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Tannery Wastewater Treatment Using Coconut Shell for Small-Scale Irrigation Scheme

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Abstract: *The research was carried out to analyses some selected physical and chemical properties of Industrial effluent of tannery industry in Maiduguri. Coconut shell powder was applied in three varied doses of 5, 10, and 15 mg to one litre of industrial effluent designated as sample TC1, TC2 and TC3 respectively. Each sample has three replicate. The coconut shell was cleaned using tap water to eradicate possible strange material present in it (dirt and sands). Washed material was sun dried for 2 to 5 hrs and then crushed with mortar and pestle to reduce the size of the shell. Finally, the shell was oven dried for 40mins and at last received the coconut shell activated carbon. 20 litres of industrial effluent was collected in one jerry can and nine litres were measured in nine different plastic bottles designated as TC1R1, TC1R2, TC1R3 TC2R1, TC2R2, TC3R3, TC3R1, TC3R2, TC3R3 and another designated as TC4R1, TC4R2, TC4R3 which served as the control sample respectively. The dosages 5,10 and 15 mg of activated coconut shell was added to effluent in duplicate respectively, and allowed to stay for 24 hrs then taken to NAFDAC laboratory for analysis, the parameters analysed were total dissolved solid, electrical conductivity, pH value, calcium content, magnesium content and nitrate. The result revealed that there is significances reduction in values of those parameters in all the treatment.*

Key words: *Tannery: Effluent and Coconut shell*

1.0 INTRODUCTION

1.2 Background of the Study

Most toxic chemicals in the environment are discharged by industries into water, air and soil. Once they get involved in biological process, it becomes difficult to eliminate them from the environment and they disturb various biochemical processes, leading to

undesirable results. Numerous potentially mutagenic chemicals have been studied because they can cause mutagenic, damaging and inheritable changes in the genetic material (Khanna and Sharma, 2013, p. 105). Wastewaters discharged from tanning industries contains high level of BOD, COD, electrical conductivity and heavy metals especially Cr above permissible limit as recommended by various regulatory agencies making it potentially toxic (Lal, 2009). Usually tanning industries discharge their wastewater on land and into nearby rivers and indirectly is being used for irrigation of crops and vegetables. This practice has ultimately led to movement of potentially toxic metals from water to plant system and ultimately to human beings Sinha *et al*., (2008). It is well known that Cr (VI) is a potent carcinogen to humans and animals as it enters cells via surface transport system and gets reduced to Cr (III) inducing genotoxicity Matsumoto *et al*., (2006). Thus, Cr loaded effluent used for irrigation disrupts several physiological and cytological processes in cells. Chidambaram *et al*., (2009) leading to reduced root growth, biomass, seed germination, early seedling development Irfan and Akinici (2010), and induces chlorosis, photosynthetic impairment and finally leading to plant death. The current pattern of industrial activity alters the natural flow of materials and introduces novel chemicals into the environment. The released organic compounds and heavy metals are one of the key factors that exert negative influences on man and environment, causing toxicity to plants and other forms of biotics and abiotics that are continually exposed to potentially toxic heavy metals Puthur, (2010). In tanning industries, the raw hide undergoes a series of chemical treatments before it turns into flattening leather. This includes soaking, liming, dehairing, deliming, bating, degreasing and pickling. For all these steps the chemicals like sodium sulphide, ammonium chloride, sodium sulphite, hydrogen peroxide, formate, sodium bicarbonate, chromate and chloride are used which are quite toxic. Thus due to these multifarious operations with an array of chemicals, the leather processing industry is one of the worst offenders of the environment (Murugan and Sohaibani, 2010). These chemical substances produce varying anomalies in mitosis, germination and growth of plants. It could also give rise to allergy at early ages, respiratory disorders, coronary problems and even cancer in middle ages Morales (2008).

1.3 Tanning Process

Leather tanning is the process of converting raw hides or skins into leather. Hides and skins have the ability to absorb tannic acid and other chemical substances that prevent decaying, make them resistant to wetting (Verma, Pramod, Ramteke and Kumar, 2008). Tanning involves a complex combination of mechanical and chemical processes. Central to the process is the tanning operation itself in which organic or inorganic materials become chemically bound to the protein structure of the hide and preserve it from deterioration. The substances generally used to accomplish the tanning process are chromium or extracts from bark of trees, such as chestnut. These tanning agents give rise to the two predominant types of tanning operations modern chrome and traditional vegetable tanning processes (Federal Ministry of Environment, 2012).

1.4 Tannery Waste Waters

Tanneries generate waste waters that are typically high in organic and inorganic pollutants. Since tanneries employ a sequence of batch processes, and use a wide range of raw materials, their effluent is complex in nature, with variations in characteristics from

time to time, process to process and tannery to tannery (IPPC, 2013). Waste water from tannery industry is considered as a serious environmental threat throughout the world (Gupta and Sinha, 2007). The tannery industries discharge large quantities of common salt during the process of tanning and deposition of this salt into the soil takes place when the water comes in contact with the soil. Besides chlorides, toxic substances like chromium, sodium sulphide, sodium carbonate and ammonium sulphate are present in the discharged effluent which manifolds the soil pollution (Rajan and Arias, 2007). Pre-tanning processes contribute 80-90 percent of the toxic pollution in the industry and generates noxious gases such as hydrogen sulphide, as well as solid wastes and chrome sludge (Thanikaivelan, Vaidya, and Desai, 2004).

1.5 Effect of Tannery waste water on the components of the biosphere

Environmental concerns in a tannery include the prevention and control of emissions to water, air, and soil. A range of process chemicals is used, some of which may require special treatment in the effluent. The environmental effects that have to be taken into account in any tannery comprise not merely the load and concentration of the classic pollutants, but also the use of certain chemicals, e.g., biocides, surfactants, and organic solvents (IPPC, 2013). Tannery industry is a primary polluter of the environment and has a strong potential to cause soil, water pollution (with its high oxygen demand, discolouration and toxic chemical constituents (Song, as cited in Tadesseand Guya, 2017)), plants, vegetables, terrestrial and atmospheric systems owing to the discharge of untreated effluent.

1.6 Effect of tannery waste water on soil

Soil pollution by metals is essentially different from air or water pollution because the persistence of heavy metals in soil is reportedly much longer than in other compartments of the biosphere. Removal of heavy metals from polluted soil is difficult. Once deposited on the soil certain metals such as lead and chromium may be virtually permanent (Okeyode and Moshood, 2010). Although heavy metals like iron, molybdenum, manganese, zinc, copper, magnesium, copper, selenium and nickel play major roles in the growth and development of plants, but may be toxic beyond certain level (Edday, Odoemelan andMbaba, 2006).The most common heavy metals found in the soil are cadmium, chromium, copper, mercury, lead and zinc (Marques *et al.,* 2008). Moreover, using sodium chloride as raw material in tanneries releases a high concentration of chloride and nitrate (Babyshakila, 2009) as the end product of oxidation of nitrogen whereas sodium carbonate, sodium bicarbonate, sodium chloride and calcium chloride in tanning causes the alkalization of the soil resulting to increase in pH (Mondal, Saxena, and Sinha, 2005).

1.7 Effect of Tannery waste water on plant growth

Repeated metal exposure of plants affects its physiological processes such as photosynthesis, water relations and mineral nutrition (Patton, Dauble and Mckinstry, 2007). The impact of toxicity was evident as visible symptoms of chlorosis, yellowing and immature fall of leaves, poor growth and retarded flower, fruit and green yields. Metabolic alterations by metal exposure have also been described in plants either by direct effect on enzymes or other metabolites. This was possibly attributed to the imbalance of nutrients and nutritional disorders in the plants due to metal interactions with plant nutrients

(Chunillal, Kindness and Jonnaladda, 2005). The effluent is an inevitable consequence of industrial process. In arid and semi-arid regions of the country, where shortage of water becomes limiting factor, the effluent is being used for irrigational purposes by the farmers in agriculture and agro-forestry practices. Since the production of wastewater is a continuous process, it can cater for substantial irrigation requirements. This alternative use of wastewater will not only prevent the waste from becoming an environment hazard but also will serve as a potential source of fertilizer if used rationally and at appropriate concentration (Saxena and Srivastava, 2002). Therefore, there is need, for the current study, to evaluate the effect of company treatment on biotoxicity of tannery waste water using coconut shell.

2.0 Materials Methods

The materials used for this research work are the cocanut shell obtained from a local mill area and tanning wastewater obtained from a tanning area in Maiduguri. The experimental work was conducted in the Ramat polytechnic Maiduguri in AE laboratory. Following are equipment/tools used for the practical's.

1. Blender
2. Containers
3. Desiccated
4. Digital weighing balance
5. Distilled water
6. Filter paper
7. Glass cups
8. Measuring cans
9. Measuring cylinder
10. Oven
11. Pestle and mortar
12. Plastic Bottle
13. Coconut shell powder
14. Sensitive Balance
15. Sieve size 425
16. Stop watch
17. Tannery wastewater

2.1 Characterization of the adsorbents

The characterization of coconut shell powder was carried out by determining the following physical and chemical parameters:

2.2 Moisture content

The moisture content of the adsorbents was determined by weighing 10g of coconut shell into

cans. This was placed in an oven and heated for 5hour at constant temperature of 105°C.The sample was then removed and put rapidly into desiccators in order to prevent more moisture uptake from atmosphere. The sample was re-weighed; the difference in the mass constitutes the amount of moisture content=w2-w3/w2-w1

Where:

W1= Weight of can

W2= Initial weight of can with sample

W3= Final weight of can with sample

2.3 Adsorbent pH

The determination of the adsorbent pH was carried out by weighing 1g of coconut shell, then boil
in a beaker containing 100 cm3 of distilled water for 5minutes, the solution was diluted to 200
cm3 with distilled water and cooled at room temperature, the pH of each was measured using
a pH meter (model ATPH-6).

2.4 Bulk density

The bulk density of the adsorbent was determined using archimenpdes's principle by weighing at 10 cm^3 measuring cylinder before and after filling with the adsorbent. The measuring cylinder was then dried and the adsorbent was then packed inside the measuring cylinder, leveled and weighed. The weight of the sample packed in a measuring cylinder was determined from the difference in weight of the filled and empty measuring cylinder. The volume of water in the container was determined by taking the difference in weight of the empty and water filled measuring cylinder. The bulk density was then determined using Equation 3.3

$$\text{bulk density} = \frac{w2-w1}{v} \qquad \text{Equation 3.3}$$

Where:

W1 = Weight of empty measuring cylinder
W2 = Weight of cylinder filled with sample
V = Volume of cylinder

2.5 Preparation of the Adsorbent

Homogeneous mixture of coconut shell was thoroughly washed with distilled water to clean dirt and mud and heated to the temperature of 104°C for 3 hours. The coconut shell was grinded into powder using pestle and mortal and sieves using Steve size N. 425µ.

2.6 Batch experiment

Coconut shell was obtained from a small local milling area in Zabarmari ward Jere local government and the tannery wastewater was collected from tannery industry Lawan Bukar and experiment was conducted in Agricultural Engineering laboratory at University Maiduguri Borno state. The experiment helps us to investigate the adsorption capacities of coconut shell powder on removal of chromium (Cr) from tannery wastewater. The experiment was conducted for different process like adsorbents dosage of 5, 10, 15g, and 20g contact time of 30, 60, 90, and 120min, blender speed of 650 and 950 rpm. Tannery industry wastewater was collected 3 glass cups capacity and was put on the blender for different adsorbent dosage, contact time and different speeds. The treated samples with various processes was filtered and the settled particles removed. The clear samples after settlement (24 hours) was further tested by a Digital spectrophotometer to find out the reduction in concentrations of chromium (Cr) in the tannery wastewater.

The adsorption removal percentage was calculated by using Equation 3.4

$$\text{Percentage Removal} = [(Co-Ct)/Co \times 100] \qquad \text{Equation 3.4}$$

Where:

Co= Initial concentration; Ct= Concentration after adsorption by adsorbent.

2.7 Spectrophotometer test on Chromium

The test was conducted by NAFDAC in Maiduguri using universal sample holder, following procedures below;

1. Press and hold ON button until spectrophotometer turns on
2. Scroll to and select PROGRAMMED TESTS from menu.
3. Scroll to and select ALL TESTS (or another sequence containing 22 chromium)
4. Scroll to and select 22 chromium from menu.
5. Rinse a clean tube (0290) with sample water. Fill to 10mL line with sample.
6. Insert tube into chamber, close lid and select SCAN BLACK.
7. Remove tube from Spector. USE the 0.1g spoon (0699) to add one measure of ×Chromium
Reagent Powder (V-6276). Cap and shake until powder dissolves. Wait 3 minutes for full color development.
8. During waiting period, fold a piece of filter paper (0465) in half then half again to form a cone. Push corners together to open end, and insert into funnel (0459).
9. At the end of 3 minutes waiting period, filter sample into a clean tube. Mix. Insert tube chamber, close lid and select SCAN SAMPLE. Record result.
10. Press OFF button to turn spectrophotometer off or press EXIT button to exit to previous menu or make another menu selection.

2.8. Data analysis

The chemical concentration of the tannery wastewater samples was analyzed using excess spreadsheet package.

3.0 Result and Discussion

The results on the experimented cocanut shell on the treatment of the tannery was water for irrigation purposed was presented below.

Table 1: Characterization of the Effluent

Parameters	Concentration	FAO Standard
Ca	1.92	40.1
Mg	1.89	24.3
Na	0.87	23
Cr	0.93	0.05
Tds	669	500
Ec	31.0	26.4
Temp	30.7	26.2
pH	6.95	6.5 – 9.2

The Characterization of the Effluent shows that all the parameters were within the FAO standard of Irrigation water quality except electric conductivity, temperature and toxic dissolve solid which were above the standard limit as shown in the table 1 above.

Table 2: Mean Concentrations of Waste Quality parameters

Treatment	PH	TDS	EC	Temp	Ca	Cr	Mg	Na
T5	6.4 [a]	872 [a]	4764 [a]	27.367[a]	1.36[b]	18.78 [a]	1.4 [b]	0.2467 [b]
T10	6.24 [a]	883 [a]	4764 [a]	27.467 [a]	1.35[b]	0.8325 [b]	1.28 [b]	0.1967 [b]
T15	6.57 [a]	872 [a]	4764 [a]	26.367[b]	1.38[ab]	0.7367 [b]	1.34 [b]	0.34 [ab]
TC	6.49 [a]	882 [a]	4764 [a]	26.875[ab]	1.605[a]	0.6067 [b]	1.865[a]	0.53 [a]
FAO	6.5-9.2	500	99	26.2	40.1	0.05	24.3	23

Table 2 shows the result of concentration of the following parameters, Total dissolve solid, Electric Conductivity, Temperature, pH, Calcium, Magnesium, Sodium and chromium in the treatment. The concentration of total dissolve solid decreases with increased in dosage of the absorbent from T5 to T10, but generally has increased when compared with the control TC. However, the value does not fall to the FAO standard of irrigation water quality. The concentration of electric conductivity neither increases nor decrease compared to the control and finally it does not fall within the FAO standard of irrigation water quality. The concentration of temperature decreases with increased in dosage of the absorbent from T5 to T10 and then decreased in T15 which has the highest absorbent but, generally has increased when compared with the control TC.

However, the values are above the FAO standard of irrigation water quality, the concentration of pH decreases with increased in dosage of the absorbent from T5 to T10 and increased in T15, but generally has increased when compared with the control TC. However, the values fall within FAO standard of irrigation water quality. The concentration of Calcium decreases with increased of the absorbent from T5 to T10 and increased in T15, but generally has decreased when compared to the control TC. However, the values fall within FAO standard of irrigation water quality.

The concentration of Magnesium decreases with increased of the absorbent from T5 to T10 and increased in T15, but generally has decreased when compared with the control TC. However, the values fall within FAO standard of irrigation water quality. concentration of sodium decreases with increased of the absorbent from T5 to T10 and then increased in T15 which has the highest absorbent but generally has decreased when compared with the control TC. However, the value falls within FAO standard of irrigation water quality. concentration of chromium decreases with increased of the absorbent from T5 to T10 and then decreased in T15 which has the highest absorbent but generally has increased when compared with the control TC. However, the value does not fall within FAO standard of irrigation water quality.

Table: 3 Correlations Matrix Among the Parameters

	PH	TDS	Temp	Ca	Cr	Mg	Na
PH	1						
TDS	-0.5272	1					
Temp	-0.9101	0.37194	1				
Ca	0.37024	0.49308	-0.2604	1			
Cr	-0.1245	-0.5767	0.46282	-0.3661	1		
Mg	0.38563	0.38954	-0.2014	0.98248	-0.18737	1	
		1		3			

As illustrated from table 3, the correlation in the table above shows there is relationship between Ca to Ca and Ec to Ca and EC to Ec and there is relationship Mg to Mg which is 1 and there is relationship between cr to Mg and cr to cr the result shows there is relationship between Na to Mg, cr and Na and there is relationship between pH to Mg, NO3, Na and pH there is relationship between TDS to Ca, EC and TDS and there is relationship between TEMP to TDS and TEMP respectively. And there is no relationship between the remaining parameter that has negative values in the table 3 above.

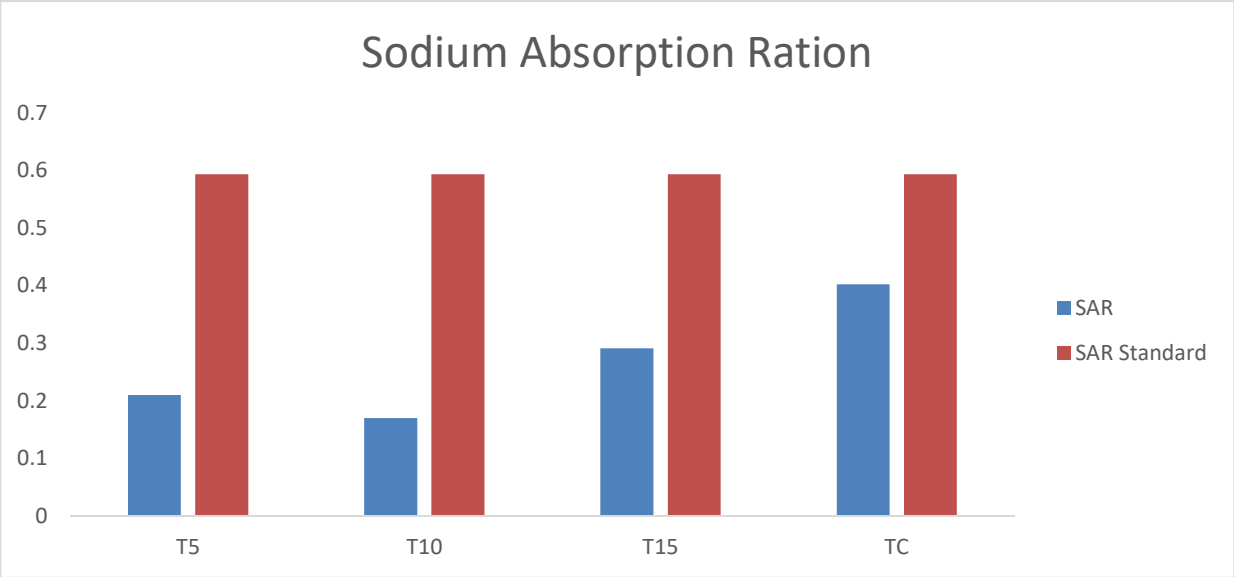

Figure: 1 Shows the Comparison between Calculated and Standard Value Sodium Absorption Ratio

The Characterization of the effluent shows that all the treatments experimented were within Sodium absorption ratio (SAR) standard of irrigation water quality.

3.0 CONCLUSION AND RECOMMENDATION

3.1 Conclusion

In the present study, experiments have been conducted forth removal of Cr (VI) in tannery industrial wastewater using coconut shell silica powder as an adsorbent. Took now the ability of coconut shell silica powder for removing Cr(VI) in the tannery industrial

wastewater, the experiments were conducted with varying adsorbent dosage, contact time and pH against the initial concentration of 292mg/L. There salt showed that the maximum percentage removal of Cr(VI) in the tannery industrial wastewater at an optimum adsorbent dosage of 15 g, contact time of 120 min., pH of 4 respectively, using coconut shell silica powder was 88.3%. The experimental data on removal of Cr(VI) from tannery industry wastewater is validated with the Cr(VI) in an aqueous solution of same initial concentration of tannery industry waster. Also, the obtained maximum removal percentage of Cr (VI) in a tannery industry wastewater using coconut shell silica powder with an optimum process parameters were verified with the other physic-chemical parameters, COD, BOD, and SO^{2-} in a tannery industry wastewater. This study concluded that the experimental investigation done for this study may be reproduced for removing Cr (VI) from tannery wastewater or from any chromium based water and industrial wastewater.

3.2 Recommendation

It is therefore recommended that

1. Environmental managers implement and enforce laws to further subject industrial influence toxicity evaluation, hence ensuring complains to permissible limit before they are finally discharge.
2. The ministry of agricultural and rural development should carry out sensitization on the use of coconut shell further for treatment of tannery waste water.
3. That further researcher should have carried out to compare the results of coconut shell to another agricultural waste such as bagasse (sugarcane), and banana peels.

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Analytical Solution of Two-dimensional Heat Equation in the Context of COVID 19 using Dirichlet Boundary Condition

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Abstract: *The study focused on analytical solution of two- dimensional heat equation with Dirichlet boundary condition in the context of COVID 19 , by method of separation of variable of a partial differential equation which is transformed to second-order differential equation and double Fourier series was used to obtain the analytical result. Also, the result of the analytical solution was used applied in the context of COVID 19, the result obtained in problem1 shows that the graph is moving downward on the value -1.98 and 0.25 and maintained a straight line, while in problems 2 the result shows that the graph is moving upward on the values 0.99 and 0.001 and also maintained a straight line. This shows that COVID 19 has the highest level in problem 2 than 1 because the heat has a significant effect on problem 2. Analytical solution of two- dimensional heat equation is time-consuming and also is simpler, efficient, and precise; hence the study recommended that the method should be applied into a multidimensional heat transfer equation in the context of COVID 19 with a view to solving scientific and engineering problems.*

Key words: *2 dimension, heat equation, COVID 19 and Dirichlet Boundary Condition*

1. Introduction

Two dimensional heat equations.

$$u_t = k\left(u_{xx} + u_{yy}\right)$$

Related formulae hold:

$u = \iint G_2(x, y; x', y', t)(x', y')dx'dy'$ with $G_2(x, y; x', y', t) = G_1(x, x') = G_1(y, y', t)$ (ivrii, 2017)

Study of some Selected uniqueness results for the singular heat equation is obtainable, the study also reveals by Eigenfunction of some problems that remain effective (young, 1984).

Pot-Pot refrigerator was solved by explicit and implicit numerical procedures, the end result was compared and it reveals that the numerical method used is more natural than the analytical techniques. it has been observed that the outcome fit very well with predictable evolution system (Nalasco, Jacome and Hurtado-Lugo , 2017).

An optimal control problem for the heat equation with phase change taking latent heat of fusion in to account has been obtained. The outcomes for the input function is a series of step function and a smooth function can be found to approximate this optimal solution, but its result most likely lead to suboptimal solutions (Josef ,2016).

Kurt (2008) investigate the study for a square interms of elliptic functions, the numerical result has been computed and compared by the technique of separation of variable and finite element. The study also reveals that the technique gives exact result than the others method in the solution of the two-dimensional heat equation.
Uba, Grema and Mai (2019) examine the solution of one-dimensional heat equation using residue calculus; the study investigates that method of separation of the variable. It has been found that residue theory was also used to solve the second other differential equation after separation of variables, residue calculus is time-consuming and it is simpler, effective and accurate. The study also reveals that the method can be extended into multidimensional heat equations. The method also can be compared with the other numerical method.
The heat equation is pretentious second-order partial differential equations (PDE) that describes the variation in temperature in a specified area over a while. Heat, is a vital problem in many physical disciplines including science and technology, is an energy transit and it is a branch of thermodynamics which deals with the amount of heat transfer among two or more equilibrium state of a system in a medium or between media. (Dabrat, kapoor and Dhawan , 2011 and Suresh 2018).
Finite element-finite difference method has been established for solving parabolic two-step micro heat transport equations in a three-dimensional double-layered thin film exposed to ultrashort-pulsed lasers, It is revealed that scheme is unconditionally stable for the heat source and the numerical results for thermal analysis of a gold layer on a chromium padding layer are found and it's also revealed that the technique can be applied to multiple layers and irregularly shaped geometries (Brian, 2014).

Kutanaei, Ghasemi and Bayat , (2011). The study that the solution obtained from the numerical simulations is compared with those obtained by the finite volume (FV) method. The results show that the present method is in very good agreement by finite volume method and this is due to the fact that the radial basis function-based differential quadrature (RBF-DQ) process is an exact and flexible method in the solution of heat conduction problems.
A comparative study between the Fourier transforms and Wavelet transforms for the one-dimensional heat equation was studied, (Husein and Alaa, 2016).

A solution of one-dimensional Heat Equation by the method of separation of variables using FOSS tools Maxima was used. The results obtained by the separation of variables are the same as the results achieved by using Maxima program (Sudha, Geetha and Harshini, 2017).
Samaneh and Soltanalizadeh (2014) assert that the solution of the second-order two space dimensional diffusion equation by using the differential transformation method. Changing the model of the partial differential equation into a system of linear equations and computational difficulties of the other methods can be abridged by applying this method and also made emphases only in the solution of two-dimensional inhomogeneous diffusion equations subject to a nonlocal boundary condition.
Douglas equation was used to achieve implicit finite-difference equations for two-dimensional heat- transfer equations, also accuracy was observed by the Fourier series process for stability analysis (Gülkaç , 2015).
Adi and Alexander (2008) investigate that the Boundary condition for the case in which the heat equation is satisfied outside the domain of interest with no limitations on the equation inside was developed

Johansson, B.T. (2016) examine that the result of Properties of a method of fundamental solutions for the parabolic heat equation leads naturally to a process of numerically approximating solutions to the parabolic heat equation represented a system of fundamental solutions (MFS)and a discussion around the convergence of such an approximation was built-in.

comparative study between the analytic solution and numerical solution of one-dimensional heat diffusion equation focus to Robin boundary conditions multiplied by a small parameter epsilon greater than zero, the numerical result reveals that the numerical solution of the differential equation with Robin boundary condition is very close by in certain sense of the analytic solution of the problem through homogeneous Dirichlet boundary conditions when ε tends to zero (LOZADA-CRUZ, RUBIO-MERCEDES AND RODRIGUES-RIBEIRO, 2018).
Elliptical domain has been made with the governing of two dimensional (2D) heat equation that is discretized with the Finite Difference Method (FDM) and the stability condition has been defined and the numerical result by writing MATLAB codes has been found with the stable values of time-domain (Mehwish, Asif and Shakeel, 2020).
Saeed (2015), Investigate the analytical and numerical solution of one-Dimensional a rectangular Fin with an Additional Heat source. The study also investigated the influence of the heat source on the temperature profiles and the fin efficiency was discussed in the case of the heat source $\psi = 0$ for the wide range of parameters (M).

Analytical and numerical methods were used in the correlation of the solution of two-dimensional steady-state heat conduction, and the result obtained shows that the finite element is in good agreement with the analytical values and solution reveals that it can be effectively used to more complex thermal problems (Suresh 2018).

The theory of heat equations was first established by Joseph Fourier in 1822; Heat is the dynamic energy of particles that are being exchanged and is associated with the study of Brownian motion. The one, two, and three-dimensional wave equation was revealed by Alembert and Euler. The solutions of heat and wave equations have attracted the attention of various authors in mathematics, such as the optimal homotopy asymptotic method (OHAM), the modified Adomian decomposition method (MADM), the variational iteration process, the differential transform method (DTM), the Homotopy perturbation method (HPM) (Hassan, Rasool, Poom and Arif 2019).

Most of the study mentioned above did not apply the Analytical method in the Solution of Two-dimensional Heat Equation, in order to solve problems in the Context of COVID 19 using Dirichlet Boundary Condition. But they applied many methods and numerical techniques to solve it. The objective of this paper, is therefore to determine the application of the analytical method in the solution of two-dimensional heat equation in order to solve problems in the contex of COVID 19 using Dirichlet-Boundary Condition.

2. Methodology

$$\frac{\partial T}{\partial t}=\kappa\left(\frac{\partial^2 T}{\partial X^2}+\frac{\partial^2 T}{\partial y^2}\right)$$ We put $T(x,y,t)=X(x)Y(y)\tau(t)$

$$\frac{1}{X}\frac{d^2X}{dx}+\frac{1}{Y}\frac{d^2Y}{dy^2}=\frac{1}{\kappa\tau}\frac{d\tau}{dt}=-\mu^2(say)$$ Where μ^2 is separation constant, μ be real

Then $\tau=A_1e^{-\kappa\mu^2 t}$

$$\frac{1}{X}\frac{d^2X}{dx^2}=-\left(\frac{1}{Y}\frac{d^2Y}{dy^2}+\mu^2\right)=-p^2(say)$$

$$\frac{d^2X}{dx^2}+p^2X=0 \ \ and \ \ \frac{d^2Y}{dy^2}+q^2Y=0$$

$X=A\cos px+B\sin px \ \ and \ \ Y=C_1\cos qy+D_1\sin qy$ and $q^2=\mu^2-p^2$

$$T(x,y,t)=(A\cos px+B\sin px)(C_1\cos qy+D_1\sin qy)A_1e^{-\kappa\mu^2 t}$$

$$T(x,y,t)=(A\cos px+B\sin px)(C\cos qy+D\sin qy)e^{-\kappa\mu^2 t} \text{ Where } C=C_1A_1,\ D=D_1A_1$$

The boundaries of the rectangle $0\le x\le a,\ 0\le y\le b$ are preserved at zero temperature. If at t = 0, the temperature T has prescribed value f(x,y) show that

t >0, the temperature at a point within the rectangle is given by

$$T(x,y,z)=\frac{4}{ab}\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}f(m,n)\sin\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi x}{b}\right)e^{-\kappa\mu_{mn}^2 t} \text{ Where}$$

$$f(m,n)=\int_0^a\int_0^b f(x,y)\sin\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi x}{b}\right)dxdy \text{ and } \mu_{mn}=\pi^2\left(\frac{m^2}{a^2}+\frac{n^2}{b^2}\right)$$

Solution

$$\frac{\partial T}{\partial t}=\kappa\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}\right),\ 0<x<a, 0<y<b, T>0$$

$$T(x,y,0)=f(x,y),\quad 0<x<a,\ 0<y<b,\ t>0$$

$$T(0,y,t)=f(a,y,t)=0 \qquad 0<y<b,\quad t>0$$

$$T(x,0,t)=f(x,b,t)=0 \qquad 0<x<a,\quad t>0$$

The solution of the equation is

$$T(x,y,t)=(A\cos px+B\sin px)(C\cos qy+D\sin qy)e^{-\kappa\mu^2 t} \text{ Where } \mu^2=p^2+q^2$$

$$T(x,y,t)=0 \text{ and } T(x,0,t)=0$$

$$A=0 \text{ and } l=0 \text{ thus } T(x,y,t)=BD\sin px\sin qye^{-\kappa\mu^2 t}$$

Also the boundary condition $T(a,y,t)=0$ and $T(x,b,t)=0$, $\sin pa=0$, $\sin qb=0$, $p=\frac{m\pi}{a}$ and $q=\frac{n\pi}{a}$ respectively, where $m=1,2,3,\cdots$ and $n=1,2,3,\cdots$

Hence using the superposition principle

$$T(x,y,t)=\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}A_{mn}\sin\left(\frac{mx\pi}{a}\right)\sin\left(\frac{nx\pi}{b}\right)e^{-\kappa\mu_{mn}^2 t} \text{ Where } \mu_{mn}^2=p^2+q^2=\pi^2\left(\frac{m^2}{a^2}+\frac{n^2}{b^2}\right)$$

Finally, the given initial condition implies

$$f(x,y)=\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}A_{mn}\sin\left(\frac{mx\pi}{a}\right)\sin\left(\frac{nx\pi}{b}\right)$$

From this it clearly that it represents a double Fourier series particularly the sine series, to obtain we use orthogonal double Fourier series and so

$$A_{mn}=\frac{2}{a}\frac{2}{b}\int_0^a\int_0^b f(x,y)\sin\left(\frac{mx\pi}{a}\right)\sin\left(\frac{nx\pi}{b}\right)dxdy$$

Hence the require solution is

$$T(x,y)=\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}F(m,n)\sin\left(\frac{mx\pi}{a}\right)\sin\left(\frac{nx\pi}{b}\right)e^{-\kappa\mu_{mn}^2t}$$

$$T(x,y)=\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}F(m,n)\sin\left(\frac{mx\pi}{a}\right)\sin\left(\frac{nx\pi}{b}\right)e^{-\kappa\mu_{mn}^2t}\ \text{Where}$$

$$F(m,n)=A_{mn}=\frac{4}{ab}\int_0^a\int_0^b f(x,y)\sin\left(\frac{mx\pi}{a}\right)\sin\left(\frac{nx\pi}{b}\right)dxdy$$

3. RESULT

Problem 1 : solve the equation $u_t=\left(u_{xx}+u_{yy}\right)\quad 0<x<\pi,\quad 0<y<\pi\quad t>0$

$$u(x,y,0)=x(\pi-x)y(\pi-y)\quad 0<x<\pi,\ 0<y<\pi$$

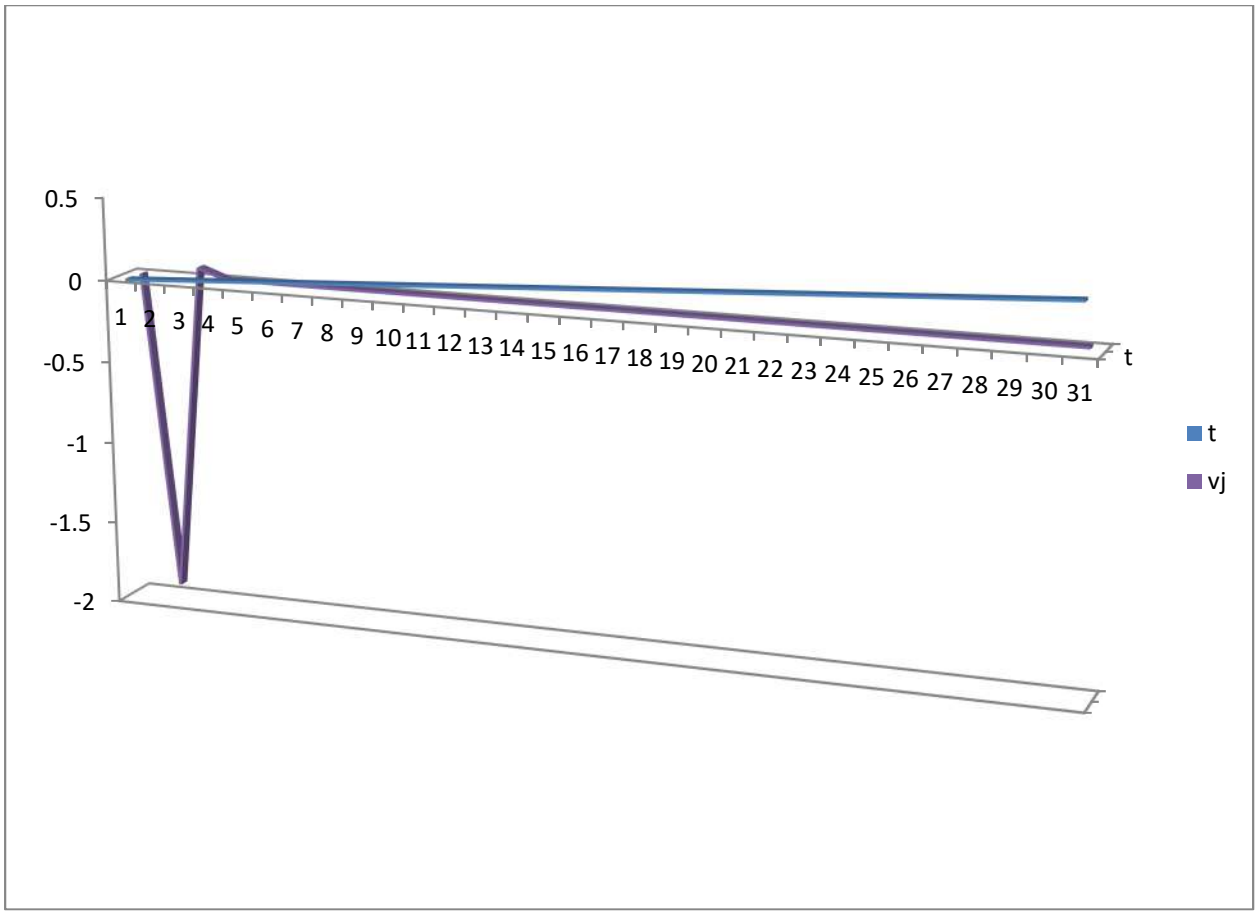
$$u(0,y,t)=u(\pi,y,t)=0,\quad u(x,0,t)=u(x,\pi,t)=0$$

$$u(x,y,t)=\sum_{n=1}^{\infty}\sum_{m=1}^{\infty}c_{nm}\cos nx\cos mye^{-t\left(n^2+m^2\right)}$$

$$u(x,y,0)=\sum_{n=1}^{\infty}\sum_{m=1}^{\infty}c_{nm}\cos nx\cos my$$

$$c_{nm}=\frac{4}{\pi^2}\int_0^{\pi}\int_0^{\pi}x(\pi-x)y(\pi-y)\cos nx\cos mydxdy=\frac{4(-1)^{n+m+2}}{n^2m^2}\ \text{Using double Fourier series}$$

$$u(x,y,t)=\sum_{n=1}^{\infty}\sum_{m=1}^{\infty}\frac{4(-1)^{n+m+2}}{n^2m^2}\cos nx\cos mye^{-t\left(n^2+m^2\right)}$$



Problem 2 : solve the equation $u_t = (u_{xx} + u_{yy}) \quad 0 < x < \pi, \quad 0 < y < \pi \quad t > 0$

$u(x,y,0) = x \quad 0 < x < \pi, \ 0 < y < \pi$

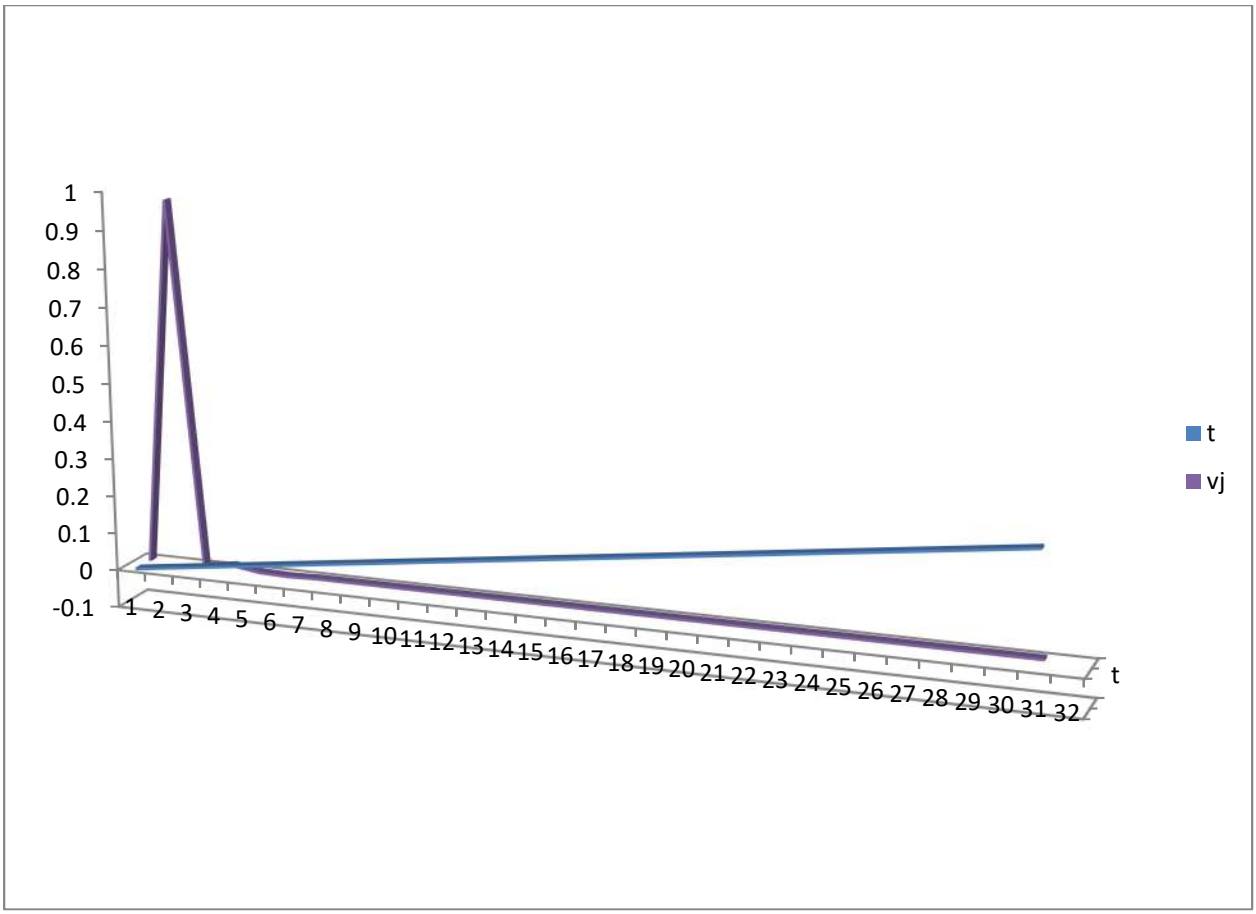
$u(0,y,t) = u(\pi,y,t) = 0, \quad u(x,0,t) = u(x,\pi,t) = 0$

$$u(x,y,t) = \sum_{n=1}^{\infty}\sum_{m=1}^{\infty} c_{nm} \cos nx \cos my e^{-t(n^2+m^2)}$$

$$u(x,y,0) = \sum_{n=1}^{\infty}\sum_{m=1}^{\infty} c_{nm} \cos nx \cos my$$

$c_{nm} = \frac{4}{\pi^2}\int_0^{\pi}\int_0^{\pi} y \cos my dx dy = \frac{4}{m^2}\left[(-1)^m - 1\right]$ using double Fourier series

$$u(x,y,t) = \sum_{n=1}^{\infty}\sum_{m=1}^{\infty} \frac{4\left((-1)^m - 1\right)}{m^2} \cos nx \cos my e^{-t(n^2+m^2)}$$



Conclusion

Analytical solution of two- dimensional heat equation with Dirichlet boundary condition in the context of COVID 19 was solved, by the method of separation of the variable of a partial differential equation and transformed to the second-order differential equation and double Fourier series was used to obtain the analytical result. Also the result of the Analytical solution was used to apply in the context of COVID 19, the result obtained in problem 1 shows that the graph is moving down ward on the value -1.98 and 0.25 and maintained a straight line, while in problems 2 the result shows that the graph is moving upward on the values 0.99 and 0.001 and also maintained a straight line. This shows that COVID 19 has the highest level in problem 2 than 1 because the heat has a significant effect on problem 2.

Thus, the result found in problem 2 shows that COVID 19 has the tendency of extension beyond the expected limit.

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Effects of Storage Containers (Plastics and Galvanized Iron) on Physicochemical Qualities of Water

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Abstract: *Water, a single most important resource to mankind constitutes 70% of the earth's surface and 75% of our body. This resource is very important, yet, fresh water is limited, and potable water is scarce. This is why there is a tendency to store this limited resource to ensure water security, both for domestic and industrial purposes. This paper tries to compare water stored in galvanized and plastic tanks over a period of three months. Three sets of water samples (20 liters each) were obtained from the same source (dug well-ground water). One was used as control and the other two were stored in plastic and galvanized tanks respectively. After three months the water in the plastic and galvanized tanks were analyzed for their physical and chemical/geochemical characteristics. The results were then compared to the results obtained from the control sample. The three results were then compared to world health organization (WHO) and National Agency For Food And Drugs Administration Control (NAFDAC) limits for potable water. The results obtained showed a general deterioration of both samples but the water sample from the galvanized tank deteriorated more.*

Key words: *Water, Security, Plastic, Galvanized, WHO standards.*

Introduction

Water is stored for a variety of reasons which include covering of peak demand, smooth out variation in supply, provide water security in case of supply interruption or disaster. There may be various other reasons for water storage (Perlman 2010) Water security is the capacity of a population to ensure that they continue to have access to potable water, it is an increasing concern arising from population growth, drought and climatic changes etc, (Wikipedia 2011)

The most important reason may be to provide water security for domestic. municipal and industrial uses. Water could be seen every where but potable water is scarce hence if available must be stored for future use.

To ensure water security especially in drought-stricken areas, water is often stored for very long periods to last out the drought periods.

One important factor in water storage is the material for the construction of the storage facility. These materials range from wood, concrete, plastics, and galvanized iron etc. The materials must be chemically pure so as not to pollute the stored water, hence it is imperative to ascertain the level of contamination of the construction material for the storage facilities on the stored water (Harter, 2003). For this study plastic and galvanized steel tanks are put under scrutiny.

Plastics are synthetic polymers derived from petroleum and are composed of hydro - carbons which means that the basic elements in plastics are hydrogen and carbon. Other elements that make up plastics include oxygen, nitrogen, chlorine, fluorine (Volume library 2001)

Plastics are characterized by low strengths, low stiffness (modulus of elasticity) which is less than one tenth that of metals except reinforced plastics. Plastics have a tendency to creep-change in dimensions under prolonged loading.

Plastics are sensitive to temperature changes they lose strength at higher temperatures Thermal expansion of plastics is about ten times that of metals (Griskey, 2009)

All these deficiencies are overcome by the addition of suitable fillers and compounds. Pure plastics are not used for any plastic products.

Some of the element added to reinforce plastics includes silicon in silicones and sodium in lonomers. With these fillers in place, plastics are made into a variety of products including tanks. (Volume library 2001)

Galvanizing is a process of coating a base metal iron steel with a thin layer of zine to protect it from corrosion. The product is galvanized iron steel which could be made into several products including water tanks. The presence of zinc slows down corrosion considerably but does not stop it completely. (Microsoft encarta 2009)

Materials and Methods.

Materials.

Three water samples were drawn from the same well (dug well-ground water) located near the Department of chemical Engineering, The Federal Polytechnic Nasarawa, (Table 1). Each sample was 20 liters. One sample was stored in a covered plastic container, the second sample was stored in a galvanized iron tank. The third water sample was taken for immediate analyses (control).

The instruments utilized in the study include

(a) Digital Atomic Absorption Spectrophotometer, (AAS),(HACH DR/2000 model.
(b) HANNA instrument pH meter model H198229.

Methodology

After three months (90) days the samples in the galvanized iron and plastic tanks were taken to the laboratory for analyses. The same parameters measured in the fresh water sample were measured for these samples, they include, Total dissolved solid (TDS). Total suspended solid (TSS), Taste, Odour, Temperature, Colour, pH, Nitrate, Chloride, Iron and Zinc.

(a) Digital Atomic Absorption Spectrophotometer (AAS) (HACH) DR/2000 model.

This equipment measures the concentrations of various elements and acid radicals in water. The reagents are the standard solutions of the element whose concentration is being determined and the water sample.

(b) HANNA instrument H meter model H1.98129. This instrument measures pH. To use this instrument, it is first calibrated using a pH buffer solution. This instrument was also used for measuring TDS (total dissolved solid). A higher TDS means that there are more cations and anions in the water. With more ions in the water, its electrical conductivity increases (Harter 2003). By measuring the electrical conductivity of water, we are indirectly measuring its TDS concentration. At a high TDS concentration water becomes saline. Water with TDS above 500mg/l is not recommended for drinking (WHO,2004).

Table 1: Condition of Well

S/N	Sample No.	Source	Duration of Storage	Remark
1	Sample No. 1 (Control sample)	Bore hole water (ground water)	Sample (ground water)	The well was partially covered and the container is closed.
2	Sample No.2 (Plastic container samples	Bore hole water (ground water)	The water was stored for 3 months period	The well was partially covered. The container is fully covered up to that duration
3	Sample No.3 (Galvanized iron container sample)	Bore hole water (ground water)	The water was stored for 3 months period	The well was partially covered. The container is fully covered throughout that duration of time

Detailed results are shown in Table 2. from the analyses the following were observed, temperature, odor and taste were the same for all the samples. There were no changes. H values changed but not significantly. The water samples became more alkaline with plastic container showing more alkalinity.

The following parameters showed significant increases in values, electrical conductivity. Total Dissolved Solids (TDS), Colour, Total Suspended Solids (TSS), Nitrate (NO), Zinc (Zn) and Chloride (CI). Nitrate and chloride are used in plastic manufacture, zine is utilized in galvanized iron. Iron (Fe) and turbidity showed reduction in values.

Discussion

The result showed that the values of temperature, odor and taste did did Nitrate not change in any of the samples and they all fall within NAFDAC/WHO limits

The pH values, changed but not significant. The samples became more alkaline but the values are still within acceptable limits.

Total Dissolved Solid (TDS), Colour, Total Suspended Solids (TSS), Nitrate (NO), Zinc (Zn), Chloride (CI), these showed significant increases in values but these values still fall within acceptable limits, Table 2.

The values of iron (Fe) and turbidity showed reduction in values. This means less iron (Fe) in the stored water samples but the value of Fe from the water in the plastic container showed slightly higher values. Turbidity in both samples has very close values (9 & 10). This showed that the water samples became clearer as they stayed longer but they are still higher than the acceptable value (5).

Electrical conductivity values increased but not significantly, even the value of the control sample is well above the NAFDAC/WHO acceptable limits, the Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) increased significantly but within acceptable limits. The Nitrate (NO), Zinc (Zn) and Chloride (Cl) increased even though within acceptable values but the increases are significant because it showed the containers as not being very safe especially the galvanized iron tank for long storage durations.

The strange observation was the reduction in iron in the samples but this may be explained by the increase in alkalinity, iron is more soluble in acidic environments (Mason 1966). It is possible that the iron precipitated with increase in alkalinity and added to the increase in Total Dissolved Solids (TDS) and Total Suspended Solids (TSS). This may also be the reason for the increase in the electrical conductivity values.

Another significant observation is the increase in the value of Zinc (Zn) in the galvanized iron container sample. Pauling and Pauling (1975) indicated that Zn in moist air is oxidized and become coated with a tough film of zinc carbonate Zn,CO, (OH): This may be the reason for the increase in Zn in the galvanized iron tank sample S3. The Zine that was used to galvanize the iron container may have been oxidized to give the high values.

Table 2: Result of the Analysis

PARAMETER	SI	S2	S3	NAFDAC/WHO STDS
Temp. ^{0}C	26	26	26	-
Ph	7.26	7.57	7.31	6.8 -8.5
Electrical conductivity us/cm	231	231	249	120
T.S.D. mg/l	115.5	121	124.5	500
Colour (true). Pt.co	65	17	16	50
Turbidity NTU	18	9	10	5
T.S.S mg/l	13	46	65	200
Odour	Uni.obj.	Uni.obj.	Uni.obj.	Uni.obj.
Taste	Uni.obj.	Uni.obj.	Uni.obj.	Uni.obj.
Nitrate.(NO_3). Mg/l	12.76	32.56	37.84	45
Iron, Fe (T) mg/l	0.08	0.04	0.04	0.30
Zinc. Zn. mg/l	2	2	6	15
Chloride, Cl mg/l	11.20	18.30	18.60	250

Keys:
S1 - Control (Sample)
S2 - Plastic Container (Sample)
S3 - galvanized iron container (sample)
NTU - Nephelometric Turbidity Unit
Pt. Co.- Platinum Cobalt Unit
T.D. S - Total Dissolved Solids
T.S. S - Total Suspended Solids

The metals Fe and Zn are of nutritious value to man, animals and plants but within limited values. If the critical values are exceeded, they become toxic and can give rise to haemochromatosis and diarrhea but if there is a deficiency of these metals in human nutrition, anemia and stunted growth may occur (Sellinus & Frank 2000, Brunnel, et.al, 2007).

Excess of chloride and nitrates in drinking water could be hazardous to health especially to children. (Dissanayake 2005). These two increased in both the plastic and galvanized tanks, but the increases did not exceed the WHO recommended limit.

Conclusion

In conclusion water in both containers deteriorated but that of the galvanize diron container deteriorated more, within the period under investigation.

There may have been reactions between water and the containers, especially the iron and the trapped air. This makes it imperative that materials for manufacture of water storage facilities must be thoroughly analyzed to avoid possible contamination of the stored water.

The galvanized iron is not suitable for water storage for a long time especially where there are long drought periods.

Recommendation

Plastic containers are better for water storage but both should not be used for water storage for very long periods. As water storage is imperative in ensuring water security, further research should be carried out to improve the water storage construction materials

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Optimization of Paddy Continuous Flow Dryer Using Response Surface Methodology

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Abstract: *A continuous flow dryer was developed to address the problems associated with the drying of parboiled paddy. The continuous flow dryer was designed and fabricated using locally available materials to provide easier, faster and more efficient parboiled rice drying method. The performance evaluation was carried out using SIPI (FARO 44) paddy variety. The paddy was steamed, dried, and de-husked. Conveyor speed (5, 10, and 15 mm/s), drying temperature (90, 110, and 130 °C), and drying airspeed (1.5, 2.0, and 2.5 m/s) each at three levels were used as input variables. A Box-Behnken design (BBD) of Response Surface Methodology (RSM) was used to determine the optimum drying condition of the paddy. Drying output capacity (kg/h), total milling yield (%), head rice yield (%), and drying time (minute) were used as response variables. Regression models were developed for each response and validation of the optimum drying condition was performed. The result for the performance evaluation of the dryer showed a maximum drying capacity of 68.70 kg in 6 hours, total milling yield ranged between 52.02 to 80.79 %, head rice yield ranged between 56.13 to 77.94 %, and drying time ranged between 26.370 to 41.118 minutes. Results of the study also indicated that the developed regression models for all the response variables were significant at a 1 % level of probability (p-values < 0.0001), while the lack of fit of the models were not significant even at 5 % level of probability indicating that most of the variation in the response variables can be explained by the regression models developed. The optimum drying condition of parboiled paddy in the continuous flow dryer was: 5.000 mm/s conveyor speed, 110.529 °C drying temperature, and 2.484 m/s drying airspeed. The predicted optimum values of the response variables obtained at this drying condition were: 10.058 kg/h of drying output capacity, 76.667 % head rice yield, and 29.914 minutes total drying time. Lastly, the validation result showed that the experimental (test) values of the responses obtained at the optimized drying conditions were: 9.860 kg/h for drying output capacity; 75.217 % head rice yield; 31.8968 min. These test values are relatively close to the predicted values of responses with percentage error values of less than 10%, meaning that the difference between the experimental (test) data and the predicted data are within the acceptable limit thus confirming the suitability of the optimal drying conditions produced from the RSM. This showed that local materials can be used to developed a continuous dryer, and that RSM can be used to determine the optimum drying condition.*

Key words: *Conveyor Speed, Drying, Paddy and Validation.*

INTRODUCTION

The increase in the demand of food due to the increasing population of the world has led to the development of different crop processing machineries. Among the most cultivated crops in the world is paddy rice. Paddy processing machineries such as dryers have been developed and

modified in order to maintain the quality of the paddy. The demand for parboiled and white rice as at 2020 reached a volume of 488.3 Million Tonnes (IMARC, 2021). However, the drying of parboiled paddy is still practiced using the traditional sun-drying method. This method is tedious; time and space consuming; exposes paddy to rodents and dirt; causes internal stress in paddy which result in paddy breakage during milling (Bello *et al*., 2015).

Although there are existing designs of different types of dryers, they are mostly imported and have higher costs, which made them beyond the reach of small and medium scale paddy processors. Because of this problem, there are efforts made by some researchers to develop different dryers using locally available materials. (Owolarafe *et al.*, 2021) fabricated a cabinet dryer using locally available materials and carried out the performance evaluation of the dryer. Mondal *et al.*, (2019) developed and tested a small-scale mixed flow dryer for paddy drying. Gbabo *et al.*, (2017) developed a steam-heated platform dryer with a capacity of 4 tons per day to dry a parboiled paddy. (Kamin and Janaun, 2017) designed, fabricated, and tested a commercial scale Laterally Aerated Moving Bed (LAMB) in a local rice mill. A laboratory-scale flat-bed dryer was designed and fabricated by Ghiasi *et al.*, (2016). (Manikantan *et al.*, 2014) fabricated an integrated dryer. A commercial conveyor dryer for granulated cassava was developed by (Gragasin and Martinez, 2015).

MATERIALS AND METHODS

Sample preparation

A local variety of Paddy rice called *SIPI (FARO 44)* was used for the experiments, which was obtained from Kura local government area, Kano State, Nigeria. The total quantity of paddy used for the experiment was 300 kg and the experiment was conducted at the Agricultural Engineering workshop, Bayero University, Kano. This variety (*FARO 44*) is one of the most commonly cultivated paddy varieties in Kano, it has high yield, taste, and is commonly used by consumers. The moisture content of the paddy rice variety, after purchase, was an average of 13 % (w.b). The paddy was washed thoroughly (3 times) with tap water to avoid discolouration, odour, and contamination. The immature, unfilled grains and straw were floated off to reduce breakage during de-husking and then subjected to soaking and steaming process at constant variables of steaming time (6 hours) and steaming temperature (60 ^{o}C). After the steaming process, the wet paddy at 30 % (w.b) was loaded into the continuous dryer constructed for this purpose of the drying process.

Experimental procedure

The soaking process was done according to the method of (Ejebe *et al.*, 2015). Weight of water that is 1.3 times the weight of paddy used was heated until its temperature gets to 60 ± 2 ºC. The water was then poured into a warmer and the washed paddy was then poured into the warmer and covered rapidly and tightly for 6 hours. After the soaking process, the paddy was allowed to drip-dry for steaming process.

The steaming process was also done according to the method of (Ejebe *et al.*, 2015). The soaked paddy was washed, allowed to drip-dry, and poured into a steaming basket. The steaming basket is an aluminium vat having false bottom and perforations around ¼ its height from the base. The steaming basket was then placed on an aluminium pot with water level below the base of the steaming basket and steamed to a period when paddy begins to crack open their husks and there is steam vapour arising all over the pot. After that, the steamed paddy was ventilated by ambient air until the grain temperature reached 30-33 ºC before conveying it to the drying machine.

After the steaming process, the steamed paddy was then conveyed to the place where the developed continuous dryer was located. The drying experiment was carried out based on the method given by Pruengam *et al.* (2014). For each drying experiment, 5 kg sample of parboiled paddy was measured and drying was conducted by applying the required drying conditions of drying temperature (90, 110, and 130 ^{o}C); drying airspeed (1.5, 2.0, and 2.5 m/s), and conveyor speed (5, 10, 15 mm/s). The moisture content of each paddy sample after drying was measured using a moisture meter. The temperature of each paddy sample before and after drying was also measured using a probe thermometer. Likewise, the drying time for each paddy sample was taken After drying, the paddy was labelled for its combination of drying variables (drying temperature, drying airspeed, and conveyor speed) and stored for 2 days in bags to calm internal stresses developed during the drying processing (i.e., tempering) before the de-husking operation.

Three kilograms (3 kg) of dried paddy were taken from each of the dried samples and then de-husked using a diesel de-husking machine (N110). The de-husking machine was found in the faculty of Agriculture Bayero University, Kano, Nigeria. The weight of grains left in the huller machine for each treatment was forced out by putting rice husk into the hopper of the machine, after which the de-husked weight was measured for quality evaluation (IRRI, 1996).

The performance of the prototype continuous flow dryer was evaluated based on the drying output capacity (%), total milling yield (%), head rice yield (%) and time taken for complete drying (minutes).

Experimental design and statistical analysis

The rice variety *SIPI (FARO 44)* was used to test the performance of the continuous dryer. Response Surface Methodology (RSM) with three coded levels (−1, 0, and 1) was employed to examine the effects of three levels of conveyor speed (5, 10, and 15 mm/s); three levels of temperature (90, 110, and 130 ^{0}C); and three levels of drying airspeed (1.5, 2.0 and 2.5 m/s) on the performance of the prototype continuous flow dryer. Response surface methodology (RSM) is selected to determine the optimal conditions for drying paddy, because of its ability to find the effect of various factors on each response and its ability to determine the optimum conditions of the process. Actual levels and coded factor levels of three independent variables for optimizing the paddy drying condition using RSM are shown in Table 1.

Table 1 Actual levels at coded factor levels of independent variables used in the RSM

Symbol	Independent variable	Actual levels at coded factor levels		
		-1	0	1
X_1	Conveyor speed (m/s)	5	10	15
X_2	Drying temperature (^{0}C)	90	110	130
X_3	Drying air speed (m/s)	1.5	2	2.5

The Response Surface Methodology (RSM) with Box-Behnken Design (BBD) of 3 coded levels, 3 independent variables, and 20 experimental runs including eight centre points (Table 2) was used to optimize the paddy drying condition including conveyor speed (X_1), drying temperature (X_2), and drying airspeed (X_3) using Design-Expert software (Version 11.1.2.0, Stat Ease Inc., USA).

A second-order polynomial model was fitted to the mean values of the experimental results to get the regression equations as given in equation (1) (Cui *et al.*, 2019). Analysis of variance was carried out to find out the statistical significance of the model terms at a 5% level of probability. The accuracy of the model to describe the response variables was diagnosed against the coefficients of determination (R^2) values, the normal probability plots of the residuals, and the predicted versus actual plots. 3D surface plots were generated for various responses against two independent variables while holding the other independent variable constant.

$$y = \beta_0 + \sum_{i=1}^{k} \beta_i x_i + \sum_{i=1}^{k} \beta_{ii} {x_i}^2 + \sum \sum_{i<j=1}^{k} \beta_{ij} x_i x_j + \epsilon \quad (1)$$

Where; y = the dependent variable; β_0 = constant regression coefficient of intercept; β_i = constant regression coefficient of linear term; β_{ii} = constant regression coefficient of quadratic term; β_{ij} = constant regression coefficient of interaction term; X_i and X_j = independent variables; K = number of independent variables in the model; ϵ = the random error term.

Numerical optimization of the drying process was performed using a multiple response method called the overall or combined desirability index. The desirability index was determined using equation (2) as given by (Eren and Kaymak-Ertekin, 2007; Giri and Prasad, 2007; Myers and Montgomery, 2002).

$$DI = (Y_1 \times Y_2 \times \ldots\ldots Y_n)^{(1/n)} = \left(\prod_{i-1}^{n} d_i\right)^{(1/n)} \quad (2)$$

Where; DI = overall or combined desirability index; Y_1 (i=1, 2.....n) = the responses; n = number of the responses; d_i = desirability index for each response variable

Optimum drying conditions of parboiled paddy in the continuous dryer were provided by Response Surface Methodology (RSM) based on the maximum value of head rice yield, the minimum value of percent broken grains, minimum drying time, and maximum milling yield. Predicted values of all the responses were also derived from the optimum model. Under these conditions, a validation experiment was carried out to verify the adequacy of the model equation. Experimental values obtained were compared with predicted values by calculating their percentage error (PE) and this percentage error (PE) should be less than 10% to indicate a good fit as given in equation (3) (Nordin *et al.*, 2019).

$$PE(\%) = \frac{m_{ev} - m_{pv}}{m_{ev}} \times 100 \quad (3)$$

Where; PE (%) = percentage error; m_{ev} = experimental value; m_{pv} = predicted value

RESULTS AND DISCUSSION

Statistical significance and verification of models

The results of the effect of conveyor speed, drying temperature, and drying airspeed on performance evaluation of the continuous flow dryer using Box-Behnken design (BBD) of Response Surface Methodology (RSM) were presented in Table 2.

Table 2: Box-Behnken design showing the experimental results responses and variables

S/No.	A:Conveyor Speed (mm/s)	B:Drying Temp. (^{0}C)	C:Drying Air Speed (m/s)	Drying output capacity (kg/h)	Total milling yield (%)	Head rice yield (%)	Time taken for complete drying (minute)
1	15	130	2	9.84	68.17	62.7	30.672
2	10	110	2	8.99	72.99	77.94	33.624
3	10	90	1.5	7.32	62.03	64.27	41.118
4	10	110	2	8.5	77.69	74	35.304
5	5	110	2.5	10.12	56.41	77.06	29.748
6	5	90	2	8.14	79.21	72.26	36.978
7	10	110	2	8.9	78.24	73.42	33.822
8	10	110	2	8.37	76.69	72.57	35.904
9	10	110	2	8.9	78.02	70.51	33.84
10	5	110	1.5	7.77	58.81	71.94	38.706
11	10	110	2	8.59	80.02	72.9	34.962
12	15	110	1.5	7.78	55.56	74.97	38.688
13	10	130	1.5	8.47	54.8	60.77	35.55
14	15	90	2	8.13	80.79	74.07	36.996
15	10	130	2.5	11.45	52.02	56.13	26.37
16	10	110	2	8.93	77.58	77.58	33.78
17	15	110	2.5	10.12	54.35	73.42	29.778
18	5	130	2	9.77	71.46	67.59	30.87
19	10	110	2	9.03	77.02	75.48	33.336
20	10	90	2.5	9.08	61	66.37	33.192

The independent and dependent variables were fitted by the second-order polynomial equation to develop regression models that predict over a wide range the effect of the drying conditions on the response variables as shown in equation 4 to 7.

$$(y_{doc})^{-1.55} = 0.0345 - 0.0000A - 0.0048B - 0.0068C - 0.0001AB + 6.715 \times 10^{-6}AC - 0.0002BC - 0.0002A^2 - 0.0004B^2 + 0.0003C^2 \quad (4)$$

$$y_{tmy} = 77.28 - 0.8765A - 4.57B - 0.9275C - 1.22AB + 0.2975AC - 0.4369BC - 1.78A^2 - 0.5952B^2 - 19.22C^2 \quad (5)$$

$$y_{hry} = 74.30 - 0.4617A - 3.72B + 0.1268C - 1.67AB - 1.67AC - 1.68BC + 3.66A^2 - 8.80B^2 - 3.61C^2 \quad (6)$$

$$T = 34.32 - 0.0210A - 3.10B - 4.37C - 0.0540AB + 0.0120AC - 0.3135BC - 0.1350A^2 - 0.3075B^2 + 0.0435C^2 \quad (7)$$

Where: y_{doc} = drying output capacity (kg/h); y_{tmy} = Total milling yield (%); y_{hry} = Head rice yield (%); T = time taken for complete drying (min).

The results for the fitness of the regression models developed were presented in ANOVA table (Table 3). From the ANOVA table it is observed that the quadratic models developed for all the responses were significant at ($p<0.0001$) which showed that the models best describe the variation between the input and the response variables. From Table 3, it is also observed that the effect of lack of fit on the responses is not significant, indicating that the models best fit the experimental data. The significance of the model equations and the goodness of fit were also evaluated by considering the R^2 values. The results of the ANOVA table showed that the coefficient of determination R^2 values of all the responses (Drying output capacity, 0.9702; Total milling yield, 0.9847; Head rice yield, 0.9235; Time taken for drying, 0.9739) were above 0.8, indicating that the developed quadratic models appropriately predict the response variables. According to Zaibunnisa *et al.* (2009), the R^2 value should be at least 0.80 to have a good fit of a regression model.

Table 3 ANOVA for response surface quadratic model of the performance evaluation of the paddy continuous flow dryer

Source	df	Drying output capacity (kg/h)		Total milling yield (%)		Head rice yield (%)		Time taken for drying (min)	
		Sum of Squares	p-value	Sum of Squares	p-value	Sum of Squares	p-value	Sum of Squares	p-value
Model	9	0.0006	< 0.0001	2052.26	< 0.0001	623.14	0.0002	230.91	< 0.0001
A-Conveyor Speed	1	1.12E-08	0.9372	6.15	0.195	1.71	0.5782	0.0035	0.9413
B-Drying Temp.	1	0.0002	< 0.0001	167.27	< 0.0001	110.8	0.0009	77.02	< 0.0001
C-Drying Airspeed	1	0.0004	< 0.0001	6.88	0.1724	0.1285	0.8778	152.9	< 0.0001
AB	1	3.13E-08	0.8953	5.95	0.2018	11.22	0.1713	0.0117	0.8935
AC	1	1.80E-10	0.992	0.354	0.7458	11.12	0.173	0.0006	0.9763
BC	1	1.04E-07	0.8107	0.7637	0.635	11.33	0.1693	0.3931	0.444
A^2	1	1.81E-07	0.752	14.42	0.0593	61.22	0.0063	0.0833	0.7213
B^2	1	7.82E-07	0.5152	1.62	0.4922	354.15	< 0.0001	0.4323	0.4229
C^2	1	4.10E-07	0.6358	1689	< 0.0001	59.56	0.0068	0.0087	0.9082
Residual	10	0		31.86		51.64		6.19	
Lack of Fit	3	2.51E-07	0.9906	3.79	0.8146	6.08	0.817	0.0774	0.9925
Pure Error	7	0		28.08		45.57		6.11	
Cor Total	19	0.0006		2084.13		674.78		237.1	
R^2		0.9702		0.9847		0.9235		0.9739	
Adjusted R^2		0.9434		0.971		0.8546		0.9504	
Predicted R^2		0.9547		0.9533		0.7677		0.9611	
Adeq Precision		25.1317		22.4199		12.4432		26.8719	

The adjusted R^2 values of drying output capacity, total milling yield, head rice yield, time taken for drying were 0.9434, 0.971, 0.8546 and 0.9504 respectively as shown in Table 3. Also from the ANOVA table it can be seen that the Predicted R^2 values of drying output capacity, total milling yield, head rice yield, time taken for drying were 0.9547, 0.9533, 0.7677 and 0.9611 respectively. This showed that the difference between the adjusted R^2 and predicted R^2 value of all the response variables is less than 0.2, meaning that there is reasonable agreement between the adjusted R^2 and predicted R^2 values. This is also an indication of goodness of fit of the predicted models. From Table 3, it is observed that the adequate precision values of drying output capacity, total milling yield, head rice yield, time taken for drying were 25.1317, 22.4199, 12.4432 and 26.8719. According to Islam Shishir *et al.* (2016), the value of adequate precision should be greater than 4 for a regression model to be consistent in describing the experimental process. Therefore, from Table 3, it is observed that the value of the adequate precision for all the developed quadratic models is greater than 4, indicating the consistency of the developed models in describing the experimental data. Figure 1 shows a correlation plot between the predicted and actual value of the response variables. From Figure 1, it can be observed that the points on the graphs were reasonably distributed near the straight line, meaning that the underlying assumptions of all the quadratic models developed were appropriate. The correlation plots also suggest that the developed quadratic models were adequate in predicting the response variables for the experimental results. Figure 2 is a plot of studentized residuals versus predicted values of the response variables. From Figure 2, it can be seen that the points on the plots are randomly scattered around 0.00, pointing out that the assumption of the random errors having a mean of zero in all the developed quadratic models have not been violated. It can also be seen from Figure 2 that these points are spread randomly from left to right, indicating that the quadratic models best fit the experimental results.

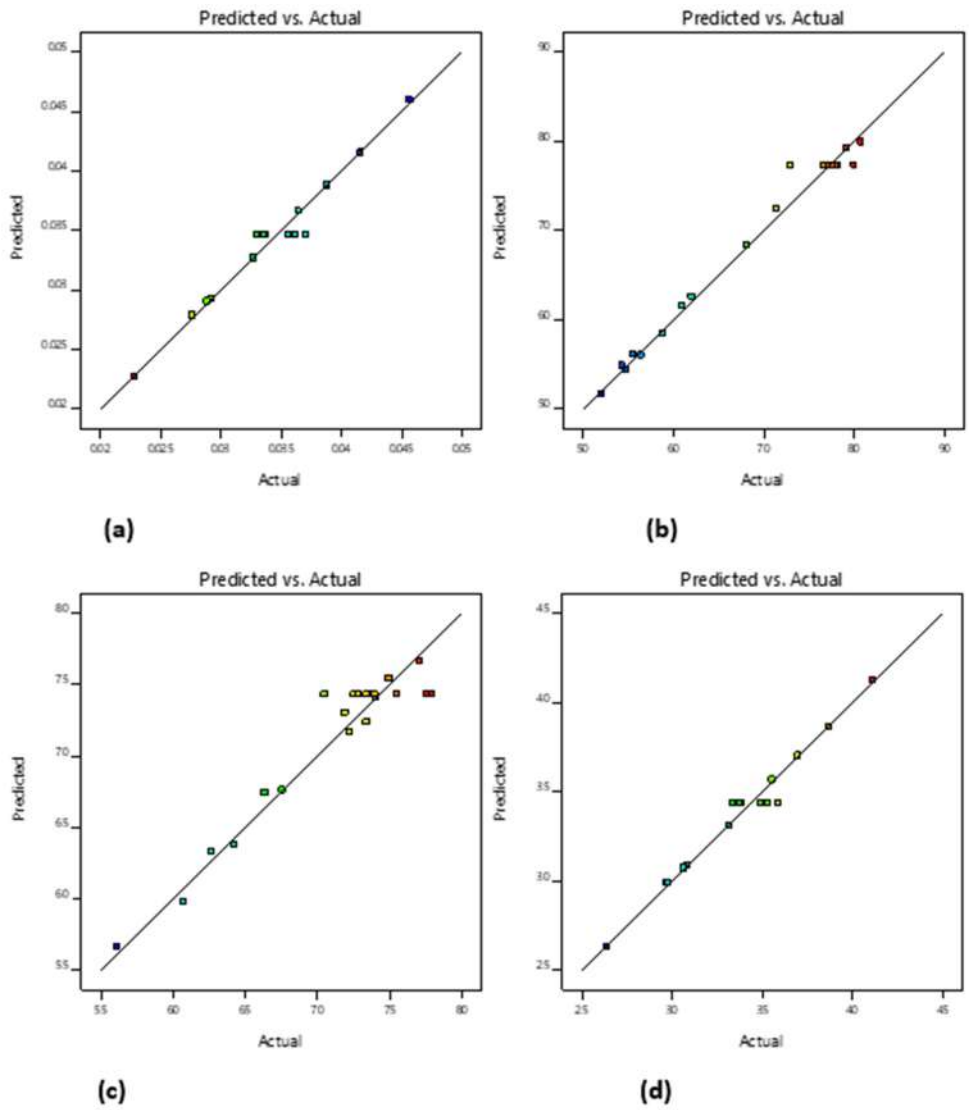

Figure 1: Correlation plot showing the distribution of predicted versus experimental values of (a) drying output capacity (b) total milling yield (c) head rice yield and (d) time taken for drying

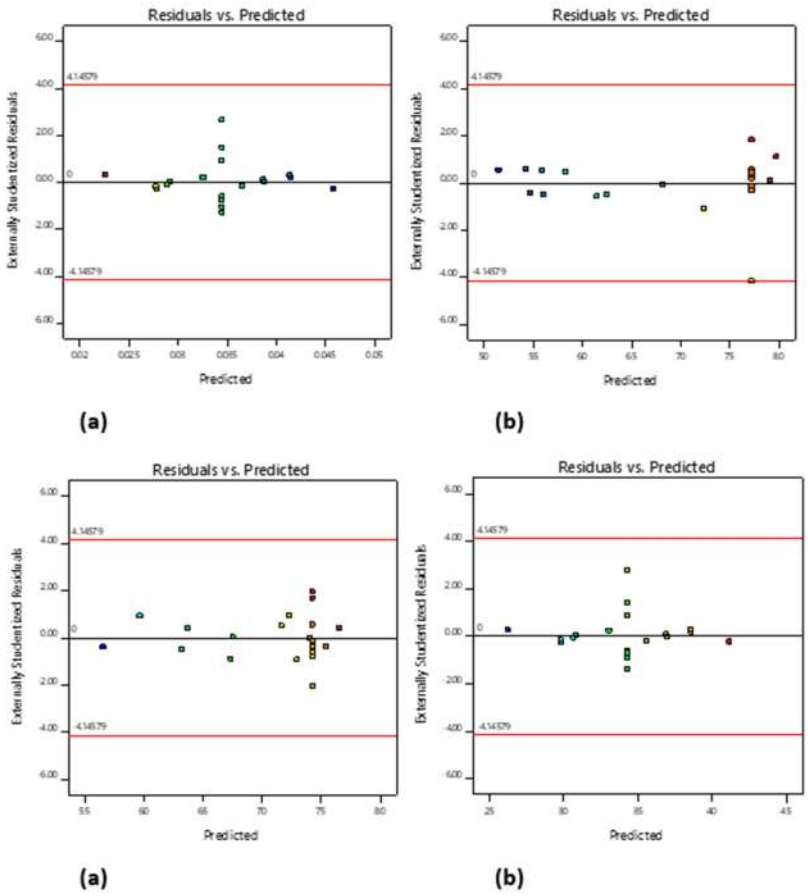

Figure 2: Plot of studentized residual versus predicted values of (a) drying output capacity (b) total milling yield (c) head rice yield and (d) time taken for drying

Effects of the input variables on the performance of the paddy continuous flow dryer

DRYING OUTPUT CAPACITY

Table 2 showed that the drying output capacity of the continuous dryer ranges from 7.32 kg/h to 11.45 kg/h with a maximum design capacity of 22.57 kg/ batch. The average drying capacity of the developed continuous flow dryer was 112.68 kg in 12 hours. This capacity is higher than the capacity of other researchers (such as Abubakar & Isiyaku, 2014 who reported a drying output capacity of 30 kg in 12 hours; Wincy et al., 2021 who also reported a drying output capacity of 60 kg in 13 hours).

Figure 3 is the surface plot of drying output capacity versus conveyor speed and drying temperature, holding drying airspeed constant. This surface plot shows the effect of each of the three independent variables and their interaction on the drying output capacity. The plot showed that the effect of conveyor speed does not affect the drying output capacity. However, Figure 3 showed that the drying temperature has a positive effect on the drying output capacity of the continuous dryer. The surface plot also showed that holding the drying airspeed constant and increasing the drying temperature from 90 ℃ to 130 ℃ causes an increase in the drying output capacity. This could be due to the decrease in the drying time when a higher drying temperature is applied to the dryer. Similar results have been reported for drying of rough rice in a flat-bed dryer by (Ghiasi *et al.*, 2016) where it

stated increase in drying temperature increases the output capacity of the flat-bed dryer. A similar report was also given by (Ibrahim *et al.*, 2014).

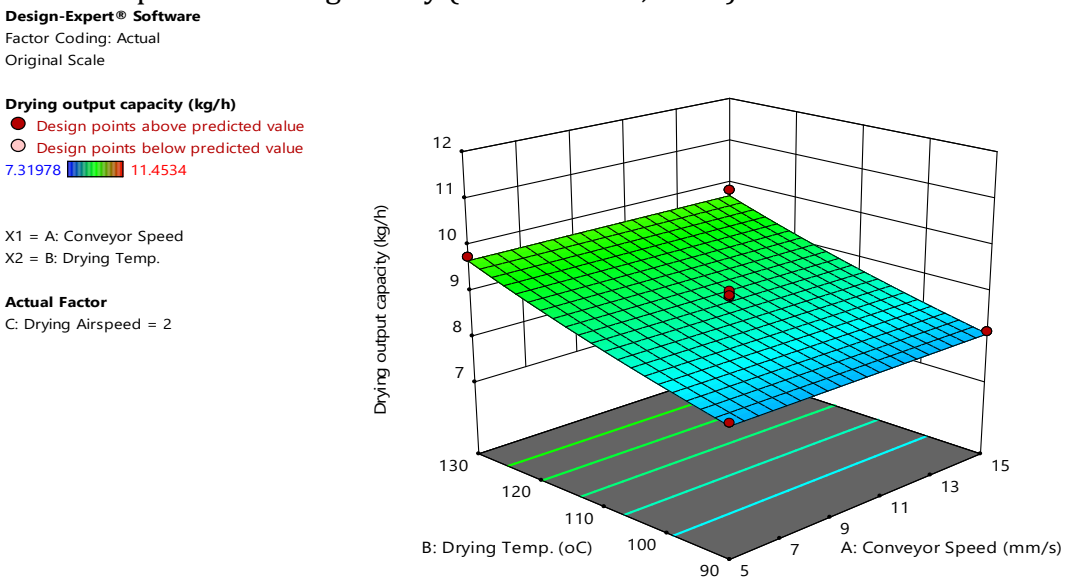

Figure 3 Response surface plot of drying output capacity versus conveyor speed and drying temperature holding drying airspeed at 2.0 m/s

TOTAL MILLING YIELD

The total milling yield of the paddy ranges from 52.02 % to 80.7944 % as shown in Table 2**.** Figure 4 is a three-dimensional (3D) surface plot showing the effect of each of the three independent variables and their interaction on the total milling yield. The plot showed that the drying temperature has a negative influence on the total milling yield of paddy. It can be observed from Figure 4 that the effect of conveyor speed also has a negative influence on the total milling yield. Therefore, figure 4 showed that increasing the conveyor speed (from 5 to 15 mm/s) and drying temperature (from 90 to 130 °C) during the drying of paddy at a constant drying airspeed decreases the total milling yield. This could be as a result of internal stress developed in the paddy at high drying conditions. Ibrahim *et al.*, (2014) while studying the performance of inclined bed paddy drying reported a decrease of about 2.47 % in total milling recovery when drying fresh paddy from 38 – 39 ^{o}C.

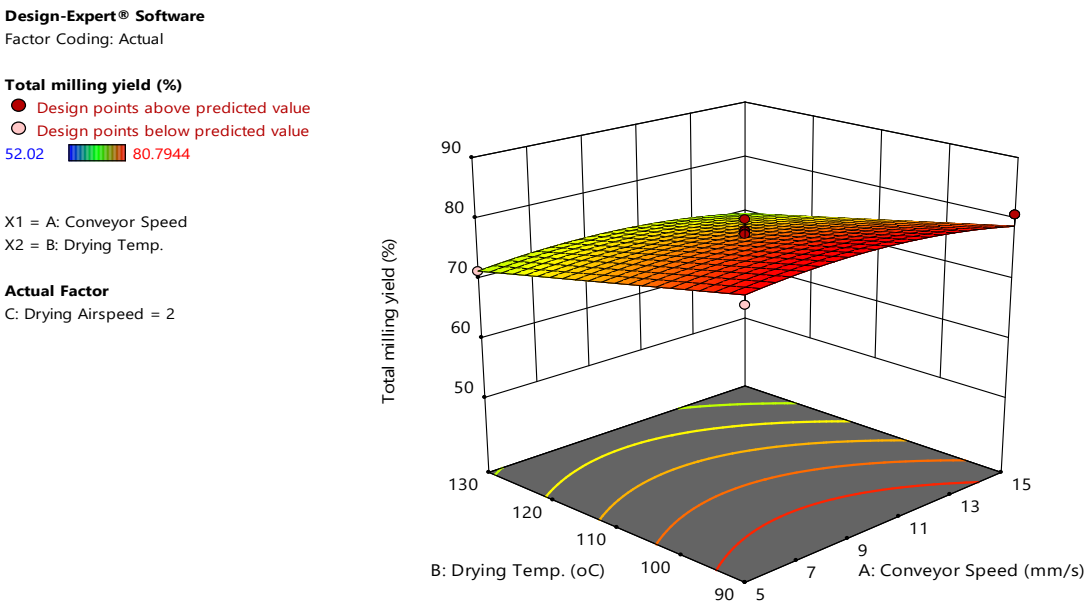

Figure 4: Response surface plot of total milling yield versus conveyor speed and drying temperature holding drying airspeed at 2.0 m/s

HEAD RICE YIELD

Table 2 showed that the head rice yield of the paddy ranges from 56.1314 % to 77.935 %**.** These findings are similar to results reported by other researchers (Ebrahim *et al.*, 2019). They reported the values of head rice yield in the range of 60 % to 80 % for parboiled rice. Figure 5 is the surface plot of head rice yield versus conveyor speed and drying temperature, holding drying airspeed constant. Figure 5 showed that increasing the drying temperature gradually from 90 ^{o}C to 110 ^{o}C increases the head rice yield, but head rice yield gradually decreases when drying the paddy above 110 ^{o}C. The surface plot also showed that there is a slight decrease in the head rice yield when the conveyor speed increases from 5 mm/s to 10 mm/s, but the head rice yield increases slightly at a conveyor speed of greater than 10 mm/s. The increase in the head rice yield could be related to less moisture gradient in final products. While the decrease in the head rice yield could be attributed to the cracks and fissures developed on the rice kernel due to the high moisture gradient when drying the paddy at a temperature above 110 ^{o}C. Reports related to the effect of the drying conditions on the head rice yield have also been presented by other researchers (Tirawanichakul *et al.*, 2012; Ebrahim *et al.,* 2019). They reported that the head rice yield of parboiled rice was relatively high when drying temperature increased up to 100 ^{o}C.

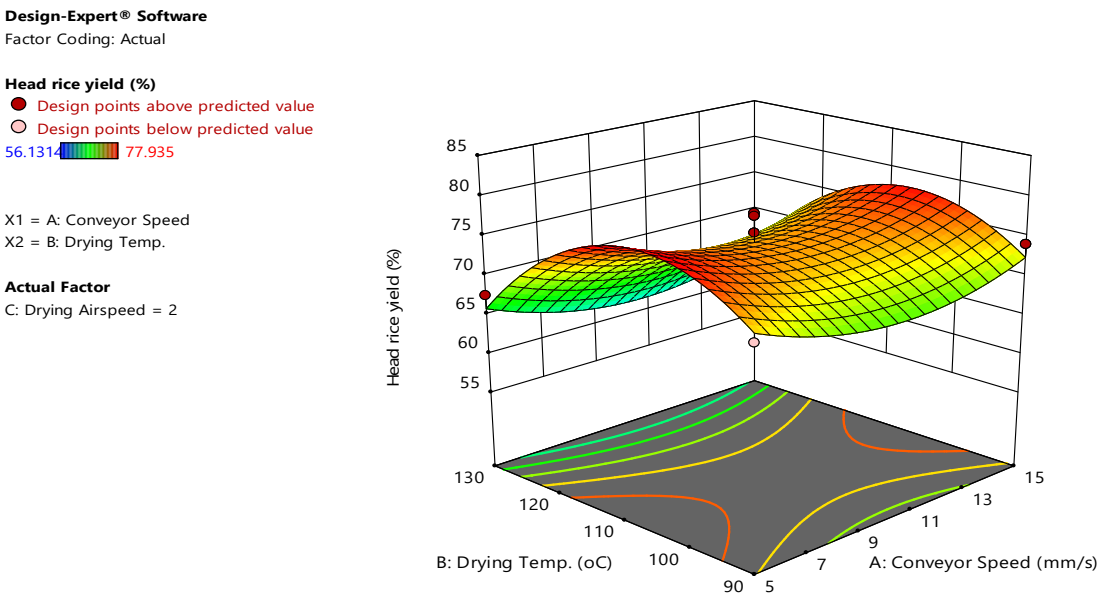

Figure 5: Response surface plot of total milling yield versus conveyor speed and drying temperature holding drying airspeed at 2.0 m/s

TIME TAKEN FOR COMPLETE DRYING

The time taken for complete drying of the paddy ranges from 26.370 min to 41.118 min as shown in Table 2. Figure 6 shows a surface plot of time taken for complete drying versus conveyor speed and drying temperature, holding drying airspeed constant. This surface plot shows the effect of each of the three independent variables on the time taken for complete drying of paddy in the continuous dryer. Figure 6 showed that the conveyor speed has a significant effect on the time taken for complete drying. Moreover, the (3D) surface plot showed that the drying temperature has a positive effect on the time taken for the complete drying of paddy in the continuous dryer. The surface plot also showed that holding the drying airspeed constant, and increasing drying temperature (from 100°C to 120°C), and increasing conveyor speed (from 10mm/s to 15mm/s), caused a decrease in the time taken for complete drying. This decrease in drying time could be attributed to an increase in the amount of water evaporation from the paddy. This result is in agreement with the results of other researches (Onwude *et al.*, 2018) where they reported that the value of drying time decreases linearly with an increase in drying temperature.

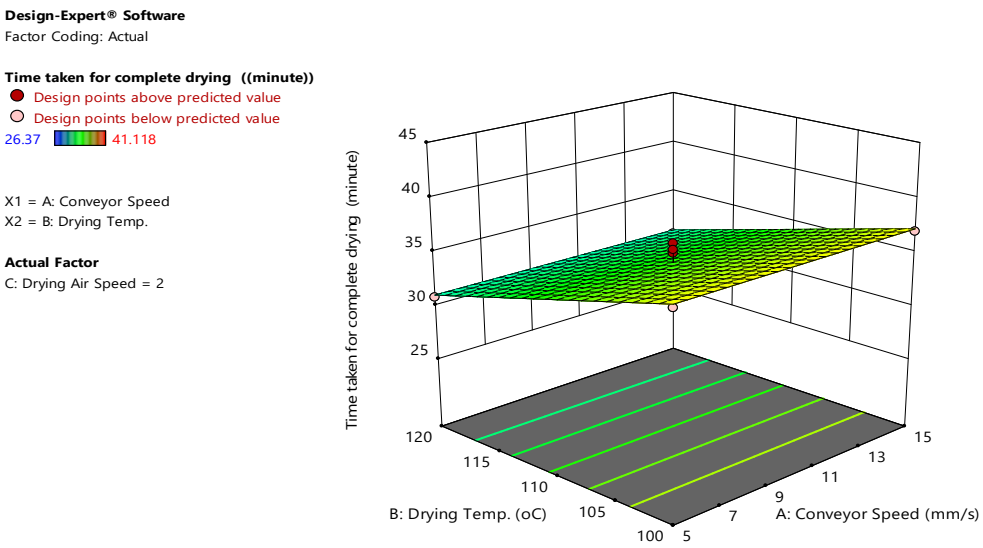

Figure 6: Response surface plot of drying time versus conveyor speed and drying temperature holding drying airspeed at 2.0 m/s

NUMERICAL OPTIMIZATION OF PROCESS CONDITIONS

The main objective of the current research was to find the optimum process variables for minimizing the drying time of parboiled paddy and maximizing head rice recovery of parboiled rice. To find the optimum drying condition, the following targets were set: drying output capacity should be maximum, Percentage head rice should also be maximum, and drying time should be minimum. The details of the set targets were presented in Table 4.

Table 4: Constraints Made for the Optimization of the Drying Condition

Name	Goal	Lower Limit	Upper Limit	Lower Weight	Upper Weight	Importance
A: Conveyor Speed	is in range	5	15	1	1	3
B: Drying Temp.	is in range	100	120	1	1	3
C: Drying Air Speed	is in range	1.5	2.5	1	1	3
Drying output capacity	Maximize	8	12	1	1	3
Head rice yield	Maximize	60	78	1	1	5
Time taken for complete drying	Minimize	30	42	1	1	4

Fig. 7 displays individual desirability values of input variables, response variables, and combined optimization with combined desirability (D = 0.8663). The value of desirability (D) ranges from (0 to 1). The desirability function (D) is a composite function describing how desirable (well-matched) the responses are at a particular level of independent factors (variables). The program of the statistical software seeks to find the values of variables, which can result in the maximum value of desirability function (Yadav *et al.*, 2010). The desirability function for input variables (conveyor speed, drying temperature, and drying

airspeed) and response variable (time taken for complete drying) is equal to 1 because their targets are set to be in range in the optimization. Other response variables (drying output capacity and head rice yield) were optimized to be at a maximum level within the desired range. The desirability function for drying output capacity and head rice yield were obtained to be 0.6402 and 0.9260 respectively. The optimum values of input variables were: 5.000 mm/s conveyor speed, 110.529 ^{o}C drying temperature, and 2.484 m/s drying airspeed. The predicted optimum values of the response variables obtained at this drying condition were: 10.058 kg/h of drying output capacity, 76.667 % head rice yield, and 29.914 minutes total drying time.

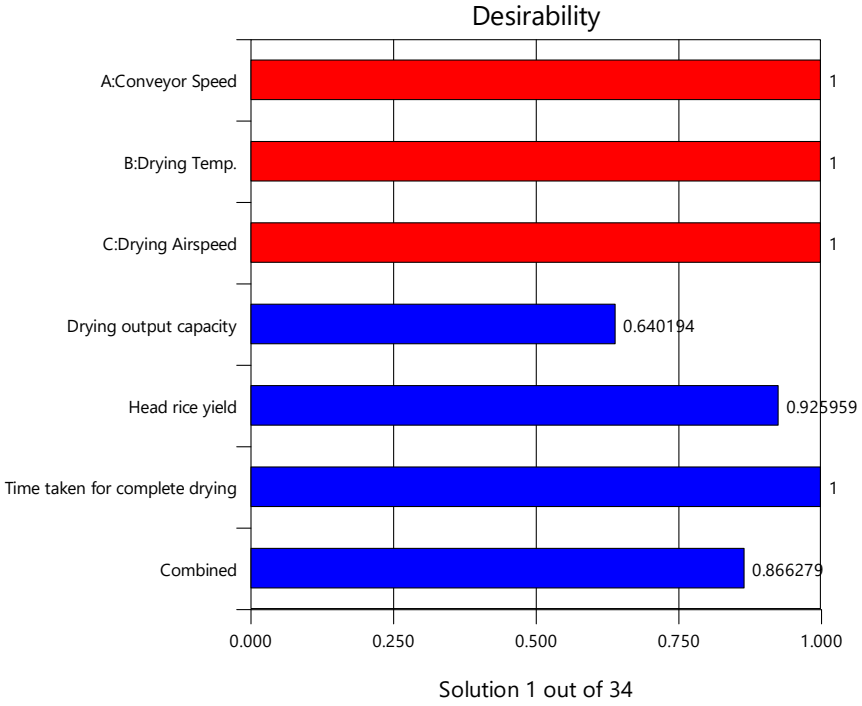

Figure 7: Individual desirability values of input variables, responses, and combined optimization

VALIDATION OF THE OPTIMAL CONDITIONS

Table 5 is a validation table showing the values of actual and predicted responses under the optimal drying condition. The validation of the optimum drying conditions suggested by RSM was achieved by drying the parboiled paddy in a continuous dryer using the optimized drying conditions of 5.000 mm/s conveyor speed, 110.529 ^{o}C drying temperature and 2.484 m/s drying air speed. The experimental (test) values of the responses obtained at the optimized drying conditions were: 9.860 kg/h for drying output capacity; 75.217 % head rice yield; 31.8968 min for drying time. These test values are relatively close to the predicted values of responses, hence confirming the validity of the optimized results and consistency of the regression models generated by the RSM software. From Table 5, it can be observed that the percentage error (PE) calculated for all the responses was less than 10%, meaning that the difference between the experimental (test) data and the predicted is within the acceptable limit thus confirming the suitability of the optimal conditions produced from the RSM.

Table 5: Predicted and test values of response variables under optimal conditions.

Optimized drying condition			Responses	Test value	Predicted value	Percentage error (PE)
Conveyor speed (mm/s)	Drying temp. (°C)	Drying airspeed (m/s)				
5.000	110.529	2.484	Output capacity (kg/h)	9.860	10.058	2.01
			Head rice yield (%)	75.217	76.667	1.93
			drying time (min)	31.8968	29.914	6.21

CONCULUSION

Response surface methodology (RSM) was used to optimize the drying condition of a continuous flow dryer. The input parameters used were conveyor speed, drying temperature and drying air speed, while the output parameters used were drying output capacity; total milling yield; head rice yield; time taken for complete drying. The optimum values of response variables obtained at optimum drying condition (of 5.000 mm/s conveyor speed, 110.529 °C drying temperature and 2.484 m/s drying air speed) were: 10.058 kg/h of drying output capacity, 76.667 % head rice yield, and 29.914 minutes total drying time. The validation of the model was conducted and the test values of responses obtained at the optimum drying condition were: 9.860 kg/h for drying output capacity; 75.217 % head rice yield; 31.8968 min for drying time. This is an indication that the RSM adequately described the developed models within the acceptable range of performance responses. It is recommended that the dryer can be improved by increasing the size of the conveyor and the number of heating elements to address the low output capacity of the continuous dryer.

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Impact of Sustainable (FADAMA) Lowland Crop Farming

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Abstract: *Most of the vast potential of (Fadama) lowlands including crop production. Though, lowlands also incorporate numerous ecosystem utilities that inhibit them from exploitative practices. Hence, (Fadama) lowland operation for crop production have a duty to consider measures to attain sustainable development goals (SDGs) in one hand. On the other hand, SDGs ought to ensure the sustainable practice of (Fadama) lowlands. This work proposes to assess the sustainability of crop production in lowland as it supports the achievement of SDGs, which tends to eradicate hunger, achieving food security with good nutrition, and improving sustainable agriculture. These goals essential to be achieved in 2030 by endorsing sustainable crop production systems, applying through agricultural practices, production accumulation and productivity, and at the same time maintaining environmental and (Fadama) lowland ecosystems. So, this work will review three major aspects as follows: Method to produce crop in climatic condition, Ideal Crops for (Fadama) Lowland, and impact of Climate on crop Quality. This paper is projected to yield sustainable processes of crop production in (Fadama) lowlands to contribute to the accomplishment of sustainable development goals (SDGs).*

Key words: *Crop farming, sustainable development Goals, Fadama lowlands*

Introduction

Rice belongs to the genus Oryza in the family Poaceae. It is a small genus of 20 to 25 species with a pantropical and subtropical distribution. Two species of the genus are cultivated: O. sativa L., the universally cultivated Asian rice, and O. glaberrima Steud., of the West African rice. [1]. It is one of the most important cereal crops in Nigeria. Rice consumption is increasing rapidly in Nigeria because of urbanization, relative ease of preparation, and convenience in storage. It is commonly boiled and eaten with stew or vegetable soup. It is also used in the preparation of several local dishes that are eaten in every home, especially during festivals and ceremonies [2]. Conversely, rice supply falls short of the demand; the country depends heavily on rice importation of over 5 million tons annually, equivalent to over $US 800 million in foreign exchange. Recently, the Federal Government of Nigeria stop

the rice importation and it boarder to "protect local producers against massive imports of rice". This strategy is motivating attention in the domestic production of rice.

However, as detailed in the Nigeria Productivity Blueprint[4] of sustainable development goal (SDG), the productivity of farmers in the agro-food sector is plagued by issues such as: a) Insufficient focus on value-adding activities and disconnections along the value chain; b) Multiple small producers with low levels of productivity; c) Issues with quality and standards across the subsector; and d) Low adoption of technology and modern farming practices [3] in [4].

Therefore, the approaches “sustainability” term remains diverse, particularly in agriculture. The challenges of diversity issues reflect faced by unique communities can be seen in different dimensions like politics, social and environmental, economic, knowledge and technology, just to mention a few that go along with (Fadama) lowlands that are located Jere Rice Bowl of Borno state which include several sub-districts such as Koshebe, Gongolon and Ayaba lowlands as agricultural resource which is anticipated to tolerate crop production requirements to be sustained in order to fulfil food needs for the next generation. (Fadama) lowlands can be retained through proper utilization of agricultural inputs, sufficient maintenance of infrastructures, and effective control on farmland from conversion Usman et al. 2019 in (Hoang and Alauddin 2012). Although, there is a deficiency of applicable measures in deciding crop production sustainability. With several signs of sustainability that are found in the SDGs, and cannot be used to quantify the sustainability of crop production since the indicators are inadequate in terms of calculations and not in agreement with some exact site for the production crop. Hence the study to checkmate and assess the (Fadama) lowland is necessary and “what is the way out for researcher to implore for a sustainable yield of crop production in (Fadama) lowlands"?
Whilst domestic production has been increasing judiciously, consumption has been increasing at a more rapidly step. Stating that consumption outshines production in Nigeria, as imported rice plays a vigorous role in closing the gap Usman et al. 2019. However, the dependence on imports at the back of limited domestic resources and production capacity naturally lead to concerns related to food security and the nation’s ability to be self-sufficient in its rice production. Unsurprisingly, policies have thus always tended to focus on increasing total production of paddy in bulk for cheap local rice with less focus on premium, specialty rice products. However, the latter seems to hold some potential towards reviving the lowland, which could help to improve the farmers’ income and SDGs.

Hence, increase in rice could yield more due to farmers using enhanced rice varieties which have potential to increase nutrition, improve food security, nurture rural development and support sustainable development goals (SDG). Therefore, it was found imperative to study the adoption of rice production technologies in Jere Local Government Area of Borno State, Nigeria. With the view of given specific attention in this report of SDGs through review of relevant papers. The objective of this paper is to prioritize a constant growth in food production, especially for rice (the staple food of the dwellers) and challenges of sustainable crop production in (Fadama) lowlands, based on sustainable development goals achievements.

Methodology

The study was steered in Jere Local Government Area of Borno State, in north-eastern Nigeria. Lying within the latitudes of 11°40^{1}and 12°05N with longitudes of 13°50^{1} and 12^{0}20^{1}E, it conquers a total landmass of 160 square kilometer [5]. It shares boundaries within the state, with Maiduguri Metropolitan Council to the north, Konduga Local Government Area to the south and Mafa Local Government Area to the east. The climate of the area is described by dry and hot seasons, with a minimum temperature ranging from 15-20°C, while the maximum temperature ranges from 37-45°C. The annual rainfall ranges from 500mm to 700mm per annum [6]. The rainy season is usually from May to October with low relative humidity and short wet seasons. Generally, the topography is low land plain, and the soil is generally sandy with short grasses and thorny shrubs. Jere Local Government Area has a projected population of 211,204 persons with annual growth rate of 2.8% [7]. Majority of the dwellers are farmers, traders and civil servants. The major ethnic groups are Kanuri and Shuwa-Arab. Others includes Hausa, Bura and Fulani and many immigrant settlers from within and outside Nigeria [8].

The Jere Rice Bowl of Borno state, Nigeria provides a further example of how rice cultivation is still thriving contrary to all odds. This is one of the most famous rice zones in Nigeria. In 1990, the Jere Farmers Development Association - Zabarmari had cause to complain to the state Governor on the release of water thus: The Rice Bowl encompasses some village units comprising over 150,000 hectares with a cultivated area of 37,900 ha which depend on the water from Alau Dam [9].

This paper was carved out through assessment of relevant literature in crop production and soil science development in lowlands from both theoretical and methodological perspectives. theoretical and methodological perspectives of this paper was written through assessment of relevant literature both in crop production and soil science discipline for lowland crop farming development. Most of the literature reviewed include papers journals, articles and sustainable development goals (SDGs) documents, and reports.

Results and Discussion

Flooding is simply an overflow of water, but there are many different types of flood depending on where that water comes from and why it is overflowing. In addition to land typology, the type of overflow has a very important meaning in determining the suitability of the area for farming. Based on its hydro- topography (fadama) lowland can be classified into five categories, namely: 1. Type A Tidal/Coastal Flooding: Tidal flooding is any flooding that results from the sea, whether that's tidal rivers overflowing, or large waves crashing the sea front. This type of flooding is usually very sudden, as the tides can change quickly and with no warning. This means that the resulting floods are extremely dangerous, especially in the case of a coastline that is frequented by pedestrians or vehicles. 2. Type B Flash Flooding: Flash flooding is usually the result of exceptionally heavy rain that overwhelms drainage systems or breeches flood defences. These floods are very fast moving and unexpected, which means that they can be very dangerous. This type of flooding is likely to rise as climate change continues. The risk is also increased by more developments being constructed on flood plains and natural drainage systems being concreted over for construction. 3. Type C. Fluvial/River Flooding: Fluvial flooding is any type of flood that results from rivers or waterways. They are usually the result of heavy

rain that exceeds river capacity and causes them to burst their banks. This type of flooding can usually be anticipated, as it results from prolonged rain and often happens regularly in the same areas. Residents can usually see the water level rising over a few days or weeks, signalling that a flood may be imminent. Other causes include obstructions in the river, such as a build-up of rubbish or a fallen tree, or runoff caused by melting snow. 4. Type D. Groundwater Flooding: Groundwater flooding occurs when the natural water level below ground rises to well above what can be accommodated. This can happen after prolonged or extremely heavy rainfall, and will result in the ground becoming so waterlogged that it can no longer drain water away naturally. The effects of groundwater flooding are often worsened by construction. Large, open areas are concreted over, removing soil and vegetation that would have contributed to absorbing the rainwater. 5. Type E. Sewer Flooding: Sewer flooding is the overflow of water from the drainage and sewerage system. It can be the result of damage in the sewers, or the capacity of the system may be overwhelmed by heavy rain, flash flooding or groundwater flooding. Sewer flooding is extremely hazardous, as the water is full of bacteria and contaminants. Wastewater and sewage can overflow into residential areas, posing a real risk to human health and safety [10]. Types D is often referred to as direct lowlands. Lowlands have the prospect to be developed into agricultural land to support crop production. Therefore, its sustainable use must be conserved for future generations.

Consequently, many Nigerians toil under the burden of poverty and unemployment as well as rampant inequality in income and access to basic services. An estimated 62.6% of the population live below the [old] international poverty line (PPP 1.25 $ per day) while some 27.9 % are multi-dimensionally poor. Unemployment has been on the rise over the past two years, with the rate more than doubling from Q4 2014 figure of 6.4% to the current (Q1 2017) figure of 14.2%. Income inequality, measured by the Gini Coefficient, stands at 43%, implying that inclusive growth remains elusive. Inequality is evident not just with respect to income, but also in terms of access to basic social services and opportunities. When Nigeria's Human Development Index (HDI value = 0.527) is discounted for inequality, it falls to 0.328 which is a loss of 37.8%. In terms of the SDGs Index which ranks countries based on their performance across the 17 goals, the country is ranked a lowly 141 out of 149 countries with a score of 36.1% against the regional average of 42.5%. In a nutshell, the country faces many challenges in her efforts to meet the SDGs, including but not limited to poverty, insecurity, social inequality, the absence of inclusive growth, youth unemployment, gender inequality, limited funding as well as prevalent weak institutional capacities.

Conclusion

The attainment of sustainable crop cultivation in tidal lowlands based to Goals #2 and #13, the program of sustainable crop creation in tidal lowland should consist of: Investigation on procedures of productive means of crop cultivation in tidal lowlands to produce with the indicators of SDGs that contribute to the realization of goal #2 of The SDGs to ensure sustainable agriculture practices. Pursuing an actual influence of climate on crop quality with agricultural waste and pollution in crop production in (Fadama) lowlands to achieve goal #13 of The SDGs to safeguard liable production system and reduce chemical use in crop production. Estimate the efficient use of agricultural inputs in crop production in (Fadama) lowlands to achieve goal #13 of the SDGs to ensure sustainable management and resource operation and competence.

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Significance statement
This study discovered the (Fadama) lowlands that can be beneficial for sustainable development goal (SDG). this study will help the researchers to uncover the critical areas of Crop farming that many researchers were not able to explore. Thus, a new theory on sustainability of crop production may be arrived at.

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Web Navigation Systems and Organizational Efficiency of Telecommunication Companies in Rivers State

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Abstract: *This study examined the relationship between web navigation systems and organizational efficiency of telecommunication companies in Rivers State, Nigeria. The study adopted a cross-sectional survey in its investigation of the variables. Primary data was generated through structured. As a macro level study, the population of the study was the four (4) major mobile telecommunication companies (MTN, Airtel, Glo and 9-Mobile). The four GSM companies are chosen based on their large subscriber base, coverage areas, number of mobile lines, revenue generation, assets and staff strength. Given that the population size was small and can be adequately covered, our study adopts a census method. Hence the sample was also the 4 telecommunication companies. However, for the purpose of date gathering, ten senior managers and supervisory managers of the four (4) mobile telecommunication companies in Nigeria bringing the total number to forty (40) respondents. The reliability of the instrument was achieved by the use of the Cronbach Alpha coefficient with all the items scoring above 0.70. The hypotheses were tested using the Spearman's Rank Order Correlation Coefficient. The tests were carried out at a 0.05 significance level. The tests were carried out at a 95% confidence interval and a 0.05 level of significance. The study findings revealed that there is a significant relationship between web navigation systems and organizational efficiency of telecommunication companies in Rivers State, Nigeria. The study concludes that web navigation systems significantly influence organizational efficiency of telecommunication companies in Rivers State. The study recommends that the systems should be upgraded on a regulated period so as to incorporate better navigation information space for easy access to information. With this, users would not confuse about the next action to take within a webpage.*

Key words: *Web Navigation Systems, Organizational Efficiency, Task Accomplishment, Service Quality*

INTRODUCTION

Increasing and intense competitiveness in the market has made efficiency the most important issue for profit and non-profit organisations for businesses. It comprises of three specific areas of firm outcome which includes financial efficiency, product market efficiency and shareholder return (Richard, Simon & Brut, 2009). It is very vital for managers to know which factors influence an organization's efficiency in order for them to take appropriate

steps to initiate them. Efficiency guarantees the continuity of the organization to be competitive in a global market place. Efficiency can be seen as a multi-dimensional construct consisting of more than simply financial efficiency (Baker & Sinkula, 2005). It describes the extent to which the organization is able to meet the needs of its stakeholders and its own needs for survival (Griffin, 2003). In this sense, efficiency depicts that an organization is achieving its mission and goals.

Zeb-Obipi (2015) posits that corporate efficiency refers to the record of achievements made by an organization (a corporation) at, or over a given, time measurable through several indices. It is measured by the extent to which an organization achieves set objectives or executes its strategies; hence efficiency measures are sourced from both corporate objectives and strategies. Atkinson (2012) defined efficiency as the achievement of results ensuring the delivery of desirable outcomes for a firm's stakeholders. Awino (2011) asserts that for an organization to be successful it has to record high returns and identify efficiency drivers from the top to the bottom of the organization. To achieve efficiency, organisations must pay premium attention to the information searching process.

Information is as old as nature, it preceded the existence of man, it plays key role in shaping and enhancement of civilization, especially as it concern organizations, families, communities, nations and the world in general, in our modern society. It assumes the form of both formal and informal conversation, meetings, telephone calls, personal conversation, letters, reports, memos and trade publications. Hardly can any organization or system perform efficiently without information (Bestman & Ikuru, 2018). Information seeking is a human activity with a goal of obtaining information. Being a subset of the human information behavior field, it is particularly concerned with methods people employ to discover and gain access to information resources (Wilson, 1999). Web information seeking is information seeking in the World Wide Web environment using a browser as the major user interface. Compared to other software environments, web is a much larger and more complex environment with massive information and complex interlinking structures. This poses even more problems for users to find the information they want.

There are basically two generic tactics to seek information on the web: querying and navigation. Querying, or searching, is the process of "submitting a description of the object (for instance, keywords) to a search engine which will return relevant content or information" (Jul & Furnas, 1997). Navigation, or browsing, is the action of moving oneself around an environment in an order, "deciding at each step where to go next based on the task and the parts of the environment seen so far" (Jul & Furnas, 1997). Users use these two tactics together to obtain information on the web. The choice of searching or browsing depends on factors like task type, web site design, user preference, and skill (Nielsen, 2013). While searching has drawn more attention for the past a few years, navigation is still a fundamental way, and even the "last mile", of getting useful information. For example, users still need to navigate through searching results to evaluate the relevance and usefulness of them.

The Web has become very large and complex. It is getting more difficult if people just rely on their intuition and follow embedded hyperlinks to locate information resources. Web navigation systems are commonly provided to guide users through the web information

space. The major goal of a web navigation system is to present an effective content index or guide and support various web navigation behaviors. It allows users to approach an abstract information space in a similar way as they travel in a physical space (Juvina, 2006). Good navigation systems not only make information easier to find and allow users to acquire more useful information, but also contribute to the overall website success.

The purpose of this paper therefore was to examine the relationship between web navigation systems and organizational efficiency of telecommunication companies in Rivers State. The specific objectives of the study included:

i. Examine the relationship between web navigation systems and task accomplishment of telecommunication companies in Rivers State.
ii. Investigate the relationship between web navigation systems and service quality of telecommunication companies in Rivers State.

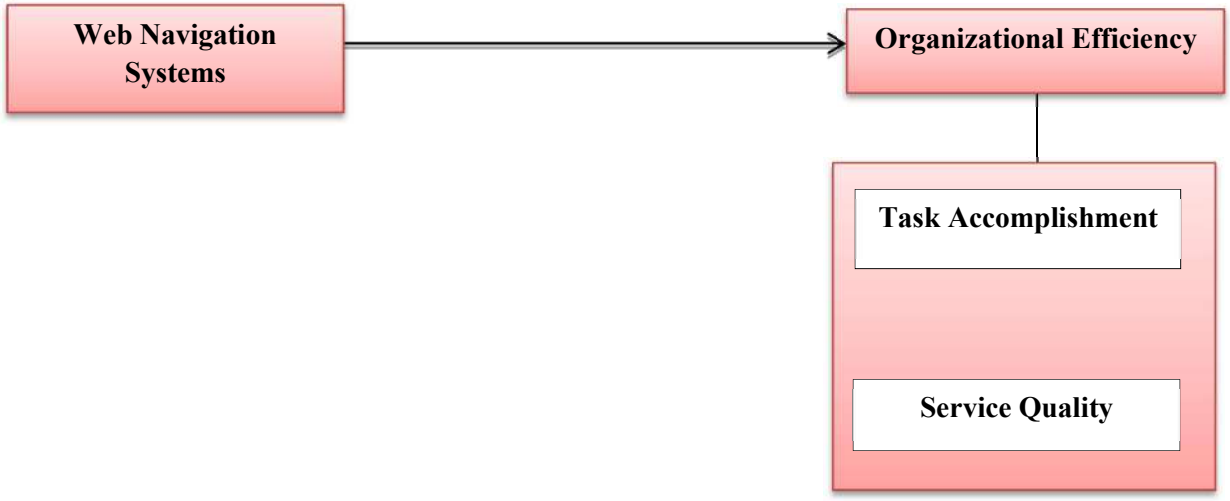

Figure 1: conceptual model for the relationship between web navigation systems and organizational efficiency

Source: Desk Research (2022)

LITERATURE REVIEW

Theoretical Foundation

Resource-Based View Theory

The baseline theory associated with this study is the resource-based theory basically because the resource-based theory suggests that resources that are valuable, rare, difficult to imitate and non-substitutable best position an enterprise for long-term success. These strategic resources can provide the foundation to develop the firm's capabilities that can lead to superior performance over time.

Relating this theory to our study, we can mean that information (communication industry) can increase their level of creativity when their information is authenticated, integrity, available, and management of risk in communication operations.

Although proponents of the resource-based view generally tend to define resources broadly, to include assets, knowledge, capabilities, and organizational processes, Grant (1991) distinguishes between resources and capabilities and provides a classification of resources into tangible, intangible, and personnel-based resources. Tangible resources include the financial capital and the physical assets of the firm such as plant, equipment, and stocks of raw materials. Intangible resources encompass assets such as reputation, brand image, and product quality, while personnel-based resources include technical know-how and other knowledge assets including dimensions such as organizational culture, employee training, loyalty, etc. While resources serve as the basic units of analyses, firms create competitive advantage by assembling resources that work together to create organizational capabilities. Capabilities, thus, refer to an organization's ability to assemble, integrate, and deploy valued resources, usually, in combination or copresence (Amit and Schoemaker 1993; Russo and Fouts 1997; Schendel 1994).

Resource-based theorists contend that physical assets, in and of themselves, can serve as sources of competitive advantage only if they "outperform" equivalent assets of competitors (Barney 1991; Rumelt 1984). Since IT systems can be purchased or duplicated fairly easily by competitors, it is often argued that physical IT resources are unlikely to serve as sources of competitive advantage (Mata et al. 1995). Such a reductionist view of technology, however, seeks to value the infrastructure solely in terms of its individual components, assumes the separability of the IT assets, and ignores the synergistic benefits of integrated systems.

Web Navigation System

Web navigation system is a set of methods that are used by users to access to information on a web page. It is a set of activities that are carried out by users to meet their own information requirements on a particular web page (Farkas & Farkas, 2000). Web navigation systems and navigation tools are the most important factors that determine the usability of web page (Galitz, 2007).

As Rosenfeld and *Morville et al* (2006) describe it "Structure and organization are about building rooms. Navigation design is about adding doors and windows." The navigation system is what enables the user to traverse the information structure. The navigation system is divided into two main categories: the embedded navigation system and the supplemental navigation system. While the embedded navigation system (e.g, global menus, local menus, contextual links) are inherent to the hierarchical structure of an information system, the supplemental navigation system (e.g, site maps, guides, site indexes) is extrinsic to a system's basic structure.

The most crucial (Rosenfeld *et al.,* 2002) information architecture component for users is the navigation system of the information space. It makes the content accessible to the target audience and combines the visual and usable functionality of the organization and labeling system. It is regarded as the most crucial component to the user because it will get

a source of frustration if the user gets lost in the information space. And customers who got lost are in most of the cases lost customers. They simply click away to a competitor website where the navigation system is more usable. There are three kinds of navigation system: embedded navigation system, supplemental navigation system and advanced navigation approaches.

1. Embedded web navigation systems consist of global navigation, local navigation and contextual navigation. Embedded web navigation systems are shown within the information space together with content. The global navigation enables the user to browse through the main areas of the information space, it is unique and identical on most of the sites. The local navigation enables the user to navigate in the actual area of the information space, it may change in different areas. The contextual navigation is embedded into the content, it consists of hyperlinks or breadcrumb navigation. It has the most distinctive granularity (Scratch Media, 2004).

2. The Supplemental navigation is mostly situated beside the content and may consist of sitemaps, indexes and guides or wizards. They provide different ways of accessing content directly in the information space. They are organized different to the overall organization system as an alphabetical order or birds eye view to the content.

3. Advanced navigation approaches aroused in some niche markets. But because of their narrow scope in usability, lack of user experience and their difficulties to implement in an efficient manner they did not become generally accepted navigation systems. Examples for such approaches are personalization, customization, visualization and social navigation. Personalization tries to present navigation options to the user based on his past behavior and information access. It works without direct user interaction. A good example is the amazon.com recommendation system presenting similar books to the user as he already bought. In contrast customization gives the user the full control over the navigation design. A reader of a news portal is able to customize the content areas presented to him on the entering page.

Concept of Organizational Efficiency

Organizational efficiency is the ability for organization to avoid wasting materials, energy, efforts, money, and time in doing something or in producing a desired result. In a more general sense, it is the ability to do things well, successfully, and without waste (Bestman & Chinyere, 2021). Organizational efficiency is all about figuring out how you can be more effective by using fewer resources, as well as less time and less money to achieve the same goal. Organizational efficiency is time-based, effort based and measurable. The main question you must ask when you're trying to determine efficiency is this: "How can I maximize the desirable results, using the least amount of money and time?" (Quain, 2019).

In this light, it can be said that Productivity is doing the right things in the right way. Once you ensure employees are being effective and efficient, you will see a rise in productivity. You should start measuring this productivity on a daily, weekly and monthly basis. You can use metrics such as number of units produced, sales or customer-satisfaction surveys. With effectiveness and efficiency in place, you will be able to establish some baseline measures of the productivity of your company.

Quain (2019) viewed efficiency as once you have employees doing the right things, you can make sure they do things right. Examine all employee tasks and determine if there is a better way to get them done. For example, perhaps your order pickers spend most of their time walking through the warehouse looking for products. To give another example, your back-office personnel may be dictating to front-office salespeople how many orders they can handle. Find more efficient ways to get work done through computerization, streamlined communication channels and rearranging of the physical environment. Daraio and Simar (2007) defined efficiency as the ratio between the quantity of input and output. They continued that efficiency is the quantity of input and output that defines the best possible outcome of a firm in its industry. Daraio and Simar's definition of efficiency clearly points to efficiency of an organization hence the concept organizational efficiency.

Hussey et al (2008) propose that efficiency of an organization is a combination of the perspective, output and input of an organization. The reviewers indicated perspective to include the individual evaluating the efficiency, the entity and their objectives. In terms of output, they referred to the type of product being evaluated and inputs referred to contributions, involvement or ideas to produce the output. The first measure, which is on perspective requires a clear identification of the entity that is evaluating efficiency, the entity being evaluated and the rationale for the assessment. The second measurement (output) identifies the outcome of interest depending on the organization. Lastly, the inputs refer to what can be used to produce the output.

Technical efficiency is defined as the capacity and willingness of an economic unit to produce the maximum possible output from a given bundle of inputs and technology. The latter concept defined as the ability and willingness of an economic unit to equate its specific marginal value product with its marginal cost. Mokhtar, Alhabashi and Abdullah (2006), in their survey of banking efficiency, contend that efficiency refers to the comparison between the outputs and inputs used in the process of producing a product or service. The researchers further propose that the concept of efficiency for them, technical efficiency is the firm's ability to obtain maximal output from a given set of inputs while allocative efficiency means the firm's ability to use inputs in optimal proportions, given their respective prices and production technology.

Measure of Organizational Efficiency

Task Accomplishment

According to Carver and Scheier (2000) individuals manage their behavior in relation to their goals by comparing their current level of performance against the desired level of performance to determine if a discrepancy is present (e.g., performance is below the goal). If a discrepancy is sensed, individuals are expected to engage in behaviors aimed at reducing the discrepancy. For instance, a negative discrepancy, indicating that one's current performance is below the goal, should result in increases in effort so as to reduce the discrepancy and align future performance with the goal (Carver & Scheier, 2000). Koole and Kuhl (2008) stated that en route to achieving a goal (which would end in either accomplishment or failure), individuals often encounter a variety of frustrations or successes, which can shape affective responses. From an AET perspective, attaining a goal

can be viewed as a positive event that elicits positive affect, whereas not attaining a goal can be viewed as a negative event that elicits negative affect (Kruglanski & Kopetz, 2009).

Research on self-regulation has demonstrated a link between goal attainment and affect (Koole & Kuhl, 2008; Kruglanski & Kopetz, 2009). The idea that daily task accomplishment should impact daily affect is consistent with Affective Events Theory (AET; Weiss & Cropanzano, 2006). Weiss and Cropanzano (2006) developed AET to explain how discrete work events provoke emotional reactions, which influence subsequent employee behavior and other outcomes. According to AET, fluctuations in work events result in fluctuations in affect. A key contribution of this theory is that it described in detail the importance of taking a more dynamic, process-based view of work phenomena. We contend that the experience of task accomplishment or failure represents an affective event that has predictable effects on employee emotions (Henkel & Hinsz, 2004; Parrot & Sabini, 1990).

Our focus is on direct perceptions of task accomplishment in each work shift, which is akin to direct assessments of goal-performance discrepancies found in the literature (e.g., Donovan & Williams, 2003). We argue that this direct assessment of task accomplishment is more likely to impact subsequent affect and action than a measure of accomplishment that is calculated as the difference between performance and goals (Carver & Scheier, 1998). As articulated above, various theories of motivation and action (e.g., Carver & Scheier, 2008; Kluger & DeNisi, 1996) view affect because of such discrepancy perceptions. Positive affect typically stems from perceptions that one is performing better than expected, whereas negative affect stems from perceptions that one is performing worse than expected (Bandura, 1997; Carver & Scheier, 1990; Carver & Scheier, 2008).

More recently, Henkel and Hinsz (2004) looked at the effect of goal success or failure on affective outcomes in a laboratory setting. Utilizing a brainstorming task for generating uses for a common object, the authors assigned participants to either a condition requiring them to set their own difficult, specific goal or a condition in which participants were assigned a goal. While success-failure was not directly manipulated in the study, Henkel and Hinsz (2004) believed that, through this manipulation, roughly half of the participants would experience success and half would experience failure (which subsequent analyses confirmed). Overall, results indicated that individuals who attained their goals experienced more positive affect and less negative affect than individuals who did not attain their goals.

Quality Service

In the service quality literature, it is generally agreed that different people understand different things regarding the service quality as a multidimensional notion. Bolton and Drew (2011); and Oliver (2000) defined customers' service quality as the difference between the actual service performance and their expectations. Like Bolton and Drew (2011); and Oliver (2000), Parasuraman et al. (2008: p19) characterized perceived service quality as "the degree and direction of discrepancy between customers' perceptions and expectations".

Service quality reflects the extent to which the delivered level of service matches Customer expectations (Lewis and Booms, 2003). One of the critical tasks of service companies is

service quality management. Quality means the degree of excellence in service performance. Consumers perceive the quality of a service by experiencing the consumption process and by comparing the experience with their expectations. Though consumers are coproducers and their participation also affects the quality, service firms cannot blame the customers. Service organizations have to be responsibility of quality performance through an effective strategic framework

The services marketing literature reveals that "service quality has been variously defined as focusing on meeting needs and requirements, and how well the service delivered matches customers' expectations" (Lewis 2003: p 22). They also proposed that "service quality is a global consumer judgement or attitude, relating to service and results from comparisons by consumers expectations of service with their perception of actual service performance" (Lewis, 2001; p 53). Service quality is the distinction between consumers' expectations for service performance and their perceptions of the service received. Zeithaml and Bitner (2006, p 45) defined perceived service quality as the judgement of a customer about the overall excellence or superiority of a product or service. They also defined service quality as, "the delivery of excellent or superior service relative to customer expectations"

The study in banking sector by Parasuraman et al. (2008, p44) stated that "customers' perceptions of quality are influenced by various gaps which lead to service quality shortfalls and, in particular, that the quality perceived in a service is a function of the gap between customers' desires/expectations and their perceptions of the service that is actually received". Supporting this definition, Lewis (2001) proposed that service quality is a measure of how well the service delivered meets customers' expectations of a product and service. For instance, the service provided by the local commercial bank (Government and private) and multinational banks in Bangladesh can be compared.

Web navigation systems and Organizational Efficiency

Literature review has identified that Information Architecture suffering from a lack of common semantics, that information architects disagree with regards to the goals of the field itself and that consequently when confronted with the complexity of real life, information architects still have to make personal decisions about how much to listen to the users (and user data), how to balance the business needs/goals with information architecture needs, or what to pick as a point of departure before creating Information Architecture strategy.

Research findings of the literature review showcased that the main study characteristics revolve around websites, and/or other channels, creating navigation for better findability and the actual organization of content parts in such a way, which allows users to make associations between them. Terms like information overload, usability, user experience, semantics, taxonomy, metadata often appear in connection with the topic. While related design deliverables are identified to be wireframes, flowcharts, storyboards, blueprints, and/or prototypes. Moreover, the definitions no longer concentrate solely on structuring the website, but the attention switches to the entire digital landscape/ecosystem (Disalvo

et al, 2008; Arango 2011; Maggi, 2013) and the enterprise as a whole environment, business values, goals, strategy, operation, culture (Roger, 2007; Wozniak et al, 2009).

From the foregoing discourse, the study hypothesized thus:

Ho_1: There is no significant relationship web navigation systems and task accomplishment of telecommunication companies in Rivers State.

Ho_2: There is no significant relationship web navigation systems and service quality of telecommunication companies in Rivers State.

METHODOLOGY

The study adopted a cross-sectional survey in its investigation of the variables. Primary data was generated through structured. As a macro level study, the population of the study was the four (4) major mobile telecommunication companies (MTN, Airtel, Glo and 9-Mobile). The four GSM companies are chosen based on their large subscriber base, coverage areas, number of mobile lines, revenue generation, assets and staff strength. Given that the population size was small and can be adequately covered, our study adopts a census method. Hence the sample was also the 4 telecommunication companies. However, for the purpose of date gathering, ten senior managers and supervisory managers of the four (4) mobile telecommunication companies in Nigeria bringing the total number to forty (40) respondents. The reliability of the instrument was achieved by the use of the Cronbach Alpha coefficient with all the items scoring above 0.70. The hypotheses were tested using the Spearman's Rank Order Correlation Coefficient. The tests were carried out at a 0.05 significance level. The tests were carried out at a 95% confidence interval and a 0.05 level of significance.

DATA ANALYSIS AND RESULTS

Table 1: Correlations Matrix between Web navigation systems and Task Accomplishment

			Navigation Systems	Task Accomplishment
Spearman's rho	Navigation Systems	Correlation Coefficient	1.000	.798**
		Sig. (2-tailed)	.	.000
		N	35	35
	Task Accomplishment	Correlation Coefficient	.798**	1.000
		Sig. (2-tailed)	.000	.
		N	35	35

**. Correlation is significant at the 0.01 level (2-tailed).

Source: SPSS Output

Ho_1: There is no significant relationship between web navigation systems and task accomplishment of telecommunication companies in Rivers State.

The result of correlation matrix obtained between web navigation systems and task accomplishment was shown in Table 1. The correlation coefficient of 0.798 confirms the direction and strength of this relationship. The coefficient represents a positive correlation between the variables. The test of significance shows that this relationship is significant at p 0.000<0.01. Therefore, based on observed findings the null hypothesis earlier stated is hereby rejected and the alternate upheld. Thus, there is a significant relationship between web navigation systems and task accomplishment of telecommunication companies in Rivers State, Nigeria.

Table 1: Correlations Matrix between Web navigation systems and Service Quality

			Navigation Systems	Service Quality
Spearman's rho	Navigation Systems	Correlation Coefficient	1.000	.824**
		Sig. (2-tailed)	.	.000
		N	35	35
	Service Quality	Correlation Coefficient	.824**	1.000
		Sig. (2-tailed)	.000	.
		N	35	35

**. Correlation is significant at the 0.01 level (2-tailed).

Source: SPSS Output

Ho_2: There is no significant relationship between web navigation systems and service quality of telecommunication companies in Rivers State.

The result of correlation matrix obtained between web navigation systems and service quality was shown in Table 1. The correlation coefficient of 0.824 confirms the direction and strength of this relationship. The coefficient represents a positive correlation between the variables. The test of significance shows that this relationship is significant at p 0.000<0.01. Therefore, based on observed findings the null hypothesis earlier stated is hereby rejected and the alternate upheld. Thus, there is a significant relationship between web navigation systems and service quality of telecommunication companies in Rivers State, Nigeria.

DISCUSSION OF FINDINGS

This study investigates the relationship between web navigation systems and organizational efficiency of telecommunication companies in Rivers State. The findings revealed that there is a positive and significant effect of navigation enhances organizational efficiency of telecommunication companies in Rivers State. The finding of the study corroborates with the study on information security and organizational efficiency, according to the study carried out by Kaplan and Nagel (2006) which postulate that to improve the effectiveness of boards in accomplishing their duties to the organizations they are accountable for, attention shall be taken for information needs and an adequate information architecture, comprising both formal and informal channels, conveying relevant information for short- and long-term strategic issues.

Based on literature, the finding supports Roger (2007) which emphasized that information architecture is a framework that helps the organization to design, implement, and manage a business plan and to incorporate it with the technology domain efficiently. It is used to assist the enterprise in running its business processes, operations, and perform changes such as meeting business goals effectively and improve decision making process. Therefore, it is commonly known for integrating and aligning business strategies with information technology (IT) resources.

CONCLUSION AND RECOMMENDATION

This study concludes that web navigation systems significantly influence organizational efficiency of telecommunication companies in Rivers State. Therefore, the study recommends that the systems should be upgraded on a regulated period so as to incorporate better navigation information space for easy access to information. With this, users would not confuse about the next action to take within a webpage.

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Flammability and Burning Behaviour of Low-Density Polyethene/Natural Rubber-Filled Coir Fibre Composites

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Abstract: *Coir is becoming more popular as a filler/reinforcement in the production of bio-composites, due to its inherent property of high lignin content coupled with non-toxicity, availability and low cost. The work aimed to study the flammability of coir fibre-filled non-vulcanized and dynamically vulcanized thermoplastic natural rubber composites. Two sets of composites, the non-vulcanized and corresponding vulcanizates were compounded using two rolls mill by melt blending of low-density polyethene/natural rubber at 90/10 ratio, respectively, filled with (0-50) per cent untreated coir fibre, and also fabricated using compression moulding techniques. The flame resistivity of the composites produced was studied using the UL-94 horizontal burning test. The ignition time and the extent of burning were found to decrease with an increase in fibre loading by up to 40%. Dynamic vulcanization was also found to improve the general stability of the composites when exposed to flames.*

Key words: Coir fibre, composites, flammability, dynamic vulcanization, thermoplastic natural rubber

INTRODUCTION

In recent years scientists and engineers have paid special attention to the way forward for the replacement of synthetic fibres such as glass and renowned carbon fibres with plant natural fibres (PNF) in the production of polymer-reinforced composites (Mahir *et al.*, 2019). Natural fibres are known to be biodegradable, cheap, have good thermal insulation

and are generally eco-friendliness. Coir fibre is one of the most important PNF with the inherent properties of low density, resistance to wear, high hardness, non-toxic, resistance to fungi, and not easily flammable (Thomason and Rudeiros-Fernandez, 2018). Coir fibres are more resilient to moisture, heat, and seawater as compared to other PNF. Coir fibre from the husk of coconut fruit that grows extensively in coastal areas is normally extracted using suitable methods of extractions such as water retting, enzymes and chemical and mechanical methods. Generally, coir is economically utilized as furnishing constituents, and in the production of other domestic products such as mats, mattresses, brushes, carpets, and insulation panels. Coir fibre is lignocellulose in nature with high content of lignin up to 46 % which made it strong heat resistant. Many authors have reported on the effect of coir fibres as reinforcement on the different properties of polymer composites (Jayavani *et al.,* 2016).

The most common matrices used in the production of composites are either thermoplastics or thermo-sets. A thermoplastic elastomer is another set of materials normally developed by melt blending of rubber (elastomer) and thermoplastic (Homkhiew *et al.,* 2018), having a wide range property of elastomer such as elasticity at ambient and service/processing temperature coupled with the ability to be remoulded, recycled and reprocessed using conventional types of machinery for processing thermoplastics (Sampath *et al.*, 2016). Natural plant fibres are sometimes added to thermoplastic natural rubber to form composites with a general improvement in stiffness and other properties (Charles *et al.,* 2021). However, one of the major disadvantages of composites filled with cellulosic fillers is the less resistance to fire.

In this research, low-density polyethene and natural rubber composites were produced using melt blending at a percentage ratio of 90/10 filled with coir fibre at different loadings up to 50%. The corresponding vulcanizates were also produced using the same compositions via dynamic vulcanization. The incorporation of coir fibre, a material of high lignin content with the characteristics of char formation, would improve the flammability exhibited by most composites with high content of cellulose.

MATERIALS AND METHODS

Materials

Coir fibre (CF): The coir fibre was obtained as waste and extracted using the water retting method. The process involved the impregnation of coir husks and allowed them to remain in the water for fifteen days followed by mechanical extraction using a wooden mallet, followed by washing and drying. Natural rubber (NR) was obtained from the National Rubber Institute, Benin. Low-density polyethene (LDPE) is obtained as commercial grade.

Equipment

Two rolls mill, Model: 5183 North Bergen U.S. A. A Compression Moulding Machine, Model: 0557 and Digital analytical weighing balance.

Methods

Fabrication of LDPE/NR/CF Composites

The composites were compounded using two rolls mill and compression moulding technique. The blend of LDPE/NR at 90 and 10 percentage ratios ($P_{90}R_{10}$) was used as the matrix for the production of composites loaded with 0-50% coir fibre. Similarly, another set (dynamically vulcanized composites) was produced by incorporating vulcanizing agents in situ, to arrive at the corresponding vulcanizates. The formulations used for the production of both non-vulcanized and dynamically vulcanized composites are shown in Table 1. Eventually, the composites produced were subjected to a flammability (UL-94 horizontal) test for the determination of ignition time and extent of burning.

Table 1: Formulation for LDPE/NR blend and their vulcanizates

S/N	Sample code	LDPE (%)	Natural Rubber (%)	Coir fibre (%)	Vulcanizing agents (Phr)				
					ZnO	MBTS	Stearic Acid	TMQ	Sulphur
1.	$P_{90}R_{10}$	90	10	0	-	-	-	-	-
2.	$P_{90}R_{10}C_{10}$	90	10	10	-	-	-	-	-
3.	$P_{90}R_{10}C_{20}$	90	10	20	-	-	-	-	-
4.	$P_{90}R_{10}C_{30}$	90	10	30	-	-	-	-	-
5.	$P_{90}R_{10}C_{40}$	90	10	40	-	-	-	-	-
6.	$P_{90}R_{10}C_{50}$	90	10	50	-	-	-	-	-
7.	$VP_{90}R_{10}$	90	10	0	5	2	2.5	1.5	2.5
8.	$VP_{90}R_{10}C_{10}$	90	10	10	5	2	2.5	1.5	2.5
9.	$VP_{90}R_{10}C_{20}$	90	10	20	5	2	2.5	1.5	2.5
10.	$VP_{90}R_{10}C_{30}$	90	10	30	5	2	2.5	1.5	2.5
11.	$VP_{90}R_{10}C_{40}$	90	10	40	5	2	2.5	1.5	2.5
12.	$VP_{90}R_{10}C_{50}$	90	10	50	5	2	2.5	1.5	2.5

(Baba, 2022)

Fabrication of Dynamically Vulcanized LDPE/NR/CF (10 - 50%)

Similarly, LDPE/NR loaded with CF (10 - 50%) were dynamically vulcanized in situ, to obtain a corresponding set of vulcanized LDPE/NR composites loaded with 0 – 50 per cent coir fibre, as shown in Table 1.

Flammability of the composites

Flammability (burning test) on the composites was carried out to study the ignition time (s) and extent of burning (mm) of the non-vulcanized and dynamically vulcanized LDPE/NR coir fibre-filled composites following ASTM D 635-76.

RESULTS AND DISCUSSION

Ignition time

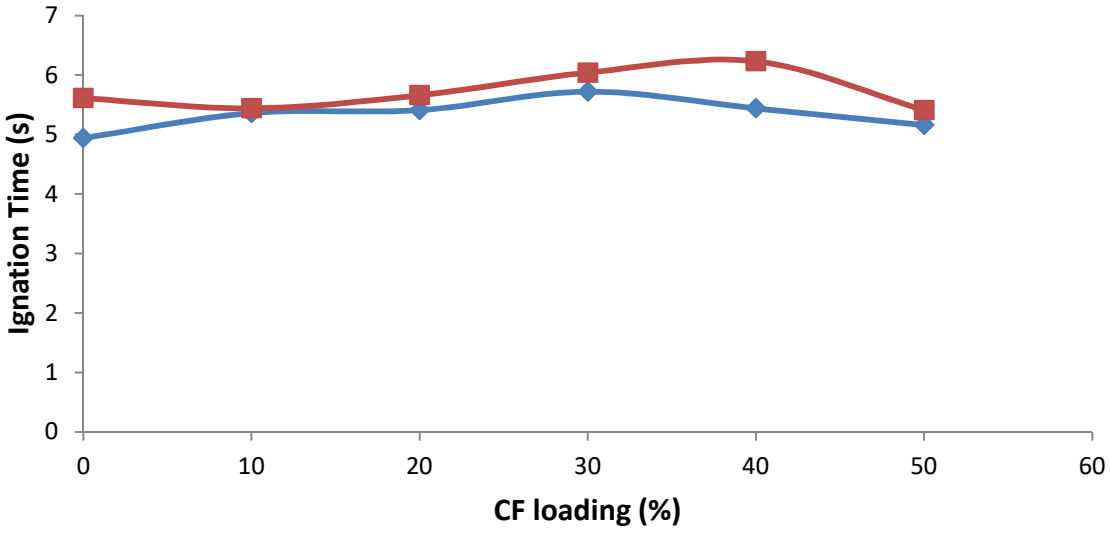

Figure 1: Effect of fibre loading and dynamic vulcanization on time of ignition of LDPE/NR filled coir fibre composites

Figure 1 showed the time taken for the non-vulcanized and dynamically vulcanized LDPE/NR-filled coir fibre to be ignited. The non-vulcanized composites loaded with 10%, 20%, 30%, 40% and 50% have recorded ignition times of 5.36s, 5.41s, 5.72s, 5.44s and 5.16 respectively. While the vulcanized samples with similar fibre loadings recorded 5.44s, 5.66s, 6.04s, 6.23s and 5.41s, respectively. The general increase in the time of ignition with CF loading could be due to high lignin and high moisture contents associated with coir fibre which could lead to a lowering of the rate of pyrolysis (Siva, 2019). It was generally indicated that non-vulcanized composites ignited faster as compared to their

corresponding vulcanizates. Dynamic vulcanization made the composites to be more compacted and stable due to a high cross-linkage formed with sulphur.

Extent of burning

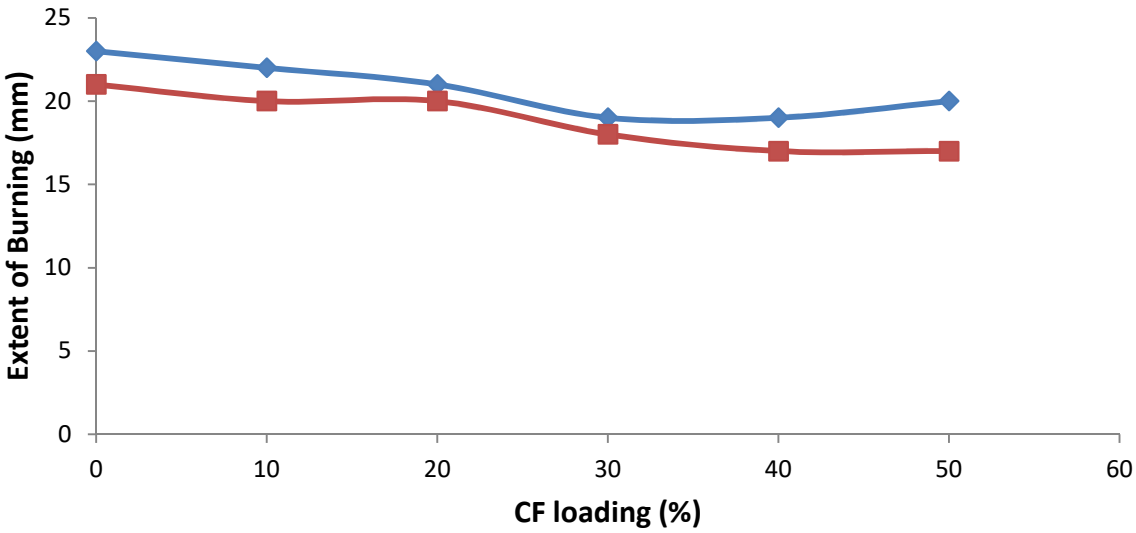

Figure 2: Effect of fibre loading and dynamic vulcanization on the extent of burning of LDPE/NR filled coir fibre composites

Figure 2 shows the effect of fibre loading and dynamic vulcanization on the extent of the burning of the coir fibre-filled LDPE/NR composites and the vulcanizates. From the result obtained the composites with higher CF content experienced a low extent of burning, this could be attributed to the high content of lignin (41-45%) from the untreated fibre embedded in the thermoplastic natural rubber matrix, as lignin immensely contributes to char formation than cellulose or hemicelluloses, thus resulted into lower flammability. Besides, the orientation of fibres and also fibre and matrix interaction contribute to the flammability of the composites.

In the presence of a flame, the burning of composites takes place in form of heating, decomposition, ignition, combustion and propagation in sequential order. In the burning of lignocelluloses, there are two forms of products that are obtained; these include high cellulose content and high lignin content. High cellulose provides the chance of higher flammability while the higher value of lignin showed a greater chance of char formation.

Behaviour of burning

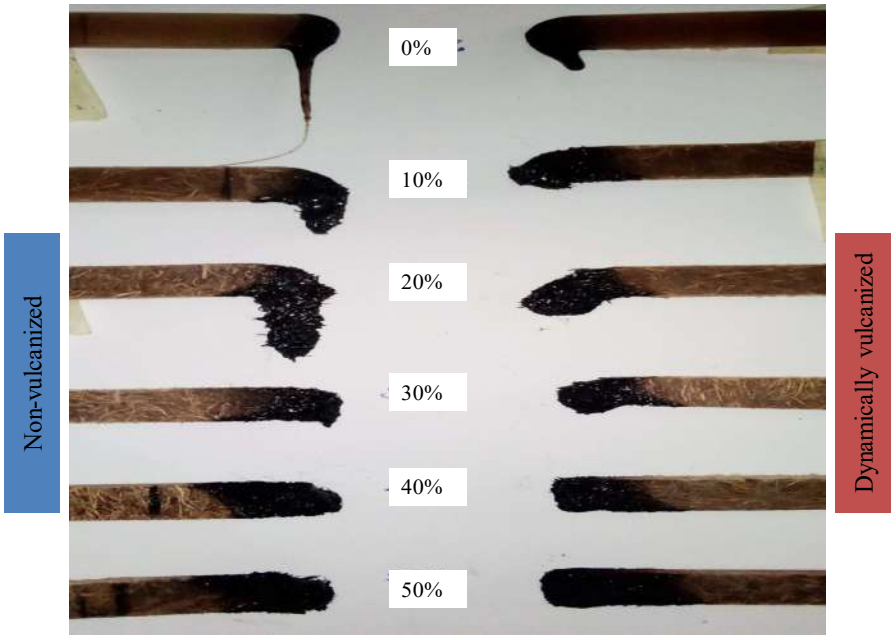

Figure 3: Burning behaviour of non-vulcanized and dynamically vulcanized LDPE/NR CF filled composites (0-50)%

Figure 3 shows the behaviour and nature of burning of the non-vulcanized LDPE/NR and dynamically vulcanized LDPE/NR composites filled with coir fibre. The unfilled non-vulcanized LDPE/NR blend and the corresponding vulcanizates burnt with flame and high dripping, although the non-vulcanized blend exhibited higher drips. The burning behaviour of LDPE/NR with drippings was reduced with the incorporation of coir fibres up to 30%. At 40% and 50% filled CF composite a char was formed with traces of white ashes, which could be attributed to the higher content of lignin with increasing coir fibre loading that supported char formation.

The general flammability characteristics were decreased with dynamic vulcanization, which was attributed to the cross-linkages that occurred during melt blending with sulphur that led to higher fibre orientation and better interaction with the matrix. Furthermore, zinc oxide as one of the additives/auxiliaries that was added during the vulcanizing process also contributed and supported the formation of char when exposed the material to a naked flame. It was reported that metal oxides, metal sulphites and metal phosphates acted as char-forming agents, and the most promising transitional metal used as flame retardant is zinc. Wu *et al.,* 2010 have shown that the addition of zinc oxide in PP composites contributed to a decrease in HRR, Total Heat Released and Smoke Production Rate of the polymer under the flammability test.

CONCLUSION

The dynamically vulcanized LDPE/NR blend burnt with less dripping as compared with the corresponding non-vulcanizates. Similarly, composites with higher CF content experienced a low time of ignition and extent of burning with char formation; which could be attributed to the high lignin content of CF.

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Sub-Soil Geotechnical Investigation in Soft Soils for Foundation Type Selection

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Abstract: *Sub-soil geotechnical investigation for foundation selection of buildings is crucial for safe structural performance and operation. It is more critical with tropical climate especially in marshy areas with a history of sinking storey or collapsing buildings like in Barnawa Kaduna and Lagos in Nigeria respectively. The area under investigation is home to the popular Shagari housing estate in Barnawa, Kaduna. The housing estate involves many blocks of three-storey buildings which experiences sinking before it becomes operational. Several solutions were devised by local planning authorities and other stakeholders in Nigeria to address the recurring anomaly. Often time, unprofessional solutions were sought by private clients to evade professional design fees. The empirical and rule-of-the-thumb approach used by contractors or developers often results in overdesign. Therefore, engagement of geotechnical investigations and its judicious use as input for building foundation selection and design are the key issues to a lasting solution to building failures in Nigeria. Hence, this study adopts a laboratory geotechnical investigation of the soil for basic and engineering properties. In addition to Atterberg limits, the investigated engineering parameters includes shear strength, consolidation, grading, and bearing capacity. Results of the geotechnical investigation showed a safe bearing capacity range of 63 kN/m² in TP 5 to 95 kN/m² in TP 4 at 1.00 m depths respectively. The bearing capacity values increased at 2 m depth with a range from 128 kN/m² in TP 1 to 150 kN/m² in TP5 respectively, using a factor of safety of 2.50. Total settlement (Oedometer) values were moderate and ranged between 0.0004 – 0.0017 m. It follows therefore that the proposed structure could be supported on an isolated wide pad foundation which may be designed at 2.00 m depth below the practical ground level for columns, using a safe bearing pressure of 125 kN/m². Optional ground beams may be provided for enhanced stability and rigidity. Furthermore, based on the result of this study, the soil can support other types of foundations with adequate design consideration for safety and cost.*

Key words: *Foundation selection; geotechnical investigation; building collapse; Barnawa Kaduna; soil bearing capacity.*

1.Introduction

Foundation is the critical part of any civil and building structure upon which all other parts of the structure draw support. Therefore, a detailed geotechnical investigation of the soil upon which the foundation footing will be founded is crucial. The genesis of notable

engineering disasters involving civil structures is a culmination of foundation distresses. Significant loss of lives results from building collapse in sub-Saharan Africa; the recent massive storey building collapse in Ikeja Lagos, Nigeria is one of many frequent occurrences. Even though, other factors like poor workmanship, use of inferior building materials, and quackery all contribute to structural failures, yet, foundation failures are critical. Usually, foundation soils are heterogeneous and non-isotropic, with significant possible variation in properties even within a short distance [1]. Critical and holistic sub-soil geotechnical investigation will yield valuable data in aiding informed decisions on foundation selection.

Many of the prevailing foundation design rules influenced by rule-of-the-thumb are often used for deciding foundation type suitable for buildings. Foundation designers used historical geotechnical data or previous designs within the same area to decide on a suitable foundation for a proposed structure. Moreover, in situations where a geotechnical investigation is used, peripheral sample acquisition is often conducted. Furthermore, the current state of practice for most construction in developing African countries involves analysis conducted on a few geotechnical parameters like consistency limits and shear strength parameters, but this approach is can be improved using more detailed tests. Moreover, a holistic geotechnical investigation is required to garner full information on the soil properties and possible performance under structural loading. As such, in addition to the standard geotechnical investigation, consolidation and bearing capacity/CBR testing are required for the settlement and strength capacity of undisturbed sub-soil samples taken at different depths.

Therefore, this study investigated the sub-soil in a site that was previously identified as soft soil by taking undisturbed soil samples at 1m and 2m depths from five (5) trial pits. The objective of this study is the laboratory geotechnical investigation of these sub-soil samples for informed decisions for the foundation selection of buildings.

2. Methodology and Experimental program

2.1. Methodology

The procedural approach of the study is subdivided into field investigation, soil sampling, and laboratory work. The field investigation entails all the activities involved in site reconnaissance, appraisal, environmental impact, and preliminary geological and geotechnical investigation.

2.1.1 Field investigation

The community where the site under investigation is situated has a geologic history of basement complexes. These basement complexes were observed to be of metamorphic origin which owes similar origins to garnet basements [2]. Developers often build two-storey buildings safely, but visible structural cracks appear under service after a long period. Nonetheless, the geology of the area was observed to have patchy rock outcrops, though generally flat terrain. It is made up of brownish lateritic sandy soil from ordinary ground level to 1.00 m depth and underlain by Brownish gravely lateritic soil up to the depth of 2.00 m as explored. The groundwater table is well below the surface of the soil, off typical foundation construction depths. The water table fluctuates in the vadose and

recharge zones during rainy and dry weather. Importantly, the site is largely free from water logging as is the case with some silty soils. The site location is depicted by a drop pin in Fig. 1.

The site was subdivided into fifteen quadrants from which a total of five (5) trial pits were manually excavated to a maximum depth of 2.00 m depth from each quadrant. Both undisturbed and disturbed soil samples were collected using core cutter samplers and sample bags respectively at 1.00 m and 2.00 m depths and conveyed to the Kaduna polytechnic civil engineering, soil and geology laboratory for analysis.

Fig. 1. Position of the study location on a google map*

*Accuracy is approximated to a few metres

2.1.2 Soil sampling

Disturbed and undisturbed soil samples were obtained at 1.00 m and 2.00 m depths per ASTM D75 and BS 1377 part 1: 1990/2016 [3][4]. Undisturbed samples were taken for consolidation and shear box tests. Moisture content, Atterberg limits, sieve analysis, natural moisture content, and specific gravity tests use the disturbed soil samples. Both the disturbed and undisturbed samples were kept in air-tight containers up to the time of testing.

2.2 Experimental program

The laboratory testing program was grouped under short and long-term. In the first group, soil samples were pulverised and a representative portion was taken for NMC, specific gravity, grading and Atterberg limits testing. The second category is those tests conducted for the bearing capacity/shear strength and consolidation settlement evaluation of the soil. The samples for consolidation settlement and shear strength evaluation were kept in their pristine state. Soil samples from the core cutters are used for these tests, details for these tests are detailed in sections 2.2.1 to 2.2.5.

2.2.1 Natural moisture content test (NMC)

The test is a non-destructive test where pulveried soil samples taken from the site in air-tight bags are assessed for water content. The test was conducted following the BS 1377:1989/BS 812-109:1990 by taking the weight of representative samples (20 - 40 g) in spherical steel cans before and after oven drying at 110^{o}C for 24 hours [5]. The statistical data accuracy is enhanced by testing three samples for each trial pit and averaging to arrive at the final result. The NMC is the ratio of the initial and final weight of the soil sample expressed in percentage. This parameter is important in computing some geotechnical parameters including porosity, and densities.

2.2.2 Specific gravity test

The specific gravity (Gs) test was conducted per BS 1377:1990 and ASTM C 128-2015 [6]. The gravimetric approach was used which entails soaking the sample in water for 24 hours for the pores to be fully saturated. Then, it was removed from the container and air-dried after which the mass was determined. Consequently, the sample (or a part of it) was placed in a graduated container and the volume of the sample is determined gravimetrically. Finally, the sample is oven-dried and reweighed again for mass determination. The determined mass values are inserted into equation 1 for relative density (specific gravity) computation and perhaps, absorption. The summary of the specific gravity of samples from the five (5) trial pits is presented in Table 1.

$$Specific\ gravity\ (apparent\ relaative\ density) = \frac{A}{B + A - C} \quad (1)$$

Where

A = mass of the oven-dried specimen, g

B = mass of pycnometer filled with water, to calibration mark, g

C = mass of pycnometer filled with specimen and water to calibration mark, g.

Table 1: Specific gravity result summary of the five (5) trial pits.

Samples	Depth (m)	M_1 (g)	M_2 (g)	M_3 (g)	M_4 (g)	Gs (g)
TP 1	1.00	22.20	50.20	90.80	75.40	2.22
TP 1	2.00	22.20	51.90	93.30	75.40	2.52
TP 2	1.00	22.20	52.20	93.40	75.40	2.50
TP 2	2.00	22.20	50.90	93.00	75.40	2.59
TP 3	1.00	22.20	51.50	92.00	75.40	2.31
TP 3	2.00	22.20	52.80	94.10	75.40	2.57
TP 4	1.00	22.20	51.90	91.60	75.40	2.20
TP 4	2.00	22.20	51.50	93.30	75.40	2.57
TP 5	1.00	22.20	51.20	91.30	75.40	2.21
TP 5	2.00	22.20	52.70	94.30	75.40	2.63

For this study, the specific gravity of the various samples from all the five (5) trial pits was determined and averaged. The averaged value is used for subsequent computations.

2.2.3 Grading test

Grading of the aggregate was conducted in two stages, firstly, the dried aggregate was sieved through stack of sieves with progressively reducing aperture sizes. Subsequently, the material finer than 75 µm was subjected to wet sieving to estimate the amount of clay and silt particles. Wet sieving following ASTM C117/136 was utilised in grading the soil from various trial pits [7][8]. The wet sieving ensures the estimation of the amount of clay and silt in any soil sample. Clay below the foundation of structures is dangerous due to variable swell and shrinkage potential. The grading result aid in soil classification and computation of other important geotechnical parameters like the D10.

2.2.4 Atterberg Consistency limits test

The pulverised soil samples from the various trial pits were sieved through the 425 µm sieve, the sieved sample is used for the tests. The tests were conducted following BS 1377:1990. For the liquid limit, a known amount of moisture as a percentage of the soil sample was added, mixed and placed in the Casagrande apparatus. A triplicate set of liquid limit (LL) tests were conducted and averaged.

For the plastic limit (PL), 3 mm diameter threads were cast and placed in steel containers for oven drying at 110°C for 24 hours. The difference in moisture content expressed as a percentage of the dry weight of the sample gives the PL of the soil. The plasticity index (PI) is computed mathematically from the difference between LL and PL. A shrinkage mould 12 cm in length was used for the shrinkage limit of the soil samples.

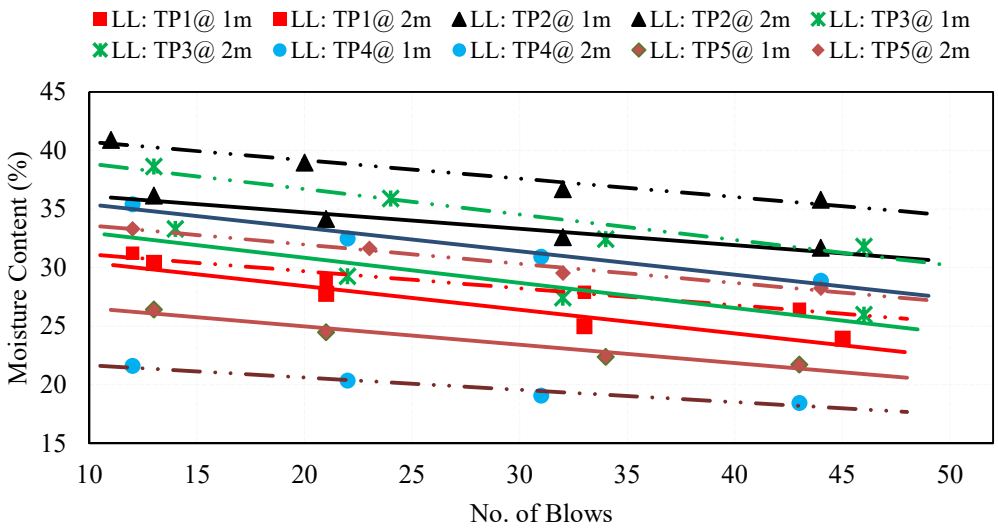

Fig. 2 . Combined Atterberg limit at 1m depth for trial pits 1-5

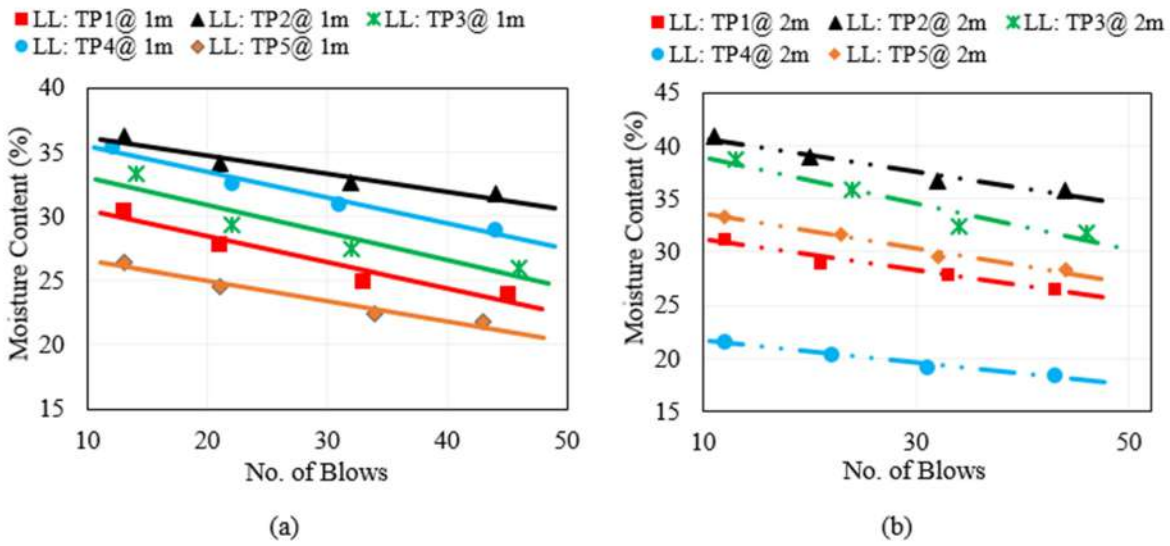

Fig. 3. Atterberg limit plots for pits 1-5 at (a) 1 m depth, and (b) 2 m depth

2.2.5 Consolidation test

The test was conducted following BS 1377 part 6:1990 for partially saturated soils [9]. The temperature of the testing laboratory was maintained to within ± 2 °C by preventing test apparatus and equipment from the heat source and direct sunlight. The Laboratory data of the consolidation (Oedometer) test were used in estimating the primary consolidation settlement for the 5 No. trial pits at the two depths explored on the soil samples collected. These values were based on the increase in the effective pressure induced by loads from the structure. Since the soil from each location is deemed to be homogenous, thus, the coefficients of volume compressibility (Mv) are used in the analysis.

The total consolidation (Pc) in each of the trial pits is calculated thus,

$$Pc\ (Oedometer) = Mv \times \Delta\delta \times H \qquad (2)$$

Where

Pc = Total settlement (Oedometer).

Mv = Average Coefficient of volume compressibility obtained from the effective pressure increment in the particular layer under consideration.

Δδ = Average effective vertical stress imposed on the particular layer resulting from the foundation pressure.

H = Thickness of the particular layer under consideration.

2.2.6 Bearing capacity according to shear box test

The bearing pressure imposed by a foundation is a function of the characteristics of the shear strength of the soil as well as the depth and dimension of the foundation. The analytical approach adopted in estimating the bearing capacity is based on Terzaghi's Equation. The bearing capacity factors are also based on Terzaghi's bearing capacity coefficients, which are functions of the angle of shearing resistance or internal friction (Ø)

of the soil samples as obtained from the direct shear box test and cohesion (C) of the soil. Terzaghi's bearing capacity equation was used assuming the worst wet site condition as no groundwater was encountered during excavation in any of the 5 trial pits explored.

$$Q \text{ (ultimate)} = CN_C + \gamma_D (Nq-1) + 1/2\ \gamma_B N\gamma \quad (3)$$

Where:

C = cohesion

Nc, Nq & Nγ = bearing capacity coefficients

γ_D & γ_B = unit weights

(a) (b)

Fig. 4. (a) Driven Core-cutter at the required depth, (b) Sample in Core-cutter.

3. Results and discussion

3.1 Result summary

The sub-soil at the proposed site is underlain by deposits of brownish Lateritic sandy soil and brownish gravely lateritic soil to a depth of 2.00 m depth explored. The soils are of different ranges of strengths and geotechnical properties. The ground was relatively soft to the 2.00 m depth explored during the excavation of the trial pits and no groundwater was encountered in any of the five trial pits explored. The analytical bearing capacity computations revealed that the bearing pressures of the sub-soil at the site are generally satisfactory for foundations designs at 2.00 m depths with a 125 kN/m^2 average bearing pressure.

The detailed result summary for all the trial pits is presented in Table 2.

Table 2: Summary of results for the geotechnical investigation

TP NO.	Depth (m)	NMC Result	Gs	Consistency limits Result				Direct shear box Result			Sieve Analysis Test	Consolidation Test			Bearing capacity
		(%)	-	LL (%)	PL (%)	PI (%)	LS (%)	C (kN/m²)	∅ (°)	γ (kN/m³)	(Passing NO.200) (%)	Cv (m²/Yr)	Mv (m²/kN)	Pc (m)	Q(SAFE) (kN/m²)
1	1.00	15.97	2.22	26	18.58	7.42	8.57	19	13	14.29	62.06	20.634	0.0129	0.0012	89.91
	2.00	10.52	2.52	29	19.96	9.04	9.29	20	15	15.46	47.54	77.790	0.0052	0.0005	127.58
2	1.00	16.02	2.50	33	18.08	14.92	10.00	18	12	14.51	86.04	5.606	0.0176	0.0017	80.31
	2.00	12.27	2.59	38	20.87	17.13	10.71	20	16	16.95	38.50	31.768	0.0044	0.0004	142.29
3	1.00	14.68	2.31	29	18.18	10.82	9.14	19	13	14.26	91.90	17.249	0.0154	0.0015	89.88
	2.00	13.93	2.57	34	21.64	12.36	10.00	20	15	16.12	47.98	19.732	0.0067	0.0006	129.27
4	1.00	14.71	2.20	31	18.19	12.81	9.07	20	13	15.20	85.26	16.983	0.0166	0.0016	94.82
	2.00	9.98	2.57	20	15.79	4.21	7.14	21		16.55	85.48	11.803	0.0080	0.0008	134.77
5	1.00	15.78	2.21	24	17.26	6.74	8.71	12	13	14.34	88.84	13.606	0.0098	0.0009	62.53
	2.00	9.24	2.63	30	21.29	8.71	10.00	21	16	17.92	28.32	29.100	0.0121	0.0011	149.77

3.1.1. Natural moisture content result

The result of the NMC from Table 2 indicated that the soil has a range of moisture content within 9 – 16 %. As evident, the site has its water table well of the foundation level, with average moisture of 13%.

Though the site exploration was done in the dry season, the NMC test revealed moderate moisture content in almost all the samples tested. This may mean that the underlying soil has a high water-holding capacity with minimum and maximum values of 9.24% to 16.02%. As the maximum average site, NMC is less than 20%, which means that the water table is well below the deepest typical standard building foundation. Furthermore, it is evident from Table 2 that NMC at a shallow depth of 1m is higher than that at 2 m for all the trial pits tested. Similarly, the NMC directly relates to all the Atterberg limits of liquid limit (LL), plastic limit (PL), and plasticity index (PI) so obtained with the except for samples at trial pit 4 at 2 m depth.

3.1.2. Specific gravity

The specific gravity (Gs) follows an indirect pattern as that of the NMC. The Gs at 1 m depth is lower than the Gs of samples at 2 m. The increase in the specific gravity with increasing depth signifies increased soil unit weight which in turn ensures better stability. The significance of higher Gs manifests in the computations of many geotechnical properties which assist in making informed decisions like the type and depth of foundation footing.

3.1.3. Atterberg limit result

The Atterberg limit values for all the sampled soil from the identified trial pits at 1 m and 2 m are presented in Table 3. The liquid limits obtained from the laboratory test vary from 20.00% to 38.00%. The Plastic limit ranged from 18.75% to 21.64%. The Plasticity index was determined within the range of 4.21% to 12.81%. These values indicate soils medium to high plasticity according to the Casagrande plasticity chart. The linear shrinkage ranged 7.14% to 10.71%, this range shows that the soils have potential for excessive shrinkage during the dry season and may swell appreciably in the rainy season. Therefore, the provision of a mat-type or continuous foundation like raft and strip may not respectively serve in this situation. Except for trial pit number 4, all the Atterberg limits of the other pits have higher values at 2 m depth than their corresponding 1 m sampled soils.

Table 3: Atterberg limit result for trial pits 1-5 at 1 m and 2 m

Trial Pit	Depth	LL	PL	PI	LS
TP 1	1.0 m	26.00	18.58	7.42	8.57
	2.0 m	29.00	19.96	9.04	9.29
TP 2	1.0 m	33.00	18.08	14.92	10.00
	2.0 m	38.00	20.87	17.13	10.71
TP 3	1.0 m	29.00	18.18	10.82	9.14
	2.0 m	34.00	21.64	12.36	10.00
TP 4	1.0 m	31.00	18.19	12.81	9.07
	2.0 m	20.00	15.79	4.21	7.14
TP 5	1.0 m	24.00	17.26	6.74	8.71
	2.0 m	30.00	21.29	8.71	10.00

3.1.4. Shear strength parameters

The result of the shear strength parameters as expressed in terms of cohesion, angle of internal friction and the unit weight of the soil is presented in Table 4. The soil is virtually a C-Æ soil with appreciable uniform unit weight.

Table 4: Shear strength result for trial pits 1-5 at 1 m and 2 m

Trial Pit	Depth	C (kN/m^2)	Ø (°)	γ (kN/m^3)
TP 1	1.0 m	19	13	14.29
	2.0 m	20	15	15.46
TP 2	1.0 m	18	12	14.51
	2.0 m	20	16	16.95
TP 3	1.0 m	19	13	14.26
	2.0 m	20	15	16.12
TP 4	1.0 m	20	13	15.20
	2.0 m	21		16.55
TP 5	1.0 m	12	13	14.34
	2.0 m	21	16	17.92

The soil is a cohesive soil with an average unit weight of 15 kN/m^3 thus, the soil exhibits sufficient ability to withstand shear stresses. The high angle of repose suggested that the soil can withstand high shear stresses which translates to a high bearing capacity. The aforesaid suggested that the soil can withstand significant shear pressures from footings and safely dissipate it to the underlying layers.

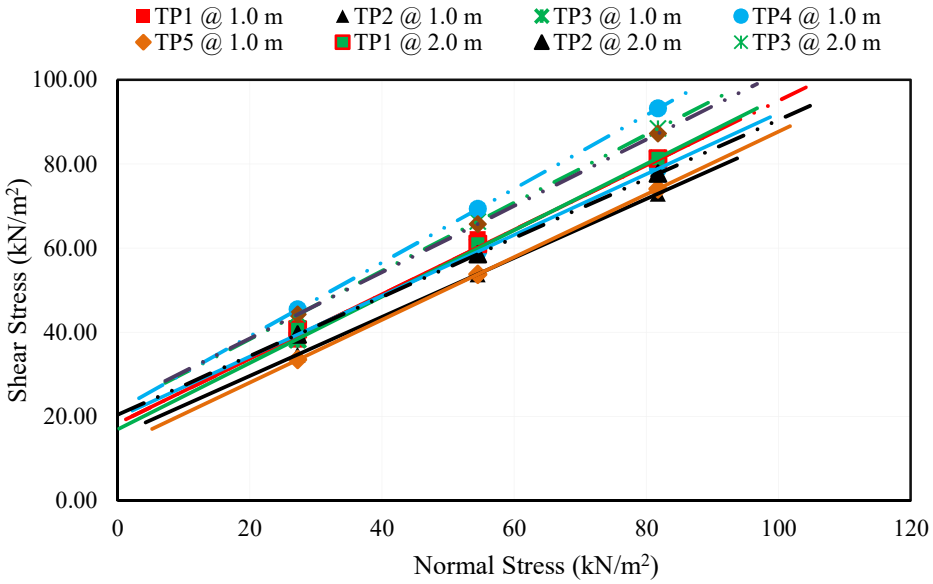

Fig. 5. Combined shear strength plot for trial pits 1-5

The combined shear stress against the normal stress plots for the trial pits 1-5 at both 1 m and 2 m depth is presented in fig. 5. As expected, it is evident from fig. 5 that a direct relationship exists between normal and shear stress. The trend is similar for all the samples at both 1 and 2 m depth.

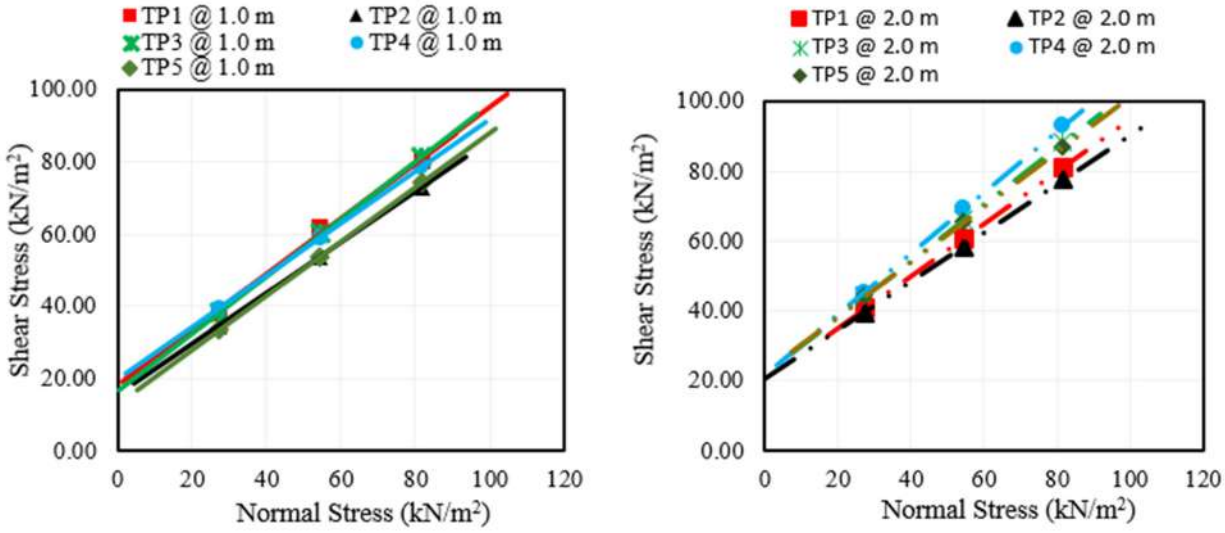

Fig. 6. Shear strength plot of trial pits 1-5 at (a) 1m depth, (b) 2 m depth

3.1.5. Consolidation result

Results of the one-dimensional consolidation test carried out on undisturbed soil samples as presented in Table 5 showed that the coefficient of volume compressibility (MV) varies from 0.0044 to 0.017 m^2/kN to 0.0294 m^2/kN. While the coefficient of consolidation (Cv) ranges from 5.606 to almost 78 m^2/year. The wide variability between TP 1 and the other trial pits could be due to relative soil heterogeneous nature even in proximate location, or perhaps laboratory setup variation. Total Oedometer settlement ranged from 0.0012 m to 0.0028 m. These values are indicative of soil material of moderate to high settlement in place.

Table 5: Consolidation parameter result for trial pits 1-5 at 1 m and 2 m

Trial Pit	Depth	Cv (m^2/Yr)	Mv (m^2/kN)	Pc (m)
TP 1	1.0 m	20.634	0.0129	0.0012
	2.0 m	77.790	0.0052	0.0005
TP 2	1.0 m	5.606	0.0176	0.0017
	2.0 m	31.768	0.0044	0.0004
TP 3	1.0 m	17.249	0.0154	0.0015
	2.0 m	19.732	0.0067	0.0006
TP 4	1.0 m	16.983	0.0166	0.0016
	2.0 m	11.803	0.0080	0.0008
TP 5	1.0 m	13.606	0.0098	0.0009
	2.0 m	29.100	0.0121	0.0011

The Mv result as presented in Table 5 is as low as a fraction of a thousand millimetres. Mv values from the various trial pits range from 4.40 x 10-3 to 17.6 10-3 m^2/kN. The recorded values suggest that no excessive settlement is expected throughout the service years of a structure built on this soil provided the safe or allowable bearing pressure of the soil is not exceeded.

3.1.6. Grading result

The wet sieve analysis conducted was quite revealing. Materials passing B.S. sieve No. 200 were moderate. This explains that the greater percentages of the soil constituents are fine to medium-sized grain materials. Values ranged from 62% to 92.04%. The resulting sieve analysis conducted on soil samples obtained at 1 m depth is presented in fig. 7. While the plot for samples obtained at 2 m depth is presented in fig. 8. The plot of the grading curve in fig. 7 suggests that most of the soils are fine-grained with a virtually high percentage of passing. On the other hand, the grading plot at 2 m depth for all soil samples except that of TP 4 indicated a coarser-grained soil. Therefore, with coarser fractions with increasing depth, the soil bearing pressure, shear strength and stiffness or incompressibility increase, hence, supporting more foundation load.

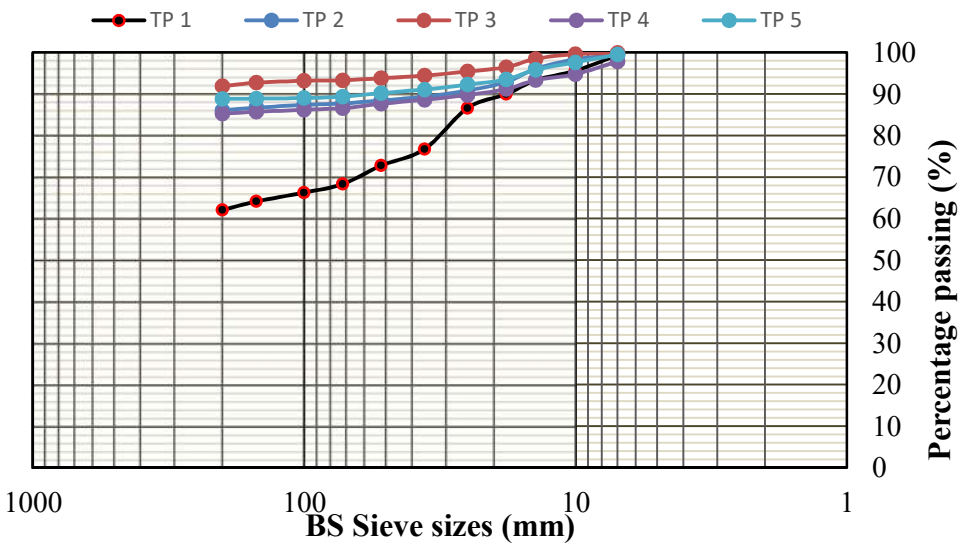

Fig. 1. Grading plot for trial pits 1-5 at 1 m depth

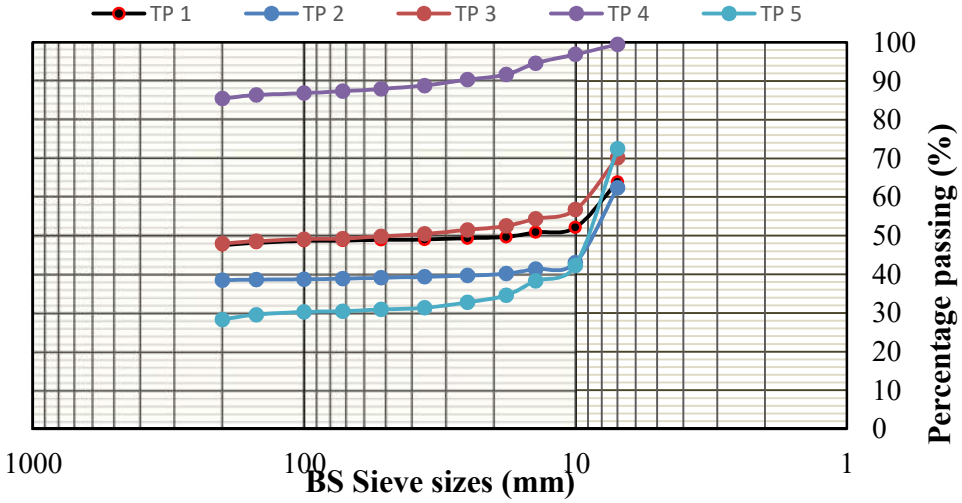

Figure. 2. Grading plot for trial pits 1-5 at 2 m depth

The result in Fig. 8 further highlighted that samples from TP 2 and 5 have the coarsest material with a percentage of 40% and less. On the other hand, TP 4 is a fine-grained soil with the larger soil proportions having a percentage passing of 80 - 90%. Overall, it can be deduced that the soil in the site is generally gravelly laterite with a high proportion of coarse material.

Conclusions and recommendation

The following conclusion are drawn based on the analysed results and careful correlation and interpretation of the field and laboratory data.

- Results of the geotechnical investigation revealed a safe bearing capacity in the range of 89.02 kN/m^2 in TP 5 to 155 kN/m^2 in TP4 at 1.00 m depths. The bearing values increased with depths ranging from 125 kN/m^2 in TP 6 to 210 kN/m^2 in TP4 at 2.00 m depths respectively, using a factor of safety of 2.50.

- No Static groundwater level was encountered in any of the five trial pits explored but adequate measures should be taken during construction to prevent ingress of moisture into the structure when in service by providing damp proof membrane and damp proof course linings.
- The excavated sides and hard-core level should be properly backfilled and well compacted with laterite to a maximum dry density of 2.00 gm/cm^3 at optimum moisture content to enhance the strength of the fill material.
- Supervision of all construction works should be carried out by qualified, experienced and certified registered civil engineers. All quality control measures and laboratory/field tests on all construction materials should be strictly carried out and documented as provided in the construction/ contract specifications.
- Total settlement (Oedometer) values ranged between 0.0012 m – 0.0028 m. It follows therefore that the proposed structure can be supported on an isolated wide pad foundation which may be designed at not less than 2.00 m depth below the ordinary ground level, using a safe bearing pressure of 120.00 kN/m^2, especially for the storey structures. However, the structural or foundation Engineer may design other footing types befitting for the proposed structure, considering the geotechnical laboratory data, financial implications and other relevant factors applicable.

Conflict of interest

The authors declare no conflict of interest concerning this paper's publication.

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The data acquisition for the study was conducted by Engr. Ibrahim Shuaibu.

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Digital Supplychain Technology Proficiency and Sustainable Competitiveness of Oil and Gas Companies in Rivers State

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Abstract: *The study concentrated on digital supply chain technologies enactment and sustainable competitiveness of oil and gas companies in Rivers State. A causal study was well-thought-out to handgrip the three (3) hypotheses articulated for the study. The survey research method was adopted for the study on a population comprised of two hundred and ninety-five (295) oil and gas companies registered with the Rivers State Ministry of Commerce and Industry, Port Harcourt. The appliance of the Taro Yamane's formula for the determination of sample size from a precise population, provided the study with a minimum sample size of one hundred and seventy (170). The study advocated the purposive sampling technique and the key respondents were Chief Executive Officers (CEOs) or branch managers of the companies investigated. 510 copies of structured questionnaire were distributed to the respondents, 345 copies were returned, yielding a response rate of 87.3 percent. Moreover, of the 345 copies of the questionnaire returned, resultantly, no more than 334 questionnaires with a response rate of 75.1% were measured for analysis. The multiple regression analysis was employed for data analysis. The results disclosed that the elements of digital supply chain technology (Big data analytics, Cloud computing systems and Mobile applications) studied had a strong, positive and significant influence on sustainable competitiveness. The study therefore, concludes that, digital supply chain technology proficiency significantly influences sustainable competitiveness of oil and gas companies in Rivers State, and recommends that, to enable a new way of working with digital supply chain technology, management of oil and gas companies should adapt their organizational structures and job designs to bring the best out of their employees and DSCT to enhance sustainable competitiveness. in their supply chain industry.*

Key words: *Big data analytics, Cloud computing systems, Mobile application, Sustainable competitiveness.*

INTRODUCTION

In these modern times, many firms globally are aspiring to cope with ever-increasing competition in view of the fact that it has consequently twisted into the prime schema for these firms. A good number of firms make choices that affect their competitive position and profitability by means of technologies which is predictable to facilitate the firm's position itself in opposition to their rivals in

the pursuit for upper hand. This is embarked on to help the firm position itself against its competitors in tracking down of sustainable competitiveness. Firm profitability is a utility of organizational prettiness (configuration) and the firm's relative position within the industry. A stout comparative outlook entails that the firm has a sustainable competitive increase that can be assiduous alongside incidence by competitors and transformations in the industry.

Sustainable competitiveness materializes as an indispensable dynamic in the perception of goods and services value, which ought to be calculated as fundamentals of competitiveness. As a result of the importance of sustainable competitiveness to the long-standing success of companies, the accessible literature takes in hand its content as well as its sources, and the diverse categories of strategies such as digital supply chain technologies that may help firms realize sustainable competitiveness.

In this day and age, global technologies, principally digital technologies, have turn out to be a significant utensil for businesses to sustain practicable partnerships and put together an enormous value linkage with other firms. Innovative digital technologies that are up-and-coming every day are on their line of attack to have an effect on virtually all business development and activities. The goal of the digital supply chain technology is to convert heterogeneous resources into competitive product and service offerings. Digital supply chain technology proficiency is built up of a number of core competencies required for harmonizing miscellaneous production skills and amalgamate manifold torrents of technologies. Digital supply chain technology is a result of prearranged set of competencies that amount to proactive, relational, coordinative use of technology by a given supply chain who desires to deliver specific good and service offerings to achieve sustainable competitiveness.

In research, the area of supply chain digital technology is starting to attract growing attention with some of the topics such as 'radiofrequency' and recently 'big data' being investigated by some scholars. A holistic approach to digital supply chain technology proficiency would set the course for streamlined implementation, starting with a digital strategy and a digital operating model. Meanwhile, firms need to adopt digital methodology proficiently in their supply chain system to achieve the potential of having an excellent level of organizational performance (Degroote & Marx, 2013). Even though most firms accept as true that the adoption of digital supply chain technologies would help them raise their supply chain performance some companies are still doubtful to set supply chain digital technology as their primary targets in digital strategies.

In contemporary exceedingly competitive business climate, generating sustainable competitiveness in a firm has to direct the way to achievement (Cao & Zhang, 2011). Conversely, the exploration for reciprocated appreciation of sustainable competitiveness for every single one supply chain partner is still not up till now impactful as challenge for both academics and practitioners exists (Fawcett &Waller, 2014; Halldorsson *et al.,* 2015). Despite the fact that a budding quantity of scholarly writings (e.g. Lee *et al.,* 2022; Marco *et al.,* 2019), which are dedicated to the field of digital supply chain technologies in conveying additional firm's performance have accumulated, it is somehow unclear how the area of supply chain digital technology has evolved and progressed in research, with research status being unclear in linking it to sustainable competitiveness. This paper therefore, analyzes the impact of digital supply chain technology proficiency on sustainable competitiveness of oil and gas companies in Rivers State. This research aims at identifying the main elements constituting the digital supply chain technology and their impact on sustainable competitiveness.

LITERATURE REVIEW AND HYPOTHESES

The Resource-Based View Theory

This present study is fixed firmly on the resource based view theory, which stipulates that the elementary foundations and drivers of competitive advantage and better-quality performance are predominantly linked with the traits of resources and capabilities, which are priceless and costly-to-copy (Peteraf & Bergen, 2003). The resource-based view supplies an avenue for firms to chart and implement their organizational policy by exploring the function of their internal resources and capabilities in attaining competitive advantage (Kristandl & Bontis, 2007; Sheehan & Foss, 2007). Several other investigations sustain the magnitude of this resource-based view (Hult & Ketchen Jr., 2001; Ramsay, 2001; Foss & Knudsen, 2003; Gottschalg & Zollo, 2007). When this strategy is well-originated and put into practice, it can significantly influence a firm's level of competitiveness (Richard, 2000; Powell, 2003; Porter & Kramer, 2006). The resource based view theory as an "inside-out" progression of policy origination is therefore, a management machination fit into place to evaluate the accessible quantity of business strategic-possessions. In fundamental nature, the resource based view is anchored on the idea that the successful and resourceful use of every single one serviceable resource that a firm can pull together lends a hand in deciding its competitiveness. This theory is relevant to this study because, proficiency in espousing supply chain digital technology architecture enhances firms' competitiveness continuously.

Digital Supply Chain Technologies

Technology is altering the way companies plan their supply chain management practices. Technological and digital innovations pave the way for more interconnected actions and transparent flow of information amongst organization, its suppliers, and potential customers. This disruptive information effect is promised to deliver unforeseen values to all entities involved in the supply chain (Buyukozkan & Goçer, 2018).

The most necessity of adopting a digital supply chain technology (DSCT) is not just investing in the latest digital technologies, it is more than that. Organizations must know how to align the existing digital initiatives with its supply chain objectives (Raab & Griffin-Crya, 2011). Every organization nowadays realizes the potential of the newest technology in vogue, and this possibly will offer businesses an opportunity to enhance organizational performance and create a strong foundation to compete and outperform rivals in the vicinity and faraway (Srivastava & Sushil, 2013).This end-to-end supply chain connectivity through the epoch of digitalization could position firms in the locus of competitive advantage where they would be able to match customer shifting requirements more proficiently (Porter & Heppelmann, 2015).

In practice, it gives the impression that more businesses are at this instant spreading over different structures of supply chain digital technologies such as radio frequency identification, big data, cloud computing, Internet of Things, and artificial intelligence amongst others to fashion cohesive and self-optimizing supply chain organisms empowering them to retort proactively to the ever-changing nature of markets (Buyukozkan & Goçer, 2018). According to Bughin *et al*. (2018), innumerable digital technologies such as Big Data Analytics, Cloud Computing Systems, Mobile applications, the Internet of Things, Blockchain, Artificial Intelligence, Man-Machine Learning and masses of supplementary application support the advancement of the supply chain of any business. This study in line with Bughin *et al.* (2018), adopts data analytics, cloud computing systems and mobile applications.

Big Data Analytics

Big data analytics refers to the application of innovative statistics to whichever kind of deposited electronic communication, which may consist of "messages, updates, and images dispatched to social networks, interpretations from sensors, and GPS indications from cell phones (Kache & Seuring, 2017). Big data analytics can supplement value and be responsible for an innovative stance by cultivating descriptive, predictive and prescriptive analysis and exhibiting them to boost performance in supply chains (Ikegwuru & Acee-Eke, 2020). Big data analytics momentously influence supply chain competitiveness (Tan, Carriollo & Cheng, 2013). Evidently, big data enables companies to accumulate enormous volume of data from sources such as videos, tweets, click streams, and equally facilitate decrease in order-to-delivery cycle times, and advance supply chain efficiency.

Cloud Computing Systems

Cloud computing refers to equally the applications transported as services by means of the Internet and the hardware and systems software in the data centers that offer those services (Amburst, Fox, Griffeth *et al.,* 2016). Cloud computing as a tender transported as a service by means of the internet and computing resources (hardware and software) in the data centers and bestows on-demand right of entry to these resources and services, delivered by service vendors to the final user by means of pay-per-use services (Ikegwuru & Esi-Ubani (2019). This cloud computing systems make available harmonization of supply chain management with IT system of a business that supports scalability, cost reduction, accessibility and efficiency in supply chain operations.

Mobile Applications

This refers to categories of application software premeditated to route on a wireless mobile device, such as a smartphone or tablet computer as an alternative to laptop computers or a laptop. Mobile applications are technologies that are modernizing supply chain operations. They materialize in the form of mobile payment, mobile RFID, advance bar code scanning, map routing and inventory optimization and they are greatly boosting supply chain operations. Mobile applications smooth the engendering of real-time information that shrinks inventory and can lead to progression in profits for the vendor (Cogliamo, Marco & Rafele, 2014).

The Concept of Sustainable Competitiveness

The vital rudiments of competitive advantage relating to the formation of values to customers were developed by (Jones, 2003). Competitive advantage is a fundamental underpinning for inventing business strategies to achieve sustainable increase (Simpson, Taylor & Barker, 2004). The tracking down of competitive advantage is an inspiration very much at the sensitivity of the strategic management literature (Ma, 2004; Cousins, 2005; Porter & Kramer, 2006; Barney). Understanding the sources of sustained competitive advantage has turned out to be a foremost field of study in strategic management (Flint & Van Fleet, 2005; King, 2007).The sustainability of a business is pulled off through competitive advantage; whereby upon the putting together of business strategies, it is indispensable to generate values to customers (Sultan & Mason, 2010).

A company experience competitiveness when it is depositing into practice a value generating strategy not concomitantly being put into operation by any contemporary or forthcoming competitors, and when these other companies are immobilized to duplicate the advantages of this method. Competitiveness thus stands for the matchless prospective that positions a company far away from its competitors, in that way endowing them with a superior position in the marketplace. Sustainable competitiveness materializes as an indispensable dynamic in the discernment of goods

and services value, which ought to be premeditated as ground rules of competitive advantage in an enduring manner.

Empirical Review

Lee et al. (2022) investigates the effect of the digital supply chain on the supply chain and organization performance and additionally evaluates the mediating effect of supply chain performance in the relationship between digital supply chain and the organizational performance in the Malaysia manufacturing industry, by means of a quantitative research design. Data was collected through an emailed online survey questionnaire to 1160 manufacturing companies listed in the Federation of Malaysian Manufacturers (FMM) directory by way of stratified sampling technique and obtaining 56 (5.43 useful for data analysis. Data was analyzed by the use of the Partial Least Square Structural Equation Modeling (PLS-SEM). Seven hypotheses, which include all the hypotheses of moderating effect are supported. The study concludes that manufacturing companies in Malaysia can think about espousing digital supply chain in the business procedure to stay put reliable in the competitive market by making available good supply chain performance and most excellent organizational performance as a whole.

Marco *et al.,* (2019) examined the relationship between investments in digital technologies and firm performances, by also investigating the exact technologies more prone to be associated with superior performance and ultimately the snowballing effect of technologies on performance. Supported on distinctive data assembled in 2017 on a sample of 1,149 Italian firms, outcomes demonstrate the positive impacts on adopters' performance and the function of robotics and laser cutting in this relationship.

Based on the review of literature, the following hypotheses were raised:

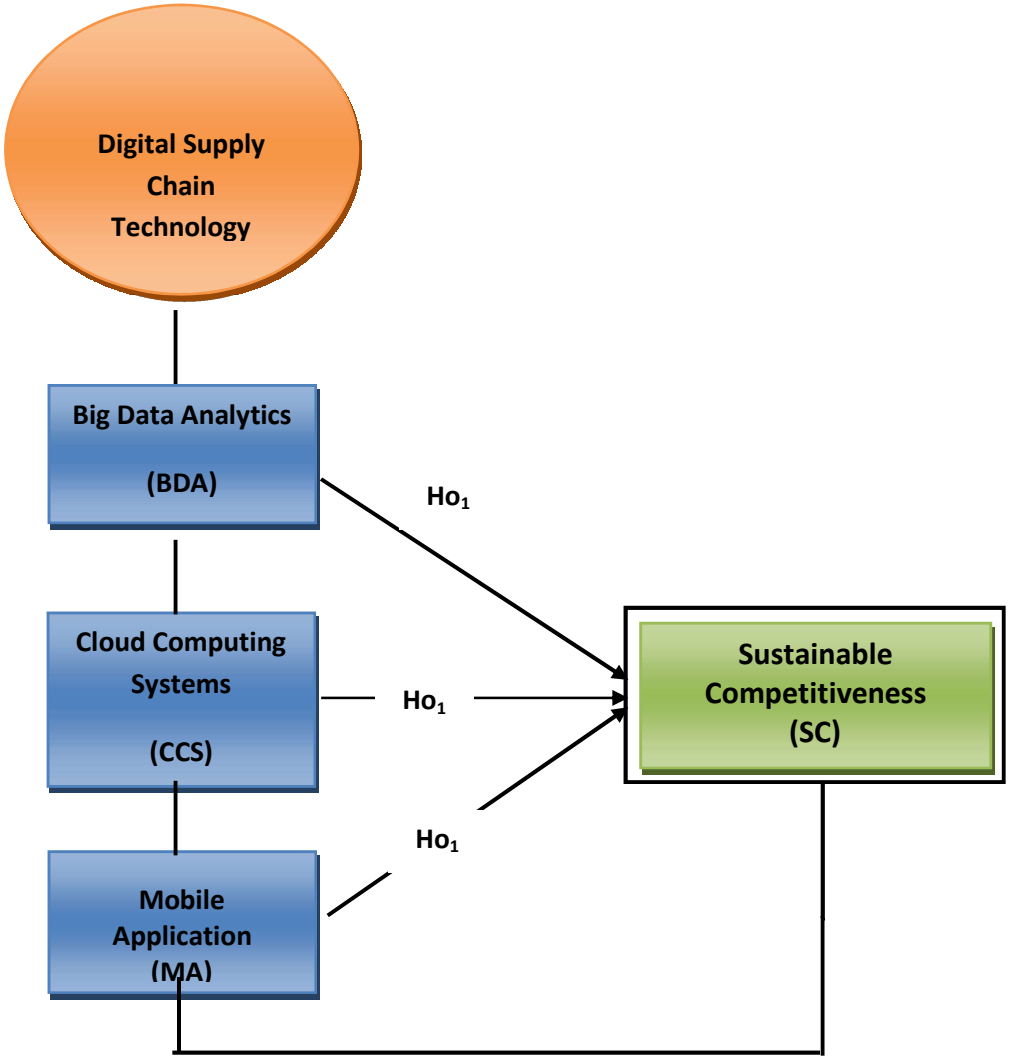

Figure 1: Research Model of Digital Supply Chain Technologies and Sustainable Competitiveness

Source: Designed by the Researcher, 2022

From the research model, the following hypotheses were raised:

Ho_1: Big data analytics does not significantly influence sustainable competitiveness of oil and gas companies in Rivers State.

Ho_2: Cloud computing systems does not significantly influence sustainable competitiveness of oil and gas companies in Rivers State.

Ho_3: Mobile application does not significantly influence sustainable competitiveness of oil and gas companies in Rivers State.

RESEARCH METHODOLOGY

Population and Sample Determination The population of the study consists of two hundred and ninety-five (295) oil and gas companies registered with the Rivers State Ministry of Commerce and Industry, Port Harcourt. The sample size of one hundred and seventy (170) was arrived at by means of the Taro Yamane's formula for the determination of sample size from a precise population. The appliance of the Taro Yamane's formula for the determination of sample size from a precise population, provided the study with a minimum sample size of one hundred and seventy (170). The study advocated the purposive sampling technique and the key respondents were Chief Executive Officers (CEOs) or branch managers of the firms investigated. 510 copies of questionnaire were distributed to the respondents, 345 copies were returned, yielding a response rate of 87.3 percent. Moreover, of the 345 copies of the questionnaire returned, resultantly, no more than 334 questionnaires with a response rate of 75.1% were measured for analysis. The multiple regression analysis was employed for data analysis.

Test of Reliability of Instrument

The Cronbach Alpha Reliability Coefficient was computed for the composite scale and each of the subscales, and the results are reported in Table 1. As we can see, the value of the Alpha coefficient for the composite scale and the subscales are all above the threshold ($\alpha \geq 0.70$); hence, they are all reliable. Table 1 shows the reliability assessment of the variables using Cronbach's alpha. It indicates how the items for each factor were internally related in the manner expected.

Table 1: Test of Reliability

Scale	Dimension	Items	Reliability
BDA	Big Data Analytics	5	0.776
CCS	Cloud Computing Systems	5	0.890
MA	Mobile Applications	5	0.754
SC	Sustainable Competitiveness	5	0.931
QDSCTSC	**Composite**	**25**	**0.975**

Source: SPSS 22.0 Window output (based on 2022 field survey data)

RESULTS

Model Summary of Digital Supply Chain Technology Proficiency and Sustainable Competitiveness

Table 2: Model Summary (n=334)

Model	R	R2	Adj R2	Std Error of the Estimate	F Change	dfi	df2	Sig. F Change	Durbin Watson
BDA	.690	.552	.550			1	332		
				4.92483	752.650			.0 00	1.869
CCS	.667	.568	.565						
						1	333	.000	1.969
MA	.776	.694	.681	167.596	.47649			.000	1.649
				294.73	62.504	1	334		

Source: SPSS 22.0 window output (2022)

a. Predictor (Constant). Big Data Analytics

b. Predictor (Constant), Cloud Computing Systems

c. Predictor (Constant), Mobile Applications

d, Dependent Variable, Sustainable Competitiveness.

Three models were tested indicating three predictors besides constant to determine the dependent variable that arrange entry requirement in the finishing equation (BDA, CCS, MA, SC). Multiple correlation coefficient measures the degree of relationship between the actual values and predicted values. Predicted values are obtained as a linear combination of X1 (Big data analytics), X2(Cloud computing systems) and X3(Mobile applications). R2 represents percentage of the variance in the dependent variable. Table 2 shows that 55.2% of the variation (model 1) in sustainable competitiveness is explained by big data analytics single-handedly, 56.8% of the variation (model 2) is explained by cloud computing systems and 69.4% of the variation (model 3) is explained by mobile applications.

Test of Model Utility

The serviceability of the overall regression statistics was tested prior to the testing of the individual hypotheses for their levels of significance. The fitness of the model can be explained by F-ratio in Table 3. The F-ratio in the model is 49.386, which is very significant at $p < 0.05$. This implies that there is significant evidence to extrapolate that digital supply chain technology is linearly related to sustainable competitiveness. The study concludes that; the regression model is useful to the extent that the predictor variables significantly predict the behaviour of the dependent variable investigated. The implication is that at least one of the independent variables has none zero coefficient. This proposes that the model is measured to be fit and that digital supply chain technology has substantial influence on sustainable competitiveness

Table 3: F-ratio Test of Digital Supply Chain Technology and Sustainable Competitiveness

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	2447.670	1	815.890	49.386	.000[b]
	Residual	3271.063	333	16.521		
	Total	5718.733	334			

a. Dependent Variable: Sustainable Competitiveness

b. Predictors: (Constant), Big data analytics, Cloud computing systems, Mobile applications

Source: SPSS Window Output, Version 22.0 (2022).

Multi-colliearity Test

Table 4 indicates that big data analytics is statistically significant and account for sustainable competitiveness of oil and gas companies in Rivers State. It has a t-statistics value of 16.893. Besides, the result indicates that a cloud computing system has a statistical significant influence on sustainable competitiveness of oil and gas companies in Rivers State. It has a t-statistics of 16.640. Further the result indicates that mobile applications has a statistically significant influence on sustainable competitiveness of oil and gas companies in Rivers State. It has a t-statistics of 7.393

More sophisticated correlations in data than just the pairwise correlations allow the use of tolerance and variance inflation factors (VIF) associated with Xh. The tolerance explains the statistics used to disclose the degree to which the independent variables have linear (straight line) relationships with one another. Tolerance values heading towards zero and values of VIF exceeding 10 are cardinal signs of multi-collinearity. This decision rule enables the study to conclude that there is no threat of multi-collinearity amongst the dimensions of the independent variables.

Table 4: Multi-collinearity Test of Digital Supply Chain Technology Proficiency and Sustainable Competitiveness (n=334)

				Unstandardized Coefficient		Standardized Coefficient		Collinearity statistics	
Model	**Dimension**	**Eigen value**	**Condition**	**B**					
Index				**Std error**	**Beta**	**T**	**Sig**	**Tolerance**	**VIF**
Constant	.087	29.4762	.865	0.39	-	2.375	0.000	-	-
.						.			
BDA	37 11	.464	.900	.044	.857	16893	0.000	1.000	1.000
CCS	0429	.6571	.307	.075	.667	16.640	0.000	1.000	1.000
.								.	
MA	0288	.4110	.640	.067	.776	7.393	0.000	1.000	1.000

Source: SPSS Window Output, Version 22.0 (2022).

DISCUSSION

In this study the effect of digital supply chain technology proficiency on sustainable competitiveness of the company investigated are proved. Results show that the positive effect of the dimensions of digital supply chain technology (Big data analytics, Cloud computing systems and Mobile applications) became stronger. Mobile application which had significant and strong influence with sustainable competitiveness became even more predictive, indicating that it is the most utilized digital supply chain technology amongst the studied companies. The predictors of digital supply chain technology proficiency showcased in this study are essential catalysts that stimulate sustainable competitiveness in firms supply chains. In view of the fact that there are numerous relations and interdependencies among activities in the value chain of oil and gas companies, the aptitude to synchronize and espouse the elements of digital supply chain technology proficiency is decisive to achieving sustained competitiveness. This is because many companies in our study are determined to improve their supply chains, but the quantity of digital technologies being applied is undersized. The researchers can state that most Nigerian oil and gas companies

now realize the positive potential of adopting digital elements in their supply chain. The implementation of DSCT can help companies develop their businesses well, improve the level of services in the entire level of supply chains and achieve sustained competitiveness in the market, and always stay ahead of the changing industries besides cutting down unnecessary expenses.

It is critical to note that, the presence of digital supply chain technologies in the supply chain process possibly will calculate approximately the amount of competitiveness in a firm's current market. Accordingly, digital supply chain technology proficiency can enhance the sustained competitiveness and supply chain collaboration of oil and gas companies. Therefore, this research completely supports the effect of digital supply chain technologies proficiency on sustainable competitiveness. Our findings corroborates Lee *et al*. (2022) findings that espousal of digital supply chain in the business procedure enables firms to remain dependable in the competitive market by supplying obtainable good supply chain performance and most outstanding organizational performance in totality. our findings are also consistent with the debate in the literature on the quintessence for the development of a supportive IT arrangement to institute collaborative connections with stakeholders (Jabbour *et al.,* 2019; Wong *et al.*, 2015);

CONCLUSION AND RECOMMENDATION

The study was conducted to determine the influence of digital supply chain technology (DSCT) proficiency on sustainable competitiveness of oil and gas companies in Rivers State. The DSCT consists of three constructs which are big data analytics, cloud computing analytics and mobile applications. The regression model valuation proves that digital supply chain technology enhances sustainable competitiveness as this research established that the independent variables of DSCT discussed early in this paper positively affect the dependent variable, sustainable competitiveness (H1, H2, H3 accepted). Improving digital supply chain technological efficiency plays a crucial role in any business. Operating businesses in thought-provoking profit margins points out that, any type of process enhancement can have a substantial influence on the bottom line. Therefore, innovative technologies such as DSCT make it easier to manage the challenges of volatility and accurately forecast demand in global supply chains and ushers in sustainable competitiveness. This study therefore concludes that, digital supply chain technology proficiency significantly influences sustainable competitiveness in oil and gas companies in Rivers State, and recommends that, to enable a new way of working with digital supply chain technology proficiency, management of oil and gas companies should adapt their organizational structures and job designs to bring the best out of their employees and DSCT to enhance sustainable competitiveness. in their supply chain industry.

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Sustainability and Challenges of Groundwater Utilization in Developing Countries: A Review

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Abstract: *Groundwater plays an important role in supporting human well-being and economic growth in both urban and rural surroundings, as well as supporting various aquatic ecosystems in Africa. Thus, subsurface water has high significance to the growth and well-being of Africa, if sufficiently assessed and sustainably exploited. This paper highlighted some key groundwater problems and difficulties in developing nations, particularly in Africa with probable chances for sustainable groundwater management. This has been done through a review of related pieces of literature. Groundwater resources in Africa face a growing threat of contamination from urbanization, industrial increase, agricultural and mining activities, and from improper sanitation practices, and over-exploitation owing to growing demand to meet human and agricultural demands. To attain the demand gap of enough freshwater resources the implementation failed in most developing nations owing to fast population growth, urbanization, climate change, improper sustainable skills, and policies for good implementation of sustainable groundwater infrastructure and environmental management. Furthermore, the condition might be poorer in the sub-Saharan region, because of their fast population growth. In the region, the proportion of people who enjoyed piped water on their buildings, which is the preferred choice for urban areas, certainly reduced from 42% to 34% (WHO and UNICEF, 2014a). This noticeably shows that accessibility to 'safe' drinking water sources continues to be a key problem in cities in developing nations. Equally, the trends are the same in good sanitary services. Urban residents without access to improved hygiene increased by 40%, from 541 to 754 million, between 1990 and 2012 (WHO and UNICEF, 2014a).*

Key words: *Challenges, Groundwater, Pollution & Sustainability*

Introduction

The total water resources accessible around the world are projected to be in the order of 46,000 km^3/annum, including about 36,000 km^3/year of surface water and 10,000 km^3/annum of subsurface water (Trenberth *et al*. 2007). Considering the continental level, America has the major portion of the world's total freshwater resources at 45%, then Asia

at 28%, Furthermore, Europe possesses 15.5% and Africa was estimated to be 9%. In terms of resources per resident in each world continent, America has 24,000 m^3/annum, Europe 9,300m^3/annum, Africa 5,000m^3/annum, and Asia 3,400.1m^3/annum (FAO 2003) in Gaye & Tindimugaya, 2019.
In addition, around the world, regions that have sustainable subsurface water balance are decreasing daily. Three difficulties that dominate subsurface water use are depletion owing to over-pumping; waterlogging and acidity owing to insufficient drainage and inadequate conjunctive use; and pollution owing to agricultural, industrial, and other human actions. In regions of the world, particularly with high population density (Shah, 2001).

MacDonald *et al.* (2012) produced the first quantitative maps of subsurface water resources in Africa which exposes the extent and distribution of freshwater stored as subsurface water. The volume of subsurface water is projected to be 0.66 million km^3, more than 100 times the annually renewable freshwater resources and 20 times the freshwater stored in African lakes (Gaye & Tindimugaya, 2019).

According to Gaye & Tindimugaya, 2019. the maps shown in figure 1, establish the uneven distribution of subsurface water across the region and, in particular, the huge subsurface water volumes accessible in the sedimentary basins of northern Africa. The potential for boreholes yielding greater than 5 Lit/ sec outside of large sedimentary basins is not common but limited to specific areas needing careful examination and development. However, for many African countries, suitably sited and constructed boreholes support a hand pump (a yield of 0.1–0.3 Lit./sec), and sufficient storage is available to bear abstraction through annual variations in recharge.

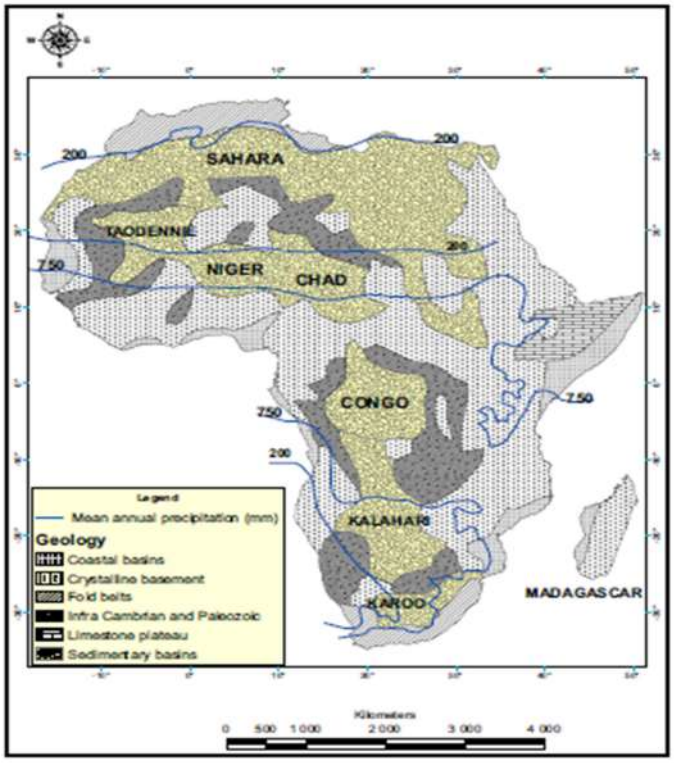

Fig. 1 Groundwater regions of Africa
Source: Gaye & Tindimugaya, 20

Furthermore, urbanization contributes to problems of freshwater sustainability, which also contributes to increasing in freshwater demand. For example, in the Asia–Pacific regions, water usage per day per capita varies from 250–300 litres, although in developing nations it is projected to vary from 60–200 litres per capita per day (IWA 2002). The growing urbanization leads to higher water demand and the associated demand for sanitation services dwelling huge stress on water resources and their infrastructures. Setting up water and wastewater industries is huge capital intensive and maintenance costs for collecting of sewage, transport, and treatment, but at the same, while providing a low return on assets (less than 5% /year) (Wilderer 2004). This is partially because sewage systems are locally designed to act only as a channel to transport wastewater to its destination, the treatment plant. The contaminated disinfection plant is also compromised as cities enlarge meanwhile the infrastructure becomes unable to deal with the growing load of contaminated water produced. Furthermore, the removal of untreated sewage to water bodies is not acceptable and even conveyance to long distances through aging infrastructure takes the risk of leakage and polluting subsurface water owing to leachate (Burn *et al*. 2003; 1998; Eiswirth *et al.* 2000).

It is currently assessed that 1.1 billion people around the world lack quality water resources likewise 2.6 billion people faced the absence of acceptable hygiene (UNICEF *et al.* 2004). The associated global health burden is projected that nearly 4000 – 6000 children are losing their lives daily due to the consumption of contaminated water, good hygiene, and bad sanitation (WSSCC, 2004). UN MDG's intended to minimize the percentage of people lacking access to freshwater sustainability and sanitation at least by half in the year 2015. Accessibility to freshwater is still a serious problem in higher percentages in Asian nations where around 675 million people are deprived of freshwater resources (UNICEF *et al.* 2004). In Sub-Saharan African nations, only around 36% of the population has access to basic hygiene (UNICEF *et al.* 2004). The MDG projected that hygiene must be delivered for nearly 2.1 billion people varies from 2002 - 2015 when adjusting for population growth. Provision of toilets for around 13 years for 2.1 billion people needs at least 44,300 installations every day for the next 13 years (assuming 1 toilet per 10 persons). Assuming the price per installation is $100 USD for basic dry hygiene, then the project needs just to construct a basic level of hygiene in the successive 13 years cost $4.4 million USD daily (UN Millennium Project 2005). In 1991, a survey showed that in developed nations, water loss as a proportion varied from 8 - 24%. Nevertheless, in middle-income nations, water loss varied from 15 - 24%, and in developing nations, water loss varied from 25 - 45% (WHO 2001). Numerous largest documented waterborne epidemics in the last 2 decades have been associated with cross-contamination in the water delivery system due to leaks (Renkevich *et al.* 1998).

In addition to the consequences on human health and food production, shortage in the delivery of freshwater leads to deep political burdens and instability. During an international freshwater day message by UN Secretary-General Kofi Annan on March 22, 2002, he warned that global security relies on resolving the water crisis and stated that

"Fierce national competition over water resources has prompted fears that water issues contain the seeds of violent conflict" (ENS 2002). How we manage increasing freshwater scarcity and yet preserve adequate water for health, sanitation, agriculture, and industry is a severe task for the close future. Various policies will be essential for the variability of climatic, economic, and cultural locations affected by freshwater scarcity. Some progress has been made in that total global freshwater abstractions began to be stable in the 1970s and 1980s, and in some industrialized nations, water abstractions have weakened owing to differences in irrigation practices, water recycling, and management (Gleick 2003; Postel 2000).

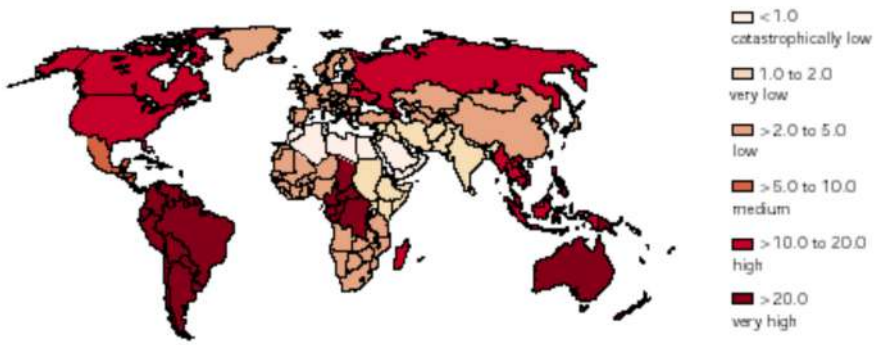

Figure 2: Water availability in 2000 (Measured in terms of 1000m^3/capita/Annum)

（**Source: UNEP, 2002a**）

Conclusion

Groundwater is one of the most vital natural resources which contributes to the global freshwater supply. The groundwater water system responds to human and climatic variations gradually (relative to surface-water systems), and climate variation still could affect the Subsurface water system significantly through changes in groundwater recharge as well as groundwater storage and utilization. These variations result from changes in temperature and rainfall or from changes in land use/land. Furthermore, the provision of high-quality water and wastewater infrastructure in developing countries requires a huge outlay of funds.

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An Evaluation of Heavy Metals Concentration at an Open Dumpsite in Borno and Remediation Techniques

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Abstract: *Dumps item leachate is known to contain several heavy metals which are detrimental to human health and the environment. Heavy metals constitute an ill-defined group of inorganic chemicals that are hazardous at certain levels of concentration. There is abundant evidence to show that heavy metal concentration can contaminate groundwater and soil and may pose hazards to humans and the ecosystem through direct ingestion or contact with contaminated groundwater and soil and ultimately results in a reduction in food quality (safety and marketability) via phytotoxicity, reduction in Land usability for agricultural production causing food insecurity and land tenure problems. Lead (Pb)and Zinc with an average value of 1.38mg/L and 2.398mg / L respectively, are the two heavy metals whose concentrations are elevated and beyond the recommended level by NESREA, FedMinEn, and the WHO in the study undertaken and adequate remediation are proffered to curtail their detrimental effects on human and the environment. The average ranking of the heavy metal concentration in the leachate Lead(Pb)(2.198mg/L)>Zinc(Zn)(1.38mg/L)>Iron(Fe)(0.58mg/L)>Chromuim(Cr)(0.23mg/L)>Copper(Cu)(0.12mg/L).*

Key words: *Concentration, Environment, Heavy Metals, and Leachate*

INTRODUCTIONS

Leachate is a complex mixture of organic, inorganic, and many unidentified toxicants which may pose a lot of risks of unknown magnitude to aquatic and human life. There are numerous health implications due to illegal waste dumping in public places and a lack of proper solid waste management.

Dumpsite leachate contains high levels of Heavy metal which ultimately contaminate either groundwater, soil, surface water, or both owning to infiltration and surface runoff. These heavy metals have no usefulness to human life and may be toxic even at trace concentrations and ultimately cause serious health concerns. Heavy metals constitute an ill-defined group of inorganic chemical hazards. Heavy metals contamination of groundwater and soil may pose risks and hazards to humans and the ecosystems through direct ingestion or contact with contaminated groundwater, reduction in food quality

(safety and marketability) via phytotoxicity, reduction in land usability for agricultural production causing food insecurity and land tenure problems. The ranking of the average concentration for Bulumkutu open dumpsites shows Lead(Pb)1.798mg/L> Iron (Fe)0.784mg/L>Zinc(Zn)>chromium(Cr)0.23mg/L>Copper(Cu)0.12mg/L. Based on the ranking, Lead(Pb) is the most important trace metal of concern at Bulumkutu open Dumpsites

RESULTS AND DISCUSSIONS

Heavy metals accumulations in wastes at dumpsites affect soil and groundwater and release concentrated leachate into the environment which further affects the food chain resulting in causing detrimental health consequences to human and aquatic life. Heavy metals when accumulated may cause serious health hazards and environmental problems because of the poisonous effects of these metals on plants and the potential health implications to humans and animals consuming such vegetables from those dumpsites.

Heavy metals elevated concentrations existed in most dumpsites at an environmentally dangerous level. According to Abbas et al (2019), municipal solid wastes may increase the concentration of heavy metals in soil and groundwater. This may have consequences on human health, host soil, and crops. This clearly shows that the environmental impacts of municipal solid wastes are influenced by their heavy metals content. The damage to the environment with regards to heavy metals comes from various sources which can be classified as urban industrial aerosol liquid and solid wastes from man and animals. mining industries and agricultural chemicals. Heavy metals (HMs) are mostly present in electronic wastes especially copper from wires Cr, Ni, Zn. Cd and Pb, including other metals and elements that are rare on the earth's crust.

Table 1.0 Measured Heavy metals at the Bulumkutu open Dumpsites

DISTANCE(m)	5	10	15	20	25
Zinc (Mg/l)	2.96	2.1	0.88	0.48	0.48
Chromium (Mg/l)	0.62	0.1	0.1	0.12	0.21
Iron (Mg/l)	0.42	0.44	0.34	1.47	1.25
Copper (Mg/l)	0.24	.17	0.02	0.09	0.08
Lead (Mg/l)	3	2.94	3	1.2	2.85

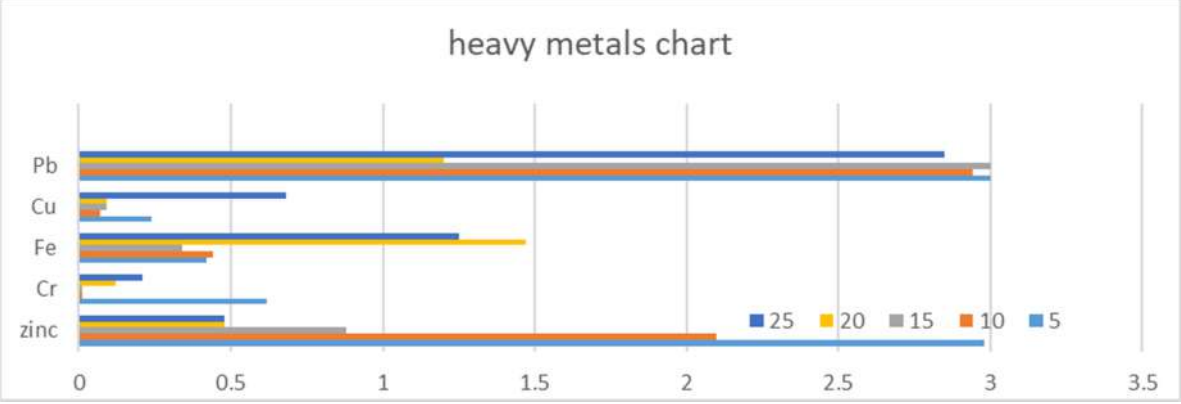

Table 1.2 NESREA LIMITS FOR LEACHATE PARAMETERS AT DUMPSITE

PARAMETERS	Pb	Cd	Cu	Fe	Na+	Cl	Arsenic	BOD	COD
MAX.LIMITS	0.1	0.01	0.01	0.5	2	250	0.05	6	30

The concentrations of Zinc(Zn) at 5,10,15,20, and 25m are 2.96 mg/L, 2.10 mg/L, and 0.88mg/L. 0.48mg/l, and 0.48mg/L respectively which is an indication that distance does not significantly affect the level of concentration of Zinc at the Bulumkutu open Dumpsite while the presence of such metals can be attributed to the presence of old scraps of metals and other Zinc element related materials at the dump site.

The observed concentrations of chromium of 0.62mg/L, 0.1mg/L, 0.1mg/L, 0.12mg/L and 0.21mg/L at a distance of 5, 10, 15, 20, and 25m at the dumpsite show evidence of the presence of wastes from the nearby leather tanneries workshops, local textile industries, and some electroplating and steel moulding activities within the vicinity of the dumpsite. The observed concentration of lead(Pb), is 3.0mg/L 2.94, mg/L 3mg/L,1.2 mg/Land 1.85mg/L at 5,10,15,20 and 25m away from the dumpsite can be attributed to lead acid-batteries, plastics, and rubber remnants, lead foil such as bottle closures, used motor oil and discarded electronic gadgets.
The observed concentration of copper (Cu) in the leachate sample at distances of 5,10,15,20 and 25m are 0.24mg/L,0.17mg/L,0.02mg/L,0.09mg/Land0.08mg/L respectively, the presence of copper in the dumpsite leachate can be attributed primarily to the products of photovoltaic solar cells. discarded old plumbing pipes and electrical cables.

High concentration of copper is a health threat as it is established that elevated levels can cause metal fumes fever with flu-like symptoms, hair and skin decolonization, dermatitis, irritation of the upper respiratory tract, metallic taste in the mouth, and nausea. Iron was observed to be of less concentration at a distance of up to 15m before it raises at 20m and slightly decreases. This can be attributed to the timespan required by its sources to decompose and contaminate the leachate. Primary sources can be discarded rods, metal scraps, etc which are reported to increase the presence of a high concentration of iron in leachate.

High concentrations of iron in leachate samples have been reported to increase the odor and color of the leachate solution thereby increasing its detrimental effects on the receptor where its taste, odor, and color are greatly distorted as reported by Moore et al,2007, Longe and Emekwohie,2017.
The observed average value for the iron in the leachate sample is 0.784mg/L which is higher than the prescribed permissible limits by NESRE of 0.5mg/L and less than the FedminEnv standard of 1.0mg/L. However, the average observed value is within the limit of the FedminEnv for discharge and may not be a cause of concern for its discharge NESREA and the FEDMinEnv are having similar and near-equal maximum limits for leachate parameters at dumpsites to be discharged to receiving bodies as stipulated in the constitution. Environmental experts are concerned about the unhealthy proliferation of dumpsites in the country without commensurable measures to curtail the effects of such on human health and the environment.

DECREASE OF LEACHATE STRENGTH WITH TIME

The degradation of the MSW over time and space results in the production of leachate that easily migrates within the water table underground, Leachate is a liquid that has seeped through solid wastes in a landfill/Dumpsite and has attracted soluble dissolved /suspended materials in the processes.

The volume of leachate generated is expected to be very high in humid regions with high rainfall or run-off and shallow water table. Any movement of the potential impacts of a landfill on groundwater quality requires consideration of the components of the leachate most likely to cause an environmental impact as well as the sources of concentration of those components. Leachate characteristics are expected to evolve over time, increasing from initial values to a peak (i.e. maximum value) and then subsequently decreasing as the potential contaminants are either flushed out of the systems (i.e. collected as leachate), biodegraded or precipitated. There is considerable evidence to suggest that the strength of leachate decreases with time. This decrease may be attributed to the biological breakdown of organic compounds to simpler compounds /elements .it can also be due to dilution effects .it has been recognized that the decline in concentration C with time T can often be empirically approximated by the first-order equation of the form

$$C=Co \exp\{-kt\}$$

Where
Co =is the representative peak source concentration
K= the 1st order constant =ln2/ (half-life)

Based on empirical observations relating to a collection of Dumpsite leachate data establish values of Co and K as shown in the table for ease of reference.

Parameters	Co mg/L	K (a¯1)	Inferred biological/ chemical half –life)(years)
BOD	35000	0.225	4.3
COD	89,000	0.192	5.5
TOC	14,000	0.260	3.6
NH3-N	12,000	0.100	19.8
CL	2,470	0.065	∞
SO4	15,000	0.079	49.5
Cd	0.160	0.125	11.6
Cu	10	0.200	5.1
Cr	0.33	0.900	0.800

The following factors are to be considered in choosing any remediation technique (s) so as to maximize the benefits of the exercise.

a) The most critical factors that will determine the appropriate and effective remediation must include the level of toxicity to reduce, mobility of the toxicity, and volume reduction.

b) Cost, long-term effectiveness /performance
c)commercial availability and general acceptance

Table 2.1 HEAVY METALS IMMOBILIZATION AT CONTAMINATED SITES USING LOCAL AVAILABLE MATERIALS

HMS IMMOBILIZES	**LOCAL MATERIALS**
Cd	Sewage sludge
Cd	Cattle manure
Cd,Cr,Pb	Rice hulls
Cr,Cd	Leaves
Cu.Pb,Zn,and Cd	Poutry manure
Pb	Bagase(from sugar cane)
Cd,Cr,Pb	straw

CONCLUSION

Dumpsites leachates contain a high level of heavy metals which ultimately contaminate either groundwater, surface water, or both owning to infiltration and surface runoff. These heavy metals have no known usefulness to human life and may be toxic even at trace concentrations and can cause serious health concerns to the environment, the presence of heavy metals at the dumpsite is responsible for the toxicity of leachate. The various level of concentration of the selected observed heavy metals at the dumpsite in the leachate sample is capable of having detrimental effects on the health of human and the environment because of the level of concentration of the Lead(Pb)and the Zinc.

Heavy metal accumulation consistently exists at waste dumpsites at an environmentally dangerous level. Municipal waste may increase the concentration of heavy metals. Adequate knowledge of the various sources of contamination and potential risks of the toxic heavy metals in contaminated soil, surface water, and groundwater is essential to enable one to choose some appropriate remediation techniques. It is, therefore, necessary to ensure that the leachate from this dumpsite is treated using any cost-effective and universally acceptable method as advocated here to curtail the effects of the heavy metals on humans and the environment. These advocated labor-based technology is recommended for developing countries in Africa like Nigeria where there is an abundance of such recommended remediation materials for field applicability and commercialization

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Design and Construction of Hydroxyoxygen (HHO) Fuel Cell

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Abstract: *The advancement in technology in our world today which results in global warming has led researchers to look for another source of renewable energy such as hydrogen. In this research, the design and construction of a fuel cell were carried out using the electrolysis of water and potassium solution; by splitting hydrogen and oxygen and recombining them to form hydroxyoxygen (HHO) gas. The materials used in the construction of the fuel cell are Water; potassium; 45Amhs/12v battery; Candle wax; Fuel Tank; Reactor; Safety Bubbler; Battery Cables and; Thread. The performance had been tested and works effectively having an output power of 3.4Watt producing 0.5 litres of Hydroxyoxygen gas (HHO gas). HHO gases sometimes leak through the candle wax that serves as a sealant. The cell if coupled with a burner and small generator can work as a stove and HHO-operated generator respectively. It is recommended that further work should be carried out on how to control gas leakages.*

Key words: *Electrolysis, Hydrogen, HHO Gas, Water, Potassium, Energy.*

1.0 Introduction

In our modern days, the world had become advanced in technology. Many machines were developed and run on fossil fuels that generate a lot of emissions of pollutants into the atmosphere that results in global warming. All these pollutants need to be addressed in other to be minimized. Hydrogen is one of the most common elements that are known to exist and the first element found in the periodic table that is with the letter H. The ratio of hydrogen is 80% and is the main substance of the visible universe and is common on Earth. Many stars consist of the sun; which liberates energy by fusing hydrogen with helium. In fact, the sun ball formed these two elements. In a process called fusion, in this way four hydrogen atoms combine to form one helium atom generating the energy as radiation. This radiation energy is one of the most abundant sources of energy. It provides us with light, and heat makes plants grow, and makes the wind blow and rain fall, (International Energy Agency, 2013). On earth, the most familiar hydrogen compound is water where two atoms of hydrogen combine with one atom of oxygen (H_2O). All the complex molecules of life contain hydrogen. (Winter, 2009). Electrolysis is a well-known process that converts water

into hydrogen and oxygen using electricity. Electrolysis opens the door to hydrogen production from any primary energy source that can be used for electricity generation and heating etc. (Thomas, 2001).

1.1 Statement of Problem

Using raw Biomass in rural areas for cooking causes air pollution that provokes eye irritation, environmental problems, and other health challenges.
Lack of access to electricity or liquefied petroleum gas (LPG) has led the rural dwellers not to use electricity for cooking and another domestic usage.

1.2 Significance of the study

1. Reducing carbon emissions into the atmosphere due to cooking with raw biomass.
2. Free from eye irritation due to cooking with fire firewood produces smoke,
3. Promote the use of hydroxyoxygen gas for cooking in the absence of the National grid or LPG gas, especially in rural areas.

1.3 Aim and Objectives

The aim of this work is to Design and construct a Hydroxyoxygen (HHO) fuel cell, while the objectives are to:
i. design and construct the reactor that will split the hydrogen and oxygen from water and potassium solution.
ii. construct the fuel tank and safety bubbler that are capable of holding the reactor and the solution.

1.4 The Scope of the study.

This work is focused around the use of water and potassium (“Jarkanwa’’).

2.0 Literature Review

A fuel cell is an electrochemical device use for splitting hydrogen and oxygen and recombines to form hydroxyoxygen (HHO) gas, (Rajasthan, 2014).
HHO-hydroxyoxygen (HHO) is diatomic structure which was formed from the molecule of two atoms for both the gases oxygen and hydrogen. HHO is free from release of harmful gases and it doesn’t emit or produce any contaminants into the atmosphere when burned. Er-Dong, (2008).

In electrolysis, an electrical current is passed through a conductive substance (the electrolyte) in order to drive a non-spontaneous reaction. The reaction which is endothermic requires an input energy, (Pervez, 2016) in order to decompose water into hydrogen and oxygen. Water is filled into the fuel tank where it will be demineralized and will have zero conductivity and by introducing potassium hydroxide (KOH), it becomes conductive. When the reactor receives DC supply from the battery, it ionizes the molecules of hydrogen and oxygen .Thereafter bringing them together to form hydroxyoxygen (HHO).Desilva, (2015).A fuel cell is a device that generates electricity by a chemical reaction. Every fuel cell has two electrodes called respectively, the anode and cathode (Smithsonian, 2017).HHO is also known as “Brown gas “which derived from the name of Professor Yull Brown who found some unique properties of HHO (Schlapbach, 2001).

In advanced fuel cell systems, the heat released by the stack can be purposely recovered for internal (1) or external (2) heating. Examples follow:
(1) Heat can be used for conditioning reactant gases = pre-heating + humidification;
(2) Heat can be used for providing space and/or heating. (Swisher, 2002). Cogeneration by heat recovery is a powerful means to increase the overall efficiency of fuel cells systems up to 80-85 %(Jobwerx, 2004). It is very advantageous in high temperature fuel cell system. Hydrogen readily oxidizes in contact with platinum and oxygen (Vogt, 2010). While this is favourable for conversion to heat, critical safety issues are to be paid attention to. Due to the broad range of Flammability (4-75%), premixing hydrogen and oxygen prior to oxidation can easily lead to uncontrolled combustion in the mixing chamber. In order to avoid premixing, an approach where hydrogen and air are supplied from separate sources to the catalytic active combustion area was adopted. Catalytic hydrogen combustion can reach temperatures of up to 1000°C. (Eth-Zurich, 2014). Hydrogen burns differently than either propane or natural gas. In particular, hydrogen's rate of diffusion and flame velocity are roughly ten times greater than the propane or natural gas ones. The great advantage of burning hydrogen is that, Hydrogen doesn't produce pollution, but only NOx. (H_2Nitidor, 2015).
The properties of hydrogen according to Rajasthan, (2014) are: Energy density: 120-140Mj/kg at STP; Critical pressure: 12.96 bar; Triple point temperature: -259.19^{o}c; Critical temperature: -240^{o}c; Molecular weight: 2; Triple point pressure: 0.077bar; if hydrogen gas doesn't leak, it will produce 3xmuch energy compared to natural gas and; Octane number: +130.

A method by which water is split into hydrogen and oxygen is called electrolysis. The discovery of electrolysis and its use to split water dates back to the 1800_s when William Nicholson and Anthony Carlisle observed the evolution of gases during early experiment to replicate the voltaic pile (the world's first battery, invented by alessondro Volta).There are two main technologies for water electrolyte in use today alkaline electrolytic cells (AEC) and proton exchange membrane electrolyser cells (PEMEC).(Jassen,2001).High temperature water electrolysis is a third method which is currently in the research and development stage. This type of cell is known as solid oxide electrolytic cell (SOEC).These three technologies share number of similarities with their fuel cell operating in reverse. In PEMEC system, it also operates in the reverse as fuel cells (Sami Tuomi, 2013).

Rajasthan, (2014). Constructed a home gas, by hydrogen fuel cell. This was utilized and used as HHO stove. A process of electrolysis was used to generate HHO gas (hydroxyoxygen).Through a burner for heating or cooking purpose. A reactor was constructed to have one hundred and ten plates (110).The power supply was 220volt from the National grid. A NAOH was used as additive into the water and the safety bubbler was made of steel.

The output of hydrogen was about 504 litres while 254 litres for oxygen in an hour which had accumulated up to 758 litres. This supply of hydrogen gas was connected to HHO stove. The work had been tested and found to have worked efficiently. Hydrogen is a very

explosive gas and the problem in using hydrogen is the risks of fire or bursting. Other problems associated with hydrogen include storage and its production cost.

Jason (2018), Constructed improvised Hydrogen Fuel cell to generate cooking gas with an additives of KOH solution, gives out hydrogen gas when electric current is passed into it.But this hydrogen cannot be directly used as it contains moisture .In order to remove moisture, and it is sent into dryer. The dryer ensures that the hydrogen gas is completely moisture free. The fuel cell is connected to the dryer through a gas pipe. The hydrogen that is moisture free cannot directly use as cooking fuel as the amount of hydrogen expose to fire is very critical. It is passed to the collecting chamber through gas injector. The burner rim used has minute holes and sufficient amount of hydrogen is exposed to fire through the burner. The fuel cell stack and electrodes conditioner. The fuel cell stacks contain 32 sub stacks of fuel cells.

3.0 Materials and Method

3.1 Materials and Equipment used

The materials used in the construction of the fuel cell are: Water; potassium; 45Amhs/12vBattery; Candle wax; Fuel Tank; Reactor; Safety Bubbler; Battery Cables and; Thread.

3.1 Method/procedure

Is used electrolysis to produce hydrogen gas or HHO gas by splitting of water into hydrogen and oxygen. When a fuel reactor receives a DC supply and it ionizes the molecules of hydrogen and oxygen and separated it to form hydrogen and oxygen. And then further to recombine to form hydroxyoxygen (HHO).HHO cell, (2010).

$$20H_2O(L) + KOH(aq) \rightarrow 2H_2(g) + O_2(g) + K_{-(aq)} + OH_{-(aq).}$$

The hydrogen gas rise up to the upper portion of the fuel tank and flow through the hose and goes to the safety bubbler and can be used for producing heat and goes out through the out let of the safety bubbler through the hose up to the injector needle for burning. The complete setup of the fuel cell is as shown in figure1 below.

Plate1. Block diagram of complete setup process (Enel, 2013).

Reactor

Strips of metals were cut to 13.5 x 1.5 cm from a stainless steel that comprises 16 plates with gap of 1.5mm that form a complete reactor.

Plate 2. Reactor with a series of plates

Bubbler

Two perforated holes were produced on the top of the bubbler that serves as an inlet and outlet of the HHO gas. The bubbler is half filled with water, and a hose from the fuel tank is connected to the bubbler through the inlet. Another hose is also connected at the top of the bubbler that serves as the outlet of the hydroxyoxygen gas (HHOgas).

Plate 3. Safety Bubbler

Fuel Tank (electrolyser).

It had been made from a thermoplastic which produced from chlorination of polyvinyl chloride (PVC) resin. The fuel tank (electrolyser) has connected with two terminals that connect the reactor. And a hole was produced at top of the fuel tank and a hose was connected through the hole this serves as the out let of the HHO gas.

Plate 4. Fuel tank (electrolyser)

A Candle wax

The holes were produced on the surface of the fuel tank where cables were connected to the reactor and the outlet for HHO gas which a hose was fixed. All these points were sealed with candle wax to avoid leakages.

Battery

A battery of 12volt /45Amps was selected and used in a closed container that has two terminals of both positive and negative terminals and with an opening where a solution of hydrogen sulphide (H_2SO_4) can be introduced into it. The battery serves as a reservoir for storing energy and releases energy when needed.

Plate 5. Battery

Rectangular Stainless Steel

A rectangular strips of metals made from stainless steel were cut to a size of 13.5x 1.5cm these were used for construction of the reactor. For each sets of the strip one serve as anode while the other as cathode.

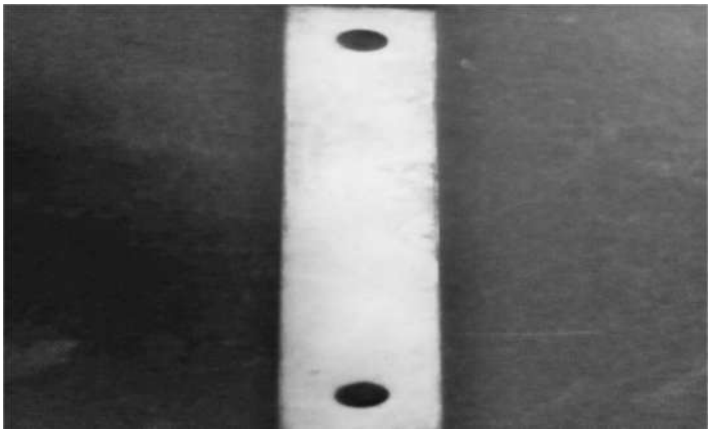


Plate 6 A rectangular stainless steel plates (13.5x1.5cm)

Thread

It had been used to worn the thread round both anode and cathode to separate the strip sheet of metal from contact with the nut.

Battery Cables

A copper cable with clips at both ends of the cables and are used to make connections between the two terminals of the battery and to that of fuel tank

2.2.1 Design Analysis

To get a desirable out put the following must be considered:

a) $lenght\ of\ the\ plate.$
b) $breath\ of\ the\ plate.$
c) $Diameter\ of\ the\ circular\ hole\ on\ the\ plate.$

$surface\ area\ of\ expose\ to\ H_2\ is\ given\ by\ Rajashthan(2014)$

$$surface\ area\ expose\ to\ H_2 = 2circle\ area - area\ of\ rectangular\ plate \quad (1)$$

$$2circle\ area = 2\pi r^2 \quad (2)$$

$$Area\ of\ rectangular\ plate = lb \quad (3)$$

$r = radius\ of\ the\ circular\ hole = 3cm$
$\pi = 3.142$
$Arbitrary\ selection$
$length\ of\ the\ plate\ = 13.5cm$
$breath\ of\ plate = 1.5cm$
$using\ equation\ 2\ \ 2circular\ area = 2 \times \pi \times 3^2 = 56.55cm^2$
$applying\ equation\ 3\ area\ of\ rectangular\ plate = 13.5 \times 1.5 = 20.25cm^2$
$Recalling\ equation\ 1\ surface\ area\ expose\ to\ H_2 = 56.55 - 20.25 = 36.30cm^2$
$The\ electrical\ resistantance\ to\ electrolyte\ is\ given\ by\ Kaveh\ (2012)$

$$R = \frac{\rho l}{A} \quad (4)$$

A standard gauge for density of stainless steel is given by Yieh (2018)

$$\rho = 7.7 g/cm^3 \quad (5)$$

The output power of the cell is given by Rajashthan (2014)

$$output\ power\ of\ fuel\ cell = IV \quad (6)$$

$I = current$
$V = voltage$
$lenght\ of\ the\ battery\ cables = 200cm$
Recall equation 4

$$R = \frac{7.7 \times 200}{36.30} = 42.42\Omega$$

$$I = \frac{V}{R} = \frac{12}{42.42} = 0.28A$$

$out\ put\ power\ of\ the\ fuel\ cell = I \times V = 0.28 \times 12 = 3.4watt$
volume of pvc tank is given by Jason (2018)

$$volume\ of\ pvc\ fuel\ tank = \pi r^2 h \quad (7)$$

$height\ of\ the\ fuel\ tank = 138cm$
$Diameter\ of\ the\ fuel\ tank = D/2 = 6/2 = 3cm$
$volume\ of\ the\ fuel\ tank = \pi r^2 h = 3.142 \times (67.5)^2 \times 138 = 1975.32cm^3$

$$convert\ to\ liters = \frac{V}{10^3} = 1.975liters \simeq 2liters$$

$$\frac{2}{3}\ of\ fuel\ tank\ fill\ with\ water\ and\ additives = \frac{2}{3} \times 2 = \frac{4}{3} = 1.33liters$$

$the\ amount\ of\ hho\ gas\ in\ liters\ will\ be\ = 2 - 1.33 = 0.67liters$
$therefore\ hho\ gas = 0.67liters$
The energy out put is given by Akanksha (2014)
$Energy\ density\ of\ H_2 = 130\ Mj/kg$
$Density\ of\ \ H_2 = 0.085\ gm/l\ \ at\ room\ temperature$

$$Energy\ out\ put = 0.67 \times 0.085 \times 0.001 \times 130 = 7.4035 \times 10^{-3}\ Mj/hr \quad (8)$$

3.0 Results and Discussions

The work was completed and tested where HHO gas flows through the nozzle to the air and a flame was brought close to the gas and ignited then burning continues as shown in the figures below.

The following are the results obtained
Table 1: Results obtained from the constructed fuel cell.

Requirements	Calculated values	Measured values	Difference
Output power	3.4watt	3.5watt	0.1watt
HHO gas produced	0.61	0.5l	0.1l
Energy output	$7.403x10^{-3}$Mj/hr.	$7.0x10^{-3}$Mj/hr.	$0.403x10^{-3}$Mj/hr.

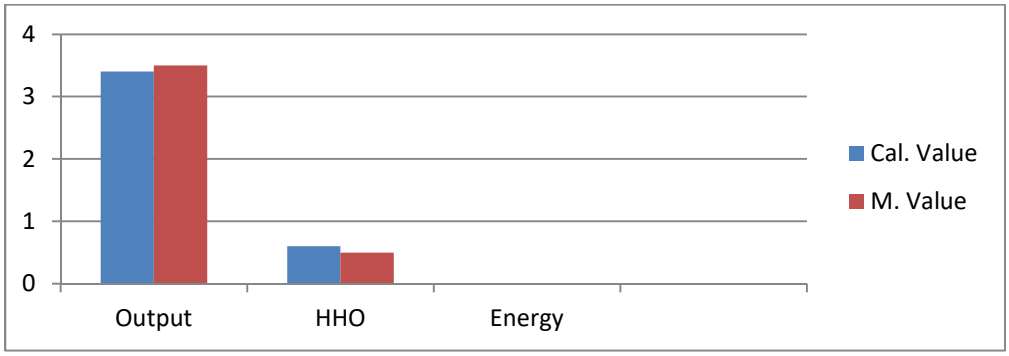
Source: Experiment (2018)

Table 1 above shows that in the design, the fuel was expected to give an output power of 3.4 watt while after the construction the power was measured to be 3.5watt with a difference of 0.1watt additional.

In fuel cell design, the hydroxyoxygen gas (HHOgas) which could be produced was expected to be present was 0.6 litres and when it was constructed the measured value of hydroxyoxygen gas (HHO gas) was measured to have 0.5 litres which resulted in a difference of 0.1litre.

By virtue of the design of the fuel cell, the expected energy output was $7.403x10^{-3}$Mj/hr. while fuel on completion, the measured value was found to be $7.0x10^{-3}$Mj/hr. The difference was $0.403x10^{-3}$Mj/hr. the complete setup of the constructed fuel cell is shown in figure 8 below.

Performance evaluation:



The graphical representation of the results obtained

Plate 8. Complete setup

Conclusion

-The design and construction of the fuel cell were carried out successfully using the method of electrolysis.

- A quantified amount of 10 grams per litre of potassium was used to form the solution (electrolyte).

- The fuel cell was tested and produces about 0.5 litres of hydroxyoxygen gas (HHO gas); an output power of 3.5 W and an energy output of $7.0x10^{-3}$Mj/hr.

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