported in Ghosh and Bhattacherjee (2013). The chemical property composition of RH as shown in Table 1.0 varies from sample to sample which may be probably due to the difference in geographical conditions, type of paddy, climatic variation, soil chemistry and fertilizers used during rice cultivation and nursing.

Table 1.0: Typical Compound Composition of Rice Husk

Constituents	Weight
Silica (SiO_2)	94.50
Calcium Oxide (CaO)	0.48
Manganese Oxide (MnO)	1.09
Magnesium Oxide (MgO)	0.23
Iron Oxide (Fe_2O_3)	0.54
Aluminum Oxide (Al_2O_3)	0.21
$SP_2O_5K_2ONa_2O$	Traces

Source: Ghosh and Bhattacherjee (2013)

Table 2.0 presents the typical elements composition as accounted for in RH and reported in Mistry (2016). The bulk density ranged from 96 to 160 kg/cm^3 and Oxygen ranged between 31 – 37, the likely composition that suggested the combustion agent.

Table 2.0: Typical elements composition of rice husk

Property	Range
Bulk density (kg/m^3)	96 - 160
Hardness (Mohr's scale)	5 - 6
Ash, %	22 – 29
Carbon, %	≈ 35
Hydrogen, %	4 - 5
Oxygen, %	31 - 37
Sulphur, %	0.04 – 0.08

Source: Mistry (2016)

The basic and the elemental compositions of different portions of the rice dust are presented in Tables 3.0 and 4.0.

Vol. 8, Issue 1, pp.1-9, 2021

Print ISSN: ISSN 2055-6551(Print)

Online ISSN: ISSN 2055-656X(Online)

Table 3.0: Elemental composition of different parts of the rice grain dust

Elemental composition	Outer surface of husk, % weight	Inside the husk, % weight	Inner surface of husk, % weight
Carbon	6.91	62.54	30.20
Oxygen	47.93	35.19	42.53
Silica	45.16	2.27	27.27

Source: Korotkova *et al*. (2016)

Table 4.0: The basic composition of rice grain dust

Composition	Silica	Lignin	Cellulose	Protein	Fat	Others
% weight	18.8 – 22.3	9 – 20	28 – 38	1.9 – 3.0	0.3 – 0.8	9.3 – 9.5

Source: Korotkova *et al*. (2016)

Pozzolanic activity of RH ash has been greatly dependent on silica content, silica crystallization phase as well as size and surface area of ash particles (Kulkarni *et al*., 2014). The pozzolanic characteristics of RH enhance good concrete strength, improvement in impermeability and increase durability of concrete (Kulkarni *et al*., 2014).

The inhibition characteristics of a number of plants have been extensively studied. The phyto-chemical study of RH has confirmed the presence of tannins, saponins, and flavonoids among other effective corrosion inhibitors, and this has promoted the inhibition of mild steel in aggressive acidic media (Eddy and Ebenso, 2008; Alaneme *et al*., 2015). Alaneme *et al*. (2015) concluded that the inhibition characteristics efficiency of RH ash increased with increase in concentration and decrease as temperature increases in both HCl and H_2SO_4 acid solution.

Periwinkle shell characteristics

Many research studies have been conducted on alternative uses of periwinkle shell (PWS) for construction and other possible applications. Organic fillers produced from agricultural wastes have also gained tremendous attention from plastic industry with primary advantages of low densities, minimal cost, low energy consumption, biodegradable, etc as reported by Onuegbu and Madufor (2012). Several works have been reported on organic fillers reinforced thermoplastic composites, such as cocoa nut shell, palm kernel shell (Ishidi, 2014), snail shell powder (Onuegbu and Igwe, 2011), oyster shell powder (Nwanonenyi *et al*., 2013) studies. This has called for the study of the properties and characteristics of periwinkle shells at a wider range from physical, chemical and mechanical properties since it belongs to agricultural wastes. Periwinkle is classified under the family of Littorinidae. The width of the shell ranges from 10 to 12 mm at maturity, average length of between 16 to 38 mm, and depending on the species, the shell height is normally reach 30 mm, 43 mm or 52 mm (Elakhame *et al*., 2017). The proper bonding achieved when decreasing the sieve size from 350 μm to 100 μm as observed and concluded in micro-structural studies by Elakhame *et al* (2017) is the condition that enhanced the hardness values, density and compressive strength characteristics of the periwinkle shells. Periwinkle shell ash has been found

Vol. 8, Issue 1, pp.1-9, 2021

Print ISSN: ISSN 2055-6551(Print)

Online ISSN: ISSN 2055-656X(Online)

to have good strength in concrete and is suggested to be a replacement for cement (Shehu *et al*., 2016). Periwinkle shell ash exhibited the density of 1.24 kg/cm^3 (Aku *et al*., 2012) and this indicated that periwinkle shell particles will be more suitable as filler material (Aigbodion and Agunsoye, 2010). Obot *et al* (2015) concluded that periwinkle shell grains are predominantly Calcium Oxide with best abrasive properties considered being wear resistance. The hardness and compressive strength obtained at 87 % by its weight, resin at 12 % and 0.5 % for methyl ethyl ketone peroxide hardener and cobalt naphthalene from the study suggest it is suitable for abrasive property application. The chemical composition of the periwinkle shell is presented in Table 5.0.

Table 5.0: Elemental composition of periwinkle shell powder

Elemental oxide	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	Na_2O	Mn_2O_3	TiO_2	LOI
%	33.8	10.2	6.0	40.8	0.5	0.3	0.1	0.2	0.01	0.03	7.6

Source: Onuoha *et al* (2016)

In a study by Onuoha *et al* (2016) the flame propagation rate decreases when periwinkle shell powder was polymerized with polypropylene which means the flame retardant of polypropylene was enhanced.The second highest chemical composition in periwinkle shell powder is silica about 33.8 % as shown in Table 5.0. The presence of reactive silica make periwinkle shell possess pozzolan property (Abdullahi and Sara, 2015) of which on its own have little or no binding property but when mixed with lime in the presence of water it become hard like cement. At 10 % by weight, periwinkle shell ash produced average values of stiffness strength (Modulus of rupture, MOR) of 25.8 *MPa* and Modulus of elasticity (MOE) value of 108.8 *MPa* at 15 % indicated that the particles are properly coated at 10 – 15 % weight with little or not touching each other according to Abdullahi and Sara (2015). The study satisfied MOR requirement of 11.5 *MPa* for general purpose boards by EN 312-2 (1996).

Popoola *et al* (2017) reported that the bulk density of periwinkle shell ash modified with asphaltic concrete increased from 2.24 and sharply dropped to 2.31 g/cm^3 at 5.4 % and 6.6 % respectively. This significant increase and decrease according to Popoola *et al* (2017) has been because of periwinkle shell ash which increase the bulk volume and compactness of asphaltic concrete materials by filling up the tiny spaces that aggregates would not occupy, thereby resulting in low air voids.

The development of surface modified activated carbon filters has generated diversity activated carbon with far superior adsorption capacity as reported by Agbede and Manasseh (2009). Hence, Awokoya *et al* (2016) studied the use of periwinkle shell ash to develop low-cost adsorbent for removal of Cr (II) and Zn (II) ions from aqueous media in which an adsorbent dose of between 0.2 to 1.4 g, the periwinkle shell ash maximally removed Cr and Zn at 94.13 % and 87.91 %, respectively.

Vol. 8, Issue 1, pp.1-9, 2021

Print ISSN: ISSN 2055-6551(Print)

Online ISSN: ISSN 2055-656X(Online)

Potential of Rice Husk and Periwinkle Shell in Development of Plastic Composites

The emphasis placed on chemical and material products from renewable resources is highly gaining importance. The main reason being the desire for sustainable development and pollution free environment. Rice husk and periwinkle shell have been found to be wastes detrimental to the environment upon disposal. Recycling of rice husk and periwinkle shells as waste products have been conducted extensively with the aim of minimizing the environmental problems and transforming them into useful products. This is achieved by blending them with other materials to produce composite materials that have higher economic values and durability. From the studies of the properties, numerous applications and potential uses of rice husk and periwinkle shell have been noticed.

Successful works have been carried out on the admixture of RH and PWS in partial substitute for Portland cement in the preparation of high strength concretes in construction industry. Rice husk and periwinkle shell have been tested and found to be potentially useful as composite in multifunctional engineering materials applications. They are rich in silica, RH being 94.5 % and PWS with about 33.8 % by weight, this being essential factor in water treatment and purification. Some reports have shown that rice husk and periwinkle shells have potential utilization as fuel sources to produce electricity. Rice husk energy content alone have been estimated and found to be about 13.5 GJ/ton which has potential of giving a global energy of about 1.5billion GJ/year.

The RH and PWS wastes have been found to be potentially good for reinforcing agent and binder matrix as reviewed. These characteristics possessed by the materials have made them wanted for construction and manufacturing industries. Among this is pozzolanic property of which when used, the wastes give better concrete strength, improvement in concrete impermeability and durability. At a higher temperature of over 1000 ^{0}C, the silica produced from the wastes, RH and PWS, can be utilized for chemical processes such as in fillers in plastic industries, catalyst and adsorbent in development of composites. RH chemical composition has been found to contained tannins and saponins which are effective in corrosion control and therefore can be used in pipe production. The flame retardant characteristics of PWS makes it suitable for outdoor applications. Also, among the chemical property composition of RH and PWS ashes are magnesium and calcium elements which can improve the soil structure and textural classifications after degradation.

DISCUSSION

The current environmental problems and alternative green materials uses for development of composite materials have led to researching into the RH and PWS as materials. Rice and periwinkles are produced in many parts of the world and consumed as well, but because of the byproducts after removing the food values, the end products become nuisance to the environment. Many studies have shown and agreed that using RH and PWS would go a long way in renewing our environment and at the same time reaping economic benefits from these wastes.

Vol. 8, Issue 1, pp.1-9, 2021

Print ISSN: ISSN 2055-6551(Print)

Online ISSN: ISSN 2055-656X(Online)

RH and PWS are organic and degradable materials that are rich in silica. This property makes the materials suitable for reinforcing and binding with matrix agent. Their applications in the production of plastic composites is therefore numerous.

CONCLUSION

The potential negative effects of RH and PWS in the environment during yearly farming season and for the purpose of finding alternative uses for them has led researchers into studying RH and PWS properties with the aim of transforming the materials to acceptable composites products. It is generally accepted among the researchers that they are agricultural waste that needs to be cleared from environment to avert the effects of pollution and climate change. From the literature reviewed, it can be concluded that RH and PWS as organic renewable materials and agricultural wastes have the potential of being used for composite production. This will ultimately control the environment from being degraded and hence minimizing the effect of climate change.

References

Abdullahi, I and S. G. Sara (2015): Assessment of periwinkle shells ash as composite materials for particle Board production, International Conference on African Development Issues (CU-ICADI): Materials Technology Track.

Agbede, O. L and J. Manasseh (2009): Suitability of periwinkle shell as partial replacement for river gravel in concrete. Leonardo Electronic Journal of Practices and Technology. 15: 59 – 66.

Alaneme, K. K, Y. S. Daramola, S. J. Olusegun and A. S. Afolabi (2015): Corrosion Inhibition and Adsorption characteristic of rice husk extracts on Mild Steel immersed in 1M H_2SO_4 and HCL. International Journal Electrochemical Science, 10: 3553 – 3567.

Awokoya, K. N., R. O. Sanusi, V. O. Oninla and O. M. Ajibade (2016): Activated periwinkle shells for the binding and recognition of heavy metal ions from aqueous media, International Research Journal of Pure and Applied Chemistry, 13(4): 1 – 10.

Deeepa, B, L. A. Pothan, R. Mavelil-Sam AND s. Thomas (2011): Structure, properties and recyclability of natural fiber reinforced polymer composites. Department of Chemistry, Bishop Moore College, Mavelikara and Department of Polymer science and Engineering, Mahatma Gandhi University Kottayam, Kerala, India.

Doorvassan, M., S. Sathiyamurthy, S. Jayabal and K. Chidanmbaram (2014): Moisture content of rice husk particulated natural fiber polymer composites. National Conference on contemporary approaches in Mechanical, Automobile and Building Science, Karpaga Vinyaga College of Engineering and Technology.

Eddy, N. O and E. F. Ebenso (2008): African Journal of Pure and Applied 2(6).

Elakhame, Z. U, O. O. Olotu, Y.O Abiodun, E. U. Akubueze, O. O. Akinsanya, P. O. Kaffo and O. E. Oladele (2017): Production of Asbestos free brake pad using Periwinkle shell a filler materials, International Journal of Scientific and Engineering Research 8(6).

Fajar, G. A. M, R. H. S.Y Mohammad and M. Primata (2013): Extraction of rice husk silica from Abu with solvent KOH'' University Mangkurat, Conversion 2(1).

Ghosh, R and S. Bhattacherjee (2013): A review study on precipitated Silica and Activated Carbon from rice husk, Journal of Chemical Engineering and Process Technology, Vol. 4, Issue 4.

Ishidi, Y. E (2014): Physical properties of some agro-waste polymer composites. World Journal of Engineering and Physical services 2(2): 017 – 024.

Korotkova,T.G, Ksandopulo, S.J, Donenko, A.P, Bushumov, S.A and Danilchenko(2016):Physical properties and chemical composition of the rice husk and dust. Oriental Journal of Chemistry, Vol.32, No.6, pp 3213-3219.

Kulkarni, M. S., P. GovindMirgal, P. P. Bodhale and S. N. Tande (2014): Effect of rice husk ash on properties of concrete, Journal of Civil Engineering and Environmental Technology, 1(1): 26 – 29.

Majhi, S, S. Samantarai and S. Acharya (2009): Tribological behavior of modified rice husk filled epoxy composite, International Journal of Science Engineering Research 3: 1 – 5.

Maulida, S. D and F. Bukhory (2015): The tensile strength properties effect of rice husk ash as on the composite of plastic drinking bottle waste, International Journal of Scientific and Technology Research, 4(04).

Mistry, B (2016): Properties and industrial applications of rice husk, International Journal of Engineering Science and Computing, 6(10): 2677 – 2679.

Nwanonenyi, S. C, M. U Obidiegwu and T. S. Onuchukwu (2013): Studies on the properties of linear low density polyethylene filled oyster shell powder. International Journal of Engineering and Science, 2(7): 42 – 48.

Obot, M. U., S. Y. Danjuma and S. Y. Aku (2015): Development of an abrasive material using Periwinkle Shells, Journal of King Saudi University-Engineering Sciences. http://dx.doi.org//10.1016/j.jicsues.....

Ofem, M. I., F. I. Abam and I. U. Ugot (2012): Mechanical properties of Hybrid Periwinkles and Rice husk filled CNSL Composite, International Journal of Nano and Material Sciences, 1(2): 74 – 80.

Olamide, O and F. A. Oyawale (2012): Characterization of rice husk via Atomic Absorption Spectro-photometer for optimal silica production, International Journal of Science and Technology, 2(4): 210 – 213.

Orji, F. N., C. C. Egwuonwu and S. N. Asoegwu (2017): The investigation of periwinkle shell-rice husk composite as a replacement for granite in concrete, Open Science Journal of Bioscience and Bioengineering, 4(1): 1 – 5.

Onuegbu, G. C. and I. C. Madufu (2012): Effect of filler loading on the end-use properties of Maize tassel filled high density polyethylene, International Research Journal in Engineering, Science and Technology (IRJEST) 9(1).

Onuegbu, G. C. and I. O. Igwe (2014): The effects of filler contents and particle sizes on the mechanical and end-use properties of snail shell powder filled polypropylene, Journal of Material Sciences and Application, 2: 811- 812.

Oyedepo, O. J and E. O. Olukanni (2015): Experimental investigation of the performance of Palm Kernel Shell and Periwinkle Shell as partial replacement for coarse aggregate in Asphaltic Concrete, Journal of Building Material and Structure, 2: 33 – 40.

Popoola, O. O., E. Abuh and V. B. Adebayo (2017): Assessing the performance of Periwinkle Shell as on Asphaltic concrete, Journal of Multidisciplinary Engineering Science and Technology, 4(10): 8382 – 8390.

Reddy, D. V and B. S. Marcelina Alvarez (2006): Marine durability characteristics of rice husk ash-modified reinforced concrete. Fourth LACCEI International Latin American and Caribbean Conference for Engineering and Technology (LACCET 2006), “Breaking frontiers and barriers in Engineering: Education, Research and Practice”, 21 – 23 June, Mayaguez, Puerto Rico.

Shehu, U., M. R. Dodo, A. I. Gebi and A. Usman (2016): Effect of thermal ageing on mechanical properties of Za-27 Alloy/Periwinkle Shell Ash particulate composite. Nigeria Metallurgical Society, Book of Proceeding Conference and AGM, pp127-130.

Sultana, M. S., M. I. Hossain, M. A. Rahman and M. H. Khan (2014): Influence of rice husk ash and fly ash on properties of red clay, Journal of Scientific Research 6(3): 421 – 430.