CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Milling of Rice is an important activity in food chain. Rice feeds more than a third of the world's population (Khush, 1997). It has become the predominant staple food in about 33 countries of the world including Nigeria (FAO, 2004). About 85% of the total production of rice is meant for human consumption (Janick, 2002). About 90 - 95% of Nigerians consume rice and this cut across all economic classes where it is eaten in different recipes (Wudiri, 1992).

According to Oguntade (2011) and IRRI (2014), rice milling industry in Nigeria is capable of contributing significantly to employment generation, boosting the economy and maintaining the food security of the country. Rice is an ingredient in medicine. It is used to treat stomach upset, heart-burnt and indigestion, breast cancer and warts.

Few decades ago, rice grains were processed at family level before cooking. Today due to industrialization and global competitive market trend, it has emerged as one of the major industrial activities in tiny, small, medium and large scale sector to cater for the increasing population of large number of millers engaged in processing. Milling of rice has spread over in some states across the country [World Rice Statistics (2006) and Oguntade (2011)].

Rice processing operations in rice production include parboiling (soaking and steaming), drying and milling. All operations except milling are done manually using hand tools (Autrey et al., 1984).

The input to the rice mill is paddy whereas the output is parboiled rice and raw/ white rice depending upon whether the pretreatment is given to paddy or not. The objective of milling is to get whole grain rice and preserve most of the rice kernels in their original shape. The technologies for rice milling in tiny and small mills are mostly conventional in nature and are not oriented towards minimizing pollution by incorporation of in-plant pollution prevention and control measures. This unit generates substantial amount of pollution especially air pollution due to fugitive emissions from various operations [Autrey et al., (1984) and Oguntade (2011)].

The pollution is particularly high in cleaning of paddy, parboiling of paddy and milling of rice. Primary and secondary cleaning of paddy gives rise to solid waste and fugitive emission in the work environment. The coal and husk generate fly, suspended particulate matter, smoke and oxides of carbon. Residents of nearby towns suffer due to pollution generated by rice mills. Though some changes are being brought about in production process to improve the efficiency and lowering the cost of production, etc, as regards reduction and control, it remains mostly unsatisfactory [World Rice Statistics (2006), FAO (2004) and Oguntade (2011)].

Milling of rice is a crucial post-production step in rice production. The basic objective of a rice milling system is to remove the husk and the bran layers and to produce an edible, white or brown rice kernel that is sufficiently milled and free of impurities. In an ideal milling process this will result in the following fractions: 20% husk, 8-12% bran depending on the milling degree and 68-72% milled rice or white rice depending on the variety. Total milled rice contains whole grains of head rice and brokens. The by-products in rice milling are rice hull, rice germ and bran layers, and the brokens [EPA, (1995); FAO, (2004) IRRI, (2014)].

In the World over, the industrial sector has been responsible for a "significant percentage" of all environmental damage and pollution. Unlike most other countries such as Indonesia, China, India, and many other countries where rice production is produced on a large scale, the policy frameworks in Nigeria to address these environmental problems have not considerably shifted from the end-of-pipe approach and strong government intervention to cleaner production and market-based actions [EPA, (1995); FAO, (2004) IRRI, (2014)].

The first measures by the government of Nigeria to address pollution problems in the 1980s were through the introduction of regulations and control under the program of compulsory environmental sanitation and compliance with environmental laws under Gen. Buhari's military rule. This command and control approach had not been successful in raising awareness on environmental management issues. It has rather resulted in a perception that environmental management meant high costs for both capital investments and operations & maintenance (cost centre). Hence, these mandatory measures have not succeeded particularly well in responding to the environmental problems [Geiser, (2001), Nigerian Orient News, (2010)]

Comparatively, in a country like Indonesia, this was also the situation in the 1980s, but the policy framework shifted to cleaner production and market-based actions. This followed the Government of Indonesia's announcement and commitment to implementing Cleaner Production as the most effective means of protecting their environment and promoting sustainable development in Indonesia in 1995 [BAPEDAL, (1998), Geiser, (2001)].

The policy of cleaner production and market-based action has in most cases, ended up as blueprints in Nigeria. It has hardly been implemented to the latest. Most times instead of being progressive on environmental matters, Nigerian Government relapse back to the end-of-pipe approach and strong government intervention in environmental protection which are already facing out in the developed countries. For this reason, from the mid 1990s, the Ministry of Environment started to apply mixed policies and instruments which integrate the mandatory approach, partnerships and voluntary programs, and market-based & economic instruments (Nigerian Orient News, 2010).

There are several important environmental concerns associated with rice milling. According to Farouk (2006), rice milling may present a significant source of air pollution both on site and the surrounding locality resulting from releases of dust to the atmosphere from processing of the paddy or its by-products and this is a major environmental concern for rice mills. Others include high internal and external noise levels which may generate health hazards to the local community, odour form soaking reservoirs, as well as unmaintained mechanical devices which cause severe noise and dust levels thereby endangering health (Farouk et al., 2006).

Abakaliki is the largest producer of rice in Nigeria. The Abakaliki Rice Mill Company Ltd has over 5,000 workers, 2,500 rice milling machines, and a production capacity of more than 11,000 metric tonnes per month. Tonnes and tonnes of rice husks are produced every year as by product of rice processing at Abakaliki rice mills (Nigerian Orient News, 2010).

The by-products include both the solid and liquid waste such as the rice husk, bran, effluents from fuel and used water. The husks are dumped indiscriminately around the rice mills and they accumulate due to the numerous rice milling machines located in the area [Anikwe, (2000), Ekwe, (2012); Mba *et al.,* (2009)].

Again, noise of different decibels is generated from the rice milling operations and heat of high temperature comes from the parboiling operations. Most of the by-products are abandoned in the husk dumps. They are occasionally set ablaze. Moreover, there is usually smoke emitted from the rice mill continually into the surrounding communities (Njoku *et al.,* 2011).

Despite the magnitude of these wastes generated daily and the possible adverse effects on the environment, no serious attempts have been made either for their effective utilization or safe disposal. During the rainy seasons, the husk dumps are washed off as waste water into nearby streams and creeks (Mba *et al.,* 2009).

Due to the presence of the industry, there is usually influx of people from different places within and outside Abakaliki who come to buy the finished rice for consumption and sales.

In line with Ebonyi state 2009 policy geared towards making Abakaliki one of the cleanest cities in Nigeria by Ebonyi State Government and its 2012 policy to boost industrialization in tandem with the 2011 policy of the Federal Government under former President Goodluck Jonathan to boost agriculture, with great emphasis on rice production, the Abakaliki Rice Mill was slated for relocation to any of the newly established State's Rice Clusters situated at Iboko in Izzi LGA, Onu Igboji in Ikwo LGA, and Oso Edda in Afikpo South LGA selected from the 3 senatorial zones of the State(Sunday Trust Newspaper; 2012, Nigerian Orient News, 2010).

In response to the move for relocation, the rice millers and people of Amagu where the mill is located in 2012 staged a protest against the move.

They rejected the decision for the reasons that the milling processes do not pollute the environment due to the measures they are taking on sanitation. Again, that it will bring hardship to not just the owners and workers of the Abakaliki Rice Mill but also the generality of the Community and the state capital. This impasse culminated in a court case between the two parties.

1.2 Statement of the Research Problem

Rice milling is often believed to be characterised by some environmetal, social and economic effects such as environmental pollution/ degradation and and the associated health problems, as well as conflicts, infrastructural abandonment, insecurity and wastage of resources. Ebonyi State in 2009, raised alarm over environmental degradation due to the presence of Abakaliki Rice Mill.

The current policy of Ebonyi State on rice production is rather “command and control” approach as in the 1980s in Nigeria and Indonesia than “cleaner production and market-based” as tested and later adopted in Indonesia of which the Government of Indonesia’s claimed in 1995, as the most effective means of protecting their environment and promoting sustainable development in Indonesia. Although the claim by the Government is in consonance with the views of different authorities, it is on the other hand, contrary to the findings by some scholars that apart from the wastes improving soil productivity, it will also save the farmer the cost of buying artificial fertilizer since according to (Njoku et al., 2011), these economic wastes are obtained free in the study area. Also, it is not in line with the good news that it is an alternative source of energy as well as being medicinal and a whole lots of other advantages as stated in Farouk, et al., (2006).

The divergence in views has continued to generate misunderstanding over the actual effects and/ or over all effects of Rice Mill among scholars. It has also extended to the policy formulation of some states like Ebonyi State on rice Mill location. In Ebonyi State,whereas the Government stresses that the presence of Abakaliki Rice Mill pollutes the environment, impedes economic develpment of the State and constitutes many health hazards, the owners of the Rice Mill denies the claim, rather stating that they have gains to offer other than any form of loss.

It is on the premise that the mill is polluting the environment and the policy of Ebonyi State to make Abakaliki capital city of the State the cleaniest State in Nigeria, that Ebonyi State Government mandated that Abakaliki Rice Mill Company Ltd be moved from its current location. This consequently has culminated in an on-going court case between the Ebonyi State Government and the owners of the Mill (Nigerian Orient News, 2010).

According to Roguel *et al.,* (2002), further studies should be conducted to verify the effects of rice hull-burning on health and the environment. Consequent upon the divergence of the views on the hollistic effects of rice milling, there is a pressing need to investigate the hollistic environmental and economic effects as well as the health implications of rice milling using Abakaliki Rice Mill in Amagu Community as a case study.

1.3 Research Aim and Objectives

The aim of this research is to study the environmental and economic effects of Abakaliki Rice Mill Company and its health implications on its host community. The objectives are:-

1. To determine the significance of soil, water; and air pollution vis-à-vis environmental effects by the rice mill on Amagu community.
2. To obtain the economic impacts of Abakaliki rice mill company Ltd on Amagu community.

3. To determine the prevalence of environmentally related health problems on Amagu community.

1.4 Research Questions

1 What are the levels of significance of the overall environmental effects and specifically, soil, water and air pollution of Abakaliki Rice Mill on Amagu community?

2. What is the significance level of the economic effects of Abakaliki Rice Mill on Amagu community?

3. What is the significance of the prevalence rate of the environmentally-related health problems?

1.5 Research Hypotheses

Hypothessis 1:

Ho: Abakaliki Rice Mill has no significant environmental effect on the host community.

Hypothesis 2:

Ho: Abakaliki Rice Mill has no significant economic effect on the host community.

Hypothesis 3:

Ho: Abakaliki Rice Mill has no significant health implication on the host community

1.6 Conceptual Framework

This work is based on the concepts of sustainability and sustainable development. The merit of investigating the environmental and economic effects of Rice Mill and its health implications from the sustainable development theory's point of view is that it covers the components of the environment and campaigns for sustainability in the use of the resources in the environment.

Sustainability

Sustainability is the ability to maintain a certain status or process in the existing systems. The widely accepted definition of sustainability or sustainable development was given by World Commission on Environment and Development in 1987. It defined sustainable development as "forms of progress that meets the needs of the present without compromising the ability of future generations to meet their needs." For humans, sustainability is the long-term maintenance of responsibility, which has environmental, economic, and social dimensions and encompasses the concept of stewardship which is the responsible management of resource uses (Daly *et al.*, 2004).

Ecologically, sustainability can be defined as means of configuring civilization and human activity so that society, its members and its economies are able to meet their needs and express their greatest potential in the present, while preserving biodiversity and natural ecosystems, planning and acting for the ability to maintain these ideals in the very long term.

Practically, sustainability refers to three broad themes, economic, social and environmental, that must all be coordinated and addressed to ensure the long term viability of our community and the planet.

When considering existing or new individual, business, industrial and community practices or projects one must ensure that economic, social and environmental benefits are achieved. Each person, business, and industry has a role and a responsibility to ensure their individual and collective actions support the sustainability of our community.

Sustainability is important because all the choices we pursue and all the actions that we make today will affect everything in the future. We need to make sound decisions at present in order to avoid limiting the choices of generations to come. For example, if you continue wasting water and polluting the dwindling supply of freshwater that we have today, we leave future generations with no other choice than to desalinate saltwater or treat contaminated water for their consumption and daily use. We can also be assured that, if that happens, all life that depends on clean freshwater will become extinct.

The same goes with the supply of soil that we currently have. Without proper care, our soils can easily lose quality enough that they will no longer be able to encourage growth and sustain life. If that happens, future civilizations will be void of crop and other natural sources of food. They will then have no other choice but to create man-made sources for nourishment and sustenance.

If clean water and good soil become scarce enough, all life on Earth can become extinct. Keep in mind that this does not just apply to soil and water but all elements of nature that are crucial to sustaining the Earth's equilibrium.

The four types of sustainability include human, economic, social, and environmental. All four are required to maintain the entirety of life on Earth. Although interconnected, it is important to note the differences of each in terms of its nature and requirements (Daly *et al.*, 2004).

The very basic need of human sustainability is good reproductive health and safe childbearing. Those that reproduce have the responsibility of caring for their children, giving them access to proper education, and promoting their health and wellness. At some point, the children should have enough skills and knowledge such that they can sustain their own way of life. It is at that point that they become considered as productive human capital as well as individuals that can go through the process of reproduction and rearing. As long as this process is maintained at a rate that all human systems can support, human sustainability should be no cause for concern (Brower *et al.*, 1999).

Economic sustainability is having a set amount of capital for a certain period. This means that we must preserve all our resources as we consume them so that human beings in the future can enjoy them as well. To achieve this, we must regenerate our resources at a rate that is equal to or faster than our consumption (Hak *et al*., 2007).

Social capital is an important aspect of sustainability because it is through communities and civil societies that humankind can easily and inexpensively work together. Without proper levels of social capital, it can easily deplete and violence as well as mistrust can take over. When that happens, societies and everything else that depends on them will be destroyed. Through proper maintenance of and adherence to laws, rules, and values that societies have developed for the common good, social sustainability can be achieved (Hak *et al*., 2007).

Furthermore, environmental sustainability also involves ensuring that waste emissions are at volumes that nature can handle. If not, all humans and other living things on Earth can be harmed to the point of extinction.

Societies, in turn, exist totally within the realm of the environment. Considering this, we need to make sure that we manage all aspects of human life within economies and societies in a manner that will not destroy the environment that everything on Earth is dependent on. The relationship between the three pillars of sustainability is as shown in fig. 1.1

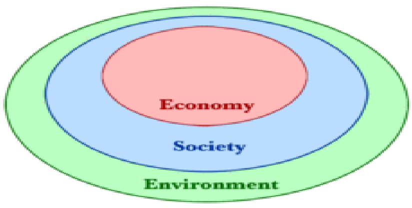

Fig.1 A diagram indicating the relationship between the three pillars of sustainability suggesting that both economy and society are constrained by environmental limits.
Source: Adams (2006).

Sustainable Development

The definition of sustainable development requires that one should see the World, the environment and its resources as a system which connects space; and a system that connects time. Perceiving the World as a system over space, one may understand for example that air pollution from an area may affect air quality of another area and thinking of the world as a system over time can make one realize that farmland practices used years back can affect agricultural practice today; and the environmental policies we approve of today may have an impact on the environment in the future.

On matter of sustainable development, Rio de Janeiro in 1992 and the Summit on Sustainable Development in Johannesburg, a decade later were held. Development and biophysical environment are intertwined and one is dependent on the other. On this note, Sustainable development supports economic development and simultaneously ensures human development and long term viability of environmental resources on which development depends. Efficient management of the resources both human and natural in rice milling business to reduce pollution of the environment; reduce conflicts, conserve and preserve resources, can be largely related to sustainable development. Sustainable development is based on environmental and economic objectives and there is need to conserve environment resources, biodiversity, and the same time use the resources judiciously to achieve certain economic goals (Bariwa, 2006).

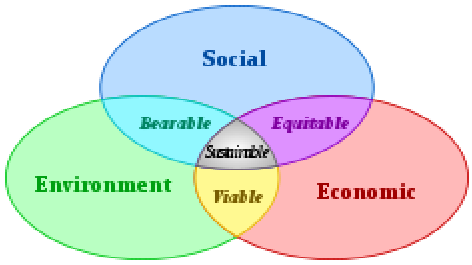

Fig.2 Scheme of sustainable development at the confluence of three constituent parts
Source: Adams (2006).

The idea of sustainable development according to Daly *et al.*, (1989) is an oxymoron as development seems to entail environmental degradation. From this perspective, the economy is a subsystem of human society, which is itself a subsystem of the biosphere and a gain in one sector is a loss from another Porritt (2006). This can be illustrated as three concentric circles in fig 1.2

Sustainable development is therefore very vital in rice milling system. Herein, resources are utilized and processes are carried out. The resources in the context of this study are the human and natural vis-à-vis, the soil, water and air components, the human beings, the rice, the machines, the money to and fro the business of rice milling.

What this study is concerned with, is a sustainable way of managing these resources so as to serve for today effectively and be able to be sustained in the next generation. On this note, the Government on one hand must come up with policies that will guarantee proper management of the resources. It should embark on development of Rice Mills or clusters that will not cause waste of resources; rather it should consider sustainable ways of managing the situations in Abakaliki Rice Mill to ensure it is kept beyond this generation while serving the people effectively.

On the other hand, the Abakaliki Rice Mill owners and workers should be able to carry out its operations in an environment-friendly manner so as not utter negatively the ecosystem. They should also be able to abide by any sustainable decisions that are in the best interest of the host community.

This in summary suggests that the principle of sustainability should be embraced by all parties involved in environmental issues as it is with Abakaliki Rice Mill and Ebonyi State Government. The government as well as the Rice Millers owes to the environment the responsibility of managing the environmental resources in such a way as to satisfy the needs of today without compromising the needs of future generation. When the both parties play their parts as pointed out in the course of managing the development, it will be said that the management and development are sustainable.

1.7 Significance of the Study

This study will be of great advantage for the following reasons:

1. It will provide a harmonized ideology on both the positive and negative effects of rice milling; hence fill the gap in knowledge existing as to the holistic effects of rice milling with respect to location.
2. It will provide a wider view on the overall effects of the Abakaliki Rice Mill Company on the people of Amagu and its environs.
3. The results of the findings would educate on the best practices in Rice Milling and locations of Abakaliki Rice Mill Company.
4. The study will provide whether the effects identified are enough to warrant the relocation of the mill to another place.
5. The research work will determine the significance of the environmental effects; economic effects of Abakaliki Rice Mill and its health implications on Amagu Community as well as the acceptability of the location of the Rice Mill where it is.

6. In a nutshell, the study will help to achieve the Sustainable Development Goals (SDGs) which among others, is to guard against environmental degradation beyond the earth's carrying capacity.
7. It will serve as a veritable tool for further and more studies on both the human and social ecological components of the environment.

1.8 Scope of the Study

This study will cover Amagu community in Abakaliki L.G.A., The community is made up of 9 villages; Amagu, Amagu Onicha, Ebia Unuphu, Okpuitumo Unuphu, Inyimagu Unuphu, Amachi Unuphu, Igbeagu Unuphu, Ndi Nwamini and Agbaja Unuphu. It will identify the environmental and economic effects and the health implications of the Rice Mill Company on the host. On that note, the study will cover two main components of the environment: - the physical environment and the economic environment. It will also study the prevalence rate of documented 5 environmentally-related health cases so as to establish the health implications as regards Abakaliki Rice Mill. The physical environment includes the soil, water, and air. The population of Amagu community is 33,284; 15835 males and 17449 females based on 2.8% inter-census projection on 1991 population of National Population Commission of Nigeria.

1.9 Limitations of the Study

The limitations to the study were as follows:

1. The reluctance of the Government agencies to release the needed data for this study. However, this was overcome by the availability of many of them

from online by many authors and reporters who did not hesistate to post such on net.

2. The dificulty in going round the community owing to the sparse settlement pattern in Abakaliki area of Ebonyi State. To overcome this difficulty, the villages were clustered for data collection.
3. The large number of variables studied and low knowledge of the the researcher in statistical data analysis. However this was overcome by consulting experts in statistics who simplified and interpreted the data in forms understandable to him.
4. This study on effect of rice mill effluent in Ebonyi River Abakaliki, Ebonyi State was supposed to cover three major aspects-the biological, physical and chemical parameters of the effluent, but due to inability of the laboratory routine analysis to capture a reasonable number of the biological parameters to warrant analysis and logical inference, the statistical analyses left out the biological properties. However, the inadequacy in coverage in terms of the parameters was overcome by analyzing in detail with the right statistical tools, the available data so as to infer meaningfully on the effects of the rice mill effluent on the water quality.
5. Financial constraint was also a limitation as it took a lot of time in the period of this research to amass the needed amount of resources necessary to complete the research. However, judicious use of the available resources made it possible for this research to be possible.

6. Difficulty in understanding the lingual franca by the respondents to the questionnaire. This was solved by the employment of interpreters in the course of the questionnaire administration.

1.10 The Study Area

1. Location and Size:

The study area is Amagu Community in Abakaliki L.G.A of Ebonyi State Amagu Community is one of the Communities in Abakaliki Local Government of Ebony of State. This is because of the location of the Rice Mill therein. Amagu Community has been a major player in the local rice sector. Inyimegu Unuphu is the particular village in Amagu wherein the Abakaliki Rice Mill Company Ltd is located. The Community is located in the Southern part of Abakailiki Urban. It is bounded in the North by Ebonyi L.G.A. to the East, by Edda community and Okpuitumo community and Ebonyi River; to the South, by Ezza North L.G.A and to the West, by the Izzi Unuphu. Fig. 3 is the map of Abakaliki L.G.A. showing Amagu community while Fig. 4 is the Map of Amagu Commuinty showing the Rice Mill. Amagu Community has a projected population of 33,284; 15835 males and 17449 females based on 2.8% inter-census projection on 1991 population (Ugo, 2009; National Population Commission, 2006).

Abakaliki Local Government Area of Ebonyi State, on the other hand is located between Latitudes 6^0 10”N and 6^0 20” N and Longitudes 8^0 00’’E and 8^0 30’’E. in the derived savannah zone of Nigeria. It has a landmass of approximately 5,935sq km. Fig 1.3 is the map of Ebonyi state showing Abakaliki L.G.A.

Abakaliki is a local government area among the thirteen local government areas in the State. National population commission figure shows that the population of the area is 134113. It is transverse by a number of rivers; Iyiudele River, Iyiokwu River, Ebonyi River and Okpuru River which forms a confluence at the Southern part of the city. The city has a boundary with Enugu and Cross- River states at the northern and respectively. On a wider scale, Ebonyi state is located in the Southeastern part of Nigeria. It is bounded to the North by Enugu and Benue States; to the East by Cross River State; to the South by Abia State and to the West by Anambra State. Fig. 1 shows that Map of Ngeria showing Ebonyi State.

The climate of the area is tropical in nature. The area experiences a bimodal pattern of rainfall from April to July and September to November with short dry spell in August commonly known as August break. It is characterized by a mean annual minimum and maximum temperature ranging from 27^{o}C to 31^{o}C. The relative humidity of the area ranges between 60-80% during rainy season (Ofomata, 1975).

The people of Abakaliki are mostly farmers. Rice, Yam and Cassava are the most popular crops. They are regarded as the highest producers of rice, and endowed with abundant natural resources both tapped and untapped including limestones, lead, zinc and salt. Abakaliki has many tourist potentials such as green lake in Government house, the rocky hill formation in water works Road.

As the administrative headquarters of Ebonyi State, Abakaliki is the most populated area in Ebonyi State due to immigration of people into the area for business and white collar jobs. Other socio-economic activities are fishing, transportation, trading, sand mining and civil service.

(Federal Surveys, Nig. 1967; Ebonyi State Ministry of Information, 1999; Ebonyi State Ministry of Lands, Survey, Housing and Planning, 2014; GIS LAB, Geo-Planning Dept, KSU, 2015).

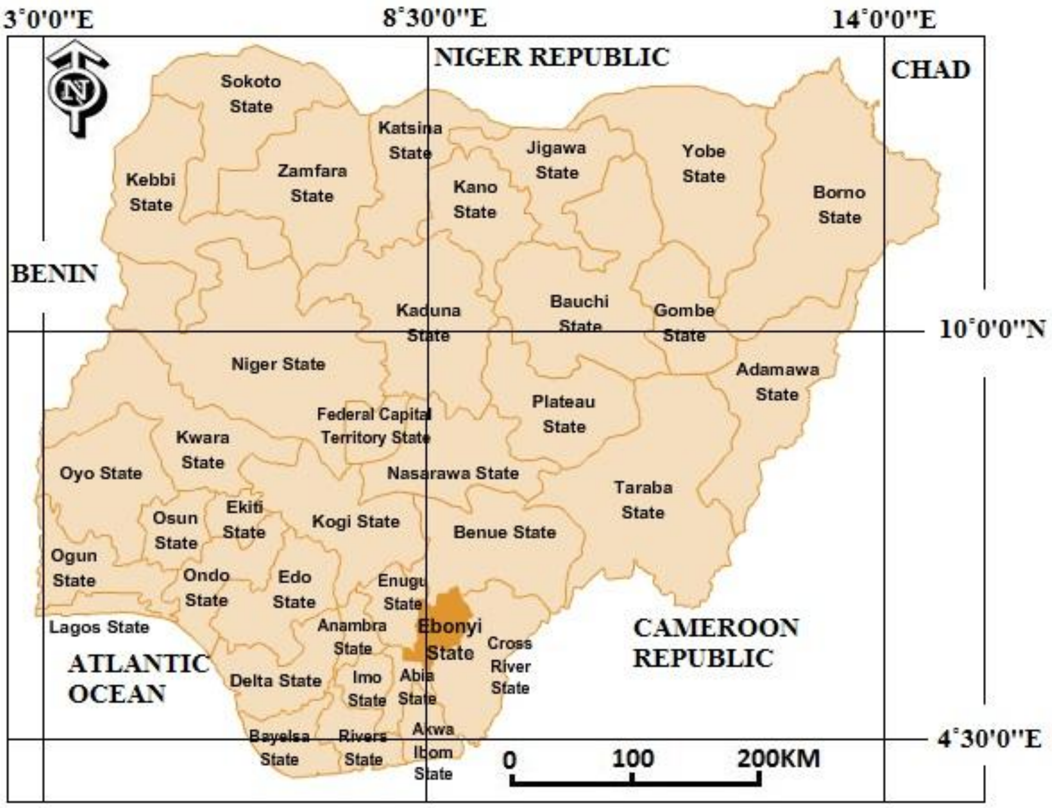

Fig. 1.3 Map of Nigeria showing Ebonyi State
Source: Author's Computation

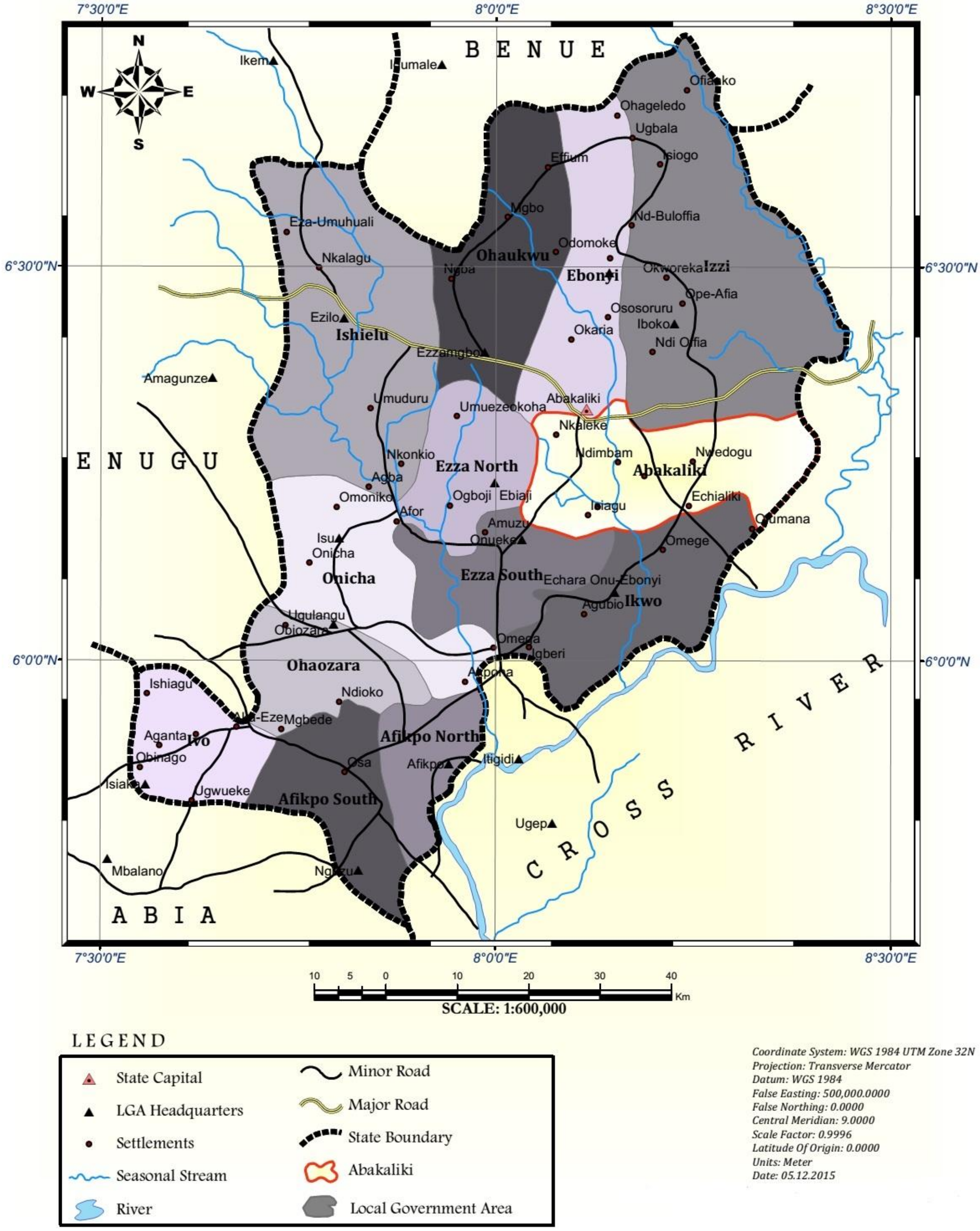

Fig. 1.4 Map of Ebonyi State, Nigeria showing Abakaliki L.G.A.

Source: GIS LAB, Geo-Planning Dept, KSU, Anyigba and Ebonyi State Ministry of Lands, Survey, Housing & Planning (2015)

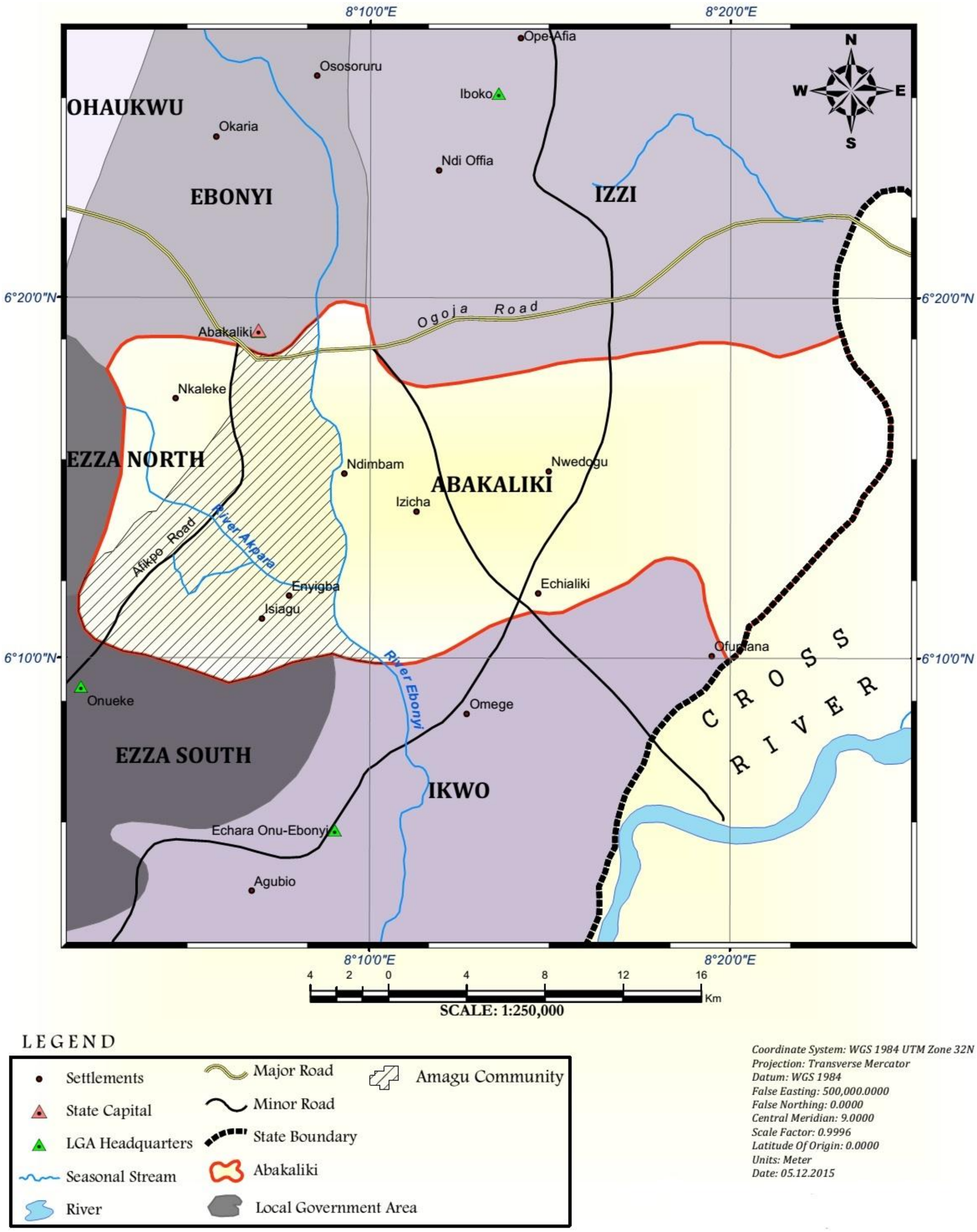

Fig. 1.5 Map of Abakaliki Local Govt. Area showing Amagu Community
Source: GIS LAB, Geo-Planning Dept, KSU, Anyigba and Ebonyi State Ministry of Lands, Survey, Housing & Planning (2015)

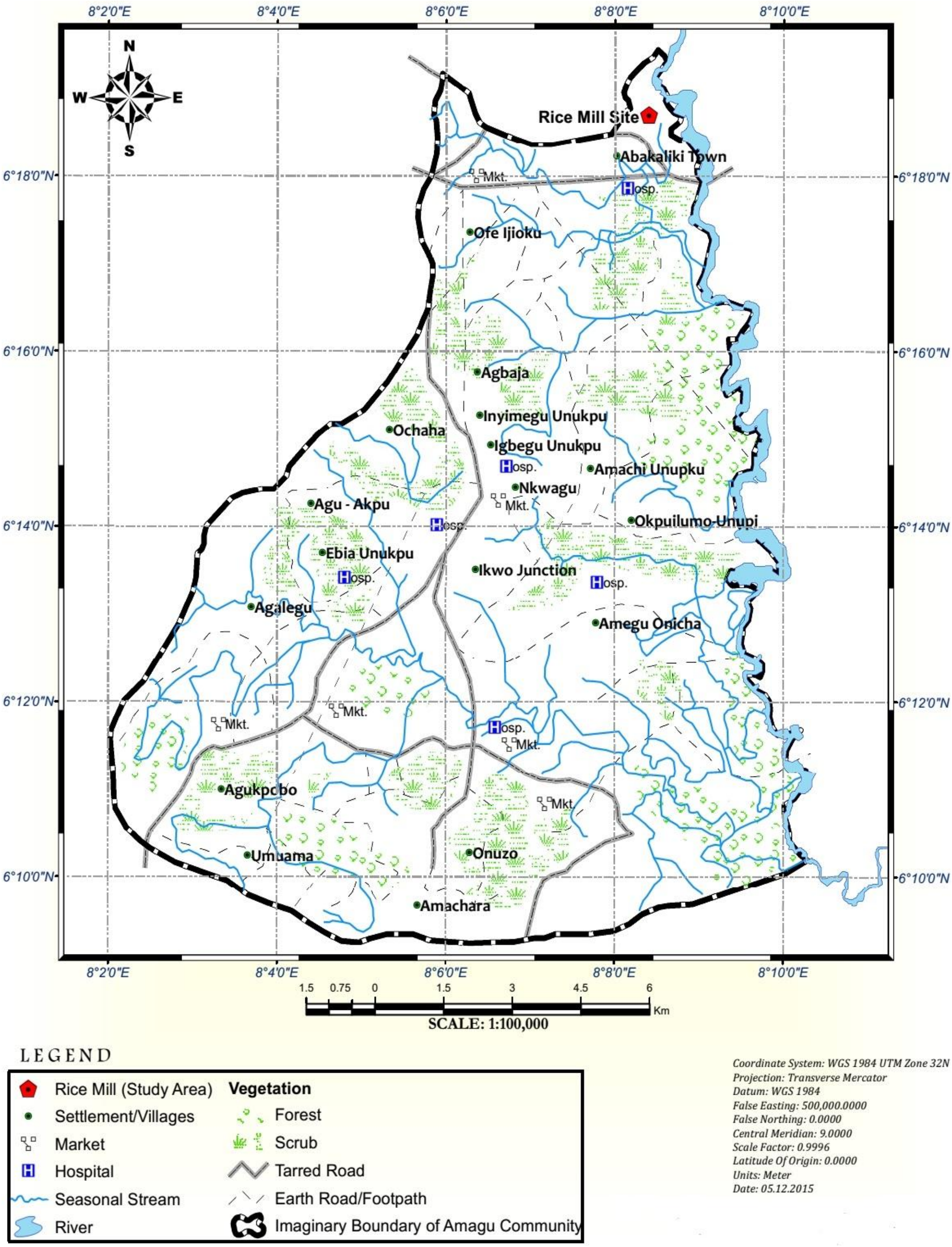

Fig. 1.6 Map of Amagu Community showing the Rice Mill
Source: GIS LAB, Geo-Planning Dept, KSU, Anyigba and Ebonyi State Ministry of Lands, Survey, Housing & Planning (2015)

2. Historical Background/Description of Abakaliki Rice Mill Ltd.

The Abakaliki Rice Mill Company Ltd was established in 1964, but rice production in the city dates back to the pre-colonial era. It was originated and is still owned by private entrepreneurs drawn from the entire Eastern States of Nigeria. It serves not just Abakaliki and its environs but the length and breadth of Nigeria. The industry has 850 registered millers. Each miller has 0.6 tonne per hour milling capacity. The mill boasts of over 5,000 workers, 2,500 rice milling machines, and a production capacity of more than 11,000 metric tonnes per month. 50% of the mill is owned by non-indigenes of Ebonyi State (Nigerian Orient News, 2012; Sunday Trust Newspaper, 2012).

The Rice Mill Company Ltd is sub-divided into:- Rice Millers, Rice Blowing, Rice Blending, Rice De-stoning, Dust/Rice Husk Carrying, Bag Stitching, Barrow Pushing, Loading/Off-loading, conveying(for Vehicle Owners/Drivers), and Mammy marketing section; they have their sub-associations.

The physical structures include: - administrative building, plants houses, restaurants, warehouses, and a petrol station owned by the Rice Mill Owners' Association, as well as automobile servicing centre. Behind the mammy market is the rice husk dump. Plate 1is the picture of rice husk dump at Abakaliki Rice Mill Industry. Women from the surroundings come there to sieve the husk for their livelihood and in turn help the millers to dispose of the husks to the husks dump site.

Plate1.1 Rice Husks Dump at Abakaliki Rice Mill Company Ltd.
Source: Author's Preliminary Field Work (2014)

3. Rice Processing in Abakaliki Rice Milling Company Ltd.

Abakaliki Rice Mill Company Ltd carries out only primary rice processing which converts paddy into basic milled rice. Activities undertaken in this stage are parboiling, drying, milling and bagging. Before rice is milled, it passes the stages of harvesting, threshing and drying (Oguntade, 2011).

Unmilled rice, known as paddy (Indonesia and Malaysia: padi; Philippines: palay), is usually harvested manually or mechanically by farmers or labour groups when the grains have a moisture content of around 25%. Harvesting is followed by threshing, either immediately or within a day or two. Subsequently, paddy is dried to bring down the moisture content to no more than 20% for milling. Drying also has to be carried out quickly to avoid the formation of moulds (Autrey *et al.*, 1984)

Mills range from simple hullers, with a throughput of a couple of tonnes a day, which simply remove the outer husk, to enormous operations that can process 4,000 tonnes a day and produce highly polished rice. A good mill can achieve a paddy-to-rice conversion rate of up to 72% but smaller, inefficient mills often struggle to achieve 60%. These smaller mills often do not buy paddy and sell rice but only service farmers who want to mill their paddy for their own consumption (Autrey *et al.*, 1984).

There are three different stages of paddy processing in commercial rice mills viz. i) parboiling process, ii) drying of the parboiled paddy and finally, iii) milling operation to get finished product. The milling operation is completely done by the mechanical energy and this demand is satisfied with grid electricity. There are two types of milling machinery, *viz*. steel huller (Engleberg type) and modern milling (combination of rubber roll sheller and polisher). The milling machinery needs higher electrical load for its several operations17 viz. pre-cleaning, shelling, separation, grading, polishing, etc. The electrical energy consumption was found to be 29.26 kWh/tonne of paddy processed by a 2 tonne per hour capacity modern mill Autrey *et al.*, (1984).

In the operation under the first process, Autrey *et al.*, (1984) explained that when rough or paddy rice is removed from storage it is cleaned to remove contaminants to produce clean paddy rice feed. The clean paddy is fed into tanks, wherein it is covered by hot water and allowed to steep for a period of time. In this steep time the moisture content of the rice is increased from 12 to 14 percent to typically about 37 percent in water introduced at a range of 145^{o}F to 170^{o}F. The temperature of this water and the optional use of air pressure permit, control of the time required to reach the desired moisture content in the rice. This operation may be continuous by batch with a series of steeping tanks employed. The steeping time may be about 40-60 minutes to a few hours depending upon the feed rice quality and the desired characteristics of the finished parboiled rice.

The steeped rice is conveyed to a second heat processing section, wherein the starch is gelatinized in a steam atmosphere for a desired time. Typically this will be done at a steam pressure of 8-10 pounds per square inch gauge with a residence time of about 5-15 minutes.

In the 2nd process, the steamed or rice is conveyed into a drying section where the moisture is reduced by the action of heated air in a series of, usually three stepped stages wherein the temperature is carefully controlled. In a typical process the temperature of the drying mixture of gas and air will be about 500 ^{o}F to 600 ^{o}F and 200 ^{o}F to 300 ^{o}F respectively, and the temperatures of the rice removed from those stages will be about 180 ^{o}F and 100 ^{o}F (Autrey *et al.,* 1984).

Between drying steps the moisture in the kernel will migrate from the center to the surface with the surface region having been dried more than the center in the previous drying step. Upon reaching ambient temperature the moisture content will have been reduced back to about 13 percent and stable parboiled rough or paddy rice will have been produced(Autrey *et al.*, 1984).

Finally, this product rice is conveyed to a Sheller machine wherein the rice grains are removed from the hulls and brown rice is discharged and sent to milling machines where the bran is removed and finished primary product of parboiled rice and by-product rice bran are recovered (Autrey *et al*., 1984).

The different operations of the rice parboiling systems are shown in plates 2(a-d)

2a Traditional rice parboiling

2**b** sun drying

2c Engle berg huller milling

2d Modern rice milling

Plate 1.2 (a-d): Stages of rice processing/Milling
Source: Autrey and Hunnell (1984).

8. Geology and Hydro-Geology of Abakaliki

According to Obasi *et al.*, (2011), the Abakaliki area of the Southern Benue Trough of Nigeria wherein the study area is located has been variously investigated by different authors (Mackay, 1946; Orajaka et al., 1989) in terms of geology. According to Ugo, (1991), the greater part of the area lies in the over-stretched sedimentary rocks. The Abakaliki shales are part of the Asu River Group sediments which were deposited in the middle Albian age (Reyment, 1965). The thickness of the sediments has been estimated to be between 1900m to 3000m (Kogbe, 1976). The sediments consist of fossilferous shales, siltstones, limestone and minor fine to coarse-grained sandstones, which are associated with saline seepages, Lead zinc mineralization, basic intensions and pyroclastics (Agumanu, 1989). The Asu River Group sediments are predominantly shales, and localized occurrences of sandstone, siltstone and limestone intercalations (Ofoegbu *et al.*, 1987). It was generally believed to have started depositing in the mid-Albian period and was deposited within the lower (or southern) Benue Trough, southeastern Nigeria. Emplaced in these Asu River Group sediments are intermediates to basic intrusive, extrusive and pyroclastics (Nwachukwu, 1972; Ofoegbu *et al.*, 1987). The group has average thickness of about 2000m and rests unconformably on the Precambrian Basement (Benkhelil *et al.*, 1989). Abakaliki Shale Formation is dominantly shale, dark grey in colour, blocky, and non-micaceous in most locations. It is calcareous (calcite-cemented) and deeply weathered to brownish clay in the greater part of the formation (Oko et al., 2010).

Obasi *et al.*, (2011), notes that the major part of the Abakaliki metropolis is underlain by aquiclude; except in locations or zones where secondary aquiferous conditions were made possible by syn- and post-depositional circumstances. The syn-depositional circumstance is the occurrence of lenses of sandstone or siltstone beds, while the post-depositional circumstances include weathering, fracturing or shearing, and volcanic intrusions. The zones are recharged mostly in the peak of rainy season and by surface waters in the area. The major river that drains the area is the Ebonyi River and its tributaries; Udele and Iyiokwu Rivers. Both tributaries are perennial and usually overflow their banks at the peak of the rains (Obasi *et al.*, (2011).

The Santonian tectonic phase resulted in series of folding and fracturing of these rocks, giving rise to chains of anticlines known as the"Abakaliki Anticlinorium" (Reyment, 1965). The major fracture system which houses the lead-zinc minerals are in the NW/NNW SE/SSE (Farrington, 1952). The origin of this basin has been discussed by Nwachukwu (1972), Olade (1975), and Olade (1979). The folding which affected these sediments resulted from compressional phase (Benkhelil, 1986).

9. Climatic Conditions of Abakaliki L.G.A.

According to Ugo (2003), the climate of Ebonyi State which is not seperable from Abakaliki is an admixture of variables of grass-land or Sahel-Savanah, and tropical forest. This region is typical of Afikpo and Ogoja which have 200 centimeters and 185 centimeters respectively of rainfall per annum. There are two major seasons in this area in a year. The dry season; this witnesses the heat of the tropical sun, without moisture. During this period the winds from the Sahara desert in the North are sometimes carried by the North-East trade winds. This is severe between December and April. By this period the rivers are frozen with exception of Ebonyi River which could be crossed without the use of canoes. The trees and grasses wither except along the creeks of the major rivers. It often brings excessive drought which is comparable to those of the Northern Nigeria. The period of dry season are further divide into periods of hot sun and harsh harmattan in which winds are mixed with sand but as it approaches the creeks and thick forests, it envelops the forest in fog (Ugo, 1991).

The effect of the above is always harsh harmattan that helps in the drought of pond and streams, causing scarcity of water. No work is done at all during this period but the search for good drinking water becomes the preoccupation of the people. Any water got in this period of the year is most often contaminated and breeds guinea worm-the scourge of both young and old. Trade, agricultural activities and many other economic activities become paralyzed (Ugo, 1991).

The second season is the rainy season which starts about May to October. During this period, cropping and other agricultural activities are carried out. Most of the annual rainfall of 100 inches to 120 inches (approximately between 200 and 185 centimeters) a year comes within this period. At a certain point in this season, rain locks everyone inside except the fishermen who enjoy a big catch in the streams and the rivers (Ugo, 1991).

The rainfall pattern is bimodal; April-July and September-November with a short spell in August. The annual rainfall is between 1200mm-1500mm ofthe derived Savannah of the Southeast agro-ecological zone of Nigeria. The mean annual temperature is about 24^0C and relative humidity is between 60-80% (Ofomata, 1975).This climatic phenomena result in common crops and grasses found in the study area which include cassava, yam etc; the grases are *pennisetum purpurea*, panicum *maximum*, *tridax procumbens;* short trees, herb and shrubs are found scattered at different locations around the site. The soil type is sandy clay loam which in some places is poorly drained (Anikwe, 2000).

10. Water Resources and Vegetation

The most outstanding river is Ebonyi River. The river beds are made of sandy deposits which are normally exposed during dry seasons as the river volumes drop very much. Wells, bore holes and municipal water supply are the major sources of drinking water and other domestic uses. This area is characterized by the usual mixed rainforest and guinea savanna species of trees, shrubs and grasses. In Nigeria, Ebonyi state is located within the transitional belt between the rain forest and guinea savanna (Ofomata, 1975).

11. Economic Activities

The main economic activity of Amagu community is rice cultivation. The markets within the area are: the Rice mill, the Nkwegu, the Ekeabe Markets, etc. It is close to the administrative base of Ebonyi State (Abakaliki Urban) and Ebonyi State University. As a result of these, majority of the inhabitants are farmers, while some others are traders and civil servants (Ugo, 1991).

1.11 Plan of the Study.

This thesis will be presented in 5 chapters with the introductory chapter as Chapter 1. Chapter 2 will review literature on environmental, economic and health implications of rice milling operations. Chapter 3 will outline the methods of the research. Chapter 4 will present the findings from the field as well as discussion of the findings, followed by a summary, conclusions and recommendations in Chapter 5.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter deals with the reviews of related literature. The literature review is on works previously done on rice milling and their effects on the environment (physical, and economic). It points out very carefully the similarities, and more importantly the differences between other researches and the current one.

2.2 Rice milling

Milling of rice is the removal of the husk and the bran layers of rice to produce an edible, white or brown rice kernel that is sufficiently milled and free of impurities (International Rice Research Institute 2014). A detailed analysis of nutrient content of rice reveals that the variation of the nutritional value of rice depends on the strain of rice, and nutrient quality of the soil rice is grown in, whether and how the rice is polished or processed, the manner it is enriched, and how it is prepared before consumption (Juliano, 1993). According to Juliano (1993), milling of rice, in addition to other factors which was not mentioned impacts on rice by affecting the nutrient quality. This finding considers the effect of the milling of rice as it concerns nutrition but did not point the implication of the nutritional quality of the milled rice on health or the environment.

2.3 Environmental Effects of Rice Milling

Rice milling produces wastes which are organic materials or by-products that can be composted or decomposed. However, their high lignin and cellulose content can make this a slow process. They comprise husk, bran, broken edible rice, stone and metals from milling equipment (Njoku *et al.*, 2011).

The large amount of water which is required for parboiling and which, most times, are not properly treated, could result in water pollution and odour nuisance to residents. Water pollution can be caused by surface runoff, which may contain high level of organic material. According to EPA (2000) and Farouk et al., (2002), due to the likelihood of rice contamination with pest infestation, handling and storage, arsenic-contaminated water, good hygiene standards should be in place to test the products entering and leaving the mill.

Some of the main issues include: hygiene standards because the product is for human consumption. Hence, due to the likelihood of the paddy rice being subjected to pest infestations or contamination in handling and storage, quality control procedures, regular hygiene checks, avoidance of arsenic-contaminated water and good hygiene standards should be in place to test the products entering and leaving the mill (USA EPA, 2000; IRRI, 2014).

The second issue is water and effluent management because parboiled rice production requires large amount of water which if not properly treated could result in water pollution and odour nuisance to residents (USA EPA, 2000; IRRI, 2014).

The third issue is the air emissions-dust, and odour management. Rice mill may present a significant source of air pollution both on site and the surrounding locality thereby endangering health (USA EPA, 2000; IRRI, 2014).

The fourth issue in rice milling environment is solid waste disposal and management. The disposal of solid waste, which includes the husk from the paddy as well as other wastes generated from the cleaning process, is another major environmental problem associated with rice milling. Pollution risks to water and soil may arise from spillage and leakage of solid fuels and burnt husks stored on the mill site (USA EPA, 2000; IRRI, 2014).

The Karnatata State Pollution Control Board (KSPCB) prescribed limit of 55 decibel of noise limit in the rice mills The solid wastes which include the husk from the paddy as well as other wastes generated from the cleaning process; spillage and leakage of solid fuels and burnt husks stored on the mill site are also the byproducts or effects of rice mill industries (IFC; 2009). Farouk, (2006) opines that high risk of accidents from locally made low cost drum boilers, and fire especially in the storage areas associated with rice milling.

From the literature, it will be observed that the environmental issues associated with rice milling operations include the following: water and effluent management, hygiene standards, air emissions-dust, noise and odour management solid waste disposal and management and industrial accidents

They considered the effects only from the negative perspective. The studies are not only on the physical environment but also appear as general statements on the negative rice mill effects on the general physical environment without reference to locality. Also, what the authors suggest is that one cannot disassociate waste generation from rice milling. They pointed out that the decomposition of rice husk is slowed down by the high lignin and cellulose content. This implies that the effects of rice milling operations stay a long time where they are found.

Oko *et al.,* (2010) attempted to correlate quality of rice with its chemical composition. They analyzed the proximate and mineral compositions of five major rice varieties in Abakaliki, South-Eastern Nigeria and found that there is significant difference ($p<0.05$) in the proximate compositions of the rice varieties studied. They in agreement with Online USA Rice Federation (2002) attributed the low carbohydrate quality of Sipi variety to milling quality and environmental factors.

Oko *et al.,* (2010) are of the view that the quality of milling and environmental factors influence the chemical composition of rice milled. This implies that the economic and health implications of rice milling are equally connected to rice milling operations.

The improvement in soil physical properties is attributable to increase in soil organic matter content (Njoku *et al.,* (2011) submits that burnt, unburnt and burnt + unburnt rice mill wastes at different rates improved the soil hydraulic conductivity and aggregate stability, crop yield and apart from improving soil productivity as shown in this study it will save the farmer the cost of buying artificial fertilizer as these wastes are mostly obtained free in the activity areas. Buttressing Njoku *et al.,* (2011), also found that the application of organic residues influences soil physical properties (bulk density, total porosity, hydraulic conductivity and aggregate stability) positively. When rice mill waste management is properly carried out and carefully monitored to supply the nutrient needed by crops, it reduces the cost of crop production and saves the cost of wastes disposal (Anikwe and Nwobodo, 2002). Echoing Aniekwe *et al.*, 2002), Meerow, (1995) stated that the quantity, rather than the type, of organic wastes has a larger effect on splash detachment; shear strength, and aggregate stability.

In the study, *"Effect of Rice Husk Mulch and Fertilizer Rates on an Acid Altisol and the Yield of Okra (Abelmoschus Esculentus) in South East Nigeria"*, Ekpe (2008) investigated the effect of blanket rice husk used as mulch. The results indicated that NPK 20:10:10 and rice husk dust used as mulch in the amended plots improved soil chemical properties and crop yield. Ekpe, (2008) states that rice husk dust used as mulch in amended plots improved the soil chemical properties like acidity and improve crop yield. In a related work, Mba et al., (2009), investigated the effects of organic amendments (poultry droppings (PD), burnt rice husk dust, (BRHD), Unburnt rice husk dust (UBRHD) and inorganic fertilizer (NPK) on soil properties and their residual effect tested in 2008. Results of the study showed that organic and inorganic fertilizers are effective in restoring the productivity of degraded soils. On that note, Mba et al., (2009) admitted that the Abakaliki rice mill wastes have environmental adverse effects but submitted that the use of these cheap and available wastes by the poor resource farmers in the area will not only improve the soil properties but enhance crop production on long term basis in the area regarded as food belt of the eastern region. The above literatures center on the physical environment-the soil (land) and they concentrate on the positive effects of rice mill wastes on the soil as it concerns agriculture.

Rice husks have been identified as having both positive and negative effects on the environment where they are produced. Whereas {Aniekwe *et al.,* (2002), Mba *et al*., (2009), and Njoku *et al*., (2011)}, highlighted the positive effects of rice wastes by stating that the soil component, texture and structure can be improved upon by quality as well as proper management of rice organic wastes, IFC (2009), Meerow, (1995) and Ekpe, (2008) looked at the effects from the negative perspective hence, the consideration of the quantity of rice husks produced from rice milling and their improper disposal into the environment as the root causes of physical pollution of the soil, aesthetics and air quality.

In his work, Fakhrul *et al*., (2008), made a contribution to the effects of rice milling operations on the air component of the environment and also reported that carbon dioxide emissions from rice processing varied from 938.2 kg to 1,360.0 kg for each tonne of finished rice and that the Carbon dioxide emissions resulting from rice processing lead to increased emissions of greenhouse gas (global warming), and associated sea level rise. They added that rice wastes could provide an alternative source of energy if properly harnessed.

Supporting Frankfurt et al., (2008), Ahiduzzaman *et al.,* (2009) studied the energy Utilization and Environmental aspects of rice processing industries in Bangladesh, and found, among other things, that biogenic carbon dioxide emission from burning of rice husk is renewed every year by the rice plant. They stated that the total CO_2 emission of rice processing in Bangladesh was estimated to be 6.1 million tonnes in 2000 and this value will increase to 11.7 million in 2030. Out of the total emissions, the biogenic CO_2 emission was estimated as 5.7 million tonnes in 2000 and this value will increase to 10.9 million tonnes in 2030. They opine that rice husk could save CO_2 by replacing fuel wood if the husk is briquetted and that even this husk could reduce non-biogenic CO_2 emission (the net CO_2 emission from fossil fuel for electricity) if the husk would be used for electricity generation.

The above findings show that much as there are negative effects of rice milling operations in terms of CO_2 generation and consequent global warming, there are also positive effects in the area of alternative energy generation compared to fossil energy.

Buttressing Mba *et al*., (2009), Opara (2010) assert that rice husk dumps are increasing in alarming proportion at Abakaliki. He opines that disposing and evacuating the rice dumps is urgently necessary because of the impending environmental hazards, degradation and pollution it posses to the people and the environs. In attempt to dispose rice husk, most communities, set the rice husk dumps on fire. Unfortunately a small heap of rice husk takes months to get burnt to ashes. Opara (2010) notes that rice husk burns to ashes at the temperature of 800^oF. Even when burnt to ashes, it is still an eyesore especially during the rainy season. He also noted that rice husk dump on fire constitute serious environmental hazards especially during the harmattan season when the dust devil and other manner of winds blow. It can set nearby buildings on fire. Some people are known to have died by unknowingly running into or stepping into rice husk dumps on fire beneath the surface.

The situation portrayed by Opara, (1998) and Mba *et al.,* (2009) is that rice husk from rice milling burns to ashes at a very high temperature; that poses a great danger and cause eye sore and environmental hazards. This is to say that they constitute both thermal and air pollution to the environment.

Ekwe, (2012) made an addition to Opara, (1998) and Mba *et al*., (2009) in a work carried out to reduce the problems caused by uncontrolled rice waste disposal, demonstrated through experiments that delignification is essential for saccharification. She posits that renewable cellulosic material especially agricultural residues rich in cellulose are one of the most abundant biomass on earth. According to her, due to the uncoordinated channel of waste disposal, these agricultural waste residues such as rice husks, undergo uncontrolled fermentation and purification where they are dumped, thereby constituting environmental pollution and health hazards. She in agreement with Amar Singh (1984) admitted that the uncontrolled fermentation and purification of the indiscriminately dumped agricultural waste residues from agro-industrial processes causes environmental pollution both on land and in the air, hence it calls for concern.

Padhan *et al.,* (2011) measured the physicochemical characteristics of rice mill wastewater and suggested that rice mill waste water should not be used as such for agricultural purpose rather; the waste waters should be treated to render them suitable for irrigation in agricultural lands. Buttressing this, Abanti, et al., (2011) observe that the significant reduction in population, reproduction, biomass and secondary production of *D.willsi* in experimental plots may be due to alkaline pH with higher content of phenols, silica, TSS, BOD, sodium and organic matter in the rice mill.

Ekpe, (2008), Abanti *et al.,* (2011) and Padhan *et al.*, (2011) point to the fact that wastes water from rice husk can be fit for agricultural purposes if they are properly treated to regulate its Ph levels.

In a nutshell, literatures on the environmental effects on rice mill show that rice milling operations have both positive and negative effects on the environment. The views are divergent on the positivity and negativity of rice milling. However, environmental matters are better treated when the components-physical environment, social environment and the economic environment are considered holistically as a system.

2.4 Economic Effects of Rice Milling

The rice husk from mills has various uses. It could serve for providing heat when cooking. It is used as a major raw material in animal feed mills. It is also used by bakers in bread making. It serves for soil stabilization in plant production. It is used as fuel for electricity generation in some Asian countries.

According to Chime (1998) rice husks through a hydrolytic processes provides the opportunity to conserve the world finite reserve of petroleum through the development for the production of fuels and chemical feedstock from renewable resources. In a study on the technological prospects of electricity self sufficiency at rice mill community through Rice husk gasification: a case study for Belcon company Ltd, Hassan, (2010) in Nigerian Orient News, (2012), posits that bio energy has significant potential contribution for sustainable energy systems, especially when converted to modern energy carriers such as electricity, gaseous or liquid fuels. On the other hand, it has an important part of today's imperfect energy systems in many sectors that slow development of the society. Maximum rice husk produced by milling process of rice mills in Bangladesh usually burned in the mill boilers to produce process heat for parboiling of paddy rice and excess husk are sold to the market as fuel for cooking purposes and a considerable portion is misused. African rice helped Africa conquer its famine of 1203 (IRRI, 2014).

About 1.775 million of people in Bangladesh are engaged in the rice processing sector (Fakhrul *et al*., 2008). According to USA Rice Federation, (2013), the rice milling industry adds more than 39,000 jobs and nearly five billion dollars to USA economy through direct, indirect and induced effects.

Direct effect is defined by USA Rice Federation, (2013) as "the direct change in economic activity related to milling industry sales. This includes purchases and sales made in immediate support for rice millers' day to day business activities and employment on economic values added by (those) activities". On the other hand, indirect effect of rice milling is the indirect change on the economic output related to rice industry's sales, one step removed from the direct economic activity but which increase or decrease in response to the industry's economic transaction. That includes construction of equipment and production of machinery as well as activities in other economic sectors that responds to economic trends in rice milling. Induced effect is the change in economic activities spread widely across the US economy. This includes economic impact on fuel use, on the production of rail cars and ships and upon other facilities that support the broader US economy, but whose use is affected by a measurable degree by rice millers' purchases and sales.

USA Rice Federation, (2013) states that milled rice is used directly as a processed product in breakfast cereals, pet foods, packaged mixes, candy soup, baby food snack items and beer. Rice by products is used in making hand soap, synthetic materials and even the straw is used as roughage feed and livestock bedding (USA Rice Federation, 2013). They also stated that rice millers increase the value of added portion of that economy by 2.1 billion dollars. They quoted a report prepared by informal economics and agricultural economics research company "each additional million dollars adds nearly 17 additional jobs". In terms of output, value, each additional million dollars in demand adds 2.4 million dollars in additional revenue.

According to Ngerian Orient News (2012) and Sunday Trust Newspaper (2012), Abakaliki Rice Mill provides job opportunities for the surrounding communities. Many people from the hinterland of Ebonyi State bring their rice to Abakaliki rice mills to be milled and this generates income for the surrounding communities. This is buttressed as the management of the company laments that if the rice mill is relocated from the current location, it be an impossible situation for the peasants who blow the rice and carry the dusts (rice husks) as they might lose their jobs alongside other groups. The rice blowers make between N300 and N500 every day (Nigerian Orient News, 2012). The bag sellers supply various bag sizes to customers who come to buy rice at different costs. The mill is so organized that the various categories of workers feel at ease doing their businesses there. There is a thriving market within the mill, run by several petty traders of foodstuffs, provisions, and other daily needs (Nigerian Orient News, 2012).

The fore going suggests that rice husks from rice milling guarantee the availability of energy supply, and in turn boost the economy. Although this technology is still alien in Abakaliki, rice mill by-products such as rice husks are used as building materials in some countries. Low carbon, white husks ashes are suitable for use in manufacturing building materials, more particularly refractory building materials. Rice husks are usually used although wheat, oats or barley husks can also be used. The economic analysis done by Francisco and Norton (1999) contained in Roguel, *et al.*, (2002) with data obtained in Palestine from farmers practicing rice hull-burning (RHB), revealed that the economic benefit from RHB ranges from $1,557.34 up to $ 2,335.94. Profit largely depends on how thick the rice hull is applied on the field (15-30 cm), where the thicker the rice hull burned, and the higher the income (Roguel *et al.*, 2002).

Farmers practicing RHB also stated some negative effects brought about by the activity in relation to their community. They cited that during the peak of the onion season, sometimes conflicts arose because the supply of rice hull was not enough and there was a high demand for it. Due to this, a stiff competition for the rice hull would develop among farmers (Roguel *et al.*, 2002).

On the other hand, the economic effects of rice mill also include the loss of income by the operators and government as a result of the outbreak of health disorders and other hazards associated with rice milling. According to Bhatt *et al.*, (2003), health effects caused by some poisonous chemicals, have economic implications. Rice is often directly associated with prosperity and fertility. Therefore, there is the custom of throwing rice at weddings in India **(**Ask.yahoo.com, 2003).

2.5 Health Implications of Rice Milling

The effects depend on the dose of concentration of exposure and individual susceptibility. Some of the primary effects of air pollutions include toxic poisoning which causes cancer, birth defect, eye irritations (Daniel *et al.*, 1997). The most common route of exposure to air pollutants is by inhalation. However, when nitrate is deposited on the soil it can promote plant growth through nitrogen fixations. Investigations reveal that rice mill workers and people staying within the rice mill environment are faced with numerous health hazards ranging from inhalation of rice husk and noise pollution leading to impaired hearing. Air pollution affects atmospheric properties through visibility reduction, fog formation and precipitation, solar radiation and alteration in temperature and wind distribution (Olarenwaju, 2002). According to Meadows (1973), particulates are the major villains in reducing visibility. They include not only the ash carbon but also aerosols particles.

Particles with radii of 0.1 to 1.0 microns have the greatest effect on visibility (Encyclopedia Americana). The role of particulates in scattering lights is a primary concern in areas of Rice mill.

Somorin, *et al.*, (2010) examined the presence of fungal contaminants in Ofada and Abakaliki rice varieties under storage in Lagos and Ogun States, Nigeria. They isolated certain species of fungi from Ofada and Abakaliki rice. They stated that some of these fungi are known to produce mycotoxins which have several health and economic implications and whose production, according to (Bankole *et al*. 1999), is the most debilitating effect of mould deterioration of stored grain and seeds. This corroborates Bhatt *et al.*, (2003) and Wu, (2008) who assert that mycotoxins are important in food safety in that they not only lead to deleterious health effects in humans and in animals, but they also pose adverse economic implications.

Rice and rice products contain arsenic, a known poison and Group 1 carcinogen (EFSA, 2009). There is no safe level of arsenic, but, as of 2012, a limit of 10 parts per billion has been established in the United States for drinking water, twice the level of 5 parts per billion originally proposed by the EPA. Consumption of one serving of some varieties of rice gives more exposure to arsenic than consumption of 1 liter of water that contains 5 parts per billion arsenic (Consumer Reports, 2012) Scientific studies suggest that the anthocyanins and tocols-based color pigments of brilliantly colored rice strains have antioxidant properties that may be useful to human health (Jang *et al.*, 2009).

It is speculated in Palestine that smoke coming from the burning rice hull, was among the sources of hostility around the neighborhood; resulting in cough/cold and other allergies experienced by the children. Some of them speculated that RHB must be the cause of one of the diseases of onion in which the leaves twisted (farmers referred to it as “twister”). Researchers, on the other hand, refer to the disease as anthracnose of onion, which is caused by soil or airborne pathogens (*Colletotrichum gloeosporioides*). They also mentioned that the storing capacity of their RHB harvest was not as long as those of their non-RHB harvest. Consequently, the researchers suggest that further studies be conducted to verify the effect of rice hull-burning on health and the environment (Roguel *et al.*, 2002).

In a study “ Occupational noise in rice mills” Prasanna (2008), following Canadian Centre for Occupational Health and Safety (CCOHS) guildlines in methods and materials, asserted that a major occupational hazard for the workers in rice mill is the noise during the operation of various machines. A noise survey was conducted in the workrooms of eight renowned rice mills of the north-eastern region of India established between 1980 and 1985 to identify the predominant noise sources and causes of high noise in workrooms of the rice mill. The sound-pressure level (SPL) in the workrooms of the rice mill varied from 78 to 92 dBA. About 26% of the total labourers were found to be exposed to higher levels of noise than 85 dBA. Subjective response indicated that about 26% of the total labourers felt noise interfers in their work and about 49% labourers were of opinion that noise interfere with their conversation.

According to Prsanna, (2008), the workers in the rice mill are exposed to high noise which will have detrimental effect on their health. They added that apart from undertaking appropriate noise control measures, preventive maintenance of machines needs to be given due importance in all rice mills.

OSHA, (2013) also stated that rice mills which is a grain-handling industry is high hazard industry where workers can be exposed to numerous serious and life threatening hazards. Among the hazards are fires, and explosions from grain dust explosion, suffocation from engulfment and entrapment in grain bins, falls from heights and crushing injuries; amputation from grain-handling instrument.

OSHA, (2013) identifies suffocation as a leading cause of death in grain storage bins in 2010. According to them, storage structures can also develop hazardous atmosphere due to gases given off from the spoiling grain and chemical fumigants. The diseases associated with such contaminations as stated by OSHA, (2013) include permanent central nervous system damage, heart and vascular disease, lung edema as well as cancer. He also opine that the gases may result to workers passing out and falling into the grain, thus becoming engulfed, suffocated and injuring themselves.

2.6 Summary of the Findings from the Literature Review

The literatures so far reviewed in this study reveal that rice milling operations impact on all the components of the environment. They effects have also been revealed to have some health implications.

Whereas the International Food Cooperation (2009) as well as Roguel *et al.*, (2002) and Bhat *et al.*, (2003), listed only the negative side of rice milling, other scholars showed that, rice milling have only positive effects.

Aniekwe *et al.,* (2002), Mba *et al.,* (2009), and Njoku *et al.,* (2011), Ahiduzzaman *et al.*,(2009), Fakhrul Isla*, et al* (2008), Mba et al.,(2009); Nigerian Orient News, (2012), Ekpe,(2008), found out the positive sides of rice milling.

It was discovered that the byproducts (husk) serves as an alternative source of fossil fuel electricity, have agricultural relevance as mulch material and regulation of the Ph level of the soil and soil stabilization. It also serves as source of income generation as well as a major raw material in animal feed mills. Also, rice husk is said to be useful in bread making. They arsenic content of rice is believed to enhance the production of arsenic based pesticides for weevil control. Lastly, it is believed that the cost of crop production is reduced and wastes disposal, saved through proper waste management.

On its own part, the health implications of rice milling have been found by {Jang, *et al* (2009), Bhat, *et al.,* (2003) and Wu, (2008)} to include outbreak of diseases like cough/cold and other allergies experienced by the children; associated with the rice milling operations and caused by smoke.

2.7 Gaps in the Literature

i. No existing literature has attempted to harmonize or weigh both the positive and negative effects of rice milling in one study. Consequently, there is yet to be a balance on the ideology of the effects of Rice Mill as an industry.

ii. No research has attempted to combine more than one component of the environment in the study of the effects of rice milling. This compromises the principle upon which sustainable development and management are based.

iii. In the aspect of methodology, no available literature on Abakaliki Rice Mill Industry made use of questionnaire. They only based their conclusions on laboratory results and inferences. None has given adequate human face in its study of the rice milling.

iv. No existing literature has attempted to study the health problems associated with rice milling using raw data from field.

v. No works done on Rice Milling in Nigeria has attempted to seek the views of the people before arriving at any environmental conclusions and recommendations.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the process and procedure which was used in data acquisition and analysis in the research. It involves research design, data needs, data sources, the study population, the sampling size, sampling techniques, research instrumentations, test of research instrumentation, data analysis and presentation as well as test of hypotheses.

3.2 Research Design

The research design was field and experimental survey. Field survey included the collection of the questionnaire data, the hospital retrievals, as well as the soil, water and air samples while experimental surveys involved the laboratory experiments carried out to get the needed data for the study.

3.3 Data Needs

The data was collected for the achievement of the set objectives which includes:

Objective 1: Determine the level of soil, water and air pollution by the rice mill on the host community.

Data to be Collected:-

i. The air quality within the rice mill environment as a result of the gaseous effluents.

ii. The physical, chemical and biological quality of the soils within the host community.

iii. The water quality of the stream- Ebonyi River that is very close to the rice mill.
iv. The significance of the environmental effects of Abakaliki Rice Mill on the host community.

Objective 2: Obtain the economic impacts of Abakaliki Rice Mill company Ltd on the host community. Data to be Collected:-

i. The employment opportunities of the Rice Mill for Amagu Community.
ii. The dependency on Abakaliki rice as food by Amagu Community.
iii. The dependency on the husks for alternative energy source of energy by Amagu Community.
iv. The dependency on husks for agricultural uses by Amagu Commuinty.
v. The significance of the economic effects on the host community.

Objective 3: Determine the implications of the environmentally related health problems in the host community such as pneumonia, catarrh, asthma, heart pains, impaired vision and the factors responsible for them. Data to be Collected:-

i. The population of the most common health cases such as pneumonia, catarrh, asthma, cholera, and diarrhea associated with rice milling operations from 2010, 2011, 2012, 2013 and 2014 among the residents
ii. The total number of affected people and the unaffected in the study area.
iii. The disease prevalence rates between 2010 and 2014.

3.4 Sources of Data

The data for this research were collected from primary and secondary sources. The primary data include questionnaire, field and laboratory measurements, while the secondary data include hospital retrievals from the health facilities (health centers) within the study area, relevant literature from books, journals, articles and publication of Ebonyi State Ministries of Lands, Survey and Planning, Commerce and industry. Data on the environmental effects of the rice milling activities were through questionnaire as well as field measurement and laboratory analyses of samples from soil, water and air. Moreover, the study relied on the secondary health surveillance data sourced from the local council of the study area for the health implications. This was to ensure the centrality and equality of source of information and gain time for proper analysis of the collected data. However, due to unavailability of secondary data on the economic situation of Abakaliki Rice Mill, the data on the economic effects were strictly from primary sources using questionnaire.

3.5 The Study Population

In order to achieve the aim of this research without any bias owing to the lingering misunderstanding as to the intent and actions of the government, the owners/workers of the Rice Mill and Ebonyi State government were not totally involved in this study. Whereas the Rice Mill owners were involved only in the area of health implications on them, the Ebonyi State views were only as captured in the papers. Again, the data on Abakaliki Rice Mill Company Ltd were got through physical visits to the industrial complex and environs by the researcher. Consequently, the study population is the total population of the 9 villages; Amagu, Amagu Onicha, Ebia Unuphu, Okpuitumo Unuphu, Inyimagu Unuphu, Amachi Unuphu, Igbeagu Unuphu, Ndi Nwamini and Agbaja Unuphu all in Amagu community. Amagu community is the ancestral home and motherland of Izzi clan located at Abakaliki L.G.A in the northern part of Ebonyi State of Nigeria. The total population of Amagu Community is 33,284; 15835 males and 17449 females based on 2.8% inter-census projection on 1991 population. (Ugo, 2009, National Bureau of Statistics, 1996)

3.6 Sampling Size and Techniques

Based on the large size of the population, a sample size derived using Taro Yamane's formula for a finite population according to Glenn (2009) in Nwachukwu (2011) was adopted. Taro Yamane formula is expressed as:

$$n = \frac{N}{1 + N(e)^2}$$

Where n=the sample size
N=the population size
E=level of significance (or limit of tolerable error (0.1)
1(unit) =constant.

Assuming the confidence level of 90% and unit of tolerable error of 10% (0.1)

$$n = \frac{33284}{1 + 33284(0.1)^2}$$

Total Sample size (n) = approximately 396

From the calculation above, a total number of 396 persons were selected. This represented approximately 1.2% of the study population while health related data was retrieved from health facilities as recorded on the study area.

However, 100 respondents were systematically randomly selected from the Abakaliki Rice Mill in order to get additional data for the health implications.

3.7 Research Instrumentation

The instruments employed in this research were field survey instruments and laboratory experimental instruments, and hospital records. These included, questionnaire, books, tape, pen and statistical tables for measurements and recordings and hand held GC Air Pollutant Monitors for air samples.

To investigate the environmental effects, economic effects, the health implications of the Abakaliki Rice Mill Company Ltd on the host community, as well as the acceptability of its location, a questionnaire-based survey was carried out on its residents. Questionnaires method is a commonly used method for research where a relatively large number of respondents are needed (Goodwin 2004).

In line with the opinion of Marshall et al (1999) and Silverman (2005), the questionnaires were used to enable the researcher gain information from a large number of subjects that enabled useful inferences to be made. In order to avoid any bias, the choice of respondents were only the residents of Amagu community, irrespective of sex, age, marital status educational background, occupation. However, they were selected from only those that had stayed in the community for not less than two years.

In order to maximize the response rate, closed questions with a range of pre-given answers was employed to give the impression that the questionnaire is simple to complete, thereby encouraging the respondent to complete the survey with eagerness and ease (Denscombe, 1998).

Owing to the presumed low level of education in the study area, the questionnaire was simplified for the respondents. The first section was on a personal data which was compulsory for all respondents. The other sections included the environmental effects, the economic effects, the health implications and lastly, the acceptability of the location of the rice mill. The effects under study were verified first by assigning numerical values to the variables and analyzed using the appropriate statistical tools.

The variables include the following:-

i. Soil quality, water quality and air quality.
ii. Job opportunities, source of revenue, source of alternative energy supply, development, dependency rate on Abakaliki rice as food.
iii. Inferences on items to testing the acceptability of the location of Abakaliki rice mill company Ltd.
iv. Recorded cases of environment-related health cases in the study area.

The questionnaire was tested to check its usefulness and reliability before they were sent to the participants. A time frame of two months was used for data collection by the researcher and other trained helpers before analysis by a competent statistician carried out.

The materials used for the collection of the water samples included; clean polythene bottles with caps, thermometer, masking tape (to indicate the date, time, temperature and source), permanent marker, gloves, cotton wool and cooler with ice packs.

The materials used for the collection of soil samples included, shovel, cutlass, trowel, nose mask, hand gloves, measuring tape and ruler, sample bags, a pen and jotting pad. The method of measurement was by the manual method whereby the soil samples were being scooped from the earth using manual tools.

3.8 Methods of Data Collection

1. Air Quality

The air quality was measured directly from the field using hand held GC; air pollutant monitors (sensitive electromagnetic monitors). In this study, sampling lasted 1 to 12 hours; reading in each parameter was taken according to hours indicated in Natural Ambient Air Quality Standard (NAAQS) and California Standard respectively. Three instruments were used namely: handheld GASMAN Nitrogen dioxide (NO_2) Gas monitor, handheld GASMAN Carbon Monoxide (CO) Gas monitor and handheld GASMAN Sulphur dioxide (SO_2) Gas monitor to measure the Nitrogen dioxide (NO_2), Carbon monoxide (CO) and Sulphur dioxide (SO_2) respectively. The instruments were hired from the Laboratory of Soil and Environmental Management, Ebonyi State University, Abakaliki.

With Gas Monitors placed in normal air, avoiding wind direction, the Gas Monitor switch was turned to the gas position. The green LED (light emitting diode) and the sounder operated once every 3 seconds. The LCD (liquid crystal display) showed 000. An alarm condition was indicated by means of the flashing red LED and sounder which would automatically reset after the gas concentration has passed out of alarm range. In order to obtain correct data CO, NO_2 and SO_2 readings were taken at 12 hourly between 9am and 8pm.

The 9 villages that make up Amagu community were divided into 3 clusters with proximity and pattern of settlement as the main bases with each of the clusters being sub-divided into 3 stationary points. The three different points in each of the 3 clusters were marked for the air quality measurements. The measurements were taking during the working and after-working periods covering 9 hours of intensive work; 15 minutes time intervals between each measurement and 30 minutes break. The work was started at 9am and ended at 8pm all covering a total duration of 12 hours. The result was supplemented with the subjective responses to environmental effects through questionnaires.

The reading on each parameter was taken twice (during working and after-working periods respectively) and replicated into three times in the morning and late in the evening at all the 9 stationary points of measurement comprising:-Unagboke Inyimagu, Divine Academy Inyimagu, EBSU farm Inyimagu, Obegu Agbaja, Ochudo City Agbaja, Azuiyiokwu Agabaja, Amagu Okpuitumo Unuphu, Ndi Nwamini and Ndi Ogbakuru Amagu. The ambient concentration of CO_2, NO and SO_2 gotten from the community were compared with the existing standard ambient air quality.

2. Water Quality

Water sampling was carried out in 12/05/2015. Ebonyi River was used as the water source being the major water body that is very close to the Rice Mill. Four different water samples from source points were collected from the river. Sampling was done according to World Health Organization (W.H.O, 2004). A total of four samples (1 liter each) were collected from source into four polythene bottle and used for the physiochemical and biological analyses. The samples were replicated for accuracy and the results of the reading were added up and mean value arrived. The samples were preserved with icepack under a temperature of 4^0C and immediately transported to Pymotech Research Centre, Enugu. The temperature of the samples was determined on site. The results were compared to World Health Organization Standards of 2012 (WHO, 2012).

The physical parameters determined were temperature, color, conductivity and turbidity. The chemical parameters were: total dissolved solid (TDS), total hardness, chloride, Nitrate, Calcium and Magnesium. The biological properties determined were: dissolved oxygen (DO), Chemical oxygen demand (COD) and E-coli.

The data collected were presented in statistical tables and analyzed using Kruskal-Wallis test.

3. Soil Quality

A survey of the site was carried out and then the soil samples were collected horizontally at the depths of 0-15, 15-30cm and 30-45cm using soil auger and shovel. The choice of collecting the soil samples horizontally was to ensure that only the soil samples at any given layer was collected. The soil was dried, sieved with 2mm mesh, taken in nylon bags for laboratory analysis.

The data collected were presented in statistical tables and analyzed using Kruskal-Wallis test.

4. Hospital Records

The hospital record from the health department of Abakaliki L.G.A was relied upon. Tables were designed and used in extracting monthly cases of the environmentally-induced health problems like Asthma, Typhoid, cholera, diarrhea, and malaria, etc (see appendix 3). The five health cases were the ones available as at time of this research and as such the only ones extracted for analysis. The data covered five years (2010 to 2014).

5. Questionnaire

The clustered systematic sampling technique was employed due to the large study population, large sample size as well as the scattered settlement pattern. The 9 villages that make up Amagu community were clustered into 3 each comprising 3 villages with each of the clusters having 132 (about 33.3%) of the total questionnaires (396) distributed as shown in table 3.1. However, the questionnaires were equally distributed to 100 Rice Mill workers using just the systematic random sampling method.

Table 3.1: Distribution of Respondents in Clusters

Respondents	Frequency	Percentage
ClusterA(Inyimagu, Amagu and Igbeagu)	132	33.3%
ClusterB (Agbaja, Ebiya, Ndi Nwamini)	132	33.3%
ClusterC (Amagu, Amagu Onicha, Okpuitumo	132	33.3%
Rice Mill Operators/ Workers	100	100

To ensure proper and wide coverage in obtaining the needed information, households within the residential areas as well as the rice mill operators/owners were systematically sampled. This was achieved by numbering the number of households in the area of study and dividing it by the number of questionnaires to be administered. The households and the Rice mill units were selected until the number allotted was exhausted and in each of them selected, one literate person was given the questionnaire to answer for efficiency.

3.9 Methods of Data Presentation and Analysis

The primary data from responses of participants concerning the environmental effects, economic effects and health implications were presented using both statistical tables and charts. However, whereas the environmental effects and the economic effects were analyzed using Wilcoxon Signed Ranks Test, the health implications (diseases prevalence) was analyzed using the Kruskal-Wallis test. The acceptability of location of the Rice Mill was analyzed using statistical tables and simple percentages and prognostic inferences.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Data Presentation and Analysis

This chapter dealt with the presentation and analysis of the primary and secondary data collected from field survey. The data collected from respondents, using questionnaire and the ones collected from health facilities, laboratory analysis of collected water, soil and air samples were first subjected to analyses with reference to W.H.O standard. Afterwards, they were subjected to statistical tests with the prime objective of establishing the significance of the environmental and the economic effects as well as the health implications of Abakaliki Rice Mill Company Ltd on Amagu community.

Table 4.1 shows that out of 396 copies of questionnaires distributed by the researcher to the residents of Amagu community, all were completed and retrieved.

Table 4.1: Questionnaires Distribution and Retrieval

Questionnaire	Frequency	Percentage
Retrieved	396	100%
Not retrieved	Nill	0%
Total	396	100%

The questionnaire was structured in 5 sections made of: the demographic data, the environmental effects, the economic effects, health implications of the Rice Mill.

4.2 Demographic Data

The survey covered the young, the middle age and the aged. Greater number of the respondents representing 58.8% was within the ages of 18-34 years, with the least being very aged of 76 years and above representing 4.6% of the total respondents. See table 4.2. What the age distribution implies is that both those who have been in the community right from the inception of the Rice mill industry and those that met it as it was already in operation but may have had the opportunities of experiences of the environments. This could influence level of reasoning.

Table 4.2: Age Distribution of Respondents

RESPONDENTS	FREQUENCY	PERCENTAGE
BELOW 18 YEARS	61	15.4%
18-34 YEARS	233	58.8%
35-75 YEARS	84	21.2%
76 YEARS-ABOVE	18	4.6%
TOTAL	396	100%

Greater number of the participants was female representing 55.1% while the males were 49.9%. This shows that the survey covered both sexes very well. This is shown in table 4.3. This choice of both sexes is to ensure that all the classes within the society were covered.

Table 4.3: Sex Distribution of Respondents

RESPONDENTS	FREQUENCY	PERCENTAGE
MALE	178	44.9%
FEMALE	218	55.1%
TOTAL	**396**	**100%**

Table 4.4 showed that most of the respondents were single in terms of marital status, representing 54%, whereas 44% represented the married class, with 2% representing the divorced group. This was to involve all the human elements in the study area.

Table 4.4: Marital Status of Respondents

RESPONDENTS	FREQUENCY	PERCENTAGE
SINGLE	214	54%
MARRIED	174	44%
DIVORCED	8	2%
TOTAL	**396**	**100%**

Table 4.5, shows that the greater number of the respondents, presenting 38.1% had Senior School Certificates as the highest qualification, followed by undergraduates that had 26%, F.S.L.C, 15.2% and graduate, 11.9%. Those that had no school certificates but knowledgeable enough of the subject matter, represented 8.8%. However, none of the respondents had postgraduate qualification. This implies that the participants cut across all classes in terms of

educational background and as such knowledgeable enough of the parameters under survey.

Table 4.5: Educational Qualification of Respondents

RESPONDENTS	FREQUENCY	PERCENTAGE
NONE	35	**8.8%**
F.S.L.C	60	**15.2**
S.S.C	151	**38.1%**
UNDERGRADUATE	103	**26%**
GRADUATE	47	**11.9%**
POST-GRADUATE	NILL	**-**
TOTAL	**396**	**100%**

Fig 4.1 showed that more of the respondents were of business class (95 persons).That was followed by the students, farmers, civil servants, artisans, applicants, Rice Mill operators and hunters whose population sizes were as follows: -83, 66, 44, 40, 27, 16, 13, and 12 people respectively. However, the survey took into cognizance almost all of the occupations common in the area of study. This reduced to the barest minimum, undue bias in survey as in many cases; many so badly fix their mind on theories that they blur their practical experiences.

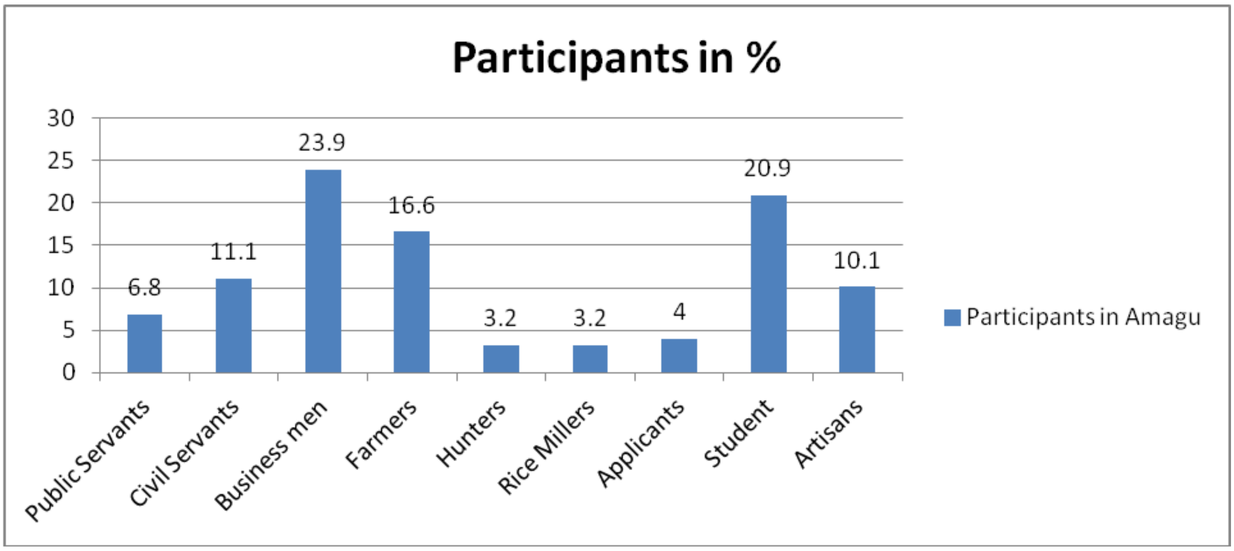

Fig. 4.1: Occupations of Participants

Table 4.6: Experience Time of Respondents

RESPONDENTS	FREQUENCY	PERCENTAGE
LESS THAN 2 YEARS	61	15.4%
2-5 YEARS	87	21.9%
6-9 YEARS	53	13.4%
10-13 YEARS	56	14.1%
14-17 YEARS	39	9.8%
18YEARSAND ABOVE	100	25.3%
TOTAL	**396**	**100%**

From table 4.6, it is shown that 25.3% of the respondents have lived in the study area for 18 years and above. However, from 1 year to<2year, 2 to 5 years, 6 to 9 years, 10 to 13 years and 14 to 17 years, there are little variations in terms of the number of respondents. This shows that those who have stayed in the study a short and long periods of time were surveyed.

4.3 Environmental Effects

4.3.1 Questionnaire Data on Environmental Effects of Abakaliki Rice Mill on Amagu Community

The environmental parameters were surveyed as shown in table 4.7

Table 4.7 Data on Environmental Effects of Abakaliki Rice Mill on Amagu Community

Item	Description	Agreed	Disagreed	Unsure
1	Dust/smokes/odour from Rice Mill disturb you	164(41.4%)	214(54%)	18(4.5%)
2	Abakaliki Rice Mill makes your village dirty.	54(13.6%)	140(35.4)	202(51%)
3	Wastes from the mill flow into Ebonyi River	218 (55%)	122(30.8%)	56 (14.1)
4	Waste from the mill improve the soil nutrients	181(46%)	103(26%)	112(28%)
5	Dumped husks block your water channels	89 (22.5%)	201(50.8%)	106(26.8%)
6	Air within Abakaliki Rice Mill is always dusty	311 (78.5%)	41 (18.4%)	44 (11.1%)
7	Surrounding bushes always catch fire	214(54.1%)	72(18.2%)	110(27.7%)
8	Noise from Abakaliki Rice Mill disturb you	224 (56.6%)	103 (26%)	69 (17.4%)
	Total	1455	996	717

Source: Author's computation from Field survey 2015.

From table 4.7, it is shown that out of total of 396 respondents, 139 respondents representing 35% of the total respondents strongly disagree that dusts, smokes and odour from Abakaliki Rice Mill disturb them while 75 respondents representing 18.9% just disagree. However, 94 representing 23.7% strongly agree and 70 representing 17.7% agree. However, 18 respondents representing 4.5% of the total respondents were not sure of the situation.

From item 2 also on table 4.7 which measured whether the rice mill makes the host community dirty, the highest number of the respondents; 140 out of 396 respondents, disagree as against 54 respondents that strongly agree.

On item 3 which tested whether the wastes from the Mill flow into the River in the area, the highest number of the respondents; 132 (33.3%) out of the 396 respondents strongly agree while 101(25.5%) respondents strongly disagree. However, 56 (14.1%) are not sure of the situation.

On item 4 that investigated whether the wastes from the Rice Mill improve the soil nutrients, the highest number of the respondents 112 out of 396 (28%) are not aware of the effects of Rice Mill wastes on the soil nutrients. However, 103 (26%) of the respondent strongly disagree, while 17% agree.

On item 5 which investigated whether the wastes clog the water channels, out of the 396 respondents, 131 (33.1%) representing the highest number strongly disagree while 106 (26.8%) are not sure. However, strongly agree and agree had 9.8% and 12.6% respectively.

On item 6, which was on whether the air in the area is always dust, the highest number of the respondents 168 out of 396 (42.4%) strongly agree, followed by agree 111 (28%). But those who were not sure of the situation were 44 (11.1%). However, 41 (10.5%) and 32 (8%) disagree and strongly disagree respectively.

On item 7 which investigated whether the presence of the Rice Mill constitutes to fire hazards in the area, greatest number of the respondents do are not sure of the effects, while 72 (18.2%) strongly disagree and 84(21.2%) of the respondents agree.

Item 8 which studied whether noise generated from the Rice disturb the community, the highest number of the respondents 116 (29.3%) agree, followed by strongly disagree that have 108 (27.3%). 70 (17.7%) of the respondents are not sure, while 68 (17.2%) and 35 (8.8%) agree and strongly agree respectively.

4.3.2 Physical and Chemical and biological Properties of Soil Samples from Amagu Community.

<u>Percentage Sand</u>:- From table 4.8, the percentages of sand in the various sites ranged from 34.00%,-63.00%; with the highest being site C, followed by site A and control site D with 44% respectively.

<u>Percentage Silt</u>:- The percentage silt in the various sites ranged from 15.4%-36.4%; with the highest being site B, followed by site A and control site D with 27.4% and 19.4% respectively (see table 4.8).

<u>Percentage Clay</u>: - The percentage silt in the various sites ranged from 21.6%-36.6%; with the highest being control site D, followed by site B and site A with 29.6% and 28.6% respectively (see table 4.8).

Table 4.8 Result of Laboratory Analysis of Soil Samples

	SAMPLE BATCHES IN CLUSTERS					
	S/N	A	B	C	Control Site	Remarks
PHYSICAL PROPERTIES	% SAND	44.00	34.00	63.00	44.00	Clayey Sand
	% SILT	27.4	36.4	15.40	19.40	
	% CLAY	28.60	29.60	21.60	36.60	
CHEMICAL PROPERTIES	pH (H_20); 1:2.5	CL	CL	CL	CL	
		5.90	6.10	5.10	5.20	Acidic
	P(Cmol/kg)	39.00	25.80	20.00	27.20	Strong acid solution
	% N	0.042	0.056	0.028	0.063	Unsuitable for dump sites
	% OC	1.66	0.57	0.24	0.16	decreased exchange capacities=encourages surface flooding
	% OM	2.86	1.00	0.42	0.32	Low in plant yield support except site A

	Mg(Cmol/kg)	5.60	4.00	1.60	3.20	
	K (Cmol/kg)	0.047	0.055	0.056	0.082	
	NA(Cmol/kg)	0.101	0.110	0.114	0.123	
	EA(Cmol/kg)	0.64	0.16	16.32	20.40	Highly exchangeable
	ECEC(Cmol/kg)	18.388	9.925	22.09	27.805	Easily exchangeable= Heavy metal concentration in the soil
	% BS	97	98	26	27	Partial micro-nutrient solubility mobility and leaching

Source: Author's Field work; Analyzed by Dept. of Soil Science and Environmental Mgt. Lab, ESUT, ENUGU

Note: *SITE A=Unagboke Inyimagu (Very close to the Rice Mill; cluster A)*
SITE B=Obegu Agbaja (Close to the Rice Mill; cluster B)
SITE C=Amagu Unuphu (Relatively far from the Rice Mill; cluster C)

From table 4.8, the texture of the soil samples were as follows: site A was clayey sandy (%sand: %clay =44.0: 28.6) site B was sandy silt (%sand: %silt=34.0: 36.4), Site C was clayey sandy (%sand: % clay=63:21.6% while the control site was also clayey sandy (% sand: clay=44.0:36.6).

The soil in Amagu from the survey being greatly of sand parent material shows that it is of good economic importance. Again, it absorbs water easily, hence reduces flooding. What this implies is that it high a high tendency of breeding less mosquitoes and low chances of promoting malaria.

PH Value: The mean pH values for the soil samples were 5.90, 6.10, 5.10 and 5.20 respectively. According to Kumar (1987), soils below 3.34 and 3.96 are extremely acidic; they tend to be an increased micro nutrient solubility, as well as heavy metals concentration in the soil. This implies that the soil at the various site were moderately acidic.

Percentage Nitrogen: The level of Nitrogen across 0-45cm depth in all the sites was between 0.042 Cmol/kg -0.063 Cmol/kg. Nitrogen above 0.4% in the soil is not suitable for refuse dumpsites because it will lead to leaching excess nitrogen into the ground water (Tel *et al.*, 1984).

Phosphorus: Across 0-45cm, the sites recorded between 20.00-39.00Cmol/kg. Control plot recorded 27.20Cmol/kg. High phosphorus aids high plant root penetration and formation of a complex chemical compound that forms strong acid solution (Tel *et al.*, 1984).

Calcium: The calcium concentration at the various sites ranges from 4.00-12.00Cmol/kg. The site A has the highest, followed by Site B with 5.60Cmol/kg.

Magnesium: Magnesium concentration in the sites ranged from 1.6Cmol/kg-5.6Cmol/kg, with the highest being site A. This was followed by site B and control site D, having 3.20 and 4.0Cmol/kg respectively.

Potassium: Potassium concentration in the sites ranged from 0.047Cmol/kg-0.082Cmol/kg, with the highest being site D. This was followed by site C and control site B, having 0.056 and 0.055Cmol/kg respectively with the least being site A.

Sodium: Sodium concentration in the sites ranged from 0.101Cmol/kg-0.123Cmol/kg, with the highest being site D. This was followed by site C, and control site B, having 0.114 and 0.110Cmol/kg respectively with the least being site A.

Exchangeable Acid (EA): The Exchangeable acidity ranges from 0.16-20.40Cmol/kg, with the control site having the highest value (20.40), followed by Site C (16.32Cmol/kg).

Effective Cat ion Exchange Capacity (ECEC): The ranges of ECEC were 9.925-27.805Cmol/kg; with the highest being the control site (27.805), followed by site A (22.09Cmol/kg). Soils above 5mg/100g are easily exchangeable and this may result to acidity and alkalinity at this level, and lead to heavy metal concentration in the soil (Kumar, 1987).

Percentage Organic Matter (%OM): The ranges of organic matter were 0.32% at the control site to 2.86% at Inyimagu (the rice mill site). According to Ekundayo *et al*, (1996), organic matter above 3.5% will favor micro-nutrient solubility and mobility, thus would favour efficient plant growth. However, the four sites considered in this study shows that it is only the Inyimagu site that is likely to efficiently support plant yield.

Percentage Organic Carbon: Organic carbon (1.6%) was recorded at the control site. At other sites, the range was 0.16-0.57. This is not conducive for heavy metal chelate formation. It decreases exchange capacities as well as infiltration of surface water thereby encouraging surface flooding (Ekundayo *et al*, 1996).

Base Saturation: Base saturation ranged between 26-98% for all sites. However the control site recorded 27% while site A (Inyimagu) recorded 98 followed by Site B (97%). According to bases saturation greater than 80% may give rise to dispersion which increases micro-nutrient solubility, mobility and leaching (Ekundayo, 2003), Site A and B fell within this category.

4.3.3 Physco-chemical and Biological Properties of Water

The result of the analysis from Pymotech laboratory was analyzed with respect to W.H.O maximum permissible standard as shown in table 4.9.

Table 4.9 Result of Laboratory Analysis of Ebonyi River Water Samples

N	Parameters	A_1	A_2	A_3	A_4	W.H.O STD.	Remarks w.r.t W.H.O
1	Temperature(^{0}c)	27.60^{0}C	27.70^{0}C	28.30^{0}C	26.80^{0}C	20-30^{0}C	Within std.
2	PH	7.50	6.85	6.90	8.75	6.50-9.50	Within std.
3	Odour	D.S	D.S	D.S	D.S	Odourless	Below std.
4	Color(%transmittance	CL	CL	CL	CL	Colorless	Within std.
5	Conductivity(us/c)	1180.00	1175.00	1183.00	1182.00	1200us/m	Within std.
6	Turbidity (NTU)	9.35	8.45	9.40	10.20	5.00NTU	Far below std.
7	Zn (mg/l)	0.17	0.16	0.18	0.17	3.0mg/l	Within std.
8	N(mg/l)	0.026	0.024	0.021	0.033	50mg/l	Within std.
9	Ca (mg/l)	90.70	91.40	89.50	91.20	200mg/l	Within std.
10	Pb (mg/l)	0.056	0.053	0.057	0.060	0.01mg/l	Below std.
11	Cl (mg/l)	227.20	228.00	227.10	226.50	250mg/l	Within std.
12	Mg (mg/l)	103.20	101.50	104.00	104.10	150mg/l	Within std.
13	Fe (mg/l)	0.025	0.024	0.026	0.025	3.0mg/l	Within std.
14	Cu (mg/l)	None	None	None	None	2.0mg/l	N.A
15	Manganese (mg/l)	0.60	0.70	0.55	0.55	0.4mg/l	Below std.
16	TH	119.63	118.8	119.50	120.59	500mg/l	Within std.
17	TS (mg/l)	35.67	36.40	35.80	34.81	500mg/l	Within std.
18	TSS (mg/l)	59.85	58.90	59.00	61.65	50mg/l	Below std.

Source: Author's Field work 2015; Analyzed by Pymotech Laboratories, Enugu and WHO Drinking water standard, 2012.

Note: *TS=Total Solid, TSS=Total Suspended Solid, THD=Total Hardness, Cl=Chlorine, N=Nitrate, Mg=Magnesium, Ca=Calcium, Mn=Manganese, Fe=Iron, Lead=Pb, Zn=Zinc, Cu=Copper, CFU= Coli form count, DO= Dissolved Oxygen, CL=Colourless D.S=Decaying smell*

Temperature: The temperatures of the four water samples collected were: - 27.6^{0}C, 27.7^{0}C, 28.3^{0}C, 26.8^{0}C. The water temperatures were within the W.H.O standard of 23^{0}C to 30^{0}C

Temperature is a critical water quality parameter; it also affects toxicity of metals (Awofulu *et al.*, 2007). This phenomenon could be said to also be responsible for the good level of fishing in the River mostly within Amagu community.

PH: The W.H.O limit is 6.5-9.5. The pH value for the water samples were 7.5, 6.85, 6.9 and 8.75. This implies that the water met the standard for pH level. High pH value affects the solubility and bioavailability of heavy metals in water (EPA, 2003).

Odour: The odour of the water samples is decaying smell. However, the W.H.O maximum permissible is odourless. This suggests that the samples were below the acceptable standard.

Conductivity: The result shows that all the collected samples recorded conductivity of 1180us/cm, 1183us/cm, 1175us/cm and 1182us/cm. All these fell within W.H.O standard of 1200us/cm.

The electrical conductivity is a measure of ions or total salt content in water (Morrison et. al; 2001). High conductivity in water is associated with the presence of dissolved solids, contaminants especially electrolytes and some metallic ore in water (Awofolu *et al.*, 2007).

Turbidity: The turbidity of the water sample was 8.45NTU, 9.35NTU, 9.40NTU and 10.20NTU. They all exceeded the W.H.O turbidity standard of 5NTU.

Turbidity is a measure of the degree to which water loses its transparency as a result of particles suspension. The high turbidity is associated with algae growth and improper waste disposal (Alpha, 1992, Havser, 2001). It is tantamount to poor water quality and as such, is unacceptable for human consumption.

Colour: Ideally, portable water should be clear and colourless as recommended by W.H.O standard. The result showed that the water samples were all colorless and were within the W.H.O acceptable standard. Although colour change may be associated with the presence of natural substance, suspended matter and bacteria which may enter into the water through run-off when there is heavy down pour.

Total Solids: The total solids recorded in the four samples were 35.67mg/l, 36.40, 35.80mg/l, 34.81mg/l respectively. The W.H.O limit is 500mg/l. That shows that the water samples were within the W.H.O acceptable standard for drinking water.

Total Suspended Solids (TOS): The total suspended solid in the samples were 59.85mg/l, 58.90mg/l, 59.00mg/l and 61.65mg/l. The W.H.O limit for TOS is 50mg/l. The samples were above the W.H.O acceptable standard for drinking water.

Total Hardness: The total hardness recorded were 119.63mg/l, 118.80mg/l, 119.50mg/l and 120.59mg/l. However, the W.H.O limits 500mg/l. This shows that all the samples met the standard in this parameter.

Water hardness occurs as a result of excessive presence of Calcium and Magnesium ion (David et al., 2005), while total hardness is a measure of all the dissolved minerals such as Calcium, Magnesium, Sodium, etc. No health effect has been associated with drinking hard water within the area, however hard water is unsuitable for domestic use because it does not easily latter with soap. Increase water hardness above 200mg/l leads to scale deposit in pipe (Van, 2003).

Dissolved Oxygen (DO): Dissolved Oxygen refers to the amount of oxygen dissolved in water. Although W.H.O do not have specific standard for DO in drinking water but research shows that the threshold for DO is 5.0mg/l for drinking water and should be more than 5.0mg/l for agricultural and domestic purposes (Cruise *et al,* 1994). The dissolved oxygen in the water sample was 19.84mg/l, 20.00mg/l, 18.55mg/l and 20.97mg/l respectively. Based on this report, the water resources are only good for domestic and agricultural purposes.

Chloride (Cl): The result showed the Chloride concentration in the samples as 227.2mg/l, 228.00mg/l, 227.10mg/l, and 226.50mg/l respectively whereas the W.H.O limit is 250mg/l. This showed that the samples met the criteria for drinking water.

Residual Chlorine in water is important because it helps to kill any micro organism that comes in contact with the water after treatment in the storage tank. Nevertheless at low concentration chlorine is harmless but at higher concentration, chlorine can react with organic matter in water and form dangerous carcinogenic trihalomethane. Chlorine presence may originate from fertilizer application, run off and septic tank effluents which probably leached through the soil and pollute the water (Tredoux *et al.*, 2000). Chlorine can travel a great distance in ground water gaining entrance into the aquifer when it comes in contact with rain water as a result of solid waste dissolution (Hughes, 2004).

Nitrate (N): The nitrate concentrations in the water samples are 0.026mg/l, 0.024mg/l, 0.021mg/l, and 0.033mg/l respectively. The W.H.O standard is 50mg/l. All the samples satisfied this requirement. Excess nitrate is associated with a health problem known as methaemoglobin (called blue-baby syndrome) in infants less than six months and pregnant women (Adekunle *et al.,* 2007, Adeyemo *et al.,* 2002). Excess nitrate in water cannot be removed by boiling but must be treated through distillation.

Magnesium (Mg): The laboratory result showed that the concentrations of Magnesium in the water samples were 103.20mg/l, 101.50mg/l, 104.00mg/l, and 104mg/l whereas the W.H.O limit is 150mg/l. All the samples met the requirement for drinking water. Excess Magnesium in water can cause slacking, depression and nerve problems.

Calcium (Ca): Calcium concentrations in the samples were 90.70mg/l, 91.40mg/l, 89.50mg/l, and 91.20mg/l, while the W.H.O limit is 200mg/l Ca.

This suggests that the samples fell within the acceptable standard. The samples are all suitable for drinking and domestic purposes. Both calcium and Magnesium are metabolic function and essential for the maintenance of a healthy body

Zinc (Zn): The concentrations of zinc in the samples are 0.17mg/l, 0.16mg/l, 0.18mg/l, and 0.033mg/l. W.H.O limit for this parameter is 3.0mg/l. This shows that the samples are within the acceptable standard. Zinc is not known to cause any health problem in human and animal but can give rise to undesirable tastes.

Iron (Fe): The W.H.O limit for Fe is 3.0mg/l. The laboratory result shows that Fe concentrations in the water samples are 0.025mg/l, 0.024mg/l, 0.026mg/l and 0.025mg/l. This implies that all the samples met the W.H.O standard. High Iron concentration in water could impact taste, discoloration, and turbidity (W.H.O, 1984).Iron also can form rust in water, clog and stain pipes (Duestsch, 2003).

Manganese (Mn): The concentrations of Manganese in the samples were 0.60mg/l, 0.70mg/l, 0.55mg/l and 0.55mg/l respectively. All these were above the W.H.O standard of 0.4mg/l. Manganese concentration in water can be a result of waste dissolution (Hughes, 2004). Stains caused by Manganese are harder to remove than ion (Williams, et al., 2005).

Lead (Pb): The concentrations of Lead in the samples are: - 0.056mg/l, 0.053, 0.057mg/l and 0.060mg/l. The W.H.O limits 0.01mg/l. The parameter is high in the samples collected as it is above the W.H.O acceptable standard. Excessive concentration of Lead is undesirable.

4.3.4 Air Quality in Amagu Community.

National Ambient Air Quality Standard (NAAQS) (1995) specifies the permissible standards of 9ppm to 35ppm for CO, 0.1ppm for NO_2 and 0.14ppm for SO_2. The results from Amagu community during working and off-working period are as shown in tables 4.10 and 4.11 respectively.

Table 4.10: Result of Air Quality during Working Period of Abakaliki Rice Mill

S/N	Sampling site	Pollutant	R_1(ppm)	R_2(ppm)	R_3(ppm)	R_4(ppm)	AV.HR
1	CLUSTER A_1	CO	0.87	0.88	0.85	0.88	30mins
	(Unagboke Inyimagu)	NO_2	0.30	0.20	0.40	0.30	30mins
		SO_2	0.10	0.09	0.10	0.11	30mins
2	CLUSTERA$_2$ (Divine Academy, Inyimagu)	CO	0.83	0.85	0.81	0.83	30mins
		NO_2	0.20	0.20	0.10	0.30	30mins
		SO_2	0.10	0.08	0.10	0.12	30mins
3	CLUSTER A_3 (EBSU FARM; Inyimagu)	CO	0.84	0.86	0.81	0.85	30mins
		NO_2	0.10	0.13	0.08	0.09	30mins
		SO_2	0.10	0.07	0.09	0.14	30mins
4	CLUSTER B1(Obegu Agbaja)	CO	0.82	0.80	0.81	0.85	30mins
		NO_2	0.00	0.00	0.00	0.00	30mins
		SO_2	0.10	0.10	0.10	0.10	30mins
5	CLUSTER B2 (Ochudo City; Agbaja)	CO	0.83	0.87	0.80	0.82	30mins
		NO_2	0.00	0.00	0.00	0.00	30mins
		SO_2	0.00	0.00	0.00	0.00	30mins
6	CLUSTERB$_3$(Azuiyiokwu village; Agabaja)	CO	0.85	0.83	0.88	0.84	30mins
		NO_2	0.10	0.09	0.10	0.11	30mins
		SO_2	0.00	0.00	0.00	0.00	30mins
7	CLUSTER C_1 (Amagu Okwuitumo Unuphu)	CO	0.84	0.84	0.85	0.83	30mins
		NO_2	0.10	0.10	0.10	0.10	30mins
		SO_2	0.10	0.11	0.12	0.07	30mins
8	CLUSTER C_2 (Ndi Nwamini Amagu)	CO	0.86	0.85	0.87	0.86	30mins
		NO_2	0.00	0.00	0.00	0.00	30mins
		SO_2	0.10	0.10	0.10	0.10	30mins
9	CLUSTERC$_3$(Ndi Ogbakuru Amagu)	CO	0.84	0.84	0.83	0.85	30mins
		NO_2	0.20	0.20	0.30	0.10	30mins
		SO_2	0.10	0.08	0.09	0.13	30mins

Table 4.11: Result of Air Quality during Off-Work Period of Abakaliki Rice Mill

S/ N	SAMPLING SITE	POLLUT-ANTS	R_1(ppm)	R_2(ppm)	R_3(ppm)	R_4(ppm)	AV.HR
1	CLUSTER A_1	CO	0.83	0.82	0.81	0.86	30mins
	(Unagboke Inyimagu)	NO_2	0.10	0.09	0.12	0.09	30mins
		SO_2	0.10	0.11	0.08	0.11	30mins
2	CLUSTER A_2(Divine Academy)	CO	0.80	0.78	0.81	0.81	30mins
		NO_2	0.10	0.13	0.07	0.10	30mins
		SO_2	0.00	0.00	0.00	0.00	30mins

3	CLUSTER A_3 (EBSU FARM)	CO	0.81	0.85	0.83	0.75	30mins
		NO_2	0.10	0.11	0.10	0.09	30mins
		SO_2	0.10	0.09	0.09	0.12	30mins
4	CLUSTER B1 (Obegu Agbaja)	CO	0.80	0.79	0.81	0.80	30mins
		NO_2	0.00	0.00	0.00	0.00	30mins
		SO_2	0.10	0.08	0.09	0.13	30mins
5	CLUSTER B2 (Ochudo City; Agbaja)	CO	0.80	0.80	0.78	0.82	30mins
		NO_2	0.00	0.00	0.00	0.00	30mins
		SO_2	0.00	0.00	0.00	0.00	30mins
6	CLUSTER B_3 (Azuiyiokwu village; Agabaja)	CO	0.81	0.80	0.81	0.82	30mins
		NO_2	0.10	0.12	0.07	0.11	30mins
		SO_2	0.00	0.00	0.00	0.00	30mins
7	CLUSTER C_1 (Amagu Okpuitumo Unuphu)	CO	0.80	0.82	0.81	0.77	30mins
		NO_2	0.10	0.14	0.06	0.10	30mins
		SO_2	0.10	0.10	0.10	0.10	30mins
8	CLUSTER C_2 (Ndi Nwamini)	CO	0.81	0.80	0.81	0.82	30mins
		NO_2	0.00	0.00	0.00	0.00	30mins
		SO_2	0.10	0.10	0.10	0.10	30mins
9	CLUSTER C_3 (Ndi Ogbakuru Amagu)	CO	0.80	0.78	0.80	0.82	30mins
		NO_2	0.10	0.13	0.07	0.10	30mins
		SO_2	0.00	0.00	0.00	0.00	30mins

Source: Author's Field work as taken and read from gas monitors of Dept. of Soil Science and Environmental Mgt. Lab, EBSU, Abakaliki.

During the working period as shown in table 4.10, the highest concentration of CO was recorded as 0.90ppm in Unagboke Inyimagu (cluster A) and the lowest value was recorded as 0.80ppm in Ochudo City (cluster B) at 30mins average hour. On the other hand, during the off-period, the highest concentration of CO was recorded as 0.86ppm in Unagboke village (cluster A);

while the lowest value of 0.75ppm was recorded in the same cluster A (EBSU Farm precisely).

In relation to the International Air Quality Standard of 35ppm at 30mins average hour, the concentration of CO recorded highest as 0.90ppm was within the permissible limit. This implies that the air quality in relation to CO within the study area was of good quality.

The highest concentration of NO_2 during the working period was recorded as 0.40ppm in Unagboke village (cluster A) and lowest value was recorded as 0.00 at two different points in cluster B (Ochudo city and Obegu Agbaja) and cluster C (Ndi Nwamini Amagu).

The 0.40ppm in cluster A is above the International Air quality Standard of 0.1ppm, thus suggesting that there was high concentration of NO_2 in the study area. However, it is not yet hazardous but at medium level based on WHO standard range of 0.00ppm-50ppm (Microsoft Encarta, 2009).

Again, the tables 4.10 and 4.11 show that the concentration of $SO_{2,}$ during working period the highest value was recorded as 0.14ppm in cluster A (precisely, EBSU Farm, Inyimagu), while the lowest value of 0.00ppm was also observed in cluster A (Divine Academy, Inyimagu precisely) as well as cluster B (Azuiyiokwu village; Agbaja). However, cluster C was between the ranges of 0.09ppm to 0.13ppm.

The highest value of 0.14ppm of SO_2 in the study area is still within the International Air Quality Standard of 0.14ppm. This suggests that the concentration of SO_2 within the study area as at time of this research was of good quality standard. This also goes to buttress that the SO_2 concentration had no significant health implications.

4.4.0 Economic Effects

4.4.1 Questionnaire Data on Economic Effects of Abakaliki Rice Mill on Amagu Community

The items under which the economic effects are as presented in table 4.12

Table 4.12 Result of Economic Effects of Abakaliki Rice Mill on Amagu Community

Item	Description	Agreed	Disagreed	Unsure
1	Abakaliki Rice is the major type of Rice in Amagu	379(95.7%)	9(2.3)	8(2.0)
2	Abakaliki Rice Mill creates job opportunities	378(95.5%)	3(0.76)	15(3.8)
3	Rice husks from the Rice Mill improves crop yield	338(85.6%)	13(3.0)	45(11.4)
4	Rice Husks are used as fowl feeds	301(76%)	32(8.0)	63(16.0)
5	Rice husks is used as an alternative source of energy	328(83%)	55 (13.7)	13(3.3)
6	Abakaliki Rice Mill is a source of your revenue	350(88.4%)	12(3.0	37(9.3)
7	Abakaliki Rice Mill boosts development	356(88.9%)	6(1.5)	37(9.3)
8	Abakaliki Rice Mill boosts your rice farming	346(87.4%)	20(5.0)	30(7.6)
	Total	2776	150	248

Source: Source: Author's computation from Field survey 2015.

Analysis of item 1 on table 4.12 shows that out of total of 396 respondents, 321 respondents representing 81% of the total respondents strongly agree, while 58 respondents representing 14.6% just agree. However, only 5 representing 1.3% strongly disagree and 4 representing 1% disagree that Abakaliki Rice is the major type of rice in Amagu Community. However, 8 respondents representing 2% of the respondents were not sure whether or not it is the major type of rice.

On item 2 which tests whether or not the Abaklikili Rice Mill creates job opportunities for Amagu community, 286 (72.2%) of the respondents strongly agreed, while 92(23.2%) agreed whereas none strongly disagreed, 3 (0.76%), disagree while 15 (3.78%) are not sure.

From item 3 which studies whether the rice husks from the rice mill improves crop yield, 246 (62.1%) strongly agree, 92 (23.2%), 45 (11.4%) are not sure. However, 5 (1.3%) disagree, and 8 (2%) strongly disagree.

On item 4 which studies whether or not, the rice husks are used as fowl feeds, 203 (51.3%), 90 (22.7%) agree while 63 (15.9%) are not sure. However, 19 (4.8%) disagree and 13 (3.3%) strongly disagree.

On item 5, 259 (65.4%) strongly agree, 69 (17.2%) agree, 55 (13.9%) are not sure. However, 10 (2.5%) and 3 (0.75%) strongly disagree.

On item 6, 282 (71.2%) of the respondents strongly agree, 68 (17.2%) agree, but 36 (9.1%) are not sure. However, 5 (1.3%) disagree while 7 (1.8%) strongly disagree.

On item 7, 273(68.9%) of the 396 respondents strongly agree, 83(20.9%) agree, but 37 (9.3%) are not sure. However, 4 (1%) disagree, while 2 (0.5%) strongly disagree.

On item 8, 277(69.9%) of the 396 respondents strongly agree, 69 (17.4%) agree, However, 6 (1.5%) disagree, while 14 (3.5%) strongly disagree.

4.5 Health Implications

4.5.1 Questionnaire Data on Health Implications of Abakaliki Rice Mill on Amagu Community

The items under which the health implications on Amagu community are as shown in table 4.13

Table 4.13: Health Implications of Abakaliki Rice Mill on Amagu Community

Item	Description	Agree	Disagree	Unsure
1	You feel catarrh, headache, sneeze and cough more in Amagu	167(42.2%)	199(50.3)	30(7.5)
2	The Rice mill smoke impairs your vision and suffocated you	151(38.1%)	199(50.3)	46(11.6)
3	Drinking Ebonyi River gives you stomach upset	104(26.2%)	125(31.6)	167(42.2)
4	Effluents(wastes) from the rice mill kill your fishes	49(12.4%)	197(49.7)	150(37.9)
5	There are much mosquito bites in Amagu	240(60.6%)	129(32.6)	27(6.8)
6	You feel skin and eye irritation more in the village	164(41.4%)	202(51.0)	30(7.5)
7	You feel hotter and more uncomfortable in Amagu	225(56.8)	152(38.4)	19(4.8)
8	Abakaliki rice mill should be relocated due to health implications	33(8.3)	348(87.9)	15(3.8)
	Total	**1133**	**1551**	**484**

Analysis of item 1 shown on table 4.13 and figure 4.2, which tried to establish whether or not the residents felt more catarrh, headache, sneeze and cough, shows that out of total of 396 respondents, 79 respondents (19.9% of the total respondents), strongly agree, 88 respondents (22.2% of the total respondents), agree. 30 representing 7.5% were not sure and 76 representing 19.1% disagreed. However, 123 representing 31% strongly disagree.

By inference, greater number of the respondents strongly agreed that they felt catarrh; headache, sneeze, and cough more while the village.

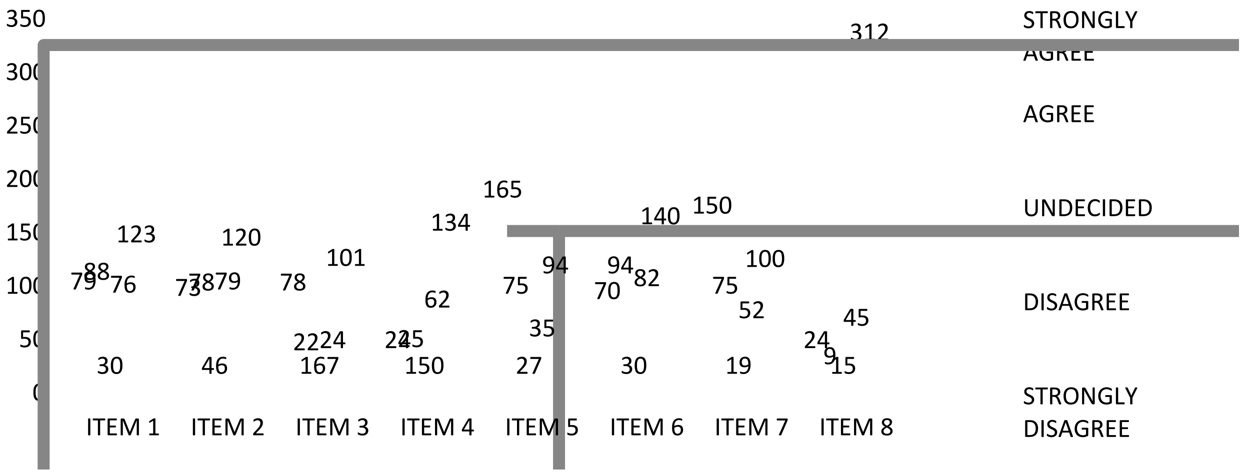

Fig 4.2: Responses to Degree of the Health Implications of Abakaliki Rice Mill on Amagu Community
Source: Author’s Field survey 2015

On item 2 which tries to establish whether or not the smoke from the rice mill impairs their vision and get them suffocated, 73(18.4%) of the respondents strongly agree, while 78(19.7%) agreed whereas 46 (11.6%) are not sure. However 79 (19.9%) disagree while 120 (30.3%) strongly disagree. It will be inferred that greater number of the respondents strongly disagreed that smoke from the rice mill impair their vision and get them suffocated.

From item 3 which studies whether those that drink the Ebonyi River suffer stomach upset. 78 (19.7%) strongly agree, 22 (5.5%), 167 (42.2%) were undecided. However, 24 (6%) disagree, and 101 (25.5%) strongly disagree. It implies that more number of the respondents were sure or aware of any health implications of drinking water from Ebonyi River.

On item 4 which studies whether or not, effluents (wastes) from the rice kill your fishes, 24 (6%) strongly agree, 25 (6.3%) agree while 150 (37.9%) are not sure. However, 62 (15.6%) disagree and 134 (33.8%) strongly disagree.

On item 5, 165 (41.6%) strongly agree, 75 (18.9%) agree, 27 (6.8%) are not sure. However, 35 (8.8%) and 94 (23.7%) strongly disagree.

By inference, greater number strongly agreed that there were more mosquito bites due to the presence of the rice mill.

On item 6, 70 (17.7%) of the respondents strongly agree, 94 (23.7%) agree, but 30 (7.5%) are not sure. However, 82 (20.7%) disagree while 140 (35.4%) strongly disagree.

The result shows that greater number of the respondents strongly disagreed skin and eye irritation more while in the rice mill.

On item 7, 150(37.9%) of the 396 respondents strongly agree, 75(18.9%) agree, but 19 (4.8%) are not sure. However, 52(13.1%) disagree, while 100 (25.3%) strongly disagree. This suggests that greater number of the respondents strongly agreed that they felt more uncomfortable while the village than outside.

On item 8, which investigated the support for the relocation of the Abakaliki Rice Mill from its current location to another place, 24 (6%) of the 396 respondents strongly agree to its relocation, 9 (2.2%) agree, but 15 (3.8%) are not sure whether it should be relocated or not. However, 45 (1.5%) disagree, while 312 (78.8%) strongly disagree to its relocation. It could be inferred that most respondents strongly object to the relocation bid.

4.5.2 Questionnaire Data on the health implications of Abakaliki Rice Mill on the owners/ workers

The items for responses from the rice mill owners/ workers on the health implications of Abakaliki Rice Mill Company Ltd are the same as the ones given to the host community shown in table 14. The data are graphically represented in fig. 12

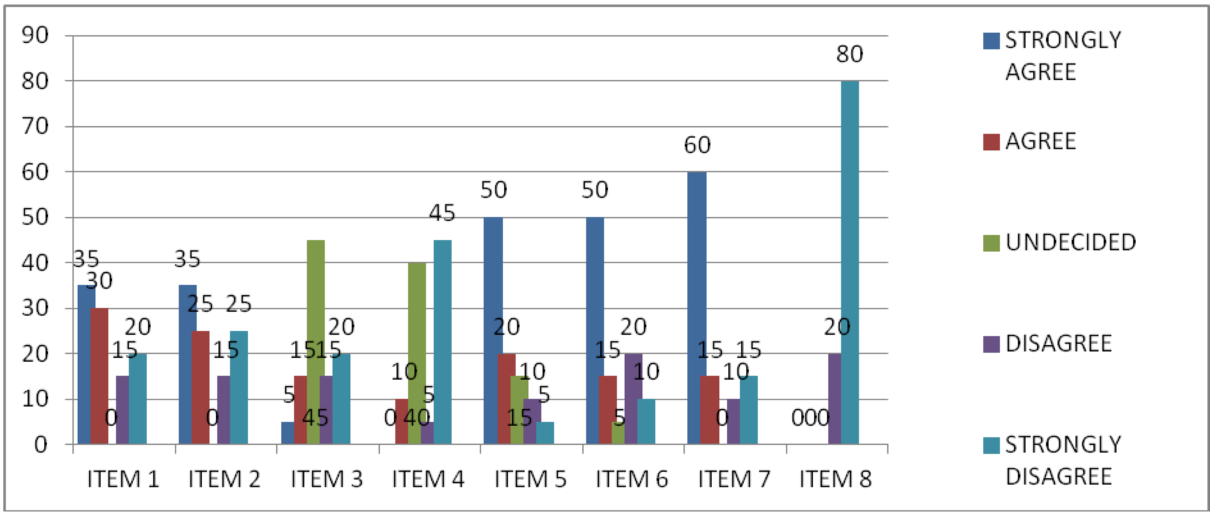

Fig 4.3: Responses to Degree of the Health Implications of Abakaliki Rice Mill on the Mill Workers/Owners

Source: Author's Field survey 2015.

From fig.4.3, the responses showed that greater number of the people representing 35% strongly agreed that they felt catarrh, headache, and sneeze and cough more in the village while 30% agreed. This implies that a total of 65% are in agreement to the situation. However, 35% are in disagreement.

Under item 2, which investigated whether smoke from the rice mill impaired their vision and got them suffocated, 35% and 25% for strongly agree and agree respectively as shown in fig. 4.3.

Under item 3 that investigated whether they suffered from stomach upset after taking Ebonyi River, whereas 20% agreed and 25% disagreed, 45% of the total of 100 respondents was undecided on the ground that they do not drink from the water while 10% strongly agreed (see fig. 4.3).

On whether or not, the effluents from the rice mill kill their fishes (item 4), 10% agreed, 40% were undecided, while 50% disagreed. This implies that half of the respondents disagreed out rightly while 40% were not aware of the situation in that aspect of the environment.

To investigate whether they were much mosquito bites which could malaria due to the presence of the Rice Mill (item 5), 70% agreed with 50% out of this figure strongly agreeing. Only 15% disagreed and 15% undecided. This implies that greater number of the respondents believed that the presence of the rice mill encourages malaria in the study area.

To ascertain skin and eye irritation among the owners and workers due to rice milling (item 6), whereas 65% agreed, 30% did not. Only 5% did not know how they felt.

To establish the comfort level of the workers and owners of the Rice Mill (item 7), 75% agreed that the felt hotter and more uncomfortable in Abakaliki than outside Abakaliki, only 25% disagreed

Item 8 which investigated the acceptability the relocation bid by the Government, 100% of the respondents disagreed with a varying degree of 20% and 80% of disagree and strongly disagree (see fig 4.3).This clearly suggests that greater number of the people within the study area are against the relocation bid by the Government.

4.5.3 Retrieved Health Data on Amagu from Health Department

From table 4.14, 20045 people were targeted for study between the five years of study.

Table: 4.14 Target Population for Disease Surveillance in Amagu Community (2010-2014)

Months	Yearly Target Population					
	2010	**2011**	**2012**	**2013**	**2014**	**Total**
January	360	380	380	118	694	**1932**
February	350	370	370	81	714	**1885**
March	300	302	372	399	792	**2165**
April	210	231	231	102	268	**1042**
May	140	155	155	359	60	**869**
June	250	284	284	464	534	**1816**
July	405	438	438	756	693	**2734**
August	380	383	383	484	764	**2394**
Sept.	240	250	250	411	536	**1687**
Oct.	120	140	140	571	13	**984**
Nov.	201	215	215	479	197	**1307**
December	130	149	156	649	150	**1234**
Total	**3086**	**3297**	**3374**	**4873**	**5415**	**20045**

Source: Health Records; Routine Monthly Records, Abakaliki L.G.A. (2015)
Note: *Target population=Total affected people + Total Unaffected people.*

2014 recorded the highest number of health cases with 5415 out of 20045 (27%). This was followed by 2013, 2012, 2011 and 2010 in the following order: 4873(24.3%), 3374(16.8%), 3297(16.4%), 3086 (15.3%).

Table 4.15 shows the diseases surveillance between year 2010 and 2014 as recorded in the health facilities surveyed. Out of the 5 environmentally related health cases surveyed, malaria was the most prevalent with 4292 cases (77.3%) of the cases, representing 49.13% of the target population. That was followed by diarrhea, pneumonia and typhoid that shared the remaining percentage in the respective order: 14.1%, 5.0%, and 3.4%, representing 8.97%, 3.23% and 2.18% of the target population. Within the study period, there was no record of asthma in the area.

Table 4.15: Total Diseases Surveillance in Amagu Community from Year 2010 to 2014.

Diseases	Months (2010-2014)												
	Jan	Feb	Mar	Apr.	M.	Jun	July	Au.	Sep	O.	N.	D.	Total
Diarrhea	195	90	76	43	35	56	106	55	32	27	29	40	784
Pneumonia	13	58	30	14	6	13	20	49	44	13	14	8	282
Malaria	482	566	668	193	56	431	530	650	460	67	87	102	4292
Typhoid	4	0	18	18	0	34	37	10	0	3	67	0	191
Asthma	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Cases	694	714	792	268	97	534	693	764	536	110	197	150	5549
Target Population	929	1082	900	600	200	1020	993	1092	705	195	550	470	**8736**

Source: Clinical Records on Environmentally-Related Health Cases from Health Facilities in Abakaliki L.G.A (2014); tabulated and computed by the Author 2015.

The highest diseases prevalence as shown in table 4.16 was in 2013while 2010 recorded the least. However, across the years; September recorded the highest prevalence rate with none of the years recording less than 33%.

Table 4.16: Prevalence Rate of Environmental Diseases from 2010- 2014

Months	2010	2011	2012	2013	2014	Total
January	13	31	96	25	75	240
February	20	33	85	68	66	272
March	24	34	28	41	88	215
April	39	41	9	68	44	201
May	36	88	14	41	30	209
June	38	42	18	48	52	198
July	35	47	19	80	70	251
August	18	37	28	88	70	241
September	48	52	33	78	76	287
October	48	23	13	59	7	150
November	55	12	24	79	36	206
December	34	51	98	71	32	286
Total	408	491	465	746	646	**2756**

Source: - Author's Computation (2014).
Note: Respective Disease Prevalence= Particular Disease/ Total Disease Cases
Total Disease Cases Prevalence= Total Disease Cases/Target Population.

Next to September was the month of December with the prevalence of 32% whereas; October had the least prevalence rate all through the years. Disease prevalence rate rose from 2010 to 2011; dropped in 2012, rose again above the three previous years but dropped again in 2014(See table 4.16)

Table 4.17 Number of affected and unaffected people

	No of People affected						**No of People unaffected**					
	2010	2011	2012	2013	2014	**Total**	2010	2011	2012	2013	2014	**Total**
January	48	118	239	118	694	**1217**	312	262	141	348	235	**1298**
Feb.	70	121	156	81	714	**1142**	280	249	214	39	368	**1150**
March	71	126	196	399	792	**1584**	229	176	176	581	108	**1270**
April	82	95	25	102	268	**572**	128	136	206	48	332	**850**
May	51	137	82	359	60	**689**	89	18	73	517	140	**837**
June	96	122	108	464	534	**1324**	154	162	176	511	486	**1489**
July	141	208	121	756	693	**1919**	264	230	317	194	300	**1305**
Aug.	48	142	138	484	764	**1576**	332	241	245	65	328	**1211**
Sept.	44	131	167	411	536	**1289**	196	119	83	160	169	**727**
Oct.	58	32	85	571	13	**759**	62	108	55	403	183	**811**
Nov.	111	26	168	479	197	**981**	90	189	47	130	353	**809**
Dec.	44	76	153	649	150	**1072**	86	73	3	267	320	**749**
Total	864	1334	1638	3263	3322	**14124**	2222	1963	1736	4873	5415	**12506**

Source: Summary of Routine Disease Surveillance on Isolated Environment-related Health Diseases in Amagu Community by Abakaliki L.G.A Health Department. (2015).

Table 4.17 shows that the number of people affected are more than the number unaffected, (52.9% as against 47.1%). From 2010 to 2014, the number affected by the diseases has been on the increase as expressed in percentages: (6.1% 9.4%, 11.5%, 34.5%, 38.3% while the number of those unaffected dropped in 2011 and further in 2012 but increased again through 2013 and 2014 even above that in 2010 as shown: 17.7%, 15.6%, 13.8%, 26%, 26.5%. From table 4.19, across the years, the month of April recorded the least number of cases (4%) while the highest number was recorded in July (13.5%).

To ensure that the conclusions were not based on mere observations, opinions and comparative analyses, the data were subjected to series of statistics analytical tools such as Mann Whitney Test, Kruskal-Wallis Test and Wilcoxon Signed Ranks Tests to test the three hypotheses formulated. Whereas Mann Whitney was used on the soil data, Kruskal wallis test was used on both the water and air data, while Wilcoxon Signed Ranks Test was used on the questionnaire data on both the environmental and economic effects as well as health. However, the related health data which are on the numbers that were affected or not by diseases were tested using also, the Kruskal Wallis Test.

4.6 Test of Hypotheses

To test the hypotheses, the null hypothesis in each case will be accepted if p – value is greater than 0.05, otherwise, it will be rejected (If $p > 0.05$, accept, otherwise, reject).

1. **Hypothessis 1:**

Ho: Abakaliki Rice Mill has no significant environmental effect on the host community.

Decision Rule: If $p > 0.05$, accept, otherwise reject.

The intent of the hypothesis is to see if Abakaliki Rice Mill has a significant environmental effect on the soil, water and air as well as the human components of the environment.

Data use: the data use are shown in tables 4.8, 4.9, 4.10 and 4.11.

Table 4.18: Mann-Whitney Test for the Physical Properties of the soils

Ranks

	Soil sample	N	Mean Rank	Sum of Ranks
Soil Physical properties	**A**	3	3.50	10.50
	D	3	3.50	10.50
	Total	6		

Test Statistics

	Soil Physical properties
Mann-Whitney U	4.500
Wilcoxon W	10.500
Z	.000
Asymp. Sig.(2-tailed)	1.000
Exact Sig. [2*(1-tailed Sig.)]	1.000

a. Not corrected for ties.
b. Grouping Variable: Soil sample

From table 4.18, there was no significant change seen in the physical properties of the soils within the period. This is because the p – value, 1.00 is greater than 0.05. This suggests that there was no significant environmental effect of the Rice Mill on the host community.

Table 4.19: Mann-Whitney Test for the Chemical Properties of the soils

Ranks

	Soil sample	N	Mean Rank	Sum of Ranks
Soil Chemical properties	**A**	12	12.58	151.00
	D	12	12.42	149.00
	Total	24		

Test Statistics

	Soil Chemical properties
Mann-Whitney U	71.000
Wilcoxon W	149.000
Z	-.058
Asymp. Sig. (2-tailed)	.954
Exact Sig. [2*(1-tailed Sig.)]	.977

Grouping Variable: Soil sample

Table 4.19 shows that the chemical properties of the soils were significantly the same; they did not change. This is because the p – value 0.977 is greater than 0.05. This implies that Rice Mill has no significant impact on the chemical properties of the soil.

Table 4.20: Kruskal-Wallis Test for the Physical properties of Water

Ranks

	Water sample	N	Mean Rank
Physical Property	**A1**	7	14.57
	A2	7	13.86
	A3	7	14.29
	A4	7	15.29
	Total	28	

Test Statistics

	Physical Property
Chi-Square	.112
Df	3
Asymp. Sig.	.990

a. Kruskal Wallis Test b. Grouping variable : Soil sample

The result on table 4.20 shows that there was no significant difference in the physical properties of the water samples within this period under review. This is because the p – value 0.990 is greater than 0.05. This implies that the Rice Mill has no significant impact on the soil physical properties.

Table 4.21: Kruskal-Wallis Test for the Chemical properties of Water

Ranks

	Water Sample	N	Mean Rank
Chemical Property	**A1**	10	20.60
	A2	10	20.15
	A3	10	20.15
	A4	10	21.10
	Total	40	

Test Statistics[a,b]

	Chemical Property
Chi-Square	.045
Df	3
Asymp. Sig.	.997

a. Kruskal Wallis Test, b. Grouping Variable: Soil Sample

The result on 4.21 shows that there was no significant difference in the chemical properties of the water samples within this period under review. This is because the p – value 0.997 is greater than 0.05. This implies that the Rice Mill has no significant impact on the water chemical properties of Amagu community.

Table 4.22: Kruskal-Wallis Test for the Air samples

Ranks

	Period when data was collected	N	Mean Rank
Air	**During working period**	108	117.46
	After working period	108	99.54
	Total	216	

Test Statistics

	Air
Chi-Square	4.532
Df	1
Asymp. Sig.	.033

a. Kruskal Wallis Test

b. Grouping Variable: Period when data was collected

From table 4.22, we can say that there is a significant difference between the air samples during and after the working hours. This is because the p– value, 0.033 is less than 0.05. This implies that the air component rice mill environment is capable of impacting negatively on the host community.

Table 4.23: Wilcoxon Signed Ranks Test for Environmental Effects of Abakalilki Rice Mill on Amagu Community.

Ranks

	N	Mean Rank	Sum of Ranks
Disagree for Environmental Effects- Negative Ranks	3[a]	4.67	14.00
Agree for Environmental Effects- Positive Effects	5[b]	4.40	22.00
Ties	0[c]		
Total	8		

Test Statistics

	Disagreement for environmental-Agree for environmental
Z	-.560[a]
Asymp. Sig. (2-tailed)	.575

From table 4.30, we can say that Abakaliki Rice Mill has no significant environmental effect on the host community. This is because the p – value, 0.575 is greater than 0.05. This implies that the null hypothesis was accepted

2. **Hypothessis 2:**

Ho: Abakaliki Rice Mill has no significant economic effect on Amagu.

Decision Rule: If $p > 0.05$, accept, otherwise reject.

The intent of the hypothesis is to see if Abakaliki Rice Mill has a significant economic effect on Amagu community.

Data use: the data use are shown in table 4.12.

Table 4.24: Wilcoxon Signed Ranks Test for Economic effects of Abakalilki Rice Mill on Amagu Community

Ranks

	N	Mean Rank	Sum of Ranks
Disagree for Economic Effects- Negative Ranks	8[a]	4.50	36.00
Agree for Economic Effects- Positive Effects	0[b]	.00	.00
Ties	0[c]		
Total	8		

Test Statistics

	Disagreement for Economic-Agree for Economic
Z	-2.521
Asymp. Sig. (2-tailed)	.012

a. Based on positive Ranks
b. Wilcoxon Signed Ranks Test

The result on table 4.24 shows that Abakaliki Rice Mill has a significant economic effect on the host community. This is because the p – value, 0.012 is less than 0.05. That is to say the hypothesis is null hypothesis was rejected.

3. **Hypothessis 3:**

Ho: Abakaliki Rice Mill has no significant health implications on the host community.

Decision Rule: If $p > 0.05$, accept, otherwise reject.

The intent of the hypothesis is to see if Abakaliki Rice Mill has a significant health implication on Amagu community.

Data use: the data used are shown in figures;4.2,4.3 and tables 4.13, 4.14 ,4.17.

Table 2.25: Wilcoxon Signed Ranks Test for Health effects of Abakalilki Rice Mill on the Amagu Community

Ranks

		N	Mean Rank	Sum of Ranks
Disagree for health - Agree for health	**Negative Ranks**	2[a]	5.50	11.00
	Positive Ranks	6[b]	4.17	25.00
	Ties	0[c]		
	Total	8		

Test Statistics

	Disagree for health - Agree for health
Z	-.980[a]
Asymp. Sig. (2-tailed)	.327

a. Based on positive ranks. A. Disagree< Agree; b. Disagree>Agree,
c. Disagree=Agree, d. Wilcox on Signed Ranks Test

Table 4.26: Wilcoxon Signed Ranks Test for Health Implications of Abakalilki Rice Mill on the Owners/ Workers

Ranks

		N	Mean Rank	Sum of Ranks
Disagree – Agree	**Negative Ranks**	5[a]	4.40	22.00
	Positive Ranks	3[b]	4.67	14.00
	Ties	0[c]		
	Total	8		

Test Statistics [b]

	Disagree - Agree
Z	-.560[a]
Asymp. Sig. (2-tailed)	.575

a. Based on positive ranks. A. Disagree< Agree; b. Disagree>Agree,
c. Disagree=Agree, d. Wilcoxon Signed Ranks Test

Result on table 4.25 and 4.26 show that Abakaliki Rice Mill has no significant health effect on the host community and the workers. This is because the respective p – values, 0.327 and 0.579 are greater than 0.05. This implies that although there may be some health effects which the Rice Mill brings, but these effects are within the permissible limits that can be coped with.

Table 4.27: Kruskal-Wallis Test for the difference between those affected by the diseases and those not affected in Amagu Community.

Ranks

Those affected and those not affected	N	Mean Rank
Affected	60	57.33
Unaffected	60	63.67
Total	120	

Test Statistics

	Affected
Chi-Square	.995
Df	1
Asymp. Sig.	.319

a. Kruskal Wallis Test
b. Test variable: those affected and those not affected.

Table 4.27 shows that there is no significant difference between those affected and those who were not affected by the prevalent cases. This is because the p – value, 0.319 is greater than 0.05. We can deduce from the result that, irrespective of the fact that there were prevalent cases, it was not necessarily so bad so as to attribute the disease prevalence only to the activities of Abakaliki Rice mill.

4.7 Discussion of the Findings

It is worthy of note that environmental issues are better addressed when the components-physical environment, social environment and the economic environment are considered holistically as a system. Under the physical environment, the following parameters were discussed:-the air quality, water quality and soil property of Amagu community.

The economic environment considered the economic indicators like income generation, job creation, development, agricultural boost, dependency as food, and alternative source of energy. On the health implications the following variables were discussed: - the type of health problems experienced, the comfort level, the effect of intake of Ebonyi River, the effect of Ebonyi River on aquatic life and to test whether or not the health implications of the Abakaliki Rice Mill Company Ltd are enough to warrant its relocation.

Air Quality is an indication of the healthfulness of the air based on the quantity of polluting gasses and particulates (liquid droplets or tiny solid particles suspended in air) it contains. Air is considered safe when it contains no harmful chemicals and only low levels of other chemicals that become harmful in higher concentrations to humans, other animals, plants, or their ecosystems.

Air is commonly monitored by the United States Environmental Protection Agency (EPA), state and local environmental agencies for concentrations of six pollutants: carbon monoxide, lead, nitrogen dioxide, sulfur dioxide, ozone, and particulates. Air samples are collected and analyzed several times daily in cities and other industrial areas. The samples are graded on a scale of 0 to 500, indicating how many parts per million (ppm) these pollutants contain. If the concentration of one or more pollutants reaches either the very unhealthy or hazardous categories, people with heart or respiratory problems are warned to stay indoors (Microsoft Encarta, 2009).

According to WHO in Microsoft Encarta, (2009), air samples are graded on a scale of 0 to 500, indicating how many parts per million (ppm) contain these pollutants. A sample of 0 to 50ppm indicates good air quality; 50 to 100ppm, moderate air quality; 100 to 200ppm, unhealthy; 200 to 300ppm, very unhealthy; 300 to 500ppm, hazardous. According to Weinstocks *et al.,* (1972), high concentration of Carbon monoxide can lead to headaches, nausea, and loss of vision, decreased muscular co-ordination, and severe effects on the body of pregnant woman, dizziness, and unconsciousness. Long term exposure can lead to death.

Rice Mill has been identified to present a significant source of environmental problems. The statistical analysis of the CO, NO_2, and SO_2 in the air samples collected during and after work periods in the Abakaliki Rice Mill shows that there is a significant difference between the air samples. That is to say that there is a disturbance of the natural air systems as a result of the activities of the Rice Mill. This is in agreement with the Amar, (1984) and Ekwe, (2012) who agree that indiscriminate dumping of agricultural wastes from agro-industrial processes causes environmental pollution in the air. The analysis goes equally to buttress Meerow, (1995), Ekpe, (2008), and IFC, (2009) who were of the same views that rice mill processes are the root cause of the physical pollution of the air quality as well as the opinion of Fakhrul (2008) that the process produces green house gas (Carbon dioxide emissions) that causes global warming.

However, based on the analysis of the selected air samples collected from Amagu community, it was discovered that the air qualities were within the WHO acceptable standard for good quality air. This is to say that the air component of the environment has no such significant adverse effect as to conclude that all the air effects totally influence in Amagu community negatively. This excludes the particulates which may have negative effect on the host community.

On water as component, analysis as shown in table 4.11 reveals that there is significant difference in the physical and chemical properties of the water samples. This probably is because the water samples were from a common source-Ebonyi River.

However routine laboratory analysis of the water samples shows that whereas, the temperatures, odour level, turbidity, lead content did not meet the WHO standard, the pH level, the colour, the total solid, and the total hardness of the water samples, Chloride, Nitrate, Magnesium, Calcium, Zinc, Iron, Manganese met the WHO standard. However, the dissolved Oxygen, Lead content of the water was above the WHO limit and as such undesirable for drinking and domestic water because it causes a variety of neurological disorder and inhibits brain cell development in children.

What the routine analysis reveals in summary is that the positive effects of the pysico-chemical properties of water out-weigh the negative effects. This is to say that the water to be made fit for drinking, domestic and industrial process, it has to be treated adequately before use.

The findings agree with IFC,(2009) which asserts that the amount of water which is required for parboiling and which most times are not properly treated and could result in water pollution and odour nuisance to residents. It also agrees with Ekpe, (2008) and Abanti, (2011) who warn that rice mill water should not be used as such as for agricultural purposes; rather they should be treated to render them suitable for irrigation in agricultural lands.

The analysis of the soil component shows that there is no significant difference in the samples in respect of the parameters studied. What this reveals is that the variability of the parameters studied is not significant. They are not enough as to reliably infer that the presence of the Rice Mill has caused any clear-cut changes in Amagu community. However, a study of the different parameters or variables in Amagu soil reveals that the positive aspects of the soil, very much out-weigh the adverse effects. It also reveals that the soil closest to the Rice Mill does not have a monopoly of neither the positive nor the negative properties, hence effects on the environment.

Moreover, the laboratory analysis of the soil samples shows that even when there are good percentages of sand, silt and clay in the soil samples, the soil is predominantly clayey-sandy. It has been proven that soil samples with such aggregates are good economically in the area of agriculture and construction. It reduces the chances of flooding, mosquitoes and consequently, reduces the prevalence rate of malaria.

Again, the distribution of the soil types could be explained by the geological formation and the process and result of denudation.

The Ph, level of the soil samples were moderately acidic; implying that the nutrients solubility is reduced moderately. This condition is capable of encouraging agriculture.

The percentages of Nitrogen were within the levels that will lead to leaching into the ground water and its consequent contamination. This is in agreement with Tel *et al.,* (1984).

The Calcium concentrations at the various sites in Amagu Community were relatively high. This could explain the hardness of water experienced in the area of study. Moreover, the leaching occasioned by Nitrogen concentration in the area will increase the level of Calcium concentration in the underground water.

From the Wilcoxon signed ranked test carried out on the economic variables/indicators, it is found that Abakaliki Rice Mill Company Ltd has very strong positive economic effects. Also, figure 4.4 clearly confirm the situation and that the negative economic effects of the Rice Mill are insignificant.

The situation in Abakaliki Rice Mill is in agreement with Orient News (2012), which states that Abakailiki Rice Mill provides job opportunities for the surrounding communities and USA Rice Federation, (2013) that states that Rice Milling Industry adds more than 39,000 jobs and nearly 5 billion dollars to USA economy via direct, indirect and induced effects. The findings also agree with Chime (1998), Frankfurt, *et al.,* (2008), Ekpe, (2008), Ahiduzzaman *et al.,* (2009), Mba *et al.,* (2009) and Aniekwe *et al.,* (2012), which are in agreement that Rice Mills provides source of income and assert that by-products of Rice Mills serve as alternative source of energy and has agricultural relevance.

The findings from the statistical analysis of the questionnaire data show that Abakaliki Rice Mill has no significant health effect on the host community. Again, from the statistical analysis of the secondary data on disease prevalence in the community, it is found also that there is no significant difference between those who were affected and those who were not affected by the prevalent cases. We can say from the data that the prevalent cases were not so bad as to attribute it only to the activities of Abakaliki Rice Mill.

Again, the results of the analysis of the data from the Rice Mill owners and workers show that there is no significant health implication of the Rice Mill on them. This is in agreement with the finding from the host community on health implications of the milling activity.

Against the backdrop of acceptability of the location, the greater majority of the people of Amagu community accept the location where it is. This is because from the analysis of data on acceptability, there is a significant difference between those that support the location of Abakaliki Rice Mill Company Ltd and those against it.

CHAPTER FIVE

Summary, Conclusion and Recommendations

5.1 Introduction

This chapter is on the summary, conclusion and recommendations of this research work which highlighted the environmental and economic effects of Abakaliki Rice Mill Company Ltd and its health implications on Amagu community.

5.2 Summary of Findings

A good number of the residents of Amagu community do not understand most of the environmental situations of their area. This is shown in the trend of opinion as sampled in table 4.7. 20% of the residents strongly agreed that the Mill has adverse environmental effects on the host community. Up to 18% are not aware whether they exist or not, while 26% of them strongly disagreed that the Mill had such adverse effects.

There was no significant change in both the physical and chemical properties of the soil and water components of the environment. However, the air component changed significantly in terms of its chemical properties. The results from the laboratory analysis of the soil, water and air samples are in agreement with the responses from the questionnaire on the environmental effects.

There was a strong agreement to the positive economic effects ranging between 51%-81% as against those in strong disagreement with the positive economic effects ranging between 0- 3.5%.

Of all the health cases associated with rice milling activities which included cancer, birth defect, eye irritation, cough/cold (Daniel *et al.,* 1997), only malaria, cholera, diarrhea, pneumonia, typhoid and Asthma were recorded for analysis. Malaria is the most prevalent of the studied environmental-borne diseases in Amagu community. From analysis, greater number of the residents strongly disagreed that Abakaliki Rice Mill has the sampled health implications (35.5%). However, 20.5% of the residents strongly agreed, while 15.3% were not sure of the health implications.

Irrespective of government campaign against environmentally-related diseases, the record shows an unsteady improvement in the health status of the people from 2010-2014. This was shown in the trend of disease prevalence which rose from 2010 to 2011, but dropped in 2012, rose again above the three previous years in 2013 but dropped again in 2014.

The research has also discovered that there was poor documentation of the health cases in Amagu Community across the years. Again, the people find it difficult to visit hospitals where proper history of their health challenges will be taken. The results of the data analyses point to the fact that the prevalent health cases may not only be as a result of the presence of the Abakaliki Rice Company Ltd in its current location, but also due to the presence of other economic activities vis-à-vis vehicular emissions of pollutants.

The findings on the environmental components and health records were in consonance with the responses from the respondents sampled through the questionnaires on the environmental effects, economic effects and health implications.

Again, the findings from the Rice Mill workers/owners on health are in agreement with the ones from the host Community.

There was a sharp difference between those that oppose to the relocation of Abakaliki rice mill from its current location to any other place and those in favour of it (87.8% and 8.3% respectively). Irrespective of the environmental effects and health implications of Abakaliki Rice Mill on the host community, the economic effects were the strong basis upon which the residents accepted the current location.

5.3 Conclusion

This research work has investigated the environmental effects, economic effects and the health implications of Abakaliki Rice Mill Company Ltd on Amagu Community.

The work has made findings on the significance of the environmental effects; economic effects of Abakaliki Rice Mill and its health implications on Amagu Community as well as the acceptability of the location of the Rice Mill where it is.

It has identified that greater majority of the people of Amagu do not believe that Abaklaliki Rice Mill has significant environmental effect on their community. The research has also proved that Abakaliki Rice Mill has a significant economic effect on Amagu community. It has also been proved that

Abakaliki Rice Mill does not have significant health implications on Amagu community.

It was also discovered that Abakaliki Rice Mill has some environmental effects of on Amagu Community but the environmental effects were not beyond the permissible limit according to World Health Organization. Moreover, it has been discovered that the economic benefits were the strong basis upon which the residents accepted the current location. The research has also revealed that Malaria is the most prevalent environmentally- related health challenge of Amagu community within the period of study.

It has been identified that the soil within the Amagu Community are predominantly sand, clay and silt with sand being of highest component. This mixture of components in the proportions identified is good for arable farming. It was discovered also that there is high concentration of Calcium in the soil. This according to Tel *et al.*, (1984) can cause hardness of water. Also it was discovered that there are much Nitrogen in the soil of Amagu Community. This can cause leaching into underground water within the area. Only Inyimagu (the rice mill site) and its immediate environs show potential for farming with percentage organic matter of approximately 3% because according to Ekundayo *et al.*, (1996), organic matter above 3.5% will favor micro-nutrient solubility and mobility, thus would favor efficient plant growth.

To fill the gaps identified in the literature reviewed; and line with the scope of the work, this particular research has investigated the impacts of rice milling considering the physical environment and economic environment vis-à-vis the health implications both from the positive and the negative perspectives. This it has achieved by studying the effects of the anthropogenic activities on both the natural and man-made environment with a particular reference to Abakaliki Rice Mill Company Ltd and Amagu Community.

5.4 Recommendations

1. Cleaner production by incorporating in-plant pollution prevention and control measures and market-based actions should be pursued to tackle solid waste and fugitive emissions instead of the end-of-pipe approach and strong government intervention in environmental management.
2. Waste water from the Rice Mill industrial process should be treated first before being disposed into the environment. That will reduce the rate of pollution of Ebonyi River vis-à-vis, soil and air components of the environment.
3. The rice husks should be employed well as agricultural mulch material, beddings in poultry and piggery in the area of study, like wise other places where there is comparative advantage on the use. This will reduce the chances of pollution of the air and water components.
4. The husks should be used as an alternative to energy from wood. This will reduce the rate of deforestation, reduce the high temperature, increase photosynthetic process in the area that is already climatically bound to be hot and with less flora.

5. Tree planting should be made a compulsory practice in Amagu Community to make up for the loss in the vegetative cover of the environment, improve on the ambient temperature of the area and the imagery of the area.
6. Instead of emitting the heat from the parboiling process into the environment, the technology which will convert the heat into electro-mechanical energy to power some the milling machines should be put in place. It will help reduce the thermal pollution common in the area.
7. The Government should come up with a legislation to ban the practice of parboiling paddy rice within the residential areas in order to help improve on the sanitary level of Amagu Community and its environs.
8. All environmental policies and decisions should be research-based and should hinge on socio-economic principles. This will not only ensure the sustainability of such programs but will guarantee environmental, social and economic sustainability of the society.
9. The State orientation agency should step up campaign on “waste to wealth” ideology. This will help transform the quantum of wasting rice husk into economic gain and help improve on the quality of the physical environment in terms of imagery and healthiness.
10. An integrated waste market for the rice husks, just like scrap markets at Onitsha and Lagos should be established in Ebonyi State. This will help shift emphasis on waste from negative perspective to the positive perspective thereby entrenching the waste to wealth ideology.

11. Waste treatment plants should be built in the state for the treatment and conversion of the husk into useful products.
12. Rice husk energy-generating plant should be built in the state for alternative power generation using rice husks as a base material.
13. Government should provide infrastructures and social amenities for the people of Amagu Community. This is because of the over usage of the resources and services due to population increase as a result of the presence of the Rice Mill.
14. There should be Government-private partnership. This is because, modern machines are too costly to afford by private individuals but with the help of the Government they could be procured with less stress. As an alternative to that, Ebonyi State Government should endeavor to upgrade the Rice Mill cluster in Amagu to the standard it is proposing for the three senatorial zones of the State.
15. The people's wish on acceptability of the location of the Rice Mill in Amagu should be granted. This is to forestall any form of social restiveness or crime which any imposition of such policies may bring.
16. There should be stringent penalty for defaulters in environmental laws. This will help reduce the health challenges recorded in the area and its attendant economic losses.
17. Mechanized and less dehumanizing method of husk disposal should be adopted. This will create more job opportunities and improve on the financial status of the workers.

REFERENCES

Abakaliki. Encyclopedia Britannica Student and Home edition. Chicago, Encyclopedia Britannica, 2010.

Abakaliki Local Government: Striving to feed the Nation: The Journey so far 1993. Harbinger Pub. Ltd, Abakaliki, Ebonyi State.

Abanti P and Sahu S. (2011) Effect of Rice Mill Waste Water on Population, Biomass, Rate of Reproduction and Secondary Production of Drawida Willsi (Oligochaeta) in Rice Field Agroecosystem**.** *IJRRAS.* vol 6(2).

Abdul, *et al*. (2009). *Study on the Level of Mechanization of Rice Processing in Kano Ktate, Nigeria.* Nigerian Stored Products Research Institute, Kano Station PMB 3032, Hadeija Road, Kano, Nigeria.

Adams, W.M. (2006). The Future of Sustainability: Re-thinking Environment and Development in the Twenty-first Century. *Report of the IUCN Renowned Thinkers Meeting*, 29–31 January 2006. Retrieved on: 2009-02-16.

Adie,V. (2012). Ebonyi: From Rice Husk to Electricity. *Sunday Trust Newspaper* http//weeklytrust.com.ng/index.php/features/10568

Agumanu, A. E. (1989). The Abakaliki and Ebonyi Formations: Sub- divisions of the Albian Asu River Group in the southern Benue Trough. Nigeria. *Journal of African Earth sciences*, Vol. 9 No 1, pp. 195-207.

Ahiduzzaman M. and Abul K. M. Sadrul Islam (2009). *Energy Utilization and Environmental Aspects of Rice Processing Industries in* Gazipur-1701 *Bangladesh* www.mdpi.com/journal/energies

Akande, S.O., (2003). *An Overview of Nigerian Rice Economy*. www.unep/etu/etp/events/agriculture/nigeria.pdf, (accessed 30 July 2009).

Anikwe, M.N. (2000). Amelioration of Heavy Clay and Soil Plant System: A Review of Biological Waste. *Agricultural Resource Journal* vol. 9, Pg 129-137

Anikwe and Nwobodo (2001). Long Term Effect of Municipal Wastes Disposal on Soil Properties and Conductivity of Sites Used for Urban Agriculture in Abakaliki, Nigeria. *Bioresource Technology. Nig. Journal of Soil Science***,** 18: 114–123, 83: 241 – 250.

APHA (1989) Standard Methods for the Examination of Water and Waste water. *American Public Health Association journal*. 18th ed. Washington DC

Arsenic in your food: Our Findings Show a Real Need for Federal Standards for this Toxin. *Consumer Reports*, November 2012.Retrieved November 22, 2012.

Autrey H.S and Hunnell J.W. (1984). *Continous Processing of Ric***e**. Riviana Foods, Inc. Houston.

Babaleye, T and Nwachukwu, I. (eds). *Proceedings of the MFA Workshop in Niger State*. IITA, Ibadan. pp. 24-31.

BAPEDAL (1998). *Cleaner Production Action Plans.* International Finance Coporation, Philippines p. 6.

Benkhelil, J.(1986) *Structure and Geodynamic Evolution of the Intercontinental Benue Trough***,** *Nigeria.* Buttik and Barrows Ventures, Jos.

Bhat R.V and Vashanti S. (2003). Food Safety in Food Security and Food Trade: Mycotoxin Food Safety Risk in developing countries. *Focus 10*. Brief 3 of 17.

Daramola B. (2005) Government Policies and Competitiveness of Nigerian Rice Economy, Paper presented at the *Workshop on Rice Policy & Food Security in Sub-Saharan Africa* organized by WARDA, Cotonou, Republic of Benin, November 07- 09, 2005. Pp 3

Boyden, S. (I981). *Integrated Studies of Cities Considered as Ecological Systems and the Role of MAB Therein*. Paris UNESCO

Brookfield, H.C. (1972) Intensification and De-intensification in Pacific Agriculture: Theoretical Approach. *Pacific view point*, vol.20, pp.30

Brookfield, H.C (1980a). *Population-environment Relation in Tropical Islands: The Case of Eastern Fiji*. Vol. 8, pp. 177-204.

Brower, M. & Leon, W. (1999). *The Consumer's Guide to Effective Environmental Choices: Practical Advice from the Union of Concerned Scientists.* New York: Three Rivers Press. ISBN 0-609-80281-X.

Chang T.T. (1976). The Origin, Evolution, Cultivation, Dissemination, and Diversification of Asian and African Rices. *Euphytica* vol. 25(1):425-41

Chorley, R.J. (1962) Geomorphology and General Systems Theory. *U.S Geology Survey Professional Paper,* No. 5000, vol. TP 23, pp. 17-19

Consumer Reports Magazine November (2012) – Arsenic in your Food. Consumerreports.org (2012-09-19). Retrieved on 2013-04-20.

Clayton, W. D., Harman, K. T. & Williamson, H. (2006 onwards). *Grass Base - The Online World Grass Flora*. Available online (accessed 12/7/10).

Cohen, Saul B., *ed*. (1998). *Abakaliki: The Columbian Gazetteer of the World*: Columbian University Press. New York, NY.

Daniel B. Botkin and Edward A. Keller (1997). *Environmental Science Earth as a living planet* 2nd Edition. World Book Inc. USA.

Denscombe, M. (1998) *The Good Research Guide: for small-scale social research project***s**. Open University Press, Buckingham.

Ebonyi State Ministry of Information (2001): *A Hidden Treasure: Ebonyi State.* Star craft International, Abuja. pp.31.

EFSA Panel on Contaminants in the Food Chain (CONTAM) (October 28, 2009). Sci*entific Opinion on Arsenic in Food.* *EFSA Journal (European Food Safety Authority*) 7(10): 1351. Doi: 10.2903/j.efsa.2009.1351

Ekpe I.I. (2008). Effect of Rice Husk Mulch and Fertilizer Rates on an Acid Ultisol and the Yield of Okra. in South East Nigeria" *International Science Research Journal* 1(2): 141-145, 2008.

Ekundayo, E.O. and A.A. Fagbami (1996); Land Use and its Association with Soils of Oyo State, South West Nigeria. *International Journal of Tropical Agriculture* 14.21-33.

Ekwe N.B. (2012) The Effect of Delignification on the Saccharification of Abakaliki Rice Husk. *Pelagia Research Library*: *Advances in Applied Science Research***,** 3(6):3902-3908.

Fakhrul Islam, et al (2008) *Personal Communication*. Agricultural University: Gazipur, Bangladesh.

Farouk and Zamman (2006) The Sustainable Approach to Rice Business in the Northern Nigeria Saccharification of Abakaliki Rice Husk. *Pelagia Research Library*: *Advances in Applied Science Research***,** 3(6):3902-3908.

Farrington, J. L., (1952). A Preliminary Description of the Nigeria Lead-Zinc Field. *Economy and Geology journal***.** Vol. 47, pp. 485-508.

Federal Ministry of Agriculture, Water Resources and Rural Development (1988) *Agricultural Policy for Nigeria*. FMAWRRD, Lagos, Nigeria.

Federal Surveys, Nigeria (1967) *Map of Abakaliki***.**

Food and Agricultural Organization (FAO) (2004). *Rice*. Available on www.fao.org/rice2004/en/rice2.html) Accessed on December 20, 2005.

Francisco & GW Norton (1999) Economic impacts of IPM practices in rice-vegetable systems. *Sixth IPM CRSP Annual Report***,** Virginia Tech, VA.

Geiser, Ken (2001). Cleaner Production perspectives 2: integrating CP into sustainability strategies. *UNEP Industry and Environment*, January-June, p. 33.

Godwin, M. (2004) "Constructing and Interpreting Qualitative Data" in: Bond, A. (ed.): *Writing your Master's Thesis Study mates*. Somerset.

Daly, H. & J. Cobb (1989). *For the Common Good: Redirecting the Economy toward Community, the Environment and a Sustainable Future.* Boston: Beacon Press. ISBN 0-8070-4703-1.

Hak, T. *et al*. (2007). Sustainability Indicators, *SCOPE 67*. London: Island Press. ISBN 1-59726-131-9.

Havsar (2001). Drinking Water Chemistry, A laboratory Manual Turbidity herp 11, 2001. Ivis pub. ACRC. Press company Florida USA pp 71.

Hornby A.S ed (1998) *Oxford Advanced Learners Dictionary*. 5th Edition.

International Finance Corporation (IFC) (2009) *Scoping study of clean Technology Opportunities and Barriers in Indonesia Palm oil and Rice mill Industries (Final report)* p.21-22.

International Rice Research Institute (IRRI) (2014). *The Rice Plant and How it Grows*. knowledgebank.irri.org

Jackson M.T. (1997) Conservation of Rice Genetic Resources: the Role of the International Rice. Genebank at IRRI. *Plant Molecular Biology* 35(1-2) 61-67.

Jang, Sungjoon and Xu, Zhimin (2009). Lipophilic and Hydrophilic Antioxidants and Their Antioxidant Activities in Purple Rice Bran. *Journal of Agricultural and Food Chemistry* 57 (3): 858–862. doi:10.1021/jf803113c. PMID 19138081.

Janick, J. (2002). *Tropical Horticulture*. Purdue University. (Available on www.hort.purdue.edu/newcrop/tropical/lecture20/rice.html) Accessed on December 20, 2005.

Jianguo G. Wu, Chunhai Shia and Xiaoming Zhanga (2003). Estimating the amino acid composition in milled rice by near-infrared reflectance spectroscopy. *Field Crops Research* 75: 1. Doi: 10.1016/S0378-4290(02)00006-0.

Juliano, Bienvenido O. (1993). *Rice in Human Nutrition*. Food and Agricultural Organization of the United Nations.

Karim, M.R. Zain, .M.F.M Jamil, M. Lai, F.C. and Islam, M.N. (2012). Strength of Mortar and Concrete as Influenced by Rice Husk Ash: A Review. *World Applied Sciences Journal* 19 (10): 1501-1513, 2012. IDOSI Publications, 2012.

Khush G.S (1997). Origin, Dispersal, Cultivation and Variation of Rice. *Plant Molecular Biology* 35 (1-2), 25-34 [3].

Kogbe, C. A., (1976). "The Cretaceous and Paleogene sediments of Southern Nigeria" in Kogbe, C. A (eds): *Geology of Nigeria*. Elizabeth Pub. Co. Lagos. pp. 275-281.

Kogbe, C. A. and Okeudu, O. E., (1978). Cartographic and Stratigraphic Investigations around Afikpo-Amasiri Area (Southeastern Nigeria). *Bulletin of the Department of Geology Ahmadu Bello University, Zaria,* 1, 19, 30.

Koleosho. H.A and Adeyinka A (2006) *Impact of Environmental Degradation/ Slum on Youth Growth and Development: Case Study of Iwaya Community, Lagos.* Paper presented at International Conference on Environmental Economics and Conflict Resolution, University of Lagos.

Mackay, R. A., (1946). A comparative study of two lead Zinc Occurrences in Plateau and Ogoja Provinces. *Annual Report; Geology and Survey of Nigeria.*

Mbah C.N and Onweremadu, E.U. (2009) Effect of Organic and Mineral Fertilizer Inputs on Soil and Maize Grain Yield in an Acid Ultisol in Abakaliki, South-Eastern Nigeria. *American-Eurasian Journal of Agronomy* 2 (1): 07-12.

Mbagwu, J.S.C and Ekwualor, G.C (1990). Agronomic Potentials of Brewers Spent Grains. *Biol Waste* 102:322-326. 34, 335-347.

Meadows, E.J. and Micelle M., et al (1999); *Evaluation of Silicosis* Pp 559-561

Meerow A (1995) Growth of two Tropical Foliage Plants Using Coir Dusts as Container Medium Amendment. *Hort. Tech*., 5: 40 – 46.

Microsoft Encarta (2009). © 1993-2008 Microsoft Corporation.

Molina, J. (2011) Molecular Evidence for a Single Evolutionary Origin of Domesticated Rice. *Proceedings of the National Academy of Sciences* 108 (20): 8351. Doi: 10.1073/pnas.1104686108.

Morrison, G. and Fatoki, (2001). *Assessment of the Impact of Point Source Pollution from Keikamma Hock Sewage Treatment Plant on Keikama River-PH: Electrical Conductivity, Oxygen Demanding Substance and Nutrient in Water* SA. 27. 475-480.

National Ambient Air Quality Standards (NAAQS) (1995): *EPA office of Policy Planning and Evaluation*. Washington D.C.

National Population Commission. *Final Result of 2006 Population Census of Nigeria, Ebonyi State Branch.*

Niessen, W.R (1977). *Handbook of Solid Waste Management*, D.G Wilson (ed.) Van Nostrand Raincrold Co. New York.

Nigerian Orient News, 2012.

Njoku C., Mbah, C.N. and Okonkwo, C. I (2011) Effect of Rice Mill Wastes Application on Selected Soil Physical Properties and Maize Yield (*Zea mays l.*) on an Ultisol in Abakaliki Southeastern Nigeria. *Journal of Soil Science and Environmental Management* Vol. 2(11), pp. 375-383, November, 2011 Available on http://www.academicjournals.org/JSSEM.

Nwachukwu, S. O. (1972). The Tectonic Evolution of the Southern Portion of the Benue Trough, Nigeria. *Geology Magazine*. 109:411-9.

Obasi, A. I; Okoro, A. U. and Ekpe, I. I. (2011) Determination of the Paleoenvironment of the Lithologic Units of Mkpuma Akpatakpa, Izzi, Southeastern Nigeria, using their Fossil Content. *Global Research Journal of Science.*

Offoegbu, C. O and Amajor, L. C., (1987) A Geochemical Comparison of the Pyroclastic Rocks from Abakaliki and Ezillo, Southern-Benue Trough Nigeria. *Journal of Mining and Geology*, vol. 23 nos 1 and 2, 45 -52.

Ofomata, G.E.K. (1975) *Nigeria in Maps (Eastern States).* Ethiopia Pub. House Benin City Pp.46.

Oguntade, A. E. (2011) Assessment of Protection and Comparative Advantage in Rice Processing in Nigeria. *African Journal of Food, Agriculture, Nutrition and Development***,** Vol. 11, No. 2, 2011 pp. 4632-4646.

Oko A. O. and Ugwu S. I. (2010) The Proximate and Mineral Compositions of Five Major Rice Varieties in Abakaliki, South-Eastern Nigeria. *International Journal of Plant Physiology and Biochemistry* Vol. 3(2), pp. 25-27.

Olade, M. A., (1975). Evolution of Nigeria's Benue Trough (Aulacogen): A Tectonic Model. *Geology Magazine***.** 112:575-83.

Olade, M. N., (1979). The Abakaliki Pyroclastics of the Southern-Benue Trough, Nigeria: their Petrology and Tectonic Significance. *Journal of Mining and Geology* vol.16 (1) pp. 17-25.

Opara Patrick Nnamdi (2010). *Low Cost Materials for Building and Construction: A Case Study of Rice Husk*. Institute for Environment Research and Development (IERD) Bells University of Technology, Ogun State.

Olarenwaju, J.A (2002): *Environmental Education*. Bibis Press, Kep House Ibadan.

Orajaka, I. P and Umenwaliri, S. (1989). Diagenetic Alteration of Volcaniclastic Rocks from Abakaliki Area, Southeastern Nigeria. *Journal of Mining and Geology*, Vol 25 (1&2), p. 97 102.

OSHA (2013). *Safety and Health*. 200 Constitution Ave. Washinton D.C/ www.OSHA. gov.

Oyeniyi, *et al.*, (2011) Waste Management in Contemporary Nigeria: The Abuja Example. *International Journal of Politics and Good Governance* Volume 2, No 2.2, Quarter II 2011.

Peter Lengyel and Ali Kazancigil (1982) Man in Ecosystems: Epistemological Perspectives, Cases and Practices. *International Social Science Journal*, Vol. 34, No. 3, UNESCO, France.

Porritt, J. (2006). *Capitalism as if the world mattered*. London: Earthscan. p. 46. ISBN 978-1-84407-193-7.

Potera Carol (2007). Food Safety: U.S. Rice Serves Up Arsenic. *Environmental Health Perspectives* vol**.**115 (6).

Prasanna Kumar GV. (2008). *Noise Health*. Medknow pub. Ltd. Ncbl.nlN/nih.gov Pg.55-67.

Publicity Bureau; Government House Abakaliki (2000): *This is Ebonyi State of Nigeria-A fact Book guide to the Salt of the Nation.*

Questions & Answers: FDA's Analysis of Arsenic in Rice and Rice Products.www. fda. gov.

Reyment, R. A., (1965) *Aspects of Geology of Nigeria*. Ibadan University Press, Ibadan. 145p.

Roguel, Malasa & Tanzo (2002). Social Impact Assessment of Rice Hull-burning & Stale-Seedbed Technique of Ipm-Crsp. *Philippine Journal of Crop Science.* 27(3): 53-58.

Sadon, F. N., Ahmmed Saadi Ibrahem, Kamariah Nor Ismail, (2012). *An Overview of Rice Husk Applications and Modification Techniques in Waste Water Treatment*. Chemical Engineering Faculty, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

Simpson, A., (1954). The Nigerian Coal field: The geology of parts of Owerri and Benue provinces. *Bulletin of the Geological Survey of Nigeria*. Pp.24.

Smith, Bruce D. (1998). *The Emergence of Agriculture*. Scientific American Library; a Division of HPHLP, New York, ISBN 0-7167-6030-4.

Somorin Y.M. and S. A. Bankole S.A (2010). Mycoflora of stored “Ofada” and “Abakaliki” Rice in Lagos and Ogun States, Southwestern Nigeria. *African Journal of Microbiology Research* Vol. 4(16), pp. 1724-1726, 18 Available online http://www.academicjournals.org/ajmr.

Tel. D.A and Hagarty (1984). Soil and Plant Analysis I.I.TA., Ibadan, Nigeria.

Ugo (1991) *Polytheism: The gods of Abakaliki***.** Handel Books Ltd. Enugu, Nigeria, WA.

USA Environmental Protection Agency (1991). *Assessing the Environmental Consumer Market***.** EPA Office of Policy Planning and Evaluation and Office of Air and Radiation. EPA 210-N-95-00 Washington.

USA Environmental Protection Agency (1995). *Protection of the Layer***.** EPA Office of Policy Planning and Evaluation and Office of Air and Radiation. EPA 210-N-95-00 Washington.

USA Rice Federation (2002) *Rice Nutrition*. (Available on www.usarice.com/foodservice/nutrition.html). Accessed in 2005. 20, 2005).

USA Rice Federation (2013). *Economics of Rice Milling*. Rice info@USA rice.com.

Weinstocks, B. and Nikki, H. (1972) *Carbon Monoxide Balance in Natural Science*, pg. 176 (4032): 290.2.

West Africa Rice Development Association (WARDA) (2002). *Nigeria’s Potential in the Rice Sector and the role of rice in Nigeria*. (Available online on: www.warda.cgiar.org/News/Nigeria2002.htm).

World Health Orgainsation (WHO 2012) Guildelines for Drinking Wayer Quality. *International Standards for Drinking Water, Geneva*, Vol. (5) pp.130

World Rice Statistics (WRS) (2006) Available online (accessed 27 July 2010)

Wu (2008). A Tale of Two Commodities: How EU Regulations have Affected U.S. Tree Nut Industries. *World Mycotoxin Journal* vol. (1): 95-102.

Wudiri B. (1992). *Developing Appropriate Rice Processing Technologies For Nigeria: the NCRI Experience in Rice Processing in Nigeria*. Proceedings of the MFA Workshop in Niger State.