ECONOMIC ANALYSIS OF SMALL- SCALE CATFISH FARMING IN IDO LOCAL GOVERNMENT AREA OF OYO STATE, NIGERIA.

BY

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ABSTRACT

This study analyzed the economics of small-scale catfish farming in Ido Local Government Area of Oyo State. Sixty small-scale catfish farmers were selected using simple random sampling technique. Structured interview schedule was used to collect information from the respondents. Descriptive analysis revealed that the average age of respondents was 45.07 years. Average year of schooling was 9.5 years and 90% of them use earthen ponds. The major problems faced by the catfish farmers were predators, high cost of inputs and finance. Per harvest cost and returns analysis revealed the gross margin as N428, 917. 78, net revenue as N370, 154.40 and the benefit-cost ratio (BCR) as 2.173. This result shows that catfish farming is a profitable enterprise. Regression analysis was employed to determine the relationship between cost of production and returns. Adjusted R^2 of 89.6% revealed that rent on land, Pond construction cost, Cost of fingerlings, feed cost, transportation, as well as salary and wages were significant factors affecting total revenue of respondents.

Key Words: Economic Analysis, Small- scale, Catfish.

INTRODUCTION

Fish farming is the sub-set of aquaculture that focuses on rearing of fish under controlled or semi-controlled conditions for economic and social benefits. Aquaculture is the rearing of aquatic organisms under controlled or semi-controlled conditions for economic and social benefits. Aquatic organisms include fishes, molluscs, crustaceans and aquatic plants. Culture implies some forms of intervention in the rearing process to enhance production such as regular stocking, feeding, protection from predators etc. [2].

Fishing, like any other hunting activities has been a major source of food for human race and has put an end to the unsavory outbreak of anemia, kwashiorkor and so on. Fish is one of the most diverse groups of animals known to man with more than 20,500 species in existence [3]. It accounts for about one fifth of world total supply of animal protein and this has moved up five folds over the last forty years from 20 million metric tons to 98 million metric tons by the year 1993 and projected to exceed 150 million metric tons by the year 2010. Fish farming also generates employment directly and indirectly in terms of people employed in the production of fishing output other allied business [6]. An estimated 43.5 million people were directly engaged (part time or full time) in primary production of fish either in capture from the wild or in aquaculture representing 3.2 percent of global 1.37 people in active agriculture and a further 4 million people were engaged on an occasional basis [4]. According to [8], small-scale and home-use catfish farming are significantly more sustainable than intensive production. Because inputs are minimized, small-scale practices can substantially reduce production costs.

The savings realized by producing fish for direct consumption reduce the farm family's cost of living and improve their quality of life. Small-scale catfish production offers Kentucky's farm families quality food at wholesale prices, a source of supplemental income, and a means of diversifying farm enterprises. These home-use techniques broaden Kentucky's farm culture and enhance opportunities in rural areas overall. When compared with livestock, it requires less space, time, money and has a higher feed conserving rate. In further production of animal meat and other production in Nigeria and in world at large, the fish serve as an additive and good nutritive supplement (ingredient) for the production of various animal meals and other products [7].

Clarias specie has wide acceptability as a food in Nigeria and because it is a fast growing specie that adapts well to culture environment and also because it can be retailed live and attracts premium price. Channel and blue catfish are both suitable for stocking in ponds. However, channel catfish are more readily available from private hatcheries and tolerate low dissolved oxygen better than blue catfish. Blue catfish grow larger than channel catfish after the second year post-stocking. There is no difference in taste or flesh texture between the two species [6]. Catfish is highly nourishing. It contains lysine as well as vitamins A that are necessary for healthy growth. It also contains some quantities of calcium, phosphorus, fat and other nutrients needed for human growth and health. Catfish is a major source of protein to an average Nigerian home and through small-scale production, it is expected that there would be an increase in the supply of catfish which directly would mean an increase in the protein supply to an average Nigerian family, and this would definitely have a positive effect on the national income as healthy people tend to work harder [5].

Most of the past studies in Nigeria focused on large scale fish farming. Some others have their focus on the nutritional aspect. To this end, an economic analysis of small-scale catfish farming, which is the focus of this study, would serve as a guide for investment decision to both current and potential farmers. Information on the various inputs that contribute significantly to output would be of much benefit to intending catfish farmers.

Objectives of the study

The major objective is to analyze the economics of small-scale cat fish farming in the study area. The specific objectives are to;

- Identify the socio- economic characteristics of catfish farmers in the study area.
- Investigate the inputs employed in catfish farming in the study area.
- Analyse the cost ant returns to catfish farming in the study area
- Identify the problems militating against catfish farmers in the study area.

Hypothesis of the study

There is no significant relationship between the cost of inputs used and total revenue generated by small-scale cat fish farmers.

METHODOLOGY

Study Area

The study area is Ido Local government area of Oyo State. It is one of the local government areas located in Ibadan, the state capital. Ido area is well drained with some rivers which the indigenes of the area used for domestic purpose and fish cultivation. There are two main seasons; the rainy season, and dry season. The rainy season is from

April to October, the dry season is November to March. The major occupation of residents in the area is farming. Population size of the area is two hundred and sixty seven thousand, eight hundred and sixty five (167,865).

Method of data collection

A list of registered catfish farmers was collected from the local government headquarters. The list of small-scale catfish farmers were extracted from the register and a random sampling technique was used to select 60 catfish farmers (40%) from the list. According to [1]'s classification, Nigerian farmers fall in to three broad categories, namely, small scale with 0.10 to 5.99 hectares, medium scale with 6 to 9.99 hectares and large scale holdings with 10 hectares upward. Structured interview schedule was administered to the selected catfish farmers. Information was collected based on the objectives of the study.

Data analysis

Data collected were analyzed using both descriptive and inferential statistics. Cost and returns analysis was also carried out to investigate the profitability of the enterprise. Descriptive analyses involve the use of tables, percentages, frequency and mean. Inferential statistics involve the use of regression analysis to establish the relationship between the dependent variable and independent variables.

This is implicitly expressed as:

$$Y= f (x_1 \ldots\ldots, x8)$$

Where Y= Total Revenue generated by respondents

X = [Rent on land(X1), Stocking density(X2), Pond construction cost(X3), Cost of fingerlings(X4), Feed cost(X5), Cost of veterinary services and drugs(X6), Transportation cost(X7), Level of education(X8), Year of experience(X9), Salaries & wages(X10)]

The a priori expectation of this study is that an inverse relationship exists between revenue and cost of production.

Cost and returns analysis investigates the profitability of the business:

Total Revenue = Output * Unit price

Total cost = Total variable cost + Total fixed cost

Gross margin = Total Revenue – Total Variable Cost

Profit = Gross Margin – Total fixed cost (depreciated value)

$$\text{Benefit cost Ratio} = \frac{\text{Total Revenue}}{\text{Total Cost}}$$

RESULT AND DISCUSSION OF FINDING

Socio-economic characteristics of respondents

Data collected showed that both male and female were involved in catfish production as 78.3% of the respondents were males while 21.7% were females. It revealed that 50% of the respondents were between the age range 41-50 years, and they constitute the largest population of the catfish farmers. Mean age for the respondents was 45.07 years.

Education is important in achieving high level of management capabilities. Findings showed that a good number of the farmers in the study area received some level of formal education. About 33 percent of the respondents claim to acquire tertiary education. On the average, the respondents spent 9.5 years in school. Eighty-three percent of the respondents claimed between 1-6 members within household. The average household size was 6. Finally, the average years of fishing experience by the farmers was 5.88 years.

Inputs employed in catfish farming

Table 1 depicts different types of inputs employed by the respondents in there production activities. Most (90%) of the farmers employed earthen ponds while only10% use catfish tanks. There are variations in pond sizes of respondents .According to them, large ponds are economical but can not be easily managed. Smaller ponds are easily managed and more suitable for those just venturing into the enterprise. Average pond size in the study area was 482 meter squared, with an average depth of 3 meters. This conforms to [8]'s submission that ponds as small as 0.25 acre or as large as 20 acres are suitable. However, ponds in the 1- to 5-acre range are more practical. The table also shows the stocking schedule of fingerlings by the farmers in the area. Average stocking rate for the respondents was 1640 fingerlings. Fertilizer is an important input to catfish farming in the study area. Eighty-six percent (86.7%) of respondents claimed to use poultry waste, 10% use cattle dung while 3.3% use NPK in the study area. Thirty three percent of respondents claimed to depend on family labour while 67% use hired labour. Other inputs used by the respondents are: land, water, feed, shovels, fishing nets, veterinary services and drugs. The average land area allotted to fishing activities by respondents was1.37 hectares. This conforms to [8]'s finding that fish farming requires less land area compared to crop and livestock production. Underground water and rain water are major sources of water for fishing activities in the study area.

Table 1: Inputs employed by respondents

Fish pond (type)	Frequency	Percentage
Earthen pond	54	90.0
Concrete tank	6	10.0
Total	**60**	**100**
Fingerlings (stocking rate)		
1000-2000	36	60.0
2001-3000	24	40.0
Total	**60**	**100**
Fertilizer & Lime		
Poultry waste & lime	52	86.7
Cattle dung & lime	6	10.0
NPK & lime	2	03.3
Total	**60**	**100**
Labour (type)		
Family	**20**	**33.3**
Hired	**40**	**66.7**
Total	**60**	**100**

Source: Field survey, 2009

Cost and Returns Analysis per Harvest

According to the respondents, harvesting is carried out twice in a year, that is, six months interval. The following analysis is done based on per cropping operation. The average values for the sixty respondents were used.

Variable cost components for the respondents include fingerlings cost, fish meal, fertilizer and lime, vetenary services and drugs, transportation, salary and wages.

Average variable cost = # 256,930.55

Fixed cost components for the respondents include rent on land, pond construction, fishing-net, shovel, e.t.c.

Average fixed cost = #58,763.43

Average total cost = Average variable cost + Average fixed cost
= # 256,930.55 + #58,763.43
= #315,693.98

Revenue = quantity harvested (kg) * price per kg
=1,558.74 * # 440
= # 685,848.33

Benefit Cost Ratio (BCR): which is total revenue divided by total cost i.e. TR/TC.

$$BCR = \frac{TR}{TC} = \frac{685848.33}{315693.98} = 2.173$$

An investment is profitable if the BCR is greater than 1.

Gross Margin: This is calculated as revenue minus variable cost

GM = R-VC

= ₦685848.33- ₦ 256,930.55

= ₦ 428,917.78k

This shows that catfish production is profitable.

Profit**:** This is the net benefit of doing business.

Profit = Gross margin – FC (i.e. revenue – cost)

= ₦428, 917.78 – ₦ 58,763.43

= #370,154.40 k

Going by the above analyses, a catfish pond of 482 meter squared, stocked with 1640 fingerlings, within the next six months will yield 1,558.74kg of catfish to give a profit of #370,154.40k to the investor. This finding agrees with [6] and [8] that small-scale catfish farming is a profitable enterprise.

Problems faced by catfish farmers in the study area

It is clearly shown from table 2 that catfish farmers encounter diver problems in the course of their production activities. The major ones include high cost of input, predators and finance. According to the respondents, most of sources of credits demand for collaterals they could not afford, while others delay such that it does not meet up with the purpose it was meant for.

Table 2: Problems faced by the catfish farmers

Problems	Frequency	Percentage
High cost of input	47	78
Limited market sales	26	43
Inadequate extension visits	33	55
Flood problem	16	25
Predators	57	95
Finance	44	73

Source: Field survey, 2009.

* Percentage greater than 100 due to multiple responses

Result of regression analysis

The analysis determined the relationship between dependent and independent variables. The R-squared of 0.896 indicated that the estimated independent variables explained 89.6% of the variations in revenue to catfish farmers in the study area, while the remaining 10.4% are exogenous to the system. From table 3, the result showed that rent on land, pond construction cost, feed cost, transportation cost, as well as salary and wages have negative significant relationship with revenue. The negativity indicated that the variables and revenue move in opposite directions i.e. the higher the cost of negatively signed variables, the lower the revenue. This agrees with the a priori expectation of the study.

However, contrary to a priori expectation, cost of fingerlings was found to be proportionally related to revenue. This could be accredited to the fact that high quality fingerlings cost more. But at the end of the day, they produce better yield which results to higher revenue.

Table 3: Result of regression analysis

Variable	Coefficient (b)	t- ratio	significance
Constant	6447.227	0.185	0.854
Rent on land	-0.928	-8.253	0.000
Stocking Density	0.315	0.053	0.958
Construction cost (Pond)	-1.010	-7.813	0.000
Cost of fingerlings	36.466	99.474	0.000
Feed cost	-0.725	-5.280	0.000
Vet. Services & Drugs	-0.331	-0.506	0.615
Transportation	-1.133	-5.046	0.000
Level of education	2.884	0.365	0.717
Year of experience	-10.192	-1.240	0.221
Salary and wages	-0.957	-2.304	0.026

Adjusted R- squared =0. 896 F-value = 83.313 (0.000)

Source: Data analysis, 2009.

Conclusion

This study concluded that small-scale catfish farming is a profitable enterprise, especially when there is proper management of inputs, absence of predators, and when timely source of loan is available. The study concluded that there is significant negative relationship between cost of production and total revenue made by catfish farmers in the study area.

Based on the findings and conclusion of the study, the following recommendations are made: Catfish farmers should form themselves into cooperative groups or association and purchase inputs in bulk for the use of members so as to reduce per head cost of production. The cooperative groups can also provide timely loans to its members at a much reduced interest rate; as well as constitute an avenue for the farmers to share improved management information.

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PERMEABILITY AND COMPRESSIBILITY CHARACTERISTICS OF MUNICIPAL SOLID WASTE SAMPLES USING A FABRICATED INTERMEDIATE SCALE OEDOMETER

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Keywords: Compression indices, lever arm consolidomoter, dumpsite, one-dimensional loading, heterogeneous wastes

Abstract
This research work examined the geotechnical properties of municipal solid wastes related to landfilling in Akure, Nigeria. A new intermediate scale consolidation equipment was built at the Geotechnical Engineering Laboratory of the Department of Civil Engineering, Federal University of Technology, Akure, to determine the permeability and compressibility characteristics of heterogeneous municipal solid waste (MSW) samples taken at different depths from Ondo State Waste Management Board dumpsite and proposed land fill site during one-dimensional consolidation. The oedometer ring is 150 mm inside diameter, 170 mm outside diameter, and 150 mm high. Loading was accomplished by a lever arm-weight system. Three MSW samples were obtained at depths of 0.8 m, 1.4 m and 2.0 m at the existing dumpsite. The values of coefficient of permeability obtained from the consolidation tests agreed with the results obtained using the falling head permeability apparatus to test the MSW samples. Compressibility increased with depth and increasing soil content, while permeability decreased with depth for the MSW samples.

1. INTRODUCTION

Diversification of geotechnical engineering to embrace environmental geotechnics is germane to confronting the global concern for environmental sustainability and human urban habitat challenges in developing countries. Contrary to common perception, most urban growth in Africa now takes place in secondary and tertiary settlements, the towns with less than 500,000 inhabitants, rather than in its largest cities. Consequently, the smaller African cities will need the close attention of policy-makers if their growth is to be pragmatically guided taking into account challenges imposed by environmental changes resulting from population pressure and climate change [1]. Municipal solid waste (MSW), also commonly known as urban solid waste, is a waste type that includes wastes from residential (domestic waste), commercial and institutional areas, construction and demolition wastes, and wastes from municipal services. Municipal solid waste is normally assumed to include all the wastes generated by a community except the industrial wastes [2]. Landfilling is an economical way of disposing of municipal solid waste (MSW) compared to other techniques such as incineration and composting. This land often cannot be developed for beneficial uses because of differential settlement, leachate generation, and landfill gas emissions; nevertheless, it seems probable that some sites that are currently used for municipal solid waste disposal will be considered for development in the future. The reliable knowledge of geotechnical properties of waste materials is required for the evaluation and prediction of actual field behaviour of landfill sites due to MSW self-weight and external applied load. Difficulties in studying municipal solid waste (MSW) are associated with the heterogeneity of the material, which presents different types and dimensions of constituents and has components that degrade with time, generating leachate and gas. The biodegradation of the organic waste and physical chemical processes contribute significantly to modify the strength and compressibility behaviour of the waste. At the moment the physical and mechanical properties of waste materials are studied by extending to these materials the same concepts developed for soils in Geotechnical Engineering [3, 4, 5 and 6]. The objective of this research is the geotechnical characterization of municipal solid wastes with respect to its mechanical behavior in space and time using new intermediate scale consolidation equipment built at the Geotechnical Engineering Laboratory of the Department of Civil Engineering, Federal University of Technology, Akure, Nigeria.

2. MATERIALS AND METHODS

2.1. Description of the new intermediate scale consolidation equipment

A simple intermediate scale casagrande-type oedometer was designed for specimens of 150mm diameter which is a prototype of the typical casagrande-type oedometer. The oedometer was designed to use front loading lever-arm weight system. The construction stage of the designed oedometer involved the fabrication of many component parts based on the dimensions from the drawing produced during the design phase comprising of the consolidometer frame and a cylindrical sample mould. The material used was mild steel and some of the fabrication processes were machining, grinding, welding and drilling.
The consolidometer frame is made up of a lever arm, counter balancing weight, a pivot support, a base, and a hanger. The porous plates, cylindrical mould, retort stand, and dial gauge were the other components of the device. The overall dimension of the consolidometer frame was 870mm by 600mm as shown in Figure 1. The mould with dimension 150mm by 150mm is shown in Figure 2b. The fabricated equipment was used to determine the one dimensional compressibility responses of the municipal solid waste samples.

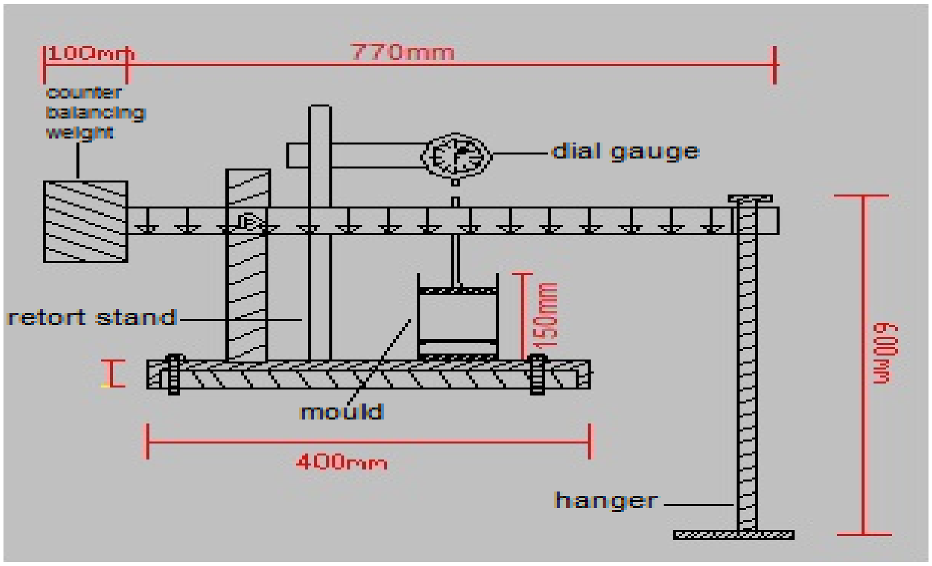
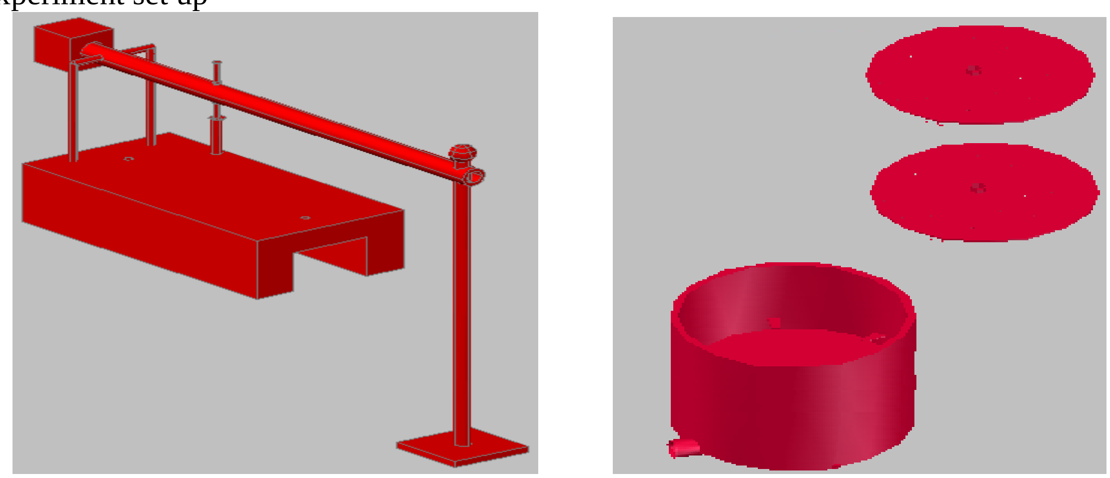


Figure 1: Schematic diagram of the fabricated intermediate scale oedometer experiment set up



(a) Loading frame (b) cylindrical mould and porous plates.

Figure 2: Isometric view of the fabricated oedometer

2.2 Experimental programme

The municipal solid waste used in the course of this project was collected from a dump site owned by the Ondo state government and managed by the state waste management board.

The Ondo State Government acquired 7 hectares (17.3 acre) of land along Igbatoro Road in Akure for the purpose of establishing a modern sanitary landfill that will ensure safe and environmental friendly disposal of solid waste generated in Akure and its environs. The land was cleared for disposal of waste generated in Akure and its surrounding towns in 2001. This site has been used as a dump site since that time. Solid waste in containers were collected and transported to the sanitary landfill using trucks. The laboratory work was carried out in the geotechnical laboratory of the Department of Civil Engineering, Federal University of Technology, Akure.

2.2.1 MSW samples

Three MSW bulk samples A, B and C were obtained at depths of 0.8 m, 1.4 m and 2.0m at the existing dumpsite. The total weight of the municipal solid waste bulk sample A is 15.5kg, sample B 21.0kg and that of sample B is 25.6kg. Each bulk sample was apportioned for the various test namely moisture content, specific gravity, percentage composition and sieve analysis, compaction, consolidation and permeability. In order to facilitate standard laboratory testing, but with representative field composition, the bulk field MSW samples were shredded manually into sizes not larger than 20mm. The shredded MSW was dried and its particle size distribution was determined using sieve analysis in accordance with [7] Part 2:9. Specific gravity test was done for the soil like materials and fines content in the MSW samples (< 2.00mm particle size).

2.2.2 Compaction (Standard Proctor Method)

Shredded oven-dried MSW samples were used to evaluate compaction characteristics. Standard Proctor compaction tests were conducted in accordance with [7] Part 4 using a 102 mm diameter mould. The testing was performed on the three MSW samples.

2.2.3 Consolidation

Confined compressibility testing was carried out in the fabricated oedometer cell determine the compressibility characteristics of MSW samples. In this testing, the MSW sample was placed in the oedometer with one porous plate on the top and another on the bottom of the sample. MSW was compacted into 150 mm inside diameter and 60 mm thick height with a tamping device. Load of 2kg was applied on the sample through the lever arm (with a ratio of 10:1) of the oedometer and the reading was taken at time intervals of 0.25, 0.5, 1, 2.25, 4, 9, 16, 25, 36, 49, 64, 81, 100, 121, 144 minutes and 24 hours from the dial gauge. The applied load was doubled from 2kg to 4kg after 24 hours and the readings were also taken. For each load increment, strain vs. time readings were recorded until the primary compression process was complete. The loading process was repeated for 8kg, 16kg, 32kg and 64kg respectively and readings taken. Data from all the load increments was (Elapse time, dial gauge reading, void ratio and pressure) was used to plot the settlement versus root time curve (Taylor's method) and void ratio (e) versus log p (pressure) graph.

2.2.4 Permeability

Constant head hydraulic conductivity tests were performed in accordance to [7] Part 5. For these tests, MSW was compacted in the rigid wall permeameter mould (with sample dimensions of 100 mm inside diameter and 200 mm height) using a tamping device. Flow rate under constant hydraulic gradient was measured. Darcy's law was used to calculate hydraulic conductivity.

3. RESULTS AND DISCUSSION

3.1 MSW Characterization and Compaction

The composition of the municipal solid wastes (MSW) tested is presented in Table 1. The sand sized component for MSW samples was 36%, 54% and 81% for samples A, B and C respectively. Sample A was taken at 0.8m, Sample B at 1.4m and Sample C at 2.0m. The natural moisture content, specific gravity and unit weight for the MSW samples increased with depth as indicated in Table 2.

Table 1: Composition of the waste samples tested

Sample	A	B	C
Waste Type	Waste Composition (%)		
Plastic	6	5	3
Metal	5	3	1
Glass	2	4	2
Paper	17	12	3
Wood	15	9	3
Textile	8	6	2
Stone	11	7	5
Soil like	36	54	81
TOTAL	100	100	100

Table 2: Summary of moisture content, specific gravity and unit weight

	Sample depth	Natural moisture	Specific	Unit Weight
Sample A	0.8	18.0	1.4	6.0
Sample B	1.4	32.0	1.6	7.5
Sample C	2.0	50.6	2.1	10.4

Figure 3 shows the gradation of shredded MSW, and it can be seen that the shredded samples consisted of particles with sizes ranging from 0.75 mm to 20 mm. Approximately 70% (by dry weight) of MSW consisted of particles with sizes less than 10 mm for samples A and B, while approximately 90% of MSW consisted of particles less than 10mm for sample C. From the result of the compaction tests summarized in Table 3, maximum dry density (MDD) and optimum moisture content increased with depth for the MSW.

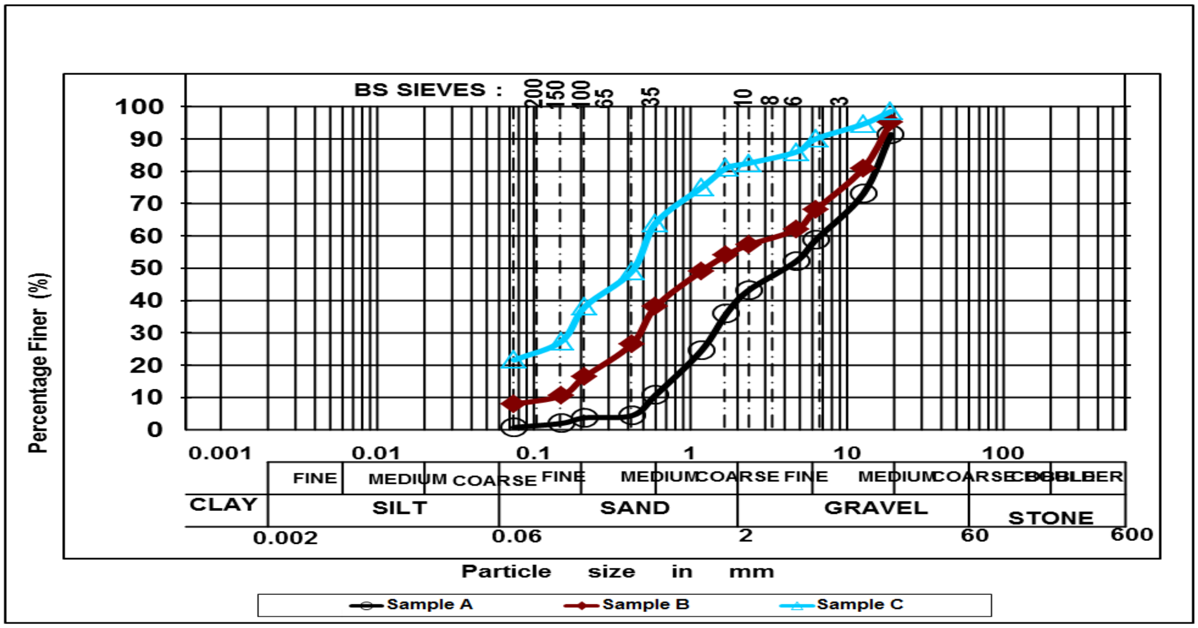


Figure 3: Particle size distribution curves for the MSW samples

Table 3: Summary of compaction characteristics

	Optimum moisture content (OMC)	Maximum dry density (MDD) (Kg/m3)
Sample A	18.0	460
Sample B	24.0	540
Sample C	32.5	970

3.2 Consolidation and Permeability

The results of the compressibility tests conducted in the fabricated oedometer are presented in Figure 4 and Figure 5. The slope of the void ratio (e) versus logarithm of pressure (Log P) plots in Figure 4 gave the compression index (C_c) which can be used to estimate the primary settlement of MSW resulting from an increase in vertical stress (Table 4). The slope of the void ratio (e) versus applied pressure (P) plots in Figure 5 gave the values of the coefficient of compressibility (a_v) in Table 4. The coefficient of consolidation (c_v) was obtained from the plot of settlement versus square root of time curve using Taylor's method. The coefficient of volume compressibility (m_v) was computed using equation (1) and the coefficient of permeability was computed from the results of the consolidation tests using equation (2). Using the ratio of secondary compression index (C_α) to compression index C_c (C_α / C_c) of 0.015 proposed by [8], the secondary compression index (C_α) which can be used to estimate the settlement that occurs after completion of the primary settlement was obtained as 0.0011, 0.0018 and 0.0029 at the depths 0.8 m, 1.4 m, and 2.0 m respectively. The compressibility characteristics for the MSW samples are summarized in Table 4. It can be seen that the compressibility indices (C_c, a_v, m_v and C_α) which indicates the magnitude of consolidation settlement increased with increasing depth of embedment for the MSW, while coefficient of consolidation (c_v) which indicates the hydrodynamic period of consolidation deceased by two orders of magnitude with increasing depth of embedment. The coefficient of permeability also decreased by one order of magnitude with increase in depth from 0.8m to 2.0m for the MSW. Values of the coefficient of permeability obtained from the constant head permeability test decreased from 6.2 x 10^{-5} m/s to 7.1 x 10^{-6} m/s with increase in depth from 0.8m to 2.0m, within the same orders of magnitude for the values obtained from the fabricated oedometer.

$$m_v = \frac{a_v}{1 + e_o} \quad \text{.....(1)}$$

where: m_v - coefficient of volume compressibility

a_v - coefficient of compressibility

e_o - initial void ratio

$$k = c_v \times m_v \times \gamma_w \quad \text{.....(2)}$$

where: k - coefficient of permeability

c_v - coefficient of consolidation

γ_w - unit weight of water

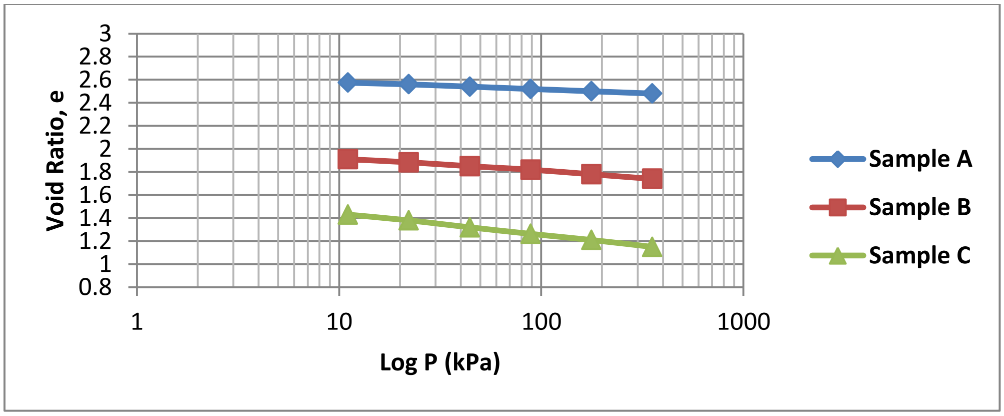


Figure 4: Plot of void ratio vs. log of pressure for the MSW

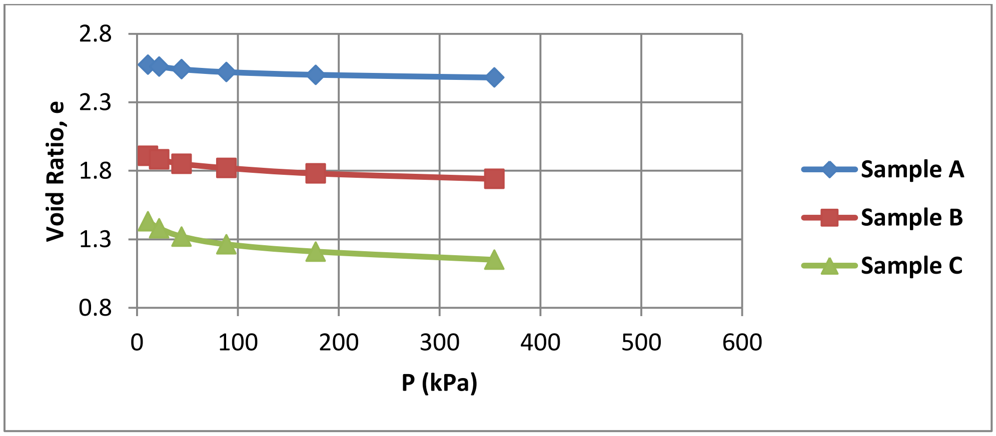


Figure 5: Plot of void ratio vs. pressure for the MSW

Table 4: Compressibility characteristics of the municipal solid wastes

Compressibility characteristics	Sample A	Sample B	Sample C
Coefficient of consolidation c_v (m^2/sec)	1.37 x 10^{-1}	1.56 x 10^{-2}	2.5 x 10^{-3}
Compression index C_c	0.07	0.12	0.19
Coefficient of compressibility a_v (m^2/kN)	1.13 x 10^{-4}	2.25 x 10^{-4}	3.38 x 10^{-4}
Coefficient of volume compressibility m_v (m^2/kN)	3.15 x 10^{-5}	7.67 x 10^{-5}	1.37 x 10^{-4}
Coefficient permeability k (m/sec)	4.3 x 10^{-5}	1.2 x 10^{-5}	3.5 x 10^{-6}
Secondary compression index (C_α)	0.0011	0.0018	0.0029

4. CONCLUSIONS

This paper presented experimental results form 1-D compression tests using an intermediate scale fabricated oedometer and permeability tests on the MSW samples taken from Ondo State Waste Management Board (OSWMB) proposed landfill site. The experimental results showed that the compressibility and permeability characteristics of the MSW significantly depended on the embedment depth of the waste. The compression index (C_c) which can be used to estimate the primary settlement of MSW resulting from an increase in vertical stress was 0.07 at 0.8 m, 0.12 at 1.4 m and 0.19 at 2.0m depth. The compressibility indices (C_c, a_v, m_v and C_α) which indicates the magnitude of primary and secondary consolidation settlement increased with increasing depth of embedment for the MSW, while coefficient of consolidation (c_v) which indicates the hydrodynamic period of consolidation deceased by two orders of magnitude with increasing depth of embedment. The coefficient of permeability also decreased by one order of magnitude with increase in depth from 0.8m to 2.0m for the MSW.

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