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Examining The Economic Benefits Of Oyster Shells In Lime Production In Ghana

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Abstract: ***This study aims at examining the economic benefits of mining oyster shells in the production of lime in Ghana. The study notes that there is inadequate knowledge about the entrepreneurial and economic potentials inherent in the use of oyster shells in lime production though the shells are in abundance in the southern sector of the Volta region of Ghana. The study, therefore, compared the production profitability of two major lime producing companies in Ghana: Carmeuse Ghana Limited, which uses limestone, and Basic Chemical Industry, which uses oyster shells to produce lime. Workers of both companies were selected using the simple random sampling technique and questionnaires were administered to them to gather information for the study. The data obtained from the questionnaires was analysed in a narrative form with the aid of graphs and tables. The study concluded that despite the fact that oyster shells are in abundance in Ghana, due to lack of knowledge about their more viable economic potentials than limestone, they are not mined as they should be for the production of lime which has many great uses. The study, therefore, recommends among others that Carmeuse Ghana Limited, and other lime producing companies, as well as the Government of Ghana should invest in tapping into the much available raw material of oyster shells in the production of lime to enhance profits and create more jobs in Ghana.***

Keywords: lime, technology, economic, Ghana, process

I. INTRODUCTION

Lime is an inorganic material which contains calcium. This material is predominated by carbonated, oxides, and hydroxides. It is also the name of the natural mineral (native lime) CaO which occurs as a product of coal seam fires and in altered limestone xenoliths in volcanic ejecta. (Krzysztof, 2013). Lime is the high-temperature product of the calcination of limestone. According to Rajput (2006), the word "lime" originates with its earliest use as building mortar and has the sense of "sticking or adhering. Although limestone deposits are found in every state, only a small portion is pure enough for industrial lime manufacturing. To be classified as limestone, the rock must contain at least 50 percent calcium carbonate. When the rock contains30 to 45 percent magnesium carbonate, it is referred to as dolomite, or dolomitic limestone.

Lime is manufactured in various kinds of kilns by one of the following reactions: CaCO3 + heat 6 CO2 + CaO (high calcium lime) CaCO3@MgCO3 + heat 6 2CO2 + CaO@MgO (dolomites lime). In some lime plants, the resulting lime is reacted (slaked) with water to form hydrated lime. The basic processes in the production of lime from oyster shells are: Quarrying of oyster shells, Washing of oyster shells, Oyster shell crushing and screening, Calcination of oyster shells, Hydration of quicklime and classification of hydrated lime, and Packaging/Transportation

Clam or oyster shells can be found in the Volta Region of Ghana. Lime is an end product of oyster or clam shells, and has the following major uses:

- ✓ Metallurgical (aluminum, steel, copper, silver and gold industries)

- ✓ Environmental (flue gas desulfurization and hazardous waste treatment)
- ✓ Construction (soil stabilization, asphalt additive and masonry lime).
- ✓ Waste Water treatment with ferrous sulfate.
- ✓ Production of lime is a potential to air pollution and, therefore, can affect the health of the citizens in the community.

The aim of this research is to assess the economic benefits of lime production in Ghanaian industries. Specifically, the study has two main objectives: measuring the awareness level of oyster shells to miners about production of lime, using oyster shells as raw material and conducting the cost-benefit analysis of lime production using oyster shells as raw material.

Again, the study will be guided mainly by the following questions:

- ✓ What are the realistic possibilities of using oyster shells in the production of limes?
- ✓ What are the processes of producing lime using oyster shells?
- ✓ What are the economic or cost-benefits of using oyster shells in the production of lime?

The study will be centered on measuring the awareness level of the importance of oyster shells in lime production by miners as well as to conduct the cost benefit analysis of lime production in Ghana. These objectives will be achieved by using questionnaires, interview, and visits to Geological survey department as well as some of the lime production companies, Environmental protection agency of Ghana and a visit to oyster shell deposited areas. The study will also include the cost-benefit analysis of lime production in Ghana.

The importance of this research lies in different phases of the production process and the end product and its usefulness to society. The study when completed will go a long way to prevent Ghanaians from wasting oyster or clam shells which are in abundance in Ghana. Most people will get to know from the results of this study that oyster shells can generate foreign revenue to the Ghanaian's economy. Again, it will enlighten people to come to terms with the fact that indeed, oyster shells found at most river banks and sea shores are a good raw material for the production of lime. The use of oyster shells in the production of lime, therefore, will help in the creation of job opportunities for Ghanaians. By so doing, entrepreneurs will have the confidence to invest in the lime production business since much revenue can be generated from there.

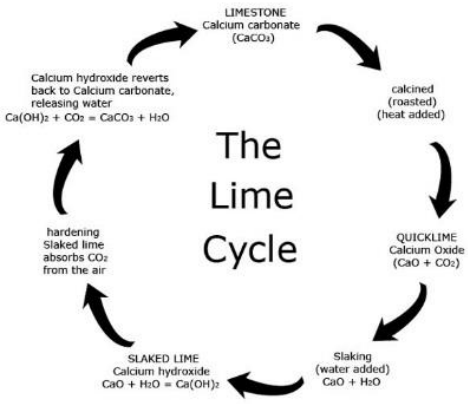
II. THE PROBLEM DEFINED

Lime is an end product of oyster shell or clam shells. Lime is used in waste water treatment, aluminum, copper, silver and gold industries, flue gas desulfurization, hazardous waste treatment, soil stabilization, asphalt additive and masonry lime and even as an additive in the production of steel. Production of lime involves quarrying, crushing and sizing, calcining, hydrating and miscellaneous transfer, storage and handling operations. It is clear that lime from oyster shells is very important to some of the processing industries in Ghana. However, most Ghanaians are not aware that lime can be produced from oyster shells. Again, most people do not know of the economic benefits that its production here in Ghana can generate for entrepreneurial investments, as well as the enormous foreign exchange that it can give to the country as a whole. It is for this reason that this research is being done to examine the economic benefits that oyster shells, which are found in abundance in Ghana can be extremely beneficial in the production of lime in Ghana.

III. RELATED LITERATURE

According to Rajput (2006), the word "lime" originates with its earliest use as building mortar and has the sense of "sticking or adhering". Lime is a calcium-containing inorganic material in which carbonates, oxides, and hydroxides predominate (Trubitt, 2003). It is also the name of the natural mineral (native lime) CaO which occurs as a product of coal seam fires and in altered limestone xenoliths in volcanic ejecta. (Krzysztof, 2013). For a lime to be classified as limestone, the rock must contain at least 50 percent calcium carbonate. When the rock contains 30 to 45 percent magnesium carbonate, it is referred to as dolomite, or dolomitic limestone (Benhelal et al., 2012).

Lime can also be produced from aragonite, chalk, coral, marble, and sea shells or oyster/clam shells (Brunt, et al., 1980). This research is limited to oyster or clam shells only. The Standard Industry Classification (SIC) code for lime manufacturing is 3274. The six-digit Source Classification Code (SCC) for lime manufacturing is 3-05-016. According to Heather (2012), the process by which lime is converted to quicklime by heating, then to slaked lime by hydration, and naturally reverts to calcium carbonate by carbonation is known as the Lime Cycle.



Source: http://en.wikipedia.org/wiki/File

Figure 1: The Lime Cycle for High-Calcium Lime

IV. GENERAL DESCRIPTION OF OYSTER SHELLS

The word "oyster" is used as a common name for a number of different families of saltwater clams, bivalve molluscs that live in marine habitats. In some species the valves are highly calcified, and many are somewhat irregular in shape. Many, but not all, oysters are in the super family called Ostreoidea. Some kinds of oysters are commonly

consumed either cooked or raw by humans as a delicacy. Some kinds of pearl oysters are harvested for the pearl produced within the mantle. Windowpane oysters are harvested for their translucent shells, which are used to make various kinds of decorative objects. A group of oysters is commonly called a bed or oyster reef. First attested in English during the 14th century, the word "oyster" comes from the old French word “oistre” which in turn came from the Latin word “Ostrea” the feminine form of which is “ostreum.”

V. TYPES OF OYSTERS

There are different types of oysters which this paper will briefly mention. These include true oysters, pearl oysters, thorny oysters, pilgrim oysters, saddle oysters, dimydarian oysters and windowpane oysters. In a study by Lasota et al (2014) which enabled them to study the unique ecophysiological and biochemical properties and variations between the Baltic and North sea population of clam shells, they discovered differences in protein content, as well as lipids and carbohydrates in the soft tissue followed by seasonal variations. As such, it is obvious that variations in seasonal conditions could affect the quality of shell even produced by a clam. This study is no different from that of

VI. ECOSYSTEM SERVICES

Oysters influence nutrient cycling, water filtration, habitat structure, biodiversity, and food web dynamics (Marjanovich et al, 2013). Oyster feeding and nutrient cycling activities could change the prevailing shallow, coastal ecosystems if restoration of historic populations could be achieved. Furthermore, assimilation of nitrogen and phosphorus into shellfish tissues provides an opportunity to remove these nutrients from the environment, but this benefit has only recently been recognized (Padilla, 2010). Jud and Layman (2011) postulated that as the ecological and economic importance of oyster reefs has become more widely acknowledged, creation of oyster reef habitat through restoration efforts has become more important - often with the goal of restoring multiple ecosystem services associated with natural oyster reefs (Lasota et al, 2014). Despite the fact that mention is made about how the shells help to change the prevailing dynamics of the eco-system in any reef, Marjanovich et al (2013), also attempt discussing into detail some of the benefits of sea shells when used as reflectors in easy production of solar energy.

VII. AREAS OF OYSTER SHELLS DEPOSIT IN GHANA

Oyster shells could be found in the southern part of Volta region of Ghana. The main sources are the towns and villages around Volta Lake and the Keta lagoon.

Figure 1: Map of Ghana

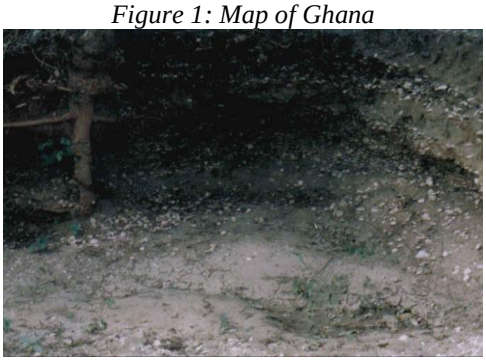


Figure 2: Oyster shells being dugged or extracted from the soil

(Source: Minerals Commission, Ghana www.ghanamining.org).

Figure 5: The Volta River

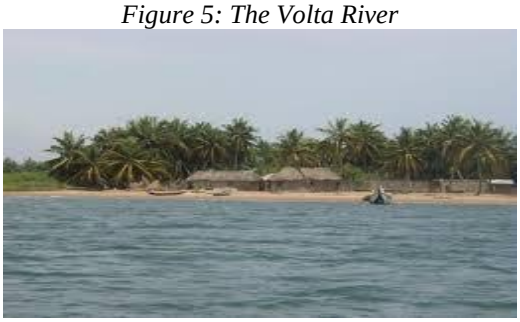


Figure 6: The Keta Lagoon

(Source: Wikipedia Encyclopedia)

Some of the oyster shells deposit areas that have been visited in the Volta region are as follows: Sogakope, Keta, Anloga, Anlo Afiadenyigba, Anyako, Nolopi, Seva, Atsiavi, Alakple, Anyanui, Tegbuie, Woe, Blekusu, Azizadzi, Adina and Vodza. It is interesting to note that apart from most of

these places in Ghana, many other places around the world also have large deposits of oysters which also remain untapped. In Beukerna et al. (1999), for example, the very problems Ghana faces in terms of the lack of knowledge of the presence of oyster leading to their non-exploitation is also highlighted. They make reference to the need for the possible exploitation of shell production in the Dutch Wadden sea.

CHEMICAL PROCESS OF LIME

The process of the progressive change of oyster shells to lime is shown in the formula:

Ca (OH) 2 + CO 2 ↔CaCO3 + H 2O

If hydrated lime is exposed to carbon dioxide and it may revert back to calcium carbonate

LIME PRODUCTION FROM OYSTER SHELLS

According to Rhea (1993), the process of making lime from oyster shells including passing the shells through a crusher to limit the maximum thickness, passing the crushed shell over a screen to limit the minimum size, washing the screened shells, passing them to a rotary kiln, heating the kiln with a fuel giving off no solid product in its combustion, and cooling the calcined product.

The flow diagram of lime production can be different from plant to plant, and generally depends on the technological characteristics of the production process in place. Nevertheless, the process includes five basic steps: 1.Quarrying of oyster shells, 2.Washing of the shells, 3.Oyster shells crushing and screening, 4.Calcinations of oyster shells 5.Hydration of quicklime and classification of hydrated lime, and 6. Packaging / Transportation (Oates, 2000). For the sake of simplicity, these steps are used to generalize the flow diagram of the production process in the plants under scope.

The importance of sea shells in the production of bioceramic nanopowders is greatly highlighted in the paper of Agaogullari et al. (2012). Their study proposes a new approach for developing highly bioactive fine powders of Ca-phosphates, which invariably can be used afterwards to build up hydroxyapatite-based ceramic bone-scaffolds from sea urchins through the study's proposed methods. A similar presentation by Krumnacher (2001) confirms the beneficial relationship between lime and cement technology in the thesis submitted to the Virginia Polytechnic and State University.

ENVIRONMENTAL IMPACT OF LIME PRODUCTION

According to Boynton (1980), lime production is characterized by large emissions of CO_2 and by other environmental impacts. The process of lime production involves the emission of large quantities of CO_2, main actor of climate change. In fact, the production of 1t of lime entails the emission of around 1.2t of CO_2 (Ochoa et al, 2010), making lime one of the produced materials with the highest associated specific emission of CO_2. The environmental impact of lime production can be local, regional or global in scale. Local effects include dust emissions and change in landscape because of the mining of oyster shells. Emitted sulfur dioxide and nitrogen oxides contribute to acid rain on regional scale, whereas CO_2 emission contributes to global climate change (Brown (2013). Lime is used in the various field, some of them are as follows: Metallurgy, Mechanical industries, Aluminum industries, Copper industries, Steel industries, Silver industries, Gold industries, Environment, Flue gas desulfurization, Hazardous waste treatment, Construction, Soil stabilization, Asphalt additive, Masonry lime, and Waste water treatment with ferrous sulfate (Oates, 2000).

VIII. METHODOLOGY

The steps to achieve the aims of the study include the following: searching for areas of oyster shells deposit; this was done with the help of the Geological Survey Department of Ghana and personal visitation to the sites that were identified; measuring the awareness level of Ghanaians about the importance of this natural resource through questionnaire administration and conducting interviews; projecting the various processes through which oyster shells could be used in the production of lime; and finally calculating and projecting the cost-benefit analysis of using oyster shells to produce lime as compared to other sources of lime production.

IX. RESEARCH DESIGN

The study was designed to derive first-hand information through books, journals and the internet in addition to the field studies undertaken using instruments such as questionnaire check list and personal observation. Data was collected from the population using the following data collecting techniques or instruments: questionnaire, interviews, check list and physical observations of the oyster shell deposit areas. Furthermore, photographs of some of the oyster shell deposits were taken.

The population consisted of the industries that produce lime using oyster shells as raw materials (Basic Chemical Industry in Tema, Ghana), industries that produce lime using limestone as raw materials (Carmeuse Ghana limited) and areas of oyster shell deposits in the southern part of Volta region of Ghana. The sampling procedure used for this study was simple random sampling. The workers in Carmeuse Ghana Limited were selected and used as the sample unit, as well as the workers in Basic Chemical Industry. The data that was obtained from the questionnaires was analysed in a narrative form with the aid of graphs and tables. The analysis for the survey data was done by collating, grouping and manually counting of the survey. The Statistical Package for the Social Sciences (SSPS) version 16 was also helpful in the analysis of the data. The analyzed results were presented in tabular and graph form.

X. RESULTS AND DISCUSSIONS

This part of the study focuses on the presentation and discussion of results from the data collected.

Section One: Awareness Level

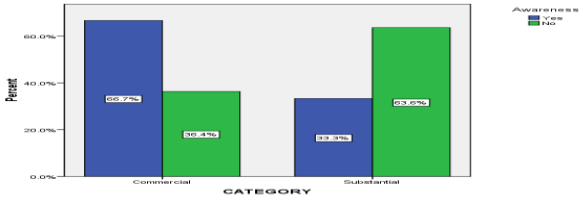


Figure 1: General awareness

GENERAL AWARENESS LEVEL OF MINERS OF THE USE OF OYSTER SHELLS IN LIME PRODUCTION

With reference to the graph above, the data was collected from oyster shells deposits in the southern part of the Volta region through the use of questionnaires. The result is grouped into different categories, which are commercial miners and substantial miners. From the graph, the general awareness level of commercial miners on oyster shells to produce lime was 66.7% and that of the substantial miners was 33.3%. 36.4% of commercial miners are not aware whilst 66.7% showed that they are aware. And also, 33.3% showed the substantial miners' awareness level whilst 63.6% showed that they are not aware.

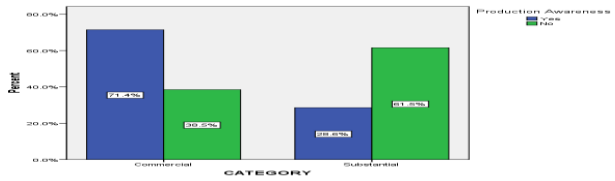


Figure 2: Production Process Awareness of Miners

PRODUCTION PROCESS AWARENESS

Fig 2 above shows the data collected from the oyster shells miners in the southern part of the Volta region. It was categorized into two categories, commercial miners and substantial miners. 71.4% showed that commercial miners are aware or know the production process and 38.5% showed that they do not know the production process of lime using oyster shells as raw material. Whilst 28.6% of substantial miners know how lime is produced from oyster shells, 61.5% of substantial miners do not know how lime is produced using oyster shells.

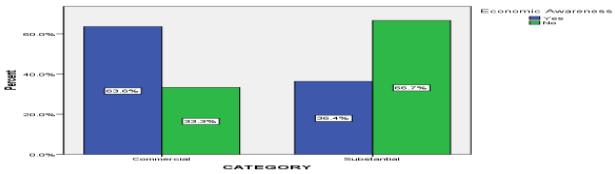


Figure 3: Economic awareness

ECONOMIC AWARENESS LEVEL OF OYSTER SHELL MINERS

With reference to Fig 3 above, the data was collected from oyster shells deposits in the southern part of the Volta region through the use of questionnaires. The result is grouped into two categories, which are commercial miners and substantial miners. 63.6% shows the economic awareness level of the commercial miners and 33.3% also shows that the commercial miners are not aware of any economic value of oyster shells. Whilst 36.4% show that substantial miners are aware of the economic value of oyster shells and 66.7% shows that they are not aware of the economic value of oyster shells. The level of awareness of commercial miners is higher than that of the substantial miners because they mine and sell so they know how economic valuable it is.

The data showed the age groups who are into oyster shells mining. It was found out that there are two categories of miners: commercial and substantial miners. The 31-35 years group recorded the highest percentage in the category of commercial miners, whilst 18-25 years group recorded the lowest. In the category of substantial miners, above 35 years group recorded the highest percentage and 18-25 years group recorded the lowest. In all, it is clear that 31-35 years group is the group that is mostly into oyster shell mining.

LEVEL OF EDUCATION

The next focus of the study was on the level of education of oyster shells miners in the southern part of the Volta region of Ghana. The result was categorized into two categories namely the commercial and substantial miners. The results revealed that those who did not go to school recorded the highest percentage in both categories and S.H.S graduates recorded the lowest percentage in both categories.

		CATEGORY		
		Commercial	Substantial	Total
Quantity a day	2-5 HP	2	1	3
		66.7%	33.3%	100.0%
	6-10 HP	7	5	12
		58.3%	41.7%	100.0%
	11-15 HP	1	3	4
		25.0%	75.0%	100.0%
	Above 16 HP	0	1	1
		.0%	100.0%	100.0%
Total		10	10	20
		50.0%	50.0%	100.0%

(HP stands for Head Pan)
Source: Field Survey, March 2016

Table 1: Quantity of Oyster Shell Mine

QUANTITY OF OYSTER SHELLS MINED A DAY

Table 1 showed the result of the quantity of oyster shells that the people of the southern part of Volta region of Ghana mine a day. The result was categorised into two categories, such as commercial and substantial miners. In the category of commercial miners, 2-5 HP (Head pan) is the most quantity of oyster shells people mine a day and nobody mines above 16 HP a day. 11-15 HP is the most quantity that people mine a day in the category of substantial miners and 2-5 HP recorded the lowest. In all 6-10 HP is the quantity that most people mine a day.

SECTION 2: COST - BENEFIT ANALYSIS

This part of the study is an answer to the research question stated in the introduction of this research – the cost-benefit analysis of lime production in Ghana using oyster shells as raw material. This section of the research consists of two parts namely cost-benefit analysis of lime production using oyster shells as raw material and cost-benefit analysis of lime production using limestone as raw material.

PART I: WHERE OYSTER SHELLS ARE USED FOR LIME PRODUCTION

The data for this result was collected from Basic Chemicals Industries LTD at Tema. The analysis was classified into three stages: input, processing and output. The fixed cost was not considered but only the variable cost was considered and all the analysis was based on monthly activities.

STAGE 1: INPUT STAGE

Below is the calculation for expenses on raw material for a month.

Two trucks of oyster shells a day cost GH₵1,800.00

Expenses on raw material for 26 working days cost GH₵46,800.00

Therefore, the total expense on raw material for a month cost **GH₵46,800.00**

STAGE 2: PROCESSING STAGE

Expense on power for a month cost GH₵3,500.00

Expense on labor (Employees) for a month = GH₵4,680.00

Expense on machine maintenance = GH₵1,200.00

Therefore the total expenses on processing = **GH₵9,380.00**

STAGE 3: OUTPUT STAGE

Bag of lime produced from one truck of oyster shells is 335 bags.

Two trucks of oyster shells produced 670 bags of lime a day

Total bags of lime produced a month is 17,420 bags

One bag of lime cost GH₵25

Total amount earned for a month = **GH₵ 435,500.00**

INCOME STATEMENT

Sales		GH₵435,500.00
Operating expenses:		
Raw material expense	46,800.00	
Utilities expense	3,500.00	
Wages and salaries expense	4,680.00	
Maintenance expense	1,200.00	
56,180.00		
Net income		**GH₵379,320.00**

PART 2: WHERE LIMESTONE IS USED FOR LIME PRODUCTION

The data for this result was collected from Carmeuse Ghana Limited in Takoradi. The analysis was classified into three stages: input, processing and output. The fixed cost was not considered but only the variable cost was considered and all the analysis was based on monthly activities. The price of limestone varies according the grain size. For the purposes of this study, the current price of fine grain was used in the analysis.

STAGE 1: INPUT STAGE

Price of raw material: (fine grain) one metric ton of limestone = GH₵350.00

400 Metric tons of limestone processed a day = GH₵140,000.00

Expense on raw material for a month = **GH₵3,276,000.00**

STAGE 2: PROCESSING STAGE

Expense on utilities a month = GH₵82,000.00

Expense on wages and salaries GH₵300,000.00

Expense on maintenance GH₵ 20,000.00

Total expense on processing for a month = **GH₵402,000.00**

STAGE 3: OUTPUT STAGE

Bags of lime produced a month = 644,205

Price of a bag of lime = GH₵28.00

Total amount earned a month = **GH₵18,037,740.00**

INCOME STATEMENT

Sales	**GH₵18,037,740.00**	
Operating expenses;		
Raw material expense	3,276,000.00	
Wages and salaries expense	300,000.00	
Utilities expense	82,000.00	
Maintenance expense	20,000.00	3,678,000.00
Net income		**GH₵14,359,740.00**

Raw material	Sales GHS	Expense GHS	Profit GHS	Profit %
Oyster shell	435,500.00	56,180.00	379,320.00	87.10
Limestone	18,037,740.00	3,678,000.00	14,359,740.00	79.61

Table 2: Cost- Benefit Analysis

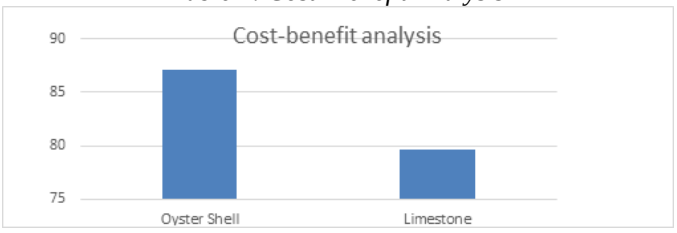


Figure 4: Profit

XI. COST-BENEFIT ANALYSIS

With reference to the graph above, 87.1% showed the profit gain for lime production using oyster as raw material and 79.61% also showed the profit for lime production using limestone as raw material. This means that it is more profitable to use oyster shell to produce lime is more than the profit from limestone to produce lime. Therefore, oyster shell involves fewer expenses than limestone.

XII. CONCLUSION

Based on the study, it was noticed that:

- ✓ There are Limestone deposits in Ghana, but they are not being used to produce lime due to its Calcium Carbonate Content.
- ✓ Oyster shells are deposited in Ghana in large quantities, but it is only one company, which is privately owned that makes good use of it and it is Chinese owned.
- ✓ The government of Ghana is not involved in the lime business even though it is a big job creation avenue waiting to be tapped.
- ✓ Because people have little knowledge about the prospects inherent in the lime business, they do not want to invest in it.

XIII. RECOMMENDATIONS

The following are some of the recommendations from this research:

- ✓ Government should invest more in the lime business especially adopting the use of oyster shell to produce lime since it will reduce unemployment in the country
- ✓ Investors should feel free to invest in the lime business in Ghana since they are in abundance.
- ✓ Government should assist the oyster shell miners by providing the necessary equipments to them.
- ✓ Carmeuse Ghana Limited should consider using oyster shells as a major raw material to produce lime since per the accounting and economic projections made, oyster shells are cheaper to use in the production of lime as compared to limestone.
- ✓ Basic Chemical Industry limited should take the safety of its employees serious.
- ✓ Government should consider setting up lime industries in the southern part of the Volta region to enable it earn more money to boost the economy.

Ghanaians should be educated about the economic viability of lime in general, as well as oyster shells in the production of lime. This will encourage entrepreneurs to consider investing in the lime business.

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