Journal of Environmental Science and Resources Management *Volume 4, June 2012*

© 2012 Cenresin Publications
www.cenresinpub.org
ISSN 2277-0097

THE ENERGY POTENTIAL OF RICE HULL AS BIOFUEL FOR DOMESTIC USE

I. Yerima[1] and Richard T. Isa[2]
[1]Department of Biological Sciences, University of Maiduguri, Nigeria
[2]Mill Six, Jalingo Taraba State
E-mail: yerima.ibrahim@yahoo.com, richtea4u2000@yahoo.com

ABSTRACT

Due to increasing cost of Domestic Energy coupled with Desertification, increasing human population, high cost of electricity and petroleum gas, a survey of Rice hull dumping site was carried out in Maiduguri, with the aim of evaluating rice hull as a waste for domestic energy in this Ecological zone. Five parameters were examined and measured to determine their influence on the energy value of rice hull. The parameters include moisture content, density, air pocket, ash, and caloric value. All the five parameters interplay for rice hull to effectively burn as a fuel. However, low level of moisture and high number of air pocket (aeration) showed prominence, and significance in the efficiency of the material as biofuel.
Keywords*:* *Rice hull, Energy Biofuel, Moisture and caloric value.*

INTRODUCTION

The need for renewable energy sources, couple with environmental issues, such as global warming, drought and desertification, correct and timely waste disposal methods are gaining much attention, as such the concept of briquettes or using rice hull as source of fuel is perhaps a much overlooked example of a way to reduce or lessen the carbon emission from fossil fuel consumption and provides a better waste disposal method for organic waste from rice.Rice hull (or rice husk) are the hard protecting covering of grains of rice. In addition to protecting rice during the growing season, rice hull can be put to use as building material, fertilizer, insulation material or fuel. The rice hull is made of hard materials including opaline, silica, and lignin. The hull is mostly indigestible to human and not easily degraded or decomposed due to high lignin content. During the milling process, the hull are removed from the grain to create white rice. The very ligh content in amorphous silica of the hulls confer to them and to their ashes (SiO_2 ~ 20wt%) after combustion of very valuable properties. Lack of process stability, low loading rates, slow recovery after failure and specific requirement for waste composition are some of the other limitations associated with it (Van Gerpen. 2004). Rice hull is an organic substance which is one of the oldest process used for obtaining fuel and rice with industrial waste and stabilization of the environment. This is a waste generated from rice milling and used under aerobic condition as a source of biofuel. For many, biofuel are still relatively unknown. Either in liquid form (ethanol), gaseous (biogas) or solid form (rice hull). Biofuels are simply fuels derived from biological materials such as cereals, grains, sugar crops, cellulosic materials, like grasses, trees as various waste products from crops, wood processing facilities and municipal solid waste, can also be converted to liquid biofuel like ethanol. But the process is more complex relative to processing sugars and grains. Techniques are being developed however to more effectively convert cellulosic crops and crop waste to ethanol. Cellulosic can also be gasified to produce a variety of gases, such as hydrogen, which can be used directly in some vehicle or can be used to produce synthesis gas which is further converted to various type of liquid fuels, such as dimethyl ether (DME) and even synthetic gasoline and diesel. Oil seed crops like rape seed, soya bean and sun flower can be converted into diesel fuel, a liquid fuel which can be either blended with conventional methyl esters or burnt as pure biodiesel. Organic waste material can be converted into energy forms which can be used as automotive fuel, waste oil (cooking oil) can be converted into biodiesel. Animal manure and organic household waste can be converted into biogas (methane), and agricultural and forestry waste products into ethanol. Available quantities may be small in many areas, but raw materials are generally low cost or even free. Converting organic waste material to fuel can also diminish waste management problems. The use of vegetable oil as alternative fuels has been around for 100 years. When the inventor of the diesel engine Rudolph Diesel. First tested peanut oil, in his compression ignition engine (Meyer et al, 2004). The use of vegetable oils for engine fuels may be insignificant today but occupy a prominent position in the development of alternative fuels. Plant oils usually contain free fatty acids, phospholipids, sterols, water, odourants and other impurities. Because of these, the oil cannot be used as fuel directly. To overcome these problems the oil requires slight chemical modification mainly transesterification, pyrolysis and emulsification. Among these the transesterification is the key and foremost important step to produce the cleanest and environmentally safe fuel from vegetable oil. Biodiesel is the monoalkyl esters of long chain fatty acids derived from renewable feed stocks, such as vegetable or animal fats, for use in compression ignition engine. Biogas is the gas generated from organic digestion under anaebic conditions by mixed or specific population of microorganism. It is an alternative energy source which has been utilized both in rural and industrial areas since 1958 (Stuckey 1984).

Briquette (or briquette) is a block of flammable matter which is used as fuel to start and maintain a fire. The common ones are charcoal and biomass briquettes. Charcoal briquettes may vary from lump charcoal made from hard wood material and usually produce less ash. Compressed charcoal made by compressing charcoal from sawdust and other wood by products with a binder and other additive like paraffin or petroleum solvents to aid in ignition. Biomass was the first fuel mankind learned to use for energy. Wood is still by far our most important source of non-fossil fuel energy meeting about 13% of primary energy demand (Craig 2001). Before the first world war about 40% of U.K agricultural land was devoted to Bioenergy. This is source . Bioenergy is clean efficient, and sustainable. Austria uses about 13%, United State uses about 3% electricity from Bioenergy. (Craig 2001). Biomass briquettes are made from agricultural waste and are a replacement for fossil fuels such as oil or coal, and can be used to heat boilers in manufacturing plants, and also have applications in developing countries. Sawdust is a popular biomass briquette emerging in developing countries sawdust is compressed and extruded to make a reconstituted log which can replace firewood. It is a similar process to forming wood pellet, but on a larger scale. There are no binder involved in this process. The natural lignin in the wood bind, the particle wood together to form a solid. Burning a wood briquette is far more efficient than burning firewood. Because moisture content of a briquette can be as low as 4% where as green fire wood may be as high as 65%. Rice hull which is the focal point of this research is an inexpensive byproduct of human food processing serving as a source of fiber that is considered a filler ingredient in cheap pet foods. Rice hull is useful in many ways such as mesoporous molocules sieve, which are applied as catalysts for various chemical reactions as a support for drug delivery system and as an adsorbent in waste water treatment. It is a source of fiber that is considered a filler ingredient in foods. It provides excellent thermal insulation so its use as building material. Rice hull can be composed and used as fertilizer in four month. It can produce biofertilizer. Charity and Yerima (2010) indicated that rice hull could be decomposed by earth worm in the first two weeks of inoculating until at the fourth week where 0.5kg of rice hull was degraded, with proper technique rice hull can be burned and used to power steam engines. The ash produced after the husk have been burned and used as aggregate and fillers for concrete and board production. Economical substitute for microsilica or silica fumes, absorbent for oils and chemicals or as soil ameliorant. Source of silicon, as insulation powder in steel mills , also as repellants in the form of vinegar tar and as a release agent in the ceramic industry. The combustion of rice hull has dual benefits such as eliminating the need to dispose off the byproduct and efficient combustion in the boiler will prevent the indiscriminate burning of rice hulls in the field, which is a problem of all rice producing areas in the country. In many countries where rice is the main cereals crop, rice is responsible for most of the methane emissions. Farmers in some of the arid regions try to dispose rice hulls directly to some areas thus increasing the chances of famine in the long run. Rice hull also require much more treatment in order to decay.

MATERIAL AND METHOD

Several parameters were examined and measured on rice hull with the aim of determining its energy content and efficiency as an alternative source of energy particularly for our domestic use in dry land rural communities of Borno State Nigeria. The parameters measured include moisture content, ash content, densities, air pockets, and caloric value. The moisture content was determined by measuring an initial quantity and weight of rice hulls and drying it thoroughly. 1000 grams (1kg) of rice hull was measured using Harris weighing machine. The rice hull was dried in the open air using a metal tray, but a perforated metal plate was used in covering the rice hull to ensure that some quantity was not lost to blowing wind. This was done to prevent loss in weight due to blown off quantity. Loss in weight was measured after the third day of drying and repeated after the sixth day. The ash content was measured by measuring 1000gms (1kg) of rice hull using Harris weighing machine. The 1000gms was burnt on a metal plate to ensure no quantity of the ash was lost after burning, during the burning process, the sample (at an interval of 10 minutes) were mixed to ensure complete and uniform combustion. The sample took approximately four hours to burn completely to ashes. The density of the rice hull is the mass per unit volume, where the 100cm^3 of rice hull was measured and its mass determined using an electronic weighing machine. The density was therefore determined by dividing its mass by its volume. Density (P) = $\frac{\text{Mass}}{\text{Volume}}$

Air pocket which was one of the parameters measured play a significant role in the efficiency of rice hull as a fuel. An electronic weighing machine was used to measure 1 gram of rice hull and the air pockets were counted manually to determine the number of air pockets per unit volume of rice hull. This procedure was repeated and an average of the count was taken. The caloric value of the rice hull was determined using the

percentage value of ash content and moisture content. The gross (or higher) caloric values (HCV) was calculated thus:
HCV = 20.0 X (1-A-M) $Mjkg^{-1}$
Where A= % ash content
M = % moisture content

The net (or lower) caloric value (LCV) which take into account uncovered energy from the water vapour from inherent moisture and from the oxidation of the hydrogen content is sometimes used. The LCV was therefore calculated as follows.
LCV = 18.7 X (1 – A- M)- 2.5
X M Mj/Kg

RESULT AND DISCUSSION

The result of this research indicate that, after a thorough drying of this rice hull, a loss in weight was observed due to moisture content. The loss in weight was 50g (1000-950g) which constitute about 5% of the total initial weight of 1000gms. This 50g difference account for some weight of the material. However, loss in weight of a material like rice hull may not be due to adhesive moisture of the rice hull alone but also partly due to surface moisture. Considering this, it is important to note that at the milling point where rice hull was collected, it was relatively dry and believed to be free of surface moisture. Low level of surface moisture in rice hull, even at collection point can be attributed to the high concentrate of opaline on the outer surface of the rice hull. This impedes the atmospheric transfer of moisture into the rice hull. Also 2.1 to 6.0% of the rice hull consist of a biopolyester called cutin which in combination with wax produced by the rice plant form a highly impermeable barrier(charity and Yerima. 2010).The 50g loss in weight has therefore been attributed to adhesive moisture content of rice hull, and assumed to be low in moisture content.

The exposure of the rice hull to open air for drying and not using the oven was to curtail the loss in weight from other volatile but essential substances to the real value of rice hull. Such substance could be oils, the bio oils product at optimum temperature. Majority of the bio oil include phenol aromatic nitrogenated compound alkenes and alkanes resins and adhesive moisture. Adhesive moisture has caloric affiliation and influence the potency of the rice hull as fuel and time to heat the cooking surface. The adhesive moisture act as a solvent that increase the mobility and efficiency of the volatile substance in heating the cooking surface within a short period of time. Whereas surface moisture delays the cooking period where it has to be evaporated before heating the cooking surface. By this certain amount of calories are diverted and utilized in evaporating the surface moisture before heating the cooking surface. So 1000g of rice hull with 5% adhesive moisture will be more efficient in heating the cooking surface, than 1000g with 10-20% surface moisture. Letcher and Kolbe (1994) observed that the maximum possible gas from 1000g of dry organic plant material is $416m^3$ at 25^0c with 20-40 moisture content and the maximum energy that can be obtained from burning 25 litre of methane gas (1mole) is 890kj 1mole. More energy would be obtained given a lower moisture content. The Ash content was obtained after burning the rice hull, a significant loss in weight was observed. 700gm loss in weight was believed to be due to volatile substance, lost in gaseous form combustion and shrinkage. The net weight of 300gm was the ash which constitute 30% of the burnt rice hull (1000g). The 70% loss was due to volatile substance and moisture (adhesive and surface) gases, smoke, oils, tannin and resin. Where there is incomplete combustion there is an increase in weight of ash because the unburnt portion add to the weight of ash, since they still retain non-evolved gasses. The Philipine Rice Research Institute invented a stove called Malighya rice hull stove which burn rice hull with high efficiency. With this stove 1kg of rice hull was burnt in 28 minutes. The stove boil a litre of H_2o in 5 minutes at sea level(Hugan 1994). The density of rice hull was determined after measuring $100cm^3$ of rice hull and its mass recorded. The density of the rice hull was determined by dividing the mass by its volume. The density was found to be $0.49g/cm^3$. Higher density means better compaction and cohesion to burn as a fuel. It was reported that Acacia Seyal produce good, dense firewood (Andrew 1993). The density of a material has an implication on its burning rate to release energy. Material that are exceedingly density burn slowly over a long period of time to justify the cooking time, where as materials that are slightly dense or loseburn, faster and waste full or materials over a cooking period. One other important measurement in rice hull is the air pocket which was recorded as the number of air pocket/vol of rice hull. An average of 44 air pockets/gram was recorded. This indicate high level of aeration per unit volume of rice hull to aid combustion and burning as a fuel. High aeration enhance the efficiency of the materials as a fuel. So 1kg is expected to contain about 44 x 1000 = 44000 air pockets which is adequate enough for a cooking time take less time. Oxygen availability is important for combustion in rice hull, air pocket retain and circulate the oxygen enough for fueling to cook food.

The size of air pocket relates to the number, in this case it was uniform in size. The final and most important of the energy value of rice hull or any biomass is the caloric value. The caloric value was calculated based on the ash and moisture content. The higher and lower caloric value. Values were found to be 3110.04 kcal/kg and 2877.99kcal/kg respectively. The caloric value of rice hull which is in the range of 13-17 Mj/kg (FAO 1990) indicates that rice hull has a high energy value. the accuracy in estimate of caloric value of rice hull is directly dependent on accuracy in ash and moisture content determination. Hugan (1995) indicates that 1kg of rice hull can boil 1 litre of water in five minutes. The waste material is smokeless and easy to light and burns slowly due to high density. Alejandros et al (2002) indicates that if rice hull will be accessible near urban areas, it would be highly effective at reducing household cooking cost than firewood which is paid and not as transportable as charcoal. Liquefied petroleum gas (LPG) is sometimes used in the morning to a given means of cooking school children food and also during rainy season when it is difficult to access dry firewood. Rice hull cooking is less expensive than gathered firewood for cooking because paper is used for fire starting with rice hull, in case of firewood it is commonly ignited with kerosene. It was further reported by Alejandros (2002) that the overall prices of using rice hull but with the LT 2000 stove is roughly about 1/3 less than urban market owing to higher marketing and transport cost, smoke emission and accessing fuel was mentioned as problem by 12% and 10% of users respectively. Controlling heat output and putting out the fire was also mentioned as problem by approximately 5% of users. In the overall the users of this Lt 2000 stove found it advantageous for heating up quickly, lowering fuel cost and reducing smoke emission compared to their previous cooking system. In the end when the LT 2000 stove was introduced using rice hull, consumption of firewood, charcoal, and LPG decreased by

73%, 76% and 43% respectively. In another development Salman (2012) indicated that the largest potential fuel stove for ethanol lignocellulosic biomass include material such as agriculture residue (corn Stover) crop straw and bagasses, herbaceous crop woody crop and other waste bioethanol from such could be attractive for disposing of this residue. After all it does not interfere with food security. This is important in both rural and urban areas for energy and environmental concern, employment, agricultural development, foreign exchange and socio-economic issue.

CONCLUSION

It can be concluded that in selecting a biomass for fuel, rice hull is foremost among the agricultural waste. However one should consider the level of moisture particularly, low surface moisture (dry biomass of rice hull) from collection point. It is also believed partially decomposed rice hull are poor as a solid fuel due to weakening of the lignin and loss of the active but volatile substance. However once materials are decomposed alternative use like biogas generation can be employed. The combustion of rice hull in its original form is very slow, a paper is used as a starter or fabrication into briquettes and the use of high technology like the malighaya rice hull stove can serve as a source of low cost energy. This will ensure an environmentally acceptable means of disposal, employment, agricultural development foreign exchange and socio-economic issue. With the malighaya rice hull stove, a family of five only need 800kg of rice hull per year (Phil Rice 1993) which implies 2.2kg/ day. The ash of rice hull (RHA) is high in morphine silica as a source of silicon a release agent in the ceramic industry and an insulation powder in steel mills.

ACKNOWLEDGMENT

I wish to thank the Department of Biological Sciences, University of Maiduguri for the permission to use the Laboratory Facilities and staff. I cannot end this acknowledgement without thanking Mohammed Ali for his Technical assistance and Prof. S.D Yusuf for his encouragement and advice.

REFERENCES

Alejandros De maio Sukie and Roger Samson. REAp- Canada and Emily Guara Paghida et sa Kausivagan Development Group (2002) impact of rice hull stove on fuel Expenditure and Green house Gas Emissions in Rural House-holds in Negros Occidental Philippines pp. 1-11.

Andrew Mc. A (1993) Acacia Segal. A Handook for extension worker published by School of Agricultural and Forest Science, University of Wales, Bangor, Gwynedd LL57, 2UN, UK. Pp 12-12

ANON (2001) Bioenergy: The Energy Debate 12st century fuel, British Biogreen pp19 vol. 54. Craig Donnellsn Independence Educational publisher Cambridge.

Bardiya, N. and Gaur, A.C. (1997) Effects of carbon and nitrogen ratio on rice straw biomethenation. J. Rural Energy 4 (1-4) pp 1-16.

Charity, I.E and Yerima, I,(2010) conversion and Degradation of Rice hull into Biofertilizer using Earthworm and cowdung unpublished Bio.sc thesis Dep't of Biological science University Maiduguri pp 12-15

FAO (1990) Environmental and Energy paper. The briquetting of agricultural waste for fuel www.google.com.

Hugan, R. (1994) The product fuel stove Publications of International Rice Research Institute, Vietenam.

Letcher, T.M and Kolbe, F.F. (1994) Journal of Energy in Southern Africa, 5 (3) 87-91.

Malgwi, D.I B.O. Sanyaolu and S.S. Garba (2003) Potentials for Biomass based fuel-ethanol project in Nigerian. Nigeria Journal of Renewable Energy vol. 11 No1 and 2 PP 60-95.

Mende T.C. and R. Samson (2006) Relative Bioenergy Potentials of Major Agricultural Crop Residues in the Philippines. Philippine Journal of Crop Science (PJCS) 31 (1) 11-28.

Meyer, L.C. Sager D.V. and Naik S.N. (2004) Technical aspect of Biodiesel production by Transesterification. A Review. Renewable sustainable Energy. Rev.3.

PhilllRice (1995) Rice Technology bulleting Development of Agriculture, Philippine Rice Research Institute ISSN 0117 – 1799.

Salman, Z. (2012) Bioethanol, Biofuel, Biomass Energy 3 comment pp 7 -17.

Van Gerpen, I. (2004) Biodiesel processing and production. Fuel processing technology