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Mathematical Prediction of Waterleaf Evapotranspiration Using Three Models in Maiduguri

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Abstract: The knowledge of crop evapotranspiration (E_{Tc}), the combined process of evaporation and plant transpiration, is important in agriculture for scheduling farm operations and designing and managing irrigation and drainage systems. Development of crop coefficient (K_c) can enhance crop evapotranspiration (E_{Tc}) estimates in specific crop growth stages. However, locally determined K_c information is not available for many important crops in Nigeria. This research was, therefore, conducted to determine the growth parameter stage, specific K_c and crop water use for waterleaf at the Ramat Polytechnic Agricultural Research Farm which is located in a semi-arid climatic zone in Maiduguri. Drainage type lysimeter was used to measure crop water use under water balance system and local weather data were used to determine the reference evapotranspiration (E_{To}). A lysimeter was used to measure the daily evapotranspiration of waterleaf on a sandy loam soil. Crop coefficient was developed from measured E_{Tc} and E_{To} calculated using weather data. Crop evapotranspiration observed from the field using the lysimeter and those estimated using models were compared using Nash- Sutcliffe efficiency (NSE). The outcome of the experiment revealed that, correlation analysis among the growth parameters showed that, there is strong positive relationship of about (82% to 90%). Similarly, crop evapotranspiration values of waterleaf in Maiduguri semi-arid region was found to be averagely 3.65, 4.88, 5.48 and 5.34 mm at each growth stages, respectively, with seasonal total E_{Tc} of 177.44 mm. The crop coefficient values of waterleaf were found to be 0.62, 0.82, 0.86 and 0.76 at each growth stages respectively. The values of E_{Tc} determined from the lysimeter were validated by Blaney-Morin Nigeria (BMN), Blaney-Criddle (BC) and Hargreaves models and better agreement was recorded between the E_{Tc} calculate from empirical model for the waterleaf using Nash- Sutcliffe efficiency (NSE) and T-test software. Therefore, the study revealed that, drainage lysimeter can be said to be functional and efficient to use in the region.

Keywords: Waterleaf; Blaney-Morin Nigeria; Blaney-Criddle; Hargreaves and Crop Coefficient

1.0 INTRODUCTION

1.1 Background of the Study

Irrigation plays an important role in food production globally. Irrigation is the supply of water to crops by artificial means, designed to permit farming in arid region and to offset the effect of drought in semi-arid region and even in areas where total seasonal rainfall is adequate or average (Vaughan *et al.*, 2007). Accurate evapotranspiration estimates are essential to identify the time variations on irrigation needs, to improve the allocation of water resources, and to evaluate the

effect of the use of the land and changes in the management of the water balance (Ortega – Farias *et al.*, 2009). Evapotranspiration can be obtained by direct or estimate measures of climatic elements, using empirical methods. The direct method is represented by several types of lysimeters, being the most accurate method, and considered standard – tool for the determination of evapotranspiration (Bernardo *et al.*, 2006; Amorim, 1998). There are several empirical methods in literature that use meteorological elements data to estimate the evapotranspiration. These methods are based on observations and statistical analysis, and are generally adequate for a specific climatic or region condition (Gravilan *et al.*, 2006). **Vegetables contain 80 to 95 percent water, because they contain so much water, their yield and quality suffers very quickly from drought. When vegetables are sold, a “sack of water” with a small amount of flavoring and some vitamins is being sold. Thus, for good yields and high quality, irrigation is essential to the production of most vegetables. Most vegetables are rather shallow rooted and even short periods of two to three days of stress can hurt marketable yield.** Waterleaf (*Talinum triangulare* Jacq.) is a plant to the family Taliniaceae and commonly found in humid tropics. It has been recognized in many countries of Africa; it is claimed to have South American origin but an African origin may not be doubted (Schipper, 2000). Waterleaf is an erect glabrous perennial herb (80-100cm tall), usually strongly branched; roots are swollen and fleshy. The leaves are alternate, simple, almost sessile and succulent (Oluwole *et al.*, 2018) Waterleaf cultivation like other leafy vegetables cultivation in home gardens improves nutritional quality for the family and may provide additional income for female farmers. As a result of its high nutritional value that provide good source of crude protein (22.1%), and vitamins, waterleaf is playing a major role in efforts to eradicate malnutrition in Africa (Tata *et al.*, 2016). Evapotranspiration (ET) It is the combination of two separate processes through which, water is lost from the soil surface via evaporation process and from the crop by transpiration. (Allen, 1998). Similarly, Konukcu (2007) classified evapotranspiration as actual evapotranspiration E_{Ta} , Crop evapotranspiration E_{Tc} , reference evapotranspiration E_{To} or potential evapotranspiration E_{Tp} . Crop Evapotranspiration is the evapotranspiration from disease-free, well-fertilized crops, grown in large fields, under optimum soil water conditions and achieving full production potential under the given climatic conditions. Crop coefficient (K_c) is defined as the ratio of the crop evapotranspiration to the reference evapotranspiration and can be calculated by different methods (e.g. single crop coefficient method and dual crop coefficient method) (Jensen *et al.*, 1990; Allen *et al.*, 1998). Crop coefficient K_c is the ratio of potential evapotranspiration for a given crop to the evapotranspiration of a reference crop. It represents an integration of effects of four primary characteristics that adjusts the crop from reference grass (i) Crop height, (ii) Albedo, (iii) Canopy resistance, (iv) Evaporation from soil; especially exposed soil. The factors determining the crop coefficients are crop type, climate, soil moisture evaporation, crop growth stage (Vaughan *et al.*, 2007). According to (Allen *et al.*, 1998), there are many models based on meteorological data which allow estimating evapotranspiration in different climates and geographical conditions. The Penman-Monteith FAO model PMF is generally presented as a standard model for estimating ET The main limitation of this model is the need of many meteorological data entries which limits its applicability in areas where data is less available, especially in developing countries. Some simpler models that use parameters or variables that are commonly measured in meteorological stations are more advisable to estimate (ET) in scarce-data areas. Similarly, (Tabari, 2010) reported some simpler mathematical models for calculating evapotranspiration indirectly are the Priestley-Taylor PT method (Priestley and Taylor, 1972), and the Hargreaves-Samani HS method (Samani, 2000; Hargreaves and Allen,

2003). The HS method is a simple method that only requires data such as temperature and latitude of the area of study. Houshang *et al*, (2015) have compared five different evapotranspiration models as shown in equation 2.1 to 2.5 with the observed ET using lysimeter in Kermanshah western part of Iran

(a) FAO56-Penman-Monteith Method by Allen et al 1998

$$ET_o = \frac{0.408\Delta(R_n - G) + r \frac{900}{T+2} U_2 (e_s - e_{sa})}{\Delta + \gamma (1 + 0.034u_2)} \quad 2.1$$

Where, u_2 and $(e_s - e_a)$ are wind speed at 2 m height ($m\ s^{-1}$) and saturation vapour pressure deficit (kPa).

(b) FAO-Penman Method, adopted by Doorenboss (2000)

$$ET_o = c \left[\left(\frac{\Delta}{\Delta + \gamma} \right) (R_n) + \left(\frac{\gamma}{\Delta + \gamma} \right) (2.7) (w_f) (e_z - e_z) \right] \quad 2.2$$

Where, ET_o , $(e_z - e_a)$, γ , Δ , R_n , W_f and C are reference evapotranspiration ($mm\ day^{-1}$), vapour pressure deficit at height z (kPa), psychrometric constant ($kPa\ ^\circ C^{-1}$), slope vapour pressure curve ($kPa^\circ C^{-1}$), net radiation ($MJ\ m^{-2}$ per day), the wind function and adjustment factor which is equal to 1 respectively.

(c) FAO-Radiation Method 1975 Revised by Doorenboss (1997)

$$ET_o = b \left[\frac{\Delta}{\Delta + \gamma} + \frac{R_s}{\lambda} \right] - 0.3 \quad 2.3$$

Where, RH is the relative humidity (%) and $b = 1.066 - 0.13 \times 10^{-3} RH + 0.045U_d - 0.2 \times RHU_d - 0.015 \times 10^{-4} RH^{-2} - 0.11 \times 10^2 U^2$

(d) Turc-Radiation method 1961 adopted by Razzaghi (2010)

$$ET_o = a_r (0.013) = \frac{T_{mean}}{T_{mean} + 15} \left(\frac{23.8856R_s + 50}{\lambda} \right) \quad 2.4$$

Where, T_{mean} and R_s are mean daily air temperature ($^\circ C$), and solar radiation ($MJ\ m^{-2}\ d^{-1}$), a_r is equal 1.0 for $RH_{mean} \geq 50\%$ and it is equal $1 + (50 - RH_{mean})/70$ for $RH_{mean} < 50\%$.

(e) Priestley and Taylor method

$$ET_o = \frac{1}{\lambda} \alpha = \frac{(\Delta)}{\Delta + \gamma} (R_n - G) \quad 2.5$$

Where, α is a constant ($\alpha = 1.26$).

(f) Hargreaves and Samani method, Hargreaves [1987]

$$ET_o = \frac{1}{\lambda} (0.0023) R_A - TD^{\frac{1}{2}} (T + 17.8) \quad 2.6$$

Where, R_A , TD and T are extra-terrestrial solar radiation received on earth's surface ($MJ\ m^{-2}\ d^{-1}$), difference of mean maximum and mean minimum air temperatures ($^\circ C$) and mean daily air temperature at 2 m height ($^\circ C$) respectively.

According to Pereira and Pruitt (2004), although electronic data logging weather stations are becoming the norm for some countries, this is not the case on global basis. the rarely available automatic weather stations require qualified personnel for operation and maintenance of the very

sensitive instruments. semi-arid climate, concluded that the values of RMSE indicate that, the FAO56 - Penman-Monteith, Hargreaves and Samani were found to be the most appropriate models for the studied region. Priestley and Taylor method and FAO-Penman methods and Turc-Radiation method had the worst results among the studied models. FAO- Penman-Monteith, Hargreaves-Samani methods recommended for evapotranspiration estimation, irrigation planning and scheduling and irrigation projects water requirement application under different crop patterns in semi-climatic region, however the author emphasized the FAO56 penmen method need many meteorological data entries which limits its applicability in areas where data is less available, especially in developing countries. Also Penman-Monteith equation is often difficult and expensive to obtain for practical applications (Stefano and Ferro, 1977). Therefore, the current study is undertaken to determine the growth parameters, crop evapotranspiration (ETc) and crop coefficient (Kc) of waterleaf using drainage in semi-arid region of Maiduguri North-Eastern Nigeria.

2.0 MATERIALS AND METHOD

2.1 Experimental Site

Field experiment was conducted at the Teaching and Research Farm, of the Ramat Polytechnic, Maiduguri, in the Sudano-Sahelian region of northern Nigeria. The site lies between latitude 11°5 N and longitude 13°09E (Kyari *et al.*, 2014).

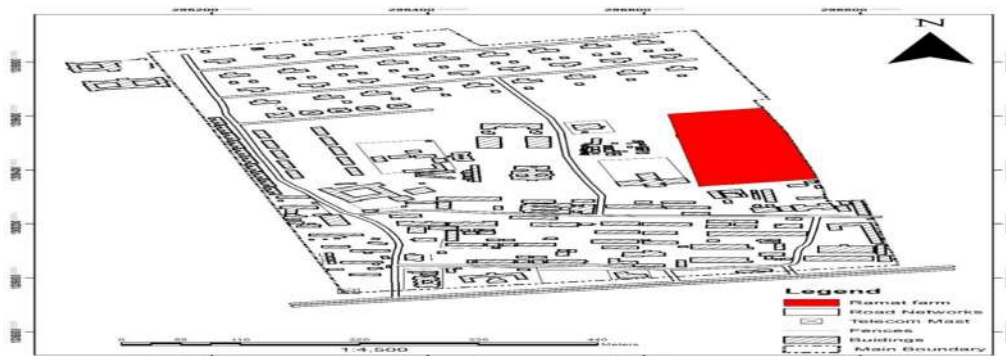


Figure 1: Digitize Map of the Study Area.

Table 1: Mean Soil Characteristics of the Experimental Site (0-30 cm)

Soil type (USDA soil classification)	Sand loamy
Clay (%)	8.0
Silt (%)	11.8
Sand (%)	80.2
p ^H	6.8
Field capacity (vol. %)	16.2
Wilting point (vol. %)	3.2
Available water content (vol. %)	13.0
Bulk Density (g/cm ³)	1.70
Organic matter (%)	3.99

Source : Agricultural Research Farm Rampoly

2.2 Agronomic practices

The location for excavation was marked after clearing the site from its previous vegetation in preparation for installation of the non -weighing lysimeter. To effect installation, the soil was

excavated in layers, with soil from each layer placed in a separate pile. When the proper depth was reached; the bottom of the hole was leveled. The surface area of the excavation – 3.58m² by 1.6m deep was done manually. This was done to provide some space to allow for the installation of the lysimeter manually. The field layout for the experiment consists of the developed lysimeter planted up with waterleaf stands transplanted from the nursery. The vegetable under study was transplanted on a spacing of 20cm by 15cm. The lysimeter installation was accomplished by six people with the use of shovels, and a few hand tools. The tank was lowered into and centered in the hole upon a stable concrete foundation. The tank was checked to ensure that it sat level on the bottom of the hole. Soil was backfilled around the outer tank to stabilize the tank as can be seen in figure 3.2. In other words, the outside lysimeter was first filled with soil to provide a firm support to the lysimeter. In other to prevent transport of materials from the soil into the drain pipe, a wire mesh of about 0.20mm was placed at the bottom of the lysimeter, upon the hole drilled, to act as a filtering mechanism. The formation of the filter was achieved first by placing a screen over the hole, then gravel and finally sand. Then the inner tank was backfilled with soil, restoring the soil to the depth from which it was excavated. The soil was packed periodically in an attempt to return it to its original bulk density. In the installation, a freeboard of about 10cm from the ground surface was allowed and the process of irrigation was carried out with its attendant drainage. But before the transplanting, the lysimeter has stopped draining from the drainage pipe after saturation and the initial soil moisture data taken. The receiving vessel being a discarded plastic 20-litre emulsion paint container was placed in an adjacent pit for the collection of the percolated water. The field layout for the experiment consists of the developed lysimeter planted up with waterleaf stands transplanted from the nursery. The vegetable under study was transplanted on a spacing of 20cm by 15cm. weeding was done almost on daily basis during the course of this study, this is because weeds do not only compete with the crops for space and nutrients but also, transpire at a rate which affect, negatively the result of the evapotranspiration studies. Farm yard manure (Poultry) was applied to the Research lysimeter at 500g, the first dosage of fertilizer was applied after the first week of transplanting at a depth of 5-8cm, while the second dosage was also applied four weeks after planting.



Plate 1: Installation of a Lysimeter



Plate 2: lysimeter showing Waterleaf Crop

3.0 RESULTS AND DISCUSSION

Table 1 shows the correlation results as among the growth parameter in the study area. The parameters considered were number of leaves per plant, stem diameter, plant height, longest leaf length and longest leaf width of the waterleaf crop experimented using lysimeter was analyzed at ($p < 0.05$).

Table 1: Correlation coefficients among growth parameter of waterleaf

WL	NLPP	SD	PH	LLL	LLW
NLPP	1				
SD	0.8386**	1			
PH	0.6639*	0.8120**	1		
LLL	0.3811*	0.8228**	0.9997**	1	
LLW	0.4161	0.7814*	0.9986**	0.9975*	1

NLPP= Number of leaf per plant, SD=Stem diameter, PH= plant height, LLL= Longest leaf length, LLW= Longest leaf width, WL = Waterleaf **=highly significant and *=significant.

As shown in Table 1 number of leave per plant showed a significant positive association with stem diameter (0.8386**), followed by plant height (0.6639**), and the longest leaf length and longest leaf width exhibited not significant association of (0.3811 and 0.4161) respectively. Correspondingly, the stem diameter, showed a highly significant positive association with plant height, longest leaf length and longest leaf with corresponding values (0.8120**, 0.8228**and 0.7814**) respectively. Conversely, plant height exhibited extremely significant positive association values of (0.9907** and 0.9986) with longest leaf length and longest leaf

respectively. Likewise, positive significant association (0.9975**) was observed between longest leaf length and longest leaf width. The results are in line with the finding (Egharevba 1999).

3.2 Estimated stage –wise sorghum crop coefficients (Kc) of the waterleaf crops at different stages of growth

Table 2 shows the estimated crop coefficients of waterleaf at different stages of growth in the experiment farm were presented in an internationally recognized growth stages

Table 2: Estimated stage –wise crop coefficient (Kc) of the waterleaf

Day after Planting	ETc lysimeter (mm/day)	ETo reference (mm/day)	Kc (-)
Initial 1-7DAP	3.65	5.9	0.62
Dev 8-17DAP	4.88	5.95	0.82
Mid 18-29DAP	5.46	6.36	0.86
Late 30-36DAP	5.34	6.99	0.76

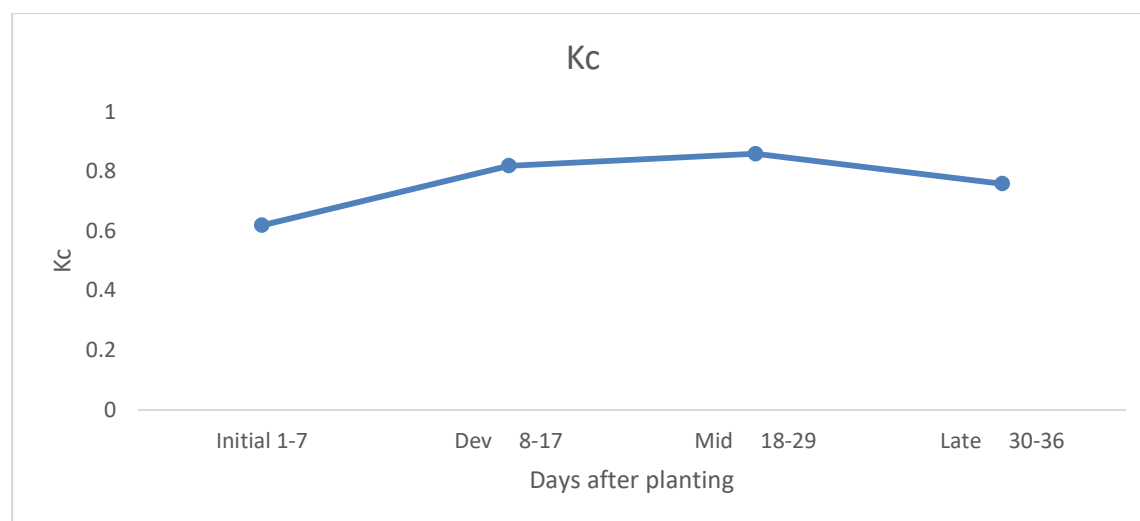


Figure2: Plot of stage –wise crop coefficient (Kc)

The curve presented in Figure 2 represents the changes in the Kc of waterleaf crop over the length of the growing season. The shape of the curve represents the changes in the vegetation and ground cover during plant development and maturation that affect the ratio of ETc to ETo. The Kc increased from the initial to development stages while reached its highest and relatively remained constant at the mid-season stage (Figure 4). The Kc declined rapidly during the late season stage. Higher Kc values were recorded from 18 - 29 days after planting as compared to the values in the initial and late of the crop life cycle. The maximum Kc value was 0.86 at 12

days after planting for the reason that changed in Kc could be attributed to the seasonal variation of leaf size which is in line with the findings of Zhang *et al* (2005).

3.3 Performance evaluation comparison between ETc observed using Lysimeter and other three empirical models for water leaf crop.

Table 3, shows the observed and predicted waterleaf evapotranspiration at different stages of growth respectively. Similarly, Table 4.4 shows the model performance comparison, which resulted in very good agreement. Etc predicted using the three models selected and ETc observed from the field using lysimeter for the waterleaf crop exhibited a high degree of agreement.

Table 3: Performance evaluation comparison between ET observed versus predicted from (BMN, BC and HG models) for waterleaf crop at different growth stages.

Table	Stages of growth (DAP)		Lysimeter Method (mm/day)	Blaney–Morin Nigeria (BMN) (mm/day)	Blaney – Criddle (BC) (mm/day)	Hargreaves (HG) (mm/day)	4:
	Initial	17	3.65	5.25	4.16	4.76	
	Dev8-17		4.88	5.24	4.51	4.54	
	Mid	18-29	5.48	5.4	5.31	5.42	
	Late	30-36	5.34	5.96	5.4	5.14	

Performance evaluation comparison between ETc observed using Lysimeter and other three empirical models for three crops.

Models	RMSE	NSE	RSR	Performance Rating
Blaney-Morin Nigeria	3.12	0.68	0.51	Good
Blaney-Criddle	2.81	0.94	0.04	Very Good
Hargreaves	0.87	0.96	0.02	Very Good

The output of the validation revealed NSE values of (0.68, 0.94, and 0.96) and RSR values of (0.51, 0.04, and 0.02) for Blaney –Morin Nigeria, Blaney-Criddle and Hargreaves respectively, which indicated that their performance was very good for predicting evapotranspiration of water leaf in the region and performance output of the models were rated “ Good, Very Good’ and Very Good” for the corresponded BMN, BC and HG model respectively. Similarly, the observed and predicted water leaf evapotranspiration were also analyzed using z-test as shown in Table 5-.7 which indicating that there was no significance difference between the predicted and observed crop evapotranspiration at ($P < 0.05$) since the value of z-cal is less than Z critical. Thus, the applicability of BMN, BC and HG models is a good representation of calculating evapotranspiration for semi-arid region with sandy loam in the study area.

Table 5: Calculated z-test for ETc Lysimeter and Blaney-Morin Nigeria (BMN) for four stages of growth

z-test	ETc Lysimeter	ET BMN
Mean	5.030119	5.475191
Variance	0.526241	0.33857
Stage of growth	4	
level of significance 5%		
z-cal	-0.76478	
Z critical two-tail	1.9634	

Table 6: Calculated z-test for ETc Lysimeter and Blaney-Criddle (BC) for four stages of growth

z-test	ETc Lysimeter	ETBC
Mean	5.030319	4.945594
Variance	0.526341	0.36157
Stage of growth	4	
level of significance 5%		
z-cal	0.140969	
Z critical two-tail	2.4732	

Table 7: Calculated z-test for ETc Lysimeter and Hargreaves (HG) for four stages of growth

z-test	ETc Lysimeter	ETHG
Mean	5.030319	3.945594
Variance	0.526341	0.36157
Stage of growth	4	
level of significance 5%		
z-cal	0.140969	
Z critical two-tail	2.4732	

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

An experiment was conducted to determine the values of the growth parameters and crop evapotranspiration at stages of growth of waterleaf crop. The study was conducted at the research farm in Ramat Polytechnic, Maiduguri, Nigeria, from 16th February to 23rd March 2020. The observed crop evapotranspiration and predicted was analysed using Nash- Sutcliffe efficiency (NSE) and statistical analyses (z-test) as follows; Correlation analysis among the growth parameters showed that, there is strong positive relationship of about (82% to 90%). The crop evapotranspiration values of waterleaf in Maiduguri semi-arid climate and sandy loam soil is averagely 3.65, 4.88, 5.48 and 5.34 mm at each growth stage, respectively, with seasonal total ETc of 177.44 mm. The crop coefficient values of this crop for in region and soil is found to be

0.62, 0.82, 0.86 and 0.76 at each growth stage, respectively. The values of ET_c determined from the lysimeter were validated by Blaney-Morin Nigeria (BMN), Blaney-Criddle (BC) and Hargreaves models, better agreement was recorded between the ET_c calculate from empirical model for the waterleaf using Nash- Sutcliffe efficiency (NSE) and T-test soft wire. Therefore, the study revealed that drainage lysimeter can be said to be functional and efficient to use in the region.

4.2 Recommendations

The results from this study have shown that a locally made, well designed and developed simple drainage lysimeter can be used to generate ET data for waterleaf crop and other similar crops where standard climatic data measurements are not available. Therefore, the following recommendations are onward:

- (i) Since this experiment is season study in a single environment, further research over seasons are required so as to develop reliable values.
- (ii) The experiment should be repeated in similar agro-climatic condition in order to confirm the findings.
- (iii) Similar experiment are needed to be conducted at different agro-ecological zone of Nigeria.

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Utilization of Oil Palm Empty Fruit Bunch Fiber Waste for Microwaves Application

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Abstract: The dielectric properties of high density polyethylene (HDPE) filled with oil palm empty fruit bunch (OPEFB) fiber has been investigated at filler loading 30, 40, 50, 60 and 70 % fiber. Five different composites with dimensions 3.5cm × 6.1cm and thickness 0.62cm were prepared for open ended coaxial probe technique. Also, another five different composites with dimensions 0.228 × 0.114cm and thickness 0.5cm were prepared for rectangular waveguide technique. The HDPE-OPEFB compounding was carried out in a Brabender blending machine and the pellets were made in a mold using hydraulic hot pressed machine. Results shows that for both techniques the permittivity increased with increase in percentage of OPEFB filler contents. Results also shows that the permittivity value is higher at lower frequencies and decreased as the frequency increases. However, the dielectric loss factor for the waveguide show a slight increase with frequency for the 70% and 100% composites which may be attributed to software malfunction.

Keywords: Oil palm fiber, High Density Polytechnic, Dielectric Constant, Loss Factor

INTRODUCTION

Material scientist, researchers and industries in the past decades have been attracted to natural fibers because of their specific advantages as compared to the conventional or synthetic fibers. It is environmentally friendly, and the issue of environment is top at the national and international agenda. Hence, the natural fibers because of its biodegradable nature unlike synthetic fibers has become center of attraction. This is in addition to low cost and low density. (Mohanty, 2002) and (Singha, 2008).

Polymers eg. Polyethylene has been found to be applicable in many field of research in the world today. They are frequently compounded with natural minerals so as to improve their properties. Glass fiber is used to improve the stiffness and strength of thermoplastic material (Sanadi, 1995). Polymer-fiber composites are mostly cheap to produce because the natural fiber is readily available, also it possess improved mechanical and electrical properties (Ibrahim, 2011). This research work is aim finding out the electrical properties of the composites prepared with different ratio of environmentally friendly high density polyethylene (HDPE) and oil palm empty fruit bunch fiber (OPEFB) from 8GHz to 12GHz (X band) in the microwave frequency band. OPEFB is a solid waste and was chosen for this research so that excess waste will be reduced from the environment. The composite product from this research can be used as a substrate in various microwave applications such as microstrip antenna and transmission lines components which can be found in mobile communication, aerospace and defense industry.

In his work (Boudenneb, 2006), reported that the value of dielectric constant decreased as frequency increases. This means that at higher frequency the value of the dielectric constant is low which may be attributed to space charge polarization and likewise the loss factor.

THEORY

A dielectric material simply put, is a capacitor and a resistor in parallel. The current passing through any of such sample would have the real and imaginary part. By so doing, the complex permittivity or relative permittivity, ϵ^* relates to material's ability to respond to the electric field by its polarization.

Relative permittivity can be defined as the measure of the amount of polarization (Kochetov, 2013). The imaginary part represents the loss factor which is a measure of the losses involved in the polarization processes. Permittivity behavior with respect to frequency is very sensitive to material properties influenced by addition of fillers. Any change of the molecular structure of a dielectric will show up if the related polarization phenomena are occurring in the measured frequency range (Andritsch, 2010). The loss tangent $\tan(\delta)$ is the ratio of the loss factor to the dielectric constant.

The permittivity of materials is related to a variety of physical phenomena. Ionic conduction, dipolar relaxation, atomic polarization, and electronic polarization which are the main mechanisms that contribute to the permittivity of a dielectric material. Typical behavior of permittivity (ϵ' and ϵ'') as a function of frequency are shown in Figure 1. At Low frequency range, imaginary permittivity, ϵ'' is dominated by the influence of ion conductivity by free ions. In dielectric spectroscopy, measurement of dielectric and electrical properties of materials are as a function of frequency in time domain. Their measurement is based on the interaction of external electric field with the electric dipole moment and charges of the materials. Three important properties are associated with the properties of dielectric. These properties are as follows (Haj. Lakhdar *et al*, 2014); complex permittivity, complex conductivity and complex electric modulus.

$$\left. \begin{array}{l} \epsilon^* = \epsilon' - j\epsilon'' \\ \sigma^* = \sigma' + j\sigma'' \\ M^* = M' + jM'' \end{array} \right\}$$

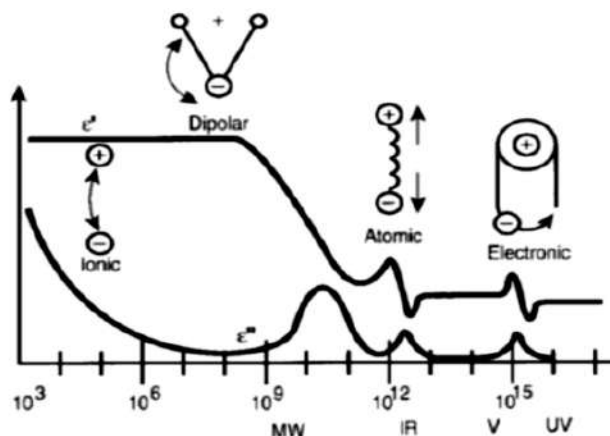


Fig.1: Frequency dependence of permittivity for a hypothetical dielectric material

MATERIALS AND METHODS

Materials

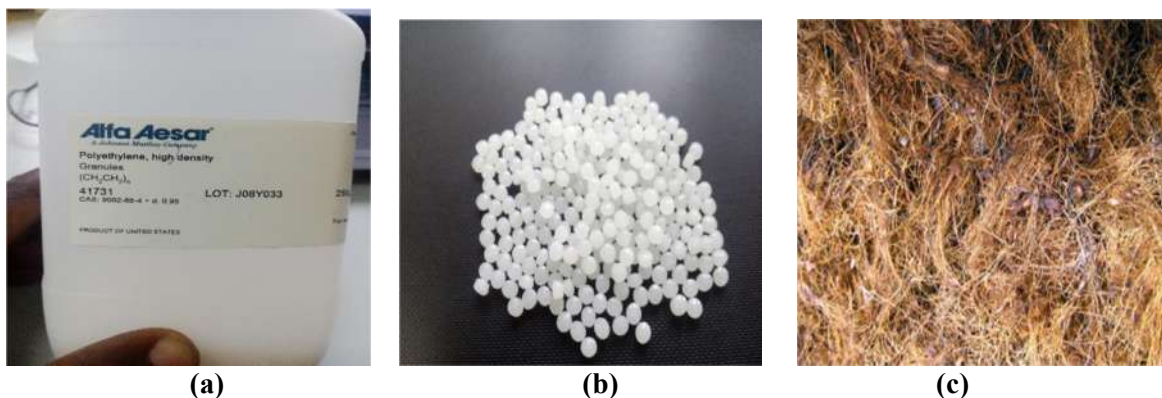


Fig. 2: Photos (a) brand of HDPE (b) HDPE (c) OPEFB

Methods

The oil palm empty fruit bunch (OPEFB) was soaked in distilled water for 24 hours. Then the mixture was heated at about 100°C and removed from the oven. This process was repeated twice. Later, the fiber was filtered and washed with acetone and dried in an oven at 100°C to remove the wax layer of the fibers. The long chains of small molecules of the fiber were then grinded and sieved to the size of 200µm for use in the next step. The compounding of OPEFB and HDPE was carried out in a Brabender blending machine at 150°C with rotor speed at 50 rpm in 15 min of blending. The substrates were prepared by placing 22g of the blends into a mold with the dimension of 3.5x6.1 cm and thickness of 0.8 cm, and for the smaller pellets 6g of the blend was placed into a mold of dimension 0.228 by 0.114cm and thickness 0.5cm. Using a hydraulic hot press machine, the OPEFB-HDPE composites were preheated for 10 minutes with upper and lower platen temperature at 150°C. Breathing time of 8 minutes was allowed to release bubble sand to reduce void. The OPEFB-HDPE composites were then pressed at the same temperature for another 7 minutes at a pressure of 110 k/bar and left to cool at a pressure of around 110 k/bar for 10 minutes.

Table 1: Composition of raw materials used composite preparation

<u>HDPE Granules</u>		<u>OPEFB</u>		<u>Total Mass</u> <u>(g)</u>
<u>Mass (%)</u>	<u>Mass (g)</u>	<u>Mass (%)</u>	<u>Mass (g)</u>	
70.0	35.0	30.0	15.0	50.0
60.0	30.0	40.0	20.0	50.0
50.0	25.0	50.0	25.0	50.0
40.0	20.0	60.0	30.0	50.0
30.0	15.0	70.0	35.0	50.0



Fig. 3: HDPE-OPEFB composite and pellets

Measurement of dielectric properties

Permittivity measurements were performed using two different techniques. First is using open ended coaxial probe (OEC) technique fig. 4a. Secondly, is using rectangular waveguide (RWG) technique based on the Agilent N5230A PNA-L network analyzer fig. 4b.



(a)



(b)

Fig. 4: (a) OEC (b) network analyzer and waveguide

RESULT AND DISCUSSION

Permittivity result using open-ended coaxial probe (OEC)

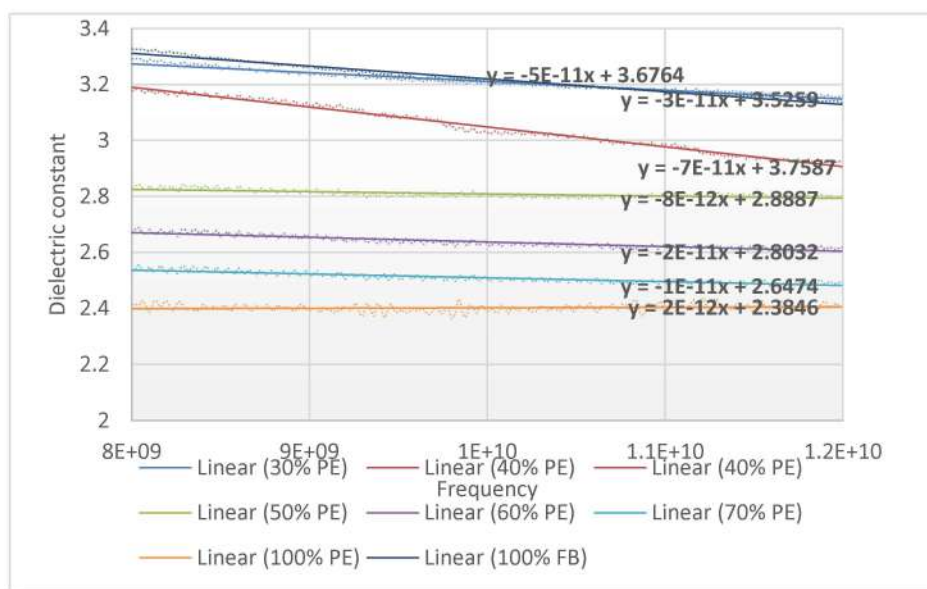


Fig. 5: Variation of dielectric constant with frequency using OEC

Table 2: Trendline equations

Samples	Equations
30% PE	$y = -3E-11x + 3.5259$
40% PE	$y = -7E-11x + 3.7587$
50% PE	$y = -8E-12x + 2.8887$
60% PE	$y = -2E-11x + 2.8032$
70% PE	$y = -1E-11x + 2.6474$
100% PE	$y = 2E-12x + 2.3846$
100% FB	$y = -5E-11x + 3.6764$

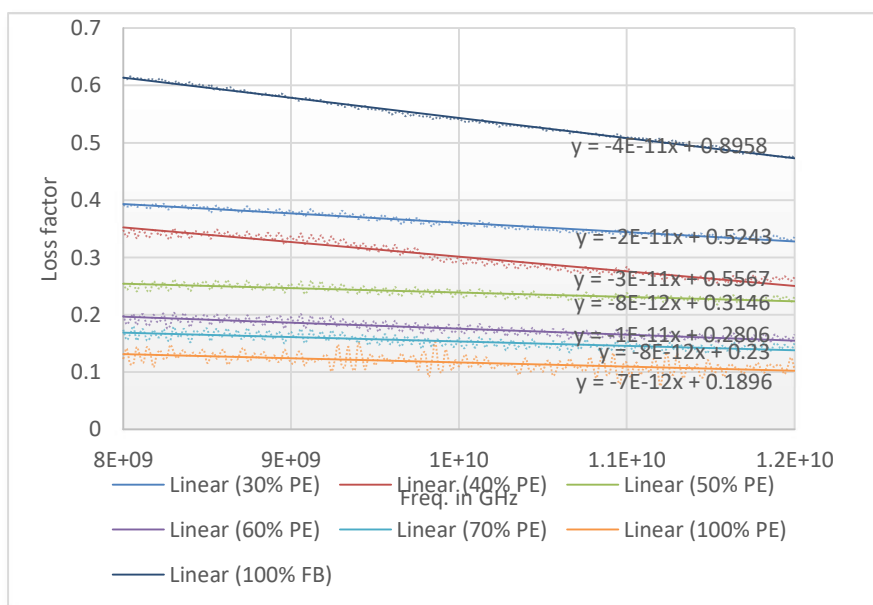


Fig. 6: Variation of loss factor with frequency using OEC

Table 3: Trendline equations

Samples	Equations
30% PE	$y = -2E-11x + 0.5243$
40% PE	$y = -3E-11x + 0.5567$
50% PE	$y = -8E-12x + 0.3146$
60% PE	$y = -1E-11x + 0.2806$
70% PE	$y = -8E-12x + 0.23$
100% PE	$y = -7E-12x + 0.1896$
100% FB	$y = -4E-11x + 0.8958$

For this work, the particle size of the OPEFB chosen is combination of 200 μ m and 300 μ m which gives a higher permittivity values. Dielectric constant of 3.5667 and loss factor of 0.4683.

It is observed from the result that, the value of dielectric constant is smaller for the composite with lower content of OPEFB. However, the value of the dielectric constant increase as the percentage of the OPEFB increase. The composite with high percentage of OPEFB has the highest value of dielectric constant. This result is in agreement with the findings by (Chen *et al*, 2003).

Effective Medium Theory reported that the permittivity of polymer-based composite can be increase by adding fillers with higher permittivity values.

The result shows that the permittivity decrease with frequency for all samples. At higher frequencies the movement of charge cannot keep up with the alternating field, and the polarisation mechanism ceases to contribute to the polarisation of the dielectric. Hence as the frequency increase the material net polarisation drops since each polarisation mechanism ceases to contribute and this give rise to drops in dielectric constant. This decrease in dielectric constant

as filler decreases in a composite as frequency increase is supported by works of (Syeds and Ambika, 2014).

Table 4: Real and Imaginary parts of permittivity for all samples at 8GHz (OEC)

Samples	Dielectric constant	Loss factor	$\epsilon_r = \epsilon' - j\epsilon''$
HDPE	2.4124	0.1226	$2.4124 - j*0.1226$
OPEFB	3.5667	0.4683	$3.5667 - j*0.4683$
HDPE-OPEFB-30%PE	3.2907	0.3917	$3.2907 - j*0.3917$
HDPE-OPEFB-40%PE	3.1773	0.3479	$3.1773 - j*0.3479$
HDPE-OPEFB-50%PE	2.8302	0.2553	$2.8302 - j*0.2553$
HDPE-OPEFB-60%PE	2.6704	0.1995	$2.6704 - j*0.1995$
HDPE-OPEFB-70%PE	2.5327	0.1737	$2.5327 - j*0.1737$

Permittivity result using rectangular waveguide technique (RWG)

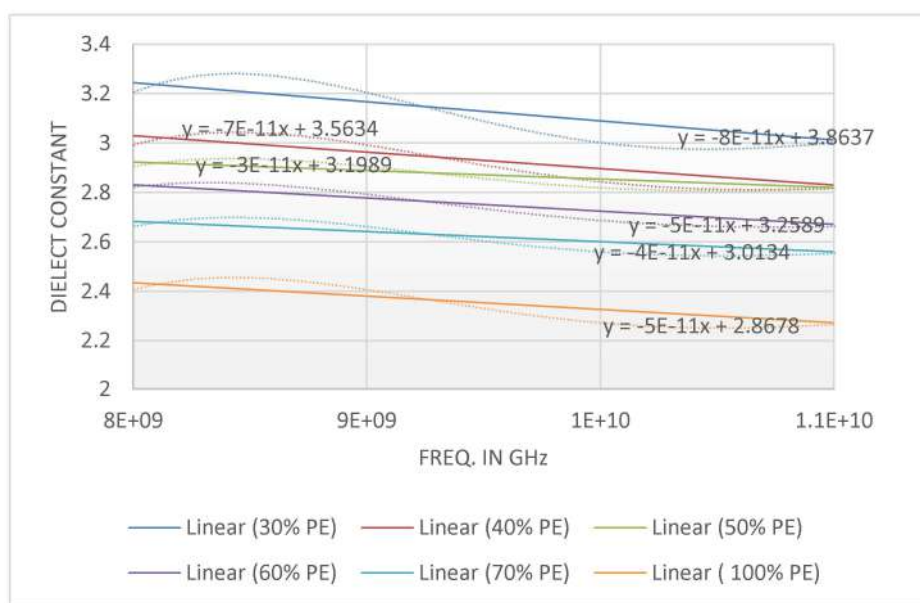


Fig. 7: Variation of dielectric constant with frequency using RWG

Table 5: Trendline equations

Samples	Equations
30% PE	$y = -8E-11x + 3.8637$
40% PE	$y = -7E-11x + 3.5634$
50%PE	$y = -3E-11x + 3.1989$
60% PE	$y = -5E-11x + 3.2589$
70% PE	$y = -4E-11x + 3.0134$
100% PE	$y = -5E-11x + 2.8678$

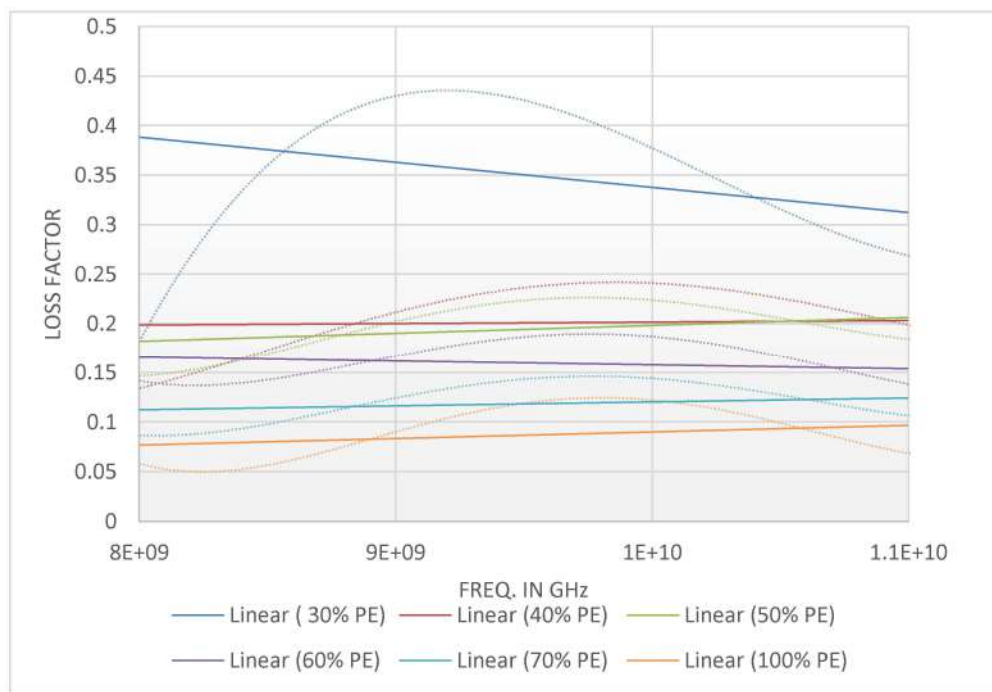


Fig. 8: Variation of loss factor with frequency using RWG

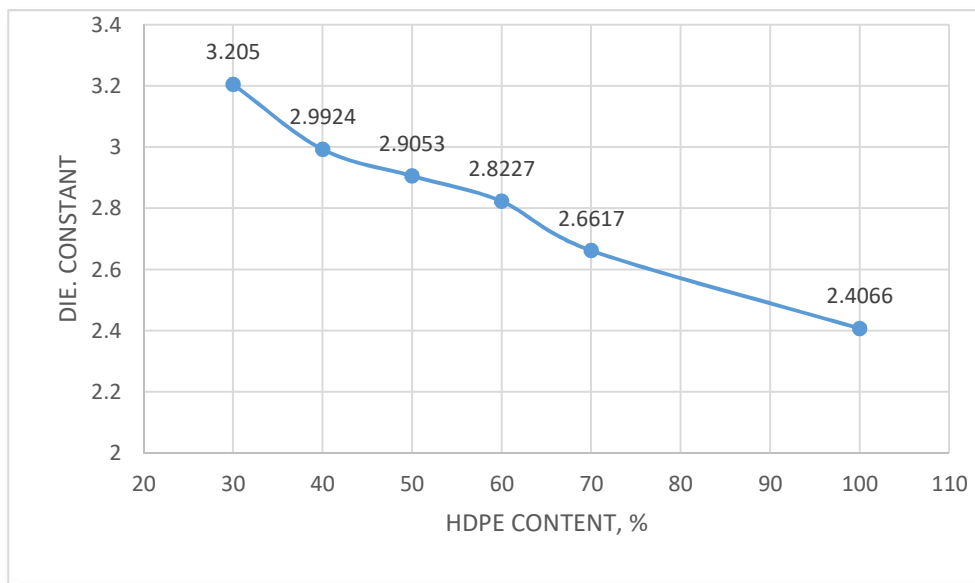


Fig. 9: Variation of dielectric constant with HDPE % content

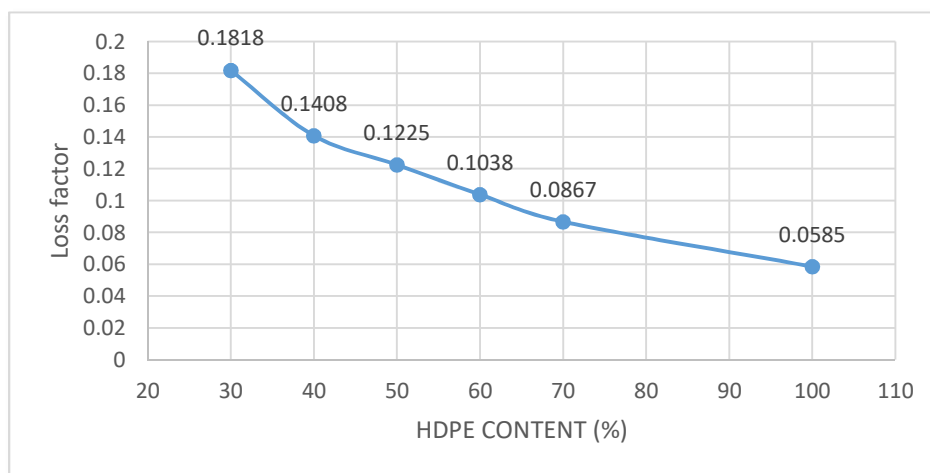


Fig. 10: Variation of loss factor with HDPE % content

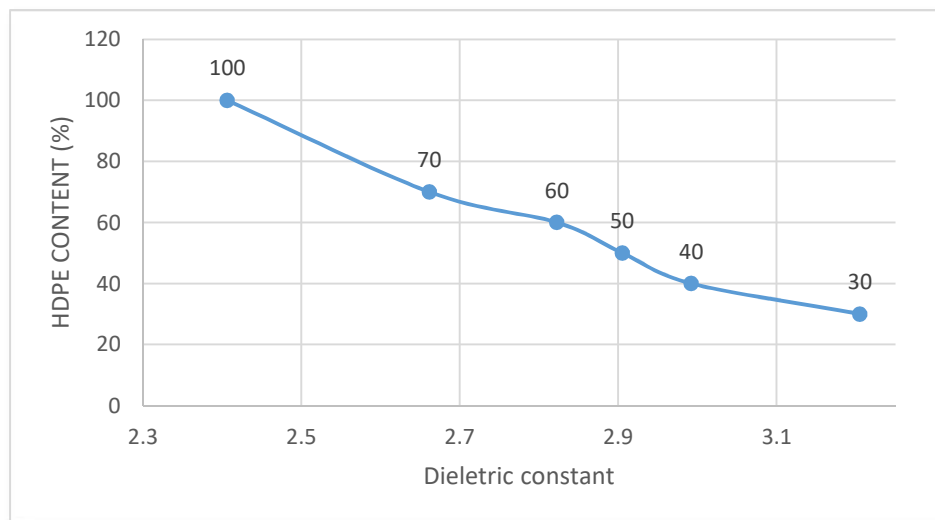


Fig. 11: Variation of HDPE % content with dielectric constant

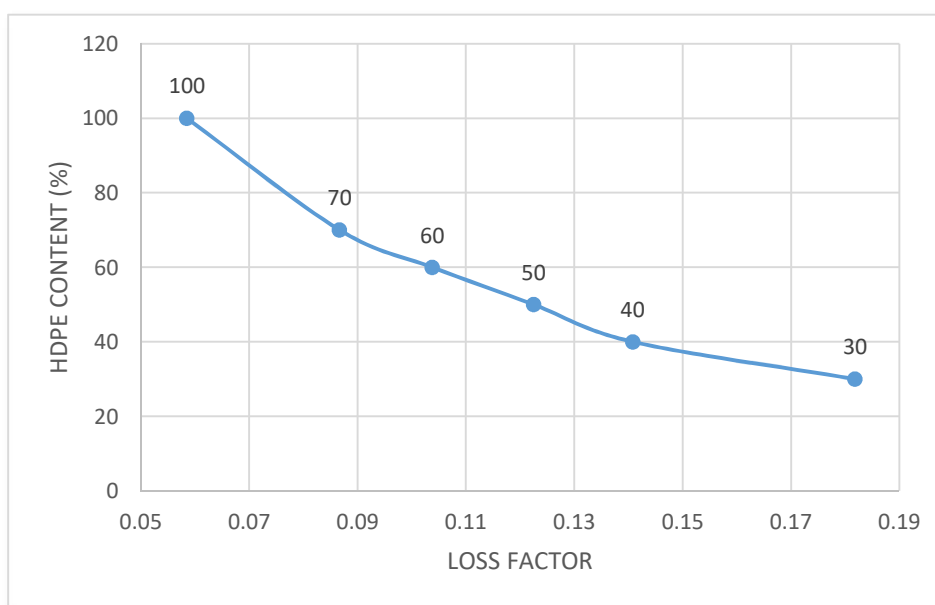


Fig. 12: Variation of HDPE % content with loss factor

From figures 5 and 7 it can be seen that the composite with least % of HDPE (30% HDPE and 70% OPEFB) has the highest permittivity value of 3.205 and this trend decrease as the % of HDPE increases. This trend was reported by (Chen *et al*, 2003). This is because increase in effective dipole moment of the composites due to the polar groups in the filler material. (Faiz, 2013) observed the same trend for coconut fibre-polypropylene composites. The dielectric loss also follows the same trend. Further, high dielectric constant is observed at lower frequencies and is due to the heterogeneous conduction in the multiphase of the composites as reported by (Wang, and Chen, 2012).

Table 6: Real and imaginary parts of permittivity for all samples at 8GHz (RWG)

<u>Samples</u>	<u>Dielectric constant</u>	<u>Loss factor</u>	<u>$\epsilon_r = \epsilon' - j\epsilon''$</u>
HDPE	2.4066	0.0585	$2.4066 - j*0.0585$
OPEFB	3.6000	0.7171	$3.6000 - j*0.7171$
30% HDPE	3.2050	0.1818	$3.2050 - j*0.1818$
40% HDPE	2.9924	0.1338	$2.9924 - j*0.1338$
50% HDPE	2.9053	0.1465	$2.9053 - j*0.1465$
60% HDPE	2.8227	0.1418	$2.8227 - j*0.1418$
70% HDPE	2.4066	0.0867	$2.4066 - j*0.0867$

There is a gradual decrease in loss factor of the composites at frequency of 11GHz which may be in agreement with measurement carried out by (Abdullah et al, 2008). This decrease values of dielectric loss at high frequency of 11GHz for the composites suggests that they are lossless materials at microwave frequencies. (Syeda and Ambika, 2014). The dielectric loss arises due to the localized motion of charge carriers.

Conclusions

In this article, the dielectric properties of HDPE-OPEFB were investigated at frequency range of 8-12GHz (X-band). The result show that the dielectric constant and the loss factor depends on the fiber content loading. The dielectric properties increased with increased percentage of fiber.

Further, the dielectric constant and loss factor are frequency dependent. At lower frequency the values are high and gradually decrease as frequency increase.

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Application of Schlumberger Method to Investigate Sub-Soil Formation in Tudun Wada Area of Maiduguri Metropolis, Northern Nigeria

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Abstract: The geophysical survey, using Vertical Electrical Sounding (VES) adopting Schlumberger configuration were conducted using ABEM SAS Terrameter, across Tudun Wada area of Maiduguri Metropolis Northeast Nigeria to evaluate the soil potential of the area. Based on interpretation by Computer software Interpex IXID. All of the sounding points sample revealed three geo-electric layers/geologic units. The geologic units with hydro geologic significance include; first layer, second layer and third layer and characterized resistivity values range from 11.057-2044 Ωm , 1.7731-65.851 Ωm respectively. The layer thickness of the first and second layer vary from 6.1081- 0.50383 m and 0.71006-18.326 m.

Keywords: Resistivity, Delineate, Lithology, Maiduguri, Vertical Electrical Sounding

I. Introduction

Site investigation and estimation of soil settlement characteristics are essential parts of a geotechnical design process. Geotechnical engineers must determine the average values and variability of soil properties (Al-Jabban M.J.W (2013).

Geophysical methods are used for the delineation of subsurface sequence, identification of geological structures and determination of physical parameters of rock formations. These information enhance rapid characterization of subsurface formations, identification of competent subsurface layers, determination of thickness and depth required for the design of civil engineering foundation. Virtually all civil engineering structures (e.g roads, dams, runways, bridges e.t.c) are sited on earth materials (soils, regolith or rocks). Investigating the subsurface at a proposed site to ascertain fitness of the host earth materials is important prior to the design of such structures (Olorunfemi et al., 2004). Geotechnical and civil engineering structure failure could result from the nature of the subsoil, undetected near-surface/subsurface geological structures, features induced by anthropogenic activities or inhomogeneities in soils and geomaterials constituting the foundation (Olorunfemi et al., 2000a; Olorunfemi et al., 2000b, Oladapo et al., 2008; Akintorinwa et al., 2011 and Fatoba, 2012). Such anomalous features are amenable to geophysical delineation (Olorunfemi, 2008).

Soil will be threatened if losses it water during drought causing foundation to settle near the perimeter where the soil dries most quickly. The interaction between soils and solid materials is one of the main problems encountered in civil engineering practice, such as: retaining walls, pile foundations, shallow foundations, earth reinforcement and earth dams. The friction between different construction materials and soils postulating that the most important factors affecting the friction are: normal stress level, moisture content, roughness and soil composition.

II. Material And Methods

Tudun Wada area is situated few meters behind the Department of Security Services (DSS) and bordered from east and west by Yerwa Government Girls Secondary School and PHCN Bulunkuttu Unit Maiduguri respectively. It is located between latitudes $11^{\circ}50'$ and $50^{\circ}24'$ N and longitudes $13^{\circ}06'$ and $13^{\circ}07'$ E. Lateritic soil is usually considered as a good natural foundation and building material.

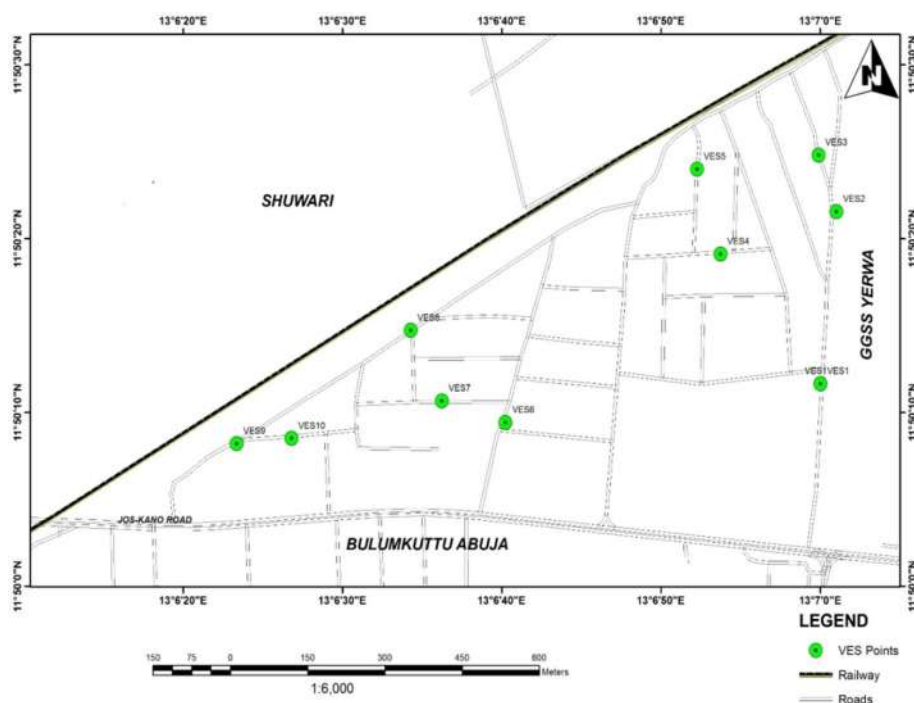


Figure 1: Map of the study area indicating sounded 10 points

Data Collection: In geophysical surveys, the Terremeter SAS 300 permits natural or induced signals to be measured at extremely low power consumption. Moreover, it can be used in a wide variety of application where effective signal noise discrimination is needed. In the resistivity mode, it comprises a battery powered, deep-penetration resistivity meter with an output sufficient for a current electrode separation of 2000 m under good surveying condition. Discrimination circuitry and programming separates DC voltage, self-potential and noise from the incoming signal. The resistance V/I is calculated automatically and displayed in digital form in kilo-ohms ($k\Omega$), or milli-ohms ($m\Omega$). The Terremeter SAS 300 contains three main units, all housed in a single casing: the transmitter, the receiver and the microprocessor. The electrically isolated transmitter sends out well-defined and regulated signal currents. The receiver discriminates noise and measures voltage correlated with transmitted signal current (resistivity surveying mode).

Table 1: Apparent Resistivity Data for the Ten VES Points

AB/2	MN/2	VES1	VES2	VES3	VES4	VES5	VES6	VES7	VES8	VES9	VES10
1.0	0.2	70.01	71.01	800.0	55.01	50.01	30.01	70.01	58.01	900.5	25.86
1.5	0.2	67.83	37.54	558.6	53.54	45.47	28.31	10.72	32.48	492.4	26.30
2.0	0.2	60.84	37.74	498.1	52.22	40.30	22.38	10.74	18.35	146.5	25.93
2.5	0.2	49.15	36.87	373.3	52.08	38.27	19.98	10.30	13.83	79.29	25.44
3.0	0.2	38.66	37.44	257.9	54.75	36.42	18.98	10.82	12.97	72.26	26.07
4.0	0.2	30.11	35.58	149.0	54.64	34.41	16.88	9.460	12.56	60.41	25.55
5.0	0.2	27.15	34.69	97.71	52.51	31.45	15.01	9.980	12.14	47.90	24.41
6.5	0.2	25.15	35.06	76.79	53.33	32.45	16.72	11.23	13.24	47.86	25.06
8.0	0.2	23.01	30.13	77.69	51.83	33.46	18.09	5.690	17.56	50.29	22.9
10	0.2	20.82	28.65	65.72	49.23	37.60	20.49	14.03	16.88	50.18	22.30
8.0	1.5	20.15	25.00	64.75	48.23	36.78	20.23	15.23	15.98	50.29	21.45
10	1.5	19.26	25.18	63.69	48.89	37.18	21.89	16.78	18.21	49.98	23.43
13	1.5	20.03	25.02	68.99	47.13	40.81	26.74	15.52	19.95	49.85	22.49
16	1.5	20.95	25.62	70.34	47.13	41.22	32.88	16.52	23.36	51.23	24.33
20	1.5	25.82	30.79	75.92	40.71	43.26	35.17	19.73	28.01	50.60	24.67
25	1.5	28.3	32.99	75.69	38.92	47.87	52.67	24.08	36.56	51.83	27.95
30	1.5	29.45	34.00	75.04	35.38	45.31	55.11	31.65	45.42	55.25	37.42
40	1.5	30.94	33.23	90.81	30.61	49.50	68.92	40.32	58.65	70.74	46.91
50	1.5	32.28	32.81	96.10	29.46	48.89	87.15	45.22	65.53	83.75	47.40
65	1.5	30.44	30.89	100.1	27.94	52.16	95.99	50.07	77.95	88.04	60.35
80	1.5	33.56	29.93	110.2	28.04	53.91	100.8	50.06	82.71	90.32	61.63
100	1.5	35.12	35.56	120.2	35.02	52.93	131.0	48.20	89.38	100.2	63.61

Data Processing: Interpex is a software company dedicated to the production of high quality affordable software for the processing, interpretation and display of geophysical data. The Model Entry dialog box allows for dynamic column and row manipulations to make model entry more convenient. Either the layer thickness (or depth) and/or the resistivity can be fixed in the inversion process. Forward and inverse model calculations can be carried out using buttons on the model entry dialog. Models can be inverted using either the layer depth or layer thickness. Graphics are presented as the Sounding data on the left hand side with the model on the right hand side. Interactive property sheets allows for user configuration of displayed data. For DC and IP data, the model can be displayed on the same axes as the data. Menu commands and toolbar buttons are available for estimating a layered model (DC and IP data only), estimating a smooth model or analyzing equivalence of the layered model. Forward modeling, inverse modeling, smooth model estimation and equivalence analysis can be carried out individually. Profiles and soundings can be selected by name or by point and click at a map location. Soundings on a profile can

be selected by point and click on a profile location. A model can be copied to the model clipboard and then back to an individual sounding, all soundings on a profile or to every sounding in the database. Consequently, data obtained was apparent resistivity of the area under study though the data was characterized by some errors. In order to obtain better model or near precise data were smoothened and alternative model was displayed alongside the original curve and each time the curves smoothened, the raw data was also adjusted to the required values. The data afterward was fed in to computer for interpretation, analyses and credible conclusion

III. Result

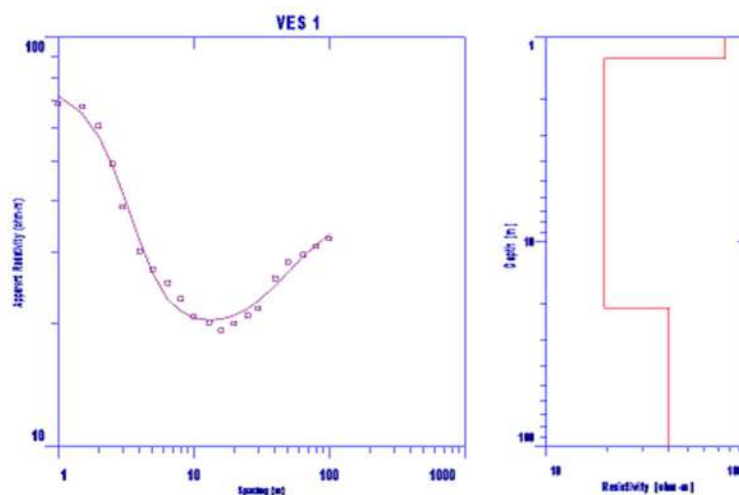
Data generated from the Vertical Electrical Sounding using Schlumberger configuration were presented as Geoelectric sounding curve and Geoelectric section. Geoelectric section shows the subsurface layers, resistivity, depth and thickness while Geoelectric Sounding Curves were obtained by plotting the apparent resistivity value against the electrode spacing using Computer software IX1D for interpretation. All of which were iterated thereafter on the computer with the same software program, to minimize as much as possible the errors which yield near better curves.

Table 2: Summary of Interpretation of data

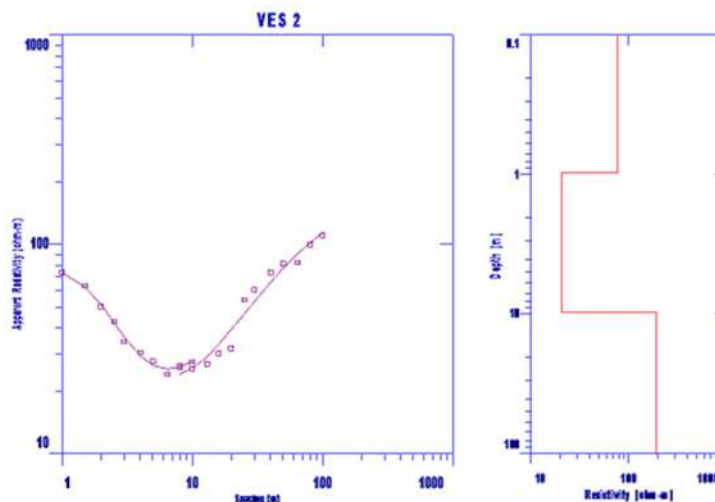
VES	$\rho(\Omega m)$	Thickness (m)	Depth (m)	Lithology	Curve type	Elevation (m)	Error %
1	76.292	1.2654	1.2654	-clay	H	-1.2654	4.94
	19.445	19.651	20.916	-unconsolidated wet clay		-20.916	
	40.231			-sandy clay			
2	38.145	4.9732	4.9732	-clay sand	H	-4.9732	2.95
	9.0897	2.6503	7.6235	Wet clay		-7.6235	
	36.254						
3	831.42	1.1162	1.1162	-laterite	H	1.1162	4.38
	65.815	18.326	19.442	-sandy		19.442	
	142.86			-silty			
4	53.221	11.959	11.959	-sandy clay	Q	-11.959	2.89
	21.875	57.263	69.222	-clay		-69.222	
	214.80			-sand			
5	49.913	1.1381	1.1381	-sandy clay	H	-1.1381	2.63
	25.633	3.2314	4.3695	-clay		-4.3695	
	53.082			-sand			
6	29.115	1.5769	1.5769	-clay fresh water	H	-1.5769	5.92
	5.1829	1.9252	3.5021	-fresh ground water		-3.5021	
	229.79			-sand and gravel			
7	11.057	2.5005	2.5005	-fresh ground water	K	-2.5005	17.58
	2.3597	1.2811	3.7816	-fresh ground water		-3.7816	

	89.647			-dry clay			
8	118.17	0.48792	0.48792	-laterite	H	-0.48792	6.46
	11.058	6.1081	6.5961	-fresh ground water		-6.5961	
	169.29			-laterite			
9	2044.0	0.50383	0.50383	-dry clay	H	-0.50383	9.50
	48.653	20.614	21.118	-laterite		-21.118	
	146.87						
10	26.208	5.4963	5.4963	-clay	H	-5.4963	4.95
	1.7731	0.71006	6.2063	-dry clay		-6.2063	
	100.06						

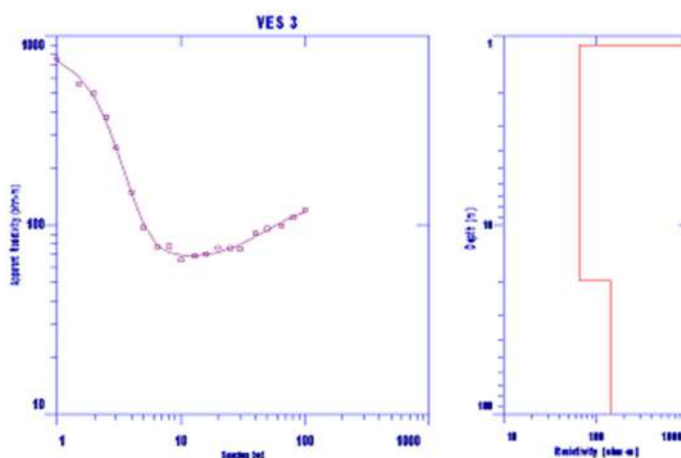
The interpretation of vertical electrical sounding (VES) data for the survey is quantitative. The following are display of the interpreted data.



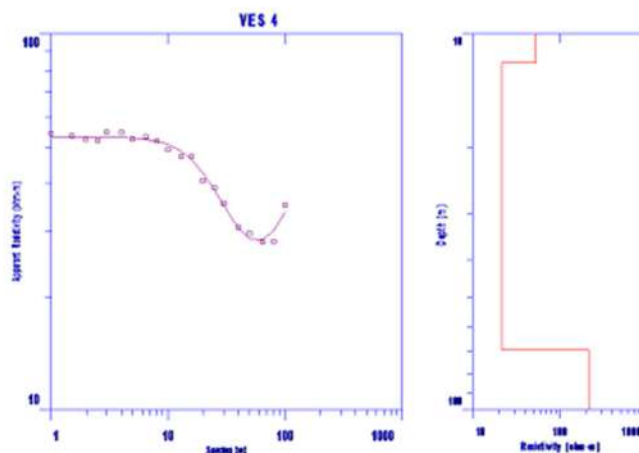
VES 1: The VES show a three layer succession with first two layers having thickness of 1.2654 m and 19.651 m respectively, and the last layer of infinite thickness. This is a type H curve indicating a dry layer under laid by water saturated layer. If the first and second layer made up of same materials will they have the resistivity in this range 19.445 Ω m? But the other section is saturated. If in the same vein the material of third layer with resistivity of 40.231 Ω m which is over laid by moist region is same as layer two, can they have low resistance but only part of it is saturated with water. The sounding point has a fitting error of 4.94%.



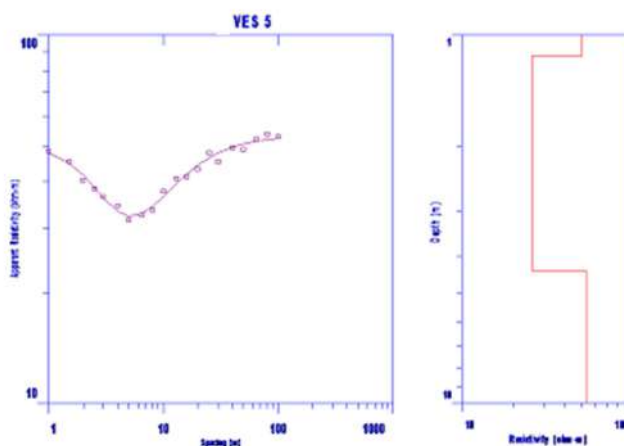
VES 2: This VES point with a fittings error 2.95% is related to the last layer but thickness of first layers differs the former is thinner with value 1.265 m while the latter is thicker with 4.9732 m . It has a three-layer case revealing a high resistance of 38.145 Ωm in the first layer under laid by moisture layer with resistivity of 9.0897 Ωm . If both layers contain the same material will they have same low resistivity? But with one section saturated with water, would they have same formation if the resistivities of third and second layer are the same low resistance with one part saturated with water? The lithologies in this sounding point are sandy clay, wet clay and claye sand. It is H type curve.



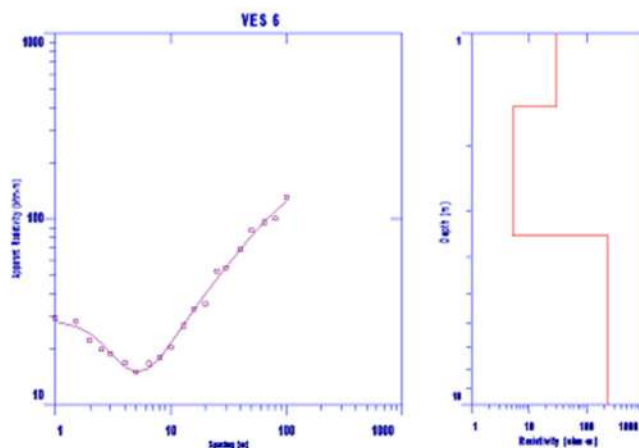
VES 3: Three layer cases were sample in this VES point with 4.38%. It is thinner with thickness of 1.1162 m than the previous two but related in same pattern with high resistivity of 831.42 Ωm under laid by moist region with resistance of 65.815 Ωm at just depth of 19.442 m . If these two layers have same materials will they have same low resistivity? But one part is moist. If in the same vein the second and third layers are dominated by same material, will they have similar resistivity but section of it is, saturated with water. This is H type sounding point with laterite, sandy and silty formation.



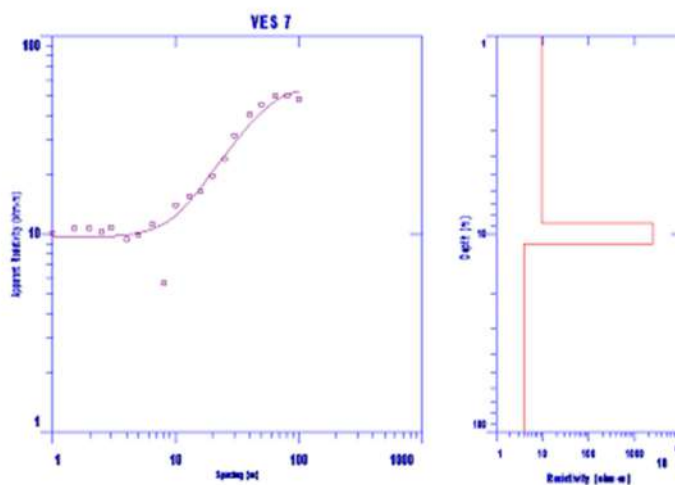
VES 4: The VES show a three-layer succession with first two layers having thickness of 11.959 m and 69.222 m respectively and the last layer of infinite thickness. This sample point is different from the previous ones in that it is *Q* type curve. Will the low resistivity of 21.875 Ωm be attributed to all three layers if supposing made up of same material with one part saturated with water? This VES point has a lithology of sandy clay, clay and sand.



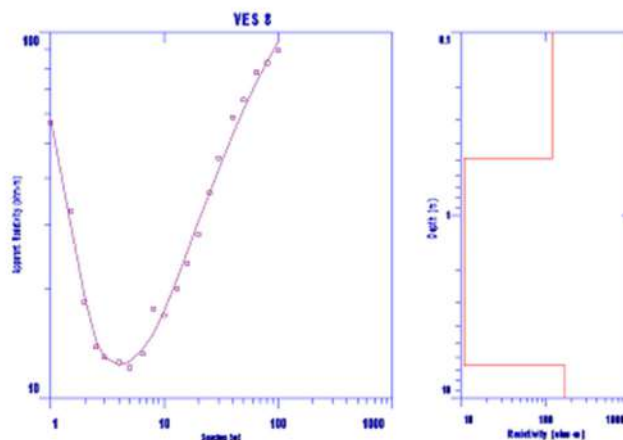
VES 5: This profile with less than 3% fitting error recorded three layers. It has a similarity with previous VES points but it is thinner in first layer which pervious with resistivity of 49.913 Ωm under laid by moisture content layer with value 25.633 Ωm . If the layer is occupied by same material will they have same low resistance with one part domicile with moisture? The infinitely layer with 53.083 Ωm , if having a similar low resistance with the layer two, can the material in the sub surface be same with one part saturated with water? The formations are sandy clay, clay and sand. This is a type *H* curve.



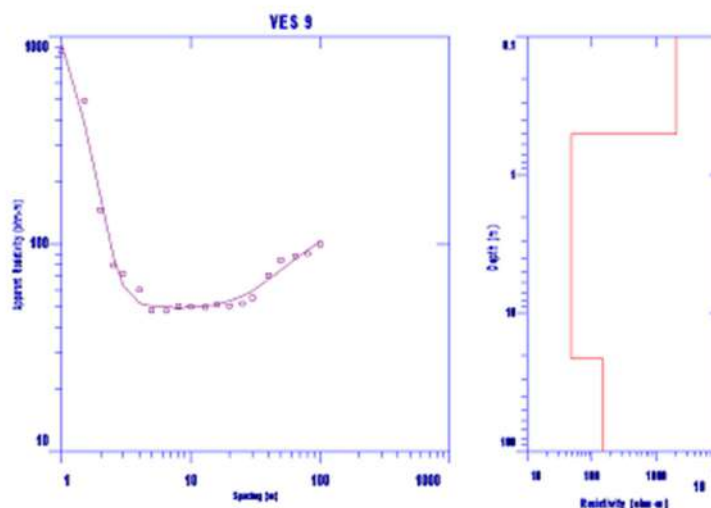
VES 6: This sounding point with fitting error of 5.92% has succession of three layers. It has similarity with above layers but the first and second layer with thin values 1.5769 m and 1.9252 m respectively. The first and second layers are dominated by low resistivity of 29.115 Ωm and 5.1829 Ωm material because both are water saturated region. In the other hand third layer is impervious because it has a very high resistivity of 229.29 Ωm . The lithologies are clay fresh water, fresh ground water and sand and gravel. It is type *H* curve.



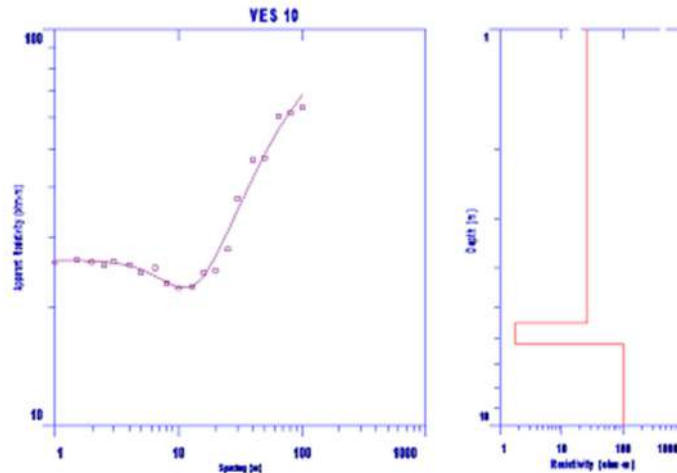
VES 7: Three-layer case profiled with fitting error up to 17.58%. The first and second layers have low resistivity of 11.057 Ωm and 2.3597 Ωm at a depth of 2.5005 m and 1.2811 m respectively. In third layer the resistivity gone up 89.647 Ωm because of impermeable nature of the material. The first and second layers are made up of same materials which differ from the rest of the VES points discussed. This gives the evident for heterogeneity of the earth. It has a following formations fresh ground water, fresh ground water and dry clay. It is type *K* curve.



VES 8: This sounding point has a sequence of three layers profile with a fitting error of 6.46%. It is however, related to the rest of the sounding points because first dry layer with value $118.17 \Omega m$ under laid low resistance of $11.058 \Omega m$. If supposedly, having the same material will the resistivity be conformed to low with one section of it is saturated with moisture. The infinite layer under laid by low resistance, has a high resistivity of $169.69 \Omega m$ dominated by laterite material while the first two are made up of laterite and fresh ground water. Layer two of the proceeding VES point is related to this second layer in the formation which fresh ground water.



VES 9: This shows a three layer with fitting error of 9.50%. Layer one has a high resistance of $2044.0 \Omega m$ at very thin thickness of less than $1 m$ indicating very dry zone under lay by moist layer at very lengthy depth of $21.118 m$. beneath this layer is another dry section with high resistivity of $146.87 \Omega m$. There is a similarity between this and the last sounding point. If layer one and two contain same material will they have same low resistivity with one section dominated by moisture? Same apply to layer second and third, if made up of same material can they have similar resistivity but only one part is moist. It has lithologies of dry clay and laterite and it is type *H* curve.



VES 10: In this VES point three layers sample having a fitting error 4.95%. This profile has a very good relationship but thicker than most of the VES points and has a resistivity of $26.208 \Omega m$ with thickness of $5.4963 m$ under lain another water saturated zone at a depth of $6.2063 m$ with resistivity of $1.7731 \Omega m$ but in third layer the resistivity gone up to $100.06 \Omega m$. if these three layers were made of same material will they have same low resistivity? But one section is dry. The lithologies are clay, wet clay and dry clay and a type *H* curve.

IV. Discussion

The Vertical Electrical Sounding modelling carried out in 10 VES stations was used to derive the geo-electric section of various profile; which indicate the existence of three geologic layers in the study area in each VES points where the survey was carried out. This comprised of first layer, second layer and third layer. The layer one consists of sandy soil or gravel with resistivity range from $11.057 \Omega m$ to $2044.0 \Omega m$ and thickness range from $0.48792 m$ to $11.959 m$. There is some small content of moist material suspected to be clay indicated by the low value of resistivity which was referred to as VES 6, 7 and 10. All were drilled in the same side of the tar road in the west side. The layer two has a resistivity ranges from $1.7731 \Omega m$ to $65.815 \Omega m$ thickness varies from $0.71006 m$ to $57.263 m$ which is highest layer in terms of thickness and it is in the VES 4, which is more appropriate for other geophysical activities especially Drilling of Boreholes, due to a probable high water content. The layer three has a resistivity ranges from $36.254 \Omega m$ to $229.79 \Omega m$ which move infinitely in depth. Therefore the bedrock from topsoil or earth's surface ranges from $1.1162 m$ to $69.222 m$ respectively.

Furthermore, it is observe that the geo - electric curve type identified in the area with the exception of VES 4 and 7 which are *Q* and *K* respectively, the rest are *H*. Therefore, from the data analysis of the curve types, curve *H* is most dominants in the area. However, the resistivity distribution reveals that, the resistivity is lowest in the most part of the area with value $1.7731 \Omega m$ at just less than 1 m which is found in the western part of the area. From the indication of the data analysis the study area is underlain by clay soil which has an adverse effect on foundation due it contraction and expanding nature thereby causing crack on building structures. Clear evidence of a structure problem is the appearance of cracks on column or beams. Vertical cracks are more problematic than horizontal ones. Cracks on walls appear in most new buildings which are the result of the settlement of foundations; although depending on circumstances they could appear also in the older buildings. Some cracks, which are classed as (hairings) can be repaired and should not create a serious problem if repaired with a coat of paint. If these cracks however continue to appear and the gap becomes larger, this is something more serious.

V. Conclusion

Vertical Electrical Sounding (VES) technique carried out at 10 VES stations in Tudun Wada area of Maiduguri Metropolis Northeast Nigeria to reveal the soil potential of the area. Computer aided interpretation of the VES data showed that the model curves consist of mainly K , Q and H with three geoelectric layers/geologic units. The result of successful Electrical Drilling indicates that top soils are mostly dominated by dry material suspected to be either sand or gravel while in the second layer significance amount of moisture content is observed base on the pattern of resistivity value ranges from 11.057-2044 Ωm , 1.7731-65.851 Ωm respectively. However by considering the result obtained it is an indication that the study area has a good land for boreholes and other Engineering and Architectural activities, due to the features that enhance. The geophysical investigation carried in the area using Schlumberger array further delineated that the area is underlain by clay soil manifest itself in form of cracks.

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Oil Removal Potential of Indigenous Bacterial Consortium Isolated from Oil Contaminated Site in Maiduguri

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Abstract: The aim of this work was to test the ability of microbes domicile on oil contaminated soil to break the hydrocarbon pollutant, hence the isolation and oil removal by bacterial consortium were analysed using soil obtained from different mechanical workshop within Maiduguri metropolitan council out of the 96 different samples collected sample, 5 different bacterial isolates were found to be present in all samples viz *Bacillus subtilis*, *P. Aeruginosa*, *Corynebacterium* sp, *E. coli* and *Staphylococcus aureus* with microbial load ranges from 4×10^4 to 6×10^3 respectively. The level of removal was analysed by spectrometry analysis using measurement of initial and final concentration. A maximum of 84% removal was observed and minimum of 80% was also observed.

Keywords: Contamination, Oil, Bacteria, Removal

Introduction

Pollution is defined as the presence of chemical substances such as oil spills and other waste products out of place or present at a higher quantity than the normal concentration that has undesirable effects on a living organism (FAO and ITPS, 2015). Although the mainstreams of pollutants have human origins, some contaminants can arise naturally in the environment as products of mineralisation and can be toxic at certain concentrations. The diversity of contaminants is constantly increasing due to agrochemical, petrochemical and industrial developments. The effects of soil and water contamination also depend on soil properties since these controls the mobility, bioavailability, and residence time of contaminants (Rodríguez-Eugenio et al, 2018)

Petroleum-based products are the most important energy source worldwide used for many industrial and domestic applications; it is made up of hundreds to thousands of aromatic hydrocarbons and aliphatic hydrocarbons (Yuniati, 2018). Petroleum is complex mixtures of hydrocarbon and its derivatives including naphthenes e.g. cyclohexane, aromatics, paraffin e.g. methane, it is one of the major sources of energy than natural gas. These phenomena occur naturally underneath the earth's surface after decomposition of organic matter for million years ago (ITOPF, 2017). Petroleum hydrocarbons can be regarded as containing mixtures of compound categorised as saturated aromatic hydrocarbons (phenolic compounds, fatty acids, ketones, esters, and porphyrins), alkanes (linear, branched), and resins (pyridines, carbazoles

quinolines, carbazoles, sulfoxides, and amides). Hydrocarbons containing single bonds are called saturates. Saturates represent the highest percentage of crude oil constituents (Ionescu, 2013).

The general petroleum is hydrocarbons which have a great discrepancy in their individual molecular configuration. Moreover, the simplest hydrocarbons are the paraffin that forms natural gas, liquids that are refined into crystalline waxes and gasoline (Speight, 2014). The aliphatic hydrocarbons are composed of normal alkanes and branched alkanes (C_nH_{2n+2}), with n representing a number (Abdul-Hamid, 2013). Complexities in the structure of the petroleum hydrocarbons limit the success of biotransformation of crude oil constituents and hence the inability of the microorganisms to metabolize the products in short period of time (Zhou et al, 2012). Similarly, the susceptibility of hydrocarbons to biotransformation can be associated with structural complexity and orientations (Speight and Arjoon, 2012).

Linear alkanes appeared to be the most complex in bio-transformation; this is followed by branched alkanes, then small aromatics and less complex susceptible to biotransformation, cyclic alkanes. High molecular weight aromatic hydrocarbons proved very difficult to be transformed by organisms (Speight and Arjoon, 2012). Oil is also classified as cracked products, gasoline and jet fuels simply because of environmental effects such as difficulty in cleanup and high volatility. (Alimohammadi, et al 2017; Duke, 2016).

Oil readily get into the atmosphere and causes pollution in copious ways including Leaking, accidental discharge or during the process of exploration, manufacture, purifications, transportations, as well as storage of petroleum product. Most magnitude of natural crude oil spillage was estimated to be six hundred thousand metric tons annually and thirty to 50 per cent (30–50%) of oil spills are either directly or indirectly caused by human error, with twenty to forty per cent (20–40%) of all spills caused by equipment failures or malfunction. These Releases of hydrocarbons pollutant to the environment as a result of accident or due to unusual human activities is the main causes of water and soil pollution (Coral and Karagoz, 2005).

Methodology

Sample Collection

Contaminated soil was collected from different car repair workshops in the study area (Maiduguri, Borno state). The contaminated soil was taken from the surface and at five centimetres below the surface. The samples were put into sterile plastic bags and kept at low degrees Celsius.

Preparation

The Bushnell Hass broth was prepared according to the manufacturer's guidelines (Himedia): 3.27g of the powdered Bushnell Hass broth in 1000 ml of water. This was prepared and dispensed into various sized conical flasks; the sample was subjected to vigorous shaken for the powder to be properly dissolved. It was then sterilized in an autoclave at 121°C for 20 minutes. The bacterial consortium was inoculated onto the prepared and sterilized Bushnell Hass broth and 1% oil was added to the broth to serve as carbon supply. The Bushnell Hass broth was incubated at the temperature of 37°C for 24h.

Beads prepared from sodium alginate an inoculated with bacterial consortium, used oil were added and read. Serial dilution was performed up 6×10^5 to obtain the bacterial load on the soil. The colonies obtained were sub cultured unto Blood agar, Mc Conkey agar, EMB agar and further biochemical test were conducted.

Results and Discussion

Oil removal by bacterial consortium

		OD @ 480 nm					OD	
	Time	Initial concentration	I	II	III	Mean	Removal	Removal %
1	24	0.51	0.031	0.036	0.034	0.08	0.43	84.641
2	48	0.51	0.042	0.041	0.031	0.09	0.42	81.699
3	72	0.51	0.035	0.042	0.045	0.09	0.42	81.961
4	96	0.51	0.043	0.041	0.04	0.10	0.41	80.915
5	120	0.51	0.042	0.042	0.045	0.10	0.41	80.588
6	144	0.51	0.044	0.041	0.04	0.10	0.41	80.719
7	168	0.51	0.043	0.042	0.04	0.10	0.41	80.719

Bacterial isolate from oil contaminated site

Sample	Bacterial isolates	Bacterial Load
1	<i>Pseudomonas aeruginosa</i> , <i>Staphylococcus aureus</i>	4×10^4 ,,
2	<i>Pseudomonas aeruginosa</i> , <i>Staphylococcus aureus</i>	4×10^3 5×10^4
3	<i>Bacillus subtilis</i>	,,
4	<i>Corynebacterium sp</i>	6×10^3
5	<i>E. coli</i>	4×10^4

Base on the outcome of this research work conducted to investigate the presence of bacteria as well as its bacterial load from a soil sample, 5 different bacterial isolates were found to be present in all samples viz *Bacillus subtilis*, *P. Aeruginosa*, *Corynebacterium sp*, *E. coli* and *Staphylococcus aureus* with microbial load of ranges from 4×10^4 to 6×10^3 respectively. According Brooijmans et al (2009), bacteria strains such as *Bacillus subtilis*, *Burkholderia*, *Aeromicrobium*, *Gordonia*, *Brevibacterium*, *Corynebacterium sp* *Pseudomonas fluorescens*, *P. aeruginosa*, *Bacillus sp.*, *Acinetobacter lwoffii*, *Flavobacterium sp.*, *Micrococcus roseus*, and *Alcaligenes sp.*, Among total of 94 isolates only 6 of them were able to grow on petroleum containing agar media showing their ability to use hydrocarbon as their carbon source

The rate of oil removal in relation to time was completed, within the 168 (7days) hours analysed oil removal was more at the first 24 hours with slight decline till the last 168 hours.

Biodegradation take days or months to commence despite the addition of nutrient but adapted bacteria takes less time. Maximum oil removal was attained at 30 min. Oil removal potential of bacterial consortium obtained from contaminated site and immobilized on alginate beads was analysed using various environmental factors such as time and concentration. The consortium was isolated species of bacteria were responsible for the job, similarly. Species from the isolated bacteria were confirmed to have a history of petroleum biodegradation. The level of removal was analysed by spectrometry analysis using measurement of initial and final concentration. A maximum of 84% removal was observed and minimum of 80% was also observed.

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Characterization of *Fusarium Oxysporum* Associated with Tomato Infection

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Abstract: Tomatoes are still susceptible to *Fusarium* wilt diseases caused by *Fusarium oxysporum* f. sp. *lycopersici*. The disease is the responsible for great losses in tomato production across the globe, more especially during Warmer climates, as such a study was conducted to asses the prevalence of *Fusarium oxysporum* Associated with Tomato Infection in some farms within Maiduguri to ascertain it involvement in tomato spoilage, samples were collected from farms and were analysed the results showed the most in vitro radial growth after incubation. A total of 5 storage fungi were recovered from tomato. The result indicates, *Aspergillus niger*, *Penicillium* species, *Aspergillus flavus*, and *Alternaria alternata*, *Fusarium oxysporum* has the highest frequency. Out of the total of 9 equivalents to 47% were *Fusarium oxysporum* while 10 equivalents to 53% were other fungi, this showed that *Fusarium oxysporum* is most prevalent in tomato infection within the studied sample.

Keywords: *Fusarium oxysporum*, Tomato, Fungi, Infection

Introduction

Fusarium oxysporum has a wide-reaching distribution in soil and are found in rhizosphere of many plant species. It is an anamorphic species that cause several diseases such as vascular wilt, yellows, corm rot, root rot and damping-off (Gordon and Martyn, 1997). Despite various genetic modifications in advancement of deferent varieties of *F. oxysporum*, that are resistant to tomato, the tomatos are still susceptible to *Fusarium* wilt diseases caused by *Fusarium oxysporum* f. sp. *lycopersici*. The disease is the responsible for great losses in tomato production across the globe, more especially during Warmer climates (Onyekachukwu and Adefoyeke, 2017). Some strains that induce root rots or vascular wilts are accountable for enormous yield losses on crops of economical importance including tomato, chickpea, wheat, beans, cucumber etc. Higher incidence of the wilt may inflict a yield decline of up to 5q/h in chickpea. *Fusarium* wilt is also a major limiting factor in tomato production which adversely affect yield by causing damage of up to 15% annual loss to canning tomatoes in advanced countries like USA, but exact amount of loss in India and other developing countries are not known (Peter and Rai, 1976). The life cycle

of *F. oxysporum* begins in the soil where the spore germ tube, or mycelium enters through a wounds or passes the root tips of susceptible hosts. The developing mycelium enters the xylem vessels all the way through their pits after traversing the root cortex and travels upwards via the plant towards the stem and crown (Abu Bakar, et al, 2013)

Tomato (*Lycopersicon esculentum*)

Tomato (*Lycopersicon esculentum*) is one of the world's most widely cultivated vegetable crops for consumption as fresh fruits and various types of processed products (Hariprasad et al., 2009). Tomato is a highly required because of its nutritive value generally and specific paramount in vegetarian diets globally. It also serves as good source of vitamins C, A and minerals such as Fe and Cu (Sandani and Weerahewa., 2018)

The proper management and control of the causative agent of fusarium wilt, the *Fusarium oxysporum* with soil origin has not been successful as the fungus lives particularly in or near the dynamic environment of the rhizosphere and can frequently survive long periods in soil with the help of resistant structures. It has been recorded that the commonly applied control measures against this pathogen infection are pre plant fumigation and fungicide application. Other biological mode of control was also adopted. Several different methods have been attempted to manage the *Fusarium* wilt disease. Induction of host resistance and biological control has been prominent among other approaches. The defence mechanisms of a tomato plant have been activated through the induction of the expression of β -fructosidase, by a combination of chitosan and endophytic bacterial strain.

Comprehensive understanding of pathogen populations and diversity at the species level is important, as high genetic diversity indicates a rapid change in genetic structures. This, in turn, shows the development of more virulent species and strains in response to management practices, changed environments, and increased biological fitness of these species. Screening the pathogen population, therefore, helps us in studies aimed at reliably detecting variations in the population structure of the pathogen, which in turn enable us to understand population biology of the pathogen (Akbar et al, 2018). Many studies reported that molecular techniques using different markers could detect genetic diversity within and among populations to a certain extent, including pathogenicity variation, geographical, and host differences (Li et al 2012).

Fusarium oxysporum

Fungal soil-borne pathogens such as *Fusarium oxysporum* f. sp. *radicis-lycopersici*, first observed in 1969 in Japan (Sato and Araki, 1974), and *Fusarium oxysporum* f. sp. *lycopersici*, described over 100 years ago in the UK causes tomato wilting (Inami et al., 2014), *Fusarium oxysporum* is an anamorphic species that includes both pathogenic and nonpathogenic strains. Plant pathogenic forms cause a wilt disease and are grouped into formae speciales based on their host range; some are further subdivided into pathogenic races. Many formae speciales are comprised of multiple clonal lineages and, in some cases, a pathogenic race is associated with more than one clonal lineage, suggesting independent origins. Although some evidence suggests one pathogenic race may give rise to another, recent derivation of a pathogen from a non pathogen has not been documented. Most new occurrences of *Fusarium* wilt appear to be the result of a recent introduction rather than an independent local origin of the pathotype. Asexual

propagation is the dominant influence on population structure in *F. oxysporum* and the absence of sexual reproduction is not likely to prevent this pathogen from continuing to inflict significant damage on susceptible crop hosts (Gordon, 1997)

Methodology

Study Area and sample collection

The study was conducted in Maiduguri Metropolis, Borno State, Nigeria. The State is located in the north-eastern geopolitical zones of the country, lies in latitude 10⁰N and 13⁰E. It shares international boundaries with the Republic of Niger to the north, Chad to the North east and Cameroon to the east. It also shares national boundaries with Adamawa to the south, Yobe to the west and Gombe to the west. The State has an area of 69,435sq kilometres (NPC).

The samples were collected from different tomato farm, alone custom irrigation farm area.

Procedure

Twenty eight gram of commercially prepared PDA (Potato dextrose agar) was transferred into a conical flask. One litre of distilled water was added and boiled to dissolve and later sterilized by autoclave at 121⁰C for 15 minutes. It was allowed to cool before being poured into plates (petri dishes).

Isolation and Identification of Associated Fungi

The unhealthy sample were cut through by means of placing the infected site on prepared Potato dextrose agar (PDA) with sterile distilled water and plated on Saboroud dextrose agar (PDA) and incubated at room temperature for 24 to 48 hours. Representative colony types were purified by sub culturing on fresh PDA plates. Pure cultures were transferred to slants of PDA for future use. The isolated fungi were identified based on the isolates colonial characteristics on culture plates and microscopic features in slide cultures. A sterile inoculating needle were used to fetch a portion of each mycelia colony and aseptically placed on a clean microscope slide and observed under the microscope.

Result and discussion

Table 1: showing characterised *Fusarium oxysporum* and other fungi form tomato rot

s/no	<i>Fusarium oxysporum</i> isolates	Other Fungal isolates
1	-	+
2	+	-
3	+	-
4	+	-
5	+	-
6	-	+
7	-	+
8	+	-
9	-	+
10	-	+
11	-	+
12	+	-
13	-	+
14	-	+
15	+	-

16	+	-
17	+	-
18	-	+
19	-	+

Isolates showed the most in vitro radial growth after incubation. A total of 5 storage fungi were recovered from tomato. The result indicates, *Aspergillus niger*, *Penicillium* species, *Aspergillus flavus*, and *Alternaria alternata*, *Fusarium oxysporum* has the highest frequency

Out of the total number 9 equivalents to 47% were *Fusarium oxysporum* while 10 equivalents to 53% were other fungi, This showed that *Fusarium oxysporum* is most prevalent in tomato infection within the studied sample. Although the pathogenic isolate caused the most severe root rot at pH 6 and 30°C, in this case the pH and temperature were not assed this is in conformity with the work of Gordon and Martyn, (1997) Who says *Fusarium oxysporum* has a wide-reaching distribution in soil and are found in rhizosphere of many plant species. It is an anamorphic species that cause several diseases such as vascular wilt, yellows, corm rot, root rot and damping-off. This phenomenon was observed in most of the samples analysed and the scenario is most prominent in *Fusarium oxysporum* dedicated affected tomato.

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Online Educational System (e- learning): Evidence from Selected Tertiary Institutions in Borno and Yobe State

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Abstract: Since the beginning of the COVID-19 pandemic Tertiaries/Universities around the world are taking rapid actions to ensure students learning continuity and secure the well-being of their students. This study aims at exploring the student's e-learning experience in Borno and Yobe Tertiaries/Universities as well as e-learning readiness during the pandemic. While each tertiary/university is unique, we hope our assessment can provide some insights into how well the student's e-learning experience was during the pandemic. The construction of online educational systems lies within three principal activities: Design, Implementation and proper Post-Implementation Assessment. There is not enough knowledge or experience in those aspects. Efficient execution of these three major activities necessitates the use of design and educational models to achieve the cost and time efficiency, as well as high academic quality. The utilization of online educational systems would benefit from a structured approach to design, implementation, and student's assessment. The researcher proposes a general formulation of model as well as a framework for finding such patterns, so that it can improve the online educational systems for both teachers and students, allowing for more accurate assessment and more effective evaluation of the learning process. Mobile Assisted Language Learning (MALL) is a term used to describe using handheld computers or cell phones to assist in language learning, such as Technology enhanced learning (TEL) has the goal to provide socio-technical innovations (also improving efficiency and cost effectiveness) for e-learning practices, regarding individuals and organizations, independent of time, place and pace. Learning Management System (LMS) It is a software application for the administration, documentation, tracking and reporting of training programs, class room and on-line events, e-learning programs and training content. It is designed to teach how e learning can be implemented and made effective, using popular LMS Moodle.

Keywords: COVID-19, e-learning experience; e-learning readiness; and Mobile Assisted Language Learning

Introduction

In December 2019, the outbreak of the new coronavirus in Wuhan, China, escalated dramatically into a global health emergency (WHO, 2019). As a result, it has become an international concern of a public health emergency on January 2020 according to the World Health Organization (WHO), the new disease has been called COVID-19, on 11 February 2020.

COVID-19 has been declared on 11 March 2020, as a global pandemic (WHO Situation Report—51, 2020). One main objective that has been launched by most governments around the world, is to control this highly infectious virus by imposing general lockdowns, social distancing

procedures, converting traditional education to distance education, and other procedures (Gonzalez. et al. 2020)

In recent decades, the use of information and communication technologies (ICT) for educational purposes has increased, and the spread of network technologies has caused e-learning practices to evolve significantly (Kahiigi et al. 2008). The multiplicity of perspectives surrounding e-learning causes confusion and sometimes, even contradictions (Mason & Rennie, 2006). Not only have different concepts been attributed to e-learning, but the term has also been substituted by others, such as computer-based learning (CBL), technology-based training, and computer-based training, which actually predate the first mention of e-learning in the mid-1990s (Friesen, 2009) or the more recent online learning.

Moreover, some people confuse the concept of e-learning with the concepts of a virtual campus or online courses, which can be part of the e-learning universe but do not sufficiently define it.

E-learning is the use of new multimedia technologies and the Internet to improve the quality of learning by facilitating access to resources and services, as well as remote exchange and collaboration (Alonso et al., 2005). e-Learning is defined as all forms of electronic supported learning and teaching, which are procedural in character and aim to affect the construction of knowledge with reference to individual experience, practice and knowledge of the learner. Information and communication systems, whether networked or not, serve as specific media to implement the learning process (Bates 2005).

E-learning is a broad combination of processes, content, and infrastructure to use computers and networks to scale and/or improve one or more significant parts of a learning value chain, including management and delivery (Aldrich, 2005). eLearning is essentially the computer and network enabled transfer of skills and knowledge. e-Learning refers to using electronic applications and processes to learn. e-Learning applications and processes include computer-based learning, Web-based learning, virtual classrooms and digital collaboration. Content is delivered via the Internet, intranet/extranet, the audio or video tape, the satellite TV, and the CD-ROM. It is used by educational institutions to enhance and support the class room teaching and offer courses to a larger population of learners across the globe. It can be self-paced or instructor led and includes media in the form of text, image, animation, streaming video and audio (Harasim et al. 1995).

According to (Karrer, T, 2006) e-Learning has created new markets for teaching and learning material and equipment, attracting the attention of academic institutions as well as companies supplying them in different sectors – computer manufacturers, software producers, publishing houses and special training providers. It has also led to the reorientation of government policy, in particular, towards encouraging the spread of e-learning techniques and developing the skills and know-how required for their use. Therefore, e-learning was assigned a key role in the pursuit of the policy objective, announced at the Lisbon Summit in March 2000, for making ‘the most competitive and dynamic knowledge-driven economy in the world’. The e-learning initiative was launched by the European Commission to encourage its spread. This was followed by its incorporation into the European employment strategy in the form of a specific objective of ‘developing e-learning for all citizens. To achieve this, States committed themselves to ensuring that ‘all education and training institutions have access to the Internet and multimedia resources by the end of 2001 and that all the teachers and trainers concerned are skilled in the use of these technologies by the end of 2002 in order to provide all pupils with a broad digital literacy’. Despite its central importance in government policy and significant interest in the scale of the actual and potential market, there is an acute shortage of quantitative information on the extent of

e- learning in providing initial and continuing vocational education and training and on the rate at which it is growing.

There is also an increased use of virtual classrooms (online presentations delivered live) as an online learning platform and classroom for a diverse set of education providers. In addition to virtual classroom environments, social networks have become an important part of e-learning. Social networks have been used to foster online learning communities around subjects as diverse as test preparation and language education. Mobile Assisted Language Learning (MALL) is a term used to describe using handheld computers or cell phones to assist in language learning (Karrer, 2006). This study therefore, was aimed at exploring the student's e-learning experience in Borno and Yobe state Tertiary institutions as well as e-learning readiness during the pandemic

Problem Statement/Justification:

The COVID-19 lockdown has made significant disruptions in academic activities globally. In this study, we aimed to assess the satisfaction status of Borno and Yobe students with online learning during this pandemic. Although a substantial proportion of students are using digital platforms for learning, many of them are not satisfied due to several challenges related with access and use of online study. We therefore, suggest following recommendation to the government, policymakers, and institutional authorities.

There should be made a uniform academic plan for the universities and colleges to continue the learning process during an emergency. The infrastructural facilities should be available to all educational institutions for regulation of digital learning process during future health emergencies. Adequate funding needs to be ensured to improve the education system and provide training to stakeholders. A targeted intervention strategy is needed to develop positive study space for students belonging to the vulnerable section of society.

In this critical public health crisis, open-source digital learning strategies should be adopted by teachers for conducting online classes. It is need of the hour to develop multi-prolonged strategies to build resilient education system, which can ensure skill development for the productivity of the young minds. To increase socioeconomic status for access and use, students would be helped with scholarships because socioeconomic status is an effective variable predicting life satisfaction.

Objective(s) of the Study:

Developing and deploying effective eLearning programs may require products and services supplied by a variety of vendors, leaving one to connect the dots. One way to start is to define the goals of the desired learning solution. The definition of the goals of an e-Learning solution is driven by the following factors:

i. Perform task analysis

Determining the tasks to be taught, identifying subtasks and other elements involved, and identifying the knowledge, skills, and attitudes required to complete the tasks efficiently and effectively.

ii- Perform training needs analysis

Identifying the target audience for the training. Identifying the shortfall in knowledge, skills, and attitudes of this audience and determining what the target learners need to know.

iii- Review existing capabilities

Reviewing existing methods and infrastructure for providing training or meeting learning needs.

iv- Determine expectations

Identify concrete expectations and/or ROI requirements from the desired eLearning solution. The development of an eLearning strategy begins by setting goals. Without a true understanding of the goals of the eLearning strategy, it will be difficult, if not impossible, to be successful. Before implementing eLearning, organizations need to set common goals or objectives. Common goals and objectives include the following:

v- The reduction of learning costs

As a small business owner, you realize that online transactions cost a part as much those requiring paper or staff. It's the same with eLearning because there is no paper work, no delays, and no travel expenses. To reduce the time required for effective learning electronic learning is sometimes called "just-in-time" learning. Such learning enables employees to take what they have just learned from their computer screens and apply it to the tasks at hand.

vi- The motivation of employees

eLearning is considered an effective way to keep up with new technology, to generate new ideas, and to keep your workforce fresh and inspired.

vii- The improvement of the flexibility of course delivery

Most of the smaller businesses don't have the staff to manage their training and development initiatives. E-Learning technologies can overcome these administrative restrictions.

viii- Expansion of the capabilities of the business

Small organizations need to get more out of their high-potential employees. eLearning helps employers to be taken to a higher level of contribution.

Literature Review

A study that aims to investigate the characteristics, benefits, drawbacks and features that impact E-learning has been presented in (Ms & Toro, 2013). Some of the demographic features such as behaviors and cultural background impact student education in the E-learning domain. Therefore, for lecturers to design educational activities to make learning more effective, they should understand these features. The study is applied to students in Lebanon and England to assist instructors to understand what scholars expect from the learning management systems.

e-Learning services have evolved since computers were first used in education. There is a trend to move towards blended learning services, where computer-based activities are integrated with practical or classroom-based situations.

Bates and Poole (2003) and the OECD (2005) suggest that different types or forms of e-learning can be measured as a continuum, from not e-learning, through classroom aids, such as creating classroom lecture PowerPoint slides available to students through a course web site or learning management system, to laptop programs, to hybrid learning, through to fully online learning. This classification is somewhat similar to that of the Sloan Commission reports on the status of e-learning, which refers to web-enhanced, web supplemented and web-dependent to reflect the increasing intensity of technology use. In the Bates and Poole continuum, 'blended learning' can cover classroom aids, laptops, and hybrid learning, while 'distributed learning' can incorporate either hybrid or fully online learning. It can be seen then that e-learning can describe a wide

range of applications, and it is often by no means clear even in peer reviewed research publications which form of e-learning. However, Bates and Poole argue that when instructors say they are using e-learning, this most often refers to the use of technology as classroom aides, although over time, there has been a gradual increase in fully online learning.

The purpose of the study in (Gaebel et al. 2014) is to conduct a survey on the varieties of E-learning organizations, skills, and their anticipations for the forthcoming. Blended and online learning are taken into account. Some of the questions related to intra-institutional management, arrangements and services, and quality assurance. The outcomes of the survey showed that from 38 diverse countries and systems, there are 249 organizations broadly conceived the same causes for the increasing use of e-learning.

The study in (Yengin et al. 2011) illustrated that the most vital role in the e-learning design outlook is online lecturers. As a result, considering the issues impacting lecturers' performance should be taken into the account. One of the features that impact the usability of the system and lecturers' presentation is satisfaction. The results showed, to produce a simple model called the "E-learning Success Model for Instructors' Satisfaction" that is related to public, logical and technical communications of instructors in the entire e-learning system, the features associated with teachers' satisfaction in e-learning systems have been examined.

The comparison between different E-learning tools in terms of their goals, benefits and drawbacks are presented in (Aljawarneh et al. 2010). The comparison assists in providing when to use each tool. The outcomes show that instructors and students prefer to use MOODLE over Blackboard in the e-learning environment. One of the major challenges that face the E-learning environment is security issues since security is not combined into the active learning development process.

A study in (Arkorful & Abaidoo, 2015) aimed to explore the literature and provide the study with a theoretical context by reviewing some publications made by different academics and universities on the definition of E-learning, its use in education and learning in institutions of higher education. The general literature described the pros and cons of E-learning, which showed that it needs to be enforced in higher education for teachers, supervisors and students to experience the full advantages of acceptance and implementation.

Assessing the learning effectiveness of e-learning was studied in (Somayeh et al. 2016). This analysis study was conducted using the databases of Medline and CINAHL and the search engine of Google. The research used covered review articles and English language meta-analysis. 38 papers including journals, books, and websites are investigated and categorized from the results obtained. The general advantages of E-learning such as the promotion of learning and speed and process of learning due to individual needs were discussed. The study results indicated positive effects of E-learning on learning, so it is proposed that more use should be made of this education method, which needs the requisite grounds to be established.

Computer-based Learning (CBL)

Computer-based learning, sometimes abbreviated to CBL, refers to the use of computers as a key component of the educational environment. While this can refer to the use of computers in a classroom, the term more broadly refers to a structured environment in which computers are used for teaching purposes. The concept is generally seen as being distinct from the use of computers in ways where learning is at least a peripheral element of the experience (e.g., computer games and web browsing) (Kahiigi, et al. 2008).

Computer-Based Training (CBT)

Computer-Based Trainings (CBTs) are self-paced learning activities accessible via a computer or handheld device. CBTs typically present content in a linear fashion, much like reading an online book or manual. For this reason, they are often used to teach static processes, such as using software or completing mathematical equations. The term Computer- Based Training is often used interchangeably with Web-based training (WBT) with the primary difference being the delivery method, where CBTs are typically delivered via CD- ROM, WBTs are delivered via the Internet using a web browser. However, CBTs pose some learning challenges as well. Typically, the creation of effective CBTs requires enormous resources. The software for developing CBTs (such as a Flash or an Adobe Director) is often more complex than a subject matter expert or teacher is able to use. In addition, the lack of human interaction can limit both the type of content that can be presented as well as the type of assessment that can be performed. Many learning organizations are beginning to use smaller CBT/WBT activities as part of a broader online learning program which may include online discussion or other interactive elements (Lowenthal, et al. 2009).

Computer-Supported Collaborative Learning (CSCL)

Computer-supported collaborative learning (CSCL) is one of the most promising innovations to improve teaching and learning with the help of modern information and communication technology. Most recent developments in CSCL have been called E-Learning 2.0, but the concept of collaborative or group learning whereby instructional methods are designed to encourage or require students to work together on learning tasks has existed much longer. collaborative learning s h o u l d b e distinguishing from the traditional 'direct transfer' model in which the instructor is assumed to be the distributor of knowledge and skills, which is often given the neologism E-Learning 1.0, even though this direct transfer method most accurately reflects Computer-Based Learning systems (CBL) (Karrer, T. 2006).

Technology-Enhanced Learning (TEL)

Technology enhanced learning (TEL) has the goal to provide socio-technical innovations (also improving efficiency and cost effectiveness) for e-learning practices, regarding individuals and organizations, independent of time, place and pace. The field of TEL, therefore, applies to the support of any learning activity through technology (Hiltz, S. 1990).

Learning Management System (LMS)

It is a software application for the administration, documentation, tracking and reporting of training programs, class room and on-line events, e-learning programs and training content. It is designed to teach how e learning can be implemented and made effective, using popular LMS Moodle. Moodle is a free and open-source e learning software platform. That means there is no cost or license fee for deployment. Moodle is designed to help educators create on-line courses with focus on interaction and collaborative construction of content (Bates, A. 2005).

Methodology

The Model used for Online Education Systems

The model used for online education systems is shown in Figure 1. This is partly due to the institutions' need to rationalize the operation to handle the growing number of online students and courses, and partly due to the fact that the users are increasingly expecting More sophisticated services.

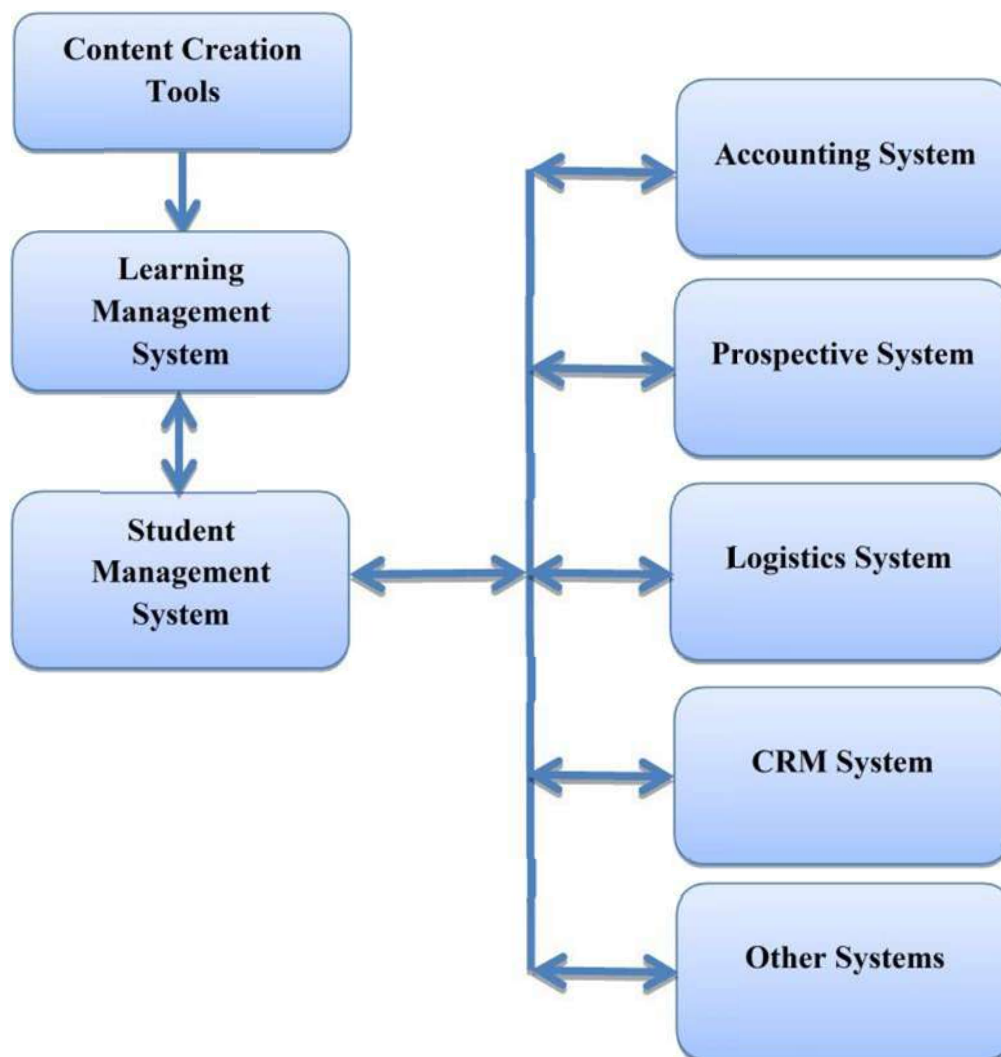


Figure 1. Model for Online Education Systems

This model includes Customer Relation Management (CRM) systems and prospective systems to show the need for integration with marketing and sales related systems. It also includes logistics systems to show that it could be necessary to integrate systems that handle shipment of textbooks and other physical material to distant students.

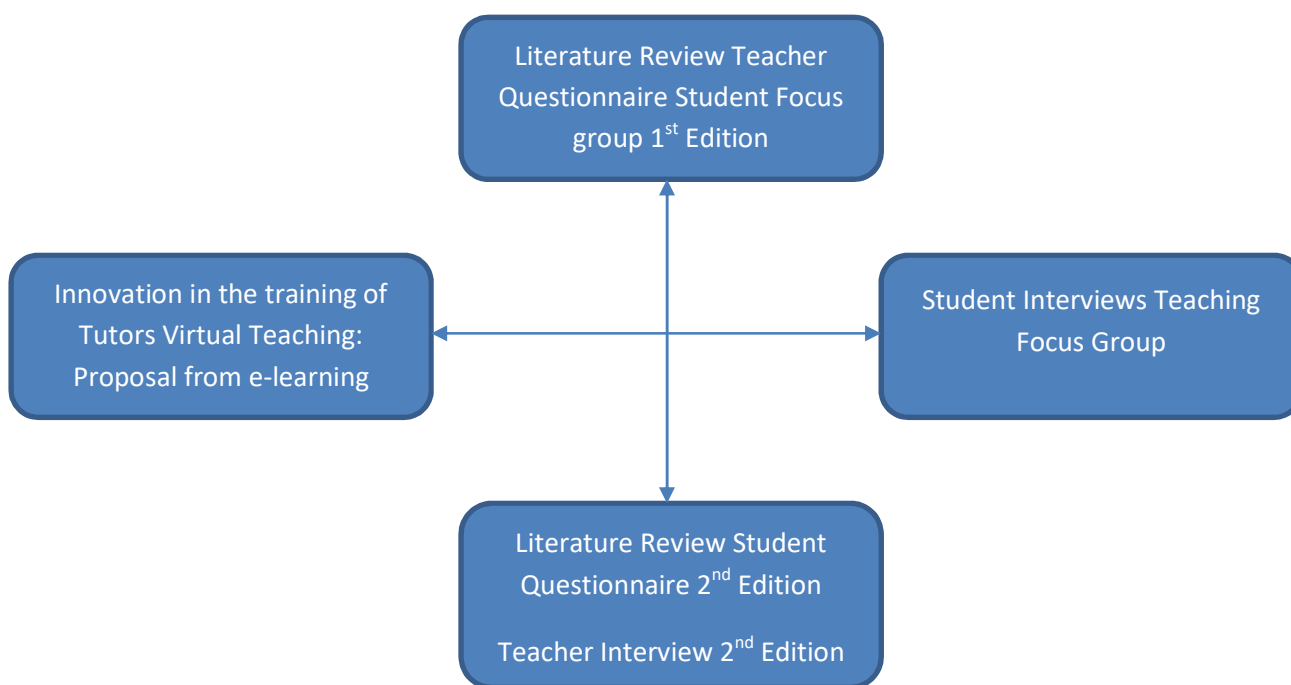
1. Target Population and Sample Size to be covered.

A study conducted in the fall of 500 College students at different areas in Tuticorin district found that students attending survey come to college with most of them owning computers, having internet access, having studied computers in high school, and considering themselves to be intermediate computer users. These numbers indicated were still lower than what has been reported in the studies conducted at majority serving institutions. Therefore, the survey can claim to give a more comprehensive view about e-learning in the Tuticorin District and its rate of development than has been available up to now.

Material and Methods

Methods

NSS & RRC students collected data in 4 levels. The methods for collecting data for Level 1 (reaction) and Level 2 (learning) can be built into the process much more easily. Because e-learners can be remotely located, some of the methods of data collection are more difficult to use, such as focus groups and direct observation. Level 3 (Changes in skills) applied the learning to enhance behaviors and Level 4 (Effectiveness) improved performance because of enhanced behaviors. Figure below shows the block diagram of method of data collection.



Sources of the data

The data used for the study are obtained from several sources which includes both primary and secondary. The following research questions were put forth to about 200 people:

1. Features.
2. Keeping track of grades on assignments and tests online
3. Online access to sample exams and quizzes for learning purposes.
4. Online syllabus
5. Turning in assignments online
6. Online readings and links to other text-based materials.
7. Taking quizzes and exams online.
8. Getting assignments back online with instructor comments and grades.
9. Online sharing of materials among students.
10. Online discussions.

Reference period of the data to be covered

It has already been collected. Few Departments & students said that they had previous experience taking a fully online course (78.6%) and students were mixed as to whether they plan on taking an online course in the future, with 52.9% saying yes and 47.1% responding no.

Method of Processing and Analyzing

The strategy for data analysis, for the expedition between raw data and analyzed data, was applied to every informational index gathered, and different investigations, It's comprised the following steps:

- i. All raw data was typed up. For instance, the discussion board and email messages.
- ii. Each data set is then inspected separately for similarities or differences within the responses, or for subjects rising up out of the data.
- iii. Once this had been completed for the individual data sets, a table is drawn up that involved all data sets so as to examine any bury data set melodies.

The implementation of a comprehensive measurement and evaluation system will require five key elements:

- i. Different types of collected data can be classified into five levels (the first four were developed by Kirkpatrick in the 1950s)
- ii. Measure participant reaction with the program and capture planned actions during the actual learning activity.
- iii. Measure change in knowledge skills or attitude.
- iv. Measure change in on-the-job behavior and specific application actions.
- v. Measure changes in business impact for either individuals or work units.
- vi. Compare the monetary benefits of the program to the actual cost of the program

The main Purpose of Assessing and Measuring an e-Learning application is

- i- Determining whether the e-learning course has accomplished its objectives.
- ii- Identifying the strengths and weaknesses in the e-learning process.
- iii- Identifying who benefited the most or the least from the course.
- iv- Collection of data to assist in developing future applications.
- v- Determining the benefit/cost ratio of the e-learning course other demands for evaluation.
- vi- The newness of e-learning to many groups brings pressure to develop information about its effectiveness and efficiency as a learning solution.
- vii- e-learning being not a proven process, there is a need to show value now rather than later when it becomes a routine process.

The suggested ways to evaluate e-learning are

- i. The types of data are the same, both quantitative and qualitative.
- ii. The levels of evaluation are the same (five levels of evaluation).
- iii. The data collection methods are the same for each of the levels of evaluation.
- iv. The methods to isolate the effects of e-learning are the same.
- v. The methods of converting data to monetary values are the same.
- vi. The methods of analyzing and reporting data are the same.

Several issues are different in e-learning:

The methods for collecting data for Level 1 (reaction), and Level 2 (learning) can be built into the process much more easily than traditional methods.

Results (Expected outputs/Results)

It is intended to enrich and complete the traditional face-to-face teaching and learning in control with highly interactive, self-learning tools, including hypertext, exercise bases, simulations, and virtual and remote laboratories. It is also seen as a substitution for traditional face-to face teaching and learning, providing open distance learning in the context of continuing education. Successful e-Learning students share certain qualities and abilities. They are

- i. E-Learning requires motivation and self-discipline. Successful e-Learning students are able to study independently and incorporate study time into their busy lives. Students should set aside regular study time. e-Learning requires a real commitment to keep up with the flow of the process and to finish within the required period of time.
- ii. Define your goals and plan for success. Define your goals and objectives for your e-Learning experience. Understand the requirements and plan ahead so that you will know what's expected of you and how your performance will be evaluated.
- iii. e-Learning requires good reading and writing skills. The ability to efficiently read and interpret instructions is a critical skill in e-Learning. Most activities and communications are also written, so it is important to be comfortable with your ability to express yourself through writing.
- iv. Incorporate work, life, and other educational experiences as part of the learning process. e-Learning requires the student to make inferences based on experience as well as facts. Meaningful reflection and critical analysis of information are an essential part of the learning process. Look for opportunities to apply what you have learned in your life.
- v. Be willing and able to commit adequate time to the e-Learning process. e-Learning is a convenient way to receive education and training, but it is not easier than the traditional educational process. In fact, it often requires more time and commitment.
- vi. Have access to the necessary equipment and create some personal space. It is important that you have a place to study in a peaceful and focused manner. To be a successful e-Learner you must believe that meaningful, high-quality learning can take place without a traditional classroom. When properly designed and executed, e-Learning is a highly effective and rewarding learning environment.

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Effect of Moringa Oleifera Seed Extract against Some Selected Bacteria and Some Fungi

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Abstract: *This research work was performed to test the potentials of Moringa seed extract in controlling the growth of some bacteria and fungal species. The extract showed resistance against all the fungal isolates including Aspergillus niger, Penicillium verricosum, Aspergillus flavus, Rhizopus oligosporus, Aspergillus fumigatus, Fusarium graminearum and Mucor Circinelloides. The extract showed activity against some of the bacterial isolates including Staphylococcus aureus, Bacillus subtilis and Streptococcus pyogenes with minimum inhibitory concentration of 100mg/ml each, on the other hand resistance were observed in E. coli, S. typhi and K. pneumoniae*

Keywords: *Moringa, fungi, Bacteria*

Introduction

Moringa Oleifera belongs to the monogeneric family, moringaceae, and is widely cultivated in many tropical countries, e. g, Africa, India, Srinlanka, Thailand, Burma, Mexico, Malaysia and the Philippines (Fehey, 2005). It has been used for treating bacterial infection, fungal infection, Inflammation, sexually-transmitted diseases, malnutrition and diarrhea (Fehey, 2005, Farooq *et al*, 2012,), documented plant herbs due to their extraordinary nutritional and medicinal properties. (Fehey, 2005). Different parts of this plant were used in native systems of medicine for the treatment of variety of human ailments and are also eaten as vegetable.

Due to beneficial properties of this plant, it has been extensively researched for over the last 10 years (Foild *et al*, 2001). Because of high fat content of its seed (35-42% by weight). It can be used as biofuel, vegetable oil, cosmetic medicine. It has been reported that polypeptides in seeds are one of the best natural coagulants and can bind to many moieties and possesses antimicrobial properties that can be used for water treatment (Anwar *et al*, 2007a). The presence of some phytochemical substance especially a short polypeptide found in the seed extract was reported to act directly on microorganisms and result in growth inhibition by disrupting cell membrane synthesis as essential enzymes (Bukar *et al*, 2010).

The synthetic antioxidants are mainly butylated hydroxyl anisole (BHA) and butylated hydroxyl toluene (BHI), which are used in many food formulations to enhance their oxidative

stabilities during storage. Antioxidants derived from natural sources are in high demand for food application to replace the synthetic antioxidants (Lutterodt *et al*, 2011). MO seed oil its edible and reported to be a rice sources of monounsaturated fatty acid, particularly oleic acid (C18:1) (71-74% of total fatty acids) (Ruttarattanamongkol *et al*, 2014). High oleic acid have been proved to be more resistant toward oxidation (Anwar *et al*, 2007b). Our previous study suggested that the high oleic acid content of the (MO) oil coupled will its low peroxide value and acidity may qualify the (MO) oil as a natural derived antioxidant in food and cosmetic industries (Ruttarattanamongkol *et al*, 2014). Moringa seed oil was reported to enhance the oxidation stability of some vegetable oils during deep-frying (Anwar *et al*, 2007b).

In recent years, interest have been generated in the development of safer antifungal agent from natural plant products such as essential oils and extracts to control fungal disease, various plant material is believed to have antifungal activity, as many essential oils and plants extracts have been reported to have antifungal activities will no side effects on human and animals (Tabassum and Vidyasagar, 2013). Previous in vitro and in vivo investigation suggested that the essential oil and plant extracts could be used as an effective antifungal agent against many phytopathogenic fungi

Moringa Oleifera is a highly valued plant, distributed in many countries of the tropics and sub-tropics. It has an impressive range of medicinal uses will high nutritional value. Different part of this plant contains a profile of important minerals, and are a good source of protein, vitamins, B-carotene, amino acids and various phenolics (Farooq *et al*, 2007). The Moringa plant provides a rich and rare combination of zeatin, quercetin, kaempferol and many other phytochemicals. It is very important for its medicinal values.

METHODOLOGY

SAMPLE COLLECTION

The sample (Moringa oleifera seed) were brought from Pompomari Kareto Close Maiduguri: it was grinded into a fine powder after drying at room temperature, then and take it to the laboratory.

PROCEDURE AND EXTRACTION

50g of Moringa Oleifera seed were mixed with 50ml of water and 50ml of ethanol separate round up bottom flask

- ii. The flask was introduced to the condenser and insert it inside the heating mantle
- iii. The extractor was 30°C and was allowed to run for 30 minutes
- iv. The flask was removed and allow the temperature to fall down
- v. Mixture was then filtered using filter paper and funnel
- vi. Then the extractor was transferred into a clean container .

ANTIMICROBIAL ACTIVITY

A portion of the organisms were subcultured using spread method on to a freshly prepared growth media for bacteria and SDA for fungi with a sterile wire loop. The extract was introduced at different concentration into the inoculated plates and incubated at room temperature over

night. The presence or absence of growth around the antagonist shows an indirect measure of the extract to inhibit the growth of organisms.

RESULT AND DISCUSSION

Effect of *Moringa Oleifera* seed extract on some selected fungi

TABLE 1.

Organism	Ethanolic extract	Aqueous extract
<i>Aspergillus niger</i>	R	R
<i>Penicillium verricosum</i>	R	R
<i>Aspergillus flavus</i>	R	R
<i>Rhizopus oligosporus</i>	R	R
<i>Aspergillus fumigatus</i>	R	R
<i>Fusarium graminearum</i>	R	R
<i>Mucor circinelloides</i>	R	R
<i>Candida albicans</i>	R	R

TABLE 2.

Organism	Zone of inhibition	MIC Mg/ml
<i>Staphylococcus aureus</i>	15	100
<i>Bacillus subtilis</i>	14	100
<i>Streptococcus pyogenes</i>	25	100
<i>E. coli</i>	R	R
<i>S. typhi</i>	R	R
<i>K. pneumoniae</i>	R	R

DISCUSSION

This study reports the Antifungi activity of different concentrations of *Moringa Oleifera* seed extract against *Aspergillus Miger*, *PenialliumVerucosum*, *Aspergillus Flavus*, *Rhizopus oligosporus*, *Aspergillus*, *Fumigatus*, *Fusarium graminearum*, *Mucor Circinelloides*, *Candida*. The result of antifungal activity of the investigated extract are shown in Tables 1 and 2 in this study both ethanol and water extracts showed no inhibition against the fungi tested. In this study, a positive result was observed in ethanol extracts of *Moringa* seed at concentration of 100mg/ml. The highest antibacterial activity of 15cm was recorded in *staphylococcus aureus* and activity was also recorded in *Bacillus Subtilis*, *Streptococcus pyogenes* and *Pseudomonas aeruginosa* with inhibition zone of 15mm, 14, 25mm respectively.

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Assessment of Rectangular 3-Dimensional Heat Equation Using Dirichlet Boundary Condition

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Abstract: The main focus of these studies is an ASSESSMENT OF RECTANGULAR 3-DIMENSIONAL HEAT EQUATION USING DIRICHLET BOUNDARY CONDITION, by a method of separation of the variable of a partial differential equation which is converted to the second-order differential equation and triple Fourier series was used to obtain the result. Also, the result obtained in problem1 shows that in the graph the heat equation and time there are moving in a parallel direction and there not in closed range, the boundary condition maintained a straight line, while in problems 2 the result shows that in the graph that the heat equation and time there are moving closed range and also the boundary condition maintained a straight line. it shows that in problem2 that when the values of the time and boundary are taken at the closed interval the heat and time will move at a closed range, while in problem 1 the heat and time are taken at the open interval, the heat and time will move in a parallel direction. Hence the study recommended that the assessment should be applied to scientific and engineering problems.

Keywords: 3 dimensions, heat equation, and Dirichlet Boundary Condition

1. INTRODUCTION

3-Dimension heat equation with an initial condition is given by

$$u_t = \alpha(u_{xx} + u_{yy} + u_{zz}) \quad t > 0, (x, y, z) \in \Omega$$

$$u(x, y, z, 0) = f(x, y, z) \quad (x, y, z) \in \Omega \quad \text{where, } \Omega \subset R^3$$

parabolic partial differential equation which defines the distribution of heat or variation in temperature is known as a heat equation, one of the most common boundary conditions is a Dirichlet boundary condition is a type of boundary condition, named after Peter Gustav Lejeune Dirichlet (1805-1859) Cheng, A (2005) and (Saeed, 2017)

Partial differential equations (PDEs) are useful tools in the field of physics, engineering, and Applied Mathematics, they are also an equation that contains derivatives of an unknown function concerning two or more independent variables (Olusegun *et al*, 2017; Norazlina *et al* 2020).

The theory of heat equations was first developed by Joseph Fourier in 1822, Heat is the dynamic energy of particles that are being exchanged and is connected with the study of Brownian motion. The one and

three-dimensional wave equation was discovered by Alembert and Euler. The solutions of heat and wave equations have attracted the attention of various authors in mathematics, such as the optimal homotopic asymptotic method (OHAM), the modified Adomian decomposition method (MADM), the variation iteration method, the differential transform method (DTM), the homotopic perturbation method (HPM), (Hassan *et al* 2019).

Joseph Fourier (1768-1830) was a French mathematician and Physicist best known for initiating the study of the Fourier series with applications to the theory of oscillating systems and heat transfer. (Tracy 2017)

Uba, Grema, and Mai (2019) examine the solution of a one-dimensional heat equation using residue calculus; the study investigates the method of separation of the variable. It has been found that residue theory was also used to solve the second order differential equation after the 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.

Xingri. (2022) study on the case wherever the domain is three-dimensional, and develop the associated “effective boundary conditions” (EBCs), which found the effects of the inclusion.

Dirichlet to Dirichlet boundary conditions for the heat equation in one, two, and three dimensions were estimated using simple numerical methods (ALEXANDER, 2011).

Benyam, (2015) investigate that the dimensional heat equation with Dirichlet boundary condition was solved numerically, finite element and difference scheme is used to calculate the numerical solutions, one-dimensional heat Equation together with initial condition and Dirichlet boundary conditions using finite difference approaches do not always converge to the exact solutions and also It is indicated that the amount of numerical instability in finite difference techniques has been obtained. Analytic solutions and numerical solutions obtained by these two methods are compared graphically into two and three dimensions heat equations. Adi, (2008) investigate Near-field infinity-simulating boundary conditions for the heat equation.

semi linear parabolic problem through a nonlocal Dirichlet boundary condition is considered, stability analysis has been achieved and the convergence of approximations towards a solution of the continuous problem is revealed and also the uniqueness of a solution was proved and Error estimates intended for the time discretization are achieved (Slodička. 2011).

Bezuneh, (2018) investigated The solution of heat equation using separation of variables by considering homogenous Dirichlet boundary condition, and also the application of heat equation is also involved.

Neil. (2014) investigate the Regularity of Boundary Points in the Dirichlet problem for the heat equation it was found that Simple necessary and sufficient conditions for the regularity of semi-singular boundary points were achieved

Kurt (2008) investigate the study of a square in terms of elliptic functions, the numerical result has been computed and compared by the technique of separation of variable and finite elements. The study also reveals that the technique gives an exact result as the others method in the solution of the two-dimensional heat equation.

A weak well-posedness results of the strongly damped linear wave equation and of the nonlinear Westervelt equation with homogeneous Dirichlet boundary conditions are established on every arbitrary three-dimensional domain or any two-dimensional domain that can be achieved by a limit of NTA domains represented by the same geometric constants.

Nonlinear heat equation with Dirichlet and mixed boundary condition was found using existence and non-existence result for the non-linear heat equation (Canan, 2007).

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.

Using the method of memory division and compression, with an analysis of the field in the form of arrays for data collecting and storage, one might solve the large-scale (three-dimensional) heat equation that is a part of partial differential equations (subspace Krylov) , Mat lab programmes was used to did the technique of a desirable speed through the speed of communication and exchange of data between processors, as well as the distribution of data between all participating processors (Ahmed. 2013).

In the context of COVID 19, analytically solving the two-dimensional heat equation with the Dirichlet boundary condition. In problem 1, the result indicates that the graph is moving down and maintaining a straight line, whereas in issue 2, the result indicates that the graph is moving up and maintaining a straight line on the values 0.99 and 0.001, (GREMA, et al2022).

2. METHODOLOGY

3-dimensional heat equation

Cartesian coordinates system

$$\frac{\partial T}{\partial t} = k \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} \right) \quad \text{and} \quad T(x, y, z, t) = X(x)Y(y)Z(z)\tau(t)$$

$$\frac{1}{X} \frac{d^2 X}{dx^2} + \frac{1}{Y} \frac{d^2 Y}{dy^2} + \frac{1}{Z} \frac{d^2 Z}{dz^2} = -\frac{1}{\kappa \tau} \frac{d\tau}{dt} = -\mu^2 \quad \text{where } \mu^2 \text{ is a separation constant, } \mu \text{ being real}$$

$$\tau(t) = Ge^{-\kappa t}$$

$$\frac{1}{X} \frac{d^2 X}{dx^2} + \frac{1}{Y} \frac{d^2 Y}{dy^2} = \frac{-1}{Z} \frac{d^2 Z}{dz^2} - \mu^2 = -\lambda^2 \quad \text{say and} \quad \frac{d^2 Z}{dz^2} + \gamma^2 Z = 0 \quad \text{where } \gamma^2 = \mu^2 - \lambda^2$$

$$\text{Thus } Z(z) = E_1 \cos \gamma z + F_1 \sin \gamma z \quad \text{and} \quad \frac{1}{X} \frac{d^2 X}{dx^2} = \frac{1}{Y} \frac{d^2 Y}{dy^2} - \lambda^2 = -\alpha^2, \text{ say}$$

$$\frac{d^2 X}{dx^2} + \alpha^2 X = 0 \quad \text{and} \quad \frac{d^2 Y}{dy^2} + \beta^2 Y = 0 \quad \text{where } \beta^2 = \lambda^2 - \alpha^2$$

$$X(x) = A \cos \alpha x + \beta \sin \alpha x \quad \text{and} \quad Y(y) = C \cos \beta y + D \sin \beta y$$

$$T(x, y, z, t) = (A \cos \alpha x + \beta \sin \alpha x)(C \cos \beta y + D \sin \beta y)(E_1 \cos \gamma z + F_1 \sin \gamma z) e^{-\kappa \mu^2 t}$$

Where $E = E_1 G$, $F = F_1 G$ and $\mu^2 = \alpha^2 + \beta^2 + \gamma^2$

$$T(x, y, z, t) = \frac{8}{abc} \sum_{n=1}^{\infty} \sum_{n=1}^{\infty} \sum_{q=1}^{\infty} F(m, n, q) \sin\left(\frac{mx\pi}{a}\right) \sin\left(\frac{ny\pi}{b}\right) \sin\left(\frac{qz\pi}{c}\right) e^{-\lambda^2 t}$$

$$F(m, n, q) = \int_0^a \int_0^b \int_0^c f(x, y, z) \sin\left(\frac{mx\pi}{a}\right) \sin\left(\frac{ny\pi}{b}\right) \sin\left(\frac{qz\pi}{c}\right) dx dy dz \text{ where}$$

$$\lambda^2 = \kappa \pi^2 \left(\frac{m^2}{a^2} + \frac{n^2}{b^2} + \frac{q^2}{c^2} \right)$$

$$T(0, y, z) = T(x, 0, z) = T(x, y, 0) = 0 \text{ Gives } A = C = E = 0, \text{ Also } T(a, y, z) = T(x, b, z) = T(x, y, c) = 0$$

$$\sin \alpha a = 0, \sin \beta b = 0, \text{ and } \sin \gamma c = 0 \Rightarrow \alpha = \frac{m\pi}{a}, \beta = \frac{n\pi}{b}, \gamma = \frac{q\pi}{c}$$

Where $m = n = q = 1, 2, 3, \dots$

$$\text{Thus } \lambda^2 = k \mu^2 = k(\alpha^2 + \beta^2 + \gamma^2) = k \pi^2 \left(\frac{m^2}{a^2} + \frac{n^2}{b^2} + \frac{q^2}{c^2} \right)$$

$$T(x, y, z) = \sum_m \sum_n \sum_q k_{mnq} \sin\left(\frac{mx\pi}{a}\right) \sin\left(\frac{ny\pi}{b}\right) \sin\left(\frac{qz\pi}{c}\right) e^{-\lambda^2 t}$$

Now the initial condition $T(x, y, z, 0) = f(x, y, z)$

$$f(x, y, z) = \sum_m \sum_n \sum_q k_{mnq} \sin\left(\frac{mx\pi}{a}\right) \sin\left(\frac{ny\pi}{b}\right) \sin\left(\frac{qz\pi}{c}\right)$$

$$k_{mnq} = \frac{2}{a} \frac{2}{b} \frac{2}{c} \int_0^a \int_0^b \int_0^c f(x, y, z) \sin\left(\frac{mx\pi}{a}\right) \sin\left(\frac{ny\pi}{b}\right) \sin\left(\frac{qz\pi}{c}\right) dx dy dz$$

3. RESULTS

Problem 1.

$$u_t = \frac{9}{7} (u_{xx} + u_{yy} + u_{zz}) \quad 0 \leq x \leq \pi, 0 \leq y \leq \pi, 0 \leq z \leq \pi, t > 0$$

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

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

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

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

$$\frac{7T'}{9T} = \frac{X''}{X} + \frac{Y''}{Y} + \frac{Z''}{Z} \quad \text{then} \quad \frac{X''}{X} = R, \quad \frac{Y''}{Y} = P, \quad \frac{Z''}{Z} = S, \quad \frac{7T'}{9T} = R + P + S$$

$$X'' - RX = 0, \quad Y'' - YP = 0, \quad Z'' - ZS = 0$$

$$\text{Case 1. } R = \mu^2 > 0, \quad P = \lambda^2 > 0, \quad S = \eta^2 < 0$$

$$X'' - \mu^2 X = 0, \quad Y'' - \lambda^2 Y = 0, \quad Z'' - \eta^2 Z = 0$$

$$X(x) = c_1 e^{\mu x} + c_2 e^{-\mu x}, \quad Y(y) = c_3 e^{\lambda y} + c_4 e^{-\lambda y}, \quad Z(z) = c_5 e^{\eta z} + c_6 e^{-\eta z}$$

$$X(0) = X(\pi) = 0 \Rightarrow c_1 = -c_2$$

$$Y(0) = Y(\pi) = 0 \Rightarrow c_3 = -c_4$$

$$Z(0) = Z(\pi) = 0 \Rightarrow c_5 = -c_6$$

The solution is trivial

$$\text{Case 2 } R = \mu^2 = 0, \quad P = \lambda^2 = 0, \quad S = \eta^2 = 0$$

$$X'' = 0, \quad Y'' = 0, \quad Z'' = 0 \quad \text{then} \quad X(x) = c_1 x + c_2, \quad Y(y) = c_3 y + c_4, \quad Z(z) = c_5 z + c_6$$

$$X(0) = X(\pi) = 0 \Rightarrow C_1 = -C_2$$

$$Y(0) = Y(\pi) = 0 \Rightarrow C_3 = -C_4$$

$$Z(0) = Z(\pi) = 0 \Rightarrow C_5 = C_6$$

The solution also trivial

$$\text{Case 3 } R = \mu^2 < 0, \quad P = \lambda^2 < 0, \quad S = \eta^2 < 0$$

$$X'' + \mu^2 X = 0, \quad Y'' + \lambda^2 Y = 0, \quad Z'' + \eta^2 Z = 0$$

$$X(x) = C_1 \cos \mu x + C_2 \sin \mu x$$

$$Y(y) = C_3 \cos \lambda y + C_4 \sin \lambda y$$

$$Z(z) = C_5 \cos \eta z + C_6 \sin \eta z$$

$$X(\pi) = 0 \Rightarrow C_1 \cos \mu \pi + C_2 \sin \mu \pi = 0 \quad \text{then } \mu = n \text{ and} \quad X(x) = C_n \sin nx$$

$$Y(\pi) = 0 \Rightarrow C_3 \cos \lambda \pi + C_4 \sin \lambda \pi = 0 \quad \text{then } \lambda = m \text{ and} \quad Y(y) = C_m \sin my$$

$$Z(\pi) = 0 \Rightarrow C_5 \cos \eta \pi + C_6 \sin \eta \pi = 0 \quad \text{then } \eta = k \text{ and } Z(z) = C_k \sin kz$$

$$T(t) = C_w e^{\frac{-9t}{7}(n^2+m^2+k^2)}$$

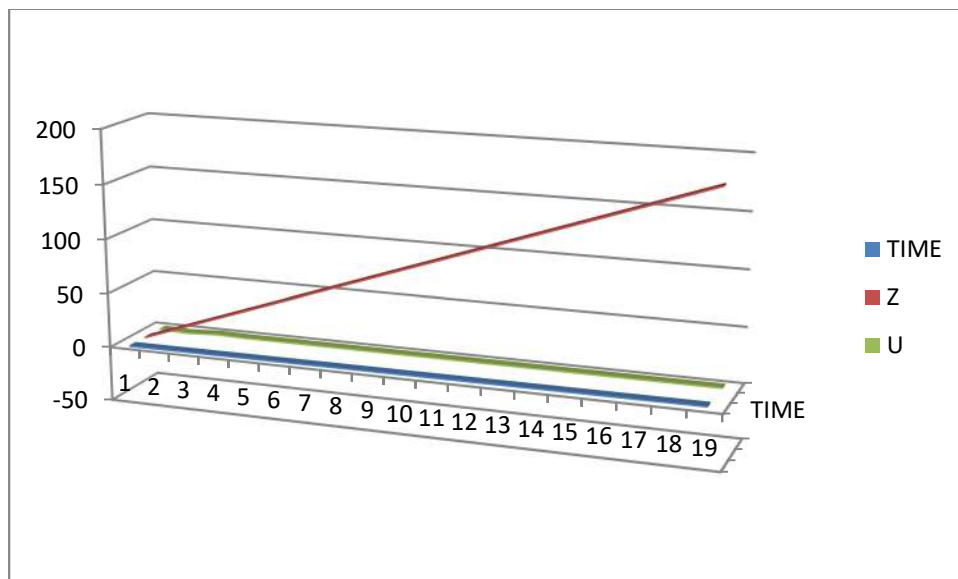
$$u(x, y, z, t) = \sum_{n=1}^{\infty} \sum_{m=1}^{\infty} \sum_{k=1}^{\infty} C_{nmk} \sin nx \sin my \sin kz e^{\frac{-9t}{7}(n^2+m^2+k^2)}$$

$$u(x, y, z, 0) = \sum_{n=1}^{\infty} \sum_{m=1}^{\infty} \sum_{k=1}^{\infty} C_{nmk} \sin nx \sin my \sin kz$$

$$C_{nmk} = \frac{1}{abc} \int_0^a \int_0^b \int_0^c f(x, y, z) \sin nx \sin my \sin kz dx dy dz$$

$$C_{0,0,k} = \frac{8}{\pi^3} \int_0^\pi \int_0^\pi \int_0^\pi z \sin kz dz = \frac{8}{k} [(-1)^{k+1}]$$

$$u(z, t) = \sum_{k=1}^{\infty} \frac{8}{k} [(-1)^{k+1}] \sin kz e^{\frac{-7tk^2}{9}}$$



Problem 2.

$$u_t = \frac{1}{2} (u_{xx} + u_{yy} + u_{zz}) \quad 0 \leq x \leq \pi, 0 \leq y \leq \pi, 0 \leq z \leq \pi, t > 0$$

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

$$u(x, 0, z) = u(x, \pi, z) \quad 0 \leq x \leq \pi, 0 \leq z \leq \pi, t > 0$$

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

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

$$\frac{2T'}{T} = \frac{X''}{X} + \frac{Y''}{Y} + \frac{Z''}{Z} \quad \text{then} \quad \frac{X''}{X} = R, \quad \frac{Y''}{Y} = P, \quad \frac{Z''}{Z} = S, \quad \frac{2T'}{T} = R + P + S$$

$$X'' - RX = 0, \quad Y'' - YP = 0, \quad Z'' - ZS = 0$$

$$\text{Case 1. } R = \mu^2 > 0, \quad P = \lambda^2 > 0, \quad S = \eta^2 < 0$$

$$X'' - \mu^2 X = 0, \quad Y'' - \lambda^2 Y = 0, \quad Z'' - \eta^2 Z = 0$$

$$X(x) = c_1 e^{\mu x} + c_2 e^{-\mu x}, \quad Y(y) = c_3 e^{\lambda y} + c_4 e^{-\lambda y}, \quad Z(z) = c_5 e^{\eta z} + c_6 e^{-\eta z}$$

$$X(0) = X(\pi) = 0 \Rightarrow c_1 = -c_2$$

$$Y(0) = Y(\pi) = 0 \Rightarrow c_3 = -c_4$$

$$Z(0) = Z(\pi) = 0 \Rightarrow c_5 = -c_6$$

The solution is trivial

$$\text{Case 2 } R = \mu^2 = 0, \quad P = \lambda^2 = 0, \quad S = \eta^2 = 0$$

$$X'' = 0, \quad Y'' = 0, \quad Z'' = 0 \quad \text{then} \quad X(x) = c_1 x + c_2, \quad Y(y) = c_3 x + c_4, \quad Z(z) = c_5 z + c_6$$

$$X(0) = X(\pi) = 0 \Rightarrow C_1 = -C_2$$

$$Y(0) = Y(\pi) = 0 \Rightarrow C_3 = -C_4$$

$$Z(0) = Z(\pi) = 0 \Rightarrow C_5 = C_6$$

The solution also trivial

$$\text{Case 3 } R = \mu^2 < 0, \quad P = \lambda^2 < 0, \quad S = \eta^2 < 0$$

$$X'' + \mu^2 X = 0, \quad Y'' + \lambda^2 Y = 0, \quad Z'' + \eta^2 Z = 0$$

$$X(x) = C_1 \cos \mu x + C_2 \sin \mu x$$

$$Y(y) = C_3 \cos \lambda y + C_4 \sin \lambda y$$

$$Z(z) = C_5 \cos \eta z + C_6 \sin \eta z$$

$$X(\pi) = 0 \Rightarrow C_1 \cos \mu \pi + C_2 \sin \mu \pi = 0 \quad \text{then } \mu = n \text{ and} \quad X(x) = C_n \sin nx$$

$$Y(\pi) = 0 \Rightarrow C_3 \cos \lambda \pi + C_4 \sin \lambda \pi = 0 \quad \text{then } \lambda = m \text{ and} \quad Y(y) = C_m \sin my$$

$$Z(\pi) = 0 \Rightarrow C_5 \cos \eta \pi + C_6 \sin \eta \pi = 0 \quad \text{then } \eta = k \text{ and} \quad Z(z) = C_k \sin kz$$

$$T(t) = C_w e^{-\frac{t}{2}(n^2+m^2+k^2)}$$

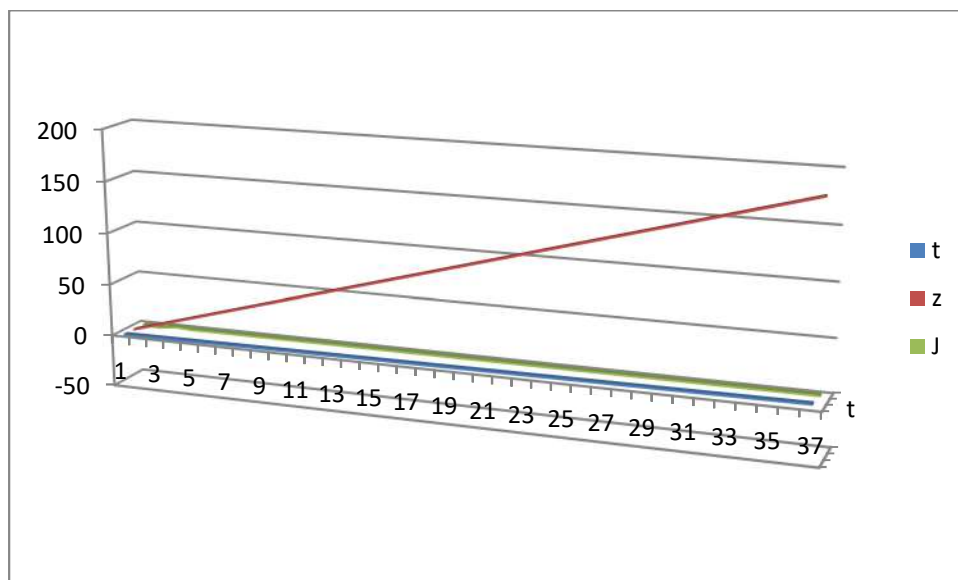
$$u(x, y, z, t) = \sum_{n=1}^{\infty} \sum_{m=1}^{\infty} \sum_{k=1}^{\infty} C_{nmk} \sin nx \sin my \sin kz e^{-\frac{t}{2}(n^2+m^2+k^2)}$$

$$u(x, y, z, 0) = \sum_{n=1}^{\infty} \sum_{m=1}^{\infty} \sum_{k=1}^{\infty} C_{nmk} \sin nx \sin my \sin kz$$

$$C_{nmk} = \frac{1}{abc} \int_0^a \int_0^b \int_0^c f(x, y, z) \sin nx \sin my \sin kz dx dy dz$$

$$C_{0,m,0} = \frac{8}{\pi^3} \int_0^{\pi} \int_0^{\pi} \int_0^{\pi} y \sin my dy = \frac{8}{m} [(-1)^{m+1}]$$

$$u(y, t) = \sum_{m=1}^{\infty} \frac{8}{m} [(-1)^{m+1}] \sin my e^{-\frac{tm^2}{2}}$$



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