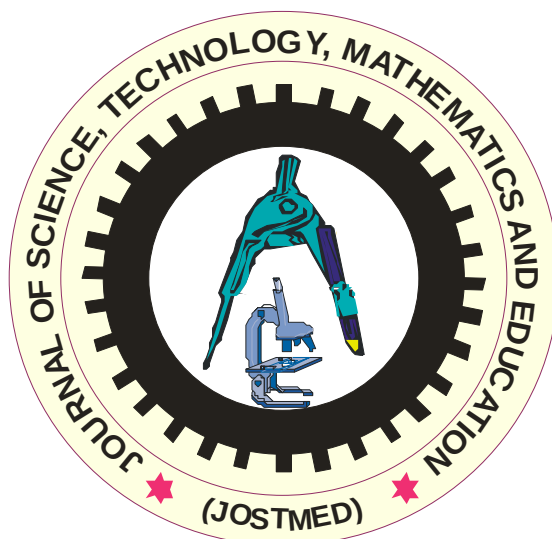


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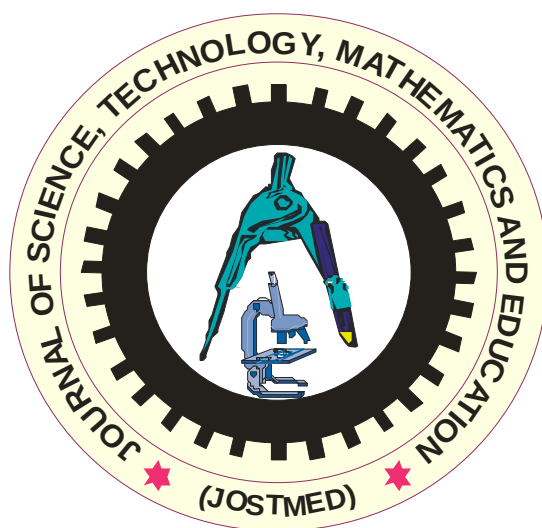
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ARTICLES AND RESEARCH REPORTS ON SCIENCE

SALT TOLERANCE IN SOME AFRICAN RICE (*Oryza glaberrima* Steudel) GENOTYPES

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Abstract

Salinity symptoms are prominent on the first and second leaves of susceptible genotypes and are visualized by leaf rolling, brownish and whitish leaf tip, drying of leaves, reduced root dry weight and stunted growth leading to complete cessation of growth and dying of seedlings. Forty-three O. glaberrima genotypes were screened for salt tolerance at 12ds/m at the seedling stage to investigate its tolerance to salinity stress, validate the aforementioned growth biometrics and determine genetic associations amongst genotype with tagged SSR markers. These effects were studied by evaluations, using the Standard Evaluation System of IRRRI for salt tolerance under hydroponic systems. The degree of growth inhibition due to salt injury varied with susceptibility to salinity and genotype. Four moderately tolerant (TOG5331, TOG7428, TOG12405 and TOG12407) and two tolerant (TOG9047 and TOG12373) genotypes were obtained. Thus, TOG9047 and TOG12373 are considered potential salt tolerant Oryza glaberrima genotypes. These candidate O. glaberrima genotypes could be adopted for plant improvements in breeding programmes.

Keywords: *Oryza glaberrima*, salt tolerance, salinity, seedling stage

Introduction

Oryza glaberrima, commonly known as African rice, is one of the two domesticated rice species (Linares, 2002). It is indigenous to Nigeria and has been cultivated for the past 3,500 years (Hardcastle, 1959). The earliest cultivation of improved rice varieties (*O. sativa* L.) started in about 1890 with the introduction of upland varieties to the high forest zone in Western Nigeria. Consequently, by 1960 *O. sativa* had taken over from *O. glaberrima*, which is now limited to some deep-flooded plains of the Sokoto-Rima river basin and other isolated pockets of deep swamps all over the country (Imolehin, 1991). Farmers in these regions have preference to *Oryza glaberrima* due to their tolerance to some biotic and abiotic stress (Jones *et al.*, 1997; Linares, 2002); hence, the need for its preservation through cultivation alongside the Asian species. Soils in these arid/semi-arid regions show some degree of salinity. A saline soil is defined as having a high concentration of soluble salts, high enough to affect plant growth. Salt concentration in a soil is measured in terms of its electrical conductivity, and soil salinity limits rice production (Mohammed-Nejad *et al.*, 2008). Salinity affects rice growth in varying degrees at all growth stages starting from germination through maturation (Maas & Hoffman, 1977). The seedling stage is the most sensitive and very important stage as it affects crop establishment (Singh *et al.*, 2008). A comparison of salt tolerance during germination and emergence with that during succeeding growth stages showed that while rice was very tolerant of salinity during the germination process, it was very sensitive during the first to second leaf stages. Salinity reduces the growth of plant through osmotic effects, reduces the ability of plants to take up water and this causes reduction in growth. There may be salt specific effects. If excessive amount of salt enters the plant, the concentration of salt will eventually rise to a toxic level in older transpiring leaves causing premature senescence and reduces the photosynthetic leaf area of a plant to a level that cannot sustain growth (Munns, 2002). Gregorio *et al.* (1997) emphasized that salinity symptoms were prominent on the first and second leaves and were visualized by leaf rolling, formation of new leaf, brownish and whitish leaf tip, drying of leaves and also reduction in root growth, stunted growth and stem thickness leading to complete cessation of growth and dying of seedlings. Extremely high salt stress conditions cause severe damage to plants, while moderate

to low salt stress affects the plant growth rate along with most of the growth and yield parameters. Accurate phenotypic identification of tolerant lines is difficult because of the extensive effect of the environment on salt tolerance (Singh *et al.*, 2008). This has necessitated the use of hydroponic culture solutions for salinity tolerance screening for crops such as rice (Gregorio *et al.*, 1997).

The study presented here was conducted to obtain salt tolerant *Oryza glaberrima* genotypes and evaluate their association to salt tolerance.

Materials and Methods

Place of Study and Plant Materials

The study was carried out in the glass house of the Department of Biological Sciences, Ahmadu Bello University, Zaria. Forty-three African rice genotypes evaluated for the study were obtained from Africa Rice, Ibadan Station, Nigeria.

Evaluation of Salt Tolerance

Rice seeds were directly sown at a rate of two per hole in the Styrofoam float which was suspended on a 15litre four-corner dark coloured plastic tank. After germination, the seedlings were thinned to one plant per hole. Seven days after seeding, 1g of FeSO₄ and 10 g of Peter's 20-20-20 water soluble fertilizer were added to the distilled water in the plastic tank. The nutrient tanks (15- liter capacity) were filled with the hydroponic solution high enough to touch the rubber net bottom of the Styrofoam. Eight days after seeding, 50 g of NaCl was used for salinization (equivalent to 12 dS/m). The pH was maintained at 5.0 ± 0.1 using 1N HCl and 1N NaOH by utilizing sensitive paper strips. Due to evaporation and transpiration, the loss of solution volume in the bowls was made up with water daily. One gram of FeSO₄ was added weekly and 10 g of Peter's water soluble fertilizer fortnightly to maintain the nutrient concentration in solution (Gregorio *et al.*, 1997).

The study was conducted in a completely randomized design with three replicates. and control checks 1R29 and Pokkali served as the susceptible and tolerant check respectively. Salinized and non-salinized hydroponics were maintained for 30 days. Salinity symptoms were scored using the standard evaluation system (IRRI, 1997).

Data Collection and Analyses

Seedling height (cm) and leaf blade colour were taken twenty-eight days after salinization. Root length (RL) (cm) were measured and recorded. Root dry weight (RDW) (mg) and shoot dry weight (SDW) (mg) and Leaf number (LN) were taken.

Quantitative data were analyzed using Analysis of variance (ANOVA) and mean separation using Duncan Multiple Range Test (DMRT). This was performed using the GLM procedure of Statistical Analysis System (SAS Institute Incorporation, 1999).

Evaluation of Rice Genotypes with Tagged Salt Tolerance Markers

Genomic DNA was extracted from young leaf tissues following the method described by Aliyu *et al* (2013), using 5 mg of leaf materials from at least 3 seedlings. Quantified DNA from each genotype was subjected to PCR amplification with 7 SSR primers (RM17, RM240, RM286, RM493, RM495, RM10711 and RM10793) tagged to salinity tolerance (Aliyu *et al.*, 2013). For each marker, allelic bands were scored on a 1 (present) and 0 (absent) binary codes. Only prominent and unambiguous bands were scored for data reliability. Genetic similarities were evaluated using the single data analysis for neighbor joining analysis of the DARwin 5 version 5.0.157 software. (Perrier and Jacquemond, 2006)

Results

Phenotypic biometrics of forty-three (43) *Oryza glaberrima* genotypes screened for salt tolerance at EC 12 dS/m with the tolerant- (Pokkali) and susceptible (IR29) checks as well as the response of *Oryza glaberrima* to salt injury at seedling stage based on their phenotype and standard evaluation score (IRRI, 1997) are presented in table 1. The genotypes showed varied visual symptoms of salt injury in salinized conditions. A ratio of approximately 1:6 tolerant and moderately tolerant genotypes (14%) to highly susceptible genotypes (86%) at an electrical conductivity (EC) of 12dsm⁻¹ was observed. Four moderately tolerant (TOG5331, TOG7428, TOG12405 and TOG12407) and two tolerant (TOG9047 and TOG12373) genotypes were obtained. These tolerant genotypes (TOG9047 and TOG12373) were comparable to the highly tolerant genotype (Pokkali). Nine *Oryza glaberrima* genotypes (TOG5314, TOG5321, TOG5508, TOG6600, TOG6785, TOG7390, TOG7428, TOG8044 and TOG9396) were more susceptible than IR29 (susceptible check). The effect of salinity on genotypes were highly significant ($P < 0.01$) based on the biometrics investigated. The interactions between salinity and genotype were also significant ($P < 0.01$) on plant growth parameters.

Variations in seedling heights were observed for all genotypes. The seedling heights were shorter in salinized conditions compared to plants grown in non-salinized conditions. Seedling heights of susceptible genotypes recorded higher percentage reductions than that of tolerant genotypes. Percentage reduction in seedling height for Pokkali and IR29 was 24% and 29% respectively. TOG 5479 showed the least reduction in seedling height ($P < 0.01$) of 16% and 19% respectively. However, most of the moderately tolerant to tolerant genotypes showed growth rate (computed with reference to non-saline treatment) ranging from 74.5% to 95.9%. About 35% of the genotypes exhibited growth rate above 100% while 33% of the genotypes showed growth rates below 74.5% (least growth rate observed in tolerant genotypes). The growth rates of genotypes within the tolerance range (74.5% and 99.9%) were about 32%.

Tillering ability was not significantly affected by salinity stress. Most of the genotypes showed no difference in number of tillers in salinized conditions. Reduction in tillers for Pokkali and IR29 were 15% and 5% respectively.

Root length was significantly affected by salinity. All genotypes showed varied responses to root length. This ranged from 8.51 cm in Pokkali, 8.77 cm in TOG9047 to 13.7cm in TOG12407 among the tolerant genotype. Some genotypes showed no increase or decrease in root length under salinized conditions.

General reductions in the root dry weight across all genotypes were obtained. A significant positive association ($r = 0.61$) was observed between root length and root dry weight. In susceptible genotypes root dry weight obtained was as low as 0.07 g and as high as 1.57 g. Root dry weight (1.93 g) was highest in Pokkali. TOG9047 and TOG12373 showed root dry weight ranging from 0.80 g to 1.33 g.

Genetic diversity based on tagged SSR markers

Two clusters groups (Figure 1) were obtained on the dendrogram constructed with seven SSR markers based on neighbor joining analysis to characterize tolerant and susceptible genotypes. Most of the susceptible genotypes (97.3%) clustered together in Cluster group 1 except for TOG14101 which out clustered in group 2. The moderately tolerant to tolerant genotypes (83.3%) clustered in group 2 except for TOG7428 found clustering in group 1.

Table 1: Phenotypic biometrics of forty-three (43) *Oryza glaberrima* genotypes screened for salt tolerance at EC 12 dS/m with the tolerant- (Pokkali) and susceptible (IR29) checks

S/N	GENOTYPE	SH	G.RATE (%)	TN	RL	RDW	SES SCORE
1	IR29	13.73 ^{cj}	42.60 ^{hi}	3.00 ^a	7.33 ^{bf}	0.43 ^{fj}	9.00 ^d
2	POKKALI	28.87 ^a	74.50 ^{fg}	3.00 ^a	8.51 ^{af}	1.93 ^a	1.00 ^a
3	TOG12405	22.60 ^{ac}	131.30 ^{cd}	2.67 ^{ab}	11.93 ^{ae}	1.09 ^{bi}	5.00 ^c
4	TOG12303	20.73 ^{ad}	92.50 ^e	3.00 ^a	12.50 ^{ae}	0.77 ^{bj}	9.00 ^d
5	TOG12373	19.40 ^{bf}	85.30 ^{ef}	3.00 ^a	11.15 ^{af}	1.33 ^{bc}	3.00 ^b
6	TOG12407	21.65 ^{ad}	98.60 ^{de}	3.00 ^a	13.7 ^{ab}	1.23 ^{bd}	5.00 ^c
7	TOG12444	17.73 ^{bg}	92.10 ^e	2.67 ^{ab}	11.00 ^{af}	0.60 ^{dj}	9.00 ^d
8	TOG14101	6.97 ^{ik}	15.60 ^j	2.00 ^{bc}	8.93 ^{af}	0.57 ^{dj}	9.00 ^d
9	TOG5282	19.87 ^{be}	82.30 ^{ef}	3.00 ^a	13.90 ^{ab}	1.13 ^{af}	9.00 ^d
10	TOG5284	13.80 ^{cj}	114.00 ^d	3.00 ^a	12.65 ^{ad}	0.63 ^{cj}	9.00 ^d
11	TOG5313	19.77 ^{be}	70.90 ^g	3.00 ^a	12.50 ^{ae}	0.53 ^{dj}	9.00 ^d
12	TOG5314	10.47 ^{gk}	77.50 ^f	2.67 ^{ab}	9.07 ^{af}	0.30 ^{fj}	9.00 ^d
13	TOG5321	9.95 ^{gk}	134.10 ^{cd}	3.00 ^a	7.45 ^{bf}	0.40 ^{ej}	9.00 ^d
14	TOG5406	14.60 ^{bj}	88.40 ^{ef}	3.00 ^a	12.15 ^{ae}	0.50 ^{dj}	9.00 ^d
15	TOG5418	4.40 ^k	44.30 ^h	1.50 ^c	8.50 ^{af}	0.17 ^{hj}	9.00 ^d
16	TOG5456	6.70 ^{ik}	370.00 ^a	1.50 ^c	4.80 ^f	0.13 ^{ij}	9.00 ^d
17	TOG5331	12.65 ^{ek}	87.00 ^{ef}	3.00 ^a	13.10 ^{ac}	1.20 ^{ac}	5.00 ^c
18	TOG5457	20.22 ^{bd}	347.60 ^b	2.80 ^{ab}	12.12 ^{ae}	0.77 ^{bj}	9.00 ^d
19	TOG5479	19.73 ^{be}	132.10 ^{cd}	2.67 ^{ab}	11.63 ^{af}	0.63 ^{cj}	9.00 ^d
20	TOG5508	8.20 ^{hk}	37.40 ⁱ	2.00 ^{bc}	4.85 ^f	0.13 ^{ij}	9.00 ^d
21	TOG6165	13.45 ^{dj}	138.10 ^{cd}	2.00 ^{bc}	10.15 ^{af}	0.17 ^{hj}	9.00 ^d
22	TOG6193	6.20 ^{ik}	69.90 ^{fg}	2.00 ^{bc}	6.50 ^{ef}	0.23 ^{fj}	9.00 ^d
23	TOG 6600	10.55 ^{gk}	75.80 ^f	2.50 ^{ab}	9.40 ^{af}	0.07 ^j	9.00 ^d
24	TOG6762	16.30 ^{dh}	132.90 ^{cd}	2.67 ^{ab}	14.67 ^a	1.50 ^{ac}	9.00 ^d
25	TOG6785	6.40 ^{ik}	66.20 ^f	2.00 ^{bc}	5.75 ^{ef}	0.07 ^j	9.00 ^d
26	TOG7134	17.40 ^{bg}	118.90 ^d	2.67 ^{ab}	10.40 ^{af}	0.80 ^{bj}	9.00 ^d
27	TOG7191	17.10 ^{bg}	121.20 ^{cd}	3.00 ^a	13.13 ^{ac}	1.37 ^{ad}	9.00 ^d
28	TOG7390	11.10 ^{ek}	68.20 ^{fg}	2.33 ^{ac}	6.70 ^{cf}	0.23 ^{fj}	9.00 ^d
29	TOG7401	14.30 ^{cj}	56.00 ^g	3.00 ^a	12.73 ^{ad}	0.67 ^{cj}	9.00 ^d
30	TOG7426	19.83 ^{be}	73.20 ^{fg}	2.33 ^{ac}	6.33 ^{ef}	0.43 ^{ej}	9.00 ^d
31	TOG7427	17.20 ^{bg}	164.60 ^c	2.33 ^{ac}	12.63 ^{ad}	0.87 ^{bj}	9.00 ^d
32	TOG7428	21.30 ^{ad}	95.9 ^{cd}	3.00 ^a	10.07 ^{af}	1.07 ^{bh}	5.00 ^c
33	TOG7742	23.47 ^{ab}	83.80 ^{ef}	3.00 ^a	12.93 ^{ad}	1.57 ^{ab}	9.00 ^d
34	TOG7943	15.27 ^{bi}	71.60 ^{fg}	2.67 ^{ab}	10.33 ^{af}	0.73 ^{bj}	9.00 ^d
35	TOG7992	20.20 ^{bd}	99.40 ^{de}	3.00 ^a	15.07 ^a	1.13 ^{af}	9.00 ^d
36	TOG8006	15.95 ^{bh}	109.90 ^{de}	2.50 ^{ab}	8.50 ^{af}	0.40 ^{ej}	9.00 ^d
37	TOG8008	21.00 ^{ad}	102.00 ^{de}	3.00 ^a	13.9 ^{ab}	0.60 ^{gi}	9.00 ^d
38	TOG8044	18.75 ^{bg}	92.30 ^e	3.00 ^a	7.70 ^{ef}	0.07 ^j	9.00 ^d
39	TOG9047	17.87 ^{bg}	105.40 ^{de}	2.67 ^{ab}	8.77 ^{af}	0.80 ^{bj}	3.00 ^b

40	TOG9276	6.65 ^{ik}	137.50 ^{cd}	1.50 ^c	5.65 ^{ef}	0.17 ^{hj}	9.00 ^d
41	TOG9278	14.67 ^{bj}	49.20 ^h	3.00 ^a	13.83 ^{ab}	1.27 ^{ae}	9.00 ^d
42	TOG9281	23.37 ^{ab}	82.20 ^{ef}	3.00 ^a	14.93 ^a	1.33 ^{ad}	9.00 ^d
43	TOG9395	17.33 ^{bg}	67.10 ^{fg}	2.67 ^{ab}	9.80 ^{af}	1.10 ^{ag}	9.00 ^d
44	TOG9396	10.80 ^{gj}	66.20 ^f	3.00 ^a	7.50 ^{be}	0.23 ^{fj}	9.00 ^d
45	TOG9524	18.57 ^{bg}	70.80 ^{fg}	3.00 ^a	11.50 ^{af}	1.03 ^{bi}	9.00 ^d
	C.V	16.21	12.22	14.94	19.5	18.83	
	R2	0.76	0.77	0.66	0.78	0.74	
	STDEV	6.44	3.63	0.53	3.81	0.64	
	MIN	1	17.6	1	1.03	0.07	
	MAX	31.6	570	3	20.6	1.93	
	P VALUE	<.01	<.01	<.05	<.01	<.01	

column values followed by the same letters are not significantly different using Duncan's Multiple Range Test.

Key: C.V: - Coefficient of Variance, SH- Seedling Height, G.RATE- Growth Rate, TN- Tiller number, RL- Root Length, RDW- Root Dry Weight, SES- Standard Evaluation system

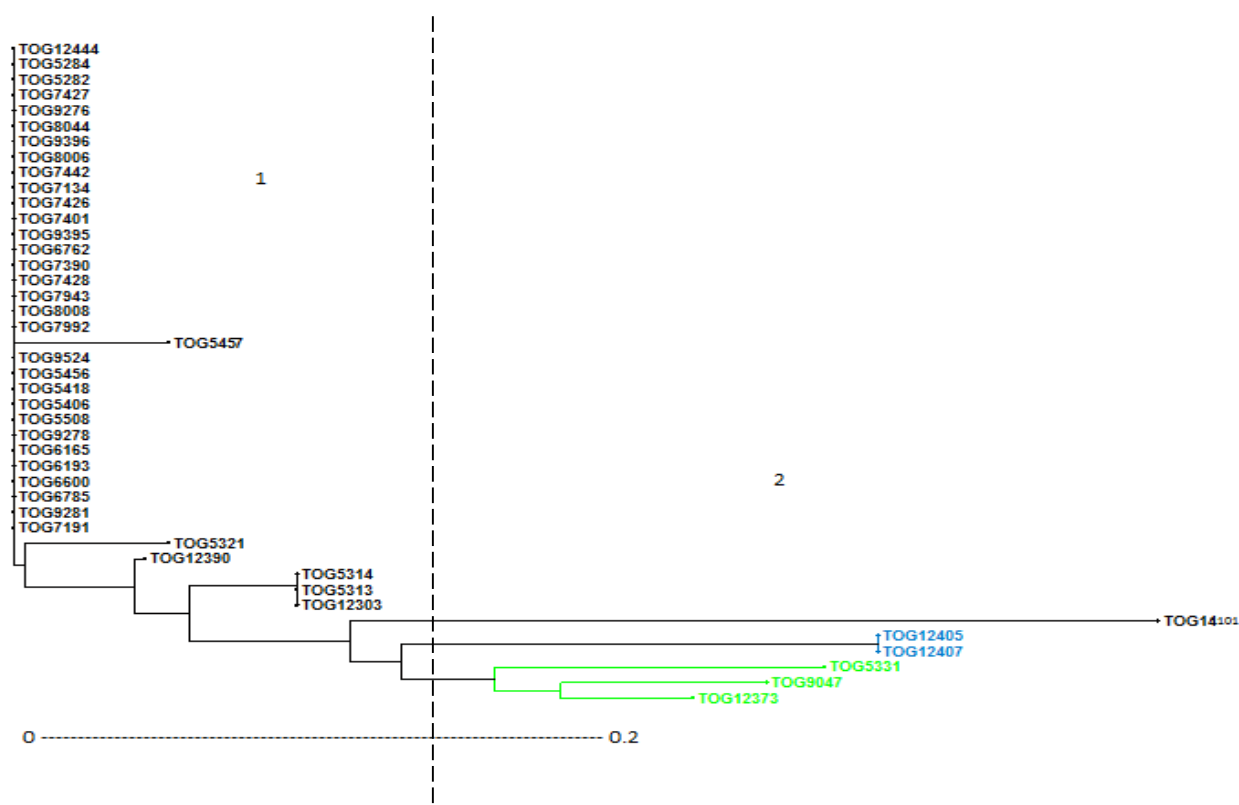


Figure 1: Dendrogram of 43 *Oryza glaberrima* genotypes (green colour – tolerant, blue colour- moderately tolerant) based on 7 salt tolerant tagged Polymorphic SSR Markers Derived from UPGMA Cluster Analysis using DARwin5 software (version 5.0.157)

Discussion

Some degree of cultivar tolerance to salinity and other abiotic stress is available in rice germplasm (De De Datta *et al.*, 1993; Gregorio, 1997). African *O. glaberrima* screened at 2-3 leaf stage at EC 12 dsm⁻¹ for 14 days were highly susceptible at seedling stage with a survival rate of 0-16% while the tolerant control nona Bokra showed complete survival (Akbar *et al.*, 1987). Substantial genetic variability in the rate of sodium uptake by rice roots is present, signifying a sizeable potential for genetic improvement.

Genotypes showed varied response to salt tolerance. Salt tolerant genotypes showed reduce plant growth rate which implies a reduction in energy utilization thus conserving energy by maintaining low growth rate. Susceptible genotypes were characterized by their inability to absorb salt in water. The toxic ions sneak into the plant along with the water stream which moves from soil to the vascular system of the root by different pathways like symplastic and apoplastic pathways Garciadebleas *et al.* (2003).

A highly significant effect of salinity on seedling height, tiller number, root length and biomass dry weight was obtained at seedling stage. However, Tolerant genotypes showed lower reductions in characterized traits than in susceptible ones. Seedling height was shorter in susceptible than tolerant genotypes indicating that salinity stress affect the seedling height of the genotypes by interfering with growth mechanisms thereby affecting the photosynthesizing abilities of these genotypes.

On the other hand, the tiller numbers produced by some tolerant and susceptible genotypes were higher in salinized treatments. Increased tillering ability in salinized conditions in some genotypes might be due to the genotypes tillering ability and vigour. Alternatively, it might have been due to unclear morphological determinants which might have triggered some mechanisms that triggered the genotypes to respond more vigorously in the bid to escape long exposure to the stress factor. Increased tillers have also been reported by Afza *et al.* (2009) in their work on double haploid and induced mutation in breeding salt tolerance in rice and wheat. Reduction in tillering ability of susceptible genotypes was also observed. This result was in accordance with the report of Farah and Anter (1978) and Aliyu *et al.* (2013) that salinity decreased tillering in sensitive rice than in tolerant genotypes. The reductions in the growth parameters observed in the genotypes are in line with report from previous investigations. At salinity levels as low as 1.9 dS/m, seedling growth is significantly reduced Munns (2002) reported that many rice cultivars suffer a 50% reduction in growth at 7.5 dS/m.

The roots of sensitive genotypes were more affected by salinity than the tolerant genotypes. This could have been due to osmotic effect caused by salinity. It had been reported that salinity caused some morphological changes like reduction of shoot (Mishra *et al.*, 1995), root length (Evers *et al.*, 1997) and restriction of rooting (Lopez and Satti. 1996). Munns *et al.* (1995) also reported that, salinity might directly or indirectly inhibit cell division and enlargement in plant's growth phases. Alam *et al.* (2004) attributed the possible reasons for decrease in the root growth in salinized plants as reduction of photosynthesis, which in turn limits the supply of carbohydrates needed for growth and reduction of turgor in expanding tissues resulting from lowered water potential in root growth medium. Plasticity due to salinity stress in susceptible genotypes was observed with some growth parameters (increased root length, root dry weight, and tillering ability). This could be attributed to the initial vigour of these genotypes in the bid to escape unfavorable condition as they compete for nutrients.

Genetic diversity and the relationship between and among species are of great importance for rice breeding. Genotypes derived from genetically similar types clustered together as species exhibited a spatial structure of genetic variation. This was supported by works of Ge *et al.* (1999), Joshi *et al.* (1999) and Ren *et al.* (2003). The different level of diversity may be

attributed to the rate of mutation, migration, dispersal mechanisms, biotic and abiotic selection intensities which are determined by location, climate and soil as also reported by Kark *et al.* (1999). Tagged molecular markers to abiotic stress could be utilized in the profiling of salt tolerant lines within and between species (Aliyu *et al.*, 2013). The ability of the tolerant genotypes to cluster together was as a result of selection pressure by the tagged markers.

Conclusively, TOG9047 and TOG12373 could be considered as potential salt tolerant *Oryza glaberrima* genotypes.

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ANALYSES OF PSEUDOSECTION SPECIFIC ROUTES OF DIFFERENT ORIENTATIONS OF
FAULT-TRACES TO DETERMINE GROUNDWATER FLOW PATTERN AT A 4 KM²
TRANCHE OF NEW DEVELOPMENT, GIDAN KWANO CAMPUS PHASE II,
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Abstract

Having drawn general conclusions with respect to groundwater prospects from the results of a vertical electrical sounding survey of a 4km² tranche of New Development at the Gidan Kwano Campus Phase II, it is necessary to examine further the groundwater recharge prognoses of the NE-SW trending subsurface fault-traces that have been pinpointed. Thus, this study was concerned with the analyses of pseudosection specific routes of the different orientations of fault-traces culminating at locations P2-1 (Station1, Profile2), P3-1 (Station1, Profile3), P4-1 (Station1, Profile4), P8-1 (Station1, Profile8), P9-1 (Station1, Profile9), and P6-2 (Station2, Profile6). The pseudosections along the NE-SW diagonal fault-traces of these locations confirm that the fault-traces culminating at these points are continuous subsurface fracture routes for groundwater flow; furthermore, the observed flow pattern has been classified in this study as either "normal" or "reverse." Thus, it is recommended that based on the current survey regime, an appropriate "water farm" scheme should be centred on these locations. Such a water farm scheme would involve the drilling of boreholes down to the total depth (TD) surveyed for the individual points of interest and feeding their output to a storage facility for onward processing and distribution through an appropriate purpose-specific waterworks for the Gidan Kwano Campus Phases I and II.

Keywords: *Fault-Trace, pseudosection, groundwater, prognosis, recharge*

Introduction

The work completed at the 4 km² tranche of New Development of the Gidan Kwano Campus (GKC) of the Federal University of Technology (F.U.T.), Minna, was a 2km x 2km dual vertical electrical sounding (VES)-induced polarisation (IP) survey represented in the grid formats of Figs 1 and 2. The Schlumberger array of the VES mode, at 100m station-spacing, was employed for the survey. The survey trend was an east-west (or transverse traverse, TT) sense for individual stations and a south-north profile, thus defining a two-dimensional configuration. The station-designation format for this study also follows a two-dimensional spatial awareness: principal profile lines are in the north-south direction, with the first profile line being the westernmost line of longitude; numerical station-designation is from west to east. The actual field survey proceeded from south to north because it was most convenient for the survey crew as the southwestern portion of the area of study was considered the most distant from the staging point and thus the most "difficult" to tackle; this "difficulty" had to be tackled first. Thus, the first assigned station of survey based on this format is the most extreme southwestern point in the 2 km by 2 km grid appropriately called P1-1; that is, Station 1 of Profile 1. Station 2 of Profile 1 (P1-2) is exactly 100m to the north of Station 1; Station 3 of Profile 1 (P1-3) is exactly 100m to the north of Station 2 and exactly 200m north of Station 1, and so on. P2-1 means Station 1 of Profile 2; this is exactly 100m to the east of P1-1; P3-1 is exactly 100m to the east of P2-1 and exactly 200m to the east of P1-1. With respect to geoelectrical studies that have been carried out at the local Basement Complex of which the location of this study is a part, the following works are cited: Abdulrashid (2005); Salako *et al.* (2010); Jonah *et al.* (2013); Jonah *et al.* (2014A); Jonah *et al.* (2014B); Jonah *et al.* (2014C); Jonah *et al.* (2015A); Jonah *et al.* (2015B); Jonah *et al.* (2015C); Jonah *et al.* (2015D); Jonah *et al.* (2015E); Jonah *et al.* (2015F); Jonah and Olasehinde (2016).

The result of the fault-trace of water-bearing fracture signatures inferred from a combination of the geoelectric cross-sections and the induced polarisation tables is shown as Fig.3 whilst that of the trace of low-resistivity signature trend inferred from the pseudosection plots is shown as Fig.4.

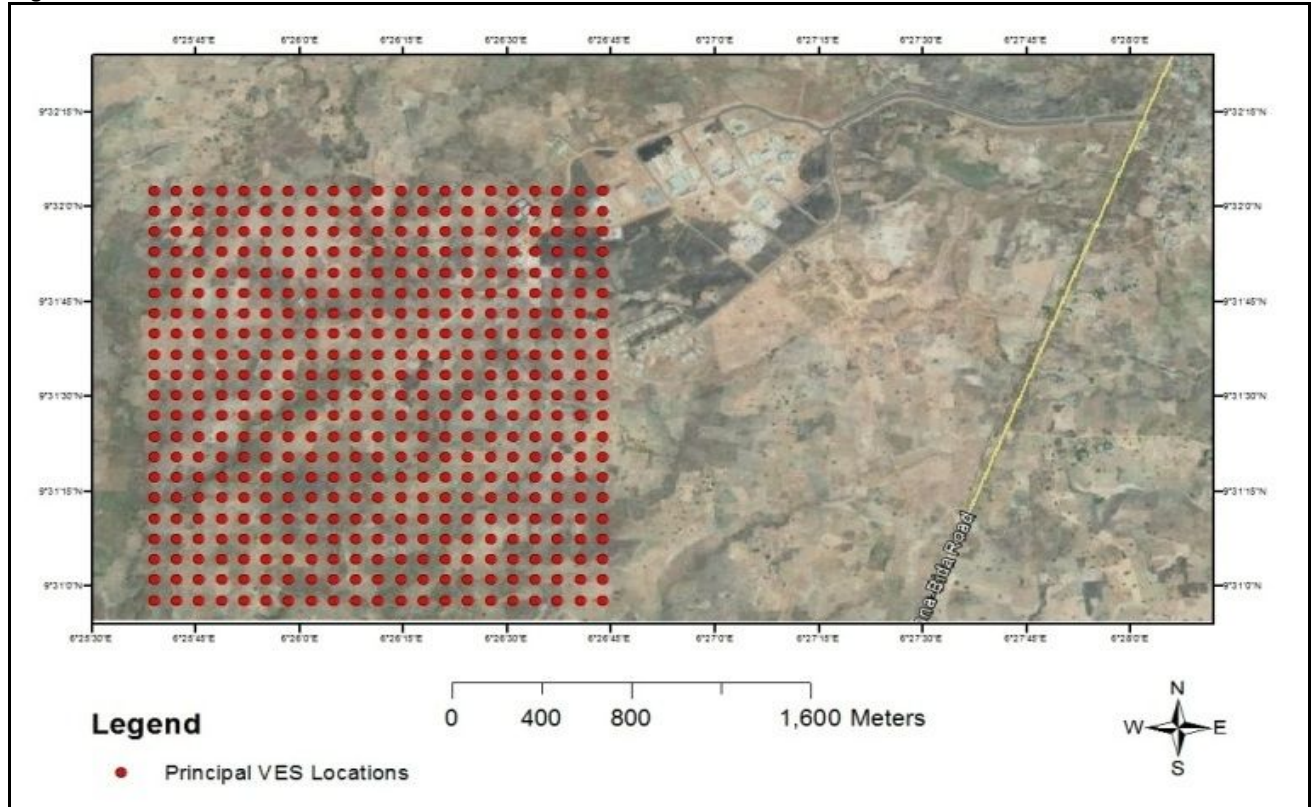


Fig.1: Grid of the 4km² tranche of New Development at the GKC. (The tadpole-shaped feature is

Phase I, the present developed portion of the GKC, seen to the northeast of the red-dotted grid of the 4km² areal extent; the Minna-Katereji-Bida Road is seen as the linear slope to the far east of the grid.)

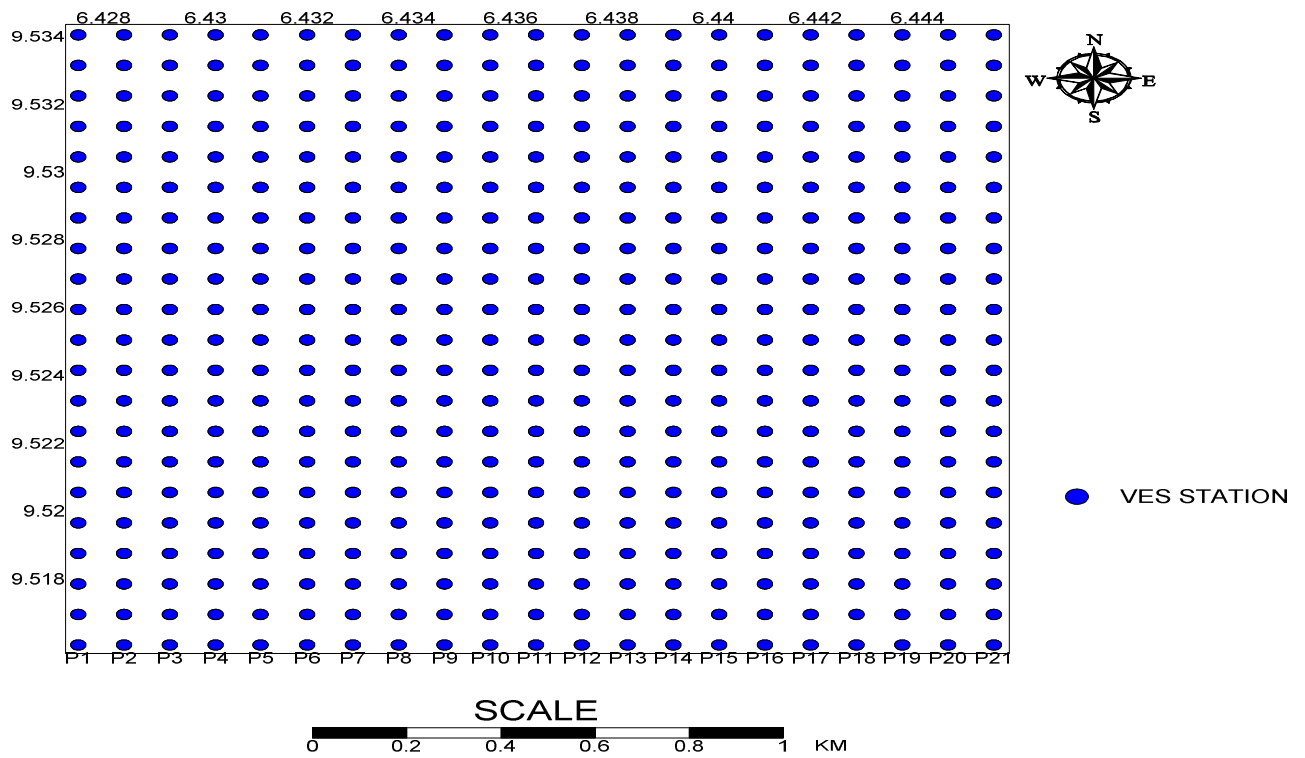


Fig.2: Conventional grid matrix format of the layout of Fig.1

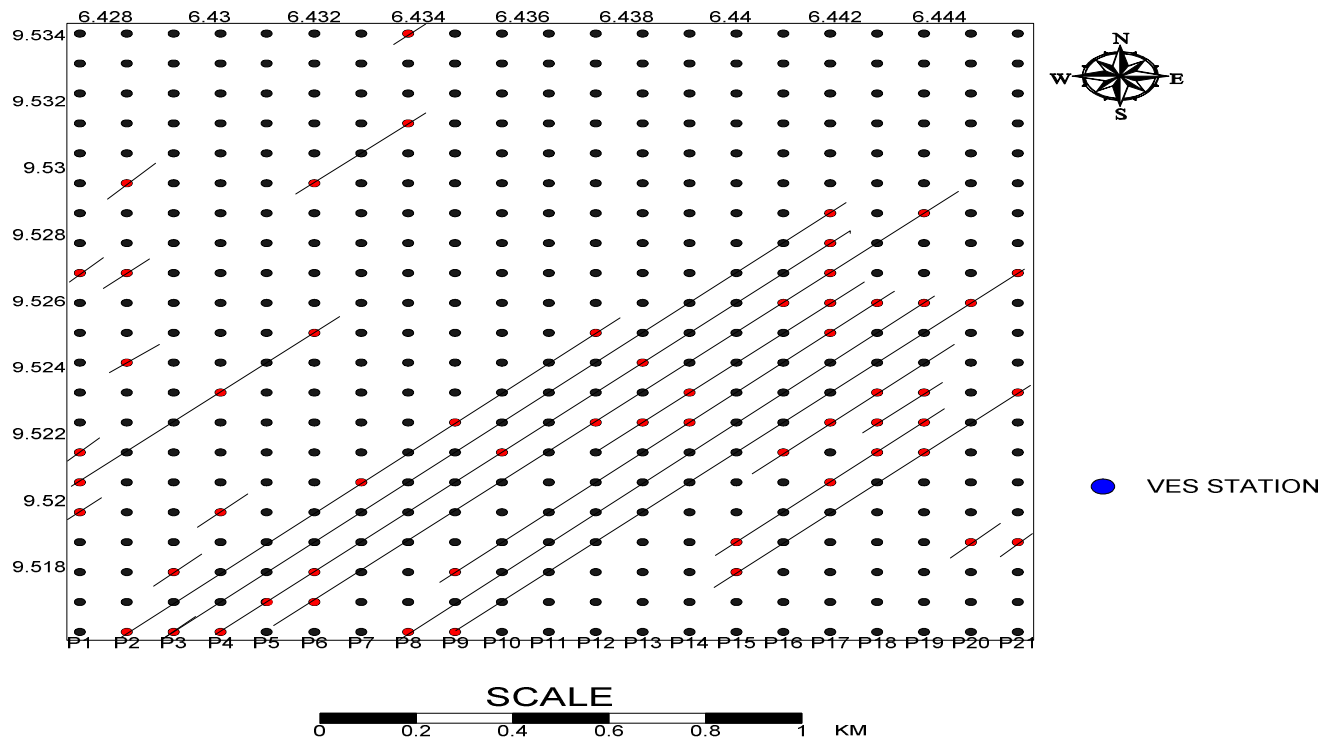


Fig.3: Fault-trace of fracture signatures inferred from a combination of the geoelectric cross-sections and the induced polarisation tables on the conventional grid matrix of the layout of survey stations

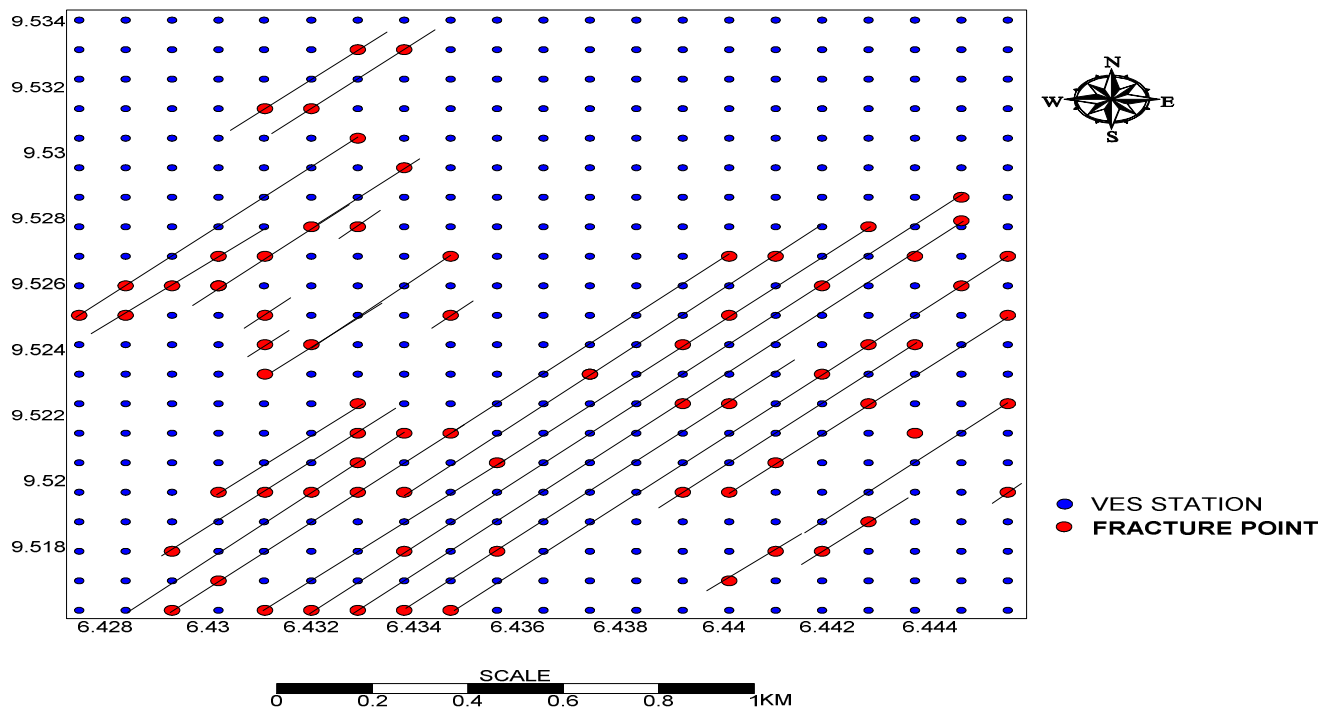
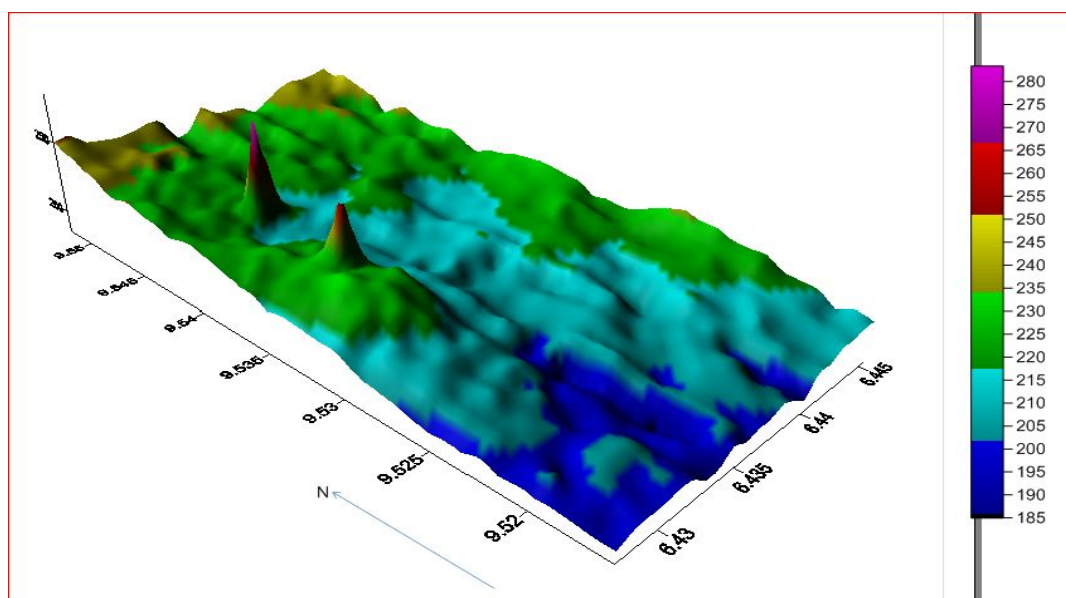


Fig.4: Trace of low-resistivity signature trend inferred from the pseudosection plots on the conventional grid matrix of the layout of survey stations

The slope of the landform of which this 4km² is a tranche indicates a resultant north-south east-west tilt (see Fig.5) which would suggest groundwater prospects at the southwestern portion; observations of Figs 3 and 4 strongly corroborate this fact. Thus, conclusion drawn from the interpretation route for groundwater potentials at the 4km² area of study indicates that there is discerned a sense of “geological fault-sources” at the right of the central mid-plane much close to the southeast and also a sense of “geological fault-sinks” at some points on the first transverse traverse line much close to the southwest. These “geological fault-sinks” located on the slope of the landform of the area of study are the most important aquifer locations because they are situated on the low-slopes of subsurface fault lines; the generally shallow nature of the water-bearing fractures concentrated on the high-slope at the right of the central mid-plane much close to the southeast is the perfect “aquifer source” for the generally deeply-incised nature of the water-bearing fractures concentrated on the low-slope at the southwest. Examination of Figs 3 and 4 shows that only for P3-1, P8-1, and P9-1 do the traces for coincide at the “sink.” Information gleaned from Fig.3 (the “most reliable” trace) is now used to analyse the different “primary geological fault-sinks” and the sole “secondary geological fault-sink” due to water-bearing fractures only; the “primary geological fault-sinks” are those located on the first east-west TT line at P2-1, P3-1, P4-1, P8-1, and P9-1 while the “secondary geological fault-sink” is that located on the second east-west TT line at P6-2. These “sources” and “sinks” basically defines a northeast (NE)-southwest (SW) fault trend.



It seen in Fig.6 that, along the diagonal connecting P2-1, P9-8, and P12-11, the information gleaned from the pseudosection plot indicates a groundwater recharge in the direction of P12-11 as deduced from the resistivity trend. There is a “low-resistivity plunge” in the high-slope direction. Since groundwater recharge exists along that diagonal, it should be designated “reverse recharge trend.”

“Geological fault-sink” at P3-1: The fault-line culminating at P3-1 extends over a diagonal length of 1800m (1.8km). The result of the pseudosection along the fault-line culminating at P3-1 would determine if the groundwater recharge prognosis for P3-1 is very good.

Pseudosection along Fault-Trace Culminating at P3-1: The fault-trace of interest here connects P3-1 and P17-15; the cross-section along this fault-trace is shown as Fig.7.

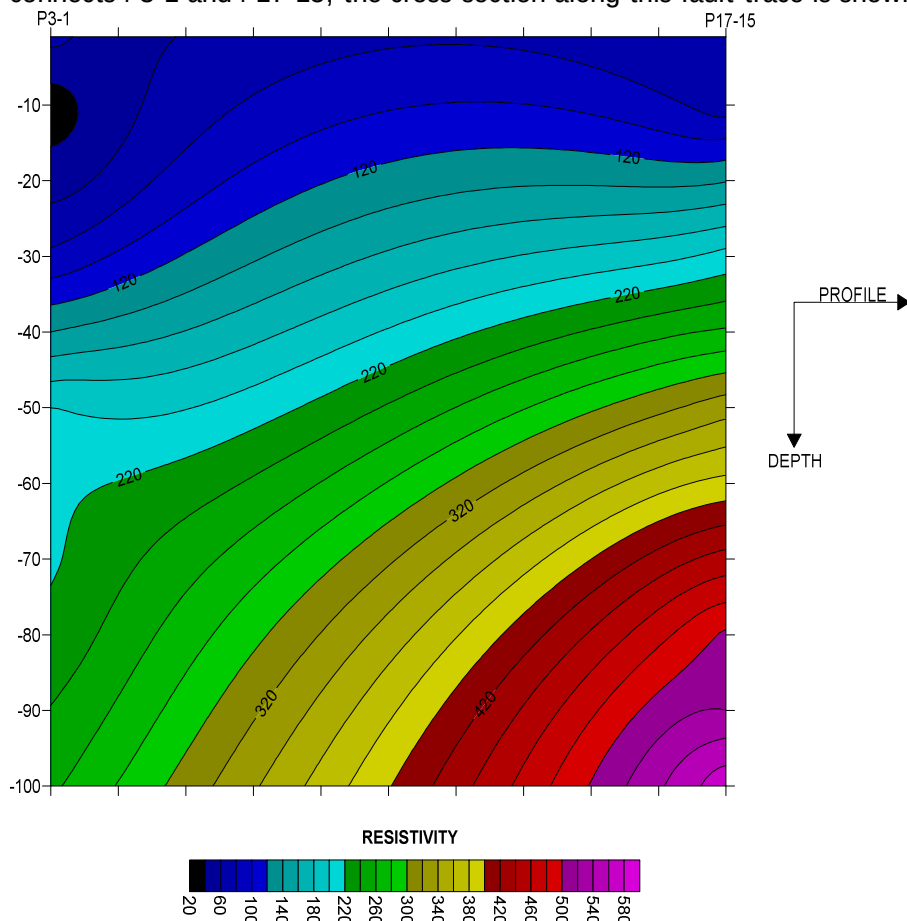


Fig.7: Pseudosection along fault-trace connecting P3-1 and P17-15

It seen in Fig. 7 that, along the diagonal connecting P3-1 and P17-15, the information gleaned from the pseudosection plot indicates a groundwater recharge in the direction of P3-1 as deduced from the resistivity trend. In this case, there is a “low-resistivity plunge” in the low-slope direction. Since groundwater recharge exists along that diagonal, it should be designated “normal recharge trend.”

“Geological fault-sink” at P4-1: The fault-line culminating at P4-1 extends over a diagonal length of 1675m (~1.7km). The result of the pseudosection along the fault-line culminating at P4-1 would determine if the groundwater recharge prognosis for P4-1 is very good.

Pseudosection along Fault-Trace Culminating at P4-1: The fault-trace of interest here connects P4-1, P5-2, P6-3, P10-7, P13-10 and P17-14; the cross-section along this fault-trace is shown as Fig.8.

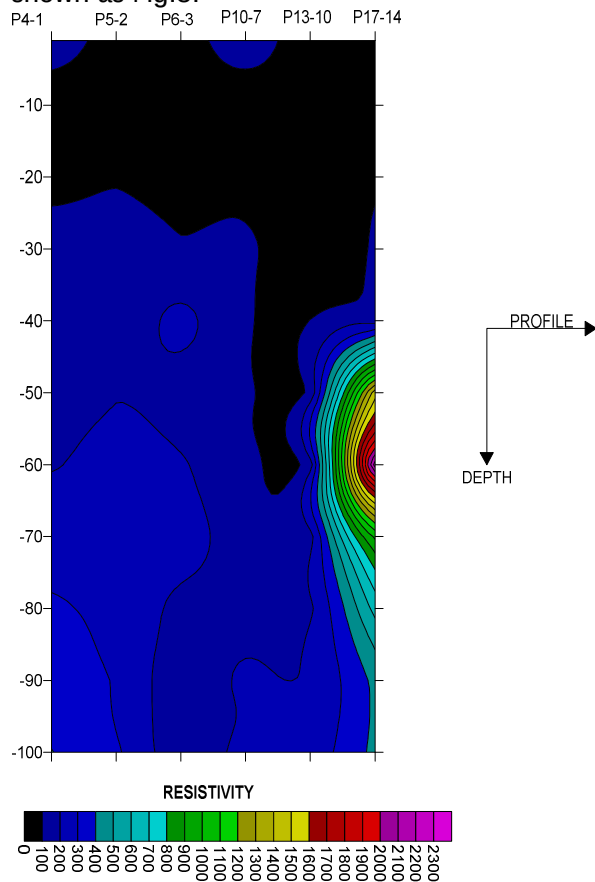


Fig.8: Pseudosection along fault-trace connecting P4-1, P5-2, P6-3, P10-7, P13-10, P17-14

It is observed in Fig.8 that, along the diagonal connecting P4-1, P5-2, P6-3, P10-7, P13-10 and P17-14, the information gleaned from the pseudosection plot indicates a groundwater recharge in the direction of P4-1, as best as could be made out, and as deduced from the resistivity trend. In this case, there is a “low-resistivity plunge,” as it were, in the low-slope direction. Since groundwater recharge exists along that diagonal, it should be designated “normal recharge trend.”

“Geological fault-sink” at P8-1: The fault-line culminating at P8-1 extends over a diagonal length of 1400m (1.4km). The result of the pseudosection along the fault-line culminating at P8-1 would determine if the groundwater recharge prognosis for P8-1 is very good.

Pseudosection along Fault-Trace Culminating at P8-1: The fault-trace of interest here connects P8-1 and P19-12; the cross-section along this fault-trace is shown as Fig.9.

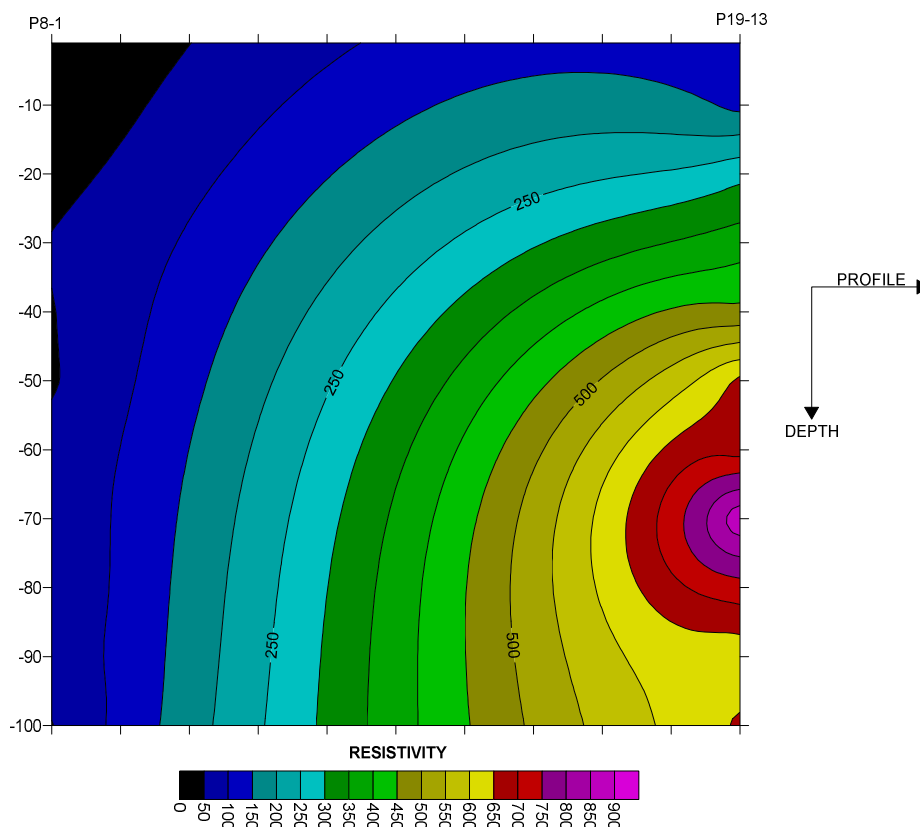


Fig.9: Pseudosection along fault-trace connecting P8-1 and P19-12

It seen in Fig.9 that, along the diagonal connecting P8-1 and P19-12, the information gleaned from the pseudosection plot indicates a groundwater recharge in the direction of P8-1 as deduced from the resistivity trend. In this case, there is a “low-resistivity plunge” in the low-slope direction. Since groundwater recharge exists along that diagonal, it should be designated “normal recharge trend.”

“Geological fault-sink” at P9-1: The fault-line culminating at P9-1 extends over a diagonal length of 1537.5m (~1.5km). The result of the pseudosection along the fault-line culminating at P9-1 would determine if the groundwater recharge prognosis for P9-1 is very good.

Pseudosection along Fault-Trace Culminating at P9-1: The fault-trace of interest here connects P9-1, P20-12, and P21-13; the cross-section along this fault-trace is shown as Fig.10.

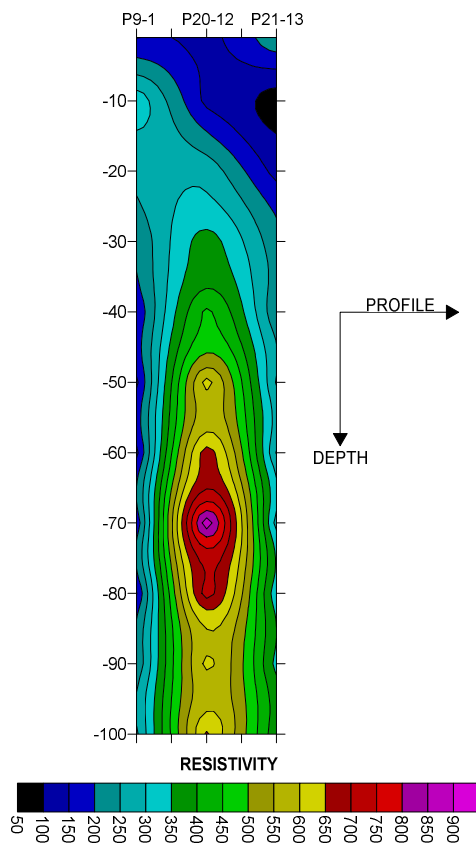


Fig.10: Pseudosection along fault-trace connecting P9-1, P20-12, and P21-13

It seen in Fig.10 that, along the diagonal connecting P9-1, P20-12, and P21-13, the information gleaned from the pseudosection plot would, at first glance, indicate a groundwater recharge in the direction of P21-13 as deduced from the resistivity trend, and there is a well-discerned “low-resistivity plunge” in the high-slope direction. Since groundwater recharge exists along that diagonal, it should be designated “reverse recharge trend.” However, upon closer inspection of Fig.10, it is observed that in spite of the “reverse recharge trend” designation for P9-1, there are pockets of low-resistivity bodies at depths here which imply that P9-1 could be exploited on a “standalone” basis.

“Geological fault-sink” at P6-2: The fault-line culminating at P6-2 extends over a diagonal length of 1687.5m (~1.7km). The result of the pseudosection along the fault-line culminating at P6-2 would determine if the groundwater recharge prognosis for P6-2 is very good.

Pseudosection along Fault-Trace Culminating at P6-2: The fault-trace of interest here connects P6-2, P12-8, P16-12, P17-13, and P19-15; the cross-section along this fault-trace is shown as Fig.11.

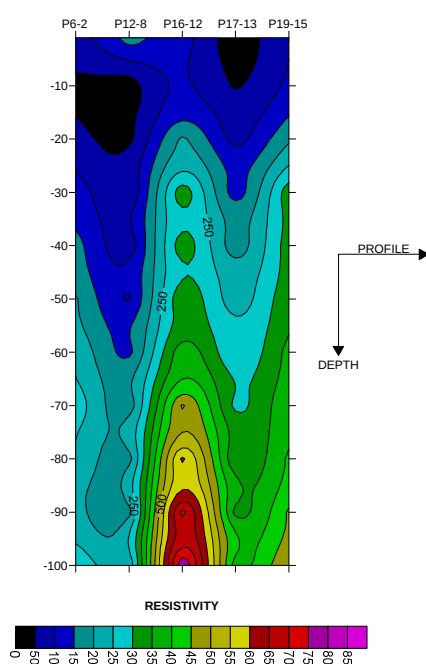


Fig.11: Pseudosection along fault-trace connecting P6-2, P12-8, P16-12, P17-13, and P19-15

It seen in Fig.11 that, along the diagonal connecting P6-2, P12-8, P16-12, P17-13, and P19-15, the information gleaned from the pseudosection plot indicates a groundwater recharge in the resultant direction of P12-8 as deduced from the resistivity trend. In this case, there is a resultantat “low-resistivity plunge” in the low-slope direction. Since groundwater recharge exists along that diagonal, it should be designated “normal recharge trend.”

On the “Ideal Groundwater Recharge Curve.” In conformance with the slope of the landform and the fact that P8-1 is on the low-slope of the diagonal connecting it to P19-12 and the conclusions drawn from independent studies that P8-1 is a good prospect, the shape of the resistivity profile curve of the pseudosection plot of Fig.9 should be considered the “ideal groundwater recharge curve.” Having established the fact of this situation, it then means that P8-1 is a perfect groundwater “sink” considering that the resistivity profile progressively “plunges” to P8-1. The ideal shape would be a “dome” of decreasing high-resistivity signatures having its core at the high-slope such that its low-resistivity end “plunges” to the low-slope.

Conclusion

The pseudosections along the NE-SW diagonal fault-traces of P2-1, P3-1, P4-1, P8-1, P9-1, and P6-2 confirm that the fault-traces culminating at these points, as observed in Figs 3 and 4, are continuous subsurface fracture routes for groundwater flow. The observed flow pattern has been classified in this study as either “normal” or “reverse.”

Groundwater Recharge Prognosis for P2-1 Based on Pseudosection Analysis of the Fault-Trace Culminating at P2-1. Prognosis is good and the recharge trend is “reverse.”

Groundwater Recharge Prognosis for P3-1 Based on Pseudosection Analysis of the Fault-Trace Culminating at P3-1. Prognosis is good and the recharge trend is “normal.”

Groundwater Recharge Prognosis for P4-1 Based on Pseudosection Analysis of the Fault-Trace Culminating at P4-1. Prognosis is good and the recharge trend is “normal.”

Groundwater Recharge Prognosis for P8-1 Based on Pseudosection Analysis of the Fault-Trace Culminating at P8-1. Prognosis is good and the recharge trend is “normal.”

Groundwater Recharge Prognosis for P9-1 Based on Pseudosection Analysis of the Fault-Trace Culminating at P9-1. Prognosis is good and the recharge trend is "reverse."

Groundwater Recharge Prognosis for P6-2 Based on Pseudosection Analysis of the Fault-Trace Culminating at P6-2. Prognosis is good and the recharge trend is "normal."

Location of Best Curve-Fit for the Defined Ideal "Groundwater Recharge Curve." P8-1

Recommendation

Based on the current survey regime, an appropriate "water farm" scheme should be centred on the locations of P2-1, P3-1, P4-1, P8-1, P9-1, and P6-2. Such a water farm scheme would involve the drilling of boreholes down to the total depth (TD) surveyed for the individual points of interest and feeding their output to a storage facility for onward processing and distribution through an appropriate purpose-specific waterworks for the GKC Phases I and II.

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THE EFFECT OF ETHANOL VAPOUR ON SHELF LIFE OF FRESH BANANA FRUIT

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Abstract

*Banana (Musa species) are not only sources of food, they are sources of beverages, feeds, medical, ritual and ornamentals. However, its availability has been seriously hindered by its short shelf life due to environmental and microbial influences. This study therefore evaluated the effects of ethanol vapour pretreatment on proximate composition, shelf life and sensory attribute on storage of banana fruit. Fresh banana fruits were pretreated with 20cm³ ethanol vapour at concentrations of 0%, 25%, 95% and stored for two weeks in a 30-litre plastic bucket at ambient temperature. Results showed that pretreatment of banana with ethanol vapour prolonged the shelf life of fresh banana fruits by slowing down ripening and reduced the percentage spoilage to 20%, 50% and 80% at 95%, 25% and 0% concentration of ethanol vapour respectively. The moisture and the carbohydrate contents of ethanol vapour pretreated banana after 2 weeks of storage significantly ($p < 0.05$) increase with decrease in concentration of ethanol vapour while crude fat, crude fiber and protein contents significantly ($p < 0.05$) decreased with decrease in concentration of ethanol vapour. Also the firmness of all ethanol vapour pretreated banana was significantly reduced compared to the fresh banana. The aroma and overall acceptance was higher in ethanol vapour pretreated banana compare to 0%. A total of three fungal genera from *Saccharomyces* spp., *Aspergillus* spp. and *Rhizopus* spp. were isolated. Untreated banana fruits have the highest abundance of the three genera. This research revealed that ethanol vapour prolonged the shelf life of fresh banana by slowing down ripening, enhanced the nutritional and sensory attribute of fresh banana at higher concentration.*

Keyword: *Banana, shelf life, ethanol, proximate, sensory*

Introduction

Bananas are monocotyledonous plants in the genus *Musa* which belongs to the family Musaceae (Wong *et al.*, 2002). Banana plant is a large perennial herb with leaf sheaths that form trunk-like pseudostems. Fruits mature in about 60 - 90 days after the appearance of flowers (Khair, 2012).

Bananas are cultivated in more than 100 countries of the world and provide food for millions of people (De Langhe *et al.*, 2009). Total banana and plantain production all over the world is 95.8 million metric tons (FAOSTAT, 2009). Bananas are not only the source of food, they also have other purposes. They are the sources of beverages, feeds, medical, ritual and ornamental materials. Alcohol, beer, vinegar and wine are usually produced from fruits of banana (Nelson *et al.*, 2006). The diuretic and disinfectant effects of *Musa* potash and the strong astringent effects of *Musa* sap make its use relevant in traditional medicine. In Africa, *Musa* plants has different and various uses in ceremonies related to birth, funeral rites and religion. Banana is used as a treatment for gastric ulcer and diarrhoea and also beneficial for preventing cancer and heart disease because of high vitamin A and B6 contents (Emery, 1997). Its potassium content reduces cardiovascular disease and thus controls blood pressure (Blade, 2003).

Banana, being a tropical fruit with perishable nature, post-harvest losses of the fruits due to rotting in the market are innumerable (Pillay & Tripathi, 2007). Its availability has been seriously hindered by its short shelf life due to environmental and microbial influence. Different biochemical and physiological changes take place within a short span of time during ripening (Batra & Manna, 2007). Increasing its shelf - life, therefore, will not only increase its availability but as well improve the market value and the quantity of the fruit. Recently, there has been

substantial interest in non biological control agents to replace the existing chemical applications. Non-biological control involves chemicals product such as ethanol that are Generally Regarded as Safe "GRAS". For a long time, ethanol has been used as a fungicide treatment because it is an environmentally friendly disinfectant. Its vapour has been reported to provide antimicrobial properties and prolong the shelf life of fruits such as apple. Ethanol is a familiar constituent of many beverages and is considered to be the least toxic of the straight-chain alcohols. The effectiveness of ethanol vapour has been reported to improve the shelf life of fruits such as mango and apple, however, there is limited information on its effects on shelf life of banana. Ethanol dips have been reported to control post-harvest decay of cherry, table grapes, peaches and nectarines. It was comparable with other applications made in commercial like 1-MCP (Smith *et al.*, 2000; Russell, 2001; Seiler. 2008)). On this note, this studied aimed at improving the shelf life of fresh banana fruit using ethanol vapour. It is hoped that the results obtain from these study will help in developing the strategy for preventing the loss of banana fruit and spoilage.

Materials and Methods

Sample Collection

Freshly harvested matured healthy banana fruit were purchased from main market Lapai, Niger State in the month of July, 2014. The samples were collected in a sterile poly bag and taken to the laboratory in the Department of Biological Sciences Ibrahim Badamasi Babangida University Lapai Niger State Nigeria for further study. Fruits were surface sterilized by rinsing in 2.0mM (150mgKg⁻¹) Sodium hypochlorite (commercial bleach).

Preparation of Ethanol

Various strengths of ethanol 95%, 25% and 0% were prepared from absolute alcohol. Twenty five percent (25%) ethanol was prepared by taken 25cm³ of absolute alcohol in measuring cylinder and 75cm³distilled water was added. Ninety five percent (95%) of ethanol was prepared by taken 95cm³ of absolute alcohol in measuring cylinder and 5cm³ of distilled water. 0% ethanol was prepared by using ordinary distilled water without any addition of alcohol (Gabler *et al.*, 2005).

Pretreatment of Banana

Ethanol vapour pretreatment was done by incubating five gram(5g) of banana samples in a 30-L plastic bucket containing 20 cm³ alcohol per kilogram of banana in a beaker and a filter paper wick to aid evaporation at various strength of 95%, 25% and 0%. The containers were sealed at the top and kept for 24 hrs at ambient temperature (28±2°C). Zero percent (0%) served as the control. Three replicate of each was made. After 24 hrs, the beaker and the wick were removed and banana were kept at ambient temperature for 14 days (Plotto *et al.*, 2006).

Proximate Analysis

Proximate analysis of banana was carried out based on the separation of food components into groups or fractions in accordance with their nutritional value. Samples of the fresh banana fruits were collected earlier for proximate analysis before storage and after 14days of storage in alcohol vapour. Samples were analysed using AOAC (2005) methods to determine moisture, carbohydrate, crude proteins, crude fat, crude fibre. Three replicate of each experiment was made.

Percentage Spoilage

Percentage spoilage was calculated thus:

$$\frac{\text{Number of spoilt banana}}{\text{Total number of banana}} \times 100$$

Total number of banana

Organoleptic Evaluation

For organoleptic evaluation, the colour, flavor, taste and firmness were assessed. Five trained and experienced panel were involved to assess the freshness parameter which involved complete familiarization with the food in its most desired state - fresh, uncontaminated, and with the most desirable qualities - followed by familiarization with a range of samples at diminishing stages of freshness. The 0-5 organoleptic hedonic scale is used (1=dislike very much; 2= dislike; 3=neither dislike nor like; 4= like; 5=like very much) (Feng *et al.*, 2012).

Fungal Isolation and Identification

Banana fruits were assayed for microbial growth. One representative fruit pieces per bucket was taken from each experimental group and placed in sterile 1 mL conical flask, one flask for each bucket and 99 mL of sterile phosphate buffer was added to the flasks and the fruit pieces were gently agitated for 2 min. Small aliquots of buffer (2mL) were then taken and put in a petri dish containing potato dextrose agar (PDA) for the isolation of fungi (Plotto *et al.*, 2006). Fungal isolates were identified using fungal family of the World Mycological Monographs (Cannon and kirk, 2007; Amadi and Adebola, 2008).

Statistical Analysis

Analysis of Variance (ANOVA) was used to analyze the data generated and Duncan New Multiple Range Test (DNMRT) was used to separate the means.

Results

Proximate Compositions

The results on the proximate compositions of ethanol vapour pretreated banana (*Musa species*) are presented in Table 1. The percentage moisture contents of fresh untreated banana ($12.01 \pm 0.01\%$) was significantly ($p < 0.05$) lower as compared to moisture contents of 25% ethanol vapour pretreated banana (15.0 ± 0.01) and 0% ethanol vapour pretreated banana (25.00 ± 0.11). However, there was no significant difference in the moisture contents of fresh banana as compared to moisture of 95% ethanol vapour pretreated banana (10.43 ± 0.01).

The ash contents significantly ($p < 0.05$) increased with decrease concentration of ethanol vapour (Table 1). The ash contents of fresh banana (12.63 ± 0.05) was significantly ($p < 0.05$) lower as compared to ash contents of 25% ethanol vapour pretreated banana (13.10 ± 0.01) and 0% ethanol vapour pretreated banana (15.20 ± 0.10). However, there was no significant difference in the ash contents of fresh banana as compared to ash of 95% ethanol vapour pretreated banana (12.71 ± 0.01).

The crude fat contents (Table 1) significantly ($p < 0.05$) increased with increase concentration of ethanol vapour after 14 days of storage. The crude fat contents of fresh banana (9.35 ± 0.15) was significantly ($p < 0.05$) higher as compared to crude fat contents of 25% ethanol vapour pretreated banana (8.60 ± 0.15) and 0% ethanol vapour pretreated banana (6.20 ± 0.05). But there was no significant difference in the crude fat contents of fresh banana as compared to crude fat contents of 95% ethanol vapour pretreated banana (9.25 ± 0.05).

The crude fibre contents significantly ($p < 0.05$) increased with increase concentration of ethanol vapour after 14 days of storage (Table 1). The crude fibre contents of fresh banana (11.80 ± 0.005) was significantly ($p < 0.05$) higher as compared to crude fiber contents of 25% ethanol vapour pretreated banana (10.20 ± 0.015) and 0% ethanol vapour pretreated banana (8.90 ± 0.15). But there was no significant difference in the crude fiber contents of fresh banana as compared to crude fiber contents of 95% ethanol vapour pretreated banana (11.73 ± 0.15).

The results revealed that the crude protein contents of fresh banana (4.10 ± 0.10) was significantly ($p < 0.05$) higher as compared to crude protein contents of 95%, 25% & 0%

(3.85 ± 0.05 , 3.20 ± 0.25 & 2.90 ± 0.05) ethanol vapour pretreated banana (Table 1). However, there was no significant difference between the crude protein contents of 95% & 25% ethanol vapour pretreated banana.

The carbohydrate content (Table 1) of ethanol vapour pretreated banana significantly ($p < 0.05$) increased with decrease in concentration of ethanol vapour. The carbohydrate content of ethanol vapour pretreated banana 52.03 ± 0.005 (95%), 53.10 ± 0.11 (25%) and 55.10 ± 0.12 (0%) after 14 days of storage was significantly ($p < 0.05$) higher than carbohydrate content of fresh banana (50.11 ± 0.01).

Organoleptic Scoring

The result of the organoleptic assessment of ethanol vapour pretreated banana after 14 days of storage are shown in Table 2.

The flavour scores of ethanol vapour pretreated banana increased with increase concentration of ethanol vapour. The scores of ethanol vapour pretreated banana 3.50 ± 0.21 and 3.00 ± 0.31 for 95%, and 25% concentration respectively after 14 days of storage was significantly ($p < 0.05$) higher as compared to aroma scores fresh banana (2.50 ± 0.32).

There was no significant difference in the taste scores of ethanol vapour pretreated banana 3.50 ± 0.01 , & 3.10 ± 0.11 (for 95% and 25% concentration after 14 days) as compared to taste scores fresh banana (3.50 ± 0.10). However, the taste score (2.50 ± 0.10) of banana pretreated with 0% ethanol vapour after 14 days of storage was lower compare to the taste scores of fresh banana and other concentrations. The taste steadily decreased from fresh banana and 95% concentration to 25% and 0%.

The firmness of banana was found to decrease from fresh banana to 95%, 25% & 0% concentrations of ethanol vapour. The firmness at 95% ethanol vapour pretreated banana was significantly higher than that of 25% and 0% concentration.

The Colour scores of ethanol vapour pretreated banana increased with increase concentration of ethanol vapour. The colour scores of ethanol vapour pretreated banana 2.70 ± 0.10 and 2.30 ± 0.02 for 25%, and 0% concentration after 14 days of storage was significantly ($p < 0.05$) lower as compared to colour scores of fresh banana (3.50 ± 0.02). However, there was no significant difference in the colour scores (3.50 ± 0.13) of 95% ethanol vapour pretreated banana as compare to the colour score of fresh banana.

The overall acceptance score (3.70 ± 0.11) of 95% ethanol vapour pretreated banana was significantly ($p < 0.05$) higher as compared to overall acceptance score of 25% ethanol vapour pretreated banana (3.20 ± 0.11) and fresh banana (3.00 ± 0.11). But banana pretreated with 0% ethanol vapour had the least overall acceptance score (2.00 ± 0.11).

Shelf life

The pretreatment of banana with ethanol vapour prolonged the shelf life (Fig. 1) of fresh banana and reduce the percentage spoilage. The banana pretreated with 95% ethanol vapour produce the lowest spoilage of 20% followed by 25% ethanol vapour with spoilage of 50% while the 0% ethanol vapour cause the highest percentage spoilage 80%.

Fungal Isolates

Three different genera of fungi *Saccharomyces* spp., *Aspergillus* spp. and *Rhizopus* spp. were isolated from fresh, pretreated and untreated banana (Table 3). The most frequently occurred in all was genus *Saccharomyces* spp. in the entire banana. However, the untreated banana has more of genera *Aspergillus* spp. and *Rhizopus* spp.

Discussion

The fruit quality is determined by size (finger length and thickness), evenness of ripening, absence of blemishes defects, and the arrangement of the clusters (Khair, 2012). In the present study, storage of banana results in deterioration of most of the physical features of banana as observed in banana pretreated with 0% ethanol vapour. The skin of the banana which was initially yellowish green turned to black, the softness of banana was also found to increase after 14 days of storage. However, banana pretreated with ethanol vapour at 95% concentration and to a lesser extent 25% concentration was found to be in good condition after 14 days of storage. The skin colour was found to remain the same as it was on the first day. The findings were an indication of shelf life extending properties of ethanol vapour. These results were in agreement with earlier reports that ethanol dips and vapors controlled postharvest diseases of peaches, citrus fruit, and table grapes (Gabler and Smilanick, 2001; Gabler *et al.*, 2002; Karabulut *et al.*, 2003). Ethanol vapors applied to whole apples reduced ethylene and CO₂ production of fresh-cut apples, and their shelf life was increased due to maintenance of visual quality (Bai *et al.*, 2004).

It was also found that the pretreatment resulted in more pleasant aroma than the fresh untreated banana. This result was in contrary to the perception of undesirable flavor in fruit tissue when exposed to ethanol for 24 h reported by Bai *et al.*, (2004); Plotto *et al.*, (2003).

Analysis of proximate composition gave a quantitative idea of moisture, ash, protein, fat and carbohydrate composition in a food. Water is required for many biochemical reactions in the body (Ashifat *et al.*, 2012). However, high moisture content will increase the susceptibility of fruit to microorganism attacked. The decrease in moisture contents of fresh banana compared to ethanol vapour pretreated banana and at 0% (control) could be as a result of increase availability of water with ripening of the banana. However, the insignificant difference in the moisture contents of fresh banana as compared to moisture of 95% ethanol vapour pretreated banana indicated the delayed ripening of banana caused by 95% ethanol vapour. This delayed ripening will favour its preventive properties against microbial contamination. Thus the storage time of 95% ethanol vapour will be high.

The increase in carbohydrate content of ethanol vapour pretreated banana with decrease in concentration of ethanol vapour after 14 days of storage may be linked to the delayed ripening of banana caused by ethanol vapour. The high content of carbohydrate in this study is comparable with the value reported for Garden Egg fruit (Auta *et al.*, 2009). This high carbohydrate content is beneficial since carbohydrate constitute a major class of naturally organic compounds that are essential for the maintenance of plant and animal life and also provide raw material for many industries (Ebun-Oluwa & Alade, 2007).

This study also revealed that increased ethanol vapour pretreatment cause increase in protein fiber, protein and fat contents of banana. This is a very good attribute because high fibre content of banana (11.80 ± 0.005) is an indication of its good preventive properties against constipation and metabolic disorders such as diabetes.

The decrease in fat content with increase concentration of ethanol vapour after 14 days of storage and the decrease observed between fresh and pretreated banana (9.35 ± 0.15) is a desirable property as excess fat consumption is implicated in etiology of many degenerative disease.

High protein diet support growth, movement, body defense in both human and livestock (Eddy, 2004) thus the low protein content of banana observed in this study is an indication that its consumption will have little or no effect on improving the body defense system. The ash content give a measure of the total amount of inorganic compound like minerals present in plants. Banana was found to contain considerably high level of ash (12.65 to 15.20). This finding is an

indication that Banana is a good source of minerals and thus can be used as a mineral supplementing fruit.

In the present study, the prevention of spoilage of banana with increase concentration ethanol vapour and the prolonged shelf life of ethanol vapour pretreated banana may be attributed to inhibitory effect in ethylene production resulting in delayed ripening, the mode of action of the ethanol in the banana would be by conversion of acetyldehyde which in turn act as inhibitors of ethylene production (Plotto *et al.*, 2003). Similar prolong shelf life due inhibitory effect of methanol vapour on ripening has been previously reported for banana (Jiang *et al.*, 1999) and mango (Plotto *et al.*, 2003). And also the prolonged shelf life may be linked to the antimicrobial activities of ethanol vapour, which reduce the microbial load of pretreated banana and thus result in increase shelf life.

In the present study, banana preserved with ethanol vapour showed increase in organoleptic score as compared to untreated banana (control). The increase in flavour scores of pretreated banana may be attributed to the accumulation of ethanol and some methyl esters. These findings agreed with earlier data published by Jinhe *et al.* (2005) where ethanol pretreatment of apple increase the aroma contents.

The softening of fruit during ripening is a major attribute that often dictates shelf life. During ripening partial disassembly of the fruit cell wall is largely responsible for softening and textural changes (Alexander and Grierson, 2002). Therefore, in the present study the significant decrease in the texture scores of pretreated banana as compared to the control group may also be attributed to the delay of ripening process.

Conclusion

In conclusion, this study revealed that pretreatment of fresh banana with ethanol vapour prolonged the shelf life of fresh banana by slowing down ripening, enhance the sensory attribute, increase the carbohydrate and decrease the moisture contents of fresh banana. It is therefore recommended that the use of ethanol vapour as food preservatives should be encouraged. However, evaluation of the safety and toxicity of ethanol vapour in pretreated banana is of paramount important.

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Table 1: Proximate compositions of ethanol vapour pretreated banana (*Musa species*)

PARAMETERS	Fresh Banana	After 14 days		
		95%	25%	0%
MOISTURE	12.01±0.01 ^a	10.43±0.01 ^a	15.0±0.01 ^b	25.00±0.11 ^c
ASH	12.63±0.005 ^a	12.71±0.01 ^a	13.10±0.01 ^{ab}	15.20±0.10 ^b
CRUDE FAT	9.35±0.15 ^b	9.25±0.05 ^b	8.60±0.15 ^{ab}	6.20±0.05 ^a
CRUDE FIBRE	11.80±0.005 ^b	11.73±0.15 ^b	10.20±0.015 ^{ab}	8.90±0.15 ^a
CRUDE PROTEIN	4.10±0.10 ^c	3.85±0.05 ^b	3.20±0.25 ^b	2.90±0.05 ^a
CARBOHYDRATE	50.11±0.01 ^a	52.03±0.005 ^a	53.10±0.11 ^a	55.10±0.12 ^c

Values follow by the same superscript along the rows are not differ significantly at $p < 0.05$, values are Mean $\pm$ SEM of triplicate determination

Table 2: Organoleptic assessment of ethanol vapour pretreated banana (*Musa species*)

Sensory attribute	Fresh banana	After 14 days		
		95%	25%	0%
Flavour	2.50±0.32 ^b	3.50±0.21 ^c	3.00±0.31 ^c	2.00±0.32 ^a
Taste	3.50±0.10 ^a	3.50±0.01 ^a	3.10±0.11 ^a	2.50±0.10 ^a
Firmness	3.50±0.01 ^c	2.90±0.22 ^b	2.10±0.21 ^a	2.00±0.01 ^a
Colour	3.50±0.02 ^b	3.50±0.13 ^b	2.70±0.10 ^a	2.30±0.02 ^a
Overall acceptance	3.00±0.11 ^{ab}	3.70±0.11 ^b	3.20±0.11 ^{ab}	2.00±0.11 ^a

Values follow by the same superscript along the rows are not differ significantly at $p < 0.05$, values are Mean $\pm$ SEM from Eight panelist

Table 3: Fungi isolated from fresh, ethanol vapour pretreated and untreated banana fruits

Banana	Saccharomyces spp	Fungi	
		Aspergillus spp	Rhizopus spp
Fresh banana	+++++	-	-
95% pretreatment	+++++	-	++
25% pretreatment	+++++	+	++
0% pretreatment	+++++	+++++	+++++

+++++ = Abundance ++ = slightly present - = not isolated

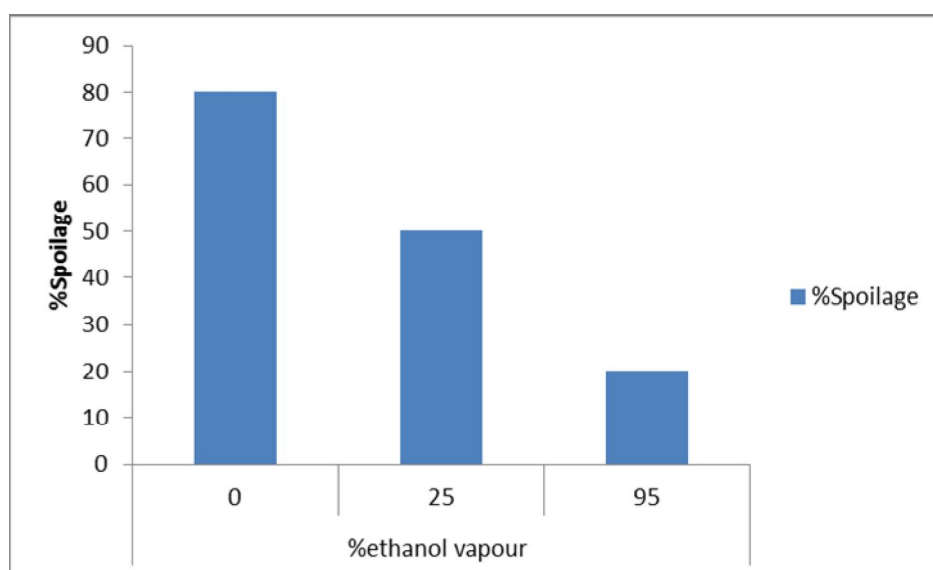


Fig. 1: The Shelf Life of ethanol vapour pretreated banana

SUBMERGENCE TOLERANCE IN SOME RICE (*ORYZA SPECIES*) GENOTYPES

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Abstract

To elucidate tolerance of rice genotypes to submergence stress and validate the efficiency of submergence protocol in rice, twenty nine genotypes obtained from the Africa Rice, Ibadan station Nigeria were evaluated. The evaluations were conducted at the Botanical garden, Ahmadu Bello University, Zaria. All genotypes showed escape (6.89%) and quiescent (93.11%) strategies to mitigate submergence stress. Submergence stress significantly ($p < 0.05$) reduced plant survival (0 – 99%). Six genotypes (20.69%) showed growth recovery as water receded in the first week of desubmergence. Growth recovery was lost at seven and fourteen days after desubmergence. The efficiency of submergence evaluation protocol was best at 7DAS as against 14DAS. FARO 57, NERICA-L-52, IR64 SUB1, W 8-45 and FKR 54 varieties showed significant ($p < 0.05$) recovery plasticity in morphological traits ranging from 0-11.5% within 7 to 14 days of de- submergence. Three cultivars (FARO 36, GAMBIKA and NERICA-L-52) showed high tolerance to submergence stress and exhibited both escape and quiescent strategies during submergence and after de-submergence. Thus, FARO 36 and NERICA-L-52 can be cultivated in flood prone regions to mitigate flooding. They could be further utilized in breeding programs for the enhancement of rice landraces.

Keywords: *Oryza species, Shoot elongation, Quiescence, Submergence tolerance*

Introduction

Climate change has become a major concern worldwide. In Africa, major symptoms of such change include disruption of normal climate patterns over large areas, increasing incidence of drought and extreme temperatures, heavy flooding and increasing levels of salt stress both in inland and coastal areas. These problems have progressively become more severe in frequency and severity (Desanker and Magadza, 2001; Hulme *et al.*, 2001). Rice is cultivated on 144 million farms worldwide, more than for any other crop with productions spreading across at least 114 countries (FAO, 2013). It is grown in widely diverse production environments topographically and strongly affected by soil type, water regime and climatic factors (Khush, 1984). There are five types of growth environments for rice based mainly on the water regime, namely; irrigated, rainfed lowland, tidal wetland, deepwater, and upland or dryland areas (Khush, 1984). In Africa, rice is grown in four ecosystems: upland (38% of planted area), rainfed wetland (33%), deepwater and mangrove swamps (9%) and irrigated wetland (20%) (Balasubramanian *et al.*, 2007). More than 50% of the world's rice crop area is irrigated and it contributes about 73% to total rice production. This is an indication of the importance of water regime in the development and yield of rice plant. Complete or partial submergence is an important abiotic stress that affects 10–15 million ha of rice fields in South and Southeast Asia, causing yield losses estimated at US\$1 billion every year (Dey and Upadhyaya, 1996). This number is anticipated to increase considerably in the future given the increase in sea-water level, as well as an increase in frequencies and intensities of flooding caused by extreme weather events (Bates *et al.*, 2008; Akinwale *et al.*, 2012). Flash floods are highly unpredictable and can occur at any growth stage of the rice crop, resulting in yield loss of 10% to 100% depending on water depth, duration of submergence, temperature, turbidity of water, light intensity and age of the crop (Aliyu *et al.*, 2015; Akinwale *et al.*, 2012; Setter *et al.*, 1995). In Nigeria, approximately 70% of rainfed lowland rice farms are prone to seasonal flooding which is a major constraint to rice production in some major rice producing states. Yield loss can range from 10% to total destruction. Among the most frequently affected states in Nigeria are Kebbi, Niger, Kogi and Taraba states which account

for 80% of rice ecology in Nigeria (Erenstein *et al.*, 2003). As a semiaquatic plant, rice is generally intolerant of complete submergence and plants die within a few days when completely submerged (Mohanty *et al.*, 2013). Since deep water rice and lowland rice comprise nearly 33% socio-economic vulnerability to climate change of the world's rice-growing area (Bailey-Serres *et al.*, 2010), flood is a major source of production losses in these important rice ecosystems. Often, transient flash flood occurs and is followed by longstanding stagnant floods. This type of flood reduces the survival chance of rice plants and causes severe damage to rice yields. For example, rice production losses in Bangladesh and India due to flash floods were estimated to be around 4 million tons per year, and this lost in production (had there been no floods) could have fed 30 million people (IRRI, 2010). Africa is particularly vulnerable to climate change because of the over-dependence on rainfed agriculture and the high incidence of poverty. Considering that changes in the global climate will result in more extreme events, such as floods, substantial economic benefits can be achieved from the development of improved rice varieties that are more resilient to climate change. This would allow rice producers to adapt to worsening global climate and allow them to mitigate the adverse effects of climate change in the future. Systematic screening of rice germplasm in Asia has shown that there are excellent flood-tolerant rice genotypes locally available. Among these are FR13A and FR43B of India, Kurkaruppan of Sri Lanka and GodaHeenati of Indonesia (IRRI, 2010). It is from these local genotypes within Nigeria, we intend to establish flood-tolerant rice varieties and validate the submergence protocol.

Materials and Methods

Plant Materials, Sterilization and Pre-germination

Preliminary phenotypic screening and germination test was conducted at the Botanical garden of the Department of Biological sciences, Ahmadu Bello University. A total of twenty nine (29) genotypes were obtained from the Africa Rice center, Ibadan station, pre-screened for viability and subjected to complete submergence stress.

Rice seeds were cleaned and placed in an oven at 50°C for five days to break seed dormancy. The seeds were surface sterilized with 0.1% Mercury Chloride (HgCl₂), and rinsed with distilled water. Sterilized seeds were soaked in water in a Petri-dish lined with Whatman's filter paper and placed on laboratory bench until germination. Benlate solution was added to prevent fungal infection. Pre-germinated seeds were sown, two seeds per genotype, in rows of three in 30x30cm plastic trays which served as nursery. Each genotype was labeled appropriately and watered regularly (200ml/day).

Preparation of seed pots and transplanting

Sterilized loamy soil, mixed with NPK (15:15:15) fertilizer at the rate of 30 kg/ha was placed in black polythene bags (15cm diameter). Each polythene bag was filled with about 3kg of soil, and watered until the soil was fully saturated. Seeds were pre-germinated for 21 days on nursery bed before they were transplanted to the polythene bags. Each genotype was labeled appropriately using plastic tags. Each polythene bag was placed in a 1m x 1m plastic tank in rows of five in a randomized block design (RBD) with three replications (Aliyu *et al.*, 2015).

Submergence evaluation

Submergence treatment was administered 30 days after transplanting by gradually increasing water level at 5cm per day until a maximum of 100cm water level was attained. Plants were submerged for a period of 14days. Control set up was left un-submerged. Water was raised to 2cm above the soil surface (Akinwale *et al.*, 2012).

Data collection

Survival count was taken immediately after de submergence (0DAS), seven days after desubmergence (7DAS) and 14 days after desubmergence (14DAS) (Aliyu *et al.*, 2015; Akinwale

et al., 2012; Sarkar & Bhattacharjee, 2011; Septiningsih *et al.*, 2009; Xu *et al.*, 2006). Other phenotypic parameters measured after desubmergence were; Plant Height (cm): measured from soil level to the tip of the flag leaf, Tiller Number: the number of tillers per genotype was counted at 0DAS, 7DAS and 14DAS, number of leaves per plant, leave diameter (cm) values were taken. Data obtained were subjected to analysis of variance (ANOVA). Where significant ($p < 0.05$), Duncan's Multiple Range Test was used to separate the means. The degrees of association of the morphological parameters were determined using the Pearson's correlation index.

Results

Performance of 29 Rice Genotypes Screened for Submergence Tolerance

Response to submergence tolerance was largely genotype dependent. Percentage survival after desubmergence (immediately after desubmergence (0DAS), 7 days after desubmergence (7DAS) and 14 days after desubmergence (14DAS) ranged from 0-100%. Tiller number, number of leaves and leaf diameter were not significantly ($P < 0.05$) affected by submergence stress in genotypes evaluated. Immediately after de-submergence (0DAS), percentage survival varied between 57.67% and 100%. Four genotypes (CG14, FKR 19, NERICA-L- 43 and TOG 7148) recorded 100% survival upon de-submergence. TOG6632 was most susceptible with a percentage survival of 57.67%. The tolerant check (IR64 SUB1) showed an 89.00% survival percentage (Table 1). At 7DAS, percentage survival ranged between 40% and 100%. IR64, NERICA-L-43 and TOS6455 were most tolerant with a survival percentage of 100. This was significantly ($p < 0.01$) higher than survival scores for all other genotypes at this growth stage. NERICA-L-43, IG 133 and IR 64 SUB1 sustained the survival percentages from 0DAS to 7DAS. FARO44, NERICA-L-53, TOG6632 and W8-45 showed significant recovery within this period with increasing survival scores. TOG7218 was most susceptible to submergence stress at 7DAS.

Survival percentages at 14DAS ranged from 17.67% to 73.33%. IR 64 SUB-1 was the most tolerant genotype with a survival percentage of 89.00%. NERICA-L-52 showed consistent tolerance to submergence stress with a 73.33% tolerance between 7DAS and 14DAS. This consistency was similar to that of IR 64 SUB-1, though with differences in tolerance level. FKR54 showed slight recovery of 40% to 44.67% from 7DAS to 14DAS while TOG 7412 was most susceptible to submergence stress as it was completely lost at 14DAS (Table 1).

Table 1: Performance of 29 Rice Genotypes Screened for Submergence Tolerance

GENOTYPES	Survival (%) 0DAS	Survival (%) 7DAS	Survival (%) 14DAS	Plant Height (cm) at 0DAS	Tiller Number at 0DAS	Number of Leaves at 0DAS	Leave Diameter cm 0DAS
CG 14	100.00 ^a	78.00 ^{ab}	51.00 ^b	19.33 ^c	2.33 ^a	3.67 ^b	0.23 ^a
FARO 36	78.00 ^b	73.33 ^{ab}	51.00 ^b	26.00 ^b	2.33 ^a	3.00 ^b	0.20 ^a
FARO 44	73.33 ^b	89.00 ^a	55.67 ^b	31.00 ^{ab}	2.67 ^a	5.33 ^a	0.33 ^a
FARO 57	73.33 ^b	62.33 ^b	62.33 ^{ab}	31.33 ^{ab}	2.67 ^a	3.67 ^b	0.23 ^a
FKR 54	78.00 ^b	40.00 ^c	44.67 ^c	24.00 ^b	2.33 ^a	2.67 ^{bc}	1.33 ^a
FKR 19	100.00 ^a	73.33 ^{ab}	55.67 ^b	21.67 ^b	2.67 ^a	3.67 ^b	0.27 ^a
GAMBIAKA	89.00 ^{ab}	78.00 ^{ab}	51.00 ^b	24.33 ^b	2.33 ^a	3.33 ^b	0.23 ^a
IG 133	78.00 ^a	78.00 ^{ab}	40.00 ^c	31.67 ^{ab}	2.00 ^a	2.33 ^{bc}	0.23 ^a
IR 64	89.00 ^{ab}	89.00 ^{ab}	66.67 ^{ab}	32.67 ^{ab}	3.00 ^a	4.33 ^{ab}	0.40 ^a
IR 64 SUB1	89.00 ^a	89.00 ^{ab}	89.00 ^a	23.67 ^b	2.67 ^a	3.33 ^b	0.10 ^a
NERICA L-43	100.00 ^a	100.00 ^a	40.00 ^c	25.67 ^b	2.00 ^a	2.33 ^{bc}	0.20 ^a
NERICA L-52	78.00 ^b	73.33 ^{ab}	73.33 ^a	42.33 ^a	3.00 ^a	6.33 ^a	0.30 ^a
NERICA L-53	73.33 ^b	84.33 ^{ab}	53.00 ^b	22.33 ^b	2.00 ^a	1.33 ^c	0.20 ^a

RAM 133	66.67 ^{bc}	62.33 ^{ab}	33.33 ^e	11.67 ^c	2.00 ^a	4.00 ^{ab}	0.13 ^a
TOG 7218	89.00 ^a	40.00 ^c	35.33 ^e	9.00 ^d	1.67 ^a	2.00 ^{bc}	0.10 ^a
TOG 7250-A	89.00 ^{ab}	73.33 ^{ab}	55.67 ^b	24.67 ^b	2.67 ^a	4.67 ^{ab}	0.17 ^a
TOG 7412	84.33 ^a	89.00 ^{ab}	0.00 ^f	0.00 ^f	0.00 ^a	0.00 ^b	0.00 ^a
TOG 7439-B	89.00 ^{ab}	68.67 ^b	22.33 ^f	16.00 ^c	1.67 ^a	2.00 ^{bc}	0.13 ^a
TOG 8347	89.00 ^{ab}	44.67 ^{bc}	40.00 ^c	17.33 ^c	2.00 ^a	1.33 ^c	0.13 ^a
TOG 6632	57.67 ^c	73.33 ^{ab}	40.00 ^c	19.67 ^c	2.00 ^a	2.33 ^{bc}	0.17 ^a
TOG 6640-B	84.33 ^{ab}	73.33 ^{ab}	50.33 ^f	17.67 ^c	1.67 ^a	2.33 ^{bc}	0.30 ^a
TOG 7148	100.00 ^a	73.33 ^{ab}	51.00 ^b	27.33 ^{ab}	2.33 ^a	2.67 ^{bc}	0.15 ^a
TOS 6455	89.00 ^{ab}	86.00 ^{ab}	17.67 ^f	12.00 ^c	1.33 ^a	0.67 ^d	0.10 ^a
VANDANA	89.00 ^{ab}	89.00 ^{ab}	55.67 ^b	29.33 ^b	2.67 ^a	4.67 ^{ab}	0.40 ^a
W 8 45	62.33 ^{bc}	89.00 ^{ab}	66.67 ^{ab}	31.67 ^{ab}	2.00 ^a	6.33 ^a	0.40 ^a
WITA 9	73.33 ^b	66.67 ^b	40.00 ^c	27.67 ^b	2.00 ^a	2.33 ^{bc}	0.23 ^a
WITA 12	68.67 ^{bc}	73.33 ^{ab}	57.67 ^b	18.67 ^c	2.33 ^a	3.67 ^b	0.33 ^a
WITA 4	73.33 ^b	68.67 ^b	57.67 ^b	35.33 ^{ab}	2.33 ^a	3.33 ^b	0.40 ^a
POKALLI	73.33 ^b	55.67 ^b	51.00 ^b	26.67 ^b	2.33 ^a	2.00 ^{bc}	0.27 ^a
CV	26.14	30.94	83.52	87.35	98.28	88.06	70.13
R2	0.34	0.12	0.33	0.3	0.29	0.33	0.34
P VALUE	0.55	0.01	0.05	0.05	0.8	0.61	0.58

Means with the same superscript along columns do not differ significantly ($p < .05$) from one another using the Duncan's multiple range tests. DAS= days after de submergence.

Survival percentages for non-submerged (control) genotypes at 14DAS indicated that all genotypes except IR 64 SUB-1, TOG7218 and TOG6640-B showed 100% survival. This was significantly higher than the survival percentages observed in submerged genotypes. Submergence caused total loss of some plants at this evaluation stage. The positive control checks showed greater tolerance and survival compared to the un-submerged control. In response to submergence stress, NERICA-L-52 and IR64 exhibited greater shoot elongation of 24.5% and 21% over the un-submerged control treatment. No genotype showed greater tillering ability or increase in leaves numbers upon comparison with the control treatment. FKR 54 showed wider leaf diameter under submergence stress than in the control treatment. Few genotypes were lost as water receded at 14DAS; a 100% loss in plant developmental traits was inputted for these genotypes (Table 2).

Table 2: Percentage Effect of Submergence Stress on 29 Rice Genotypes at 14DAS

GENOTYPE	SURVIVAL AT 14DASPH (%) (%)		TN (%)	NL (%)	LD (%)
CG 14	49.00	50.40	22.30	75.50	71.30
FARO 36	49.00	38.80	22.30	84.20	77.80
FARO 44	44.30	33.30	11.00	76.30	61.20
FARO 57	37.70	30.40	11.00	73.80	75.80
FKR 54	55.30	53.80	22.30	84.70	-26.70
FKR 19	44.30	36.30	11.00	73.80	68.20
GAMBIAKA	49.00	39.20	22.30	79.20	64.60
IG 133	60.00	54.40	33.30	88.10	80.80
IR 64	33.30	-21.00	0.00	71.10	42.90
IR 64 SUB1	-6.60	45.60	11.00	73.40	85.70

NERICA L-43	60.00	37.40	33.30	85.00	71.40
NERICA L-52	26.70	-24.50	0.00	63.80	64.70
NERICA L-53	47.00	34.30	33.30	91.40	69.20
RAM 133	66.70	81.80	33.30	74.20	84.70
TOG 7218	57.70	85.10	16.50	84.60	92.00
TOG 7250-A	44.3	57.50	11.00	76.1	83.00
TOG 7412	100.00	100.00	100.00	100.00	100.00
TOG 7439-B	77.70	72.40	44.30	87.90	87.0
TOG 8347	60.00	71.10	33.30	91.40	86.30
TOG 6632	60.00	34.40	33.30	85.90	81.10
TOG 6640-B	73.30	71.00	44.30	84.50	71.40
TOG 7148	49.00	55.60	22.30	83.80	85.00
TOS 6455	82.30	70.40	55.70	94.40	88.90
VANDANA	44.30	41.30	11.00	69.50	55.60
W 8 45	33.30	28.80	33.30	72.50	42.90
WITA 9	60.00	27.20	33.30	89.40	69.30
WITA 12	42.30	48.10	22.30	75.50	49.20
WITA 4	42.30	4.50	22.30	80.40	33.30
POKALLI	49.00	54.40	22.30	84.60	66.30

14DAS= survival at 14 days after de submergence. PH=Plant height, TN= Tiller number, NL= Number of leaves, LD= leave diameter.

There was a strong positive correlation between survival at 14DAS with and plant height ($r^2=0.94$), tiller number ($r^2=0.94$), number of leaves ($r^2=0.89$) and leave diameter ($r^2=0.85$) (Table 3). All other morphological parameters showed some degree of positive correlation with one another (Figure 1).

Table 3: Correlation Coefficient for Traits Measured in 29 Rice Genotypes Subjected to Submergence Stress

	14DAS	PH	TN	NL	LD
14DAS	1				
PH	0.94*	1			
TN	0.94*	0.82*	1		
NL	0.89*	0.81*	0.87*	1	
LD	0.85*	0.88*	0.79*	0.83*	1

*= significant at $p<0.01$

Discussion

Submergence stress affects the physiological and metabolic processes (Sarkar *et al.*, 2006; Bailey-Serres & Voisenek, 2010) of plants. Expectedly, the decline in percentage survival of the genotypes due to submergence stress indicates that submergence stress strongly influences survival of rice plants (Aliyu *et al.*, 2015). Differential response observed amongst genotypes in tolerance or susceptibility to submergence stress was largely due to their escape or quiescence strategies to mitigate the prevailing stress conditions. Plants with escape mechanisms responds to submergence stress by exhibiting enhanced shoot elongation. In contrast, minimum shoot elongation which promotes growth recovery upon de-submergences was characteristic of the

quiescence mechanism (Fukao and Bailey-serres, 2008). Genotypes that exhibited escape strategies showed some degree of lodging after de-submergence which ultimately affected their survival as the water level recedes. Growth recoveries observed in some of the genotypes indicates the ability of those genotypes to survive under short periods of submergence. Ability to recover after de- submergence is a desirable trait in genotypes as it ensures production of sufficient biomass for plant productivity. This was corroborated by Sarkar and Bhattacharjee (2011). Pandey and Bhandari (2007) reported that plants ability to quickly re-generate after submergence is key to its survival. This in return is hinged on plants ability to maintain a high carbohydrate content. This will lead to quick development of new leaves and accumulation of greater biomass (Sarkar & Bhattacharjee, 2011). Ram *et al.* (2002) reported that stem elongation competes for energy with maintenance process and could reduce the chances of survival of rice during submergence. It is hence imperative for submergence tolerant genotypes to exhibit limited stem elongation. Akinwale *et al.*, (2012) suggested that shoot elongation is associated with cost, as energy and carbohydrate are expended in cell division and elongation. Singh *et al.* (2010) also mentioned that limited stem elongation is associated with variety's ability to survive submergence as energy required for maintenance process are made readily available, not used for stem elongation. Luo *et al.* (2011); Sarkar and Bhattacharjee (2011) reported that rice adapts to submergence either by elongation or quiescence (reduced activity) depending on the nature of the flood. This was also supported by Xu *et al.* (2006); Sarkar and Panda (2009) and Hattori *et al.* (2009). Plant height was strongly correlated with survival at 14DAS. This could be attributed to the fact that most of the genotypes exhibited the escape strategy rather than the quiescence mechanisms. This was contrary to the findings of Akinwale *et al.* (2012) and Singh *et al.* (2010) who found stem elongation (plant height) to have a negative relationship with percentage survival. Their report was based on the evaluations of progenies from tolerant parents. Sarkar and Bhattacharjee (2011) stated that great elongation benefits plants during submergence by restoring contact with the air above the flood water. This improves internal aeration for aerobic respiration and photosynthesis. Setter *et al.* (1995) reported that one of the causes of intolerance to complete submergence in some rice cultivars was the desiccation of leaves after de submergence. The sharp decline in number of leaves between control and stressed genotypes could be attributed to desiccation of leaves after de submergence. This could also be explained that plants might have reduced their utilization of resources during submergence stress thus affecting other growth traits. Furthermore, loss of genotypes after 14DAS could be due to inability of the plant to continuously sustain itself in the stress environment owing to energy depletion. Tolerance to submergence stress as exhibited by Nerica L-52 is indicative of the fact that there exists some degree of tolerance to abiotic stresses within local germplasms of plant genotypes. The ability of IR64 sub-1 to maintain high survival percentages could be because of the presence of the SUB-1 gene which has been introgressed into it. Fukao and Bailey-Serres (2008) stated that submergence tolerance conferred by SUB1A gene is related to suppression of elongation thereby enhancing survival by reducing carbohydrate consumption.

This result clearly indicates that NERICA-L-52 showed great potentials for submergence tolerance. It hence implies that this genotype can be considered as a candidate in breeding for submergence. This will also increase the gene pool of submergence tolerant genotypes.

In conclusion, rice genotypes showed escape and quiescent strategies to mitigate submergence stress. Submergence stress affected plant survival (0 – 100%) and phenotypic growth parameters evaluated. FARO 36, GAMBIKA and NERICA-L-52 showed high tolerance to submergence stress by exhibiting moderate plant height and reduced number of leaves during submergence and after de-submergence. Six genotypes (20.69%) showed growth recovery as water recedes in the first week. This was however lost at 14DAS thus validating the efficiency of the submergence evaluation protocol. FARO 57, NERICA-L-52, IR64 SUB1, W 8-45 and FKR 54 showed recovery plasticity in morphological traits ranging from 0-11.5% within 7 to 14 days of

de- submergence. Hence, FARO 36 and NERICA-L-52 which are released rice varieties can be cultivated in flood prone regions and for future breeding programs for the enhancement of other local rice genotypes.

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BACTERIOLOGICAL QUALITY AND PHYSICOCHEMICAL ASSESSMENT OF WATER VENDED BY PUSHCARTS WITHIN ILORIN METROPOLIS, KWARA STATE, NIGERIA

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Abstract

*Vended water is one of the primary sources of water for many households in Ilorin. Water samples were collected from the plastic Jerrycans of 20 different water vendors delivering their water to consumers using pushcarts. Physicochemical and bacteriological analyses were conducted on the water samples. The pH, chloride content, suspended solids, and total hardness of the water samples ranged from 6.80 – 8.40, 0.60 - 15.62 mg/l, 0.001 - 0.025g/100ml, and 0 to 80 mg/l respectively. The bacterial count ranged between 0 - 1.5×10^4 cfu/ml while the total coliform ranged between 0 – 2400 MPN per 100ml of the water samples. The counts of *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Salmonella* spp. and *Shigella* spp. of the water samples ranged from 0 to 2.6×10^3 cfu/ml, 0 to 1×10^3 cfu/ml, 0 to 1×10^2 cfu/ml, and 0 to 3×10^3 cfu/ml respectively. Faecal coliform (*E. coli*) was not isolated. The bacteria isolated were: *Bacillus sphaericus*, *Bacillus megaterium*, *Micrococcus roseus*, *Micrococcus varians*, *Micrococcus lylae*, *Micrococcus* sp., *Staphylococcus saprophyticus*, *Staphylococcus capitis*, *Staphylococcus epidermidis*, *Staphylococcus intermedius*, *Staphylococcus simiae*, *Staphylococcus lentus*, *Corynebacterium matruchotii*, and *Enterobacter aerogenes*. Sanitary evaluation revealed lack of good hygiene by the water vendors. The study revealed that most of the vended water was potable. It is recommended that the consumers should not use this water for drinking purpose without additional treatment at the point of use.*

Keywords: *Evaluation, Quality, Pushcarts, Vended water, Sanitary appraisal*

Introduction

Water is one of the most important elements for all forms of life. It is indispensable in the maintenance of life on earth. It is also essential for the composition and renewal of cells (Solomon *et al.*, 2011). Less than one per cent of the world's surface or below-ground freshwater is accessible for human use. This has resulted to an inadequate supply of water for human use in many parts of the world (Hutin *et al.*, 2003). Nowadays, a large percentage of the rural population in developing countries continue to live without adequate access to safe and convenient water supply and sanitation (Dada, 2009).

Nigeria is blessed with abundant water resources but largely untapped. The total volume of water available in surface and groundwater resources is sufficient to meet current drinking water demands. However, lack of efficient distribution capacity coupled with highly variable rainfall patterns have led to water scarcity in some areas particularly in the North (Joseph, 2012).

The inadequacy of water is as a result of factors such as geometric increase in population, water wastage from running taps, decrease in well capacity, increased water requirements, rainfall fluctuations, inability of the government to provide potable water for the citizens and pollution of water (Eniola *et al.*, 2015). In Nigeria, more than 90% of rural areas and 60% of urban areas face water related problems. The average daily per capita consumption of water in Nigeria is 46 litres which is far below the internationally recommended minimum requirement of 115 litres per person per day. This shortfall in water requirement is due to differences in availability and supply (Utsev & Aho, 2012).

Bacteria cause the majority of the water related illnesses. The most prevalent pathogenic bacteria that causes water related diseases are *E. coli* O157:H7, *Salmonella* sp., *Shigella* sp., *Campylobacter* sp., *Vibrio cholerae* and *Pseudomonas* sp. These organisms cause diseases such as diarrhoea and gastroenteritis, salmonellosis, typhoid fever, shigellosis, and cholera (Eniola *et al.*, 2015). *E. coli* is the predominant faecal coliform bacteria found in the gut of warm-blooded animals. The presence of *E. coli* in water indicates direct contamination with faecal matter (Saha *et al.*, 2011).

There are various sources of water supply to households in Nigeria. It could be by the individuals sourcing the water themselves such as from streams, rivers or by collecting rain water. It could be water provided by the government distributing the water to various homes through a piped system or by the private sector of the population, by packaging the water in sachet or bottles. Water vending is a means of water supply to households for use. Due to the inadequacy of the government to provide adequate and potable water for the population, majority resorted to getting water from water vendors which is now on the increase in many parts of the country.

Water vending is taken as a sign of failure in these piped systems, which still provide water to only a minority of urban dwellers in many parts of the world. When collecting international statistics on access to water those who buy their water from vendors along with people who get their water from unimproved wells or surface-water sources are classified as not having reasonable access to an improved water supply (Kjellén, 2010).

Water vendors are individuals that sell the water to the final consumers usually for households use or for small scale production processes. In this context, water vending does not include bottled or packaged water or water sold through vending machines. Water vending may be undertaken by formal bodies such as water utilities, registered associations, and by informal and independent suppliers. Where formal vending is practiced, the water typically comes from treated utility supplies and it is supplied through tanker trucks or from standpipes (Onyenechere *et al.*, 2012). Informal suppliers tend to use a range of sources, including untreated surface water, dug wells and boreholes to deliver small volumes of water for domestic use, often in plastic containers or Jerrycans. Water vendors use a range of modes of transport to deliver drinking water for sale directly to the consumer including wheelbarrows, trolleys, pushcarts (WHO, 2011).

In Ilorin, Kwara State, Nigeria, water vending is usually practiced by the Hausa ethnic group of the population and they are fondly called '*Mai Ruwa*' meaning 'Water sellers'. They are uneducated and water vending serve as their means of livelihood. The final consumers use the water for domestic activities such as drinking, washing, cooking, and bathing.

Both the quality and adequacy of vended supplies can vary significantly, and vended water has been associated with outbreaks of diarrheal disease (Hutin *et al.*, 2003; WHO, 2011).

This research was conducted due to the fact there is need to know the quality of vended water supplied to households by the pushcarts especially in the dry season of the year.

The objectives of this research were to determine the counts of bacteria, total and faecal coliform; counts of pathogenic bacteria: *Staphylococcus aureus*, *Salmonella* sp., *Shigella* sp., and *Pseudomonas aeruginosa* in the vended water; isolate, characterized and identified the bacterial isolates; determine the physicochemical characteristic; and conduction of the sanitary appraisal of the Jerrycans of the water vendors.

Materials and Methods

Collection of vended water samples

Water samples were collected from 20 different water vendors at different locations such as Zango, Fate-Tanke, G.R.A and Basin areas of Ilorin metropolis, Kwara State, Nigeria. The water samples were collected by pouring off some water from the Jerrycans of the water vendors into a sterile 500ml conical flask. Then, the sample was taken immediately for bacteriological and physicochemical analysis.

Determination of pH

The electrode of a standardized pH meter was inserted into the water sample and allowed to stand for about one to five minutes in order to obtain a non- fluctuating pH value. The pH value was taken when the reading was stable (Goldman and Green, 2009).

Determination of suspended solids

Whatman filter paper was dried at 105°C in an oven for one hour to obtain an initial weight. It was used to filter 100ml of the water sample, dried at the above temperature, and weighed to obtain final weight. The difference in weight represents the suspended solids (Bilotta and Braziera, 2008; Sule *et al.*, 2016).

Determination of chloride content

Argentometric titration was used to determine the chloride content. One hundred millilitre of the water sample was measured using a measuring cylinder and poured into a conical flask. Then, 2ml of 5% potassium chromate was added as an indicator. The solution was titrated with 0.1N silver nitrate solution (AgNO_3) until the colour changed from yellow to faint pink. The titre value multiplied by a factor of 3.55 gives the chloride content in mg/l (Sawyer *et al.*, 2000).

Determination of total hardness

One hundred millilitre of the water sample was measured and 5 drops of 25% ammonia and 3 drops of erichrome black-T was added as an indicator to give a purple colour. The resulting solution was titrated with 0.1N EDTA until a light blue colouration was obtained. Titre value multiplied by 100 gives the total hardness in mg/l (De Zuane, 1997; Sule *et al.*, 2016).

Isolation and enumeration of bacterial count

The pour plate technique was used. The water sample was serially diluted using ten fold serial dilution, and 0.1ml aliquot from 10^{-1} and 10^{-2} dilutions were taken into separate sterile Petri dishes followed by the addition of nutrient agar which has been cooled to about 45°C. The plates were incubated and the counted colonies expressed in cfu/ml (Fawole & Oso, 2007).

Enumeration of total and faecal coliform

Multiple tube fermentation method was used to determine the total coliform count in MPN per 100ml of the water sample while eosin methylene blue agar was used to determine the counts of *E. coli* (Goldman and Green, 2009).

Isolation and enumeration of pathogenic bacteria

Aliquot (0.1ml) from 10^{-1} and 10^{-2} dilutions of the water sample was transferred on solidified mannitol salt agar, salmonella-shigella agar, and cetrinide agar media using spread plate technique. After incubation, the number of characteristics colony of *Staphylococcus aureus*, *Salmonella/Shigella*, and *Pseudomonas aeruginosa* was counted. They were further confirmed through Gram staining and biochemical tests (Fawole and Oso, 2007; Willey *et al.*, 2008).

Purification and preservation of isolates

Subculturing of the mixed culture was done repeatedly on nutrient agar until pure culture was obtained and the slants were stocked in the refrigerator until they are needed (Brown, 2007).

Characterization and identification of bacterial isolates

The bacterial isolates were characterized on the basis of their colonial morphology, cellular and biochemical characteristics (Cowan and Steel, 1985; Fawole and Oso, 2007).

Sanitary appraisal of water vendors' containers

The sanitary appraisal of water vendors' containers was done at the sampling point by physically examination of their containers as well as questioning the pushcart operators. The following parameters were observed: source of water, colour of the container, presence of cap, presence of algal growth in the container, as well as asking them about how frequent they wash their containers.

Results

Physicochemical characteristics of the water samples

The physicochemical characteristics of the water samples varied. The pH of the water samples, chloride content, suspended solids, and total hardness ranged from 6.80 to 8.40, 0.60 to 15.62 mg/l, 0.001 to 0.025 g/100ml, and 0 to 80 mg/l respectively (Table 1).

Bacteriological counts of the water samples

The bacterial count ranged from 0 to 1.5×10^4 cfu/ml. Counts of *S. aureus*, *Pseudomonas aeruginosa*, *Salmonella* sp. and *Shigella* sp. ranged from 0 to 2.6×10^3 cfu/ml, 0 to 1×10^3 cfu/ml, 0 to 1×10^2 cfu/ml, and 0 to 3×10^3 cfu/ml respectively. *E. coli* (faecal coliform) was absent in all the water samples. The total coliform of the vended water ranged between 0 to 2400MPN/100ml (Table 2).

Characterization and identification of bacterial isolates

The bacterial species isolated were: *Bacillus sphaericus*, *Bacillus megaterium*, *Micrococcus roseus*, *Micrococcus varians*, *Micrococcus lylae*, *Micrococcus* sp., *Staphylococcus saprophyticus*, *Staphylococcus capitis*, *Staphylococcus epidermidis*, *Staphylococcus intermedius*, *Staphylococcus simiae*, *Staphylococcus lentus*, *Corynebacterium matruchotii*, and *Enterobacter aerogenes* (Table 3). The occurrence of the bacterial isolates is presented in Table 4.

Sanitary appraisal of the water vendors' containers

All the water samples from the water vendors were sourced from borehole. The sanitary appraisal of the water vendors' containers is presented in Table 5.

Table 1: Physicochemical characteristics of water samples from water vendors

Sampling sites	pH	Chloride content(mg/l)	Suspended solids (g/100ml)	Total hardness (mg/l)
Fate Tanke vendor 1	6.80	0.60	0.025	13
Fate Tanke vendor 2	7.10	1.07	0.016	12
Zango vendor 1	6.90	7.81	0.012	0
Zango vendor 2	7.60	5.68	0.011	32
Zango vendor 3	7.70	11.36	0.006	0
Zango vendor 4	7.30	9.94	0.005	20
Zango vendor 5	7.60	9.94	0.010	28
Zango vendor 6	6.80	9.94	0.001	24
Zango vendor 7	7.70	12.78	0.001	0
Zango vendor 8	7.70	9.23	0.001	24

Zango vendor 9	7.60	10.65	0.007	35
Zango vendor 10	7.60	15.62	0.011	0
Zango vendor 11	7.50	2.56	0.013	80
GRA vendor 1	8.10	1.07	0.011	15
GRA vendor 2	7.80	0.71	0.010	15
GRA vendor 3	7.70	0.71	0.013	20
GRA vendor 4	7.80	1.07	0.012	20
Basin vendor 1	8.10	0.89	0.023	50
Basin vendor 2	8.40	0.83	0.014	25
Basin vendor 3	8.40	1.07	0.016	30

Table 2: Bacteriological counts of water samples from water vendors

Sampling Sites	Bacterial counts (cfu/ml)	<i>S. aureus</i>	<i>Pseudomonas aeruginosa</i> (cfu/ml)	<i>Salmonella</i> spp. (cfu/ml)	<i>Shigella</i> spp. (cfu/ml)	<i>E.coli</i> (cfu/ml)	Total Coliform (MPN/100ml)
Fate Tanke vendor 1	0	0	0	0	0	0	4
Fate Tanke vendor 2	1 x 10 ²	0	0	0	0	0	240
Zango vendor 1	5 x 10 ³	1 x 10 ³	1 x 10 ²	0	0	0	43
Zango vendor 2	2.6 x 10 ³	0	0	0	1 x 10 ²	0	2400
Zango vendor 3	1.5 x 10 ⁴	0	0	0	0	0	9
Zango vendor 4	7 x 10 ³	2.6 x 10 ³	0	0	0	0	23
Zango vendor 5	7 x 10 ³	0	0	0	0	0	2400
Zango vendor 6	1.1 x 10 ³	0	0	0	0	0	9
Zango vendor 7	7 x 10 ³	0	0	0	2 x 10 ²	0	23
Zango vendor 8	1.4 x 10 ³	0	0	0	0	0	9
Zango vendor 9	4.6 x 10 ³	0	0	0	0	0	43
Zango vendor 10	4.6 x 10 ³	0	0	1 x 10 ²	3 x 10 ³	0	43
Zango vendor 11	0	0	0	0	0	0	0
GRA vendor 1	0	0	0	0	0	0	4
GRA vendor 2	0	0	0	0	0	0	0
GRA vendor 3	1 x 10 ³	0	0	0	0	0	2400
GRA vendor 4	1 x 10 ³	0	0	0	0	0	1100
Basin vendor 1	1.5 x 10 ⁴	0	1 x 10 ³	0	0	0	43
Basin vendor 2	1 x 10 ³	0	0	0	0	0	23
Basin vendor 3	1 x 10 ³	0	0	0	0	0	23

Table 3: Characterization and identification of bacterial isolates

Bacterial isolates	Gram reaction	Cell shape	Cells' arrangement	Motility	Oxidase	Catalase	Coagulase	Haemolysis	Starch	Citrate	Indole	Urease	Glucose	Lactose	Sucrose	Maltose	Mannitol	Raffinose	VP	Nitrate	Cellobiose	Trehalose	Fructose	OF	Arahinose	Identified organisms
1	+	R	s	+	-	+	-	α	-	-	-	+	A	A	A	A	A	-	-	-	-	A	A	F	-	<i>Bacillus sphaericus</i>
2	+	C	cl	-	+	+	-	α	-	-	-	+	A	-	-	A	A	+	-	-	-	-	A	O	-	<i>Micrococcus roseus</i>
3	+	c	cl	-	+	+	-	α	-	-	-	+	A	A	A	A	A	-	-	+	-	A	A	O	-	<i>Micrococcus varians</i>
4	+	c	s	+	-	+	-	α	-	-	-	-	-	-	A	A	A	-	+	+	-	A	A	F	-	<i>Staphylococcus saprophyticus</i>
5	+	c	sl	-	-	+	-	γ	-	-	-	-	A	-	A	A	A	-	+	+	-	-	A	F	-	<i>Staphylococcus capitis</i>

6	+	c	cl	-	+	+	-	β	+	-	-	+	A	A	A	-	A	-	+	+	-	A	A	F	-	<i>Staphylococcus epidermidis</i>
7	+	r	cl	-	+	+	-	α	+	+	-	+	A	A	A	A	A	-	-	+	-	-	A	F	-	<i>Bacillus megaterium</i>
8	+	c	cl	-	-	+	-	β	-	+	-	+	A	A	A	-	A	-	-	+	-	A	A	F	-	<i>Staphylococcus lentus</i>
9	+	r	cl	-	+	+	-	γ	-	+	-	+	A	-	A	A	-	-	-	+	+	-	A	F	-	<i>Corynebacterium matruchotii</i>
1	+	c	cl	+	-	+	+	α	-	-	-	+	A	A	A	-	A	-	-	+	-	A	A	F	-	<i>Staphylococcus simiae</i>
0													G	G	G		G					G				
1	+	c	cl	+	-	+	+	β	-	-	-	+	A	A	A	A	A	-	+	+	-	A	A	F	-	<i>Staphylococcus intermedius</i>
1													G	G	G	G						G				
1	+	c	s	-	+	+	-	α	-	+	-	+	A	A	A	A	A	-	-	-	-	A	A	O	A	<i>Micrococcus lylae</i>
2													G	G	G	G	G					G				
1	+	c	cl	-	+	+	-	α	-	-	-	+	A	A	A	A	A	-	-	-	-	A	-	-	-	<i>Micrococcus sp.</i>
3													G	G	G	G	G					G				
1	-	r	cl	+	-	+	-	β	+	-	+	+	A	A	A	A	A	-	+	+	-	-	A	F	-	<i>Enterobacter aerogenes</i>
4													G			G	G									

Key: - = Negative reaction; + = Positive reaction; c = Cocci; r = Rod; s = Single; cl = Cluster; Ch = chain; F = Fermentative; O= Oxidative; OF = Oxidation-Fermentation; AG = Acid and gas; A = Acid only; VP = Voges proskauer

Table 4: Occurrence of bacterial isolates

Sampling sites	<i>Bacillus anthracis</i>	<i>Micrococcus roseus</i>	<i>Micrococcus varians</i>	<i>Staphylococcus</i>	<i>Staphylococcus</i> <i>us. Capitis</i>	<i>Staphylococcus</i> <i>us epidermidis</i>	<i>B. megaterium</i>	<i>Staphylococcus</i> <i>us. lentis</i>	<i>Corynebacterium</i>	<i>Staphylococcus</i> <i>us. simiae</i>	<i>Staphylococcus</i> <i>us. intermaris</i>	<i>Micrococcus</i>	<i>Micrococcus</i>	<i>Enterobacter</i>
Fate Tanke vendor 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fate Tanke vendor 2	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Zango vendor 1	+	+	+	-	-	-	-	-	-	-	-	-	-	-
Zango vendor 2	-	+	+	+	+	-	-	+	-	-	-	-	-	-
Zango vendor 3	+	+	+	-	-	-	-	-	-	-	+	-	-	-
Zango vendor 4	+	+	+	-	-	+	-	+	-	-	-	-	-	-
Zango vendor 5	+	-	+	+	+	+	+	-	-	-	-	-	-	-
Zango vendor 6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zango vendor 7	+	-	-	+	+	+	+	+	-	-	-	-	-	-
Zango vendor 8	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Zango vendor 9	+	+	+	-	-	-	-	-	-	-	-	-	-	-
Zango vendor 10	+	-	+	-	-	-	-	-	-	-	-	-	-	-
Zango vendor 11	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GRA vendor 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GRA vendor 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GRA vendor 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GRA vendor 4	-	-	-	-	-	-	-	-	+	+	-	-	+	-
Basin vendor 1	+	-	-	-	-	+	-	-	-	+	-	+	-	+
Basin vendor 2	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Basin vendor 3	-	-	-	-	-	-	-	-	-	-	-	+	-	-

Key: -, not isolated; +, isolated

Table 5: Sanitary appraisal of the water vendor's containers

Sampling sites	Colour of container	Presence of cap	Algal growth	Washing of container
Fate Tanke vendor 1	Yellow	Yes	No	Daily
Fate Tanke vendor 2	Yellow	Yes	No	Daily
Zango vendor 1	Yellow	Yes	No	Daily
Zango vendor 2	White	Yes	No	Daily
Zango vendor 3	Yellow	Yes	Yes	Weekly
Zango vendor 4	Blue	Yes	Yes	Weekly
Zango vendor 5	Blue	Yes	Yes	Weekly
Zango vendor 6	Blue	Yes	No	Daily
Zango vendor 7	White	Yes	No	Weekly
Zango vendor 8	Yellow	Yes	No	Weekly
Zango vendor 9	Yellow	Yes	Yes	Weekly
Zango vendor 10	Yellow	Yes	Yes	Daily
Zango vendor 11	Yellow	Yes	No	Daily
GRA vendor 1	Yellow	Yes	No	Daily
GRA vendor 2	Blue	Yes	No	Daily
GRA vendor 3	White	Yes	No	Daily

GRA vendor 4	Yellow	Yes	Yes	Daily
Basin vendor 1	Yellow	Yes	Yes	Weekly
Basin vendor 2	Yellow	Yes	No	Weekly
Basin vendor 3	Yellow	Yes	No	Weekly

Discussion

pH is an important factor that affects the growth and survival of microorganisms in water. Most microorganisms especially bacteria grow best at neutral to slightly alkaline pH. The pH range set by WHO (2011) is between 6.5 – 8.5 and the pH of the water samples were within the acceptable standard. In a similar study, Agbabiaka and Sule (2010) obtained the pH range of 6.4 – 7.4 from selected borehole water samples within Ilorin metropolis.

Suspended solid in water is dependent on the amount of inorganic and organic matter which is held in the water column (Bilotta and Braziera, 2008). Suspended solids lowered the effectiveness of the disinfecting property of chemicals used in water treatment. The result obtained for suspended solids is below the limit of 500 mg/l allowed (Standards Organization of Nigeria, 2007). Chloride increases the electrical conductivity of water and thus increases its corrosiveness. In metal pipes, chloride reacts with metal ions to form soluble salts, thus increasing levels of metals in drinking water. In this study the chloride is within the limit of 250mg/l (SON, 2007).

Water containing calcium carbonate at concentrations below 60 mg/l is generally considered as soft; 60–120 mg/l, moderately hard; 120–180 mg/l, hard; and more than 180 mg/l, very hard. Exposure to hard water has been suggested to be a risk factor that could exacerbate eczema (Yusuf *et al.*, 2015). The maximum permitted level of total hardness is 60mg/l as set by SON (2007), the water samples were within the range of permitted level.

Only five of the water samples met the standard of not more than 100 cfu/ml of bacterial cells (WHO, 2011). In a study on treated piped water in parts of Ilorin metropolis, Eniola *et al.* (2015) obtained bacterial count in the range of 1.0×10^4 to 2.25×10^5 cfu/ml.

Staphylococcus aureus, *Salmonella* sp., *Shigella* sp., and *Pseudomonas aeruginosa* were isolated in 2, 1, 3 and 2 out of the twenty vended water samples respectively. Makut *et al.* (2015) reported the contamination of wells and boreholes with pathogenic microorganisms. *E. coli* was not isolated in all the water samples. In a similar study on selected borehole water samples in Ilorin metropolis, Agbabiaka and Sule (2010) had zero count of faecal coliform.

Seven out of the twenty water samples met the maximum permitted level of 10 coliform/100ml of water allowed by SON (2007). In a similar study Agbabiaka and Sule, (2010) obtained total coliform which ranged from zero to 16 MPN of coliform/100ml.

A total of 14 bacterial species belonging to genera *Bacillus*, *Micrococcus*, *Staphylococcus*, *Corynebacterium* and *Enterobacter* were obtained in this study. In a study on treated piped water in parts of Ilorin metropolis, Eniola *et al.* (2015) observed the dominance of *Bacillus subtilis*, *Enterobacter aerogenes*, and *Micrococcus luteus*.

The sanitary appraisal revealed that some of the water vendors used white Jerrycans for collection of water and this encourage algal growth. All the water vendors used plastic caps to cover their Jerrycans and not all of them wash their Jerrycans on daily basis.

Conclusion

It can be concluded from this study that some of the vended water are not potable in regard to their bacteriological and physicochemical quality.

Recommendation

The water vendors should wash their jerry cans daily with detergent and clean water and should observe strict sanitary measures while fetching the water and during delivery to the final consumers. The water needs additional treatment before drinking. There is need to keep the environment where the water is being fetched clean. The carts or trolleys used by the water vendors to convey the water to the final consumers should be regularly washed and kept clean. The water vendors should ensure sourcing their water from treated potable sources.

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RESISTIVITY INVESTIGATION OF GROUNDWATER POTENTIAL IN THE CENTRAL PART OF FEDERAL CAPITAL TERRITORY (FCT), ABUJA, NIGERIA

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Abstract

A resistivity survey was carried out in order to investigate the groundwater potential in parts of Gwagwalada Area council. The geo-electrical method used in the survey was Vertical Electrical Sounding, which was used to determine the groundwater potential of the study area. Twenty-five (25) Vertical Electrical Soundings were established using ABEM Terrameter SAS 300C using the Schlumberger configuration with a maximum current electrode spread of 100 m. The results revealed that the area was underlain by three to four geo-electric layers. The top lateritic soil has resistivity values ranging from 686 Ω m to 6364 Ω m and thickness of 0.8 m to 16.3m, the second layer is composed of sand/clay intercalation with resistivity values varying between 62 Ω m and 471 Ω m and thickness varying between 0.2 to 18 m, while the partly weathered/fresh basement layer has resistivities ranging from 2084 Ω m to 11978 Ω m with thickness varying between 0.3 m to 16.5 m. Overburden thickness contour map was established across the whole 25 VES stations and average thickness value of the overburden was 10 m. The thickness and resistivity of the aquifers for twelve VES selected for the Geoelectric section have good potential for groundwater accumulation due to their overburden thickness which is mainly weathered basement with low resistivity value.

Keywords: Resistivity, Aquifer, Schlumberger Array, Overburden thickness

Introduction

Geophysics as its name indicates has to do with the physics of the earth and its surrounding atmosphere. In applied Geophysics several approaches maybe made to determine more accurately the exact location of a structure or deposit. It measures the apparent resistivity of soils and rocks as a function of depth or position, according to (Geovision, 2000).

According to (Telford, *et al* 1976), the purely scientific investigation of such subjects as the rate of evaporation of water from lakes, the chemical constitution of different rocks and waters from streams and ponds the measurement of natural earth currents, potential variation and impurities in the atmosphere all have definite influence on methods of locating deposits which applied geophysicist seeks.

Before any further geophysical work such as drilling can be carried out on an area surveyed by the airborne method, a confirmation has to be made using ground survey. This is because in airborne survey, geological indications tend to merge into one another thus giving an impression of only one indication (Parasnis, 1986).

Location and Geology of the Study Area

Abuja the Federal Capital Territory (FCT) in fig 1.0, lies within the longitude 6°27'00"E and 7°23'24"E and the latitude of 8°15'00"N and 9°12'00"N (Ideh and Sanni, 1998). Almost predominately are high grade metamorphic and igneous rocks of the Precambrian age (Mamman and Oyeboji, 2002). Generally, the North North East (NNE) and South South West (SSW) of the FCT are made of gneiss, migmatites and granites which characterize the Northern Nigeria. The outcrop of schist belts is found along the Eastern margins of the Area the belts broadens as one moves southwards and maximum size is found to the South Eastern region of the FCT. The geology of the FCT is same as that of Gwagwalada, central part of FCT. The population grew

from 80,841 to 157,770 between 1991 and 2006 (NPC, 2006) and (Uzodinma, 2004). The area like most Northern Nigeria region is underlain by basement complex. The central part of FCT, Gwagwalada consist of granite, gneiss, diorites, horn blende schist, mica schist, feldspathic, quartz schist and migmatites. While some rock outcrops are found in various places around, some are concealed by a thin weathered layer, underlying the FCT almost predominately are high grade metamorphic and igneous rocks of Precambrian age (Mamman and Oyeboji, 2002), Gwagwalada enjoys higher rainfall total than the more southerly region of the FCT. The FCT experience heavy rainfall occurrence during the months of July, August and September. These three month contribute about 60% of the total rainfall in the region (Dawam, 2000).

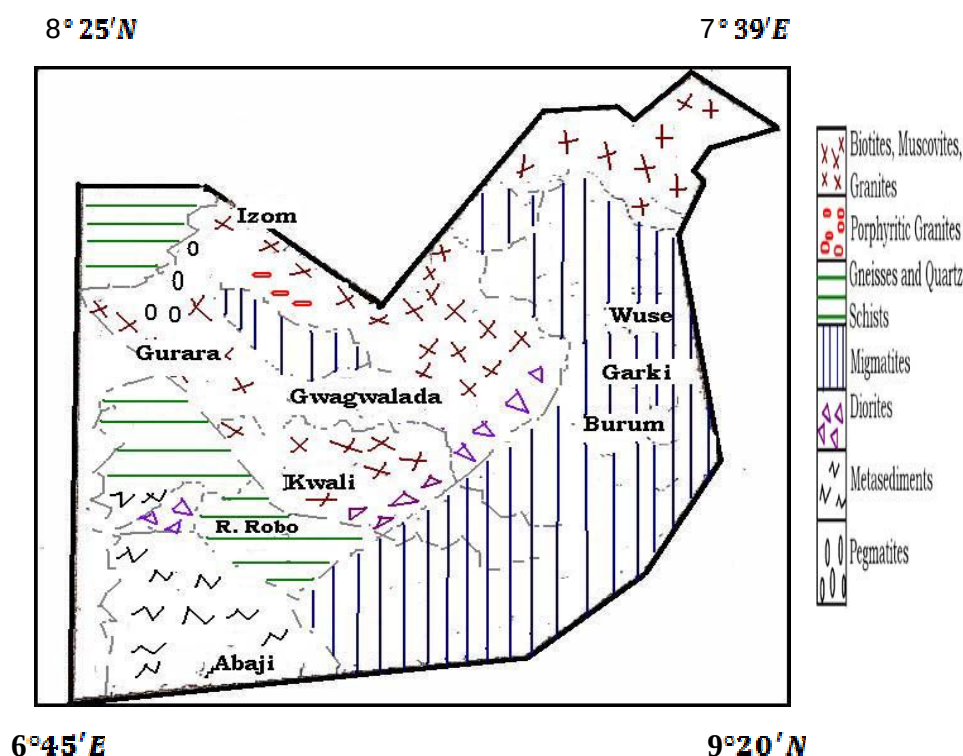


Figure 1.0: The Geologic map of the Federal Capital Territory (Physical setting, 2003)

Materials and Method Theory of Method

Consider a continuous current flowing in an isotropic homogeneous medium. If δA the element surface and J the element density in ampere/meter², then the current passing through δA is $J \cdot \delta A$. The current density J and the electric field E are related through Ohm's law:

$$J = \sigma E \quad (1)$$

Where E is in volts/meter and σ is the conductivity of the medium in Siemens per meter (s/m).

The electric field is the gradient of a scalar potential,

$$E = -\nabla V \quad (2)$$

Where V is in volts. Thus we have

$$J = -\sigma \nabla V \quad (3)$$

If charge is conserved (no current sources or sinks) within a volume enclosed by a surface A , we can write

$$\oint_A J \cdot dA = 0 \quad (4)$$

Gauss's theorem states that the volume integral of the divergence of current throughout a given region is equal to the total charge enclosed, so that in this case,

$$\int_V \nabla \cdot J dV = 0$$

Taking V as an infinitesimal volume enclosing a given point, we get for this point

$$\oint \mathbf{J} \cdot d\mathbf{V} = \oint (\sigma \nabla V) \cdot d\mathbf{V} = 0$$

Hence,

$$\oint \sigma \nabla V \cdot d\mathbf{V} + \sigma \oint \nabla^2 V \cdot d\mathbf{V} = 0 \quad (5)$$

Instrumentation

The ABEM Terrameter SAS 300C was used in this research work for data collection in Gwagwalada. The four electrode Schlumberger array with a maximum current electrodes spacing AB/2 of 100m was used for this survey. A rod was hammered into the ground where the site is located, which serves as the mid point from which AB/2 (half spacing between current electrodes) can be measured in both directions by means of measuring tape with respect to the required spacing from 0.3m to 5m for MN/2 (half spacing between potential electrodes).

The current and potential electrodes were then driven down into the ground at the desired spacing as indicated along the measuring tape. The rechargeable 12V battery was connected to a SAS 300CTerrameter. The current and potential electrodes are connected to an ABEM Terrameter SAS 300C with the four short cables by their clips to connect the positive and the negative terminals on the Terrameter to the two potentials reels and current cables.

AB/2 was measured in both directions from 1.0m to 100m using the reference point. Similarly, MN/2 was also measured on both sides with values varying from 0.3m to 5m.

Data Analysis and Interpretation

According to Todd (1980), the electrical resistivity method of all the surface geophysical methods has been applied most widely in groundwater exploration studies; this is because it can clarify the zone and it is inexpensive (Mazac *et al* 1985). The electrical resistivity method can be best employed to estimate the thickness of the overburden and also the thickness of weathered/fractured zones with reasonable accuracy (Zohdy *et al*, 1974.)

From Table 1.0, it is evident that the only type of three layer VES sounding curve obtained in this area is the H-type, however their also exist few number of 4-layered type of VES curve namely (QH, HK- types) in basement complex terrains, the intermediate layer of the H-type is commonly water saturated and often characterized by low resistivity, high porosity, low specific yield and low permeability (Jones, 1985).

Table 2, shows the typical view of the parameter of the subsurface as obtained from the interpreted result of the study area. If the curve is taken to be one with three layers, it can be determined if it falls into one of the four types of VES curves.

1. Type H curve ($\rho_1 > \rho_2 < \rho_3$)
2. Type K curve ($(\rho_1 < \rho_2 > \rho_3)$)
3. Type A curve ($(\rho_1 < \rho_2 < \rho_3)$)
4. Type Q curve ($(\rho_1 > \rho_2 > \rho_3)$)

where there are more than three layers we have combination curves, for n-2, for example, a four- layer curve has a 2-letter combination like HA ($\rho_1 > \rho_2 < \rho_3 > \rho_4$) cited by Koefoed (1984).

Data Presentation

Table 1 shows the measured resistivity, and their corresponding apparent resistivity values for VES 1, VES 2 and VES3 collected from different parts of Gwagwalada Area council, the AB/2 ranges from 1m to 100m respectively while the MN/2 ranges from 0.3m to 5.0m respectively and the K value was calculated using eqn (3). The results of the remaining 22 VES in presented in

Appendix A. The resistivity value of each of the VES was gotten via the Terrameter and the apparent resistivity was calculated for each of the VES using eqn (4).

$$\frac{\rho_a}{MN} = \pi \left\{ \left(\frac{AB}{2} \right)^2 - \left(\frac{MN}{2} \right)^2 \right\} R \quad (6)$$

Data Interpretation

Fig 2.0 shows the Map of the survey area indicating the number of VES points, their locations and lines of profile of each of the data interpreted.

Fig 3.0 shows the interpretation obtained for VES 1, VES 2 and VES 3. The data was interpreted using the convectional curve matching and (WinResist) computer iteration method. Each of the resistivity plots, shows number of layers, resistivity, thickness and depth of the area.

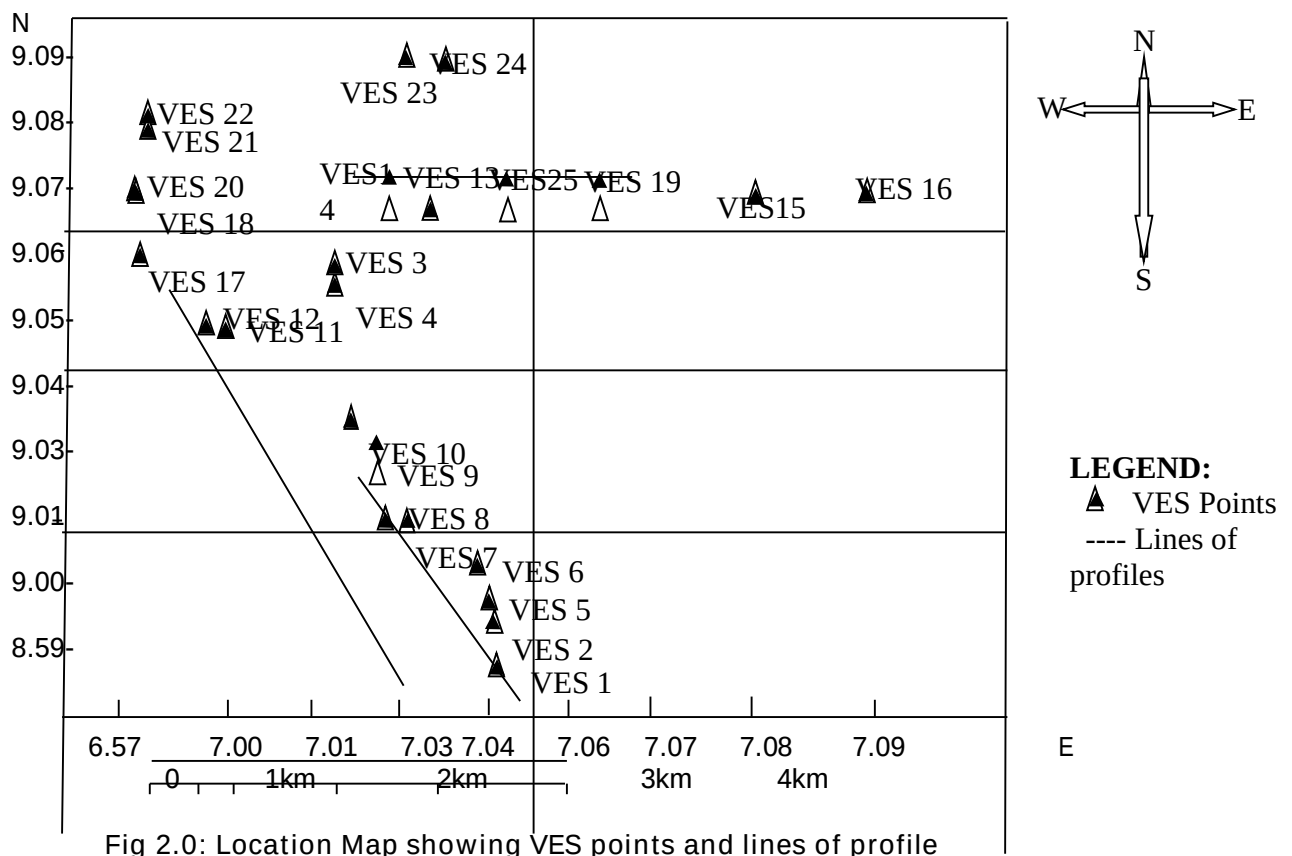
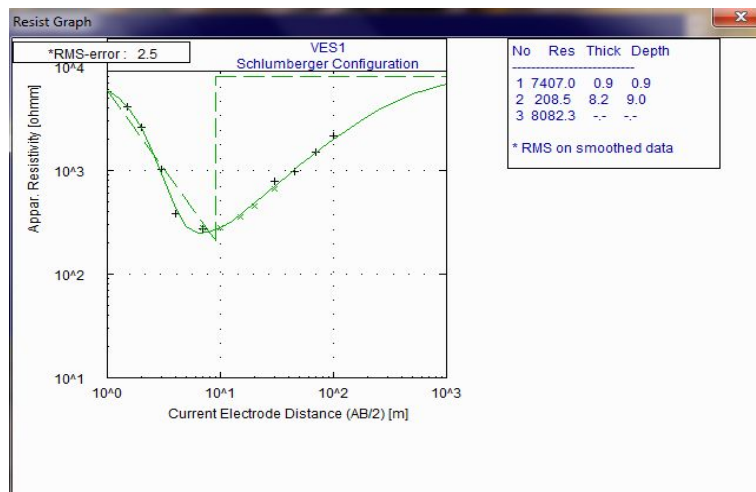


Table 1: Result of VES 1, VES 2 and VES3

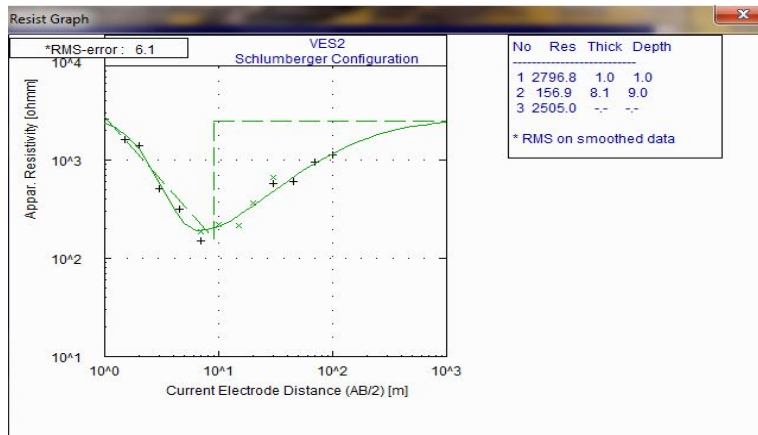
S/N O	AB/2	MN/2	K	VES 1 LATITUDE N08°59'25" LONGITUDE E07°04'848"		VES 2 LATITUDE N08°59'341" LONGITUDE E07°04'911"		VES 3 LATITUDE N09°06'849" LONGITUDE E07°01'164"	
				R (Ω)	ρ(Ωm)	R (Ω)	ρ(Ωm)	R(Ω)	ρ(Ωm)
1	1.00	0.3	4.76	1211.56	5767.0	549.37	2615.0	175.08	833.4
2	1.50		11.31	359.78	4069.1	143.15	1619.0	37.82	427.7
3	2.00		20.52	128.45	2635.8	68.81	1412.0	12.70	260.6
4	3.00		46.69	21.78	1016.9	10.82	505.2	3.83	178.8
5	4.50		105.54	3.61	381.0	3.03	319.8	1.57	165.7
6	7.00		256.09	1.07	274.0	0.59	151.1	0.66	169.0
7	7.00	1.0	75.36	3.72	280.3	2.46	185.4	2.27	171.1
8	10.00		155.43	1.80	279.7	1.44	223.8	1.22	189.6
9	15.00		351.68	1.02	358.7	0.61	214.5	0.68	239.1
10	20.00		626.43	0.73	455.7	0.58	363.3	0.48	300.7
11	30.00		1411.43	0.47	663.4	0.47	663.4	0.31	437.5
12	30.00	5.0	274.75	2.84	780.2	2.12	582.5	1.99	546.8
13	45.00		628.00	1.56	979.7	0.96	602.9	1.02	640.6
14	70.00		1530.75	0.99	1515.4	0.62	949.1	0.63	964.4
15	100.0		3132.15	0.69	2161.2	0.36	1127.6	0.43	1346.8

Table 2: Interpretation of VES 1, VES 2 and VES 3

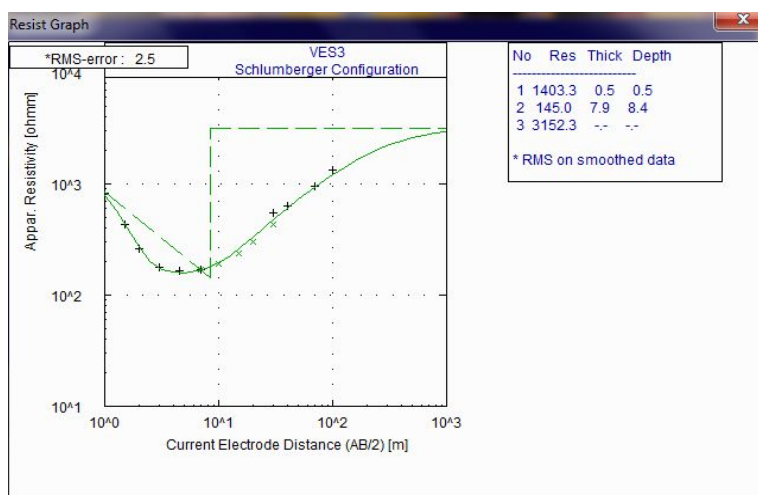
VES STATION	LATITUDE (E)	LONGITUDE (N)	RESISTIVITY (ΩM)	THICKNESS (M)	DEPTH (M)	LAYER TYPE	CURVE TYPE
1	8.59255°	7.04848	7407.0	0.9	0.9	Topsoil	H-Type
			208.5	8.2	9.0	Weathered layer	
			8082.3	—	—	Fresh basement	
2	8.59341	7.04911	27 96.8	1.0	1.0	Topsoil	H –Type
			156.9	8.1	9.0	Weathered layer	
			2505.0	—	—	Fresh basement	
3	9.06849	7.01164	1403.3	0.5	0.5	Topsoil	H-type
			145.0	7.9	8.4	Weathered layer	
			3152.3	-	-	Fresh basement	



(a)



(b)



(c)

Fig. 3.0 Resistivity plot for (a) VES 1, (b) VES 2 and (c) VES 3

Deductions and Conclusions

The result of the VES interpretations was used to generate various basement maps such as 3D, the overburden thickness and the topsoil resistivity map. Fresh basement is characterized by high resistivity value which is close to 1000 Ωm in almost all the locations. The overburden is assumed to include all materials above the presumably fresh basement.

The shape of the VES curves depends on three factors: the thickness of each layer, the number of layers in the subsurface and the ratio of the resistivity of the layer.

Analysis of Geoelectric Section in each Profile

The Geoelectric sections are shown in figures 4a, 4b, and 4c. Generally, the section revealed 3 subsurface layers. The topsoil thickness is relatively thin along this section (figure 4a, 4b, 4c). The geo-electric characteristics give the respective layer resistivity values and thickness. The sections identified a maximum of three geologic subsurface layers. The study of this layer shows that the resistivity value of fresh bedrock often exceeds 1000 Ωm , but where it is fracture /sheared and structured with fresh water, the resistivity often reduces to below 1000 Ωm (Olayinka and Olorumfemi, 1992).

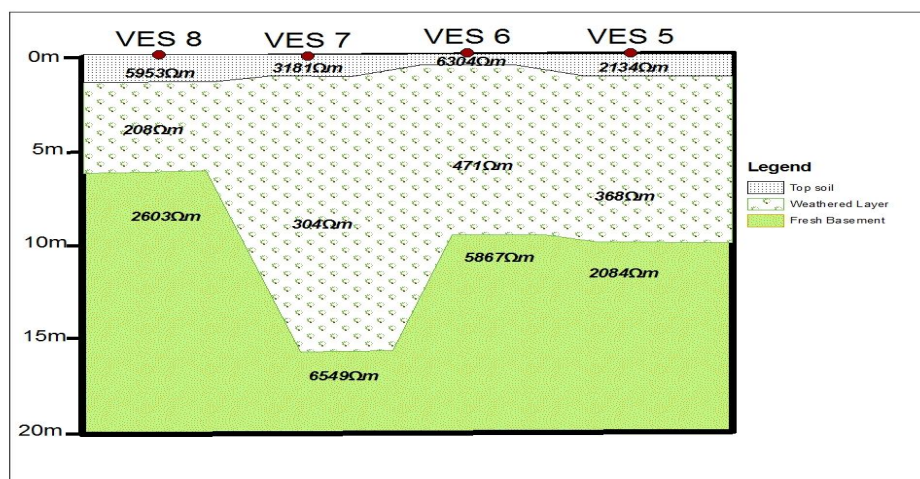


Fig 4.0a Profile1: Geoelectric section across VES 8, 7, 6, 5

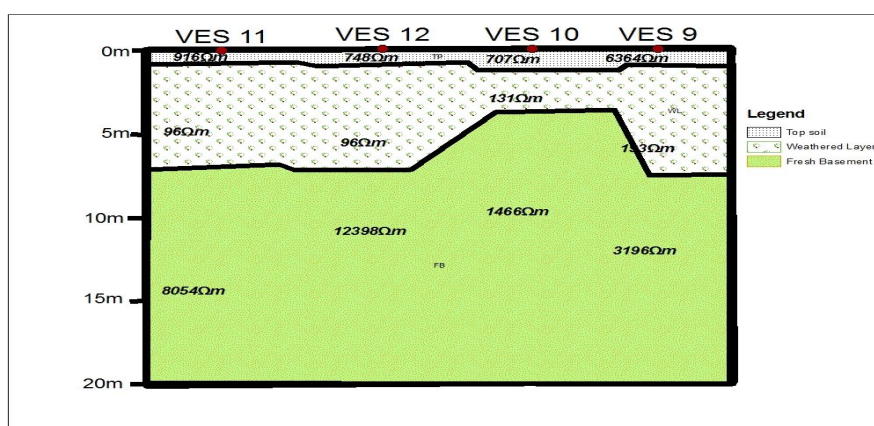


Fig 4.0b Profile 2: Geoelectric Section across VES 11, 12, 10, 9

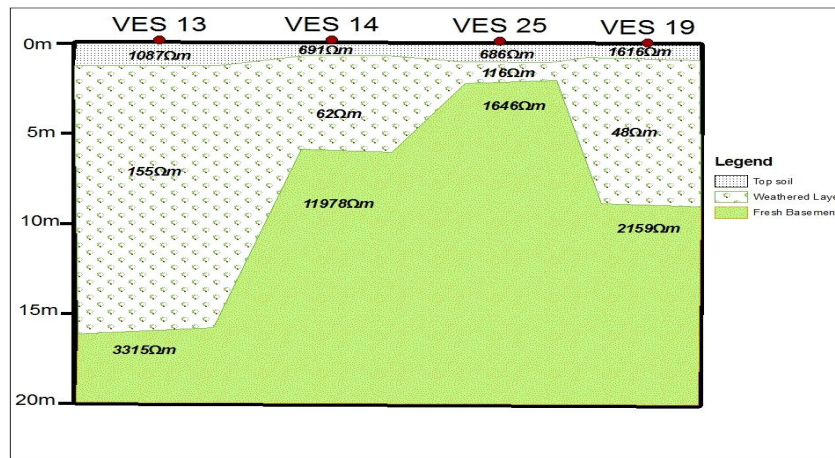


Fig 4.0c Profile3: Geoelectric section across VES 13, 14, 25, 19

The Overburden Thickness Contour Map

The overburden is assumed to include all materials above the presumably fresh basement. The depth to the bedrock varies from 3.5m to 16.5m and the average depth to the bedrock is 10.0m (fig 5.0).

The overburden thickness contour map (Figure 5.0) shows that the weathered basement has an increasing thickness values towards the north-eastern and north-western axis which suggests the presence of an aquiferous zone.

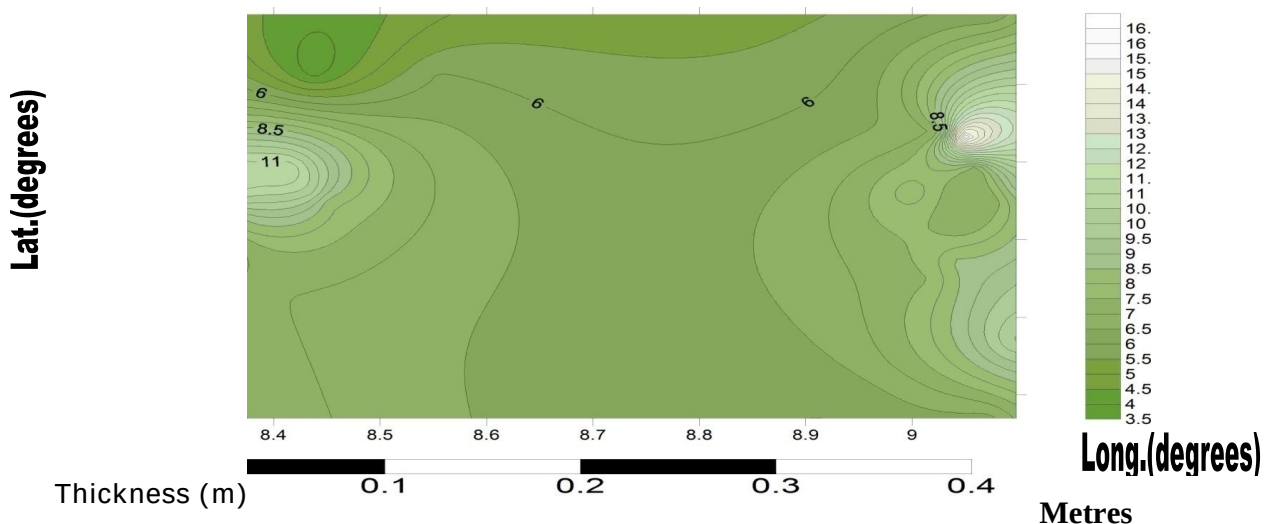


Fig 5.0: The Overburden Thickness Contour Map

The Topsoil Resistivity Contour Map

The map reveals the heterogeneity in the composition` of topsoil, whose composition varies from sandy clay to laterite. The topsoil resistivity varies from 500Ωm to 7500Ωm (fig 6.0).

From fig (6.0) it can be observed that the region with topsoil resistivity values ranging from 3000 Ωm to 7000 Ωm with thickness value ranging from 6.8m to 7.2m i.e. the northwest region with a constant resistivity value of 3000 Ωm, shows that the topsoil is characterized by high resistivity value.

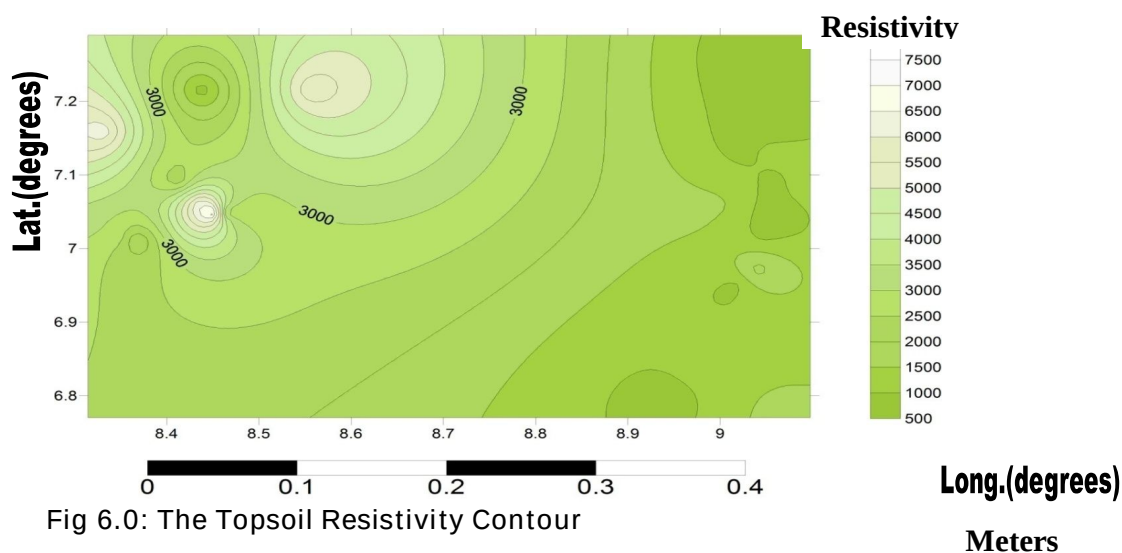


Fig 6.0: The Topsoil Resistivity Contour

Conclusion

The result presented in this work has attempted to define the sub-surface lithology and geo-electric response underlying formations in part of the Gwagwalada area council Abuja, Nigeria. The area is underlain by three to four layers of different lithological units such as topsoil, weathered layer, fractured layer and fresh basement; the aquifer thickness varies from 3.5m to 16.5m. The resistivity value of the weathered basement varies from 57.9Ωm to 471.1 Ωm.

The depth to the bedrock varies from 3.5m to 16.5m and the average depth to bedrock is 10m. It has also been established from this study that Overburden thickness contour map was suited for estimating thickness of the subsurface layering (Fig 5.0). The presence and development of weathered layer underlain by fractured basement are components of aquifer system and zone of groundwater accumulation in the study area. It can therefore be concluded that low resistivity and significantly thick weathered rock and fractured basement constitute the aquifer in this area. It can be concluded based on all the findings made in the interpretation of the VES data, 12 VES Points 5,6,7,8,9,10,11,12,13,14,19, and 25 are strongly recommended as most viable locations for the development of groundwater resources in the study area.

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MENTORING RELATIONSHIP PATTERNS AMONG CERTIFIED LIBRARIANS IN NIGERIA

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Abstract

This study summarizes a survey conducted to discover the mentoring relationship patterns used by certified librarians in Nigeria in their professional and official library institutions. The research method was a descriptive survey. The research instrument was distribution of questionnaires designed by hand. The population was participants at the 1st Conference of certified Librarians, National Universities Commission, 18th – 23^d May, 2014, Maitama, Abuja, FCT, Nigeria. The survey revealed that: almost all certified librarians (120 or 100%) in Nigeria have had some form of mentoring relationship; more certified librarians (90 or 75%) use personal approach or contact to enter into mentoring relationship with their mentors; more certified librarians are satisfied with the mentoring method used by their mentors personal contact(75%), telephone (13.3%) email (11.7%) none by teleconference, and more certified librarians (100 or 83.3%) do not have mentoring programmes offered by their institution to staff. This paper recommends the Nigerian Library Association and the Committee of University Librarians to explore the possibilities and use of mentoring programmes for librarians in Nigerian universities and colleges as it would bring several professional and psychosocial benefits to certified librarians.

Keywords: *Patterns, Mentoring, Relationship, Certified Librarians, Nigeria*

Introduction

Individuals learn a great deal through their interactions with others, especially those with different backgrounds, expertise, and seniority in their organizations. One important way relationship can serve as a forum for personal learning is by using mentoring system (Allen & Poteet, 2011). The original meaning of the word, mentor, refers to a person who sponsors, guides and develops a younger or new person in an organization. Mentors do play a significant role in teaching, inducting and developing the skills and talents of others in their career.

Mentoring is an age long process where the more experienced takes the less experienced into his/her fold to infuse with knowledge and understanding over a period of apprenticeship. Mentoring is the process whereby a more knowledgeable person, usually a superior, takes a younger person in a career track to coach, instruct and transfer skill and expertise to the person over a period of time is not prescribed only voluntary. In Africa, this can be noticed in informal modes in the skill sector of master-learner in such areas as basket weaving, cloth weaving, blacksmiths, bronze sculpture and wood crafts which has kept these professions going. In Nigeria, the library profession is experiencing a challenge in skill and manpower development. Since the current number of world certified and acclaimed librarians are small, the need for mentoring relationships among librarians in Nigeria cannot be overstated. Most young and new qualified librarians for instance in cataloging wallow in the dark of the profession and stumble in discharging their duties due to inadequate mentoring relationships or programmes. This is because, there are no clear cut patterns of relationships geared towards the mentoring of the young and inexperienced librarians in Nigeria.

Mentoring creates rooms for capacity building, professional development and other psychosocial support forms which the young and upcoming librarians in Nigeria cannot adequately learn due to the almost nonexistent formal or structured relationships in most libraries. This thereby leaves the training of the beginner to informal patterns of inculcating with skill to become familiar with the career to equip for professional life. Mentoring has become a key in professional and psychosocial

support in several fields to build capacity and develop professionalism (Allen & Poteet, 2011; Bello & Mansor, 2011).

Literature Review

Patterns of mentoring in various professions are well documented and viewed of immense significance. This is because the professional and psychosocial support mentoring provides both for the mentor and the mentee (Ekwelem, Okafor, Ukwoma, 2011; Atulomah, 2011; Asadu & Onyegiri, 2011; Zakari & Okojie, 2011). Mentoring is a method of training and development program used to increase group and/or individuals' potentials to carry out particular duties and responsibilities, familiarize with new techniques, and care for all aspects of mentees life (Hanford & Ehrich, 2006). Mentoring patterns have been designed and administered based on differences and uniqueness of people involved and an organization in terms of beliefs, orientations, stresses, strengths and weaknesses (Aladejana, & Ehindero, 2006).

Bosch, Ramachandran, Luévano and Wakiji (2010) noted that formal mentoring also called structured mentoring is an assigned relationship by the work organization between a more experienced person and a less experienced person. Formal mentors focus on mentees short-term career goals. Formal mentoring is created and supervised as an organizational culture and principle of relationship and development of career goals (Chansrichawla, 2005; Salami, 2008). Formal mentoring program is often viewed as the structured and coordinated relationship between mentor and mentee, using standard norms, continuously action plans, time frame, and particular objectives (Ismail & KhianJui, 2009).

Golden (2012) observed that mentoring can be informal too. In informal mentoring, the relationship is unofficial and not backed up by any specific organisational culture or policy. It is a relationship of shared concern between two people due to the passion and interests they both share as individuals and professionals. Informal relationships are developed by mutual identification whereby mentors choose protégés whom they view as younger versions of themselves (Ragins, Cotton & Miller, 2000). Informal mentoring relationships usually focus on a protégés' long-term career goals and are voluntary, unstructured and often sparked by mutual attraction and probably personal approaches from either the mentor or mentee.

A new area within mentorship literature is e-mentoring (Stokes, Garrett-Harris, & Hunt, 2003; Akin & Hilbun, 2007; Gieskes, 2010). E-mentoring involves "...mentoring projects that use technology to facilitate and support mentor relationships" (Buchanan, et al, 2005). E-mentoring uses new technologies like video or telephone conferencing to instead of traditional person-to-person mentoring for and learning (Megginson, Clutterbuck, & Garvey, 2006).

Mavrinac (2005) mentioned peer mentoring as an example of a pattern of mentoring. Peer mentoring focuses on career advancement and can be initiated informally or formally by an organization. The following are necessities for peer mentoring: specified career-development goals that coincide with organizational development goals and culture, careful selection of volunteers to be mentors and protégés, careful matching of participants, training in skills needed to fulfill essential roles and functions, continuous monitoring of the mentoring process, and evaluation of results (Terrion & Leonard, 2007).

Hypotheses

- (i) There is no significant relationship between the type of mentoring relationship used by certified librarians and the quality of their mentoring relationship.
- (ii) There are no significant differences in the forms of mentoring methods preferred by certified librarians and the medium for entering into mentoring relationships.

Objectives of the study

The objectives of this study are to:

- (i) Identify if mentoring relationships exists among certified librarians in Nigeria
- (ii) Identify the patterns of mentoring relationships among certified librarians in Nigeria, and
- (iii) Identify the methods of mentoring relationships certified librarians in Nigeria are most satisfied with.
- (iv) Identify institutions that offer mentoring programmes for their staff.

Justification of study

Mentoring patterns of relationships are geared towards increased skill and professionalism of the mentee (Greiman, 2007). Scandura and Williams (2004) noted that formal mentoring program increases leadership skill and organisational awareness. Freedman (2009) noted that effective mentoring among librarians is essential to the growth and success of librarianship in all types of library. Buchanan, Myers and Hardin (2005) averred that e-mentoring breaks the divide of time and increases the mentee in skills even beyond career.

It is in this vein that the purpose of this research is to examine the patterns of mentoring relationships among certified librarians in Nigeria with specific reference to its importance in learning and sharing of information for personal, academic and professional growth and library development of their institutions.

Methodology

The research method was a descriptive survey designed to find out the patterns of mentoring relationships among certified librarians in Nigeria. The respondents were chosen randomly from participants at the 1st Conference of certified Librarians, National Universities Commission, 18th – 23rd May, 2014, Maitama, Abuja, FCT, Nigeria. The survey was also designed to find out certified librarians enter into mentoring relationships and how satisfied they are with the pattern of mentoring relationships. The research instruments used was distribution of questionnaires by hand. The questionnaires followed the Likert model. One hundred and thirty copies of the questionnaires (130) were administered and one hundred and twenty (120) were retrieved by the researcher. A breakdown of the research respondents includes:

Position	No of Respondents	Percentage
University Librarian	8	7 %
Professor	10	8%
Deputy university librarian	8	7 %
Associate Professor	10	8%
Principal librarian	5	10 %
Reader	6	5 %
Senior librarian	10	8%
Senior lecturer	12	10 %
Lecturer 1	8	7 %
Librarian 1	12	10 %
Librarian 11	16	13 %
Assistant librarian/Graduate Assistant	8	7 %
Total	120	100 %

Data analysis, presentation and discussion of results

Table 1. Mentoring relationships among certified librarians

Table 2. Patterns of mentoring relationships among certified librarians

Table 1 -Mentoring Relationships among Certified Librarians

Table 1 discusses mentoring relationships among certified librarians in Nigeria.

Table 1.0.

Item 1	Response		
Mentoring is necessary in the library profession	Agree 98	Disagree 2	Undecided 20

Mentoring is practice of infusing the younger and inexperienced with knowledge and expertise by the more experienced person. There is an overwhelming agreement that mentoring is necessary in the library profession with 98 respondents (81.7%) while 2 disagree (1.7 %) and 20 (16.7 %) are undecided. A high number of respondents agree (98) because according to Hines (2007) mentoring is used to support new librarians. Mentoring thus is a professional activity within the library profession geared towards imparting the young librarian with technical, professional, social and organisational skills to enhance their personal and professional values (Bello & Mansor, 2013).

Table1.1

Item 2	Response		
I have (had) professional mentoring relationships in the library profession	Agree 32	Disagree 20	Undecided 68

In table 1.1 several respondents have had or engaged in one form of mentoring relationship of another. 32 (26.7%) have had mentoring for between 1-2 years, 20 (16.7%) for 3-4 years and 68 (56.7%) for 5 years and above. There is a greater number of respondents who have had mentoring relationships for over 5 years. This justifies the case that mentoring is necessary in the career profession of librarians. Asadu and Onyegiri (2011) noted that with the university library facing economic and staffing challenges, and demands for productivity and assessment measurements increasing, institutions and their libraries tend to invest more in staff training and mentoring so that they can retain a productive, well-trained and multi-faceted staff. Thus, the most economical way to provide mentoring is using experienced senior in-house staff

Table 1.2

Item 3	Response		
I am satisfied with the quality of my mentoring relationship	Agree 84	Disagree 20	Undecided 16

In table 1.2, 84 respondents (70%) are satisfied with their mentoring relationships, 20(16.7%) disagree and 16 (13.3%) are undecided. There are more respondents satisfied with their mentoring relationships. A mentoring relationship that satisfies the mentee is one that increases professional competence, builds capacity and develops expertise. Satisfaction is predicated upon psychosocial and professional factors (Bello & Mansor, 2011; Zakari & Okojie, 2011).

Table 2 – Patterns of mentoring Relationship

Table 2 deals with patterns of mentoring relationship among certified librarians in Nigeria. The method used in mentoring relationships and the satisfaction of respondents are discussed.

Table 2.1

Item 4	Response		
Personal contact is the best pattern of mentoring.	Agree 90	Disagree 14	Undecided 16

Table 2.1 deals personal contact as a mentoring pattern used by certified librarians in the mentoring relationship. To this 90 (75%) agree as the best mentoring pattern.

Table 2.2

Item 5	Response		
I receive mentoring through email and teleconference.	Agree 14	Disagree 90	Undecided 16

Table 2.2 identified email and teleconference as another mentoring pattern used by certified librarians in the mentoring relationship. While 14 (12%) agree, a larger percentage of 75% disagree.

Table 2.3

Item 6	Response		
Telephone is the best form of mentoring?	Agree 16	Disagree 90	Undecided 14

Table 2.3 mentioned telephone conversation as a mentoring pattern used by certified librarians in the mentoring relationship. On this, 16 (13%) agree. While no obvious reason is adduced for personal contact, the psychosocial significance and cost effectiveness cannot be dismissed. The other patterns would accrue some cost. Personal contact (90) is Informal mentoring which is an ongoing process. In personal contact the library and teaching faculty are possible mentors. Its success is based on the mentee's initiative and willingness to seek guidance from colleagues and teaching faculty whom he/she works with and on the availability and willingness of senior library faculty to offer guidance and advice (Aladejana, Aladejana, & Ehindero, 2006).

Table 2.4

Item 7	Response		
I am satisfied with the mentoring method of my mentor?	Agree 90	Disagree 16	Undecided 14

The mentoring method that most mentors used in the mentoring relationship shown in table 2.2 is personal contact (90 respondents). Table 2.2 shows that most respondents, 90 (75%) are satisfied with the use of this mentoring method but 16 (13%) are not while 14 (12%) are undecided. In certain traditional Nigerian culture, physical access to a relationship with a mentor is adjudged as special. This might play a role in the level of satisfaction too. The experienced mentor who has a broad knowledge of the profession and promotion process, can be helpful to the mentee in the following areas: setting goals; formulating a research agenda; providing guidance on effective teaching and professional activities, and on time management.

Table 2.5

Item 8	Response		
My institution offers mentoring programs for its staff	Agree 18	Disagree 100	Undecided 2

Table 2.5 focuses on an institutions support of mentoring program for its staff. 100 (83.3%) disagree that their institution supports mentoring programs, 18 (15%) agree and 2 (2%) is undecided. The implication is that most institutions do not have in place a formal, structured mentoring program for their library staff. However, it is important to observe that of the 18 respondents that agree their institution offer a mentoring programme for its staff 10 (6%) belong to

the Polytechnic and college of education, 4 (22%) are of university category and 4 (22%) public library i.e public service. With this, the university sector needs to inculcate into her system a formal mentoring method of on the job training. According to Popoola, Adesopo, and Ajayi (2013) the university management in Nigeria, particularly the library has failed in its strategic planning by not putting in place processes that ensure transfer of relevant skills and knowledge, by a way of mentoring.

Table 2.6

Item 9	Response		
Mentoring relationships began with a personal approach by the intending mentee?	Agree 70	Disagree 20	Undecided 30

In table 2.6 most mentoring relationships 70 (58%) started through personal approach or contact by the mentee to the mentor. However, 20 (17%) noted it was by the mentor, 18 (15%) was official and 12 (10%) accidental. This agrees with the finding in table 2.5 where 9 respondents agree that their institutions offer mentoring programs for their staff. The none-availability of an organisational culture of formal mentoring program in an institution explains the high pattern of personal contact between the mentor and the mentee shown in table 2.1 above. Personal contact agrees with Ozioko, Nwabueze and Igwesi (2014) who infer coaching as a pattern of mentoring relationship.

Table 2.6

Item 10	Response		
My work environment support mentoring relationships	Agree 59	Disagree 31	Undecided 30

In table 2.6 above, 59 (49.2%) agree their work environment support mentoring relationships, 31 (25.8%) disagree and 30 (25%) are undecided. A work environment is a professional and social relationship environment which may not in essence be formal or prescribed. Thus the work environment comprises the people and the policies in place in an institution administrative system. The high number of those who agreed their work environment supports mentoring (59 or 49.2%) disagreed with Ozioko, Nwabueze and Igwesi (2014) who asserted that mentoring through on the job training is prevalent in university libraries work environment in Nigeria.

Findings

The following are the findings of this study:

- (i) That certified librarians agree that mentoring relationship is necessary in the library profession with 98 (81.7%) respondents,
- (ii) That certified librarians use personal contact more as a preferred pattern for mentoring relationships (90 or 75% respondents) than email, telephone and teleconference,
- (iii) That more certified librarians are satisfied (90, 75% of respondents) with the use of personal contact as a mentoring pattern,
- (iv) That more certified librarians made personal contact/approach (70, % of respondents) to the mentor as a medium for entering into their mentoring relationship and 20 (16.7%) was by the mentor, 18 (15%) was official and 12 (10%) accidental,
- (v) That more certified librarians (100 or 83.3 respondents) belong to institutions that do not offer mentoring programs for their staff with 2 (1.7%) undecided and 18 (15%) have the privilege of a mentoring program in their institutions.

Conclusion

The bottom-line of this study is to provide documentation that could lead to a more efficient way to use and integrate mentoring programs into library curriculum and professional librarian's training and development. Results indicate that certified librarians are using mentoring, but not as an official programme to train and retrain the professional librarian in the work place (Asadu & Onyegiri, 2011). Mentoring is open for better and improved use in this sector that is witnessing unprecedented change.

Recommendations

- (i) The Certified Librarians Council of Nigeria should factor personal contact sessions into their conferences and make it mandatory for their members to implement through a system of reported supervision in her annual conferences,
- (ii) The Nigerian Library Association should educate members on the benefits of engaging in personal contact for mentoring in their short courses and seminars at her annual general meetings,
- (iii) The Committee of Nigerian University librarians should make it mandatory for staff to use personal contact mentoring in their staff development and relationships,
- (iv) Certified librarians should adopt the use of personal contact more in mentoring younger librarian's for career development and psychosocial relationships in their attempt to enrich the libraries and make trainings easier.

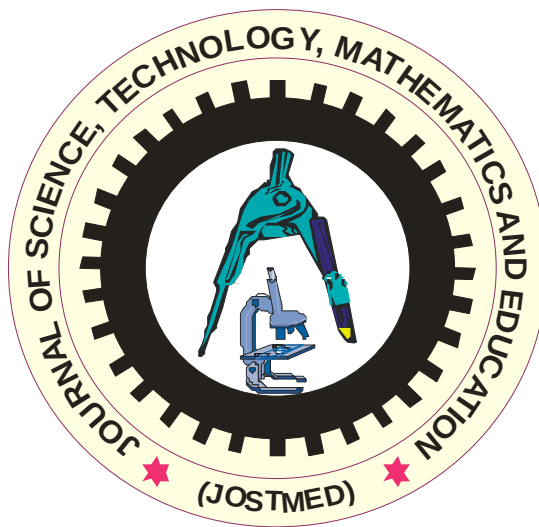
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ARTICLES AND RESEARCH REPORTS ON TECHNOLOGY

EVALUATION OF RECYCLED COARSE AGGREGATES IN PORTLAND CEMENT CONCRETE PAVEMENT

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Abstract

Sustainability of the environment has led to recycling of Portland Cement Concrete (PCC) with emphasis on the use of Recycled Concrete Aggregate (RCA) in rigid pavements and other construction applications. RCA from construction and demolition site in Centurion Pretoria, South Africa was used to evaluate its effect on PCC pavement. Natural Crushed Aggregate (NCA) was replaced with 0, 25, 50 and 75% of RCA in PCC with a targeted strength characteristic of 35 MPa. Compressive strength was determined at 7, 14, 21 and 28 days to be 25.8, 35.5, 39.9 and 43.8 MPa while flexural strength at 7 and 28 days of curing was 4.8 and 5.6 MPa respectively for NCA. RCA for all the proportions considered met the targeted compressive strength though the range of strength loss was 6.83-16.48%. The flexural strength was not affected negatively with the use of RCA.

Keywords: Recycled concrete aggregate; Portland cement concrete; pavement; compressive strength; natural crushed aggregate; flexural strength

Introduction

Interest in Portland Cement Concrete (PCC) recycling has increased steadily over the years with widespread use of Recycled Concrete Aggregate (RCA) in rigid pavement surfaces and many other construction applications (Fahtul *et al.* 2006; Hironaka *et al.* 1987; Salas *et al.* 2009a). Considering the fact that fine and coarse aggregate occupy about 75 to 80% (Ahmed, 2012), of the total concrete volume in rigid pavement, the partial replacement within recycled aggregate can be employed to reduce the cost of pavement construction (Maier and Durham, 2012) and this sustainable practice will assist in saving large areas of landfill space and provides potential cost savings to government or client. The future success of recycled PCC in rigid pavements depends on better characterization of the properties of recycled concrete aggregate and their influences on a PCC mixture for suitable paving applications. If RCAs are to be used in PCC pavements with the same confidence as that associated with the use of natural aggregates, research must identify the material and pavement design factors that have resulted in both good and unacceptable performance. RCA is typically regarded as a double phase material which consists of the original virgin aggregate and the adhered residual mortar (Tam *et al.* 2005; Tam *et al.* 2006). The RCA-made concrete will have more constituents: the new mortar and the new virgin coarse aggregates.

Two types of interfacial transition zones (ITZs) in RCA-made concrete mixtures have been identified: the old ITZ between the original virgin coarse aggregate and the adhered mortar and the other between the new mortar and the RCA. Due to high amounts of adhered mortar content in recycled aggregates, RCA can have higher water absorption, lower specific gravity, and higher porosity compared to natural aggregate (Kou *et al.*, 2012). Due to high amounts of adhered mortar existing in RCA particles, the density of RCA is usually lower than that of virgin aggregates which in turn decreases the unit weight of concrete containing RCA (Tam *et al.*, 2006; Xiao *et al.*, 2012). Domingo-Cabo *et al.* (2009) reported that a greater presence of recycled aggregates decreases the workability of the concrete, which may be related to the shape, texture and absorption characteristics of the recycled aggregate.

The use of RCA can lead to significant effect on compressive strength of concrete due to the inferior properties of the residual mortar phase of the RCA particles. However, this effect can be negligible for replacement levels up to 30% (Smith, 2009; Tam *et al.*, 2006). Volz *et al.* (2014) observed that there is no significant difference in compressive strength of the specimens made with up to 100% replacement of coarse recycled aggregate with reference concrete. The RCA was produced from crushing concrete made with $w/c=0.4$, and the studied RCA-made concrete was proportioned with $w/c=0.45$. As in the case of compressive strength, RCA replacement mostly results in a decrease in splitting tensile strength of concrete. Ravindrarajah & Tam (1985) reported that the splitting tensile strength of concrete made was consistently 10% lower than that of conventional concrete without RCA. Tabsh and Abdelfatah (2009) reported that about 25% to 30% drop in the tensile strength was observed in concrete made RCA.

Kou *et al.* (2012) observed that regardless of the type of the recycled aggregate used, the splitting tensile strength of the specimens decreased with an increase in RCA replacement ratio before the age of 28 days. However, for some types of the RCAs used, an increase in the splitting tensile strength at the age of 90 days is observed. Sagoe *et al.* (2001), reported that there is no significant difference between the splitting tensile strength of the reference and the recycled aggregate concrete specimens. Limbachiya *et al.* (2012) and Yong and Teo (2009) reported that while replacing up to 50% of coarse aggregate with RCA, there was no difference in splitting tensile and flexural strengths between the RCA and the reference, but at complete replacement results were improved for RCA due to better interlocking. The RCA replacement does not have significant negative effects on flexural strength of concrete. Xiao and Li (2005), Hu (2007), and Cheng (2005) reported that up to 100% RCA replacement at concrete mixtures of w/c varying from 0.43 to 0.57 only has marginal effects on flexural strength of concrete. Ravindrarajah and Tam (1985) also reported that increasing the RCA content does not have a significant effect on flexural strength. Absorption of water by RCA concrete is usually reported to be higher than that of virgin aggregate concrete which is mainly due to the attached porous mortar content of the RCA particles that can provide more water reservoirs, thus maintaining higher relative humidity inside the pore solution (Volz *et al.*, 2014). Salas *et al.* (2010) used up to 100% RCA for producing concrete for rigid pavement applications as part of O'Hare Airports modernization project using the two stage mixing approach developed by Tam *et al.* (2005).

Choi and Won (2009) studied the performance of a continuously reinforced concrete pavement highway section made totally with fine and coarse RCA located in Houston, Texas. Based on the results by testing core samples, it was observed that the average compressive strength decreased due to use of RCA. The modulus of elasticity of the RCA concrete was lower than that of the virgin aggregate mixture. It is interesting to note that the coefficient of thermal expansion of the RCA concrete was similar to the virgin aggregate mixtures. Higher chloride ion concentrations were observed in the case of in the case of the RCA mixtures. The quality of recycled concrete aggregate will vary depending on the properties of the recovered concrete. It is therefore necessary to evaluate the properties of recycled aggregates and its strength in pavement construction for cost and material saving.

Materials and Experimental Details

NCA is a crushed dolerite stone while RCA (plate 1) was obtained from construction and demolition of old mall site in Centurion, Pretoria, Gauteng South Africa. The building had undergone a crushing process where the required nominal size of 19 mm were stockpile. Sampling and tests were run on both NCA and RCA to determine specific gravity, water absorption, compacted bulk density, loose bulk density, flakiness, aggregate impact value, aggregate crushing value as well as the sieve analysis in accordance with relevant South African standards (TMH 1; SANS 201; SANS 5841; SANS 5842; SANS 5847). The results are presented in Tables 1-3, specific gravity and water absorption of

2.68, 0.5% and 2.69, 2.1% were obtained for natural and RCA respectively while fineness modulus of 1.7 and specific gravity of 2.63 was obtained for natural river sand.

The mix design of the concrete was done according to SANS 863 method with targeted strength characteristic of 35 MPa with strength margin of 8.5 MPa at 28 days and slump of 85 mm. Commercial Portland cement-limestone blended type CEM II/ B-L 42.5 N (SANS 50197) and average amount of water (210 //m³) were selected based on the size of aggregate. The target strength characteristic and type of cement was used to established water-cement (w/c) ratio. Constant w/c ratio was used for both NCA and RCA mixes. The mixture compositions of all mixes are presented in Table 4. Four types of mixture were prepared by replacing the natural crushed coarse aggregate with RCA at 0, 25, 50, and 75% of the total coarse aggregate content in the production of RCA-made concrete. The percentage of replacement was to identify the influences of the RCA in the concrete strength and the calculation was based on the total weight of the coarse aggregate content.



Plate 1: Appearance of NCA and RCA

Table 1: Physical properties of natural and recycled coarse aggregates

	LBD	CBD	ACV	AIV	10% FACT	Water absorption	Dry bulk density	Apparent bulk density	Flakiness
NCA	1345	1453.5	14	19.7	289	0.5	2.592	2.692	29.5
RCA	1190	1340	20	23.7	160	3.9	2.611	2.713	35.3
Sand	1233.5	1320	-	-	-	2.1	2.530	2.672	-

Table 2: Sieve analysis for fine aggregates

Sieve size, mm	Sand	Specification
4.75	100	90-100
2.36	100	
1.18	98	
0.600	91	
0.425	84	
0.300	35	5-25
0.150	7	
0.075	1.0	

Table 3: Sieve analysis for recycled coarse aggregates

Sieve size, mm	Natural crushed aggregate	Recycled concrete aggregate	Specification
26.5	100	100	100-100
19.0	93	87	85-100
13.2	25	19	0-50
9.5	5	3	0-25
6.7	1	1	0-5
4.75			

Table 4: Concrete mix proportions

	0	25 %	50 %	75 %
Cement (kg/m ³)	330	330	330	330
Fine aggregate (kg/m ³)	668	668	668	668
NCA (kg/m ³)	1120	840	560	280
RCA (kg/m ³)	0	280	560	840
Water (kg/m ³)	210	210	210	210
w/c	0.64	0.64	0.64	0.64

All concrete mixtures were prepared and produced in the laboratory and referenced as NCA, RCA-25, RAC-50 and RCA-75%. All the samples were cast in steel moulds, kept in wet conditions for a day in the moulds before demoulding at a temperature of 23⁰ C (Figure 1). Cube samples of 150 x 150 x 150 mm size for each mixture and three cubes from the same sample of concrete were water cured until the day before the test date. The cubes were used to measure average compressive strength while 100 x 100 x 500 mm prism was used to test for flexural strength. Development of the compressive strength was monitored by testing the cubes at 7, 14, 21 and 28 days and flexural strength test was monitored for 7 and 28 days.



Figure 1: Batching, Mixing and Cast Concrete

Results and Discussion

Table 1 show that both the loose and compacted bulk density as well as the absorption capacity of NCA were higher than RCA. The aggregate crushing strength and impact value, the results show that RCA had an average 20% and 23.7% more losses than NCA correspondingly. As expected, the strength of the crushed concrete affects the ACV and AIV of the aggregate. Nevertheless, all the results of RCA are within the acceptable limit for structural application.

The test results of the compressive strength of the concrete for both NCA and RCA are presented in Table 5 and shown in Figure 2. The results show that the compressive strength at 28th day for all the concrete considered was higher than the 7th day which was as a result of increase in amount hydration with higher curing age. Generally, the 7-day compressive strength is 60-70% of the 28-day compressive strength for the RCA concrete and this falls within the range of normal concrete cured with water i.e. 60-80% (Mindess *et al.*, 2003; Neville, 1996). It was observed that there is a gradual decrease in compressive strength as the percentage of RCA increases. After 28 days of curing the RCA for all the percentages considered achieved target compressive strength (35 MPa) though RCA-25, RCA-50 and RCA-75 produced compressive strength that were 6.83, 11.39 and 16.4% lower than NCA concrete, respectively. These values confirmed the trends found in the literature that reported a decrease in compressive strength when NCA is replaced with RCA (Obla and Kim, 2009; Chen *et al.*, 2003; Xiao and Li, 2005). Though, the reduction observed in this study was only 16.4% in comparison with NCA but RCA did not significantly decrease the compressive strength of concrete. This was due to a better interfacial bond between aggregate and cement paste in the presence of rough RCA. The weakness of RCA was due to porous adhered cement paste

prevailed over its surface roughness and high water absorption, resulting to decrease in the compressive strength of concrete.

Table 5: Results of Compressive Strength

Days	NCA	RCA-25	RCA-50(MPa)	RCA-75
7	25.8	25.4	22.7	21.6
14	35.5	30.2	29.7	28.2
21	39.9	36.6	34.1	32.3
28	43.9	40.9	38.5	36.7

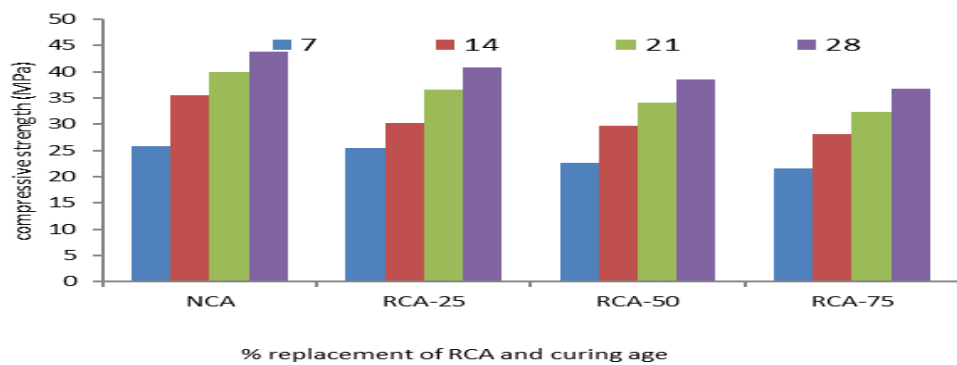


Table 6 and Figure 3 showed that the flexural strength of concrete also increase with curing age for all proportions of RCA. The highest flexural strength obtained at 28 days was 5.4 MPa for RCA-25 which is 14.82% lower than the 7-day flexural strength of 4.6 MPa. It is obvious from Figure 3 that RCA has no negative effect on the flexural strength of the concrete though there were reduction in values of 3.57, 7.14 and 7.14% for RCA-25, RCA-50 & RCA-75, respectively. The aggregate characteristics of RCA contributed to the production of better interfacial bond and mechanical interlocking.

Table 5: Results of Flexural Strength (MPa)

Days	NCA	RCA-25	RCA-50(MPa)	RCA-75
7	4.8	4.6	4.5	4.5
28	5.6	5.4	5.2	5.2

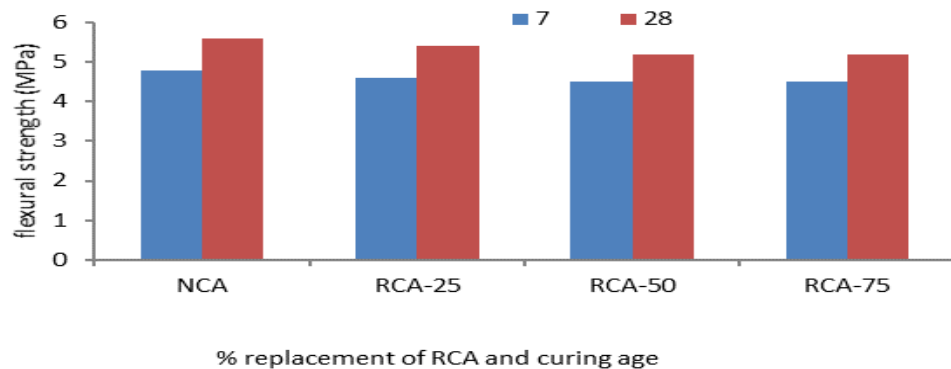


Figure 3: Flexural strength of NCA & RCA

Conclusion

The following conclusions can be drawn based on the study carried out:

- (i) The RCA had higher water absorption and density of concrete decreased with increase in proportion.
- (ii) Compressive strength after 28-day curing for all the proportions was higher than that of 7-day.
- (iii) The 28-day compressive strength for all proportions exceeded the target strength of 35 MPa although there is decrease in compressive strength as the proportions of RCA increases.
- (iv) RCA had no significant adverse effect on the compressive strength of PCC. For instance, the 28-day compressive strength of RCA-75 decrease by only 16.4% (that is, from 43.9 MPa for the control to 36.7 MPa). Though, RCA was less strong than NCA but has better interfacial bond between aggregate and cement paste in the presence of rough RCA.
- (v) The 28-day flexural strength of the concrete was higher than 7-day flexural strength for all the proportions of RCA. The highest flexural strength value of 5.4 MPa was obtained after 28-day curing for R-25, which is 14.82% lower than the 7-day flexural strength value of 4.6 MPa.

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EFFECTS OF MOISTURE CONTENT VARIATION ON SOME ENGINEERING PROPERTIES OF ALMOND (*Terminalia catappa*) SEED

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Abstract

*The physical and mechanical properties of Almond seed at different moisture content levels of 6.78%, 12.39%, 17.11% and 21.97% were investigated in this study. The physical and mechanical properties determined using standard procedures were length, width, thickness, arithmetic and geometric diameter, surface area, sphericity, specific gravity, bulk density, angle of repose and coefficient of static friction (on wood, glass and steel surfaces); rupture force, compressive strength and tensile strength were also determined on the seeds. A total of one hundred and twenty seeds were used for the study. This comprises of thirty seeds (randomly taken) per moisture content level. These thirty seeds were then replicated into three groups of ten seeds for the experiment (three groups of ten seeds for each of the moisture content level). The length, width and thickness obtained for the samples of the almond seeds were in the range of 25.42-28.63mm, 23.69-26.63mm, and 7.51-9.18mm respectively. The calculated values of the geometric mean diameter and sphericity ranged from 16.48-19.07mm and 64.66- 66.63% respectively. The results of the surface area varied from 853.6-1143.04mm². A high variation in the surface area of the seeds was observed with respect to the different moisture content levels. The mechanical properties showed that the fracture force and compressive strength decreased from 2689N to 2499N, 410N/mm² to 398 N/mm² respectively with an increase in moisture content (6.78%-21.9%). The tensile strength obtained for moisture levels of 6.78%, 12.39%, 16.11% and 21.9% were 3.20Mpa, 3.90Mpa, 4.20Mpa and 4.60Mpa respectively. From the study, it was observed that the physical properties of the seed determined as function of moisture content varied significantly (at $p \leq 0.05$) with increase in moisture content as the average length, width, thickness, surface area of the seed, specific gravity, sphericity and coefficient of static friction (on all three surfaces) increased; while the weight and angle of repose were not affected significantly by the moisture content. However, true and bulk density decreased as moisture content of the seed was increased. The tensile strength of *Terminalia catappa* increased with increase in moisture content while the fracture force and compressive strength reduced with increase in moisture content. These parameters are important in designing equipments and systems for harvesting, handling, storage and processing operations of the seed.*

Keywords: Almond seed, moisture content, physical properties, mechanical properties, bulk density

Introduction

Almond (*Terminalia catappa*) is a large tropical tree in the family of *combretaceae* that grows mainly in the tropical regions of Asia, Africa, and Australia. The tree is known as umbrella tree in Nigeria; it provides shade for relaxation and meeting points in some compounds. The crop is one of the lesser known legumes in the tropics and in Nigeria ecosystem (Mbah *et al.*, 2013). The fruit is called *Mkpuru edo* in Igbo language. The seed forms an important source of balanced food because it is rich in protein (14.1-24.7%), fat (21.8-23.8%), ash content (3.5-4.1%), fiber (6.4 14.0%), carbohydrate (29.5-39.2%), calcium (20.7-29.8mg/100g), phosphorus (16.0-17.2mg/100g), iron (0.7-1.4mg/100g), zinc (0.8-1.2mg/100g), tannin (0.3-0.4mg/100g), phytate (0.1-0.3mg/100g) (Mbah *et al.*, 2013).

The fruit pulp is fibrous, sweet and edible when ripe which is widely eaten by children as forage snack. The seed has an important place in the human nutrition and it can be used in fresh, dried or processed form (Akpabio, 2012). According to Mbah *et al.*, (2013), the seed is highly cherished by children and is used by many rural dwellers in Southern Nigeria to fortify the local complimentary foods which are low in protein. It also forms part of the local feedstock for tropical aquarium fishes in Nigeria (Agatemor and Ukhun, 2006).

Increase or decrease in the moisture content of almond seed can affects its physical and mechanical properties. The moisture content is the quantity of water present in the seed and it is usually expressed in percentage. Today, much study have been published on the physical and mechanical properties of grains and legumes by other researchers such as Saçılık *et al.* (2003) for hemp seed; Paksoy and Aydın (2004) for squash seed; Yalçın (2006) for cowpea seed; Orhevba *et al.*, (2013) for dika nuts; Kibar *et al.*, (2010) for rice; Gunner *et al.*, (2003) for hazelnut; Altuntaş and Demirtola (2007) for some legumes seeds; Yalçın *et al.* (2007) for pea seed; Pradhan *et al* (2008) for karanja; Altuntaş and Yildiz (2007) for faba seeds kernel; Amin *et al.*, (2004) for lentil seeds and Çalışır *et al.* (2005) for rape.

The development of adequate harvesting, storage and processing systems and machine are influenced by the physical and mechanical properties of almond seed. Most of these machines and systems used are generally designed without considering some of these engineering properties of almond seed, resulting in inadequate applications, reduction in work efficiency and an increase in production loss. There are few data describing the effect of moisture on some physical and mechanical properties of almond seed. Thus, this project was undertaken to investigate and provide concise information and data on some selected engineering properties of *Terminalia catappa*. This is to aid the design and development of machines and systems for the harvesting, handling storage and processing of the seed. Thus, the objectives of this study are to determine some selected physical and mechanical properties of almond seed under different moisture contents.

Materials and Methods

The almond fruits samples used for this study were obtained from trees around the Federal University of Technology, Minna, Niger state. The outer flesh of the fruits was manually removed with a knife and were oven dried for six hours to a moisture content of 6.57% to enable easy removal of the seeds from the nuts with least percentage of cracking.

A total of One Hundred and twenty seeds were used for the study. This comprises of thirty seeds (randomly taken) per moisture content level. These thirty seeds were then replicated into three groups of ten Seeds for the experiment (three groups of ten seeds for each of the moisture content level). The samples were numbered to avoid the repeat of measurements with the same seed. All foreign materials such as dust, stones, chaff, immature and broken seeds as well as bad seeds were removed by winnowing and picking. Sample selection was randomized all through the tests.

The initial moisture content of the seed was determined using the method employed by Aviara *et al.*, (2014) in determining the moisture contents of Shea nuts. The samples were transferred to separate polythene bags and reconditioned to moisture content levels of 6.78%, 12.39%, 17.11% and 21.97% W.B. The reconditioning technique to attain the desired moisture content for kernel was reported by Bart-Plange *et al.*, (2012). This process involves the addition of a calculated amount of distilled water added to each sample and the bags were then sealed tightly. The samples were refrigerated at a temperature of 5°C for a week to enable the moisture to be distributed uniformly throughout the sample.

The required quantity of the samples were then taken out of the refrigerator and allowed to warm up to room temperature for about 2 hours. Measurements of length (L), Width (W) and Thickness (T) were done using a vernier caliper with resolution of 0.01mm for each of the moisture content levels. The arithmetic and geometric average diameters of almond seed was calculated according to the method reported by Kiani Deh Kiani *et al.*, (2008).

The weights of the seeds were determined with the use of a digital weighing balance. The sphericity ϕ (%) was calculated using the relationship reported by Davies (2010). The surface area (S) of the seed was determined using the relationship reported by Arthur (2009). The bulk density of the samples was determined by the method reported by Kibar *et al.* (2010). The liquid displacement method, as described by Tavakoli *et al.* (2009), was used to determine the true density of the seed samples.

The static coefficient of friction was determined with respect to three test surfaces namely: plywood galvanized steel sheet and glass; as described by Mingjin *et al.* (2003). The angle of repose was determined by the geometrical approach described by (Chukwu and Akande, 2007).

The specific gravity was obtained according to the method described by Olaoye (2000), Adejumo (2003). The mechanical properties of the seed which include fracture force, compressive strength and tensile strength were obtained using Testometric Machine (ZDM50-2313/56/18, Germany).

Data analysis

Data obtained were analysed using design expert software; this is with a view to determine the relationship between moisture content and the properties.

Results and Discussion

The results of the study are as presented in Tables 1 to 17.

Table 1: Effect of Moisture Content on some Physical Properties of *Terminalia catappa* at Different Moisture Content

Parameters	6.78 % wb Sample A	12.39 % wb Sample B	17.11 % wb Sample C	21.97 % wb Sample D
Length (mm)	25.42±0.47 ^a	26.70±0.50 ^b	27.57±0.25 ^c	28.63±0.18 ^d
Width (mm)	23.69±0.68 ^a	25.13±0.22 ^b	26.27±0.19 ^c	26.63±0.23 ^c
Thickness (mm)	7.51±0.43 ^a	7.71±0.03 ^a	8.24±0.03 ^b	9.18±0.07 ^c
Geometric mean diameter (mm)	16.48±0.05 ^a	17.26±0.11 ^b	18.08±0.02 ^c	19.07±0.06 ^d
Arithmetic mean diameter (mm)	18.88±0.24 ^a	19.84±0.18 ^b	20.69±0.03 ^c	21.48±0.10 ^d
Surface area (mm ²)	853.69±6.57 ^a	936.38±11.32 ^b	1027.08±1.97 ^c	1143.04±6.59 ^d
Weight of seed (g)	7.06±0.03 ^a	7.59±0.29 ^a	7.64±0.13 ^a	8.82±0.70 ^b
Sphericity (%)	64.66±0.81 ^a	64.87±1.44 ^a	65.41±0.57 ^a	66.63±0.23 ^b
Bulk density (g/cm ³)	0.58±0.01 ^a	0.54±0.01 ^b	0.50±0.01 ^c	0.48±0.01 ^d
True density (g/cm ³)	1.27±0.01 ^a	1.09±0.01 ^b	1.04±0.01 ^c	0.98±0.01 ^d
Angle of repose (°)	38.84±1.64 ^a	46.74±0.85 ^b	51.54±1.81 ^c	52.29±2.0 ^c
Specific gravity	0.79±0.01 ^a	0.87±0.01 ^b	0.91±0.01 ^c	0.95±0.01 ^d
Coefficient of friction				
Wood surface	0.52±0.02 ^a	0.57±0.03 ^b	0.59±0.05 ^b	0.67±0.04 ^b
Glass surface	0.49±0.01 ^a	0.51±0.02 ^a	0.54±0.01 ^b	0.57±0.02 ^b
Steel surface	0.52±0.02 ^a	0.54±0.02 ^{ab}	0.57±0.02 ^b	0.62±0.03 ^c

*values followed by same superscript alphabet are not significantly different at (P<0.05) along the rows. Values are Mean ±Standard deviation.

Table 2: ANOVA for Length

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	5.534193569	1	5.534193569	1316.657118	0.0008
A-Moisture content	5.534193569	1	5.534193569	1316.657118	0.0008
Residual	0.008406431	2	0.004203215		
Cor Total	5.5426	3			
Std. Dev.	0.06483221		R-Squared	0.998483305	
Mean	27.08		Adj R-Squared	0.997724958	
C.V. %	0.239409934		Pred R-Squared	0.994690656	
PRESS	0.029427568		Adeq Precision	69.26441392	

Table 3: ANOVA for Width

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	5.023056035	1	5.023056035	41.83370617	0.0231
A-Moisture content	5.023056035	1	5.023056035	41.83370617	0.0231
Residual	0.240143965	2	0.120071982		
Cor Total	5.2632	3			
Std. Dev.	0.346514044		R-Squared	0.954373012	
Mean	25.43		Adj R-Squared	0.931559518	
C.V. %	1.362619126		Pred R-Squared	0.713943304	
PRESS	1.5055736		Adeq Precision	12.34630464	

Table 4: ANOVA for Thickness

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	1.671669713	2	0.835834857	6415.34116	0.0088
A-Moisture content	1.521435793	1	1.521435793	11677.5815	0.0059
A ²	0.168909888	1	0.168909888	1296.44576	0.0177
Residual	0.000130287	1	0.000130287		
Cor Total	1.6718	3			
Std. Dev.	0.011414328		R-Squared	0.99992207	
Mean	8.16		Adj R-Squared	0.9997662	
C.V. %	0.139881475		Pred R-Squared	0.99601514	
PRESS	0.006661887		Adeq Precision	168.45472	

Table 5: ANOVA for Geometric Mean Diameter

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	3.701268775	2	1.850634387	297272.779	0.0013
A-Moisture content	3.683640447	1	3.683640447	591713.868	0.0008
A ²	0.028644206	1	0.028644206	4601.20206	0.0094
Residual	6.22537E-06	1	6.22537E-06		
Cor Total	3.701275	3			
Std. Dev.	0.00249507		R-Squared	0.99999832	
Mean	17.7225		Adj R-Squared	0.99999495	
C.V. %	0.014078544		Pred R-Squared	0.999914	
PRESS	0.000318319		Adeq Precision	1199.11988	

Table 6: ANOVA for Arithmetic Mean Diameter

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	3.747246282	1	3.747246282	6099.4426	0.0002
A-Moisture content	3.747246282	1	3.747246282	6099.4426	0.0002
Residual	0.001228718	2	0.000614359		
Cor Total	3.748475	3			
Std. Dev.	0.024786262		R-Squared	0.99967221	
Mean	20.2225		Adj R-Squared	0.99950831	
C.V. %	0.122567746		Pred R-Squared	0.99869814	
PRESS	0.004880004		Adeq Precision	149.079831	

Table 7: ANOVA for Surface Area

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	46251.36669	2	23125.68334	73934.0953	0.0026
A-Moisture content	45863.23693	1	45863.23693	146627.318	0.0017
A ²	565.0126628	1	565.0126628	1806.37689	0.0150
Residual	0.312787804	1	0.312787804		
Cor Total	46251.67948	3			
Std. Dev.	0.559274355		R-Squared	0.99999324	
Mean	990.0475		Adj R-Squared	0.99997971	
C.V. %	0.056489649		Pred R-Squared	0.9996542	
PRESS	15.99360327		Adeq Precision	596.917314	

Table 8: ANOVA for Weight of Seed

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	1.410039095	1	1.410039095	11.4807247	0.0772
A-Moisture content	1.410039095	1	1.410039095	11.4807247	0.0772
Residual	0.245635905	2	0.122817952		
Cor Total	1.655675	3			
Std. Dev.	0.350453923		R-Squared	0.85164002	
Mean	7.7775		Adj R-Squared	0.77746003	
C.V. %	4.505997087		Pred R-Squared	0.29605863	
PRESS	1.165498123		Adeq Precision	6.4678281	

Table 9: ANOVA for Sphericity

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	2.335789769	2	1.167894885	212.916272	0.0484
A-Moisture content	2.062486587	1	2.062486587	376.00726	0.0328
A ²	0.302500024	1	0.302500024	55.1480944	0.0852
Residual	0.005485231	1	0.005485231		
Cor Total	2.341275	3			
Std. Dev.	0.074062344		R-Squared	0.99765716	
Mean	65.3925		Adj R-Squared	0.99297148	
C.V. %	0.113258162		Pred R-Squared	0.88020492	
PRESS	0.280473226		Adeq Precision	30.227682	

Table 10: ANOVA for Bulk Density

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	0.005807942	1	0.005807942	126.180171	0.0078
A-Moisture content	0.005807942	1	0.005807942	126.180171	0.0078
Residual	9.20579E-05	2	4.6029E-05		
Cor Total	0.0059	3			
Std. Dev.	0.006784465		R-Squared	0.98439696	
Mean	0.525		Adj R-Squared	0.97659544	
C.V. %	1.292278976		Pred R-Squared	0.92198292	
PRESS	0.000460301		Adeq Precision	21.4422016	

Table 11: ANOVA for True Density

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	0.043347615	1	0.043347615	24.4047943	0.0386
A-Moisture content	0.043347615	1	0.043347615	24.4047943	0.0386
Residual	0.003552385	2	0.001776193		
Cor Total	0.0469	3			
Std. Dev.	0.0421449		R-Squared	0.92425618	
Mean	1.095		Adj R-Squared	0.88638427	
C.V. %	3.848849312		Pred R-Squared	0.53052189	
PRESS	0.022018523		Adeq Precision	9.4299935	

Table 12: ANOVA for Angle of Repose

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	114.4299374	2	57.21496869	177.720672	0.0530
A-Moisture content	102.8183138	1	102.8183138	319.373412	0.0356
A ²	10.33069248	1	10.33069248	32.0891132	0.1112
Residual	0.321937613	1	0.321937613		
Cor Total	114.751875	3			
Std. Dev.	0.567395464		R-Squared	0.99719449	
Mean	47.3525		Adj R-Squared	0.99158347	
C.V. %	1.198237609		Pred R-Squared	0.8565474	
PRESS	16.46145527		Adeq Precision	27.8583961	

Table 13: ANOVA for Specific Gravity

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	0.013697446	1	0.013697446	90.5454175	0.0109
A-Moisture content	0.013697446	1	0.013697446	90.5454175	0.0109
Residual	0.000302554	2	0.000151277		
Cor Total	0.014	3			
Std. Dev.	0.012299475		R-Squared	0.97838899	
Mean	0.88		Adj R-Squared	0.96758348	
C.V. %	1.397667563		Pred R-Squared	0.8611967	
PRESS	0.001943246		Adeq Precision	18.1638144	

Table 14: ANOVA for Coefficient of Friction on Wood Surface

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	0.011009641	1	0.011009641	33.0938547	
A-Moisture content	0.011009641	1	0.011009641	33.0938547	
Residual	0.000665359	2	0.000332679		
Cor Total	0.011675	3			
Std. Dev.	0.018239499		R-Squared	0.94300997	
Mean	0.5875		Adj R-Squared	0.91451495	
C.V. %	3.104595596		Pred R-Squared	0.73568151	
PRESS	0.003085918		Adeq Precision	10.9811417	

Table 15: ANOVA for Coefficient of Friction on Glass Surface

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	0.003613847	1	0.003613847	118.190847	0.0084
A-Moisture content	0.003613847	1	0.003613847	118.190847	0.0084
Residual	6.11527E-05	2	3.05764E-05		
Cor Total	0.003675	3			
Std. Dev.	0.005529591		R-Squared	0.9833598	
Mean	0.5275		Adj R-Squared	0.9750397	
C.V. %	1.048263612		Pred R-Squared	0.89630287	
PRESS	0.000381087		Adeq Precision	20.7522762	

Table 16: ANOVA for Coefficient of Friction on Steel Surface

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	0.005672672	2	0.002836336	1218.48957	0.0203
A-Moisture content	0.005416572	1	0.005416572	2326.9587	0.0132
A ²	0.000302753	1	0.000302753	130.062666	0.0557
Residual	2.32775E-06	1	2.32775E-06		
Cor Total	0.005675	3			
Std. Dev.	0.001525696		R-Squared	0.99958982	
Mean	0.5625		Adj R-Squared	0.99876947	
C.V. %	0.271234802		Pred R-Squared	0.97902671	
PRESS	0.000119023		Adeq Precision	75.1970958	

The results showed that the different levels of the moisture content had significant differences ($p < 0.05$) on the length, width, thickness, arithmetic and geometric diameter, surface area, sphericity, specific gravity and coefficient of static friction (on wood, glass and steel surfaces) of the seed with the exception of weight and angle of repose; the different levels of moisture content had no significant differences ($p < 0.05$) on weight and angle of repose.

From Table 1, physical properties such as length, width, thickness, geometric and arithmetic mean increased with increase in moisture content from 6.78% to 21.79% w.b. The length, width and thickness increased from 25.42 to 28.63mm; 23.69 to 26.63mm and 7.51 to 9.18mm respectively with increase in moisture content; Chukwu and Musiliu (2010) reported the following

values for cowpea: Length (9.48 ± 1.46 mm), width (6.75 ± 0.66 mm), thickness (5.35 ± 0.73 mm).

Figures 1 to 13 graphically shows the effect of moisture content on the length, width, thickness, arithmetic and geometric diameter, surface area, sphericity, specific gravity and coefficient of static friction (wood, glass and steel surfaces) of the almond seeds.

There was significant difference in the length (Figure 1) as the moisture content increased from 6.78% to 21.97% ($p < 0.05$). Similar results have been reported by Sağlık *et al.* (2003) for hemp seed, Paksoy and Aydın (2004) for squash seed, and Yalçın (2006) for cowpea.

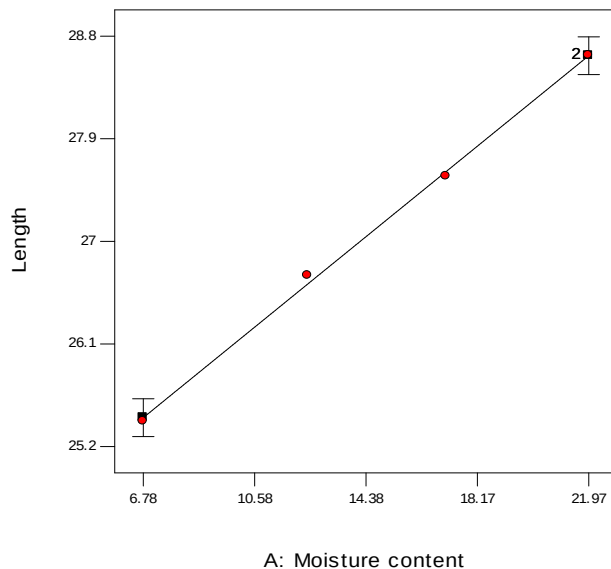


Fig.1: Effect of Moisture content on Length

There was significant difference in the width and thickness (Figures 2 and 3) as the moisture content increased from 6.78% to 21.97% ($p < 0.05$). The increase in the values may be attributed to its dependence on the three linear dimensions. Similar results have been reported by Sağlık *et al.* (2003) for hemp seed; Paksoy and Aydın (2004) for squash seed, and Yalçın (2006) for cowpea. Wang *et al.*, (2007) found the thickness of fibered flaxseed to be polynomially related to moisture content, while Isik (2007) found an exponential relationship between the projected area of round red lentil grains and moisture content.

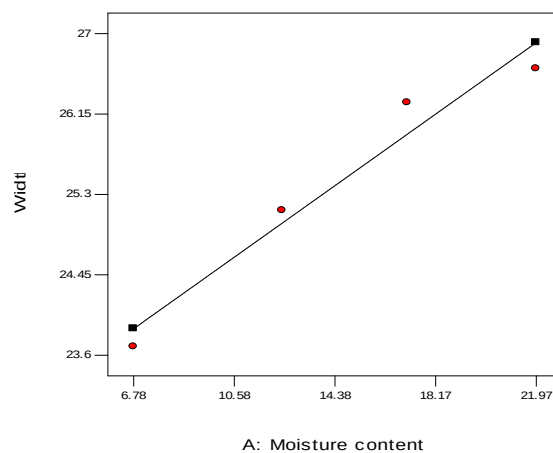
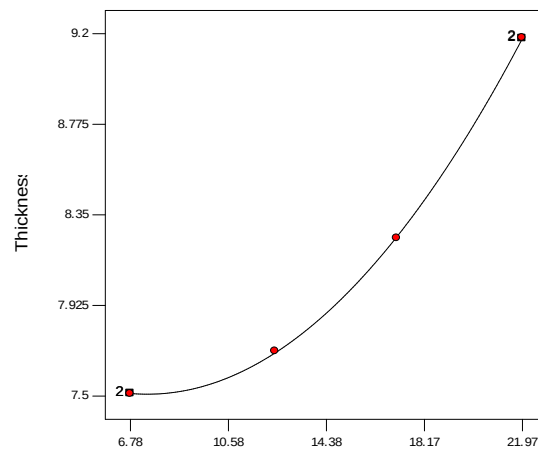


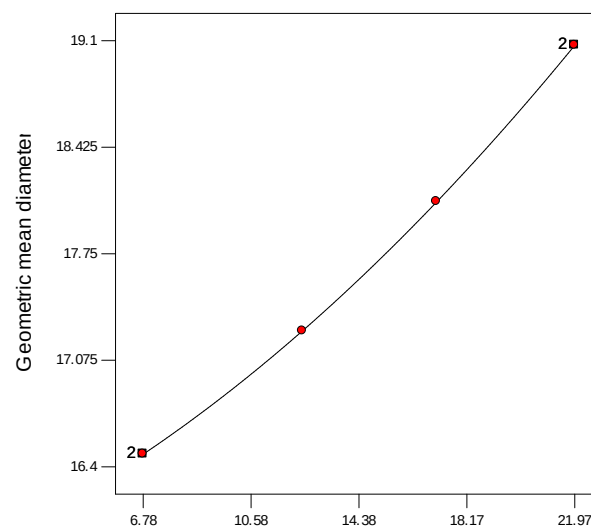
Fig. 2: Effect of Moisture content on Width



A: Moisture content

Fig. 3: Effect of Moisture content on Thickness

Figures 4 and 5 shows that the geometric mean diameter and arithmetic mean diameter increased as the moisture content increased, this agrees with the report of Irouwa *et al.*, (2016) for Achi.



A: Moisture content

Fig. 4: Effect of Moisture content on Geometric Mean Diameter

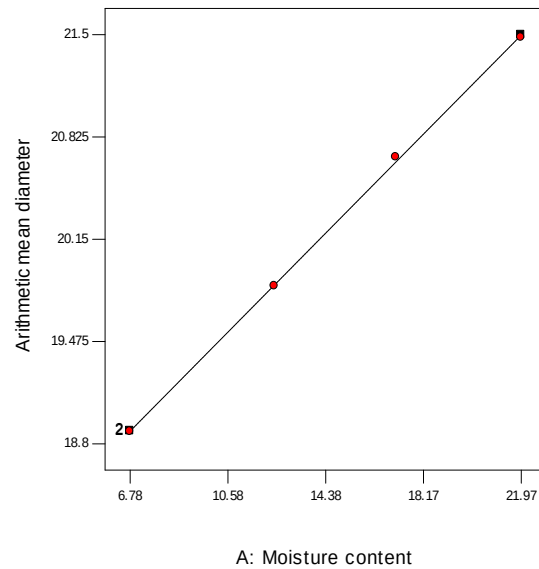


Fig. 5: Effect of Moisture content on Arithmetic Mean Diameter

It can be seen from Figure 6 that the surface area increases with an increase in moisture content. Similar trends have been reported by Irouwa et al., (2016) and Asoegwu et al. (2006) for Achi and African oil bean respectively.

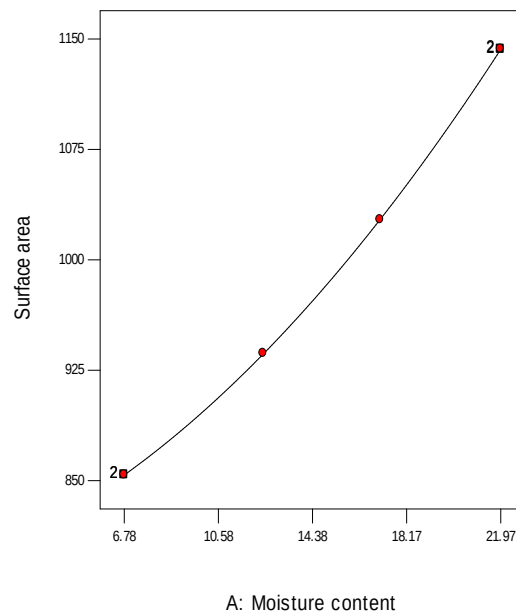


Fig. 6: Effect of Moisture content on Surface Area

The sphericity of the samples increased as the moisture content increased. The relationship between sphericity and moisture content appears quadratic as shown in Figure 7. Irouwa et al. (2016) reported a linear relationship between sphericity and moisture content for achi seeds.

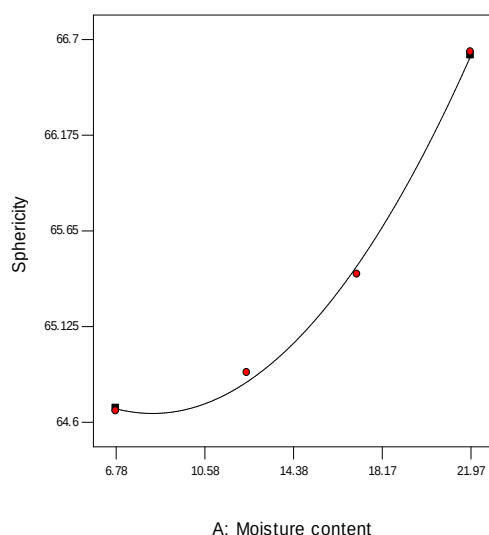


Fig. 7: Effect of Moisture content on Sphericity

The relationship between bulk density and moisture content (Fig. 8); true density and moisture content (Fig. 9) were statistically significant ($p < 0.05$).

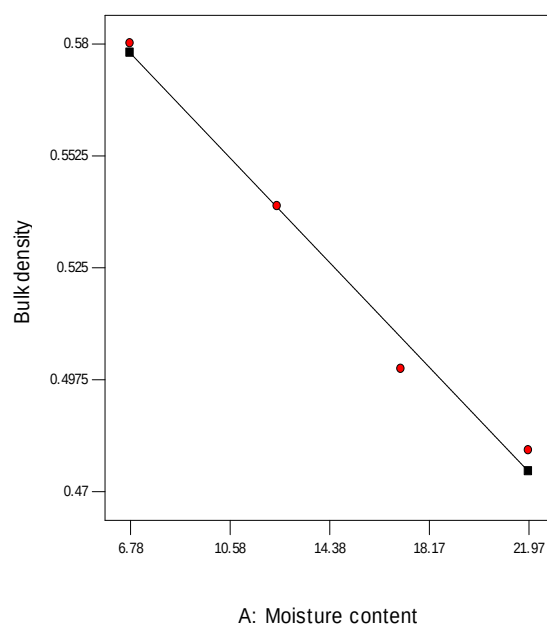


Fig. 8: Effect of Moisture content on Bulk Density

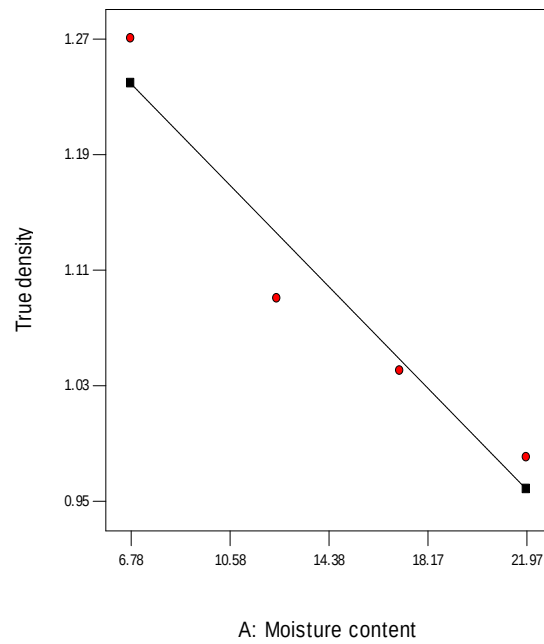


Fig. 9: Effect of Moisture content on True Density

Specific gravity increased with increase in moisture content. Specific gravity is an important quality criterion for processing of biomaterials. It is used as an estimate of solid or dry matter content of biomaterials. The higher the dry matter content, the lower the water content and the higher the specific gravity. The relationship between specific gravity and moisture content was statistically significant ($p < 0.05$). Fig. 10 graphically shows the effect of moisture content on specific gravity.

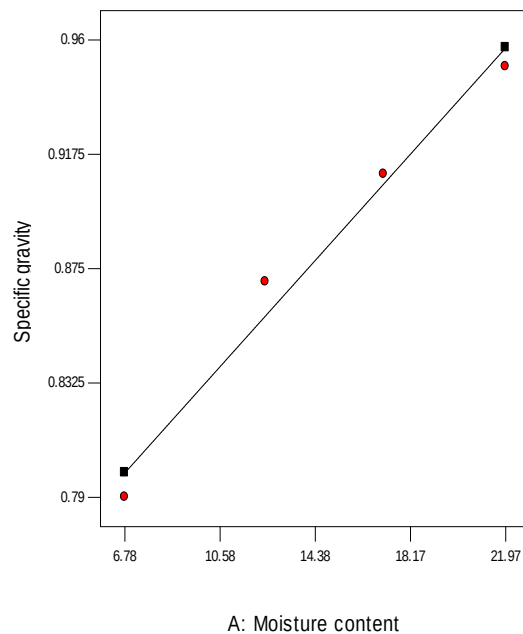


Fig. 10: Effect of Moisture content on Specific Gravity

Coefficient of friction for all samples at the various moisture content levels increased with increase in moisture content on all the surfaces used (Figures 11 to 13). This is similar to that reported by Çalışır *et al.* (2005) for rape seed and karinda seeds (Suthar and Das, 1996). The result obtained for samples on the glass surface is similar to that reported for lentil seeds (Amin *et al.*, 2004).

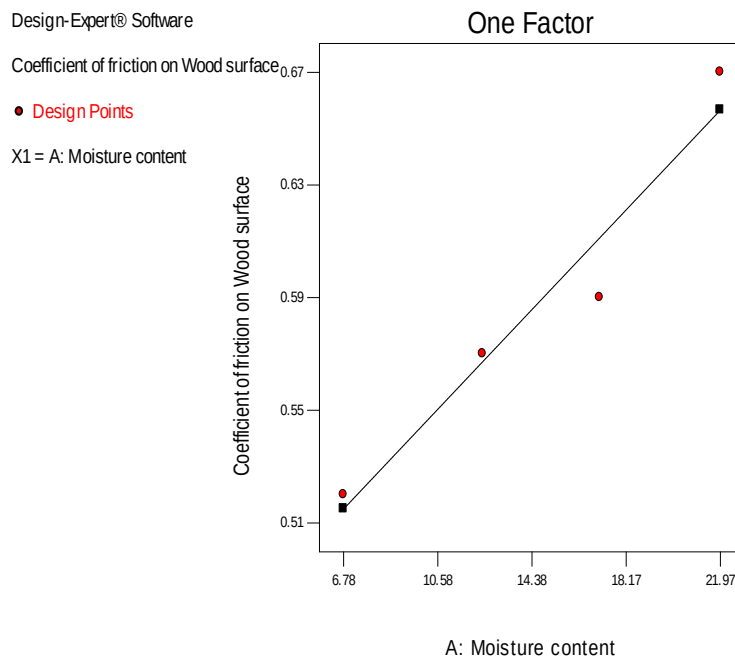


Fig. 11: Effect of Moisture content on Wooden Surface

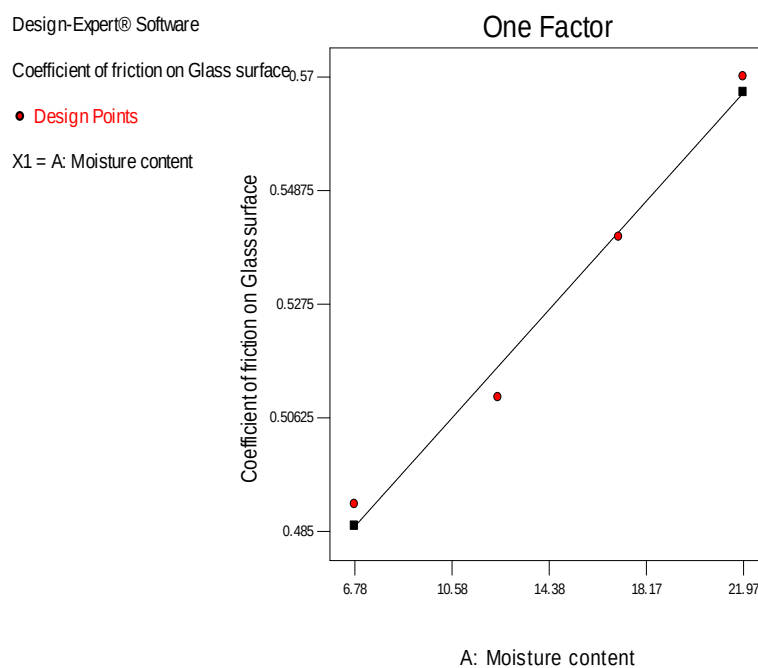


Fig.12: Effect of Moisture content on Coefficient of Friction on Glass Surface

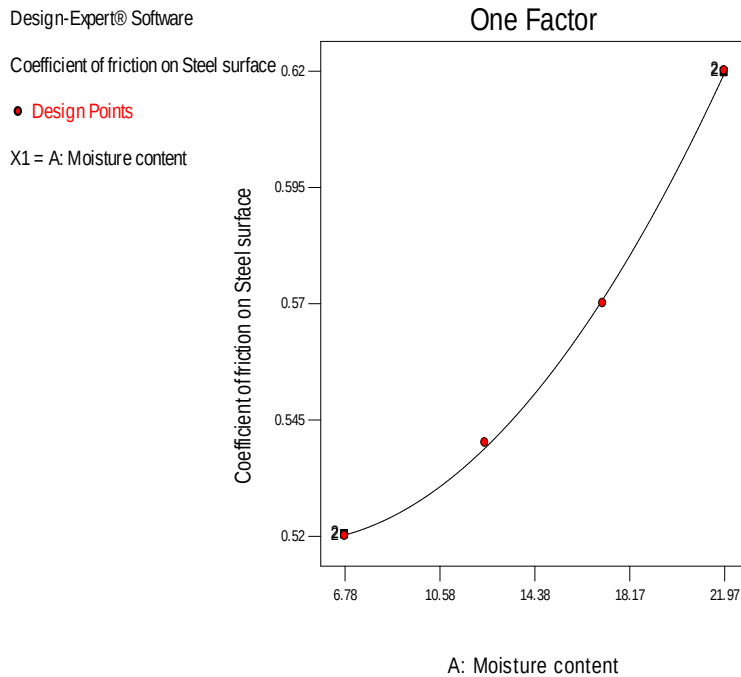


Fig.13: Effect of Moisture content on Coefficient of Friction on Steel Surface

The result also showed that the different levels of the moisture content had no significant differences ($p < 0.05$) on the weight and angle of repose of the seed. The effect of moisture content on the weight and angle of repose of the seed is also shown graphically in Figures 14 and 15.

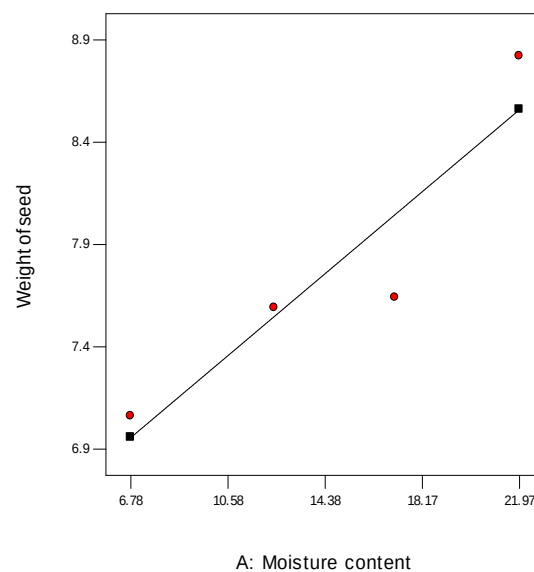
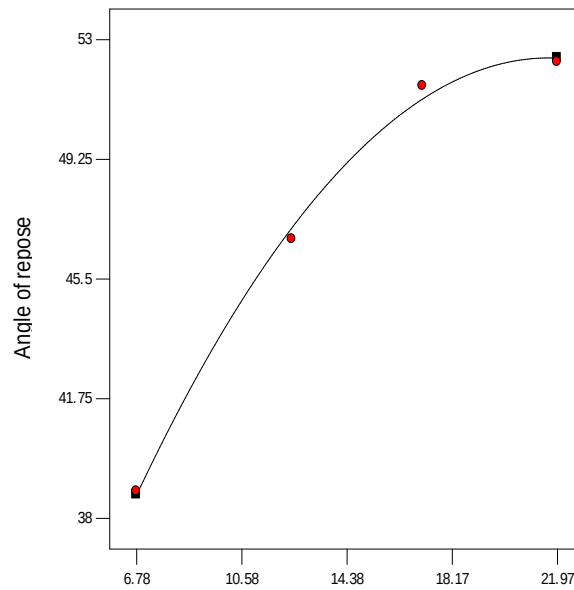


Fig.14: Effect of Moisture Content on Weight of the Seed



A: Moisture content

Fig.15: Effect of Moisture Content on Angle of Repose of the Seed

Many researchers (Aydin, 2003; Aviara et al., 1999; Wang et al., 2007) investigated the moisture dependence of physical properties of oil seeds and nuts (almond nut, high oleic sunflower seed and fibered flax seed) and reported increase of these properties with moisture content with the exception of bulk density that decreased with the increase in moisture content; in this study, true and bulk density decreased as moisture content of the seed was increased. According to Irouwa et al., (2016), there is an important and positive relationship between moisture content and axial dimensions of grains and seeds.

Table 17: Effect of Moisture Content on Mechanical Properties of Almond Seed

Moisture Content (%)	Fracture Force (N)	Compressive Strength (N/mm ²)	Tensile Strength (Mpa)
6.78%	2689±580	410±40	3.20±1.10
12.39%	2679±580	408±40	3.90±1.80
16.11%	2598±280	402±20	4.20±1.23
21.97%	2499±382	398±19	4.60±1.11

From the result presented in Table 17, fracture force decreased with increase in moisture content (6.78%w.b to 21.97%w.b) from 2689N to 2499N. The lower the moisture content, the more force is required to fracture the seeds, this indicates higher cost of operation. Also, the higher the moisture content, the less force is required to fracture the seed; this indicates lower cost of operation. This is similar to those reported by Altuntas and Yildiz (2007) on faba seeds and Gunner *et al.*, (2003) on hazelnut. The compressive strength decreased from 410 to 398N/mm² as the moisture content increased from 6.78% to 21.7%w.b and tensile strength 3.20 to 4.60Mpa with increase in moisture content. These parameters give the energy requirement and consideration governing equipment selection in size reduction operation (Orhevba *et al.*, 2013).

Conclusion

The physical properties of the seed determined as function of moisture content varied significantly with increase in moisture content as the average length, width, thickness, surface area of the seed, sphericity, specific gravity and coefficient of static friction (on all three surfaces) increased; while the angle of repose and weight were not significantly affected by the

moisture content. However, true and bulk density decreased as moisture content of the seed was increased.

The tensile strength of *Terminalia catappa* increased with increase in moisture content while the fracture force and compressive strength reduced with increase in moisture content. The findings from this research shows good agreement with some of the general trend obtained for other similar crops as reported by several authors.

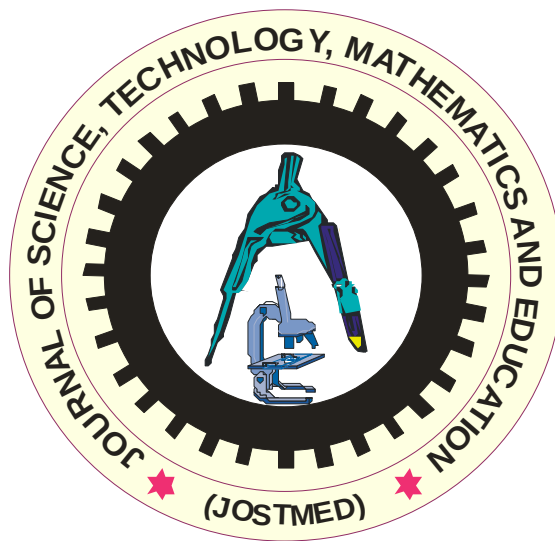
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NUMERICAL SOLUTIONS OF FREDHOLM INTEGRAL EQUATIONS OF THE SECOND KIND USING CERTAIN QUADRATURES

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Abstract

In this paper, nonhomogeneous Fredholm integral equations of the second kind are approximated using Boole's and Weddle's rules. The kernels of the family of integral equations are approximated by the two quadrature formulae due to their accuracy. In most of the problems solved, the two quadratures gives exact solutions, but where the exact solution is not obtained, the numerical approximation realized are very reasonable.

Keywords: *Integral Equations, Quadrature, Fredholm, Boole's Rule, Weddle's Rule*

Introduction

The Fredholm integral equation of the form

$$U(x) + \lambda \int_a^b K(x,t)U(t)dt = f(x), \quad a \leq x, t \leq b \quad (1)$$

Where $U(x)$ is the unknown function that appears both under the integral sign and outside it, thus making (1) Fredholm integral equation of the second kind. λ is a constant with $|\lambda| = 1$, $K(x,t)$ is a function of two variables x and t , while λ is called the kernel (or nucleus) of the integral equation. $K(x,t)$ is a smooth function. $f(x)$ is the nonhomogeneous source term which is a function of x .

The class of problems represented by (1), occur most frequently in many branches of engineering and mathematical physics. For instance, in electrostatics as represented in Love's equation (Love, 1949) and (Curtis, 1960), and was improved upon by (El – Gendi, 1969). Several other approaches were adopted by various researchers to handle problems stated in (1). Prominent among such approaches are the Chebyshev series method due to (Elliot, 1963), Chebyshev iteration method used by (Sag, 1970), Chebyshev and Legendre collocation method due to (Ghadle and Ahmed, 2016) and many other ones highlighted in the integral equations of (wazawaz, 2011). In this work, (1) is studied using two numerical quadratures, viz: Boole's and Wedle's rules.

Boole's and Weddle's Rules

The two quadratures used in this work are stated here for the sake of completeness.

Boole's rule

Consider the approximation of $\int_{x_0}^{x_n} U(x)dx$ by taking the curve representing the function,

$U(x)$, through four points. Since $x \in [x_0, x_n]$, when partitioned into n sub – intervals, the step size is given by $h = \frac{x_n - x_0}{n}$. Thus, the Boole's method will be obtained

as

$$\int_{x_0}^{x_n} U(x)dx = \frac{2h}{45} [7U(x_0) + 32[U(x_1) + U(x_3) + U(x_5) + \dots] + 12[U(x_2) + U(x_6) + U(x_{10}) + \dots] + 14[U(x_4) + U(x_8) + U(x_{12}) + \dots] + 7U(x_n)] \quad (2)$$

Weddle's Rule

On the other hand, if the curve is taken through six points at a time, and by that covering the entire interval $x_0 \leq x \leq x_n$, we obtain Weddle's rule as

$$\int_{x_0}^{x_n} U(x)dx = \frac{3h}{10} [U(x_0) + 5[U(x_1) + U(x_5) + U(x_7) + U(x_{11}) \dots] + [U(x_2) + U(x_4) + U(x_8) + U(x_{10}) + \dots] + 6[U(x_3) + U(x_9) + U(x_{15}) + \dots] + 2[U(x_6) + U(x_{12}) + U(x_{18}) + \dots] + U(x_n)] \quad (3)$$

Statement of Problem

The problem considered in this paper is the Fredholm integral equation of the second kind given as

$$U(x) + \int_a^b K(x,t)U(t)dt = f(x), \quad a \leq x, t \leq b, \quad (4)$$

with $|\lambda| = 1$, a and b as arbitrary constants, the kernel, $K(x,t)$, as a smooth function of two variables, $f(x)$ is a function of x (that is majorly a polynomial or a function that can be approximated by Taylor's series) and $U(x)$ is the unknown function.

Theorem (Uniqueness of Solution) (Wazawaz, 2011)

If the kernel, $K(x,t)$, in Fredholm integral equation (4) is continuous, bounded in the square $a \leq x \leq b$ and $a \leq t \leq b$, and if $f(x)$ is a continuous real valued function, the necessary condition for the existence of a unique solution for the Fredholm integral equation (4) is given by

$$|\lambda| M(b-a) < 1, \quad (5)$$

and

$$|K(x,t)| \leq M \in R \quad (6)$$

Methodology

In solving (4), the kernel is approximated by using (2) and (3) as illustrated in the sequel.

Application of Boole's Rule

If the integrand in (4) can be expressed as

$$\int_a^b K(x,t)U(t)dt = \sum_{\lambda=0}^N A_{\lambda} K(x,t_{\lambda})U(t_{\lambda}), \quad (7)$$

With (7), (4) can be written as

$$U(x) + \frac{2h}{45} [7K(x,t_0)U(t_0) + 32[K(x,t_1)U(t_1) + K(x,t_3)U(t_3) + K(x,t_5)U(t_5) + \dots] + 12[K(x,t_2)U(t_2) + K(x,t_6)U(t_6) + K(x,t_{10})U(t_{10}) + \dots] + 14[K(x,t_4)U(t_4) + K(x,t_8)U(t_8) + K(x,t_{12})U(t_{12}) + \dots] + 7K(x,t_n)U(t_n)] = f(x) \quad (8)$$

Next, the variable x in (8) is replaced by t_i , $i = 0(1)n$, and $U(t_i)$ is taken to be U_i , thus (8) is to be rewritten as

$$\begin{aligned}
U_i + \frac{2h}{45} [7K(t_i, t_0)U_0 + 32[K(t_i, t_1)U_1 + K(t_i, t_3)U_3 + K(t_i, t_5)U_5 + \dots] \\
+ 12[K(t_i, t_2)U_2 + K(t_i, t_6)U_6 + K(t_i, t_{10})U_{10} + \dots] + 14[K(t_i, t_4)U_4 + K(t_i, t_8)U_8 + K(t_i, t_{12})U_{12} + \dots] \\
+ 7K(t_i, t_n)U_n] = f(x), \quad i = 0(1)n
\end{aligned} \quad (9)$$

(9) will generate (n+1) equations in (n+1) unknowns. The equations thus generated can be solved using any of the linear equation solvers, such as, Mathematica, Maple, Mathcad. The values of the unknowns are substituted back in (8) to get the required $U(x)$.

Application of Weddle's Rule

The Weddle's rule stated in (3) is also implemented in (4) by rewriting it in the form

$$\begin{aligned}
U(x) + \frac{3h}{10} [K(x, t_0)U(x_0) + 5[K(x, t_1)U(x_1) + K(x, t_5)U(x_5) + K(x, t_7)U(x_7) + K(x, t_{11})U(x_{11}) + \dots] \\
+ [K(x, t_2)U(x_2) + K(x, t_4)U(x_4) + K(x, t_8)U(x_8) + K(x, t_{10})U(x_{10}) + \dots] \\
+ 6[K(x, t_3)U(x_3) + K(x, t_9)U(x_9) + K(x, t_{15})U(x_{15}) + \dots] \\
+ 2[K(x, t_6)U(x_6) + K(x, t_{12})U(x_{12}) + K(x, t_{18})U(x_{18}) + \dots] + K(x, t_n)U(x_n)] = f(x)
\end{aligned} \quad (10)$$

Also replacing x by t_i and taking $U(t_i)$ as U_i , (10) can be rewritten as

$$\begin{aligned}
U_i + \frac{3h}{10} [K(t_i, t_0)U_0 + 5[K(t_i, t_1)U_1 + K(t_i, t_5)U_5 + K(t_i, t_7)U_7 + K(t_i, t_{11})U_{11} + \dots] \\
+ [K(t_i, t_2)U_2 + K(t_i, t_4)U_4 + K(t_i, t_8)U_8 + K(t_i, t_{10})U_{10} + \dots] \\
+ 6[K(t_i, t_3)U_3 + K(t_i, t_9)U_9 + K(t_i, t_{15})U_{15} + \dots] \\
+ 2[K(t_i, t_6)U_6 + K(t_i, t_{12})U_{12} + K(t_i, t_{18})U_{18} + \dots] + K(t_i, t_n)U_n] = f_i, \quad i = 0(1)n
\end{aligned} \quad (11)$$

(11) generates (n+1) equations in (n+1) unknowns. The values of the unknown constants $U_0, U_1, U_2, \dots, U_n$ are substituted back in (10) to get the unknown function $U(x)$ in terms of x .

Numerical Experiments

In this section, the algorithms discussed in section 4 above are implemented on some selected problems. The resulting systems of equations are solved by Mathematica 7.0.

Problem 1a

Use Boole's rule to approximate the Fredholm integral equation

$$U(x) = 1 + 7x + 20x^2 + x^3 - \int_0^1 (10xt^2 + 20x^2t)U(t)dt \quad (12)$$

Solution

Using (8) and (9) with the step size, $h = \frac{1}{4}$, (12) is written as

$$\begin{aligned}
U_i + \frac{1}{90} [7(10t_i t_0^2 + 20t_i^2 t_0)U_0 + 32(10t_i t_1^2 + 20t_i^2 t_1)U_1 + 12(10t_i t_2^2 + 20t_i^2 t_2)U_2 + 32(10t_i t_3^2 + 20t_i^2 t_3)U_3 \\
+ 7(10t_i t_4^2 + 20t_i^2 t_4)U_4] = 1 + 7t_i + 20t_i^2 + t_i^3
\end{aligned} \quad (13)$$

Inserting $t_0 = 0, t_1 = \frac{1}{4}, t_2 = \frac{1}{2}, t_3 = \frac{3}{4}$ and $t_4 = 1$ in (13) yields

$$U_0 = 1$$

$$\frac{7}{6}U_1 + \frac{1}{6}U_2 + \frac{5}{6}U_3 + \frac{7}{24}U_4 = \frac{257}{64}$$

$$\frac{5}{9}U_1 + \frac{3}{2}U_2 + \frac{7}{3}U_3 + \frac{7}{9}U_4 = \frac{77}{8}$$

$$\frac{7}{6}U_1 + U_2 + \frac{11}{2}U_3 + \frac{35}{24}U_4 = \frac{1147}{64}$$

$$2U_1 + \frac{5}{3}U_2 + \frac{22}{3}U_3 + \frac{10}{3}U_4 = 29$$

Solving the above system of equations gives

$$U_0 = 1, U_1 = \frac{69}{64}, U_2 = \frac{11}{8}, U_3 = \frac{127}{64} \text{ and } U_4 = 3.$$

Next is to substitute the values of $U_i, i = 0(1)4$, in (4). This yields

$$U(x) = 1 + x^2 + x^3,$$

which tallies with the exact solution.

Problem 1b

Use Weddle's rule to approximate the Fredholm integral equation

$$U(x) = 1 + 7x + 20x^2 + x^3 - \int_0^1 (10xt^2 + 20x^2t)U(t)dt \quad (14)$$

Solution

Using (10), (11) and step size $h = \frac{1}{6}$, we have (14) rewritten in the form

$$U_i + \frac{1}{20}[(10t_i t_0^2 + 20t_i^2 t_0)U_0 + 5(10t_i t_1^2 + 20t_i^2 t_1)U_1 + (10t_i t_2^2 + 20t_i^2 t_2)U_2 + 6(10t_i t_3^2 + 20t_i^2 t_3)U_3 + (10t_i t_4^2 + 20t_i^2 t_4)U_4 + 5(10t_i t_5^2 + 20t_i^2 t_5)U_5 + (10t_i t_6^2 + 20t_i^2 t_6)U_6] = 1 + 7t_i + 20t_i^2 + t_i^3 \quad (15)$$

Using the values $t_0 = 0, t_1 = \frac{1}{6}, t_2 = \frac{1}{3}, t_3 = \frac{1}{2}, t_4 = \frac{2}{3}, t_5 = \frac{5}{6}$ and $t_6 = 1$ in (15), we have the

following system of equations

$$U_0 = 1$$

$$\frac{49}{144}U_1 + \frac{1}{54}U_2 + \frac{5}{24}U_3 + \frac{1}{18}U_4 + \frac{175}{432}U_5 + \frac{1}{9}U_6 = \frac{589}{216}$$

$$\frac{25}{216}U_1 + \frac{19}{18}U_2 + \frac{7}{12}U_3 + \frac{4}{27}U_4 + \frac{25}{24}U_5 + \frac{5}{18}U_6 = \frac{151}{27}$$

$$\frac{35}{144}U_1 + \frac{1}{9}U_2 + \frac{17}{8}U_3 + \frac{5}{18}U_4 + \frac{275}{144}U_5 + \frac{1}{2}U_6 = \frac{77}{8}$$

$$\frac{5}{12}U_1 + \frac{5}{27}U_2 + \frac{11}{6}U_3 + \frac{13}{9}U_4 + \frac{325}{108}U_5 + \frac{7}{9}U_6 = \frac{401}{27}$$

$$\frac{275}{432}U_1 + \frac{5}{18}U_2 + \frac{65}{24}U_3 + \frac{35}{54}U_4 + \frac{769}{144}U_5 + \frac{10}{9}U_6 = \frac{4601}{216}$$

$$\frac{65}{72}U_1 + \frac{7}{18}U_2 + \frac{15}{4}U_3 + \frac{8}{9}U_4 + \frac{425}{72}U_5 + \frac{5}{2}U_6 = 29$$

Solving the system of equations above yields

$$U_0 = 1, U_1 = \frac{223}{216}, U_2 = \frac{31}{27}, U_3 = \frac{11}{8}, U_4 = \frac{47}{27}, U_5 = \frac{491}{216} \text{ and } U_6 = 3.$$

Substituting for the values of U_i and t_i ($i = 0(1)6$) gives the unknown function as

$$U(x) = 1 + x^2 + x^3.$$

This again tallies with exact solution.

Problem 2a

Use Boole's rule to approximate the Fredholm integral equation

$$U(x) = 1 + 9x + 2x^2 + x^3 - \int_0^1 (20xt + 10x^2t^2)U(t)dt \quad (16)$$

Solution

The step size, h for this problem is $\frac{1}{4}$, when $n = 4$. Now, using (8) and (9) in (16)

yields

$$U_i + \frac{1}{90} [7(20t_it_0 + 10t_i^2t_0^2)U_0 + 32(20t_it_1 + 10t_i^2t_1^2)U_1 + 12(20t_it_2 + 10t_i^2t_2^2)U_2 + 32(20t_it_3 + 10t_i^2t_3^2)U_3 + 7(20t_it_4 + 10t_i^2t_4^2)U_4] = 1 + 9t_i + 2t_i^2 + t_i^3 \quad (17)$$

With $t_0 = 0, t_1 = \frac{1}{4}, t_2 = \frac{1}{2}, t_3 = \frac{3}{4}$ and $t_4 = 1$, (4) generates the following system of equations

$$U_0 = 1$$

$$\frac{35}{24}U_1 + \frac{17}{48}U_2 + \frac{35}{24}U_3 + \frac{7}{16}U_4 = \frac{217}{64}$$

$$\frac{17}{18}U_1 + \frac{7}{4}U_2 + \frac{19}{6}U_3 + \frac{35}{36}U_4 = \frac{49}{8}$$

$$2U_1 + \frac{5}{3}U_2 + \frac{22}{3}U_3 + \frac{10}{3}U_4 = 13$$

$$\frac{35}{24}U_1 + \frac{19}{16}U_2 + \frac{49}{8}U_3 + \frac{77}{48}U_4 = \frac{595}{64}$$

Solving the system of equations above gives

$$U_0 = 1, U_1 = \frac{61}{64}, U_2 = \frac{7}{8}, U_3 = \frac{55}{64} \text{ and } U_4 = 1.$$

When the values these constants are substituted in (8), the unknown function is obtained as $U(x) = 1 - x^2 + x^3$.

Thus, the approximate solution tallies with exact solution in this case too.

Problem 2b

Use Weddle's rule to approximate the Fredholm integral equation

$$U(x) = 1 + 9x + 2x^2 + x^3 - \int_0^1 (20xt + 10x^2t^2)U(t)dt \quad (18)$$

Solution

The given integral equation is approximated using (10) and (11) with step size $h = \frac{1}{6}$ to get

$$U_i + \frac{1}{20}[(20t_it_0 + 10t_i^2t_0^2)U_0 + 5(20t_it_1 + 10t_i^2t_1^2)U_1 + (20t_it_2 + 10t_i^2t_2^2)U_2 + 6(20t_it_3 + 10t_i^2t_3^2)U_3 + (20t_it_4 + 10t_i^2t_4^2)U_4 + 5(20t_it_5 + 10t_i^2t_5^2)U_5 + (20t_it_6 + 10t_i^2t_6^2)U_6] = 1 + 9t_i + 2t_i^2 + t_i^3 \quad (19)$$

with $t_0 = 0, t_1 = \frac{1}{6}, t_2 = \frac{1}{3}, t_3 = \frac{1}{2}, t_4 = \frac{2}{3}, t_5 = \frac{5}{6}$, and $t_6 = 1$, from (19) we have the following set of equations

$$U_0 = 1$$

$$\frac{2957}{2592}U_1 + \frac{37}{648}U_2 + \frac{25}{48}U_3 + \frac{19}{162}U_4 + \frac{1925}{2592}U_5 + \frac{13}{72}U_6 = \frac{553}{216}$$

$$\frac{185}{648}U_1 + \frac{181}{162}U_2 + \frac{13}{12}U_3 + \frac{20}{81}U_4 + \frac{1025}{648}U_5 + \frac{7}{18}U_6 = \frac{115}{27}$$

$$\frac{125}{288}U_1 + \frac{13}{72}U_2 + \frac{43}{16}U_3 + \frac{7}{18}U_4 + \frac{725}{288}U_5 + \frac{5}{8}U_6 = \frac{49}{8}$$

$$\frac{95}{162}U_1 + \frac{20}{81}U_2 + \frac{7}{3}U_3 + \frac{125}{81}U_4 + \frac{575}{162}U_5 + \frac{8}{9}U_6 = \frac{221}{27}$$

$$\frac{1925}{2592}U_1 + \frac{205}{648}U_2 + \frac{145}{48}U_3 + \frac{115}{162}U_4 + \frac{14717}{2592}U_5 + \frac{85}{72}U_6 = \frac{2261}{216}$$

$$\frac{65}{72}U_1 + \frac{7}{18}U_2 + \frac{15}{4}U_3 + \frac{8}{9}U_4 + \frac{425}{72}U_5 + \frac{5}{2}U_6 = 13$$

Solving the above system of equations yields

$$U_0 = 1, U_1 = \frac{211}{216}, U_2 = \frac{25}{27}, U_3 = \frac{7}{8}, U_4 = \frac{23}{27}, U_5 = \frac{191}{216}, \text{ and } U_6 = 1.$$

The values of these constants are substituted in (8) to arrive at result for the unknown function as $U(x) = 1 - x^2 + x^3$,

which is the same as the one obtained in Problem 5.2a, hence the exact solution.

Problem 3a

Use Boole's rule to approximate the Fredholm integral equation

$$U(x) = 5x - 2x^2 + \int_{-1}^1 (x^2t^3 - x^3t^2)U(t)dt \quad (20)$$

Solution

(20) is approximated by Boole's rule as stated in (8) and (9) using step size, $h = \frac{1}{2}$ to

get

$$U_i - \frac{1}{45}[7(t_i^2t_0^3 - t_i^3t_0^2)U_0 + 32(t_i^2t_1^3 - t_i^3t_1^2)U_1 + 12(t_i^2t_2^3 - t_i^3t_2^2)U_2 + 32(t_i^2t_3^3 - t_i^3t_3^2)U_3 + 7(t_i^2t_4^3 - t_i^3t_4^2)U_4] = 5t_i - 2t_i^2 \quad (21)$$

Using $t_0 = -1, t_1 = -\frac{1}{2}, t_2 = 0, t_3 = \frac{1}{2}$, and $t_4 = 1$, we have the following four equations in four unknowns

$$U_0 - \frac{4}{45}U_1 - \frac{4}{15}U_3 - \frac{14}{45}U_4 = -7$$

$$\frac{7}{360}U_0 + U_1 - \frac{2}{45}U_3 - \frac{7}{120}U_4 = -3$$

$$U_2 = 0$$

$$\frac{7}{120}U_0 + \frac{2}{45}U_1 + U_3 - \frac{7}{360}U_4 = 2$$

$$\frac{14}{45}U_0 + \frac{4}{15}U_1 + \frac{4}{45}U_3 + U_4 = 3$$

Solving the above system of equations gives

$$U_0 = -5, U_1 = -\frac{5}{2}, U_2 = 0, U_3 = \frac{5}{2}, \text{ and } U_4 = 5.$$

Substituting the values of these constants in (8) gives the unknown function as

$$U(x) = 5x,$$

which is the exact solution.

Problem 3b

Use Weddle's rule to find the approximate solution of the Fredholm integral equation

$$U(x) = 5x - 2x^2 + \int_{-1}^1 (x^2t^3 - x^3t^2)U(t)dt \quad (22)$$

Solution

Applying (10) and (11) with step size, $h = \frac{1}{3}$, in (22), we

have

$$U_i - \frac{1}{10}[(t_i^2t_0^3 - t_i^3t_0^2)U_0 + 5(t_i^2t_1^3 - t_i^3t_1^2)U_1 + (t_i^2t_2^3 - t_i^3t_2^2)U_2 + 6(t_i^2t_3^3 - t_i^3t_3^2)U_3 + (t_i^2t_4^3 - t_i^3t_4^2)U_4 + 5(t_i^2t_5^3 - t_i^3t_5^2)U_5 + (t_i^2t_6^3 - t_i^3t_6^2)U_6] = 5t_i - 2t_i^2 \quad (23)$$

Using the values $t_0 = -1, t_1 = -\frac{2}{3}, t_2 = -\frac{1}{3}, t_3 = 0, t_4 = \frac{1}{3}, t_5 = \frac{2}{3}$, and $t_6 = 1$ in (23) to get

$$U_0 - \frac{2}{27}U_1 - \frac{1}{135}U_2 - \frac{2}{135}U_4 - \frac{10}{27}U_5 - \frac{1}{5}U_6 = -7$$

$$\frac{2}{135}U_0 + U_1 - \frac{2}{1215}U_2 - \frac{2}{405}U_4 - \frac{32}{243}U_5 - \frac{2}{27}U_6 = -\frac{38}{9}$$

$$\frac{1}{135}U_0 + \frac{2}{243}U_1 + U_2 - \frac{1}{1215}U_4 - \frac{2}{81}U_5 - \frac{2}{135}U_6 = -\frac{17}{9}$$

$$\frac{2}{135}U_0 + \frac{2}{81}U_1 + \frac{1}{1215}U_2 + U_4 - \frac{2}{243}U_5 - \frac{1}{135}U_6 = \frac{13}{9}$$

$$\frac{2}{27}U_0 + \frac{32}{243}U_1 + \frac{2}{405}U_2 + \frac{2}{1215}U_4 + U_5 - \frac{2}{135}U_6 = \frac{22}{9}$$

$$\frac{1}{5}U_0 + \frac{10}{27}U_1 + \frac{2}{135}U_2 + \frac{1}{135}U_4 + \frac{2}{27}U_5 + U_6 = 3$$

Solving the above system of equations for the unknown's yields

$$U_0 = -5, U_1 = -\frac{10}{3}, U_2 = -\frac{5}{3}, U_3 = 0, U_4 = \frac{5}{3}, U_5 = \frac{10}{3} \text{ and } U_6 = 5.$$

Substituting the values of these constants in (4) gives the unknown function, $U(x)$ as

$$U(x) = 5x.$$

This result agrees with the earlier one in Problem 5.3a and are both the same as the exact solution.

Problem 4a

Solve the Fredholm integral equation below using Boole's rule

$$U(x) = -15 + 10x^3 + x^4 - \int_0^1 (20x^3 - 56t^3)U(t)dt \quad (24)$$

Solution

The given integral equation can be rewritten as

$$U(x) + \int_0^1 (20x^3 - 56t^3)U(t)dt = -15 + 10x^3 + x^4 \quad (25)$$

Using (9), (25) now becomes

$$U_i + \frac{1}{90}[7(20t_i^3 - 56t_0^3)U_0 + 32(20t_i^3 - 56t_1^3)U_1 + 12(20t_i^3 - 56t_2^3)U_2 + 32(20t_i^3 - 56t_3^3)U_3 + 7(20t_i^3 - 56t_4^3)U_4] = -15 + 10t_i^3 + t_i^4, \quad i = 0(1)4 \quad (26)$$

with $t_0 = 0, t_1 = \frac{1}{4}, t_2 = \frac{1}{2}, t_3 = \frac{3}{4}$, and $t_4 = 1$ in (8) and (9), we have the following set of equations

$$\begin{aligned} U_0 - \frac{14}{15}U_1 - \frac{14}{15}U_2 - \frac{42}{5}U_3 - \frac{196}{45}U_4 &= -15 \\ \frac{7}{288}U_0 + \frac{4}{5}U_1 - \frac{107}{120}U_2 - \frac{373}{45}U_3 - \frac{693}{160}U_4 &= -\frac{3799}{256} \\ \frac{7}{36}U_0 + \frac{26}{45}U_1 + \frac{2}{5}U_2 - \frac{338}{45}U_3 - \frac{794}{180}U_4 &= -\frac{219}{16} \\ \frac{21}{32}U_0 - \frac{121}{45}U_1 + \frac{23}{120}U_2 - \frac{22}{5}U_3 - \frac{5327}{1440}U_4 &= -\frac{2679}{256} \\ \frac{14}{9}U_0 + \frac{34}{5}U_1 + \frac{26}{15}U_2 - \frac{58}{45}U_3 - \frac{9}{5}U_4 &= -4 \end{aligned}$$

Solving system of five equations in five unknowns above, we obtained

$$U_0 = \frac{1085935}{55976896}, U_1 = \frac{2666115}{111953792}, U_2 = \frac{10618399}{55976896}, U_3 = \frac{41131777}{55976896} \text{ and } U_4 = \frac{111140301}{55976896}.$$

Using these values in (8) gives

$$U(x) = \frac{256477}{55976896} + \frac{3431683}{3498556}x^3 + x^4,$$

which can be written equivalently as

$$U(x) = 0.00458184 + 0.980886x^3 + x^4,$$

which is a good approximation to the exact solution $U(x) = x^3 + x^4$.

Problem 5.4b

Solve the Fredholm integral equation below using Weddle's rule

$$U(x) = -15 + 10x^3 + x^4 - \int_0^1 (20x^3 - 56t^3)U(t)dt \quad (27)$$

Solution

Using (10) and (11), the given integral equation becomes

$$U_i + \frac{1}{20}[(20t_i^3 - 56t_0^3)U_0 + 5(20t_i^3 - 56t_1^3)U_1 + (20t_i^3 - 56t_2^3)U_2 + 6(20t_i^3 - 56t_3^3)U_3 + (20t_i^3 - 56t_4^3)U_4 + 5(20t_i^3 - 56t_5^3)U_5 + (20t_i^3 - 56t_6^3)U_6] = -15 + 10t_i^3 + t_i^4 \quad (28)$$

When the values of $t_i, (i = 0(1)6)$, given as $t_0 = 0, t_1 = \frac{1}{6}, t_2 = \frac{1}{3}, t_3 = \frac{1}{2}, t_4 = \frac{2}{3}, t_5 = \frac{5}{6}, t_6 = 1$, (14)

generates the following system of equations

$$\begin{aligned} U_0 - \frac{7}{108}U_1 - \frac{14}{135}U_2 - \frac{21}{10}U_3 - \frac{112}{135}U_4 - \frac{875}{108}U_5 - \frac{14}{5}U_6 &= -15 \\ \frac{1}{216}U_0 + \frac{23}{24}U_1 - \frac{107}{1080}U_2 - \frac{373}{180}U_3 - \frac{33}{40}U_4 - \frac{1745}{216}U_5 - \frac{3019}{1080}U_6 &= -\frac{19379}{1296} \\ \frac{1}{27}U_0 + \frac{13}{108}U_1 + \frac{14}{15}U_2 - \frac{169}{90}U_3 - \frac{107}{135}U_4 - \frac{95}{12}U_5 - \frac{373}{185}U_6 &= -\frac{1184}{81} \\ \frac{1}{8}U_0 + \frac{121}{216}U_1 + \frac{23}{1080}U_2 - \frac{7}{20}U_3 - \frac{761}{1080}U_4 - \frac{1615}{216}U_5 - \frac{107}{40}U_6 &= -\frac{219}{16} \\ \frac{8}{27}U_0 + \frac{17}{12}U_1 + \frac{26}{135}U_2 - \frac{29}{90}U_3 + \frac{7}{15}U_4 - \frac{715}{108}U_5 - \frac{338}{135}U_6 &= -\frac{959}{81} \\ \frac{125}{216}U_0 + \frac{611}{216}U_1 + \frac{19}{40}U_2 + \frac{247}{180}U_3 - \frac{271}{1080}U_4 - \frac{101}{24}U_5 - \frac{2399}{1080}U_6 &= -\frac{11315}{1296} \\ U_0 + \frac{533}{108}U_1 + \frac{121}{135}U_2 + \frac{39}{10}U_3 + \frac{23}{135}U_4 - \frac{335}{108}U_5 - \frac{4}{5}U_6 &= -4 \end{aligned}$$

The system of equations above is solved to obtain the unknown function

$$U(x) \text{ as } U(x) = 0.0674276 + 0.671012x^3 + x^4,$$

which though not the same as the exact solution, but a very good approximation to it.

Discussion

The numerical problems presented above show that the work presented in this paper is very accurate and can be used for any linear Fredholm integral equation of the second kind. The first three set of problem give the exact solution, and the last set that does not give exact solution actually gives results that are useable in numerical computations. The results of the numerical examples emphasize the beauty of the method presented in this paper, as it overcomes the problems encountered in some of the semi – analytic methods such as Adomian decomposition method (ADM), Modified Adomian decomposition method (mADM), Variational Iteration Method (VIM), etc. For instance, the problem of determining which terms constitute the U_0 in ADM and U_0 and U_1 in mADM.

Conclusion

Numerical solution of linear nonhomogeneous Fredholm integral equation has been presented. The method proposed in this work handles problems in this class with ease and does not require large computer memory for its implementation. In addition, it gives the exact solution in most cases, and where such is not obtained, the approximate solution derive is very reliable.

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MULTIVARIATE TIME SERIES ANALYSIS ON THE PRICES OF STAPLE FOODSTUFFS IN KWARA STATE, NIGERIA

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Abstract

Due to supplementary, complementary and substitute relationship between staple foodstuffs, the prices of one or more staple foodstuffs tend to influence and could be used to predict the prices of some others. This study was therefore aimed at establishing the co-movement between the prices of some major staple foodstuffs - Rice, Maize, Garri, Millet, Guinea-Corn and Beans - in Kwara State, Nigeria. Multivariate time series models were fitted to data on monthly prices of Rice, Maize, Garri, Millet, Guinea-Corn and Beans over a period of twelve years (from January 2000 to December 2012). The cointegration relations among the prices were established by applying Johansen's cointegration tests. As a result, appropriate Vector Error Correction (VEC) model was fitted to the data. The unit root test for stationarity in the series reveals that all the series were non-stationary but they were only made to be stationary at first difference. The results from the analysis showed that there exist short term adjustments and long-term dynamics among the prices of Rice, Maize, Garri, Millet, Guinea-Corn and Beans in Nigeria over the study period. Further results showed that a Vector Error Correction (VEC) model of lag two with one cointegration equation best fits the data. The forecasting accuracy of the fitted model was determined by out-of-sample forecasts of the future prices of the selected staple foodstuffs. Suitable model's assessment criteria such as root mean square error, mean absolute error and the like were employed to determine the efficiency of the fitted model. The data employed for the study were collected from the Kwara State office of National Bureau of Statistics, Nigeria. All analyses were performed in the environment of R Statistical package.

Keywords: *Prices, Vector autoregressive, co-integration, Vector Error correction model and forecasting*

Introduction

Important food grain in Nigeria whose production is being emphasized to remedy food deficit and importation includes maize, guinea corn, millet, rice and pulses (Aihonsu and Akorede, 2002). Prices are a standard and important component of market and food security analysis because they serve as an indicator of both food availability and food access. Prices are a measure of availability because they tend to rise as the supply of food falls in relation to demand (e.g., poor production, constrained imports of food), and they tend to fall when supply expands in relation to demand (e.g., a bumper harvest). Food prices are also a measure of food access because they affect the household's purchasing power: the ability of a household to acquire goods and services based on the amount of money or other forms of wealth they possess. Consumer prices of food determine how much food a household can buy given their level of income or wealth (FEWS NET, 2009).

Rice, Maize, Garri, Millet, Guinea-Corn and Beans are among staple food items whose prices are highly unstable between seasons in Kwara State.

This work examines the relationship between price levels of staple foodstuffs in Kwara state and seeks to determine whether or not they are linked. This study therefore analyzes the trend in price of staple foodstuffs and integration between prices of these staple food items in Kwara state and determines the causal relationship between and among the series. The study is based on the assumptions that there is no causal relationship between prices of staple foodstuffs.

When large records of price quotations are available and reasonably accurate, a great deal can be learnt from them about the relationship and future prices of staple food stuff over time and

space. Research into the workings of major commodity future prices, relying largely on price of the commodities in the previous years, has amply demonstrated the value of approaching the study of the relationships and future prices through price analysis. Reported here is an attempt to employ, in a similar fashion, much less plentiful and less reliable information about the retail prices of staple foodstuffs in Nigeria to reveal salient features regarding the relationships and future prices of staple food.

The accurate measurement of the stochastic component in the prices may contribute to policy decisions regarding the possible implementation of commodity price stabilization programmes. The focus of the present work is to fit appropriate time series model on the prices of major staple foodstuffs in Nigeria. The selected foodstuffs for this study are Rice, Maize, Garri, Millet, Guinea-Corn and Beans. Results from this work shall be useful to establish the complementary relationships between the prices of these foodstuffs. By this, the future prices of these commodities can be efficiently predicted for policy formulation by interested stakeholders.

Materials and Methods

Data Description

The data for this study were obtained from National Bureau of Statistics (NBS), Kwara State office, Nigeria. The data were on monthly retail prices of staple foodstuffs (maize, garri, millet, guinea corn, palm oil and beans) in Nigeria over a period of twelve years covering between January 2000 and December 2012 inclusive.

Vector Autoregression (VAR) Model

The following structure was defined to develop a suitable time series model for the data on the prices of selected foodstuffs in Nigeria as collected.

Let $Y_t = (y_{1t}, y_{2t}, \dots, y_{nt})^T$ denote a $(n \times 1)$ vector of time series variables. The basic p -lag vector autoregressive (VAR (p)) model has the form (Hamilton, 1994; Gujarati, 1979; 2004)

$$Y_t = c + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \dots + \Pi_p Y_{t-p} + \varepsilon_t; \quad t = 1, 2, \dots, T \quad (1)$$

where c denotes a $n \times 1$ vector of constants and Π_j a $n \times n$ matrix of autoregressive coefficients for $j = 1, 2, \dots, p$. The $n \times 1$ vector ε_t , is a vector generalization of white noise: $\Pi_{11}^{(1)} Y_{1,t-1}$

$$E(\varepsilon_t) = 0 \text{ and } E(\varepsilon_t \varepsilon_s') = \begin{cases} \Sigma, & \text{if } t = s \\ 0, & \text{if } t \neq s \end{cases} \quad (2)$$

with Σ an $(n \times n)$ symmetric positive definite matrix.

Let c_i denote the i^{th} element of the vector c and let $\Pi_{ij}^{(1)}$ denote the row i , column j element of the matrix Π_1 . Then, the first row of the vector system in (1) specifies that

$$Y_{1t} = c + \Pi_{11}^{(1)} Y_{1,t-1} + \Pi_{12}^{(1)} Y_{2,t-1} + \dots + \Pi_{1n}^{(1)} Y_{n,t-1} + \Pi_{11}^{(2)} Y_{1,t-2} + \Pi_{12}^{(2)} Y_{2,t-2} + \dots + \Pi_{1n}^{(2)} Y_{n,t-2} + \Pi_{11}^{(p)} Y_{1,t-p} + \Pi_{12}^{(p)} Y_{2,t-p} + \Pi_{1n}^{(p)} Y_{n,t-p} + \varepsilon_{1t}; \quad t = 1, 2, \dots, T \quad (3)$$

Thus, a vector auto-regression is a system in which each variable is regressed on a constant and p of its own lags as well as on p lags of each of the other variables in the VAR. Note that each regression has the same explanatory variables.

Using lag operator notation, equation (1) can be written in the form

$$\Pi(L)Y_t = c + \varepsilon_t \quad (4)$$

Where $\Pi(L) = I_n - \Pi_1 L - \dots - \Pi_p L^p$ the VAR is stable if the roots of

$$\text{Det.}(\Pi_n - \Pi_1 Z - \dots - \Pi_p Z^p) = 0 \quad (5)$$

lie outside the complex unit circle (have modulus greater than one), or, equivalently, if the eigen values of the companion matrix

$$F = \begin{pmatrix} \Pi_1 & \Pi_2 & \dots & \Pi_p \\ I_n & 0 & \dots & 0 \\ 0 & \ddots & \ddots & \vdots \\ 0 & 0 & I_n & 0 \end{pmatrix} \quad (6)$$

have modulus less than one. Assuming that the process has been initialized in the infinite past, then a stable VAR (p) process is stationary with time invariant means, variances, and autocovariances.

If Y_t in (1) is covariance stationary, then the unconditional mean is given by

$$\mu = (I_n - \Pi_1 - \dots - \Pi_p)^{-1}c$$

The mean-adjusted form of the VAR (p) is then

$$Y_t - \mu = \Pi_1(Y_{t-1} - \mu) + \Pi_2(Y_{t-2} - \mu) + \dots + \Pi_p(Y_{t-p} - \mu) + \varepsilon_t \quad t = 1, 2, \dots, T \quad (7)$$

The basic VAR (p) model may be too restrictive to represent sufficiently the main characteristics of the data. In particular, other deterministic terms such as a linear time trend or seasonal dummy variables may be required to represent the data properly. Additionally, exogenous variables may be required as well. The general form of the VAR (p) model with deterministic terms and exogenous variables is given by

$$Y_t = \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \dots + \Pi_p Y_{t-p} + \Phi D_t + G X_t + \varepsilon_t; \quad t = 1, 2, \dots, T \quad (8)$$

where D_t represents an $(I \times 1)$ matrix of deterministic components, X_t represents an $n \times 1$ vector of exogenous variables, and Φ and G are parameter matrices.

Testing Stationarity: Unit Root Test

Before fitting a particular model to time series data, the series must be made stationary. Stationarity occurs in a time series when the mean and autocovariances of the series remains constant over the time series. Therefore, the stochastic process Y_t is said to be stationary if:

- (i) $E(Y_t) = \mu$, constant for all value of t (9)
- (ii) The $\text{Cov}(Y_t, Y_{t-j}) = \Gamma_j = E[(Y_t - \mu)(Y_{t-j} - \mu)^T] = \Gamma_j^T$ for all t and $j=0,1,2,\dots$ (10)

Condition (9) means that all Y_t have the same finite mean vector μ and [3.10] requires that the autocovariances of the process do not depend on t but just on the time period j the two vectors Y_t and Y_{t-j} are apart. Therefore, a process is stationary if its first and second moments are time invariant.

Frequently, differencing may be needed to achieve stationarity. To test for stationarity of a series several procedures has been developed. The most popular ones are Augmented Dickey- Fuller (ADF) test due to Dickey and Fuller (1979, 1981). The following discussion outlines the basics features of unit root tests (Hamilton, 1994).

Consider a simple AR (1) process:

$$Y_t = \rho Y_{t-1} + X_t \delta + \varepsilon_t \quad (11)$$

where X_t are optional exogenous regressors which may consist of constant or a constant and trend, ρ and δ are parameters to be estimated, and ε_t assumed to be white noise. If $|\rho| = 1$, Y_t is a non-stationary series and the variance of y increases with time and approaches infinity. If $|\rho| < 1$, Y_t is a stationary series. Thus, the hypothesis of (trend) stationarity can be evaluated by testing whether the absolute value of ρ is strictly less than one.

Hypothesis

The series are not stationary ($\rho = 1$) against H_1 : The series are stationary ($\rho < 1$)

Testing for Cointegration using Johansen's Methodology

The starting point in Johansen's procedure (Johansen, 1988; 1991), in determining the number of cointegrating vectors, is the VAR representation of Y_t . It is assumed a vector autoregressive model of order p and is expressed as follows:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + A_p Y_{t-p} + B X_t' \delta + \varepsilon_t$$

Where y_t is a k -vector of non-stationary $I(1)$ variables(If a non-stationary series, y_t must be differenced d times before it becomes stationary, then it is said to be integrated of order d . This would be written $y_t \sim I(d)$), X_t is a d -vector of deterministic variables, and ε_t is a vector of innovations.

We rewrite this VAR as:

$$\Delta y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + B X_t' \delta + \varepsilon_t \quad (12)$$

where

$$\Pi = \sum_{i=1}^p A_i - I, \Gamma_i = -\sum_{j=i+1}^p A_j \quad (13)$$

Granger's representation theorem asserts that if the coefficient matrix Π has reduced rank $r < k$, then there exist $k \times r$ matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta'y_t$ is $I(0)$, where r is the number of cointegrating relations (the *cointegrating rank*) and each column of Π is the cointegrating vector. The elements of α are known as the adjustment parameters in the VEC model. It can be shown that for a given r , the maximum likelihood estimator of β defines the combination of $Y_t - 1$ that yields the r largest canonical correlations of ΔY_t with $Y_t - 1$ after correcting for lagged differences and deterministic variables when present.

Johansen (1988) proposed two tests for estimating the number of cointegrating vectors: The Trace statistics and Maximum Eigenvalue. Trace statistics investigate the null hypothesis of r cointegrating relations against the alternative of n cointegrating relations, where n is the number of variables in the system for $r = 0, 1, 2, \dots, n-1$. Define $\lambda_i, i=1, 2, \dots, k$ to be a complex modulus of eigenvalues of Π and let them be ordered such that $\lambda_1 > \lambda_2 > \dots > \lambda_n$. The trace statistic computed as:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^n \log[1 - \lambda_i] \quad (14)$$

The Maximum Eigenvalue statistic tests the null hypothesis of r cointegrating relations against the alternative of $r+1$ cointegrating relations for $r = 0, 1, 2, \dots, n-1$. This test statistic is computed as (Engle et al., 1987):

$$\lambda_{max}(r, r+1) = -T \sum_{i=r+1}^n \log(1 - \lambda_{r+1})$$

Where λ_{r+1} is the $(r+1)^{th}$ ordered eigenvalue of Π , and T is the sample size. The critical values tabulated by Johansen and Juselius (1990) will be used for these tests.

Vector Error Correction (VEC) Models

A vector error correction (VEC) model is a restricted VAR designed for use with non-stationary series that are known to be cointegrated. The VEC has cointegration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The cointegration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

When the variables are cointegrated, the corresponding error correction representations must be included in the system. By doing so, one can avoid misspecification and omission of the important constraints. Thus, the VAR in (12) can be re-parameterized as a Vector Error Correction Model (VECM) form: (Hamelton, 1994.)

$$\Delta y_t = \Pi Y_{t-1} + \sum_{i=1}^p \Gamma_i \Delta y_{t-i} + B X_t + \varepsilon_t$$

where $\Pi = -I_n + \sum_{i=1}^p A_i$, $\Gamma_i = -\sum_{j=i+1}^p A_j$ and I_n is an identity matrix

The above specification of VECM contains information on both the short and the long run adjustment to changes in y_t via estimating Γ and Π , respectively. Matrix Π can be decomposed as $\Pi = \alpha\beta'$, where α is $n \times r$ matrix of speed of adjustments, and β is an $n \times r$ matrix of parameters which determines the cointegrating relationships matrix of long-run coefficients such that $\beta'y_{t-k}$ represent the multiple cointegration relationships. The columns of β are interpreted as long-run equilibrium relationships between variables. The matrix α determines the speed of adjustment towards this equilibrium. Values of α close to zero imply slow convergence and $r, 0 \leq r \leq n$ is the rank of the matrix Π and represents the number of cointegrating vectors in the system which can be determined using the Johansen Maximum Likelihood method (Bourbonnais, 2007; Bourbonnais & Terraza, 2008).

Model Checking

A wide range of procedures is available for checking the adequacy of VAR and VECMs. They should be applied before a model is used for specific purpose to ensure that it represents the data adequately.

Test of Residual Autocorrelation

Portmanteau Autocorrelation Test

The portmanteau test for residual autocorrelation (Gujarati, 2004) checks the null hypothesis that all residual auto-covariances are zero, that is, $H_0: E(\varepsilon_t, \varepsilon_{t-i}) = 0, i = 1, 2, \dots$. This hypothesis is tested against the alternative that at least one autocovariance and, hence, one autocorrelation is nonzero. The test statistics is based on the residual autocovariances and has the form

$$Q_h = T \sum_{j=1}^h \text{tr}(\hat{\gamma}_j' \hat{\gamma}_0^{-1} \hat{\gamma}_j / \hat{\gamma}_0^{-1}) \quad (15)$$

$$\hat{\gamma}_j = T^{-1} \sum_{t=j+1}^T \hat{\varepsilon}_t \hat{\varepsilon}_{t-j}' \quad (16)$$

and the $\hat{\varepsilon}_t$'s are the estimated residuals. For unrestricted residuals stationary VAR(p) process, the null distribution of Q_h is approximated by $\chi^2_{h(1-p)}$ distribution if T and h approaches infinity such that $h/T \rightarrow 0$.

Alternatively, (especially in small samples), a modified statistic

$$Q^*_h = T^2 \sum_{j=1}^h \frac{1}{T-j} \text{tr}(\hat{\gamma}_j' \hat{\gamma}_0^{-1} \hat{\gamma}_j / \hat{\gamma}_0^{-1}) \quad (17)$$

is usually employed in place of (15)

Autocorrelation LM Test

This test was developed by Breusch and Godfrey in 1978 (Breusch & Godfrey, 1978). Assume a VAR model for the error u_t given by

$$u_t = D_1 u_{t-1} + \dots + D_h u_{t-h} + v_t \quad (18)$$

The quantity v_t denotes a white noise error term. Thus, to test autocorrelation in u_t , we test

$$H_0: D_1 = \dots = D_h = 0 \text{ against } H_1: D_j \neq 0 \text{ for at least one } j, j = 1, \dots, h.$$

We use the LaGrange Multiplier method to perform the test. This method is very useful for finding optimal estimates under constraint conditions. Under H_0 , we only need to estimate the regular VAR model ($u_t = v_t$). So the constrained case estimates are simple. To determine the test statistic we begin with the auxiliary regression model

$$\tilde{u} = BZ + D\tilde{u} + E \quad (19)$$

where $\tilde{u} = [\tilde{u}_1 \dots \tilde{u}_T]'$, $Z = [Z_0 \dots Z_{T-1}]'$ with $Z_t = [1^T y^T \dots y^{T-p+1}]^T$ and $D = [D_1 \dots D_h]$.

Define F_i such that

$$\tilde{u}' F_i \tilde{u} = \sum_{t=i+1}^T \tilde{u}_t \tilde{u}_{t-i} \quad (20)$$

with $F = [F_1 \dots F_h]$ and $\tilde{u} = (I \oplus \tilde{u}) F'$.

This yields the least squares estimate of D given by

$$\hat{D} = \tilde{u} \tilde{u}' [\tilde{u} \tilde{u}' - \tilde{u} Z' (Z Z')^{-1} Z \tilde{u}']^{-1} \quad (21)$$

The standard χ^2 test statistic for testing whether $D = 0$ (no autocorrelation) is, under H_0 :

$$\lambda_{LM}(h) = \text{vec}(\hat{D})' ([\tilde{u} \tilde{u}' - \tilde{u} Z' (Z Z')^{-1} Z \tilde{u}'] \oplus \tilde{\Sigma}_u) \text{vec}(\hat{D}) \quad (22)$$

$$\lambda_{LM}(h) \xrightarrow{d} \chi^2(hk^2) \quad (22)$$

Normality of the Residuals

Multivariate generalization of the Jarque-Bera test (Jarque & Bera 1987) has been a major technique to test the multivariate normality of the u_t , the vector of the error terms in a multivariate time series model. This tests the skewness and kurtosis properties of the u_t (3rd and 4th moments) against those of a multivariate normal distribution of the appropriate dimension.

$$H_0: E(u_t^3) = 0 \text{ (skewness)} \text{ and } E(u_t^4) = 3 \text{ (kurtosis)} \text{ against } H_1: E(u_t^3) \neq 0 \text{ and } E(u_t^4) \neq 3$$

It is possible that the first four moments of the u_t match the multivariate normal moments, and the u_t are still not normally distributed. It is hoped that most of the "normal" properties desired by the model fitted in the u_t are met by these four moments. This situation has an analog in linear regression. We assume that the errors are independent, but we can only test whether they are correlated. In linear regression, it is adequate to test the correlation of the residuals. If they are uncorrelated, that is enough "independence" for getting the variance calculations correct. We don't worry about the other forms of dependence.

Formulation of the Jarque-Bera test uses a mean adjusted form of the VAR (p) model

$$\tilde{u} = (y_t - \bar{y}) - \hat{A}_1 (y_{t-1} - \bar{y}) - \dots - \hat{A}_p (y_{t-p} - \bar{y}) \quad (23)$$

$$\text{with } \bar{\text{var}}(\tilde{u}) = \frac{1}{T-kp-1} \sum_{t=1}^T \tilde{u}_t \tilde{u}_t'$$

Let $\hat{P}$ be the matrix satisfying $\hat{P}\hat{P}^T = \hat{\Sigma}_u$ such that $\lim(\hat{P} - P) = 0$

Now we define the standardized residuals and their sample moments

$$\begin{aligned}\hat{w}_t &= \hat{P}^{-1}\hat{u}_t \\ \hat{b}_1 &= (\hat{b}_{11} \dots \hat{b}_{k1}) \quad \mathcal{D} \hat{b}_{11} = \frac{1}{T} \sum_{t=1}^T w_{1t}^3 \\ \hat{b}_2 &= (\hat{b}_{12} \dots \hat{b}_{k2}) \quad \mathcal{D} \hat{b}_{12} = \frac{1}{T} \sum_{t=1}^T w_{1t}^4\end{aligned}$$

Finally, our test statistics are

$$\begin{aligned}\lambda_S &= T \hat{b}_1^T \hat{b}_1 / 6 \\ \lambda_S &= T(\hat{b}_2^T - 31)^T (\hat{b}_2^T - 31) / 24 \\ \lambda_{SK} &= \lambda_S + \lambda_K\end{aligned}\quad (24)$$

The third and fourth moment of u_t should be 0 and 3

Under the third moment assumption

$$\lambda_S \xrightarrow{d} \chi^2(k) \quad (25)$$

Under the moment assumption

$$\lambda_K \xrightarrow{d} \chi^2(k) \quad (26)$$

Under both assumptions

$$\lambda_{SK} \xrightarrow{d} \chi^2(2k) \quad (27)$$

Forecasting

Forecasting is one of the main objectives of multivariate time series analysis. Forecasting from a VAR model is similar to forecasting from a univariate models.

Consider first the problem of forecasting future values of Y_t when the parameters Π of the VAR (p) process are assumed to be known and there are no deterministic terms or exogenous variables. The best linear predictor, in terms of minimum mean squared error (MSE), of Y_{t+1} or 1-step forecast based on information available at time T is

$$Y_{T+1|T} = c + \Pi_1 Y_T + \Pi_2 Y_{T-1} + \dots + \Pi_p Y_{T-p+1} \quad (28)$$

for $T \geq p$

Forecasts for longer horizons h (h -step forecasts) can be obtained using the chain-rule of forecasting as

$$Y_{T+h|T} = c + \Pi_1 Y_{T+h-1|T} + \dots + \Pi_p Y_{T+h-p|T} \quad (29)$$

where $Y_{T+j|T} = Y_{T+j}$ for $j \leq 0$. The h -step forecast errors may be expressed as

$$Y_{T+h} - Y_{T+h|T} = \sum_{s=0}^{h-1} \Psi_s \varepsilon_{T+h-s} \quad (30)$$

where the matrices Ψ_s are determined by recursive substitution

$$\Psi_s = \sum_{j=1}^{p-1} \Psi_{s-j} \Pi_j \quad (31)$$

with $\Psi_0 = I_n$ and $\Pi_j = 0$ for $j > p$. The forecasts are unbiased since all of the forecast errors have expectation zero, and the MSE matrix for $Y_{T+h|T}$ is

$$\Sigma(h) = \text{MSE}(Y_{T+h} - Y_{T+h|T}) = \sum_{s=0}^{h-1} \Psi_s \Sigma \Psi_s^T \quad (32)$$

Now consider forecasting Y_{T+h} when the parameters of the VAR(p) process are estimated using multivariate least squares. The best linear predictor of Y_{T+h} is now

$$\hat{Y}_{T+h|T} = c + \hat{\Pi}_1 \hat{Y}_{T+h-1|T} + \dots + \hat{\Pi}_p \hat{Y}_{T+h-p|T} \quad (33)$$

where $\hat{\Pi}_j$ are the estimated parameters matrices. The h -step forecast error is given by

$$Y_{T+h} - \hat{Y}_{T+h|T} = \sum_{s=0}^{h-1} \hat{\Psi}_s \varepsilon_{T+h-s} + (Y_{T+h} - \hat{Y}_{T+h|T})$$

and the term $(Y_{T+h} - \hat{Y}_{T+h|T})$ captures the part of the forecast error due to estimating the parameters of the VAR. The MSE matrix of the h -step forecast is then

$$\hat{\Sigma}(h) = \Sigma(h) + \text{MSE}(Y_{T+h} - \hat{Y}_{T+h|T}) \quad (34)$$

In practice, the second term $\text{MSE}(Y_{T+h} - \hat{Y}_{T+h|T})$ is often ignored and $\hat{\Sigma}(h)$ is computed using (33) as

$$\hat{\Sigma}(h) = \sum_{s=0}^{h-1} \hat{\Psi}_s \hat{\Sigma} \hat{\Psi}_s^T \quad (35)$$

where $\hat{\Psi}_s = \sum_{j=1}^s \hat{\Psi}_{s-j} \hat{\Pi}_j$.

Lütkepohl (1991) gives an approximation to $\text{MSE}(Y_{T+h} - \hat{Y}_{T+h|T})$ which may be interpreted as a finite sample correction to (35).

Measures of Forecasting Accuracy

In most forecasting situations, accuracy is treated as the overriding criterion for selecting a forecasting method. In many instances, the word “accuracy” refers to the goodness of fit, which simply refers to how well the forecasting model is able to reproduce the data that are already known. To the consumer of forecasts, it is the accuracy of the future forecast that is most important.

If Y_t is the actual observation for the period t and F_t is the forecast for the sample period, then the error is defined as

$$v_t = Y_t - F_t \quad (36)$$

Usually, F_t is calculated using data $Y_1, \dots, Y_{t-1}$. It is a one-step forecast because it is forecasting one period ahead of the last observation used in the calculation. Therefore, we describe v_t as a one-step forecast error. It is the difference between the observation Y_t and forecast made using all observations up to but not including Y_t .

If there are observations and forecasts for T time periods, then there will be n error terms, and the following standard statistical measures can be defined:

$$\text{Mean Error (ME)} = \frac{1}{T} \sum_{t=1}^T v_t$$

$$\text{Mean absolute Error (MAE)} = \frac{1}{T} \sum_{t=1}^T |v_t|$$

$$\text{Mean Squared Error (MSE)} = \frac{1}{T} \sum_{t=1}^T v_t^2$$

Equation (36) can be used to compute the error for each period. These can then be averaged as given above to give the mean error (ME). However, the ME is likely to be small since positive and negative errors tend to offset one another. In fact, the ME will only tell you if there is systematic under-or over forecasting, called the forecasting bias. It does not give much indication as to the size of the typical errors.

Therefore, the mean absolute error (MAE) is defined by first making error positive by taking its absolute value, and then averaging the results. The idea behind the definition of mean square error (MSE) is similar. Here the errors are made positive by squaring each one, and then the squared errors are averaged. The MSE has advantage of being more interpretable and is easier to explain to non-specialist.

Each of these statistics deals with measures of accuracy whose size depends on the scale of the data. Therefore, they do not facilitate comparison across different time series and for different time intervals. To make comparisons, we need to work with relative or percentage error measures given by

$$PE_t = \left(\frac{Y_t - F_t}{Y_t} \right) \times 100 \quad (37)$$

Arising from (37), the following two relative measures are frequently used:

$$\text{Mean percentage Error (MPE)} = \frac{1}{T} \sum_{t=1}^T PE_t \quad (38)$$

$$\text{Mean percentage Absolute Error (MPAE)} = \frac{1}{T} \sum_{t=1}^T |PE_t| \quad (39)$$

Equation (37) can be used to compute the percentage error for any time period. These can be averaged as in equation (38) to give the mean percentage error. However, as with the ME, the MPE is likely to be small since positive and negative PEs tends to offset one another. Hence the MAPE is defined using absolute values of PE in equation (39).

Alternatively, Theil's U statistic can be used as a measure of forecasting accuracy. Like MAPE statistics, high values suggest poor performance in the forecast. However, and unlike MAPE, the U-Theil corrects the performance scale that MPAE had. Theil's U can be estimated as:

$$U = \frac{\sqrt{\frac{1}{n} \sum_{t=1}^n (Y_t - F_t)^2}}{\sqrt{\frac{1}{n} \sum_{t=1}^n (F_t)^2} + \sqrt{\frac{1}{n} \sum_{t=1}^n (Y_t)^2}} \quad (40)$$

The scaling of U is such that it will always lie between 0 and 1. If $U = 0$, $Y_t = F_t$ for all forecasts and there is a perfect fit; if $U = 1$ the predictive performance is not good.

Structural Vector Autoregressive (SVAR) Analysis

The general VAR (p) model has many parameters, and they may be difficult to interpret due to complex interactions and feedback between the variables in the model. As a result, the dynamic properties of a VAR (p) are often summarized using various types of structural analysis. One of the main types of structural analysis summaries is the Granger causality tests.

Analysis and Results

The time series under consideration were checked for stationary before any suitable time series model could be considered for the data. That is, variables have to be tested for the presence of unit root(s) thereby the order of integration of each series is determined. Figs 1 and 2 suggests that the series of the endogenous variables display non-stationary behaviours.

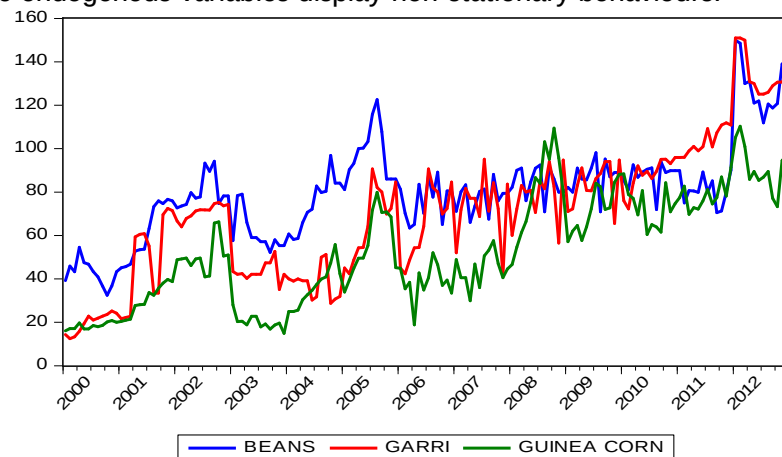


Fig. 1: Time plots of the prices of beans, Garri and Guinea corn for twelve years from 2000 to 2012

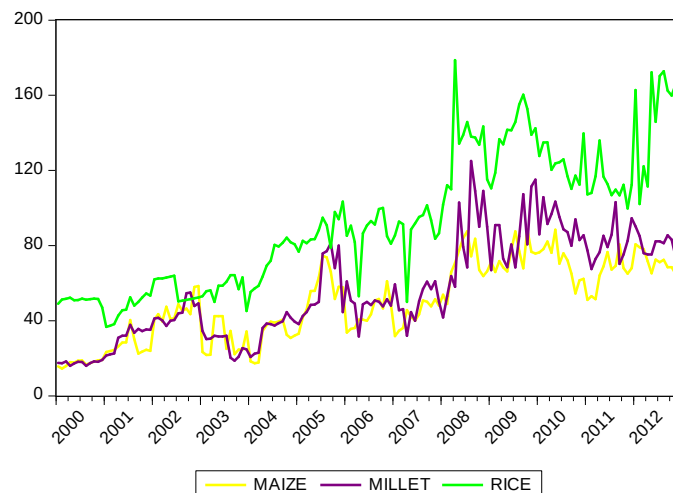


Fig. 2: Time plots of the prices of maize, Millet and Rice for twelve consecutive years from 2000 to 2012

Hypothesis

H_0 : The series are non stationary ($\rho=1$) or $\alpha = 0$ Vs. H_1 : The series are stationary ($\rho<1$) or $\alpha < 0$

Table 1: Table of results for stationarity of the series using the Unit root test

Series	Level with intercept		Level with intercept and Trend	
	Test statistic	Prob.*	Test statistic	Prob.*
	ADF	ADF	ADF	ADF
Maize	-2.812085	0.0589	-3.302502	0.0641
Millet	-1.952513	0.3077	-3.280733	0.0734
Rice	-1.107322	0.7123	-3.121823	0.7237
Guinea-Corn	-2.101532	0.2445	-3.091644	0.0508
Beans	-1.864203	0.3485	-3.174035	0.0962
Garri	-2.80328	0.0601	-3.062203	0.0817
Critical value (5%)	-2.880211		-3.439075	

Test results, presented in Table 1, indicated that the null hypothesis that the series in levels contain unit root could not be rejected for all the six series. That is, the respective p-values are greater than significance levels $\alpha = 0.05$, hence the series are integrated of degree one ($I(1)$). Since the null hypothesis cannot be rejected, in order to determine the order of integration of the non-stationary time series, the same tests were applied to their first differences (Figs. 3 and 4). The order of integration is the number of unit roots that is differenced in the series so as to be stationary.

Table 3: Unit root test results (after first difference)

Series	Level with Intercept		Level with Intercept and Trend	
	Test statistic	Prob.*	Test statistic	Prob.*
	ADF	ADF	ADF	ADF
Maize	-14.32589	< 0.0001	-11.27824	<0.0001
Millet	-13.14097	<0.0001	-12.13143	<0.0001
Rice	-19.85791	<0.0001	-19.81501	<0.0001
Guinea-Corn	-14.13909	<0.0001	-12.12869	<0.0001
Beans	-16.28760	<0.0001	-16.26299	<0.0001
Garri	-13.02529	<0.0001	-12.97029	<0.0001
Critical value (5%)	-2.880211		-3.439075	

The results in Table 3 indicate that the null hypothesis is rejected for the first differences of the six staple food stuffs given that p-values less than 5% level of significance. This implies that the six time series are integrated of degree one ($I(1)$).

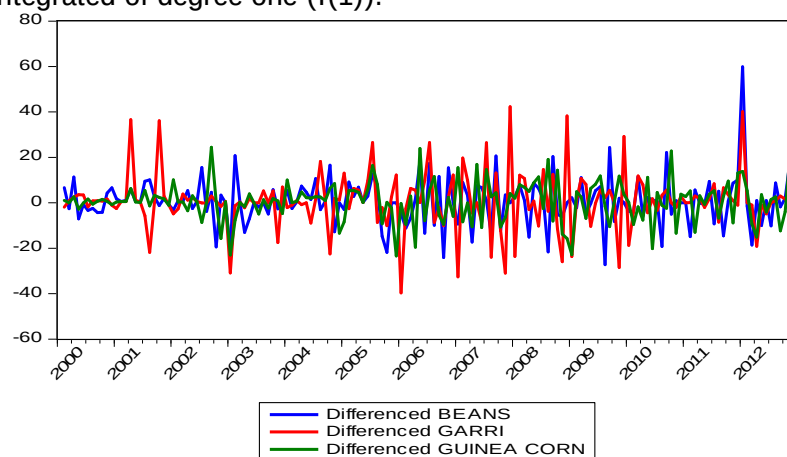


Fig. 3: Time plot of differenced data on prices of Beans, Garri and Guinea Corn

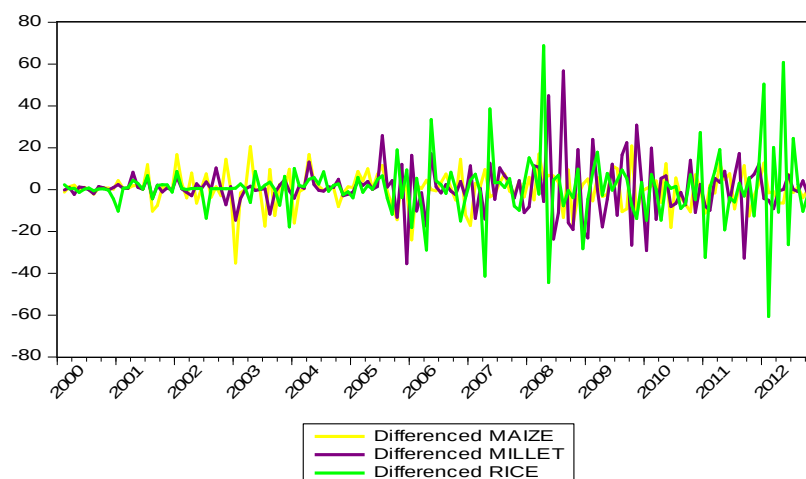


Fig. 5: Time plot of differenced data on prices of Maize, Millet and Rice

Var Model Specification

Estimating for Order of the VAR

Specifying the lag length has strong implications for subsequent modeling choices. Choosing too few lags could lead to systematic variation in the residuals whereas if too many lags are chosen it comes with the penalty of fewer degrees of freedom (as adding another lag, to the $p \times p$ variables). To determine the optimum lag length, we test for statistics which include: Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan Quin Information Criterion (HQIC) are diverse. The FPE and AIC and HQIC indicate lag length of two. We therefore choose lag length of two.

Table 4: VAR lag order selection results

Lag	FPE	AIC	HQIC	SIC
0	1.33e+14	49.5502	49.59895	49.67013
1	1.22e+12	44.85826	46.26747	49.67013
2	*1.05e+12	*44.70887	*45.19920	*46.26747
3	1.20e+12	44.82961	47.10755	47.10755
4	2.20e+13	44.94439	47.94169	47.94169

**indicates lag order selected by the criterion*

Based on the results in Table 4 using the computed FPE, AIC, HQIC and SIC values, it can be concluded that the optimum lag length is 2.

Cointegration Analysis

Since the variables are integrated of order one, we proceed to test for co-integration. Johansen (1995) cointegration test is applied at the predetermined lag 2. In these tests, Maximum Eigenvalue statistic or Trace statistic is compared to special critical values. The maximum eigenvalue and trace tests proceed sequentially from the first hypothesis –no cointegration– to an increasing number of cointegrating vectors.

The results of Cointegration tests for Rice, maize, gari, millet, guinea corn, palm oil and beans are reported in Table 4.5. The trace statistic indicates that at least two cointegrating vector ($r \geq 1$) exists in the system at the 95 percent confidence level (estimated LR statistic, 148.70 > 125.62 and 97.52 > 95.75, 5 per cent critical value). In order to cross check for identifying the specific number of cointegrating vectors, the maximal eigenvalue statistic is further employed. This statistic reduced the cointegrating equation to only one cointegrating relationship at the 95 per cent confidence level in this system (estimated LR statistic, 51.17 > 46.23, 95 per cent critical value).

Table 5: Johansen Cointegration test results (by assumption of Linear deterministic trend)

Number of cointegrating vector	Eigenvalue	Trace Test			Maximum Eigenvalue Test		
		Statistic	5 % critical value	Prob.*	statistic	5 % critical value	Prob.*
None *	0.272467	111.8006	95.75366	0.0025	48.03246	40.07757	0.0052
At most 1	0.172277	63.76814	69.81889	0.1382	28.55064	33.87687	0.1893
At most 2	0.116442	35.21750	47.85613	0.4365	18.69363	27.58434	0.4386
At most 3	0.069094	16.52386	29.79707	0.6749	10.81118	21.13162	0.6661

Table 6: Table of normalized cointegrating coefficients and their respective standard errors

Normalized cointegrating coefficients (standard error in parentheses)					
BEANS	GARRI	G.CORN	MAIZE	MILLET	RICE
1.000000	0.009934	-1.488467	-7.708178	7.595088	-0.766970
	(0.41205)	(0.88302)	(1.22142)	(1.11646)	(0.39983)

From the Johansen co-integration test, it was discovered that the rank of co-integration matrix to be equal to one. Consequently, the co-integrating vector is given by

$$\beta = (1, 0.009934, -1.488467, -7.708178, 7.595088, -0.766970)$$

The values correspond to the co-integrating coefficient of BEANS (normalized to one), GARRI, GUINEA CORN, MAIZE, MILLET, PALM OIL and RICE respectively. Thus, the vector above can be expressed as follows;

$$Beans_t = -0.009934Garri_t + 1.488467G.corn_t + 7.708178Maize_t - 7.595088Millet_t + 0.766970Rice_t$$

Vector Error Correction Model Estimation

Having concluded that variables in the VAR model appeared to be cointegrated, we proceed to estimate the short run behavior and the adjustment to the long run models, which is represented by VECM. The VEC model has the following structure:

$$\Delta Y_t = \mu + \sum_{i=1}^p \Gamma_i \Delta Y_{t-i} + \alpha B X_{t-1} + \varepsilon_t,$$

where BX_t is the error correction term given by $\beta'Y_t$ and β is the cointegrating vector. The responses of BEANS, GARRI, GUINEA-CORN, MAIZE, MILLET and RICE to short-term output movements are captured by the Γ_i coefficient matrices. The coefficient vector α reveals the speed of adjustment to the equilibrium which measures the deviation from the long-run relationship between the series.

The long run equation is given as follows:

$$Beans_t = 5.864122 - 0.009934Garri_t + 1.488467G.corn_t + 7.708178Maize_t - 7.595088Millet_t + 0.766970Rice_t \quad (**)$$

The value 0.0099 suggests that a one unit increase in the average price of Garri induces, on average, an decrease of about 0.01 units in the average price of Beans when the price of other staple foods are held constant. Similarly, one unit increase in the average price of G.corn leads to an increase of about 1.49 units in the average price of Beans when the price of other staple foods are held constant. Also one unit increase in the average price of Maize leads to an increase of about 7.71 units in the average price of Beans when the price of other staple foods are held

constant. Furthermore, one unit increase in the average price of Millet will lead to about 7.60 units decrease in the average price of Beans when the price of other staple foods are held constant. Finally, one unit increase in the average price of Rice will lead to about 0.767 units increase in the average price of Beans when the price of other staple foods are held constant. From the VAR model (**) the following Vector Error Correction Models are estimated:

Model of Average Price of Beans:

$$\Delta BnsP_t = 0.001 * (BnsP_{t-1} - 0.0099Gri_t + 1.49G.c_t - 7.71Maz_t - 7.60Mlt_t + 0.77Rce_t + 5.8) - 0.30 * \Delta BnsP_{t-1} - 0.02 * \Delta BnsP_{t-2} - 0.01 * \Delta GriP_{t-1} + 0.05 * \Delta GriP_{t-2} - 0.12 * \Delta G.cP_{t-1} - 0.01 * \Delta G.cP_{t-2} + 0.02 * \Delta MazP_{t-1} - 0.002 \Delta MazP_{t-2} + 0.23 \Delta MltP_{t-1} - 0.09 \Delta MltP_{t-2} + 0.08 \Delta RceP_{t-1} - 0.05 \Delta RceP_{t-2} + 0.69$$

.....i

Model of Average Price of Garri:

$$\Delta GriP_t = 0.02 * (BnsP_{t-1} - 0.0099Gri_t + 1.49G.c_t - 7.71Maz_t - 7.60Mlt_t + 0.77Rce_t + 5.8) - 0.08 * \Delta BnsP_{t-1} - 0.03 * \Delta BnsP_{t-2} - 0.42 * \Delta GriP_{t-1} + 0.17 * \Delta GriP_{t-2} - 0.13 * \Delta G.cP_{t-1} - 0.34 * \Delta G.cP_{t-2} + 0.24 * \Delta MazP_{t-1} - 0.13 \Delta MazP_{t-2} + 0.12 \Delta MltP_{t-1} - 0.14 \Delta MltP_{t-2} + 0.08 \Delta RceP_{t-1} + 0.02 \Delta RceP_{t-2} + 0.91$$

.....i

Model of Average Price of Guinea Corn:

$$\Delta G.cP_t = -0.04 * (BnsP_{t-1} - 0.0099Gri_t + 1.49G.c_t - 7.71Maz_t - 7.60Mlt_t + 0.77Rce_t + 5.8) + 0.22 * \Delta BnsP_{t-1} + 0.11 * \Delta BnsP_{t-2} + 0.02 * \Delta GriP_{t-1} + 0.01 * \Delta GriP_{t-2} - 0.27 * \Delta G.cP_{t-1} - 0.06 * \Delta G.cP_{t-2} - 0.04 * \Delta MazP_{t-1} - 0.02 \Delta MazP_{t-2} + 0.15 \Delta MltP_{t-1} - 0.11 \Delta MltP_{t-2} - 0.03 \Delta RceP_{t-1} + 0.002 \Delta RceP_{t-2} + 0.41$$

.....iii

Model of Average Price of Maize:

$$\Delta MazP_t = 0.06 * (BnsP_{t-1} - 0.0099Gri_t + 1.49G.c_t - 7.71Maz_t - 7.60Mlt_t + 0.77Rce_t + 5.8) - 0.22 * \Delta BnsP_{t-1} - 0.06 * \Delta BnsP_{t-2} - 0.05 * \Delta GriP_{t-1} + 0.03 * \Delta GriP_{t-2} - 0.05 * \Delta G.cP_{t-1} + 0.01 * \Delta G.cP_{t-2} + 0.12 * \Delta MazP_{t-1} + 0.04 \Delta MazP_{t-2} + 0.09 \Delta MltP_{t-1} - 0.02 \Delta MltP_{t-2} + 0.10 \Delta RceP_{t-1} + 0.06 \Delta RceP_{t-2} + 0.02$$

.....iv

Model of Average Price of Millet:

$$\Delta MltP_t = -0.10 * (BnsP_{t-1} - 0.0099Gri_t + 1.49G.c_t - 7.71Maz_t - 7.60Mlt_t + 0.77Rce_t + 5.8) + 0.01 * \Delta BnsP_{t-1} + 0.15 * \Delta BnsP_{t-2} - 0.02 * \Delta GriP_{t-1} + 0.09 * \Delta GriP_{t-2} - 0.03 * \Delta G.cP_{t-1} + 0.07 * \Delta G.cP_{t-2} - 0.23 * \Delta MazP_{t-1} - 0.09 \Delta MazP_{t-2} - 0.22 \Delta MltP_{t-1} - 0.28 \Delta MltP_{t-2} + 0.17 \Delta RceP_{t-1} + 0.04 \Delta RceP_{t-2} + 0.36$$

.....v

Model of Average Price of Rice:

$$\Delta RceP_t = -0.06 * (BnsP_{t-1} - 0.0099Gri_t + 1.49G.c_t - 7.71Maz_t - 7.60Mlt_t + 0.77Rce_t + 5.8) - 0.04 * \Delta BnsP_{t-1} - 0.07 * \Delta BnsP_{t-2} - 0.07 * \Delta GriP_{t-1} + 0.04 * \Delta GriP_{t-2} + 0.03 * \Delta G.cP_{t-1} + 0.01 * \Delta G.cP_{t-2} - 0.19 * \Delta MazP_{t-1} - 0.26 \Delta MazP_{t-2} + 0.25 \Delta MltP_{t-1} + 0.08 \Delta MltP_{t-2} - 0.53 \Delta RceP_{t-1} - 0.14 \Delta RceP_{t-2} + 1.36$$

.....vi

where: 'Δ' stands for first difference (D), the value in the bracket is the error correction term and the coefficients of error correction term are called adjustment coefficients.

Model Diagnosis

In order to ascertain whether the model provides an appropriate representation, a test for misspecification is performed.

Test for Residual Autocorrelation

Portmanteau Q-statistic test for VAR model residual serial correlation is presented below. This test is used to test for the overall significance of the residual autocorrelations up to lag 2.

Table 7: Test for residual autocorrelation and serial correlation

Lag	Q-stat	Prob.	Adj Q-Stat	LM-Stat	Prob
1	9.059484	NA*	7.916442	61.94690	0.2472
2	40.80412	NA*	40.97879	63.43891	0.0911
3	96.48770	0.4447	96.9577	61.94073	0.2311

H_0 : No residual autocorrelation against H_1 : There is residual autocorrelation

Since p-value (0.4447) > $\alpha = (0.05)$, we cannot reject H_0 . Hence we conclude that there is no residual autocorrelation at lag 3 and it is white noise.

Testing for Normality of Residual

Multivariate version of the Jarque Bera tests is used to test the normality of the residuals. It compares the 3rd and 4th moments (Skewness and Kurtosis) to those from a normal distribution.

The test has null hypothesis indicating that the error term in the model has skewness and kurtosis corresponding to a normal distribution.

$H_0: E(u^s_t)^3 = 0$ (skewness) and $E(u^s_t)^4 = 3$ (kurtosis) Vs. $H_1: E(u^s_t)^3 \neq 0$ and $E(u^s_t)^4 \neq 3$

The results in Table 8 show that the null hypothesis was not rejected

Table 8: Table of results of tests for normality of residual

SERIES	Skewness	Kurtosis	Jarque bera	Prob.
Maize	0.093690	2.848694	2.186625	0.910909
Millet	0.335336	2.708065	2.950469	0.621739
Rice	0.234704	2.870322	3.795935	0.149873
G.corn	0.149288	2.999581	1.399126	0.998004
Beans	0.112439	2.755469	2.50107	0.158121
Garri	0.236493	2.845892	1.608529	0.447417

The values of the Skewness showed that the curve of the staple foodstuffs are centered since they are approximately zero and not also have an abnormal peak with kurtosis values of approximately three also the Jarque-bera normality test shows that the price for all the six staple foodstuffs is normally distributed since the null hypothesis that the process is normally distributed was not rejected at 0.05 critical level.

Forecasting

One of the fundamental applications of time series analysis or developing a time series model is forecasting. The previous discussion confirmed that vector error correction model of order two is a good model to describe the series. In this section we examine the forecasting accuracy of the fitted model and then make a forecast for January 2013 to December 2015.

Evaluation of Accuracy

The mean square error (MSE), root mean square error (RMSE), mean absolute error (MAE) and Theil U statistics were used to assess the forecasting performance. The RMSE and MAE statistics are scale-dependent measures, but allow a comparison between the actual and forecast values. The Theil-U statistics is independent of the scale of the variables and is constructed to lie between zero and one, zero indicating a perfect fit. In evaluating the performance of the forecasting models, the lower the RMSE, MAE, MAPE and Theil-U statistic, the better the forecasting accuracy.

Table 9 reports the forecasting accuracy statistics of the estimated model. The result indicates that the estimated models are good enough to describe the series. The RMSE, MAE, MAPE values

are less than 5% and Theil-U statistics is close to zero, which indicates the difference between the actual value and the predicted value is very small. That is, the predictive powers of the models are better and suitable for n-step ahead forecasting.

Table 9: Forecasting Accuracy statistic

Forecast sample: January 2000 to December 2012

Variables	RMSE	MAE	MAPE	Theil-U
Maize	4.01	3.91	5.01	0.000559
Millet	3.77	4.79	3.78	0.000089
Rice	3.97	3.12	4.19	0.000661
G.corn	4.89	3.71	1.09	0.000078
Beans	3.54	4.73	2.11	0.000111
Garri	2.99	4.02	4.18	0.000052

Post Forecasting Analysis

Post forecasted values for the beans and the other staple foodstuffs from January 2013 to December 2015, using the vector error correction model are presented in the Table 10.

Table 10: Forecast from January 2013 to December 2015

Time	Beans	Rice	Maize	Millet	Guinea-Corn	Garri
2013m1	140.7914	166.0415	55.1923	71.4898	94.6616	132.0118
2013m2	140.8526	166.3924	56.4112	67.0044	94.5677	133.3475
2013m3	140.8515	166.7432	56.1598	67.5915	94.8838	133.1017
2013m4	141.6500	167.7597	56.5383	67.7932	95.2179	134.1484
2013m5	142.2446	168.2834	56.8742	67.9387	95.7304	134.8942
2013m6	142.8143	169.1100	57.1020	68.2607	96.2223	135.6213
2013m7	143.4502	169.8240	57.3707	68.6242	96.7052	136.3909
2013m8	144.0659	170.5790	57.6431	68.9321	97.2067	137.1630
2013m9	144.6799	171.3162	57.9043	69.2733	97.7015	137.9208
2013m10	145.2985	172.0650	58.1701	69.6065	98.1977	138.6874
2013m11	145.9157	172.8068	58.4355	69.9406	98.6940	139.4516
2013m12	146.5327	173.5522	58.7005	70.2744	99.1904	140.2159
2014m1	147.1501	174.296	58.9656	70.6090	99.6866	140.9803
2014m2	147.7673	175.0405	59.2308	70.9430	100.1830	141.7448
2014m3	148.3846	175.7847	59.4959	71.2772	100.6793	142.5091
2014m4	149.0018	176.5290	59.7610	71.6114	101.1756	143.2736
2014m5	149.6191	177.2733	60.0261	71.9456	101.6720	144.0380
2014m6	150.2363	178.0176	60.2912	72.2798	102.1683	144.8024
2014m7	150.8536	178.7619	60.5563	72.6140	102.6646	145.5668
2014m8	151.4709	179.5062	60.8215	72.9482	103.1609	146.3312
2014m9	152.0881	180.2505	61.0866	73.2823	103.6572	147.0957
2014m10	152.7054	180.9948	61.3517	73.6166	104.1536	147.8601
2014m11	153.3226	181.7390	61.6168	73.9507	104.6499	148.6245
2014m12	153.9399	182.4833	61.8820	74.2849	105.1462	149.3889

Conclusion

Over the time period considered, all the six series showed an increasing pattern, with non-stationarity structures. In order to examine the VAR model, the unit root tests (ADF tests), identification of the number of lags and cointegration analyses were conducted. Unit root tests indicated that all the series were non-stationary and were stationary at first difference at 5% significant level. The Johansen cointegration test suggests that there was at least one cointegration vector, which describes the long run relationship between the prices of Rice, Maize, Garri, Millet, Guinea-Corn, and Beans in Nigeria.

Finally, forecasting is made using vector error correction (VEC) model. Several model's diagnosis measures indicated that the estimated model is good enough to describe the data. Therefore, post forecasts were made for Beans, Rice, Maize, Millet, Guinea-Corn, and Garri from January 2013 to 2014. The result indicated that the prices of all the staple foodstuffs in Nigeria have a steady increment over time.

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EVALUATION OF HOTELLING T^2 AND MULTIVARIATE ANALYSIS OF VARIANCE TESTS

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Abstract: *Multivariate Analysis of Variance (MANOVA) which comprises of Wilks' lambda, Pillai's trace, Lawley-Hotelling trace and Roy's largest Root are compared with Hotelling T square when null hypothesis is true. Data were simulated to compared the five (5) test statistic under the two different distribution (Multivariate Gamma and multivariate Normal), sample size (10, 30, 60, 90, 400, 500, 800, 1000), number of variables $p = 2$ and equal and unequal sample size and variance co – variance matrix. The comparisons were done at two level of significant ($\alpha = 0.01$ and 0.05) using power of the test and type I error rate. The result showed that Roy's largest Root test statistic is better than all other test statistic considered when sample size are equal but Hotelling T square performed better for unequal sample size.*

Keywords: *Multivariate Analysis of variance, Hotelling T square, Type I error rate, power of the test, normality*

Introduction

The purpose of a t-test is to assess the likelihood that the means for two groups are sampled from the same sampling distribution of means. The purpose of an ANOVA is to test whether the means of more than two groups are taken from the same sampling distribution. The multivariate equivalent of the t test is Hotelling T square. Hotelling T^2 tests whether the two vectors of means for the two groups are sampled from the same sampling distribution. MANOVA is the multivariate analogue to hotelling T^2 . The purpose of MANOVA is to test whether the vectors of means of more than two groups are sampled from the same sampling distribution.

MANOVA and Hotelling T^2 are rest on three basic assumptions regarding the population: multivariate normality, equality of group population covariance matrices and independence of errors. When these assumptions are violated, MANOVA does not perform well with respect to Type I error and power. Accurate use and interpretation of these multivariate test statistics is dependent upon the assumptions of independent errors, multivariate normality, and homogeneity of group covariance matrices. When these assumptions are met, the tests perform similarly well with respect to controlling Type I error rates and maintaining appropriate statistical power, particularly in studies with relatively large sample sizes (e.g., Blair, Higgins, Karniski, & Kromrey, 1994); Hotelling, 1931; Johnson & Wichern, 2002; Ramsey, 1982; Stevens, 2001).

Investigations of Type I error rates and power have suggested that these multivariate tests may not perform well when there are violations in assumptions of multivariate normality and equality of covariance matrices (e.g., Hakstian, Roed, & Lind, 1979; Hotelling, 1931; Olson, 1974; Lee, 1971; Pillai, & Jaya, 1967). Perhaps most notable is the performance of Hotelling's T^2 in studies of unequal sample sizes when the assumptions of multivariate normality and particularly equality of covariance matrices has not been met. But (Ito, & Schull, 1964) and (Ito, 1969) have investigated the robustness of Hotelling's T^2 statistic when violating either independent or multivariate normality for large sample sizes. No extensive work has been conducted in this area for small sample sizes. In such cases, the Hotelling's T^2 demonstrated diminished power as the degree of skewness of the response variables increased (Everitt, 1979). Furthermore, when the groups' covariance matrices were not homogeneous, the Type I error rate of the Hotelling's T^2 was inflated when the groups were not of equal size and the smaller group had the larger variances (Hakstian, Roed, & Lind, 1979), (Hotelling, 1931). These results for Hotelling's T^2 are similar to those reported in studies of the performance of Pillai's Trace, Wilk's Lambda, Hotelling-Lawley's Trace and Roy's Greatest Root when there are violations in the assumption of equality

of covariance matrices (Finch, 2005), (Olson, 1974), (Sheehan-Holt, 1998). When the smaller group had the larger variance the Type I error rates were inflated, whereas when the larger group had the larger elemental covariance elements, there was a reduction in power. Non-normality characterized by relatively severe skewness also resulted in a reduction of power (Everitt, 1979), (Finch, 2005). Furthermore, when the assumptions were violated, Pillai's Trace was relatively more robust in terms of Type I error rate control compared to Wilk's Lambda and Hotelling-Lawley's Trace but exhibited somewhat lower power compared to these other tests. Not one of the common MANOVA statistics can be clearly identified as the single best test for use in all situations (Lee, 1971), (Pillai, & Jaya, 1967).

The purpose of this study is to identify the conditions under which each of the five is more robust when the assumption of normality and equality of variance co-variance matrix hold or violated using power and type I error rate. All these will be considered when null hypothesis (H_0) is true and when the number groups (g) and random variables (p) are two.

Methodology

This work targeted at comparison of Hotelling's T^2 and four multivariate analysis of variance (MANOVA) test statistic which are Wilks' Lambda, Pillai's trace, Roy's largest root and Lawley's trace using R statistics.

1. wilks' lambda

$$\Lambda = \frac{|S|}{|H+S|}$$

$$a = N - g - \frac{p-g+2}{2}$$

$$b = \begin{cases} \sqrt{\frac{p^2(g-1)-4}{p^2+(g-1)^2-5}}; & \text{if } p^2+(g-1)-5 > 0 \\ 1 & \text{if } p^2+(g-1)-5 \leq 0 \end{cases}$$

and

$$c = \frac{p(g-1)-2}{2}$$

then

$$F = \left(\frac{1-\Lambda^{\frac{1}{b}}}{\Lambda^{\frac{1}{b}}} \right) \left(\frac{ab-c}{p(g-1)} \right) \sim F_{p(g-1), ab-c, \alpha}$$

2. Hotelling – lawley Trace

$$T_o^2 = \text{trace}(HE^{-1}) = \sum_{i=1}^s \lambda_i$$

Lets

$$s = \min(p, g-1)$$

$$t = \frac{|p-g-1|-1}{2}$$

and

$$U = \frac{N-g-p-1}{2}$$

then

$$F = \frac{2(su+1)}{s^2(2t+s+1)} T_o^2 \sim F_{s(2t+s+1), 2(su+1), \alpha}$$

3. Pillai Trace

$$V = \text{trace}(H(H+E)^{-1}) = \sum_{i=1}^s \left(\frac{\lambda_i}{1+\lambda_i} \right)$$

here

$$F = \left(\frac{2u+s+1}{2t+s+1} \right) \left(\frac{V}{s-V} \right) \sim F_{s(2t+s+1), s(2u+s+1), \alpha}$$

Where $s = \min(p, g-1)$

4. Roy's largest Root

$$\theta = (HE^{-1}) = \frac{\lambda_1}{1+\lambda_1}$$

$$F = \left(\frac{2U+2}{2t+2} \right) \phi_{max} \sim F_{(2t+2), (2u+2), \alpha}$$

$$\phi_i = \frac{\theta_i}{1-\theta_i} = \frac{1-\lambda_i}{\lambda_i}$$

$$\lambda_i = 1 - \theta_i$$

5. Hotelling T Square

$$T^2 = (\bar{x}_1 - \bar{x}_2)' \left[S_p \left(\frac{1}{n_1} + \frac{1}{n_2} \right) \right]^{-1} (\bar{x}_1 - \bar{x}_2)$$

$$S_p^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1 + n_2 - 2}$$

$$F = \frac{n_1 + n_2 - p - 1}{p(n_1 + n_2 - 2)} T^2 \sim F_{p, n_1 + n_2 - p - 1, \alpha}$$

Methods

A simulation using R package was conducted in order to estimate the power of the test and Type I error rate for each of the previously discussed multivariate analysis of variance (MANOVA) test statistic (Wilks' Lambda, Pillai's trace, Roy's largest root and Lawley's trace) and Hotelling T square. In each of the four different scenarios, that is, when: null hypothesis is true, dataset are

Power												
			$\alpha = 0.01$					$\alpha = 0.05$				
Equal variance co- variance matrix	Equal	Wilk	lawley	pillai	Roy	hotel	Wilk	lawley	pillai	Roy	hotel	
		10,10	0.012	0.012	0.012	0.012	0.012	0.143	0.138	0.143	0.130	0.143
		60,60	0.060	0.059	0.060	0.058	0.060	0.103	0.103	0.103	0.103	0.103
		400,400	0.348	0.348	0.348	0.342	0.348	0.055	0.055	0.055	0.055	0.055
		1000,1000	0.110	0.110	0.110	0.110	0.110	0.114	0.114	0.114	0.114	0.114
		10,30	0.185	0.179	0.185	0.142	0.128	0.158	0.154	0.158	0.149	0.129
		60,90	0.035	0.035	0.035	0.035	0.034	0.062	0.062	0.062	0.062	0.062
		400,600	0.068	0.068	0.068	0.068	0.067	0.601	0.601	0.601	0.595	0.596
800,1000	0.152	0.152	0.152	0.152	0.150	0.547	0.547	0.547	0.544	0.541		
Type I Error Rate												
			$\alpha = 0.01$					$\alpha = 0.05$				
Equal variance co- variance matrix	Equal	Wilk	lawley	pillai	Roy	hotel	Wilk	lawley	pillai	Roy	hotel	
		10,10	0.014	0.008	0.014	0.000	0.014	0.058	0.048	0.058	0.009	0.058
		60,60	0.020	0.020	0.020	0.013	0.020	0.096	0.095	0.096	0.085	0.096
		400,400	0.189	0.189	0.189	0.187	0.189	0.389	0.389	0.389	0.385	0.389
		1000,1000	0.582	0.582	0.582	0.580	0.582	0.815	0.815	0.815	0.814	0.815
		10,30	0.028	0.025	0.028	0.005	0.007	0.101	0.097	0.101	0.074	0.055
		60,90	0.026	0.026	0.026	0.021	0.021	0.110	0.110	0.110	0.101	0.102
		400,600	0.230	0.230	0.230	0.225	0.225	0.423	0.423	0.423	0.422	0.419
800,1000	0.518	0.517	0.518	0.512	0.509	0.750	0.750	0.750	0.749	0.745		
Power												
			$\alpha = 0.01$					$\alpha = 0.05$				
Unequal variance co-variance matrix	Equal	Wilk	lawley	pillai	Roy	hotel	Wilk	lawley	pillai	Roy	hotel	
		10,10	0.035	0.033	0.035	0.031	0.035	0.115	0.111	0.115	0.108	0.115
		60,60	0.046	0.046	0.046	0.046	0.046	0.149	0.148	0.149	0.147	0.149
		400,400	0.350	0.349	0.350	0.343	0.350	0.086	0.086	0.086	0.086	0.086
		1000,1000	0.112	0.112	0.112	0.111	0.112	0.073	0.073	0.073	0.073	0.073
		10,30	0.102	0.099	0.102	0.087	0.072	0.593	0.581	0.593	0.461	0.468
		60,90	0.151	0.149	0.151	0.142	0.143	0.077	0.076	0.077	0.076	0.075
		400,600	0.075	0.075	0.075	0.074	0.074	0.535	0.535	0.535	0.530	0.530
800,1000	0.056	0.056	0.056	0.055	0.055	0.057	0.057	0.057	0.057	0.057		
Type I Error Rate												
			$\alpha = 0.01$					$\alpha = 0.05$				
Unequal variance co-variance matrix	Equal	Wilk	lawley	pillai	Roy	hotel	Wilk	lawley	pillai	Roy	hotel	
		10,10	0.020	0.018	0.020	0.000	0.020	0.061	0.055	0.061	0.018	0.061
		60,60	0.021	0.019	0.021	0.016	0.021	0.080	0.077	0.080	0.068	0.080
		400,400	0.072	0.072	0.072	0.069	0.072	0.179	0.178	0.179	0.174	0.179
		1000,1000	0.179	0.179	0.179	0.176	0.179	0.430	0.430	0.430	0.430	0.430
		10,30	0.086	0.082	0.086	0.045	0.047	0.209	0.204	0.209	0.163	0.139
		60,90	0.031	0.030	0.031	0.026	0.028	0.082	0.081	0.082	0.074	0.076
		400,600	0.111	0.111	0.111	0.110	0.110	0.245	0.243	0.245	0.241	0.239
800,1000	0.196	0.196	0.196	0.194	0.192	0.407	0.407	0.407	0.406	0.402		

normal or not, equality of variance co-variance matrix hold or not. Two factors were varied in the simulation: Sample size (n) and significant levels (α).

Data Generation

In each of the 1000 replications and for each of the factor combination, $n_1 \times p$ data matrix X_1 and $n_2 \times p$ data matrix X_2 were generated using an R package for Multivariate Normal and Gamma. The programme also performs the (Box, 1949) test for equality of covariance matrices by using the statistic:

$$M = c \sum_{i=1}^k (n_i - 1) \log |S_i^{-1} S_p| ,$$

Where

$$S_p = \frac{\sum_{i=1}^k (n_i - 1) S_i}{n - k}$$

$$c = 1 - \frac{2p^2 + 3p - 1}{6(k-1)(p+1)} \left[\sum_{j=1}^k \frac{1}{n_j - 1} - \frac{1}{n - k} \right]$$

$$\chi^2_B = (1 - c)M$$

And S_i and S_p are the i -th unbiased covariance estimator and the pooled covariance matrix respectively.

Box's M also has an asymptotic chi-square distribution with $\frac{1}{2}(p+1)(k-1)$ degree of freedom.

Box's approximation seems to be good if each n_i exceeds 20 and if g and p do not exceed 5 (Mardia, Kent, & Bibby, 1979)

H_0 is rejected at the significance level α if $\chi^2_B > \chi^2_{\alpha(p)}$.

Results

Table 1: Multivariate Normal

Table 2: Multivariate Gamma

			Power									
			$\alpha = 0.01$					$\alpha = 0.05$				
Equal variance co-variance matrix	Equal sample	10,10	Wilk	lawley	Pillai	Roy	hotel	Wilk	lawley	pillai	Roy	hotel
		60,60	0.051	0.048	0.051	0.043	0.051	0.052	0.051	0.052	0.052	0.052
		400,400	0.024	0.024	0.024	0.024	0.024	0.238	0.236	0.238	0.231	0.238
		1000,1000	0.029	0.029	0.029	0.029	0.029	0.086	0.086	0.086	0.086	0.086
		10,30	0.073	0.073	0.073	0.073	0.073	0.110	0.110	0.110	0.110	0.110
	Unequal sample	60,90	0.429	0.416	0.429	0.272	0.301	0.124	0.122	0.124	0.120	0.104
		400,600	0.046	0.046	0.046	0.045	0.044	0.106	0.106	0.106	0.106	0.104
		800,1000	0.203	0.203	0.203	0.200	0.200	0.266	0.266	0.266	0.265	0.263
			0.011	0.011	0.011	0.011	0.011	0.069	0.069	0.069	0.069	0.069
			Type I Error Rate									
Equal variance co-variance matrix	Equal sample	10,10	$\alpha = 0.01$					$\alpha = 0.05$				
		60,60	Wilk	lawley	Pillai	Roy	hotel	Wilk	lawley	pillai	Roy	hotel
		400,400	0.008	0.006	0.008	0.000	0.008	0.051	0.047	0.051	0.006	0.051
		1000,1000	0.007	0.007	0.007	0.005	0.007	0.064	0.063	0.064	0.056	0.064
		10,30	0.019	0.019	0.019	0.019	0.019	0.088	0.087	0.088	0.087	0.088
	Unequal sample	60,90	0.055	0.055	0.055	0.053	0.055	0.151	0.151	0.151	0.149	0.151
		400,600	0.035	0.034	0.035	0.012	0.015	0.120	0.112	0.120	0.076	0.063
		800,1000	0.025	0.025	0.025	0.018	0.022	0.069	0.068	0.069	0.063	0.063
			0.030	0.030	0.030	0.029	0.029	0.098	0.098	0.098	0.096	0.093
			0.053	0.053	0.053	0.053	0.052	0.128	0.128	0.128	0.127	0.124
Unequal variance	Equal sample	10,10	$\alpha = 0.01$					$\alpha = 0.05$				
		60,60	Wilk	lawley	Pillai	Roy	hotel	Wilk	lawley	pillai	Roy	hotel
		400,400	0.028	0.027	0.028	0.026	0.028	0.093	0.090	0.093	0.089	0.093
		1000,1000	0.031	0.031	0.031	0.031	0.031	0.061	0.061	0.061	0.061	0.061
		10,30	0.054	0.054	0.054	0.054	0.054	0.244	0.244	0.244	0.243	0.244
	Unequal sample	60,90	0.033	0.033	0.033	0.033	0.033	0.089	0.089	0.089	0.089	0.089
		400,600	0.033	0.033	0.033	0.033	0.033	0.089	0.089	0.089	0.089	0.089
		800,1000	0.015	0.015	0.015	0.015	0.014	0.068	0.067	0.068	0.067	0.063

Unequal variance co-variance matrix	Equal sample	60,90	0.016	0.016	0.016	0.016	0.016	0.150	0.150	0.150	0.149	0.146
		400,600	0.103	0.103	0.103	0.102	0.101	0.394	0.394	0.394	0.391	0.390
		800,1000	0.016	0.016	0.016	0.016	0.015	0.207	0.207	0.207	0.207	0.205
	Type I Error Rate											
	$\alpha = 0.01$						$\alpha = 0.05$					
	Unequal sample		Wilk	lawley	Pillai	Roy	hotel	Wilk	lawley	pillai	Roy	hotel
		10,10	0.015	0.012	0.015	0.000	0.015	0.062	0.052	0.062	0.010	0.062
		60,60	0.013	0.013	0.013	0.010	0.013	0.063	0.061	0.063	0.057	0.063
		400,400	0.023	0.022	0.023	0.021	0.023	0.113	0.113	0.113	0.111	0.113
		1000,1000	0.050	0.050	0.050	0.048	0.050	0.150	0.150	0.150	0.149	0.150
		10,30	0.073	0.071	0.073	0.033	0.038	0.224	0.218	0.224	0.174	0.138
		60,90	0.029	0.028	0.029	0.022	0.025	0.076	0.075	0.076	0.073	0.073
	400,600	0.036	0.036	0.036	0.035	0.035	0.102	0.101	0.102	0.100	0.099	
	800,1000	0.051	0.051	0.051	0.049	0.047	0.129	0.129	0.129	0.128	0.128	

When sample size are equal and data are multivariate normal, Roy has Largest power of the test and type I error rate are better than others, but when sample size are not equal Hotelling T^2 is better than others in terms of power of the test and type I error rate when null hypothesis is true. But when data are multivariate normal and and variance co – variance matrix are not equal, Hotelling T^2 , Wilk lambda and Pillai performance are better in term of power of the test and type I error rate are roughly equivalent while Lawley – Hotelling trace is better than the three mentioned but Roy's largestrootis the best. When sample sizes are not equal and very large, Hotelling T^2 is better than all the other test statistic (Table 1).

When data are multivariate Gamma, the performance of the test statistic are in this order Wilks' lambda $\geq$ Pillai' trace $\geq$ Hoteling T square $\geq$ Lawley – Hotelling trace $\geq$ Roy's largest root, but when the sample size are not equal the order change to Wilks' lambda $\geq$ Pillai' trace $\geq$ Lawley – Hotelling trace $\geq$ Roy's largest root $\geq$ Hoteling T square. Meaning that Hotelling T^2 is better. (Table 2).

When the three assumption hold with small sample size the power and type I error rate are smaller compare to when equality of variance covariance matrix is violated, but when the sample size are very large it control the power and type I error rate. When assumption of normality isviolated, the power is very high and is reducing as sample size is increasing when sample size are not equal. That is to say when sample size are not equal and very small, the power will be very high, but when the sample size are equal it does not have much effect on power and type I error rate. And when the three assumptions failed the type I error rate will be higher than when one of the assumption failed.

From all indication, Roy's largest root is more robust for two random variables with equal sample size, while Wilk' lambda, Hotelling T^2 and pillai's trace performed the same way in terms of power all through. Hoteling T^2 shows its superiority when sample sizes are not equal and exceptionally large.

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GENDER PREFERENCE IN CHILD BEARING AS PERCEIVED BY WORKERS IN KWARA STATE, NIGERIA

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Abstract

The focus of this study is to study the gender preference in child bearing as perceived from the perspective of workers in Ilorin South Local Government Area of Kwara State. The research instrument has a self-designed questionnaire named Gender preference questionnaire (GPQ). This was used to gather data from 100 respondents among the workers in the Local Government. In analyzing the data, frequency counts, descriptive analysis, Chi-square statistics were employed. The significant level of making decision was the α level of 0.05. The Chi-square analysis confirmed that gender preference is independent on religion, educational level and age, that is religion, educational level and age does not determine gender preference among workers in Ilorin south local government area. This means that gender preference is based on individual mentality irrespective of the religion, educational level and age. Seminars, conference and workshops should be organized periodically for adult members of the society to enlighten them that all gender are important and can equally perform in the family, societal growth and development. There should be cooperation among couples especially when their particular sex preference is not met.

Keywords: Gender, Preference, Child Bearing, Societal growth and Development, Perception

Introduction

In view of the serious general concern on the dangers inherent in gender preference in the country (Nigeria), an attempt to discuss issues relating to gender equality, (one of the eight (8) millennium Development Goals) in all sectors of Nigeria economy becomes pertinent and desirable. The bulk of the literature on gender preferences deals with less developed countries, where mainly the desire for a balanced number of daughters and sons (or at least one child of each sex) and a preference for sons (often together with a balance preference) is observed. For instance, Arnold (1997) provides a detailed study of 44 countries with Demographic and Health Surveys in the period from 1986 to 1995.

He finds son preference in a range of different countries, demonstrating that such preferences do not emerge from a single set of historical and cultural experiences. While the Southeast Asian nations do not show any consistent gender preference, the Caribbean is the only region studied by Arnold, where a prevalent preference for daughters has been found. In general, however, he argues that the effect of gender preferences on fertility and family planning is not very strong.

Parents' gender preferences for children are embedded in cultural and religious traditions and community norms, shaping individual attitudes and behavior. Children of a particular sex are often desired in order to provide certain utilities or to minimize financial or psychological costs (Wood & Bean, 1997). In traditional societies, male offspring are presumed to have greater economic net utility than daughters, since they provide assistance in agriculture, as well as a primitive social security system.

In some situations, however, daughters are thought to be more reliable in providing old age assistance, particularly emotional support. They are also frequently desired in order to help with household tasks or to care for younger children. Sons, on the other hand, quite often fill sex-specific religious roles and insure kinship continuity in patrilineal societies. There is some evidence that the desire for additional children (if there is any at all) is curtailed once the

minimum number of surviving male children is achieved (Wood & Bean, 1997). However, even in societies with pervasive son preference, many families consider it important to have at least one daughter among their children (Aborisade, 1997).

In Nigeria, the wave of gender preference is rising in a geometrical progression as can be seen in the rising agitation of the female members of the societies. Female “protest” is seen in the birth of several gender sensitive organization e.g Association of female lawyers, Christian Association of Nigeria women wing (CANWOW), National Association of women in Academics Association (NAWACS), Federation of Nigeria Muslim women association of Nigeria (FOMWAN), Federation of women Lawyers (FWL). Adebisi (1983) in his study of the preference for male children in Nigeria society found that the systemic blood pressure of pregnant mother with only female children was significantly higher when compared with those that have male children.

Also, Owuamanam (2001) in a study of Ekiti Yoruba speaking people of Nigeria found that spouses preferred having sons to daughters because of the continuity of family name. Even, the mother of only female children feels disappointed while the man becomes the more aggressive. He further observed that this problem causes a lot of conflict in family; as spouses may want to commit adultery to make up for the loss and to please relations or spouse. Adebisi (1983) and (Owuamanam, 2001) revealed that there is strong preference for male children in Nigeria and other parts of the world. It seems, naturally, that women are being put down. This perhaps is the reason behind the agitation of liberation, emancipation, and equality with the male folk by the women. The marriage system in Nigeria has contributed to gender preference. For instance, when a lady is married, she takes on the husband's name, culture and religion in the light of this practice, most couples would want to have male children inherit the father's name and business if all is equal.

Gender preferences for children in less developed countries have been a concern to many scholars and policy makers because of their potential negative social and demographic consequences. For example, pronounced gender preferences can lead to sex-selective abortions and hence skewed sex ratios at birth. Such instances have been documented in countries like China and South Korea where a strong son preference is responsible for abnormally masculine sex ratios (see for example, Goodkind, 1996). Gender preferences, especially son preference, can also result in sex differentials in infant and child mortality. Since female children are biologically less vulnerable than males (Waldron, 1998), female children typically have lower mortality rates than male children. Nonetheless, female infant/child mortality rates exceed male infant/child mortality in some societies suggesting that discriminatory practices by adults favoring boys over girls may be taking place (Waldron, 1983); (Wood & Bean, 1997). A related negative consequence arises from parental gender bias in the provision of basic care such as breastfeeding, nutrition, immunizations, medical treatment, and schooling. Therefore, although such gender bias may not go as far as leading to infanticide, gender preference may still be related to the health and well-being of children more generally. The implication of persistent gender preference in the context of transitioning countries experiencing rapid fertility decline has also attracted attention. It has been debated whether son preference in countries where fertility rates are falling will eventually prevent further decline as couples will continue to have additional children until they bear a child of the preferred sex. In this case, at the individual level, gender preference is associated with parity progression and contraceptive uptake; and at the aggregate level, it has implications for population growth. Alternatively, pervasive gender preference in the context of rapid fertility decline may lead to an intensification of gender preference because couples need to ensure they bear a child of the desired sex (or a certain combination of the sexes) within a smaller family size. This results in an intensified gender bias which increases a demand for sex-screening technologies but may not necessarily be a barrier to reducing fertility. The issue of gender preferences for children may also have social and demographic implications in developed and developing countries with low levels of fertility. Countries with strong sex preference coupled with strict fertility regulations (e.g. China's One Child Policy) have encountered an issue of imbalanced sex ratios at birth (Coale, & Judith, 1994); (Johansson, &

Ola, 1991). Therefore, an emergence of skewed sex ratios at birth is a likely scenario if a specific sex preference is pronounced in a society with low fertility. In the context of very low fertility where most women who have children have only one child, it may become more critical for their first or only child to be of the sex they desire. Since today's reproductive technologies can hypothetically give parents the ability to control the sex of their offspring, individuals with a specific sex preference may turn to such technologies to ensure that the sex of a child (or sex composition of children) is of their choice. If a certain sex preference persists in these countries and is acted on, it can lead to an imbalance in the sex ratio of the population. This will raise further issues such as gender imbalance in the marriage market with potential ramifications for future fertility, and in the labor market requiring a reorganization of traditionally predominantly female sectors of the economy. Thus, gender preferences for children in low fertility countries need to be addressed not only for their bioethical implications but also for their potential demographic and socioeconomic consequences.

Most prior research on gender preferences for children have studied the extent of gender preference through observable behavior measures such as the practice of sex-selective abortions, imbalance in sex ratios, sex differentials in infant/child mortality, and gender disparity in the health and well-being of children. Studies have also examined gender preference in terms of parity progression, and the contraceptive use of women with certain sex compositions of surviving children. Adebisi (1983) studied the preference for male children in the Nigerian society and found that the systolic blood pressure of pregnant mothers with only female children was significantly higher when compared to those with only male children.

In terms of individual characteristics, there are several socioeconomic variables that may influence individuals' gender preferences for children. One of the most important socioeconomic variables is education. As emphasized in the wealth-flows theory, mass education serves to reverse the wealth-flow from child-to-parent to parent-to-child because it alters children's roles (Caldwell, 1980). In addition, mass education exposes people to new values including egalitarian values and the notion of Westernized nuclear families. Therefore, exposure to Western values promoted through education may modify gender preferences for children. In other words, individuals who have had schooling may have egalitarian values, hence may not have strong preferences for children of one gender.

Changes accompanying urbanization and industrialization also have implications for gender preferences for children. In agrarian societies, intergenerational transfer of land is critical, thus land inheritance norms may affect perceptions of the relative importance of sons and daughters. In some societies, land is passed on only to sons regardless of inheritance laws. In extreme situations such as in strictly patrilineal societies, wives are not considered as members of the family for land inheritance purposes, and daughters of the deceased cannot inherit any land (Butegwa, 1994). Under these circumstances, sons may be more highly valued than daughters. For example, it has been reported that in rural Kenya, women want sons because women are granted access to land only through male children when they become widows (Korman, 1970).

However, gender preferences may be alleviated with urbanization and industrialization. Since urbanites engage in non-agricultural labor, intergenerational transfer of property such as land may be a less significant issue. Therefore, urban residents and individuals in the non-agricultural labor force may be less likely to have gender preferences for children, especially son preference. According to the new home economics model, individuals who are wealthier and whose opportunity costs are higher (especially women in the labor force) desire higher quality children, and would therefore prefer the sex of the child that brings relatively more important qualities. It is conceivable that wealthier couples may have less preference for sons while less wealthy families desire sons. Among couples who are already well-off, having a son that brings financial help to the family may not be as important. On the other hand, couples who are less well-off may have high hopes for a son for their economic returns. Also, employed women may perceive that their opportunity costs for raising a daughter are lower than for raising a son. Since

daughters are expected to provide help with household chores, women may not require as much time off from employment to perform household duties if they are raising daughters. Additionally, "companionship" for psychological gratification may be what wealthier employed women want most from a child since they have the means to acquire everything else (i.e. goods and services). Hence, wealthy individuals and employed women are less likely to have son preference. Employed women may in fact have a preference for a daughter.

In India, there is a decrease in son preference attitudes with the modernizing influence of education and urbanization as well as some evidence for a decline in son preference with the rise in wealth and wage employment of women (Bhat, Mari, & Francis, 2003). Similarly, in rural India, there was a reduction in son preference effects on contraception and fertility with increasing levels of women's education and household economic conditions (Arokiasamy, 2002). In another study of rural India, women's education, especially at secondary and higher levels, was consistently associated with weaker son preference regardless of family size (Renee, 1993). However, in the same study of rural India, wealth and women's employment were not significantly related to son preference once contextual cultural variables such as religion and marriage customs were controlled for (Renee, 1993). In Nepal, another south Asian country, women's educational level was associated with stopping behavior after the birth of a boy (Marshall, 1989).

Education and wealth do not always produce the same effects in South Asia, however. Das Gupta (1987) found that in Panjab, a northwestern state of India, women's education was associated with reduced child mortality but stronger discrimination against higher birth order girls. The author attributes this unconventional finding to the fact that educated women are reducing their family size but are still pressured to have at least one or two sons while having fewer daughters. Moreover, educated women are better equipped to manipulate their completed family size and sex composition of children. Also, in the southern state of Tamil Nadu (India), contrary to conventional expectation, couples that are socially or economically well-off were more conscious about having sons [8]. There is a narrowing of class differentials in terms of worsening sex ratios at birth and sex ratios of child mortality which appears to be, as the author puts it, "occurring not because the better-off are reverting to more egalitarian behavior, but because the poorest groups are now imitating those better off than themselves" (Basu, 1999).

The female folk should accept the stance of (Owuamanam, 2001) who opined that women are an indispensable force to be reckoned with in any society, also (Ekejuba, 1990) who noted that in terms of national developmental needs, woman have remained invisible, the case of Thailand as reported by yoddumnernattig and cited by (Arnold, 1992) reveals that; parents regard education of their children as paramount, and there is no difference in educating girls and boys in fact daughters receive preference for advanced studies because: It furnished them with jobs that guarantee regular salary, Girls are expected to support their ageing parents and Daughter's education represents her inheritance.

In a comparative analysis of gender preferences in 17 European countries, using data from family and fertility surveys (FFS) collected in the 1990s; Hank, and Kohler (2000) found that despite detectable cross-national heterogeneity, there is a strong tendency towards a preference for a mixed sex composition (if any preference is found at all.). Haughton, and Haughton, (1993) Observed that as societies develop, male preference if present should decline and female should be treated increasingly more equal. But this study aimed at gender preference in child bearing in a local government area in kwara state, Nigeria. Considering three variables, namely: education, religion and age. How they have effect on gender preference in child bearing so as to generalized it, in the state.

Statement of the problem

The problem posed in this study and to be researched on is the perception of workers in the study area, of gender preference in child bearing. To investigate workers' perception base

religion, educational qualification and age group. Also to suggest possible ways by which gender preference and bias could be discouraged.

Research Questions

This research work tends to provide answer to the following questions:

- (i) Does workers' perception of gender preference independent on their religion?
- (ii) Does workers' perception of gender preference in child bearing independent on the basis of educational qualification?
- (iii) Does workers' perception of gender preference in child bearing independent on the basis of age?

Methodology

Research Design

The research design for this study is descriptive survey design. The research is non – experimental and therefore variables were not manipulated. This makes descriptive survey research design suitable for this study. This design also accommodates generalization of findings of the study upon the target population from which only a representative sample was actually studied.

Target population and Sample

The research respondents for this study were the civil servants in Ilorin south Local Government, Kwara state, Nigeria. A total of 100 workers were drawn from various departments of the local Government. This was selected five (5) departments in the local government. Twenty (20) respondents from each department were selected using random sampling technique.

Instrument

The research instrument was Gender Preference Questionnaire (GPQ) designed by the researchers. It has Section A with ten items dealing with profile of the respondents such as gender, age, religion, Ethnic group, marital status, type of marital union, educational qualification, Number of children ever born, sex prefer, reason for preferring a particular sex. Section B has 25 items that measured the perception about gender preference in Ilorin South local government. The respondents were asked to respond to the questions on a four point Likert. Scale of strongly agree (SA = 4), agree (A = 3), disagree (D = 2) and strongly disagree (SD = 1).

Results

Research Question One: Does worker's perception of gender preference is independent on their religion?

Table 1: Religion and gender preference

Chi – square Test			
	Value	df	Asymp. Sig.(2 sided)
Pearson Chi – Square	1.693 ^a	2	0.429
Likelihood Ratio	1.986	2	0.370
Linear-by-Linear	0.848	1	0.375
Association	100		
N of valid cases			
Symmetric Measures			
		Value	Asymp. Sig
Nominal by Nominal	Phi	0.130	0.429
	Cramer's V	0.130	0.429
N of valid cases		100	

NS = Not significant ($p > 0.05$)

Table 1 indicates that the probability of chi-square test statistics [chi-square = 1.693 is $p = 0.429$] which is greater than a level of significant of 0.05 meaning that $\alpha = 0.05$ the null hypothesis of independent cannot be rejected in favour of the alternative. The research hypothesis that gender preference is dependent on religion is not supported by this analysis. Therefore, Gender preference is independent of religion. In the above table, phi (0.130) and Cramer's V (0.130) both test the strength of association between the variables. And they show poor or weak dependability of gender preference on religion in the study area.

Research Question Two

Does workers' perception of gender preference in child bearing independent on the basis of educational qualification?

Table 2: Educational level and Gender Preference

Chi – square Test			
	Value	df	Asymp. Sig. (2 sided)
Pearson Chi – Square	1.234 ^a	3	0.745
Likelihood Ratio	1.169	3	0.761
Linear-by-Linear	0.449	1	0.503
Association	72		
N of valid cases			
Symmetric Measures			
		Value	Asymp. Sig
Nominal by Nominal	Phi	0.131	0.745
	Cramer's V	0.131	0.745
N of valid cases		72	

NS = Not significant ($p > 0.05$)

From the above table 2 the probability of Chi-Square test statistic (Chi-square = 1.234 is $p = 0.745$) which is greater than a level of significant of 0.05 therefore do not reject at $\alpha = 0.05$, hence concluded that gender preference is independent of educational level. The research hypothesis that gender preference is dependent of educational level is not supported by this analysis. The phi (0.745) and Cramer's (0.745) the two test display in the above table, explain the strength of the dependability of gender preference on educational level of the respondents which is very weak phi and Cramer's = 0.131 respectively.

Research Question Three

Does workers' perception of gender preference in child bearing independent on the basis of age?

Table 3: Age and Gender Preference

Chi – square Test			
	value	df	Asymp. Sig. (2 sided)
Pearson Chi – Square	9.378 ^a	4	0.052
Likelihood Ratio	9.344	4	0.053
Linear-by-Linear	1.483	1	0.223
Association	100		
N of valid cases			

NS = Not significant ($p > 0.05$)

Table (3) shows that, the probability of Chi-Square test statistic (Chi-Square = 9.378 is $p = 0.052$) which is greater than a level of significant of 0.05 therefore the research hypothesis that there is no association between respondent age and gender preference are supported by this analysis at $\alpha = 0.05$ Hence it is concluded that gender preference does not depend on the age of respondent base on the available data for this analysis

Discussion

The study revealed that the gender preference is independent of religion, that is opinion of one preferring a particular sex than the other has nothing to do with the religion, Phi and Cramer's V of 0.130 in table 1 show poor or weak dependability of gender preference on religion in the study area.

The research hypothesis that gender preference is independent on educational level is supported by this analysis, which means that level of education does not depend on preference for gender. Because education is also likely to have an empowering effect for women. Since education allows women to explore opportunities other than traditional domestic roles, women may realize that they can attain status through opportunities other than through motherhood, especially through bearing and rearing of sons. Moreover, simply being exposed to the notion that females have other opportunities may be sufficient to change their perception of the value of daughters., Phi and Cramer's V of 0.131 in table 2 show poor or weak dependability of gender preference on education in the study area.

From table 3 the research hypothesis that there are independent between respondent age and gender preference are supported by this analysis. Hence this concludes that gender preference does not depend on the age of respondent base on the available data for this analysis.

Conclusion and Recommendations

Gender preference is independent on religion, educational level and age, that is religion, educational level and age does not determine gender preference among workers in Ilorin south local government area. This means that gender preference is based on individual mentality irrespective of the religion, educational level and age.

The war against gender bias should not be limited to lip service. There should be action plans drawn to execute it.

Seminars, conferences, and workshops should be organized periodically for adult members of the society so as to be able to recognize the fact that all gender are important and can equally perform in the family, society growth and development. There should be co-operation among couples especially when their particular sex preference is not met. Group counseling services must be put in place among students of different gender as a way to foster co-operation, unity of purpose and understanding. The policy makers should encourage individuals on the basis of their observed abilities and not on gender configurations in terms of appointment and replacement. Parents are fond of feeling anxious to knowing the sex of an unborn babies, this type of anxiety should not be allowed to create unnecessary tension in the family, and should not allow the over dosage of this feeling to weigh them down.

The government should regularly pay proper attention to the activities of United Nation Millennium Development Goal in the country as this will enhance the achievement of the Millennium target on gender equalities in every sector of the Nation's economy by the year 2015.

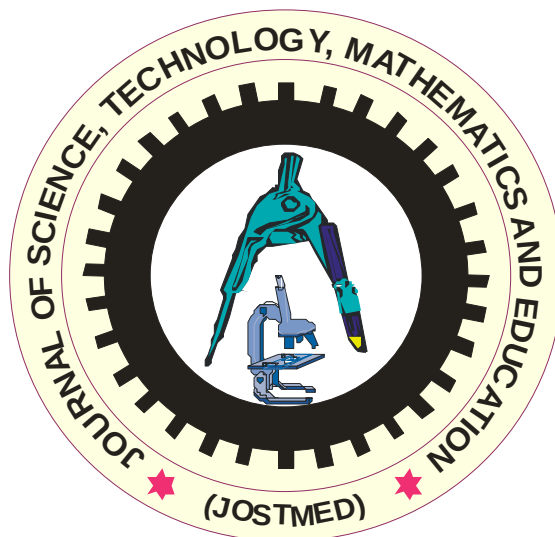
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ARTICLES AND RESEARCH REPORTS ON EDUCATION

CIVIL SERVANTS' ICT SELF-EFFICACY, AWARENESS AND READINESS FOR DISTANCE E-LEARNING PROGRAMMES' ENROLMENT IN MINNA, NIGER STATE, NIGERIA

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Abstract

The benefit of distance learning is enormous and knowledge obtained through such platforms would make civil servants more efficient and productive in their offices. However, because it was not clear whether civil servant in Minna have ICT self-efficacy, adequate awareness and readiness to enroll for distance e-learning programmes, this study was carried out. Cross sectional survey research was adopted for the study in which four research questions were raised and answered. The sample of the study consisted of 1,280 participants drawn from 10 Niger state government Ministries, Departments and Agencies (MDAs) located in Minna through simple random sampling procedure. A researchers-designed questionnaire validated by educational technology and computer experts was used in collecting data from the respondents. To determine the internal consistency of the items of the questionnaire, it was administered once in a pilot study on 120 civil servants from three MDAs who did not participate in the main study. Reliability coefficients of 0.76 and 0.81 were respectively obtained for items on ICT self-efficacy and for items on distance e-learning readiness using Cronbach Alpha formula. Data gathered from the administration of the questionnaire on participants were analysed using percentage, mean and standard deviation to provide answers to the research questions. Findings revealed that majority of civil servants (72.19%) are aware of the existence of distance e-learning platforms, only 9.92% of them currently enrolled for distance e-learning programmes, have self-efficacy (mean = 3.69 out of 5) in the use of Information Communication Technology tools for distance e-learning and that they are not ready (mean = 2.34 out of 5) to enroll for distance e-learning programmes. It was therefore recommended among others that civil servants should be encouraged to enroll for relevant distance e-learning programmes through financial assistance, loans and study scholarships in order to make them acquire knowledge that will make them better efficient and more productive in their offices.

Keywords: *Civil servants, Distance e-learning, Distance e-Learning Enrolment, E-learning Readiness, ICT Self-efficacy*

Introduction

Information and Communication Technology (ICT) refers to a range of technologies that are applied in the process of collecting, storing, editing, retrieving, and transferring information in various forms. In recent years, there has been an exponential growth in the use of ICT tools and this has made great impact both on society and on people's daily lives. It is therefore not surprising to see the increasing interest, attention and investment being put into the use of ICT in education all over the world (Saddam, Gellie & Shelanee, 2012). Notably, ICT has improved the communication between lecturers and students, and the interaction between different educational resources. Oliver (2002) asserted that the use of ICT in higher education enhances student-centered learning.

Ever since universities were founded by the colonialists and nationalists, there has still been need for distance education for learners who could not access regular university programmes because of their employment and family commitments (Omoregie, 2009). These categories of learners are those who could not meet strict regular university programmes' criteria and continually depend on open distance learning. United Nation Educational, Scientific and Cultural Organizations (UNESCO, 2002) equally stated that distance e-learning represents approaches that focus on opening access to education and training provision, freeing learners from constraints of time and place and offering learning opportunities to individuals and group of

learners. (Gesci, 2007) enumerated the features of distance e-learning to include: openness to learners, learner-centred approach, and independent learning media-supported interaction among others. Some of the goals of open and distance education as stated by the Federal Republic of Nigeria in the National Policy on Education (FRN, 2013) are to provide access to quality education and equity in educational opportunities for those who otherwise would have been denied and also to meet special needs of employers by mounting special certificate courses for their employees at their work place. Civil servants fit into these categories of people.

Civil servants are employees who work in government departments and agencies. In Nigeria, they are direct employees of the Federal and State governments, and even other Para-military forces like police, Immigration, customs and armed forces personnel are employees of statutory corporations and board's members (National Open University of Nigeria, 2014). In Minna, the capital of Niger State, civil servants form the bulk of the labour workforce and are primarily engaged by government to improve the socio-economic situation of the state. Knowledge needed to work productively as civil servants is acquired in tertiary institutions and certificate obtained serves as evidence that such knowledge has been acquired. It is generally believed that the higher the academic qualification of an employee, the more knowledgeable he is, and such knowledge is expected to be reflected in his work output, efficiency and productivity. Information Communication Technology self-efficacy enhances workers' productivity and is also crucial in distance e-learning enrolment.

Self-efficacy is regarded as knowledge, proficiency and capability associated with high performance on a job (Kirti, Mann & Gupta, 2014). With respect to the use of ICT, civil servants' self-efficacy in using relevant ICT tools needed in distance e-learning can be defined as the proficiency and capability to use computer technology to interact with instructional contents, tutors and fellow students as well as the proficiency to use same technology for examination purposes.

Oye, Lahad, and AbRahim (2012) reported that self-efficacy has been found to influence choices of whether to engage in a task, the efforts expended in performing it, and the persistence shown in accomplishing it. They added further that, the greater people perceived their self-efficacy to be, the more active and longer they persist in their efforts. Findings from a previous study conducted by Saddam, Gellie, and Shelanee. et al (2012) indicated that students have excellent self-efficacy towards ICT while another finding from a study conducted by Oye, et al. (2012) indicated that academic members of staff have moderate self-efficacy towards computer and ICT tools. While self-efficacy on the use of ICT tools is essential in civil servants' enrolment for distance e-learning programme, readiness to undergo such programme is another factor.

Borotis and Poulymenakou (2008) defined readiness as the mental or physical preparedness of an individual for some e-learning experience or action. Schreurs, Ehlers and Sammour (2008) stated that learner's readiness is essential for him to successfully engage in electronic learning. A prospective electronic distance learner needs to be mentally and financially ready to successfully enrol for distance e-learning programme.

A large number of civil servants that joined the workforce with lower qualifications may wish to further their education and acquire additional knowledge that will make them contribute more meaningfully to the socio-economic growth of their society. Although, the demand for tertiary education in traditional institution of learning remains on the high side, yet, prospective students have limited access to gain admission (Adedipe, 2007 & Moti 2010). However, due to job and family commitments, civil servants may not be able to enrol for conventional face-to-face higher education programmes but can enrol for electronic distance learning courses in accredited institutions if they have self-efficacy in the use of needed ICT tools.

Despite the enormous benefits of distance e-learning, it was not clear whether civil servant in Minna, Niger State Nigeria have ICT self-efficacy, adequate awareness and readiness to update

their knowledge through distance e-learning platforms and contribute more meaningfully to the social-economic growth of Minna. This study was therefore carried out to investigate civil servants' ICT self-efficacy, awareness and readiness to enrol for relevant distance e-learning programmes in Minna, Niger State Nigeria.

Purpose of the Study

The main purpose of this study was to determine the ICT self-efficacy of civil servants, their awareness and readiness to enrol for relevant distance e-learning programmes. Specifically, the study sought to investigate the extent to which civil servants in Minna, Niger State Nigeria are:

- (i) Aware of the existence of distance e-learning platforms;
- (ii) Currently undergoing programmes using distance e-learning platforms;
- (iii) Having self-efficacy in the use of relevant information and communication technologies; needed in distance e-learning; and
- (iv) Ready to enrol for relevant distance e-learning programmes.

Research Questions

The following research questions were answered in this study:

- (i) To what extent are civil servants in Minna, Niger State aware of the existence of distance-learning platforms?
- (ii) To what extent are civil servants in Minna, Niger State currently undergoing programmes using distance e-learning platforms?
- (iii) Do civil servants in Minna, Niger State have self-efficacy in the use of relevant information and communication technologies needed in distance e-learning?
- (iv) To what extent are civil servants in Minna, Niger State ready to enrol for relevant distance e-learning programmes?

Methodology

Cross sectional survey design was adopted for this study. It involves the use of questionnaire to elicit needed responses from civil servants on their ICT self-efficacy, awareness and readiness to enrol and update their knowledge through distance e-learning platforms. A total of 1,280 out of the 3,550 civil servants in Minna, Niger State, Nigeria was used as the participants of the study. Firstly, simple random sampling technique was employed to select 10 out of the 23 Niger State Ministries and Government Agencies (MDAs) located within Minna. Thereafter, simple random sampling procedure was used to select 128 participants from each of the 10 selected MDAs.

A researchers-designed questionnaire named Civil Servants Awareness and Readiness Questionnaire (CSARQ) was used to elicit responses from the participants. The questionnaire consists of four sections (Sections A, B, C & D). Section A was designed to collect demographic data from the participants, Section B deals with the distance e-learning awareness and enrolment status of civil servants. Section C consists of 16 items concealed with the self-efficacy of civil servants on the use of ICT tools needed for distance e-learning while Section D consists of 9 items on the readiness of civil servants to enrol for distance e-learning programmes. The questionnaire was validated by two Educational Technology experts and one Computer experts at Federal University of Technology, Minna, Nigeria. Based on experts' suggestions, four items of the questionnaire were restructured; two new items were added and two items were removed.

To determine the reliability of the questionnaire, a pilot study was conducted on 120 civil servants randomly selected from three Niger State Ministry, Departments and Agencies who were not part of the participants for the main study and reliability coefficients of 0.76 and 0.81 were obtained respectively for items in Section B on ICT self-efficacy and for items in Section C on distance e-learning readiness using Cronbach Alpha formula. Hence, the questionnaire was considered valid and reliable for this study.

A four-point rating scale of Strongly Agreed (SA, = 4 points), Agreed (A, = 3 points), Disagreed (D, = 2 points) and Strongly Disagreed (SD, = 1 point) was used in weighing responses to items in the questionnaire. A mean response of below 2.50 and below was considered “not accepted” while a mean response of 2.50 and above was considered “accepted”. Data gathered from the administration of the questionnaire on the participants of this study were analysed using descriptive statistics such as percentage, mean and standard deviation. Research questions one and two were answered using percentages while mean and standard deviation were used in answering research questions three and four. Bar charts were also used to illustrate findings on research questions one and two.

Results

Research Question One: To what extent are civil servants in Minna, Niger State aware of the existence of distance e-learning platforms?

Table 1: Status of civil servants' awareness of distance e-learning platforms

Category	N	%
Those Aware of Distance e-Learning Platforms	924	72.19
Those Unaware of Distance e-Learning Platforms	356	27.81
Total	1,280	100.00

Table 1 shows the status of civil servants' awareness of distance e-learning platforms in Minna, Niger state, Nigeria. Out of 1,280 participants, 924 representing 72.19% are aware of the existence of distance-e-learning platforms while 356 representing 27.81% are unaware. This implies that majority of civil servants in Minna, Niger State are aware of the existence of distance e-learning platforms that can be used to update their knowledge. This is further represented graphically using bar chart as presented in Figure 1.

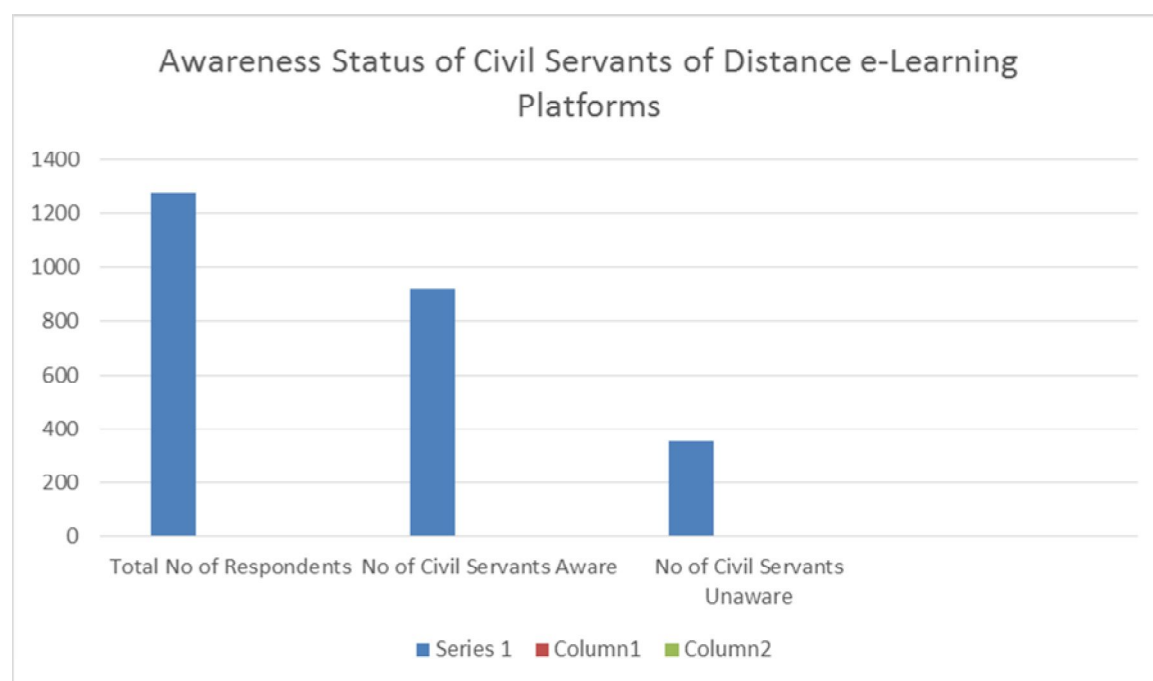


Figure 1: Graphical representation of awareness status of distance e-learning platforms by civil servants in Minna

Figure 1 is the graphical representation of civil servants' awareness status of distance e-learning platforms. The figure reveals that civil servants that are aware of the existence of distance e-learning platforms are greatly more than those that are unaware.

Research Question Two: To what extent are civil servants in Minna, Niger State currently undergoing programmes using distance e-learning platforms?

Table 2: Enrolment status of civil servants for distance e-learning programmes in Minna

Status	#	%
Those Enrolled for Distance e-Learning Programmes	127	9.92
Those Not Enrolled for Distance e-Learning Programmes	1153	90.08
Total	1,280	100.00

Table 2 shows the status of current distance e-learning enrolment by civil servants in Minna, Niger state, Nigeria. Out of 1,280 participants, only 127 representing 9.92% enrolled for distance e-learning programmes while 1153 representing 90.08% are not enrolled for distance e-learning programmes. This implies that majority of civil servants in Minna, Niger State are not enrolled for distance e-learning programmes. This is further represented graphically using bar chart as presented in Figure 2.

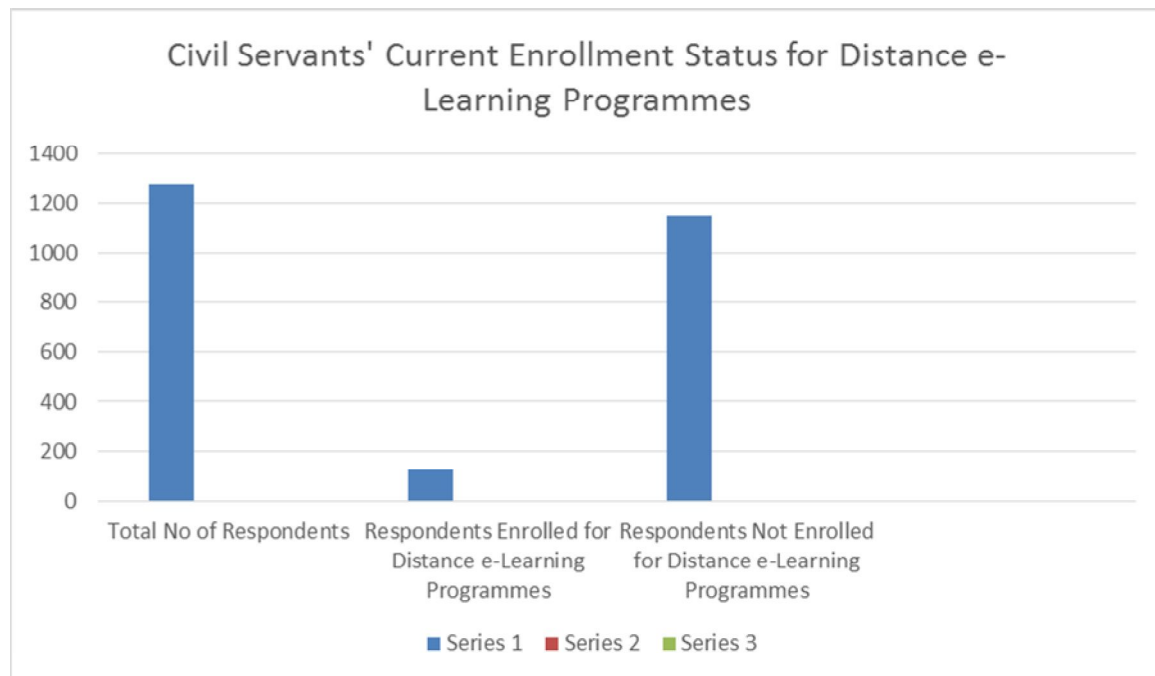


Figure 2: Graphical representation of current enrolment status of civil servants in Minna for distance e-learning programmes

Figure 2 is the graphical representation of civil servants' current enrolment status for distance e-learning programmes. The figure reveals that the number of civil servants that are not enrolled for distance e-learning programmes are greatly more than those that enrolled.

Research Question Three: Do civil servants in Minna, Niger State, Nigeria have self-efficacy in the use of relevant information and communication technologies needed in distance e-learning.

Table 1: Self-efficacy of civil servants in the use of relevant ICTs needed in distance e-learning

S/N	Item	N	Mean	SD	Decision
1	Switch on a computer.	1,280	3.62	1.12	Agree
2	Search for files in Computer	1,280	3.38	0.88	Agree
3	Access internet via its website address.	1,280	3.03	0.53	Agree
4	Have an E-mail address.	1,280	3.21	0.71	Agree
5	Send and receive E-mail messages.	1,280	3.03	0.53	Agree
6	Attach files to outgoing e-mails.	1,280	3.02	0.50	Agree
7	Download files from incoming e-mails.	1,280	2.07	0.52	Disagree
8	Create a folder, copy, move and paste files in another folder.	1,280	3.01	0.51	Agree
9	Open a previously saved file from any drive directly.	1,280	3.46	0.96	Agree
10	Print a document.	1,280	3.01	0.51	Agree
11	Use word processing packages e.g. MS Word.	1,280	3.56	1.06	Agree
12	Begin a new document.	1,280	3.23	0.73	Agree
13	Use browser such as Mozilla, Opera, or Chrome to explore navigates the Worldwide Web.	1,280	2.92	0.42	Agree
14	I have the basic skills for using the internet (e.g. using search engines to research for materials).	1,280	3.04	0.54	Agree
15	All night browsing.	1,280	2.98	0.48	Agree
16	I am computer Literate	1,280	3.02	0.52	Agree
Cumulative Mean			3.09		

Table 1 shows the self-efficacy level of civil servants in the use of relevant ICTs needed in distance e-learning. The table reveals that the respondents agreed to 15 out of the 16 items. With a cumulative mean of 3.09 which is greater than the decision mean of 2.50, this implies that civil servants in Minna, Niger State have high self-efficacy in the use of relevant information and communication technologies needed in distance e-learning.

Research Question Four: To what extent are civil servants in Minna, Niger State ready to enrol for relevant distance e-learning programmes?

Table 2: Civil servants' readiness to enrol for relevant distance e-learning programmes

S/N	Item	N	Mean	SD	Decision
1	Setting set goals and deadlines for myself	1,280	3.05	0.55	Agree
2	Learn best by figuring things out for myself	1,280	3.02	0.52	Agree
3	Can ignore distractions around me when I study	1,280	2.98	0.48	Agree
4	When I need information, do not hesitate to get it	1,280	2.87	0.37	Agree
5	Prepared to enrol for a program through E-Learning platforms	1,280	1.92	0.58	Disagree
6	Ensure i always have access to internet	1,280	2.07	0.52	Disagree
7	Family commitment and employment does not discourage me from learning something new	1,280	3.03	0.53	Agree

8	I am comfortable studying as an open/Distance electronic Education student	1,280	2.57	0.07	Agree
9	Can combine work with distance e-learning	1,280	3.01	0.51	Agree
10	Can take care of financial responsibilities involved in distance e-learning	1,280	1.92	0.58	Disagree
Cumulative Mean			2.34		

Table 2 shows the responses of civil servants' readiness to enrol for relevant distance e-learning programmes. The Table reveals that the respondents agreed to seven of the 10 items but disagreed to three items. With a cumulative mean of 2.34 which is less than the decision mean of 2.50, the Table implies that civil servants in Minna, Niger State are not ready to enrol for relevant distance e-learning programmes.

Discussion

Finding that emanated from the data gathered for answering research question one indicates that civil servants (72.19%) in Minna are aware of the existence of distance e-learning platforms. This awareness was probably as a result of series of advertisements made by distance learning institutions via broadcast media, social media, print media and electronic media.

Also, finding of this study that emanated from data gathered for answering research question two reveals that civil servants (9.92%) in Minna, Niger state are not currently enrolled for distance e-learning programmes. This could be as a result of financial implications of undergoing such programme as majority of them in their responses indicated that the financial burden of distance education is a great hindrance to enrolment for such programmes. In agreement with the findings Yusuf, and Balogun, (2011) observed that one of the most important challenges in e-government and e-learning area which governments face is the low number of the initiatives initiated in this area. Another one is the failure (complete or partial) of these few initiatives. It is reported that the main reason for these challenges is the lack of e- readiness for e-government development facilities like free internet services in the various institutions and organizations premises.

Another finding that emanated from data gathered for answering research question three reveals that civil servants in Minna, Niger state have self-efficacy (Mean = 3.09 out of 5) in the use of relevant information and communication technologies needed in distance e-learning. This is because the same ICT tools (computer and its accessories) that are being used in their offices to execute their job activities are the same tools needed in distance e-learning. This finding is in agreement with the earlier finding of Oye, et al (2012) who found that academic members of staff have moderate self-efficacy on the use of computer and ICT tools and Saddam, et al. (2012) who found that students' self-efficacy on the use of ICT tools was considered excellent and good majorly. The self-efficacy of civil servants on the use of ICT tools is probably as a result of their frequent and regular usage of the same tools in the discharge of their daily activities in their offices.

Also, finding revealed that civil servants in Minna, Niger State are not ready (Mean = 2.34 out of 5) to enroll for relevant distance e-learning programmes. This lack of readiness could be as a result of financial implications of such enrolment.

Conclusion

Based on the findings that emanated from this study, it can be concluded that civil servants in Minna are aware of the existence of distance e-learning platforms and they also have self-efficacy in the use of ICT tools in distance learning. However, despite the enormous benefits of distance learning to civil servants, their current low enrolment status and lack of readiness to

enroll for such programmes as a result of financial implications are serious issues that must be addressed.

Recommendations

- (i) Civil servants should be encouraged by government, employers and non-governmental organizations to enroll for relevant distance e-learning programmes. This encouragement could be in terms of financial assistance, access to loans and study scholarships.
- (ii) Distance learning institutions and administrators should reduce the cost of enrolment for distance learning programmes and also give option of installment payment. This could help to ease the financial burden of enrolment on civil servants.
- (iii) Government should make provision of internet service and other relevant ICT tools that can be simultaneously used for office tasks as well as studies by civil servants. This will prevent them on spending on the purchase of such items thereby reducing cost of enrolment for distance learning programmes.

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FACTORS CONTRIBUTING TO STUDENTS' POOR ACADEMIC PERFORMANCE IN
MATHEMATICS AT SENIOR SECONDARY SCHOOL CERTIFICATE
EXAMINATION IN TOTO LOCAL GOVERNMENT AREA,
NASARAWA STATE, NIGERIA

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Abstract

Performance in Mathematics by students has persistently been poor for many years. This study was aimed to identify the factors contributing to the poor academic performance and to establish the strategies that can be adopted to improve performance in Mathematics by students in secondary schools in Toto local government area. The study to determine the school based factors that affect students' performance in Mathematics in secondary schools, socio-cultural factors that affect them and their personal factors that affect academic performance in Mathematics, and established the strategies that can be adopted to improve performance in Mathematics. Descriptive survey research design was adopted for the study. The sample of the study was 120 respondents which comprised of SSCE students in Toto Local Government Area of Nasarawa State, and 18 Mathematics teachers. The major instruments used for data collection for this research was; student, and teacher questionnaires, while descriptive statistics was used for data analysis. The results revealed that factors contributing to poor academic performance include under staffing, inadequate teaching/ learning materials, lack of motivation and poor attitudes by both teachers and students, retrogressive practices. Improving on these factors and sensitization of the local community to discard practices which prohibit student's effective participation in learning mathematics could improve performance in Mathematics. It is anticipated that the findings of this study will give curriculum developers new insights into emerging issues on performance and influence the Ministry of Education on policy formulation. Students are also expected to benefit from the findings; because improved mathematics performance will give them opportunities to pursue science related courses in higher institutions of learning and middle level colleges. Therefore, recommendations were made as a means of proffering solutions the problem of poor academic performance in mathematics.

Keywords: Academic poor performance, Mathematics, Factors, Students

Introduction

Long ago before the coming of Arabs and Europeans to Africa, the African people had developed their own systems of education, although the systems varied from one community to the other, their goals were often strikingly similar. At independence in 1960 education was viewed as the means to eradicating poverty, ignorance and diseases from Nigeria. Mathematics is seen by society as the foundation of scientific and technological knowledge that is vital in social economic development of the nation. Because of this, mathematics is a compulsory subject at both primary and secondary levels in Nigeria. Mathematics is also used as a basic entry requirement into any of the prestigious courses such as medicine, architecture and engineering among other degree courses. Despite the important role that mathematics plays in society, there has always been poor performance in the subject at public/ national examinations.

Table 1: Mean Percentage of Students Performance in (SSCE) from 2012 to 2015 in
Toto Local Government Area

Year	2012	2013	2014	2015
Mean Grade	D7	E8	C4	D7

SSCE Results: 2012 - 2015

Performance in Mathematics as indicated by the SSCE results above has remained poor for the five (5) years. Hence, the need to investigate factors contributing to poor performance in Mathematics at SSCE examinations by students in Toto local government area in order to reverse or minimize poor academic performance in mathematics.

Students need to be encouraged to acquire, and be provided with, the necessary academic skills to enter mathematics and science related professions. Mastering mathematics has become more important than ever before in the world. Students with a strong background in mathematics have an advantage over those students who struggle when competing in the job market. In the job market, workers who have a strong mathematics and science background are more likely to be employed and earn more than those with lower achievement even if they have not gone to college. To compete in our 21st century global economy, it is critical that students leave high school knowledgeable and proficient in mathematics.

In concluding this section therefore, Mathematics Education must contribute towards the acquirement of these values: knowledge and skills, intellectual habits and power, desirable attitudes and ideals that are indispensable tools for a successful and balanced human existence. Therefore, this study intends to identify the factors that contribute to secondary school students' poor academic performance in mathematics and to establish the strategies /methods that can be adopted to improve performance in Mathematics by students in secondary schools in Toto local government area of Nasarawa state, Nigeria and the world at large.

Purpose of the Study

The purpose of this study was to identify the factors that contribute to secondary school students' poor academic performance in mathematics at Toto local government area of Nasarawa State. Specifically, the objectives of the study include:

- (i) To determine the school based factors that affect students' academic performance in mathematics in secondary schools;
- (ii) To identify demographic factors that affect students' academic performance in mathematics in secondary schools;
- (iii) To identify student personal factors that affect students' academic performance in mathematics in secondary schools.

Research Questions

The following research questions were formulated and answered in this study:

- (i) What are the school based factors that affects students' academic performance in mathematics in Toto secondary schools?
- (ii) Does demographic factors have an effect on students' academic performance in mathematics in secondary schools?
- (iii) Do student personal factors affect academic performance in mathematics in secondary schools?

Significant of the Study

The findings/results of the study are considered important because it may provide school authorities in secondary schools in Toto Local Government Area with significant factors that are affecting student poor academic performance in SSCE mathematics. Therefore, school authorities may begin implementing educational innovations and interventions to directly address those factors within their own schools to deter future hindrances.

Methodology

The descriptive survey research design was adopted for this study. This approach was seen as ideal, because the aim was to capture in depth views of both the mathematics teachers and their students. The sample of 120 students and 18 mathematics teachers were randomly selected from both public/private secondary schools and were involved in the study. The student questionnaire comprised sections on demographic data with items such as gender, age,

secondary school entry marks, socio-economic status and cultural, school based factors with items such as method of teaching by teachers, availability of teaching / learning materials, academic qualification, and teaching experience of mathematics teachers and motivation. Mathematics teacher's questionnaire had sections on demographic data items such as gender, age, academic qualification, and teaching experience. Socio-economic and cultural, and school based factors with items such as method of teaching, availability of teaching/learning materials, workload and motivation and finally strategies to be adopted to improve achievement in Mathematics. Descriptive statistics were used to analyze the collected data.

Results and Discussion

The following results were obtained based on the analysis of the data collected. The research questions investigated students' perceptions whether or not demographic factors including gender, parents' educational level, and socio-economic status have an effect on academic mathematics performance. Participants' responses were reviewed to identify the most frequently answered responses for demographic factors:

Demographic Characteristics of respondents

Data on table 3 indicate gender of the participants of the study where male were the majority in all categories.

Table 3: Gender of Participants

Respondents	Male (%)	Female (%)	Total
Students	65.0	35.0	100.0
Mathematic Teachers	73.0	27.0	100.0

Performance at Basic Education Certificate Examination (BECE):

The Basic Education Certificate Examination (BECE) is entrance examination to the senior secondary school in the country. Data obtained indicate that students had a mean aggregate of five (5) in mathematics performance which means the total scores of students all over the number of students involved in this study. This partly explains why there is poor academic performance on mathematics at the Senior Secondary Certificate Examination (SSCE).

Age of Students

Information obtained indicate that most of students (74.2%) were between 17 and 19 years of age, 23.8% were between 14 and 16 years, 1.9% were over 20 years and only 0.3% were below 13 years. These results are normal since the Nigeria system of education is that pupils join class one at age six, primary education is six years and secondary six years. Therefore, the students' academic performance would be negatively affected if the pupils / students join classes below the required age.

Mathematics Teachers Demographic Characteristics

The following information was obtained about mathematics teachers:

- (i) The mathematics teachers who participated in the study were 27.0% female and 73.0% males. Thus there are more male teachers in secondary schools than female teachers. The same pattern was with students. More girls need to be encouraged to take mathematics so as to have more female mathematics teachers to teach the subject in schools.
- (ii) Information obtained shows almost all teachers (66.7%) are professionally trained with Bachelor of Education degrees while 33.3% are unprofessional. Therefore, their output is expected to be good. This finding is in line with Wayne & Young (2000) who hinted that secondary school students appear to learn more Mathematics from teachers with degrees or significant coursework in Mathematics

- (iii) Ages of mathematics teachers; between 21 to 30 years of age (16.7%), between 31 and 40 years (66.7%) and over 40 years of age (16.7%). These shows mathematics teachers are very young and are energetic in teaching the subject (mathematics).

School Based Factors that Contribute to Poor Performance in Mathematics:

The data was collected and analyzed:

- (i) Methods of Teaching Mathematics: Data obtained indicate that 7% of the teachers use lecture method, 2% use project, 61% use discussions, discovery method is used by 3% while 27% of the teachers use the question/ Answer method. According to Costello (1991), lecture method is ineffective in that it turns the learners into passive participants in the learning process. However, despite the disadvantage, lecture method is useful in covering large content SMASSE (2007). Discussions, project and discovery methods creates an enabling environment for the learners and ensures that individual differences are taken care of.
- (ii) Teaching/Learning Materials for Mathematics: Information obtained on availability of teaching/learning materials for mathematics in secondary schools indicate that text books are leading with 94.1%, followed by mathematics geometrical sets (28.4%) and colored chalk (25.3%). Whereas, charts and mathematics models take 10.5% and 6.2% respectively.

According to Psacharopolous and Woodhall (1985), textbooks are a major input for performance in examinations. This view is shared by Chepcheng (1995) who observes that availability of and quality of textbooks in a secondary school is strongly related to achievement among children from lower income families especially those in rural boarding schools. that physical facilities contribute positively to students' academic performance (Munda, Tanui & Kaberia, 2000). Also 43.5% of all students indicated that schools lacked physical facilities and the ones existing were poorly used. According to Munda, et al (2000), physical facilities contribute positively to students' academic performance.

- (iii) Effectiveness of Mathematics Teachers in Teaching: Student's opinion on the effectiveness of their Mathematics teachers in teaching the subject shows that 43% indicated that they are highly effective, 27% indicated that they are average and 30% indicated that they are not effective.
- (iv) Teachers' Attitude towards Mathematics: Data obtained after analyzing teachers' responses on items soliciting their attitude towards mathematics indicate that they have a positive attitude towards the subject. The overall mean perception of Mathematics by the Mathematics teachers was 4.18 out of maximum possible score of 5.00. This implies that Mathematics teachers have a positive attitude towards Mathematics ($4.18 > 2.50$).
- (v) Mathematics Teachers' Workload: Data obtained shows that 5.6% of Mathematics teachers teach below 15 lessons per week, 50.0% teach between 16 to 30 lessons, while 44.4% teach more than 30 lessons in a week. According to the Ministry of Education (2008), a teacher in a secondary school is supposed to teach at most 30 lessons in a week. This indicates that 44.4% of mathematics teachers are overloaded. This percentage is high and may contribute to poor performance in mathematics.
- (vi) Mathematics Remedial Lessons: Information obtained shows that 55.6% indicate that remedial lessons are required in order to have mathematics syllabus completed. This means that the mathematics syllabus is overloaded, teachers do not plan well or learners are slow in learning mathematics.

Socio economic Factors affecting Performance in Mathematics at SSCE

The following information was obtained on social economic factors affecting secondary school students' performance in Mathematics at Toto SSCE.

- (i) Students' Parents/Guardians Education background: Results obtained indicate that most parents/guardians (73%) do not have education beyond secondary school education, and only 17% have college/university education. This result reflects the high illiteracy rate in study area. Thus, they may not be good role models for their children in academic matters. This result agreed with Desarrollo (2007) who indicated that the extent to which parents or other family members are actively engaged in a student's education had apposite influence on the student's achievement.
- (ii) Source of Income for Students' Parents/Guardians: Student's parents/guardians sources of income are farming (41%), salary (38%), Business (18%) and casual labour (5%). However, it was clearly indicated that the income is not consisted; therefore, students whose parents rely on them are likely to get inadequate learning resources, and other essential requirements. Performance from such student will always be poor. This finding is in line with Conger, et al (1999) which indicated that low parental socio-economic status is associated with diminished resources hence contributing to lower academic achievement. Table 5 below represents Students' Parents/Guardians Education background.
- (iii) Cultural Factors: Mathematics teacher's responses on socio-economic factors contributing to poor performance in Mathematics cited secret circumcision (initiation) (12%), beliefs (43%), early marriage (8%) and family income (62%). Also, cultural constraints negatively impact on achievement level among students. Children who come from insecure environments caused by socio-cultural practices such as cattle rustling, early marriages and female genital mutilation (FGM) show emotional problems at school. They lack concentration in class and confidence in whatever task they are given to do (Durojaiye, 1976).

Students Personal Factors Contributing to Poor Performance in Mathematics at SSCE:
Students' personal factors contributing to poor performance in Mathematics at WASSCE were found to be gender, economic factors and attitude towards mathematics. Students' attitude towards mathematics was measured using likert scale and the results obtained indicated that they have a positive attitude towards mathematics. Mwamwenda (1995) argued that the achievement of students in a subject is determined by their attitudes rather than inability to study. Haimowitz (1989) indicated the cause of most failures in schools might not be due to insufficient or inadequate instruction but by active resistance by the learners. This argument suggests that favourable attitudes towards Mathematics should be developed for achievement in the subject to improve.

Strategies to Improve Achievement in Mathematics:

The strategies suggested by the students on how to improve achievement in mathematics were grouped into five areas, which comprised of staffing, teaching and learning materials, curriculum, motivation and attitudes, and fees and levies. The same strategies were identified by mathematics teachers. All mathematics teachers (100%) and all students (100%) suggest improvement in teaching/learning materials and motivation respectively, may improve achievement in the subject (mathematics)

Recommendations

In respect of the findings carried out in this study, the researcher made the following recommendations:

- (i) The government and other stakeholders such as Non Governmental Organizations need to sensitize the local community to discard beliefs and practices such as FGM and

moralism that prohibit effective participation which result to poor performance in mathematics.

- (ii) The Ministry of Education and schools managements should motivate teachers especially after the release of examination results. This includes recommendation for promotion, subsidizing of house rents. The provision of incentives towards mathematics courses in universities and teacher training colleges through grant-in-aids and scholarships should be considered. This will help in training more mathematics teachers.
- (iii) To mitigate on the inadequacy of teaching/learning materials and equipment the government needs to enhance their provisions to schools. It should extend loan facilities and bursaries to secondary school students from poor families.
- (iv) The Ministry of Education should review the curriculum to make it relevant and flexible to the diverse needs of different regions and background of the students. Also, allocate more time to the teaching of mathematics on school time tables so that mathematics syllabus can be completed on time.

Conclusion

In the study, the following objectives were set to be achieved. The first objective was to determine the school based factor that affects mathematics performance in SSCE. Therefore, the survey established that teaching method was not wholly effective, learning/teaching are inadequate, and there is a heavy workload on teachers in teaching the subject.

The second objective was to establish demographic factors that affect students' mathematics performance in SSCE. The survey revealed that cultural factors (secret society initiation, early marriage, belief and family income), parents' educational level and socioeconomic status are having negative bearing on the students' mathematical achievement in SSCE.

Furthermore, the study intended to establish students' personal factor. Therefore, gender, economic factor, and the careless attitude towards mathematics are affecting performance in the subject. Therefore, all the objectives set were achieved.

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EFFECTS OF TWO TEACHING INSTRUCTIONAL TECHNIQUES ON ACADEMIC
ACHIEVEMENT OF BASIC TECHNOLOGY STUDENTS IN OGUN STATE
GOVERNMENT SCIENCE AND TECHNICAL COLLEGES

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Abstract

This study was carried out to determine the effects of two teaching instructional techniques (Lecture method and Guided Discovery Instructional Technique) on academic achievement of Basic Technology students in Ogun State Government Science and Technical Colleges (GSTCs). The study adopted quasi-experimental research design. Three research questions and three null hypotheses guided the study. All the GSTCs in Ogun State were the population for the study. Basic Technology Achievement Test (BTAT) was the only instrument used for the study. BTAT is a standardized test which contained 30 multiple choice questions. Each question had one correct answer and three distracters. The reliability coefficient of the BTAT was found to be 0.82 using Kuder-Richardson 20 formula. Mean, standard deviation and t-test were used for data analysis. The result of this study indicated a significant difference between the pre-test and post-test achievement scores of students taught with Guided Discovery Instructional Technique (GDIT) for hypothesis 1, no significant difference between the pre-test and post-test achievement scores of students taught with Conventional Instructional Technique (CIT) for hypothesis 2 and a significant difference between the post-test achievement scores of students taught with GDIT and post-test achievement scores of students taught with CIT for hypothesis 3. Based on this finding, the study recommended among others the adoption of better teaching techniques like GDIT to improve students' academic achievement in Basic Technology.

Keywords: *Teaching, Instructional Techniques, GSTC, CIT, GDIT, Basic Technology, Academic Achievement*

Introduction

Teaching and learning play important role in the school setting, one cannot be done without the other, this implies that both are done simultaneously. Teaching implies that a teacher who is a product of both nature and nurture impart knowledge to the learners. Carbone, Conway and Farr (2009) viewed teaching as a specialized form of bidirectional communication in which the students are active (and interactive) participants in the process of exposition. Most obviously, teaching is the communication of the facts, ideas, skills, and techniques particular to a discipline. Less obviously, teaching is the act of communicating the comprehensibility of the subject matter, demonstrating a mastery that reassures the students that they too can understand and master the material.

Instructional techniques represent all the approaches employed by a teacher in mediating instructions to his/her or group of learners. Instructional techniques according to Ogwo and Oranu (2006) are used by all teachers to present skills, knowledge and appreciations to the learners in the classroom and to engage learners in the tasks involved. Roegge, Wentlin, and Bragg (1999) cited in Shodehinde (2013) noted that the traditional approach of passing instructions in schools must be replaced with techniques which allow students to learn needed skill in the context within which the skills are used in the real world.

The Conventional Instructional Technique (CIT) which is mono-directional is widely used in schools today. Specifically, the lecture method which centers on the traditional viewpoint that the teacher is an embodiment of knowledge and it is the responsibility of the teacher to dish out or disseminate knowledge to the learners who are supposedly ignorant and blank. This technique affords the teacher to do most of the talking alone, and the students are abandoned as passive

listeners. Abdullahi (1998) cited in Oviave (2010) and supported by Uwameiye and Aduwa-Ogiegbaen, (2006) faulted this method in that students are always afraid to ask questions and express their opinions. This situation in the opinion of Abdullahi is in contrast with modern teaching which requires less talk on the part of the teacher and more activities on the part of the students. For this reason, Nwachukwu (2006) averred that good teaching always provides for a two-way communication between the teacher and the student. Ogwo (1996) cited in Lemo (2014) identified the weaknesses of CIT especially the lecture method such as; it is one-way communication affair which is autocratic and encourages students' passivity; it encourages rote learning; it is inappropriate for teaching and encouraging students to think for themselves among others.

Therefore, in search for a more productive instructional technique with utmost consideration on the student, Guided Discovery Instructional Technique (GDIT) comes to mind. GDIT is a student centered approach which increases the degree of students' interest, confidence, innovativeness, problem solving ability, creativity and consequently improves their performance in both theory and practice. Yalams and Fatokun (2007) cited in Umunadi (2009) posited that GDIT is a resource based learning which is an innovation that reverses the usual role of the teacher from that in which he is the main authority and source of all knowledge to one in which he acts simply as a guide to the students to enable him/her to make use of other sources of information. Mosston and Ashworth, (2002) averred that the intention of the GDIT is for teachers to formulate the underlying structure and content of their lessons in a manner that forces students to discover the answers to a range of problems for themselves. Within this particular methodology it is the role of the teacher to guide and facilitate student learning in order to allow student discovery as well as promote ongoing experimentation and participation.

Fakorede and Lemo (2015) observed that the value of instruction depends to a large extent on the quality of the teacher, as teachers are life-wire of a sound educational process. For teaching to be effective, novelty in the method of instruction adopted by the teacher must come to play. Olakotan, (2011) avowed that effective teaching implies that the intended outcome of the teacher's teaching is brought about and the favourable impression on the student is overtly felt. Adunfe (2008) submitted that effective teaching involves hard work and commitment on the part of the teacher. Therefore, effective teaching and learning should take-off with some ability to create resources, to turn existing resources to new uses and to make the best out of nothing. For learning to occur, teaching must be effective, this can be achieved by designing environments that are conducive so that changes in behaviour (motor, cognitive and affective) of students are accomplished efficiently. Similarly, Adunfe further reiterated that this must be done in a manner that enables the students to enjoy the learning experience and to learn the activity or subject matter being taught.

It is then envisaged that if students are well taught via adequate and effective instructional techniques, their achievement academically would in no doubt be encouraging.

Academic achievement according to Olaitan and Nwoke (1999) cited in Fakorede (2010) refers to knowledge and skills attained by a student in school subjects, designated by a score obtain in an achievement test. Accordingly, an achievement test is an instrument administered to an individual to elicit certain desires and expected responses, as demanded in the instrument, performance on which the individual is assigned a score representing his achievement. Olaitan and Nwoke noted that academic achievement is always denoted by a score, which represent the amount of learning acquired, knowledge gained or skills and competencies developed in the school subject.

Artherton (2003) noted that academic achievement hinged on several factors such as: teaching method, intelligence, background, organization, opportunity, motivation, instructional procedures, teaching aids, interest of the learner, and other environmental variable. Others

include learner's mental ability, his goals and purposes, his identification with learning, his maturation, and methods of guidance, availability of facilities and methods of testing.

So, in societies like Nigeria where standardized test of different kinds exist, the academic achievement of students is represented by the individual's response to standardized scholastic achievement tests; and the level of response given to such tests can help in determining success. This scholastic achievement test should embrace the students' general school performance in various school subjects particularly in Basic Technology which the present study addresses.

Basic technology is an integration of components of woodwork, metalwork, basic electronics, applied electricity, water flow technology, airflow technology, food preservation, automobile mechanics, technical drawing, physics, rubber technology, chemistry, plastics, building technology, and ceramics. It is a subject that introduces students at the Junior Secondary schools in Nigeria to the basic rudiment of technology. The objectives of teaching Basic Technology subject in Nigerian schools according to Federal Government of Nigeria (FGN, 2014) include:

- To provide pre-vocational orientation for further training in technology,
- To provide basic technology literacy for everyday living and
- To stimulate creativity

It should be borne in mind that Government Science and Technical College is a product of the National Master Plan on Technical and Vocational Education for the decade 2001 – 2010 (Jimoh, Dawodu, Adegoke and Komolafe, 2005). On this account, Federal and State technical colleges were renamed as Federal Science and Technical Colleges (FSTC) for federal government owned technical colleges and Government Science and Technical Colleges (GSTC) for state owned technical colleges. With this development, Federal Ministry of Education (FME, n.d) recommended that technical colleges should be converted to a 6 years programme, admitting students like secondary schools for junior secondary such that the orientation and attitude of students are moulded early in favour of Vocational and Technical Education. It was as a result of this conversion that Basic Technology becomes inevitable for students in GSTC in their first three years.

Since researchers of various degrees have faulted conventional mode of instruction based on poor academic achievement and other noteworthy reasons, it then becomes imperative for this study to determine effects of two teaching instructional techniques (Lecture method and Guided Discovery Instructional Technique) on academic achievement of Basic Technology students in Ogun State GSTCs.

Purpose of the Study

The purpose of this study was to determine the effects of two teaching instructional techniques (Lecture method and Guided Discovery Instructional Technique) on academic achievement of Basic Technology students in Ogun State GSTCs.

Research Questions

- (i) What is the difference in the mean pre-test and posttest academic achievement of students taught with GDIT?
- (ii) What is the difference in the mean pre-test and posttest academic achievement of students taught with lecture method?
- (iii) What is the difference in the mean posttest academic achievement of students taught with GDIT and posttest academic achievement of students taught with lecture method?

Hypotheses

- (i) There is no significant difference between the pre-test and posttest academic achievement of students taught with GDIT

- (ii) There is no significant difference between the pre-test and posttest academic achievement of students taught with lecture method
- (iii) There is no significant difference between the posttest academic achievement of students taught with GDIT and posttest academic achievement of students taught with lecture method

Methodology

The study employed quasi-experimental design. Specifically, the pretest, posttest, non-equivalent control group design was adopted for this study. According to Gall, Gall and Borg (2007), quasi-experimental design can be used when it is not possible for the researcher to randomly sample the subject and assign them to treatment groups without disrupting the academic programmes of the schools involved in the study.

Group	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2
Control	O_1	-X	O_2

Where O_1 = Pretest for both control and experimental group
 O_2 = Posttest for both control and experimental group
 X = Treatment given to the experimental group (GDIT)
 -X = No treatment given to the control group (CIT)
 _____ = Non-randomization

The population for the study consist all the GSTCs in Ogun State. There are seven GSTCs in Ogun State.

Simple random sampling was adopted and used to select two GSTCs (GSTC Ijebu-Igbo and GSTC Ijebu-Ode) using the table of random digits. However, the selected GSTCs were randomly assigned to control and experimental groups in their respective intact classes. In all 192 J.S 2 Basic Technology students were selected. GSTC Ijebu-Igbo was assigned to control group while GSTC Ijebu-Ode was assigned to experimental group.

Basic Technology Achievement Test (BTAT) was the only instrument used for data collection. BTAT is a standardized test which contains 30 multiple choice items. The reliability coefficient of the BTAT was determined to be 0.82 using Kuder-Richardson 20 formular. The chosen topics were taught using GDIT for the experimental group while lecture method was used for the control group.

The Two groups (experimental & Control) were subjected to a Pre-test and Post-test. Experimental conditions such as experimental bias and teachers' variability were controlled as regular Basic Technology teachers in GSTC taught the students while the researcher prepared all teaching instruments and trained the participating teachers as well.

The scores obtained from the pre-test and post-tests were analyzed using mean and standard deviation to answer the research questions while t-test statistic was used to test the hypothesis at 0.05 level of significance.

Results

The results were analyzed and presented based on the raised research questions and formulated hypotheses.

Research Question One

What is the difference in the mean pre-test and posttest academic achievement of students taught with GDIT?

Hypothesis One

There is no significant difference between the pre-test academic achievement of students and posttest academic achievement of students taught with GDIT

Table 1: Mean, standard deviation and t-test scores of pre-test and posttest academic achievement of students taught with GDIT

Experimental	N	Mean	Mean Diff.	SD	df	t-cal	t-Crit
Pre-test	97	38.26	22.55	9.33	192	13.90	1.96
Posttest	97	55.81		8.27			

$P < 0.05$, Critical = 1.96

The data presented in Table 1 indicated a significant difference between the pre-test and post-test experimental group taught with GDIT, in favour of the post test. This shows that the calculated t-value of 13.90 for experimental group pre-test, post-test mean achievement scores is significant at 0.05 probability level because the calculated t-value is greater than the t-table value(t-critical) of 1.96 at 0.05 level of significance. Therefore, the hypothesis of no significant difference was rejected.

Research Question Two

What is the difference in the mean pre-test and posttest academic achievement of students taught with lecture method?

Hypothesis Two

There is no significant difference between the pre-test academic achievement of students and posttest academic achievement of students taught with CIT.

Table 2: Mean, standard deviation and t-test scores of pre-test and posttest academic achievement of students taught with CIT

Control	N	Mean	Mean Diff.	SD	df	t-cal	t-Crit
Pre-test	95	31.23	3.04	13.21	188	0.99	1.96
Posttest	95	34.27		11.58			

$P < 0.05$, Critical = 1.96

The data presented in Table 2 indicated no significant difference between the pre-test and post-test control group taught with CIT. This showed that the calculated t-value of 0.99 for control group pre-test, post-test mean achievement scores is not significant at 0.05 probability level because the calculated t-value is less than the t-table value(t-critical) of 1.96 at 0.05 level of significance. Therefore, the hypothesis of no significant difference was upheld.

Research Question Three

What is the difference between the posttest academic achievement of students taught with GDIT and posttest academic achievement of students taught with lecture method?

Hypothesis Three

There is no significant difference between the posttest academic achievement of students taught with GDIT and posttest academic achievement of students taught with lecture method.

Table 3: Mean, standard deviation and t-test scores of pre-test and posttest academic achievement of students taught with CIT and GDIT

	N	Mean	Mean Diff.	SD	df	t-cal	t-Crit
Experimental Posttest	97	55.81	21.54	8.27	190	14.81	1.96
Control Posttest	95	34.27		11.58			

$P < 0.05$, Critical = 1.96

The data presented in Table 3 indicated a significant difference between the post-test experimental group taught with GDIT and post-test control group taught with CIT, in favour of the post-test experimental group taught with GDIT. This shows that the calculated t-value of 14.81 for experimental group post-test, and control group post-test mean achievement scores is significant at 0.05 probability level because the calculated t-value is greater than the t-table value (t-critical) of 1.96 at 0.05 level of significance. Therefore, the hypothesis of no significant difference was rejected.

Discussion

Tables 1, 2 and 3 showed the descriptive and inferential statistics of the study. The mean achievement scores are descriptive or representative scores of the group or variables they represent while the t-test provide premise for making inference or deductions on their relevant tested hypotheses.

Table 1 showed a significant difference between the academic achievement in the pretest and posttest of students taught with GDIT. This revealed the positive effects of different treatments given to the experimental group on the students mean achievement scores in the post-test achievement test. Although no treatment was given to the pre-test group before the test while treatment was given before the test in the case of the posttest. Table 2 showed no significant difference between the academic achievement in the pretest and posttest of students taught with CIT. This forms the basis while the hypothesis of no significant was upheld. This is also due to the fact that no treatment was given at both pre-test and post-test stages before the test were taken. Table 3 showed a significant difference between the post-test academic achievement of students taught with GDIT and the post-test academic achievement of students taught with CIT, in favour of GDIT, giving basis for rejecting the null hypothesis of no significant difference earlier formulated.

The findings of this study as revealed in the data analysis was corroborated by the propositions of Artherton (2003), Fakorede and Lemo (2015) who attributed academic achievement majorly to teaching methods, instructional procedures, and instructional materials among other variables. Nwachukwu (2006), Ogwo and Oranu (2006), Fatokun and Yalams (2007), and Owoso (2013) were also in agreement with the findings of this study. Their respective submissions which pointed to the fact GDIT increases the degree of students' interest, confidence, innovativeness, problem solving ability, creativity and consequently improves students' academic achievement are noteworthy corroborations to the findings of the study. Therefore, the findings of this study uphold the use of GDIT for teaching Basic Technology in Government Science and Technical Colleges.

Conclusion

From the foregoing, this study has equally affirmed that the effective organisation and presentation of learning materials to students have close ties with the various instructional techniques adopted by the teacher and the ability of the learner to assimilate. The various methods used by the teacher will determine the learning outcome of the students with corresponding satisfactory academic achievement.

Recommendations

Based on the findings of the study, the following recommendations are put forward:

- (i) Teachers must be encouraged to adopt better teaching techniques like GDIT to improve students' academic achievement in Basic Technology.
- (ii) Teachers must be encouraged to bring novelty into their methods of teaching aimed at improving students' academic achievement in Basic Technology.

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EFFECTS OF COMPUTER AIDED INSTRUCTIONAL PACKAGE ON PERFORMANCE AND RETENTION OF GENETIC CONCEPTS AMONGST SECONDARY SCHOOL STUDENTS IN NIGER STATE, NIGERIA

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Abstract

The study investigated the effects of computer aided instructional package (CAIP) on performance and retention of genetic concepts among secondary school students in Niger State. Quasi-experimental research design i.e. pre-test-post-test experimental and control groups was adopted for the study. The population of the study were all senior secondary school three (SS3) students' offering biology. A sample of 223 students was randomly drawn from six purposively selected secondary schools. The researchers' developed computer aided instructional package (CAIP) on genetic concepts was used as treatment instrument for the experimental group while the control group was exposed to the conventional lecture method (CLM). The instrument for data collection was a Genetic Performance Test (GEPET) that had 50 multiple-choice questions which were validated by science educators. A Reliability coefficient of 0.92 was obtained for GEPET using Pearson Product Moment Correlation (PPMC). The data collected were analyzed using IBM SPSS Version 20 package for computation of Means, Standard deviation, t-test, and analysis of covariance (ANCOVA). The ANOVA analysis ($F_{cal} (220) = 27.147$, $P < 0.05$) shows that students who received instruction with CAIP outperformed the students who received instruction with CLM and also had higher retention. The findings also revealed no significant difference in performance and retention between male and female students ($t_{cal} (103) = -1.429$, $P > 0.05$). It was recommended amongst others that teachers should use computer aided instructional package in teaching genetic concepts in order to improve students' performance and retention in biology subject.

Keywords: *Computer aided Instructional Package, Performance, Retention and Genetic Concepts*

Introduction

The global landscape is experiencing rapid changes in all spheres of life. Globalization is creating considerable new opportunities and new challenges as exemplified in the plethora of scientific breakthrough recorded in biotechnology, space research, energy development, telecommunications, and so on. It is obvious that if Nigeria with its cultural endowment is to successfully transform its economy and socio-cultural artifacts, it has to integrate computer technologies into its classroom for national development processes. Recent advances in pedagogy organization and presentation using technologies have changed the structure of education systems. These giant strides recorded by developed nations in technology have put additional responsibility on the educators of science (Kocakaya & Gonen, 2010). If the modern world is a product of science and technology, then a glance at the system of education in Nigeria reveals a poor state of infrastructure. The picture portrayed is that of a teacher that is limited to classroom environment with large groups of students without a subject textbook, desk and chalkboard. Teachers also complain of low performance while they are the custodian of this bedrock which is the foundation for higher knowledge (tertiary education). It is no gain saying therefore, that sound science education is pivotal to self-reliance and national development. According to John (2009), science is a way of knowing, a systematic method of learning about nature, based on observations and testing leading to the formulation of hypotheses, laws, and

theories. While education is an investment and instrument used in achieving rapid socio-economic, political, technological, scientific and cultural development.

Various individuals and groups have passed the blame of poor performance among secondary school students to parental factors, association with wrong peers, lack or unavailability of instructional materials, motivation and the likes (Asikhia, 2010). Morakinyo (2003) has also attributed the fallen level of academic achievement to teachers' non-use of verbal reinforcement (visual materials) and strategies in the course of instruction. Researchers have attempted to find out the causes of poor comprehension and performances in science subjects. Some of the problems identified include; Poor teaching methods (Mathew, 2002; Olorunkoba, 2007), abstract nature of sciences (Nsofor, 2006; & Shehu, 2006), the order of arrangement of biology scheme of work which placed abstracts concepts like genetics (Bajah, 2000), non-availability and utilization of instructional materials (Gambari & Gana, 2005; Yusuf, 2004).

The persistent poor performance in science subjects in Secondary School Certificate Examination has led to the assumption that most science teachers in secondary school in Nigeria do not make use of varied forms of teaching strategies to cope with difficulties associated with teaching and learning of science (Umoren & Ogong, 2007). Studies have also shown that most science teachers' do not possess the requisite knowledge to teach, as a result, the most prevalent method has been 'talk' and 'chalk' method. And the possible ineffectiveness of this approach may be strongly responsible for persistent poor performance of candidates in public examinations. There are so many possible reasons for the inability of science teachers in putting their lessons across to learners which may be because they are not abreast with the use computers as an innovative method of teaching. The use of computer aided instruction (CAI) has become the driving force in the delivery of instruction today. Computers have become an increasingly accessible innovative resource for educators to use in their teaching activities and improve teaching quality where quality is very expensive to reproduce or to substitute (Oguzor, 2011). Science educators must avail themselves of CAI, especially in teaching biology concepts that are considered difficult to comprehend since it is a compulsory requirement for admission into science related disciplines. The educational uses of computer that is considered to be Computer Aided Instruction (CAI) are those cases in which the instruction is presented through a computer program to a passive student or the computer is the platform for an interactive and personalized learning environment. Elizabeth (2011) averred that Computer Aided Instruction (CAI) could be in forms of drills and practice exercises, tutorials sequences to the student, animation and sometimes simulation which has the capacity of making the teaching and learning of science interactive thus improve students' performances.

Biology as a subject occupies a unique place in the secondary school curriculum and very relevant to science related fields, such as medicine, agriculture, biotechnology and genetic engineering (Kiboss, Ndirangu & Wekesa, 2004). Biology is important not only for the better life of individuals but also for preparing students for special fields such as agriculture, medicine, biotechnology, genetic engineering and so on (Sarajoni, 2001). Despite the importance of genetics to the future of students, the society and national development, students find most concepts difficult and teachers considers them abstract and difficult to understand as reflected in students' poor performance in Biology at Senior School Certificate Examinations (SSCE) in Niger State. Results of studies conducted with CAI on students' performance in biology has been mixed; the results of a study conducted in Ghana by Kofi, Appiah, Monney and Eric (2010) indicated that students that were instructed by the conventional approach performed better on the post-test than those instructed by the CAI. Finding of another study carried on pre-service Integrated Science teachers showed that CAIP enhanced their achievement at high, medium and low levels on scientific literacy when compared to the expository method of instruction (Oludu, Ilabor & Isidi, 2014). This therefore prompted the investigation of the effects of computer aided instructional package on performance and retention of genetic concepts among secondary School Students in Niger State, Nigeria.

Statement of the Problem

Parents, teachers, government and the public generally are concerned about the state of education in Nigeria. Students' performances in examinations have continued to dwindle despite governments' investment in physical infrastructure, instructional materials and in training of teachers. This problem has necessitated researchers and science educators to step-up researches aimed at finding solutions to this problem and identifying newer strategies or approaches of teaching and learning science and biology in particular. The Chief Examiner's report on secondary school students' performance in Biology in senior secondary school examinations conducted by West African Examination Council (WAEC) in Nigeria from 2004-2011 showed continued decline in performances. The following represents the percentages of students with credits (A₁ – C₆) in WAEC (2004 – 2011) in Nigeria; 42.23% in 2004; 32.90% in 2005; 37.97% in 2006; 35.61% in 2007 and 35.39% in 2008, 28.59% in 2009, 49.65% in 2010 and 38.50 in 2011 respectively

Similarly, the performance of students in Biology is also reflected in the grades obtained (A₁ – C₆), Passes and failures recorded in WAEC in Niger State. The problem of poor performances can be appreciated from the percentages of failure (F9) obtained in the following years (see table 1.2), 2004 (62%); 2005 (59%); 2006 (59%); 2007 (78%) and in 2008 (72%) This result no doubt was worrisome to all stakeholders in the education sector. And part of the reasons responsible for this continued slide may be attributed to the type of or unsuitability of instructional methodology used by teachers in secondary schools. On these bases therefore, this study will investigate the effects of computer aided instructional package on performance and retention of genetic concepts among secondary school students in Niger State.

Objectives of Study

The purpose of this study was to determine effects of computer aided instructional package on performance and retention of genetic concepts in biology among secondary school students in Niger State, Nigeria. Specifically, the study determined:

- (i) Whether there is any difference in performance of students taught genetic concepts using Computer-Aided Instructional Package (CAIP) and those taught with the Conventional Lecture Method (CLM).
- (ii) If there is gender difference in performance between students taught genetic concepts using Computer Aided Instructional Package (CAIP).
- (iii) If there is difference in retention of genetic concepts between students taught with Computer Aided Instructional Package (CAIP) and those taught using the Conventional Lecture Method (CLM).
- (iv) If there is difference in retention of genetic concepts between male and female students taught using Computer Aided Instructional Package (CAIP).

Research Questions

To achieve the stated objectives, the following research questions were formulated:

- (i) Is there any difference in performance between students taught genetic concepts using Computer-Aided Instructional Package (CAIP) and those taught with the Conventional Lecture Method (CLM)?
- (ii) Is there any difference in performance between male and female students taught genetic concepts using Computer-Aided Instructional Package (CAIP)?
- (iii) Is there any difference in retention of genetic concepts between students taught using Computer-Aided Instructional Package (CAIP) and those taught with the Conventional Lecture Method (CLM)?
- (iv) Is there any difference in retention of genetic concepts between male and female students taught using Computer-Aided Instructional Package (CAIP)?

Null Hypotheses

Four null hypotheses were formulated and tested at 0.05 alpha levels:

HO₁: There is no significant difference in the performance of students taught genetic concepts

using Computer-Aided Instructional Package (CAIP) and those taught with the Conventional Lecture Method (CLM)

HO₂: There is no significant difference in the performance of male and female students taught genetic concepts using Computer-Aided Instructional Package (CAIP)

HO₃: There is no significant difference in retention of genetic concepts between students taught using Computer-Aided Instructional Package (CAIP) and those taught with the Conventional Lecture Method (CLM)

HO₄: There is no significant difference in retention of genetic concepts between male and female students taught using Computer-Aided Instructional Package (CAIP).

Methodology

The research design adopted for the study was quasi-experimental research design i.e. a pre-test, post-test and randomized group design. The study is a randomized two groups design with subjects of the study divided into experimental and control groups by random sampling method. The experimental group received CAIP treatment while the control group did not but was however taught with the conventional lecture method. The population of this study was made up of 446 secondary schools in Niger State whose students offer Biology in 2013/2014 academic session. The population of students for the study was 46,714 including male and female students in SS3 who are between the ages of 16 and 20 years. Simple random sampling technique i.e. hat-draw method was used to select the subjects (students) for the study. The sample for this study consists of 223 students offering Biology. In all, only SS III students in six (6) senior secondary schools constituted the samples of the study. Three of the schools were purposively selected and assigned to the experimental group. This is because the three schools have computer laboratories, equipped with serviceable desktop and laptop computers which are basic requisite for the study. While the remaining three schools that were used as control group were randomly selected and used as intact classes. Computer Aided Instructional Package on Genetic Concepts (CAIP) was used as treatment instrument while a Genetics Performance Test (GEPET) used as pre-test and post-test for experimental and control groups. GEPET was reshuffled and renamed Genetic Concepts Retention Test (GECORET) which was used to measure retention among experimental and control groups. The instrument was validated by experts in science education and reliability coefficient of $r = 0.92$ using Pearson Moment Correlation Coefficient. GEPET was administered as pre-test and post-test and 2 weeks later GECORET was also given to measure retention. t-test and analysis of covariance (ANCOVA) were used to analyze the null hypotheses.

Results

Table 1 shows t-test analysis of pre-test result of experimental and control groups.

Table 1: t-test Comparison of Experimental and Control Groups on Pre-test

Group	N	df	Mean($\bar{X}$)	SD	t _{cal}	P-value	Remarks
Experimental Group	105	221	33.39	10.78	3.869	.001	Significant
Control Group	118		28.03	9.78			
Significant at 0.05 level							

The t-test result of pre-test of the experimental and control groups in Table 1 shows that, the calculated t-value ($t_{cal} (221) = 3.869$, $P < 0.05$) is significant. This meant that there was statistically significant difference between the mean scores of the experimental group (33.39) and the mean score of the control group (28.03) at the 0.05 significant levels. Therefore, the

students in the two groups were not equivalent with respect to their prior knowledge on genetic concepts in biology before receiving instruction with CAIP.

Null Hypothesis One (H_{01})

H_{01} : There is no significant difference in the performance of students taught genetic concepts using computer aided instructional package (CAIP) and those taught with the conventional lecture method (CLM).

Table 2: Analysis of Covariance (ANCOVA) on Experimental and Control Groups at Post test

Variables	SS	df	MS	F_{cal}	P-value	Remarks
Corrected Model	6169.567	2	3084.783	33.428	.001	
Pre-test (Covariate)	2505.109	1	34504.667	373.909	.001	Sig.
Group	2105.595	1	2505.109	27.147	.001	Sig.
Error	20301.823	220	2.281			
Corrected Total	26471.390	222				

Sig: Significant at 0.05 level

Table 4.8 shows the post-test analysis of ANCOVA between experimental and control groups which showed a significant difference $F_{cal} = 27.147$, $P < 0.05$. This means that at P-value less than 0.05 the mean difference of performance between the experimental and control groups of students taught genetic concepts with CAIP was significant hence, the null hypothesis was rejected. This implies that, there is significant difference between the performance scores of students taught genetic concepts with CAIP and those taught using the conventional lecture method. Schiff's Post-hoc (Least Significant Difference) analysis was used to determine which of the 2 groups was responsible for the observed differences in performance.

Table 3: Schiff's Post-hoc Analysis (LSD) on Performance between Experimental and Control Groups

Variable (i)	Variable (j)	Mean Difference	P-value
Experimental (1)	Control (2)	13.641	0.001
Control (2)	Experimental (1)	-13.641	0.001

Furthermore, mean gains statistic was carried out to compare the experimental and control groups scores at pre-test and post-test to determine which of the groups gained more.

Table 4: Mean Gains Comparison between Experimental and Control Groups

Groups	Pre test	Post test	Mean Gains
Experimental	33.39	53.56	20.17
Control	28.03	45.44	17.41

Table 4 also shows the mean gains comparison between experimental and control groups. The experimental group had a pre-test mean of 33.39 and post-test mean of 53.56 with a mean gain of 20.17. While the control group had a pre-test mean of 28.03 and post-test mean of 45.44 and a mean gain of 17.41 which is lower than that of experimental group. Thus, from the mean gain comparison, the experimental group taught genetic concepts with CAIP recorded a higher mean gain statistically greater than the mean gain of the control group taught using the conventional lecture method. Thus, the ANCOVA ($F_{cal} = 27.147$, $P < 0.05$) favoured the experimental group taught genetic concepts with CAIP.

Null Hypothesis Two

There is no significant difference in performance between male and female students taught genetic concepts using Computer Aided Instructional Package (CAIP).

Table 5: t-test Analysis of Male and Female Students Performance within the Experimental Group

Group	N	df	Mean	SD	t_{cal}	P-value	Remark
Male	65		52.65	7.95			
		103			-1.43	0.156	NS
Female	40		55.05	9.02			

NS: Not Significant at 0.05 level

Table 5 presents the t-test result of male and female students of the experimental group. The t_{cal} value of -1.429 obtained at .156 alpha level was found to be not significant ($t_{cal} (103) = -1.429$, $P > 0.05$). This meant that, there is no significant difference in the performance of male and female students exposed to CAIP on genetic concepts within the experimental group. The hypothesis was retained.

Null Hypothesis Three

There is no significant difference in retention between students taught genetic concepts using Computer Aided Instructional Package (CAIP) and those taught with Conventional Lecture Method (CLM).

To test differences in retention of genetic concepts between the groups that received instruction with CAIP and CLM, the data collected was subjected to analysis of covariance as presented in Table 6.

Table 6: Analysis of Covariance (ANCOVA) of Experimental and Control Groups on Retention

Variable	SS	df	MS	F_{cal}	P-value	Remarks
Corrected Model	10221.621	2	5110.810	42.685	.001	
Pre-test (Covariate)	5.310	1	5.310	0.044	.833	NS
Post-Post test	9675.605	1	9675.605	80.809	.001	
Significant						
Error	26341.500	220	119.743			
Corrected Total	36563.121	222				

NS: Not Significant

Table 6 presents the result of ANCOVA on the post-post-test mean score (retention) of the experimental and control groups. The F- value was found to be 80.809 at 0.05 alpha levels at P-value 0.001 ($F_{cal} (222) = 80.808$, $P < 0.05$) indicating that the difference between the mean retention scores of the experimental group and control groups is statistically significant. Hence, the null hypothesis was rejected. Therefore, there is a significant difference in retention between the experimental group students' taught genetic concepts with computer aided instructional package and those taught using conventional lecture method. Mean gains comparison was carried out to determine the group that recorded a higher retention rate between the experimental and control groups.

Null Hypothesis Four

There is no significant difference in retention between male and female students taught genetic concepts using Computer Aided Instructional Package (CAIP).

To calculate retention between male and female students taught genetic concepts with CAIP within the experimental group, t-test statistic was carried out to determine if there is a difference between male and female students.

Table 8: t-test Comparison of Retention between Male and Female Students in the Experimental Group

Group	N	df	Means	SD	t_{cal}	P-value	Remarks
Male	65	103	54.12	11.313	0.281	0.779	NS
Female	40		53.50	10.590			

NS: Not significant at 0.05 level

Table 8 presents the t-test comparison between of male and female students' retention of genetic concepts taught using computer aided instructional package. The $t_{cal} = 0.281$, $P > 0.05$ revealed that there was no significant difference between male and female students taught genetic concepts using the CAIP. The post-post result on gender ($t_{cal(103)} = 0.281$, $P > 0.05$) indicates that, there is no significant difference between the groups. The result has indicated that, there was no significant difference in retention between male and female students on retention of genetic concepts. Therefore, the hypothesis that there is no significant difference in retention between male and female students taught genetic concepts using computer aided instructional package is retained.

Discussion of Results

The findings of this study that showed that there is a significant difference in performance of students taught genetic concepts with CAIP and those taught using the CLM which agrees with the earlier findings of Fajola (2000), Yusuf and Afolabi (2010) and Yaki (2011) in Biology. Similarly, the finding is in line with the findings of Udousoro (2000), Spence (2004), Yusuf (2006) and Olusi (2008) in Mathematics which found CAI to have enhanced students' performance. Also the finding corroborates the findings of Kadayifci (1998) and Okoro and Etukudo (2001) in Chemistry using CAI. The finding agrees with the earlier findings of Bayrak (2008) and Gambari (2010) in Physics which found that the use of CAI in teaching Physics concepts significantly improved the performance of the experimental group.

Furthermore, this study revealed that CAIP has significantly influenced students' performance on genetic concepts. This may be true because present day students seem to appreciate the use of computer technologies and thus found learning using computer aided instruction more rewarding. This may not be different from the opinion expressed by Yusuf and Afolabi (2010) that CAI interactive approach significantly influence learning when compared with conventional instruction alone. And that CAI appears to be more cost effective than other instructional methods, such as teacher-directed instruction and tutoring. According to Yusuf and Afolabi (2010), the use of CAI produces higher performance than the conventional instruction alone and students learn computer instructional contents faster.

However, this finding contradicts the findings of Armstrong (1998), Mills (2001) and Onasanya, Daramola and Asuquo (2006) in Introductory Technology that the use of computer assisted instruction did not result in significant difference in performance compared to those taught with conventional lecture method. It was also observed that, because the computer aided instructional package appeals to both visual and auditory organs (multisensory) it contributed significantly in enhancing students' performance in genetic concepts learnt. This is because they are able to control the learning process; thud the CAI ensured greater comprehension and understanding. Dimerel (2004) painted this picture in a less cloudy perspective by saying that

“learning resulting from seeing 83%, hearing 11%, smelling 3.5%, touching 1.5% and tasting 1%. Therefore, one could infer that, the use of CAIP produces higher effect on learning genetics. The use of CAIP can help achieve better students’ performance in science subjects than the conventional lecture method. From the result of this study, it is observed that students taught genetic concepts with CAIP have higher achievement than those taught using conventional lecture method.

When the effect of CAIP on male and female students taught genetic concepts was analyzed using t-test statistic, there was no significant difference between them. The finding on this null hypothesis showed that, there is no significant difference between male and female students performance on genetic concepts when CAIP was used for instruction. This finding corroborates earlier findings of Bello (1990), Yusuf and Afolabi (2010) and Achuonye (2011) in Biology which showed that gender have no significant influence on performance. This finding also agrees with the findings of Anagbogu and Ezeliora (2007) which examined gender differences in scientific skills where predominantly visual material related to practical was used to determine students’ performance. In other words, performance in genetics was not influenced by either being male or female. The possible reasons for the lack of discrimination in performance by male and female students could be attributed to the fact that computer aided instructional package appealed to both sexes without discrimination, balanced simulations and animation graphics, music, text and sound; short step-principle of arranging facts and immediate feedback system used in the package which made learning more interesting and permanent. However, the finding of this study refuted earlier findings on gender conducted by Chanlin and Lihjuan (2001) that there is significant difference in performance between male and female students taught with CAI. We could therefore infer that, the use of computer aided instructional package positively influenced both male and female students’ performances in genetics.

The finding of this study corroborates the findings of Clark and Craik (1992), Fletcher-Flinn and Gravatt (1995), Oluwatoyo and Fatoba (2010) and Gultekin (2011) found that the use of CAI in instruction helped students’ retention capacities much more than the conventional instructional method. And in order to determine the direction of significant difference after rejection of the hypothesis, the pre-test and post-post-test mean scores of students’ retention was compared to determine the group with higher mean gains. The result was in favour of the experimental group that received instruction using computer aided instructional package.

There was actually no difference between male and female students retention on genetic concepts. This finding is not surprising because female students that were hitherto seen to be less friendly to computer technologies (techno-phobic) are now changing and taking up carries and specialization believed to be exclusive reserve of the male sex. Earlier findings on attitude towards computer aided instruction have shown that it is appealing, enjoyable and supports individual students learning pace. Furthermore, students are at liberty to repeat a learning task as many times as possible which is essentially different with the conventional lecture method. Therefore, computer aided instructional package enhances meaningful knowledge construction which also encourages easy retrieval of knowledge over relatively long period of time. Bello (1986) in Wasagu (1997) rightly sums it up that, “people construct meanings of what they hear and see by generating links between their existing knowledge and new phenomena”. Bloom (1990) also puts it that, “individuals construct their own knowledge in ways that are personally meaningful” to them.

Conclusion

Form the findings of the study it is concluded that the performance of secondary school students on genetic concepts can be significantly improved with the usage of computer aided instructional package (CAIP) better than the conventional lecture method (CLM) and that CAIP did not discriminate between male and female students’ performance on genetic concepts. CAIP also enhances greater retention of genetic concepts than the CLM of instruction and there is no differences in retention between male and female taught genetic concepts.

Recommendations

In the light of the findings in the study, the following recommendations are made:

- (i) Science Educators should begin to utilize computer aided instructional package in our secondary schools in order to improve on students' performance in biology to enable students pursue professional courses in tertiary institutions of learning.
- (ii) Computer aided instructional package has proven to be gender friendly since it does not discriminate between male and female student. It is therefore recommended that biology teachers should adopt its usage in order to further reduce the gap between male and female students' performance.
- (iii) The Nigerian Educational Research and Development Council (NERDC) should begin to look at the possibility of developing computer aided instructional packages or software programmes on science subjects to supplement the conventional lecture method in teaching biology.

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AN INVESTIGATION INTO MAINTENANCE ERRORS COMMITTED BY ELECTRICAL / ELECTRONICS TECHNICIANS & THEIR EFFECTS ON PRODUCTION INDUSTRIES IN BENUE STATE NIGERIA

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Abstract

The study was carried out to investigate into maintenance errors committed by electrical /electronic technicians in production industries in Benue State. Two research questions and one hypothesis guided the study. A descriptive research design was used and stratified purposive sampling technique employed to obtain respondents from production industries. The population of the study was seventy respondents comprising of forty five (45) electrical/electronic technicians and twenty five (25) supervisors working in these industries. A 30 item structured questionnaire on a four point scale was used for data collection. The instrument was trial tested in Plateau State using 20 subjects to determine the reliability of the instrument. Split half reliability coefficient formula was used and a reliability coefficient of the instrument yielded 0.68. Data collected were analyzed using descriptive statistics of mean and standard deviation to answer research questions, while a t- test was employed to test the hypotheses at 0.05 level of significance. Findings revealed that: recognition failures, memory failures, skill-based slips, among others are the common types of errors committed by electrical/electronic service technicians which often lead to either accidents or equipment breakdown or both. It was recommended that Good quality feedback should be provided to allow users to judge how effective their actions have been and the state of equipment or individual as a result of such actions.

Introduction

The useful life of man-made things can be extended by maintenance. Maintenance can be defined as those activities required to keep a facility in “as-built” or a productive condition that allows such facility to deliver its original productive capacity (Reason, 2000). Maintenance therefore is any activity designed to keep machines, equipment or building in good working condition. Maintenance encompasses all those activities that relate to keeping facilities and equipment in good working order and making necessary repairs when breakdowns occur so that the system can perform as intended (Stephenson, 1999 in Nande (2013). Maintenance activities may include monitoring the conditions of operation of equipment, carrying out emergency repairs, servicing equipment, replacing worn out parts or performing building upkeep.

Maintenance activities in Benue State production industries as elsewhere are classified into repairs and servicing, and are performed under two basic types of maintenance, namely; preventive maintenance and breakdown maintenance. Dhillon (2002) described breakdown maintenance as unscheduled maintenance or repair to return items/equipment to a defined state. Breakdown maintenance is subdivided into Opportunity maintenance, Operate to failure and Condition based maintenance.

Opportunity maintenance is specifically concerned with items other than those originally the cause of the maintenance work or repair. Opportunity maintenance work may arise as a result of damage observed or identified as requiring automatic replacement each time that plant fails. In condition based maintenance, it is the actual corrective condition of the plant or equipment that determine the form or the frequency of maintenance. Similarly, corrective maintenance is repair or replacement of components when the machinery fails to operate.

Electrical and electronics technicians involved in preventive maintenance monitors the equipment's operating conditions which usually determine their actions for repairs or servicing. Preventive maintenance may be fixed time type, design out maintenance or planned preventive. Fixed time maintenance can be described as individual or group replacement or repair prior to failure based on the prescribed date and is effective where failure is clearly time dependent. Design out maintenance on the other hand is a system of Plant condition monitoring and control which enable any faulty area to be identified before occurrence. Similarly, planned preventive maintenance is work carried out with forethought, controls and records to avoid possible further breakdown.

Maintenance and repairs are the actions involved in fixing to its original working condition any kind of mechanical or electrical device should it become out of order or broken (Defense Logistica Agency, 2011). Maintenance and repairs can also be described as restoration of a broken, damaged, or failed device, equipment, part, or property to an acceptable operating or usable condition or state (Mason, 2009). Repair is carried out after failure is detected and there is need to restore an asset to its factory condition in which it can perform its intended function. Blueprints and engineering specifications are usually followed during repairs to fix equipment components. Where replacement for broken or defective part is not readily available and machine must be quickly returned to production, the part is fabricated in the plant machine shop by experienced personnel.

Activities carried out during maintenance and repairs include: regular monitoring, inspection, clean up, lubrication, adjustment, alignment, calibration, replacement, or replenishment of the equipment. This helps to prolong an asset's useful life, prevent its breakdown and keep it in a capable condition to perform its intended function within its designed specifications (Online Business Dictionary, 2009). Maintenance servicing activities are carried out on routine basis.

Regrettably maintenance and repairs or servicing activities performed are not without human errors. Human error is an imbalance between what the situation requires, what the person intends, and what he/she does (Occupational Health and Safety Agency for Healthcare (OHSAA), 2004). Dhillon and Liu (2006) defined human error as the failure to perform a specified task or perform a forbidden action that could lead to disruption of scheduled operations or result in damage to property and equipment. The researchers added that a significantly large proportion of total human errors occur during the maintenance phase of equipment. Therefore, errors committed during maintenance work which produce unintended results such as unwanted time delay, difficulty, problem, incident, malfunction or failure during or shortly after equipment start-up or in use may be known as maintenance errors. According to Dunn (2007), more than half of errors in maintenance are recognized as recurring errors – often many times.

Dunn (2007) and Reason (2000) classified the maintenance errors to include: recognition failures, memory failures, rule based mistakes, and knowledge based errors. Others are skill-based slips and violation errors. Recognition failures are acts of improper identification and detection of objects while memory failures are incorrect acts which indicate that bits of needed materials were forgotten (Dunn, 2007). Rule base mistakes are errors committed when work procedure is forgotten or the individual fails to carry out the necessary procedures required for the work. When an individual never fully understood an operational sequence for instance; and a wrong decision made during a work procedure with some novelty, knowledge based error is said to be committed. On the other hand, skill- based slips are human errors committed due to distractions or lost of concentration in the course of work (Mason, 2009). A violation is an intentional deviation from procedures or practices. For example, non-compliant actions that have become normal, actions performed in order to necessarily get a job done is referred to as violation errors (Schreiber, 2007).

Managers of manufacturing industries consider their maintenance operations to be of high standard; however, quality performance, equipment failures and safety incidents frequently

reveal causes for concern (Dhillon, 2002). Maintenance errors pose significant financial burdens on production industries in terms of breakdowns. The impact of human error on maintenance quality, costs, safety and equipment reliability is huge (Dunn, 2007); and therefore, demands real obligation to prevent them in production industries.

Investigation into maintenance errors committed by electrical and electronics technicians in production industries in Benue State is an examination of maintenance errors committed by electrical and electronics technicians in industries. Investigation of maintenance errors committed by electrical and electronics technicians focused on identifying the types of error, causes and effects and to provide preventive strategies to be applied while carrying out maintenance actions on electrical and electronic devices and instruments in production industries.

Production industry refers to any facility devoted to the conversion of raw materials into marketable products. The production system of many modern day industries is automated. This automation has not only increased productivity level of the industries but also reduced the number of some human operations including monitoring which leads to fatigue, its resulting errors with their adverse effects including accidents and equipment failure (Reason, 1990). Okonkwo (1997) stated that in a complete electrical/electronic system, failure of one among thousands of components may be catastrophic. The electrical and electronics equipment in production industries therefore require high reliability and effective maintenance by skilled maintenance personnel which may include qualified electrical and electronics technicians.

Qualified electrical and electronics technicians employed with other maintenance personnel in production industries carry out maintenance tasks in their respective disciplines on production equipment. Many a times during maintenance process, accident occurs or after maintenance activities have been performed, equipment fails during or shortly after start-up (Kirn, Noland & Hauber, 2007) as a result of errors committed during the process (Mather, 2007). Da Vinci (2009) noted that almost on a daily basis, various degrees of industrial accidents are recorded from minor to major injuries to employees in Nigeria. The devastating effects of maintenance errors and economic losses sustained during industry breakdown cannot be ignored. It is therefore, necessary that maintenance errors committed by electrical and electronics technicians on electrical and electronics equipment which play key and dominant roles in providing complete automation of production industries in Benue State be studied, and analyzed. This will help in identifying possible causes and elimination or reduction of these errors.

Statement of the Problem

Almost on a daily basis various degrees of industrial accidents are recorded from minor to major injuries to employees and equipment due to maintenance errors committed by service technicians. Many research studies have shown that over fifty percent of all equipment fails prematurely after maintenance work has been performed on them. Dunn (2007) noted that in the most embarrassing cases, such maintenance works performed were intended to prevent the very failures that occurred. Mason (2009) explained that errors committed by service technicians can increase the amount of breakdowns which in turn results in increase risk associated with equipment failure and personal accidents.

Maintenance errors have caused losses in the past and will continue in the nearest future if not identified and corrected (Kirn, Hauber & Noland, 2007). The losses in production industries raises questions on the type of maintenance error committed and whether these errors committed by electrical /electronic technicians in production industries leads to accidents / equipment breakdown in Benue State. Identifying the types of maintenance errors committed by electrical and electronics technicians will boost the economic stability of production industries and reduce health hazards associated with such errors. Therefore, this study sought to investigate into maintenance errors committed by electrical and electronics technicians in production industries in Benue State.

Purpose of the Study

The purpose of the study is to investigate into maintenance errors committed by electrical and electronics technicians in production industries in Benue State. Specifically, the study seeks to:

- (i) Identify the types of maintenance errors committed by electrical/ electronic technicians in production industries in Benue State
- (ii) Find out whether these errors committed by electrical/electronic technicians in production industries lead to accidents / equipment breakdown in Benue State

Research Questions

The following research questions guided the study:

- (i) What are the types of maintenance errors committed by electrical / electronic technicians in production industries in Benue State?
- (ii) Do these errors committed by electrical /electronic technicians in production industries lead to accidents / equipment breakdown in Benue State?

Hypothesis

A null hypothesis was formulated and tested at 0.05 alpha levels.

HO₁: There is no significant difference in the mean responses of supervisors and electrical/electronic technicians on errors committed in production industries that lead to accidents/equipment breakdown in Benue State

Methodology

A descriptive survey design was employed for the study. The researchers used stratified purposive sampling technique to obtain respondents from production industries in Benue State. The population was 70 respondents comprising of forty five (45) electrical/electronic technicians and twenty five (25) supervisors working in production industries in Benue State. The researcher developed a 30 item structured questionnaires based on purpose, statement and the reviewed literature using a four point scale. The instrument was trial tested in Plateau state using 20 subjects to determine the reliability of the instrument. Split half reliability coefficient formula was used and a reliability coefficient of 0.68 was obtained. Data collected were analyzed using descriptive statistics of mean and standard deviation to answer research questions, while a t-test was employed to test the hypotheses at 0.05 level of significance. An item was considered needed if the mean response rating was 2.5 and above.

Results

Research Questions

- (i) What are the types of maintenance errors committed by electrical /electronic technicians in production industries in Benue State?
- (ii) Do these errors committed by electrical/electronic technicians in production industries lead to accidents/equipment breakdown in Benue State?

To answer research question one and two, mean rating responses and standard deviation of responses of electrical/electronic technicians and their supervisors working in production industries in Benue state for each item were computed. The summary of the responses are presented in table 1

Table 1: Mean and standard deviation responses on maintenance errors which result to various levels of accidents and equipment breakdown

S/N	Maintenance Errors Nt=45, Ns=25	$\bar{x}_T$	$\bar{x}_S$	SD _T	SD _S	Remarks
<i>Recognition failures:</i>						
1	Inability to identify correct object(s)	3.65	3.76	0.48	0.44	Sa/b
2	Inability to identify correct signal(s)	3.63	3.71	0.49	0.47	Sa/b
3	Inability to identify correct message(s)	3.43	3.47	0.50	0.62	Sa/b
4	Inability to detect problem state(s) at the right time cause	3.39	3.20	0.49	0.56	Sa/b

<i>Memory failures:</i>					
5	It was forgotten to put up warning sign	3.79	3.76	0.41	0.47 Sa/b
6	Following interruptions in sequence of operations, actions were forgotten and omitted or skipped	3.80	3.18	0.41	0.73 Sa/b
7	It was forgotten to replace worn out and frayed belts on equipment	3.67	3.65	0.47	0.49 Sa/b
8	It was forgotten to lock-out unsafe equipment	3.47	3.47	0.50	0.51 Sa/b
9	It was forgotten to put tag on unsafe equipment	3.39	3.41	0.53	0.51 Sa/b
<i>Rule based mistakes:</i>					
10	A spanner that loosely held a bolt was used to tighten the bolt	3.75	3.75	0.48	0.45 Sa/b
11	Person(s) involved in team work not communicated when team work was completed and equipment energized	3.69	3.71	0.51	0.47 Sa/b
12	Inability to inspect completed tasks physically	3.67	3.71	0.52	0.47 Sa/b
<i>Knowledge based errors:</i>					
13	Required servicing was not performed	3.51	3.47	0.51	0.51 Sa/b
14	Wrong equipment was installed	3.45	3.41	0.50	0.51 Sa/b
15	Wrong part was installed	3.39	3.53	0.49	0.52 Sa/b
16	An unacceptable condition of equipment was accepted	3.53	3.67	0.54	0.49 Sa/b
17	Wrong grease was applied at appropriate points of the equipment	3.50	3.60	0.71	0.51 Sa/b
18	The good practice was not followed when the problem for the first time was solved	3.71	3.56	0.46	0.51 Sa/b
<i>Skill-based slips:</i>					
19	Parts of equipment incorrectly replaced	3.67	3.56	0.52	0.51 Sa/b
20	Screws or bolts were left at 'finger-tight' rather than properly secured	3.62	3.75	0.49	0.45 Sa/b
21	Foreign objects which cause short circuit were not cleared when the job was completed and equipment energized	3.78	3.75	0.42	0.45 Sa/b
22	A screw was excessively driven and it caused wear or damage	3.70	3.63	0.46	0.50 Sa/b
23	Cable insulations were wounded	3.64	3.50	0.49	0.52 Sa/b
24	Motor bearings were over-oiled, resulting in oil being thrown onto insulation (fire hazard) and onto the floor (fall hazard)	3.53	3.44	0.50	0.51 Sa/b
25	Inaccurate measurement was taken	3.57	3.50	0.54	0.52 Sa/b
<i>Violation errors:</i>					
26	The procedure was ignored	3.64	3.71	0.53	0.59 Sa/b
27	A pair of pliers was used to tighten a nut onto a bolt	3.74	3.00	0.49	0.50 Sa/b
28	A knife was used to drive a screw	3.66	3.71	0.52	0.69 Sa/b
29	It was impossible to get job done if procedures were followed strictly	3.60	3.06	0.50	0.56 Sa/b
30	Rules were not adhered to in order to get job done faster and have thrill	3.53	3.71	0.50	0.59 Sa/b
Grand (Mean and Standard deviation)		3.60	3.53	0.50	0.52 Sa/b

NB: Nt = no. technicians, Ns = supervisors, $\bar{X}_t$ = mean response of technicians, $\bar{X}_s$ = mean response of supervisors, Sdt = standard deviation of response of technicians, Sds = standard deviation of response of supervisors Sa/b = serious accidents / serious breakdown respectively.

Table 1 indicates that the following types of errors were errors committed by electrical/electronic technicians during maintenance servicing. They include: Recognition failures, Memory failures, Rule based mistakes, and Knowledge based errors. Others were Skill-based slips and Violation errors. All the respondents in the study agreed that the identified errors in the study were types of errors committed by various electrical/electronic technicians in industries in Benue state during maintenance services and that these errors usually lead to accidents/ equipment breakdown in the state.

Values of mean and standard deviation of responses for electrical/electronic technicians on individual items range from $\bar{X}_t = 3.43$ and $Sdt = 0.41$ to $\bar{X}_t = 3.80$ and $Sdt = 0.71$ respectively; while mean values and standard deviation of responses for supervisors stood between $\bar{X}_s = 3.00$ and $Sds = 0.44$ to $\bar{X}_s = 3.76$ and $Sds = 0.73$ indicating that the various types of maintenance errors were committed by electrical/electronic technicians in production industries in Benue state during maintenance services and they usually lead to accidents or eventual breakdown of equipment. The respective high grand mean response values of technicians and supervisors ($G\bar{X}_t = 3.60$ and $G\bar{X}_s = 3.53$) on these errors further agreed with the individual item assessment of the errors by the two groups of respondents. The corresponding grand standard deviation of responses of technicians and supervisors on the various types of maintenance errors and their effects which stood between $Gsd_t = 0.50$ to $Gsd_s = 0.52$ further affirmed how closely these two groups of respondents agreed among themselves on the identified types of maintenance errors and their consequences to individuals and equipment. This may be interpreted to mean that maintenance errors committed by electrical/electronic technicians indicative of items lead to serious accidents/equipment breakdown in production industries in Benue State.

Hypothesis

There is no significant difference in the mean responses of supervisors and electrical/electronic technicians on errors committed in production industries that lead to accidents/equipment breakdown in Benue State.

Table 2: t-test of mean responses on errors committed

Group	$\bar{X}$	SD	df	SE	t-Cal.	t-Crit.	Decision
Supervisors	3.53	0.52	64	0.05	0.24	1.67	Accept
Technicians	3.60	0.50		0.05			

Note: $\bar{X}$ = Group grand mean, SD = Group standard deviation, SE = Standard error, t-cal. = calculated and t-critical = 1.67

Table 2 shows that the value of t- calculated (0.24) was less than the table value (t-critical) of 1.67 at 0.05 level of significance. This revealed that there is no significant difference between the mean responses of supervisors and electrical/electronic technicians on errors committed in production industries that lead to accidents/equipment breakdown in Benue State. Therefore, the null hypothesis was accepted indicating that the difference in means was not statistically significant.

Discussion

Finding on types of maintenance errors committed by technicians indicates that they include; recognition failures; memory failures; skill-based slips; rule-based mistakes; knowledge-based errors; and violations. This finding is consistent with Mason (2009) who noted that maintenance errors range from becoming distracted and forgetting important checks to knowingly deviating from a permit to work procedure in order to save time or to get the job done in unexpected circumstances. Similarly, Dunn (2007) classified human errors which occur in maintenance activities according to their contributing factors as recognition failures; memory failures; skill-based slips; rule-based mistakes; knowledge-based errors; and violations. Electrical and electronics maintenance technicians who are also human beings commit such errors during maintenance activities in Benue State production industries. This is attested by the two groups of respondents who confirmed that they were types of errors encountered during maintenance

services. Dunn (2007) explained that more than half of maintenance errors are recognized as having happened before-often many times.

On whether maintenance errors committed by electrical and electronics technicians in manufacturing industries can lead to accidents/ equipment breakdown in Benue State, respondents unanimously agreed that skill based errors, rule based and knowledge based errors among others usually lead to accidents and equipment breakdown in Benue state process industries. This finding agree with Abiose and Otache, (2000) as cited in Nande (2013) who observed that violation of safety rules was found to have resulted into six ocular accidents in Nigerian factories. Health and safety executive of the United Kingdom in Mather (2007) also found that more than 60% of all maintenance failures had human error as the root cause, with only 21% representing true engineering failures. This finding also agree with Kirn, Noland and Hauber (2007) who identify errors which cause equipment failures and accidents to include: Crew turnover, Skill based error, Rule based error and Knowledge based error.

Conclusion

The study clearly identified recognition failures, memory failures; skill-based slips, rule-based mistakes, knowledge-based errors, and violations errors as key errors committed by electrical/electronic technicians in Benue state production industries. It also pointed out that such errors are responsible for the various levels of accidents and equipment breakdown in the state and must be checked.

Recommendations

The following recommendations are based on the findings of this study:

- (i) The effects of maintenance errors should be investigated and pooled into database to enable maintenance personnel understand the risk involved in improper maintenance electrical/electronic gadgets.
- (ii) Good quality feedback should be provided to allow users to judge how effective their actions have been and the state of equipment or individual as a result of such actions
- (iii) Maintenance error is a form of human error therefore it is inevitable but it should be avoided and managed when it occur.

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IMPACT OF DIGITAL GRAPHICS ON SECONDARY SCHOOL BIOLOGY STUDENTS' ACHIEVEMENT ON THE CONCEPT OF POLLUTION IN AGAIE METROPOLIS OF NIGER STATE

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Abstract

This study examined the impact of digital graphics (charts showing land, water and air pollution) on secondary school Biology students' achievement in the concept of pollution in Agaie Metropolis of Niger State. Quasi experimental design was adopted for the study. A total of 120 Secondary School I (SSI) Biology students of from two senior secondary schools formed the sample of the study. The schools were randomly assigned to experimental and control groups and intact classes were used in each of the schools. The instrument used for data collection was the Biology Achievement Test (BAT) which was developed by the researchers and validated by Biology lecturers in the Department of Biological Science, Federal University of Technology, Minna. The instrument was also pilot tested and reliability coefficient of 0.86 was obtained using Pearson product moment correlation coefficient formula. Two research questions were raised and answered using mean and standard deviation. Also, two null hypotheses were formulated and tested using t-test analysis. The result revealed a significant difference in the mean achievement score of students taught using digital graphics and those taught using conventional lecture method. It also revealed no significant difference in the mean achievement score of male and female students taught using digital graphics. Based on these findings, it was concluded that the use of digital graphics is more effective in improving students' achievement in Biology than the conventional lecture method. It is therefore recommended among others that Government should provide adequate and relevant digital graphics for the meaningful teaching and learning to take place at secondary school level of our educational system.

Keywords: *achievement, biology, chart, digital graphic, students and pollution.*

Introduction

Science is a methodical approach of acquiring, understanding and interpreting knowledge for growth and development of both individual and the nation as a whole (Abakkor, 2012, & Awofobaju, 2006). The National Policy on Education stated that science subjects constitute part of the core subjects at the Secondary School Level. Study of science is important as knowledge of science is used for improving and changing attitudes and skills, improving the process of storing knowledge about an individual and its environment. Science has always been seen as the backbone of technological advancement therefore, its role in the modern world cannot be overemphasized (Lorence, 2006). Other importance of the knowledge of science include manufacturing and production of medicine, computer, mobile phones, air craft, space satellite, television to mention a few. The major branches of science comprise Biology, Physics, Chemistry and Mathematics (Abakkor, 2012).

Biology, as a core science subject, is basically concerned with the study of living organisms. It deals with the study of life, evolution of living organisms, the study of the structures and functions of living organisms and the processes by which they interact with each other as well as with their environment. Biology studies how the world is structured, how it functions and what these functions are all about, how it develops, how living things came into existence, and how they react to one another and with their environment (Maishinkafa, 2010). It is central to many science related courses like medicine, pharmacy, biochemistry, nursing, agriculture etc. This is why researchers and curriculum planners pay much attention to biology as an important science subject in the school curriculum (Maishinkafa 2010, Abdullahi, 2003).

Despite the importance of biology to individual and national development, study of biology especially at secondary school level is faced with numerous problems as a result of which the students' performance in biology has been below expectation. Abdullahi (2003) reported that, one of the major factors hindering effective teaching and learning of science (especially Biology) in Nigeria is lack of human and material resources. Other problems include lack of teacher training and retraining facilities, the curriculum content, curriculum implementation and evaluation, lack of relevant instructional materials, too large classroom sizes and lack of adequate laboratory equipment. Other researchers revealed that teachers' instructional strategies are unproductive and as such, students find many topics difficult to understand (Koroka & Ezenwa, 2009 and WAEC, 2013). Many biology teachers employed several methods in teaching to achieve meaningful learning and understanding by the students (Zenbari & Blume, 2009). For instance, Ifeakor (2005) emphasized the use of commercially produced computer assisted instructional package to teach biology.

Others ascertain that, students' poor achievement in biology can be attributed to lack of qualified teachers to handle biology (Abakkor, 2012; Thesaurus, 2013; Maishinkafa, 2010). According to them, most teachers employ the use of conventional lecture method which is a classroom-based method characterised by lectures and instructions by the teacher which make it to be a teacher-centred method of instruction. This teacher-centred method of instruction emphasizes on learning through the teacher's guidance whereby the teacher always talk to the students instead of encouraging them to interact and actively participate in teaching and learning process. In most classes, students are subjected to rote learning, where they depend on memorization without understanding the subject. This method makes students to become passive rather than active learners (Lawal, 2006; Maishinkafa, 2010; Udousoro, 2011 & Abdullahi, 2003).

However, various efforts have been made by researchers and science educators to come up with instructional strategies that will promote effective teaching, learning and understanding of biology concepts as well as improved students' achievement but all proved unsatisfactory as is shown in table 1.1

Table1: Performance of Nigerian Biology Students at WASSCE, 2008-2013

YEAR	TOTAL	(A1-C6)PASS	(D7-E8)PASS	FAILURE
2008	1005894	298555(29.68)	326092(32.41)	348890(34.68)
2009	1051557	375850(35.74)	313827(29.84)	338491(32.18)
2010	1137131	559854(49.23)	292317(25.70)	284960(25.07)
2011	1238163	413211(33.27)	397353(32.09)	402148(32.47)
2012	418423	185949(44.44)	114697(27.41)	110417(26.38)
2013	468546	204725(43.69)	114020(24.33)	119260(25.45)

Source: WAEC, 2013

Table 1 shows the percentage of students that passed biology at the Senior School Certificate Examination (SSCE) conducted by the West African Examination Council (WAEC). As the table indicates, the number of students that passed biology at credit level (A1-C6) was consistently less than 50% for a period of six years (2008 - 2013).

Therefore, it is necessary to look into current methods of teaching biology in order to get a suitable strategy that would lead to effective teaching and learning of biology. This study therefore, aimed at investigating the impact of digital graphics (charts showing land, water and air pollution) on secondary school biology students' achievement on the concept of pollution. The study also investigated the impact of digital graphic on gender achievement among the students.

Aim and Objectives of the Study

The aim of this study was to investigate the impact of digital graphics (charts showing land, water and air pollution) on secondary school biology students' achievement on the concept of pollution. Specifically, the study attempted to achieve the following objectives:

- i. Determine the impact of digital graphics (charts showing land, water and air pollution) on secondary school biology students' achievement on the concept of pollution
- ii. Determine the gender influence of digital graphics (charts showing land, water and air pollution) on secondary school biology students' achievement on the concept of pollution.

Research Questions

The following research questions were raised to justify the study:

- i. Will there be differences between the mean achievement scores of students taught the concept of Pollution in biology using digital graphics and those taught with conventional method?
- ii. Will there be differences between the mean achievement scores of male and female students taught the concept of Pollution in biology using digital graphics?

Research Hypotheses

The following null hypotheses were formulated and tested at 0.05 significant level

HO₁: There is no significant difference in the achievement mean scores of secondary school biology students taught the concept of Pollution using digital graphics and those taught without digital graphics.

HO₂: There is no significant difference in the achievement mean scores of male and female students taught the concept of Pollution using digital graphics.

Methodology

The research design adopted for this research was a quasi-experimental design (Non-equivalent, Non-randomized, and Experimental - Control group design). The experimental group students were taught the concept of pollution in biology using digital graphics (chart showing land, water and air pollution) while the control group students were taught the same concept without digital graphics but a conventional lecture method was used on them.

Table 2: Research Design Format

Group	Pretest	Treatment	Posttest
Experimental Group	O ₁	X	O ₂
Control Group	O ₃	C	O ₄

Where: O₁ & O₃ =Pretest, O₂ & O₄= Posttest, X – Treatment and C – Conventional method

The target population comprises of 495 (male = 231 and female = 264) Senior Secondary School One (SSI) Biology students in two Niger State government owned co-educational secondary schools in Agaie metropolis while the sample population comprises of 120 Senior Secondary School One (SSI) Biology students.

Two schools were purposively selected for the study. This is because there are only two government owned co-educational schools in Agaie metropolis. The selected schools were randomly assigned into experimental and control groups. From the selected schools, two intact classes were also randomly selected for the study.

The instruments used for the study were the treatment and test instruments.

Treatment Instrument: This was the digital graphics (charts showing land, water and air pollution). The concept of pollution was drawn as chart in form of concept map by the researchers in collaboration with an expert in instructional development. The charts were drawn by strictly following the SSI curriculum.

Test Instrument: This was Biology Achievement Test (BAT) test items on pollution. It consists of (20) multiple choice test items on pollution with four options (A - D) but only one of them is correct. The test items used covered all the topical areas of pollution in accordance with the SSI syllabus and they were drawn from the West African Examination Council (WAEC) past question

papers. The above instruments were both validated by three biology teachers to determine their appropriateness before being used for the study.

Reliability of the instrument was determined at Day secondary school Lapai using 20 students (male = 10 and female = 10). Day secondary school Lapai was used because there are only two co-educational secondary schools in Agaie and Lapai is not too far from Agaie. Test-retest method was used to collect two sets of data during pilot test. The two set scores were analyzed using Pearson product moment correlation coefficient formula and $r = 0.85$ was obtained.

After the researchers were granted permission to use the selected schools and also introduced to both biology teachers and students of the schools, they administered the Pretest question on both groups to determine their entry behaviour. The experimental group students were taught the concept of pollution in biology using digital graphics (charts showing land, water and air pollution) while the control group students were taught the same concept without digital graphics but a conventional lecture method was used on them. After the treatment which lasted for three weeks, a week revision was held after which the posttest was administered on them. The research lasted for six weeks.

The pretest and posttest scores collected were analyzed using mean, standard deviation and t-test statistics. Statistical Package for Social Sciences (SPSS) 20.0 version was used to analyze the data obtained. Data analyzed were used to answer the research questions and also test the hypotheses.

Results

Analysis of Pretest and Posttest scores

Table 3: t-test Analysis of Pretest Scores of Experimental and Control Groups

Group	N	df	Mean	SD	t-cal	P-value
Experimental Group	67	118	8.43(42.15%)	3.09	0.918 ^{NS}	0.360
Control Group	53		7.93(39.65%)	2.99		

NS: Not significant at $p > 0.05$

Table 3 shows summary of t-test comparisons between the mean achievement scores of control group and the mean achievement scores of the experimental group in the pre-test. This indicated that there was no significant difference in the mean achievement of the two group ($t = 0.918$, $df = 120$, $p > 0.05$). Hence it was observed that the scores of both experimental and control groups were at equal level before the treatment.

H_{01} : There is no significant difference in the achievement mean scores of secondary school biology students taught the concept of pollution using digital graphics and those taught without digital graphics.

Table 4: t-test Analysis of Posttest Scores of Experimental and Control Groups

Group	N	df	Mean	SD	t-cal	P-value
Experimental. Group	67	118	13.45(67.25%)	2.44	8.630	0.000
Control Group	53		9.67(48.35%)	2.42		

*Significant at $p < 0.05$ alpha level

Table 4 Show the mean scores and standard deviation of the experimental and control group students taught the concept of pollution using instructional materials and conventional method. The mean scores and standard deviation of experimental group are 13.45 and 2.44 and that of control group are 9.67 and 2.42 respectively. This result indicated that there was a significant difference in the achievement mean score of the experimental group and control group ($t = 8.630$, $df = 120$, $p < 0.05$). Hence the null hypothesis that there is no significant difference in the

achievement mean scores of secondary school biology students taught the concept of Pollution using digital graphics (charts showing land, water and air pollution) and those taught with conventional lecture method was therefore rejected.

HO₂. There is no significant difference in the achievement mean scores of male and female students taught the concept of Pollution using digital graphics.

Table 5: t-Test Analysis of Posttest Scores of Male and Female Students in the Experimental Group

Group	N	df	X	SD	t-cal	P-value
Male	29	65	13.83(69.15%)	2.39	1.12 ^{NS}	0.269
Female	38		13.16(65.85%)	2.47		

NS= Not significant at $P > 0.05$ alpha level

Table 5 shows the achievement mean scores of male students of the experimental group. The mean score and standard deviation of the male students are 13.83 and 2.39 respectively while that of the female students are 13.16 and 2.47. The result indicates that there is no significant difference in the mean achievement score of male and female students taught the concept of pollution using digital graphics ($t = 1.116$, $df = 65$, $p < 0.269$). Hence the null hypothesis two which states that there is no significant difference in the achievement mean scores of male and female students taught the concept of Pollution using digital graphics is thereby accepted, this implies that there is no significant difference between the two groups on their respective achievement.

Findings of the Study

The following were the major findings of the study:

- (i) Digital graphics used has significantly improved biology students' achievement on the concept of pollution. This is because the experimental group students exposed to digital graphics achieved better than the control group students.
- (ii) Male and female students exposed to digital graphics achieved equivalently on the concept of pollution. This implies that the digital graphics (charts showing land, water and air pollution) improved the achievement of both male and female students equally.

Results

The pretest scores in table 3 shows that the control group (mean of 7.93 and standard deviation of 2.99) and experimental group (mean of 8.43 and standard deviation of 3.09) are equivalent because the p-value is greater than the alpha level of significance ($p = 0.918$ greater than 0.05 alpha level), this means the experimental and the control group are equal in terms of their previous knowledge before the application of the treatment.

The result of the t-test as shown in table 4 shows that the computed t-value at (120) = 8.630 while the p-value (0.000) is less than the 0.05 alpha level of significance. The results show that the experimental group performed better than the control group. This means that the use of instructional material can enhance student performance in Biology at the senior secondary school level. This result was in line with the findings of previous studies (Aiyede, 2008; Akubulo, 2004), which provided evidence attesting to the efficacy of instructional material in facilitating meaningful learning. Koroka, Ezenwa, Wushishi & Omalu (2015) also found that the impact of concept mapping techniques on students' achievement was significant in Ecology and Genetics in Nigeria. Alice (2007) came into conclusion that those who utilize instructional material promote learning.

The results of the t-test as shown in table 5 shows that the computed t-value at $t(65) = 1.116$ while the p-value (0.269) is greater than the 0.05 alpha level of significance. Therefore, there is no significant difference in the mean achievement scores of male and female Biology students

exposed taught with instructional material. This means that instructional material can be used to enhance both the male and female academic performance in senior secondary schools in Nigeria. This finding is in line with that of Eze (2008), who found no significant difference in the performance of male and female students.

Conclusions

The results revealed that students exposed to instructional materials in Biology achieved higher than those not exposed to instructional materials. The results also revealed that instructional materials are gender friendly. This implies that exposing students to Instructional Material will enhance their higher achievement.

Recommendations

In view of the findings of this research work, the following recommendations were made:

- (i) Teachers especially in Biology should be sent on in- service training on how to effectively use instructional materials during teaching.
- (ii) School administrators should support and give necessary encouragement to teachers for effective utilization of instructional materials during teaching.

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THE USE OF MOTIVATIONAL STRATEGY IN THERE-ENGINEERING OF PRIMARY EDUCATION FOR SELF EMPLOYMENT AND PRODUCTIVITY IN NIGERIA

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Abstract

This study was set to examine motivational strategy that would be adopted to re-engineer Primary Education for self productivity in Bida Local Government Area of Niger State. The study adopted a descriptive survey research design, 270 primary school teachers across the three levels (i.e. primary two, three and four) with equal number of teachers from each level were used for the study. Simple random sampling technique was used to select the teachers and pupils used for the study. The instrument for data collection was a 25items Teacher Motivation Strategy Questionnaire (TMSQ) using modified Likert four point scale. The data collected from the administration of the instrument on the 270 respondents were analyzed using the mean, standard deviation and analysis of variance, the hypothesis were tested at 0.05 alpha level. The finding revealed that highly motivated teachers are committed to work, used appropriate teaching strategies and a reflection of substantial improvement tin pupils' achievement. The study therefore recommends appropriate motivational strategies such as enhanced salaries, sponsorship to conferences and workshops, in-service training and regular promotion of staff to boost their morale.

Introduction

Researcher in education have faced many challenges, one of which is devising solution strategy that will promote teachers' enthusiasm and build skills needed to impact knowledge. Teacher's motivation is as important as the teaching itself and provide opportunity for optimal productivity. This means that a well motivated teacher is one step towards achieving success in teaching and learning especially at the primary school level. Data from the National Centre for Education Statistics (NCES, 2010) confirms that recognition of teacher, parental support, teacher participation in school decision making control in the classroom, opportunities for professional development, increased responsibility, empowerment and authority are some of the factors that will motivate primary School Teachers for self productivity (NCES, 2010).

However, re-thinking primary teacher education is to improve pupils achievement with primary motivator of teacher, motivational strategies are steps taken by government and other stakeholders in order to boost teachers' performance within and outside the classroom leading to enhanced pupils' performance. There are forms of motivational strategies currently used to gingered teacher for high productivity, this includes according to Blasé (2004) shared governance and participatory management strategies where teacher feel. (Eze 2012) stressed that well implemented teacher' motivational strategy can increase teachers' job satisfaction and engage in the teaching activity more vigorously.

Researchers of education from various disciplines stressed that primary school teachers are faced with many challenges such as poor salaries or irregular payment of salary, lack of promotion and accommodation, lack of materials and equipment in the classroom, low teacher morale and sometimes intimidation from parents or guardians (Isyaku, 2011). Because of this organizational structure, teachers required a carefully prepared scheme or framework that monitor and manage teachers' attitude to work and it consequent effect on pupils performances.

The quality of teaching and the degree of teacher's motivation and commitment reflect the level of understanding of other key factors that promote learning among pupils.

Primary school teachers need to be appropriately motivated because they lay the foundation for pupils who intend to be in future a doctor, a nurse, engineers and any other profession (Obilor, 2005). Primary school teachers are the only people in position to imbibe, acquired values, knowledge and skills on part of the child that will transform the society for better in future (Okoro, 2013). Re-shaping primary school teachers for self productivity through motivation is yet to be achieved despite the effort made by the government to assist them to solve some problems that might arise towards discharging their duties.

Ukeneme (2008) observed that provision of adequate teaching materials, classroom accommodation, organizing seminars and workshops, paying attractive salary and taking care staff general welfare helped to improve teacher productivity which directly or indirectly developed the attitude of learner's interest in the choice of their career

In re-engineering primary education, primary school teachers should be given more attention in their profession and motivational strategies in their jobs. Retraining teachers through in service staff development, encourage teachers to enhance pedagogical skills and knowledge of subject matter through advanced academic study and to fashion new knowledge and beliefs about content and pedagogy.

In view of the identified constraints, this study seeks to examine motivational strategies that would help promote effective teaching and learning at the primary school level for optimal productivity and self-employment.

Objectives of the Study

For this study, the following objectives were set: -

- (i) To determine the extent to which motivational skillful strategies (MSS) would be impact or influence re-engineering primary education for self employment and productivity.
- (ii) To find out constraints that might affect re-engineering of primary education for self productivity.
- (iii) To proffer possible solution to the indentified constraints.
- (iv) To assess motivational strategies applicable in sample schools
- (v) Determine the effect of the motivational strategies in the re-engineering of primary education.

Research Questions

The following research questions were developed to guide the study: -

- (i) What are the motivational skillful strategies adopted by primary school teachers to re-engineer primary education for self employment and productivity?
- (ii) What are the likely constraints that may lead to effective re-engineering of primary education for self employment and productivity?
- (ii) What are the possible solutions that would help to reengineer primary education for self productivity?

Hypothesis

There is no significant difference between the mean scores of all primary school teachers and skilful motivational strategies for re-engineering primary education for self productivity.

Methodology

The research method adopted was descriptive survey study. The population of the study consists of all primary school teachers in Bida Local Government Area of Niger State based on the 2014 data census of teachers taken in the state. There are 1152 primary school teachers in Bida Local Government. A sample of 270 teachers were randomly selected from 12 primary schools. Three

different class levels were used i.e. primary II, III and IV respectively. 9 primary school teachers were selected from each class giving a total of 27 teachers per schools. The simple random sampling technique (Hat and Drawn) was used in selecting the sample size.

Modified 25 items teacher motivational strategy questionnaire (TMSQ) was used for data collection. (TMSQ) was measured on a 4 point likert – type format of Strongly Agree (SA) Agree (A) Disagree (DA) and Strongly Disagree (SD) with their corresponding numerical values 4,3,2 and 1.

A total of 270 questionnaires were distributed and collected personally by the researchers and the assistants. Mean and standard deviation scores were used to analyzed the data for the research questions. There was no hypothesis.

Face and content validity of the instrument were re-examined by two senior lecturers who are experts in Psychology and Educational Curriculum. Based on their corrections, suggestions and modifications, the instrument was considered valid, reliable, consistent and helped to improve the quality of the contents. A reliability co-efficient value of 0.81 and 0.85 was obtained using 24 primary school teachers selected from three (3) schools. These values are suitable enough to be used for the instrument in the study.

Presentation of Results and Analysis of Data

The results of the study obtained from research questions are presented in the table below:-

Research Question 1

What are the motivational skillful strategies that would be adopted by primary school teachers for re-engineering primary education for self employment and productivity?

Table 1: Mean and standard deviation of Motivational Strategies that would be adopted for Re-engineering Primary Schools for Self Employment and Productivity?

Table 1: Mean and Standard Deviation of MSS.

Items	Items Description	Mean X	S.D.	Remarks
(i)	Adequate supervision and inspection.	3.485	0.7201	Accepted
(ii)	Teacher participation in school decision making.	3.654	0.862	Accepted
(iii)	Nominating teachers for awards and competition.	3.523	0.950	Accepted
(iv)	Supporting teachers through scholarship competition.	3.453	0.852	Accepted
(v)	Parental support through PTA.	3.764	0.792	Accepted
(vi)	Training and retraining of teachers through conferences and seminars.	3.481	0.854	Accepted
(vii)	Providing opportunities for professional development of staff.	3.752	0.923	Accepted
(viii)	Providing good salary and security.	3.682	0.792	Accepted
(ix)	Providing teaching materials and equipments.	3.567	0.798	Accepted

Table 1 above shows that all items are rated above the agreeable mean of 2.7. This implies that all these skillful strategies can be used to motivate primary school teachers for the attainment of self employment and productivity.

Research Question 2

RQ2: What are the likely constraints that may lead to poor motivational strategies towards re-engineering primary education for self productivity?

Table 2: Showing the mean and standard deviation of the likely constraints that may lead to poor motivational skillful strategies towards re-engineering primary education for else employment.

Table 2: Means and Standard Deviation of Constraints

Items	Items Description	Mean	S.D	Remarks
(x)	Teachers will abandon their jobs and look for more attractive jobs.	3.741	0.892	Accepted
(xi)	Teachers will not grow professionally and this would adversely affect learning.	3.841	0.752	Accepted
(xii)	The children will have inadequate learning and acquire less skills from their teachers and unemployment would be on the increase.	3.652	0.812	Accepted
(xiii)	The teachers will be in efficient to set out the foundation for the future.	3.701	0.78	Accepted
(xiv)	Pupils will not learn the proper skill for preparing them for employment.	3.581	0.793	Accepted
(xv)	There will be less trained teachers that will impact knowledge and skills for the growing children.	3.781	0.692	Accepted
(xvi)	Government and other stake holders will not recognize teachers' effort.	3.781	0.692	Accepted
(xvii)	Illiteracy rate will be on the increase or be greater/ higher.	3.68	0.592	Accepted
(xviii)	A lot of strike will be observed.	3.781	0.876	Accepted
(xix)	There will be juvenile delinquency in the society.	3.581	0.678	Accepted
(xx)	Pupils will no longer learn proper skills.	3.653	0.758	Accepted

Table 2 above shows that the mean of each questionnaire items is above the acceptable mean. This implies that all the items listed above are likely constraints that will affect re-engineering of primary education in Nigeria. This view was supported by Ibrahim (2013) who believes that if teachers are not properly motivated then Nigeria will be gradually destroyed. The teaching profession that tend to give them economic, social and political development, thereby affecting the transformation of the children in their future.

Research Question Three: What are the possible solutions that would help to re-engineer primary education for self productivity?

Table 3: Shows the Mean and Standard Deviation of possible solutions to the constraints that can helped to re-engineer primary education for self productivity

Items	Items Description	Mean	S.D	Remarks
(xxi)	Recognizing and rewarding teachers' effort in re-thinking the future of the children.	3.781	0.891	Accepted
(xxii)	Provide medical services, accommodation and job security for teachers and their families.	3.754	0.793	Accepted
(xxiii)	Supporting and encouraging teachers through training and re-training.	3.752	0.541	Accepted
(xxiv)	Reviewing their salaries and prompt payment of salaries.	3.741	0.592	Accepted
(xxv)	Organizing seminars and workshops to update their knowledge.	3.571	0.671	Accepted

Table 3 above revealed that welfare of teachers, recognizing teacher effort, funding conferences and workshops for training and re-training of teachers may be adequate solution to the problem of re-engineering primary education. This view was supported by Ali (2011) who stressed that primary school teachers need to be properly motivated because they lay the foundation for pupils.

Hypothesis

HO₁: There is no significant difference between the mean scores of all primary school teachers and skillful motivational strategies for re-engineering primary education for self productivity. The skillful motivational strategies for re-engineering primary education for self productivity.

Table 4: Shows the analysis of variance on the mean scores of primary two, three and four teachers on the skillful motivational strategies that would be adopted for re-engineering primary education for sustainable development

Source	df	Sum of Square	Mean Square	F	P	Remark
Between group	3	10842	5421	2.34	0.40	Accepted
Within groups	267	56337	211			

Table 4 above revealed ANOVA analysis of motivational skillful strategies adopted for re-engineering primary school for self productivity. An examination of figures on the table shows that all items rated above the acceptable mean of 2.7 and F ratio of 2.34 is less than the table value at 0.05 level of significance. Thus, the null hypothesis is accepted. This implies that there is no significant difference in the ratings of primary two, three and four teachers on the motivational skillful strategies that would be adopted for re-engineering primary education for self employment and productivity.

Conclusion and Recommendations

Based on the findings, the following conclusions were drawn: -

Re-engineering of primary education may likely be faced with challenges, if teachers are not properly motivated with skillful strategies. Such challenges are: -

- (i) Teachers will abandon their jobs and look for more attractive jobs
- (ii) Pupils will not learn the proper skills for preparing them for their future
- (iii) Illiteracy rate will be increased

Therefore, the study recommends that: -

- (i) Government and other cooperate bodies should encourage and motivate primary school teachers, so as to re-shape the teachers job for self employment and productivity.
- (ii) Reviewing teachers' salaries and prompt payment of salaries as well as issuing merit award to some teacher who performed well.
- (iii) Government should organize workshops and seminars from time to time so as to update their knowledge and discuss most of their problems.
- (iv) Teachers should be given parental supports and encouragement through PTA.
- (v) Teachers should be given the full opportunities to participate in the school decision making.
- (vi) Funding of in-service training to the teachers.

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