EKSU JOURNAL OF SCIENCE AND TECHNOLOGY (EJST)

ISSN 2489-0456

Published by:

OFFICE OF RESEARCH AND DEVELOPMENT,
EKITI STATE UNIVERSITY,
ADO-EKITI, EKITI STATE, NIGERIA.

E-mail: ejst@eksu.edu.ng
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EKSU JOURNAL OF SCIENCE AND TECHNOLOGY (EJST)

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e. Materials and methods should be complete enough to allow experiments to be reproduced, and results written in past tense should be presented with clarity and precision.

f. Results should be explained, but largely without referring to the literature.

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Moran G. J, Amii R. N, Abrahamian F. M, Talan D. A. (2005), Methicillin resistant staphylococcus aureus in community-acquired skin infections. Emeg. Infect. Dis. 11: 928-930.
Pelczar J. R. Harley J. P, Klein D. A. (1993) Microbiology: Concept and applications, McGraw-Hill Inc., New York, pp 591-603.

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10.0 Editorial Board of Ekiti State University Journal of Science and Technology (EJST)

Vol. 2, No 1

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COMPARATIVE STUDY OF PERFORMANCE AND OUTCOME OF FOUR IMAGE PROCESSING SOFTWARE PACKAGES FOR MAPPING PURPOSES

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Abstract

The confidence of decisions taken with image data are dependent on the final output of the processed image. The choice of software to be used by an operator for image processing ideally should depend on the purpose of the task at hand which in turn would depend on the capabilities of each of the software. However, choice of a software for image processing as commonly practiced by operators oftentimes depended on the operator's proficiency in a particular software. This has resulted in a variety of results whose interpretation could impair accurate decision making. The aim of this research is to carry out a comparative study on the performance of four image processing software packages which includes ENVI, IDRISI, ILWIS and MATLAB. A LANDSAT Imagery, Path 191 and Row 55 acquired December, 2002 was used in this study. Six criteria were used to test the performance of each software. In addition, classification and post classification accuracy assessment of the processed image from each software was carried out. The result shows that ENVI has the least launch time and easiest in conversion to software specific format, signature training and image classifications. ILWIS is the best in colour composite generation while IDRISI gives the best post-classification results.

1.0 Introduction

In recent times, there is an increased dependence on remotely sensed images for decision making across different fields. Although land surveying and photogrammetric approaches provides very accurate maps for land use interpretations and decisions, the use of very accurate maps are not always required in many cases of land decision making. Most of these maps generally provide a description of the geographic reality, and although they may not be of high accuracy, they provide the required information necessary for quick and reliable decision making. Remotely sensed images becomes a ready-made tool for the production of these maps. Remote sensing images are of varying resolutions, images of high resolution will produce a more accurate product for interpretations. Therefore, the choice of image resolution required depends on the task to be performed. Apart from image resolution, other factors that can affect the final output of image processing are image classification approaches and the software employed. Irrespective of the resolution of the selected image and the classification approach, software capability is an important concern in the final output of image processing. Inaccuracies in image resolution and classification approach can be worsened with inappropriate selection and manipulation of image processing software. There is therefore the need to understand the purpose of image processing and the best software that can give an optimum output for the task being undertaken.

With the advent of more advanced digital satellite remote sensing techniques, the necessity of performing an accuracy assessment has received renewed interest. This does not imply that accuracy assessment is unimportant for the earlier remote sensing techniques, however given the complexity of digital image classification, there is a greater need to assess the reliability of the results. Traditionally, the accuracy of photointerpretation is assumed to be correct without any confirmation. In fact, classification of remo-

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tely sensed images are often based on photointerpretation. The obvious assumption in this approach is that the photointerpretation is 100% correct. This is a rare valid assumption which can lead to poor and unfair assessment of the digital classification (Congalton, 1991). It is therefore essential that researchers and users of remotely sensed data have a strong knowledge of the factors needed to be considered, which include, the techniques used in performing image processing and the capability of the software to be used. Failure to address these considerations can severely limit accuracy of the processed images and ability to effectively use and interpret the output image.

There have been various studies by previous researchers on accuracy assessment of processed images (Nicholas *et al*., 2008 and Gomez *et al*., 2008) and image classification techniques (Pooja *et al*., 2013 and Subhash *et al*., 2012). There is however a dearth need of study into the comparison of accuracy assessment, input and output display capabilities, colour composite generation, sample set training, processing and post processing operations in different image processing software. ENVI, IDRISI, ILWIS & MATLAB are examples of software applications that can be used to process an image. Image processing software uses raw remotely sensed imagery to produce interpretable product and consequently, to derive data/information. These software contain in themselves, sets of tools for the computer-assisted interpretation of remotely sensed data. Based on the foregoing, the aim of this study is to carry out a comparative study of the performance of four image processing software; ENVI, IDRISI, ILWIS and MATLAB for interpretation of land use information. Therefore, this study carries out image processing of LANDSAT 7 image using ENVI, IDRISI, MATLAB and ILWIS. It compares the ease and accuracies of each software based on six criteria (launch Speed, conversion to software specific format, colour composite generation, signature training, image classification and post-classification). The paper is organized as follows: Section 2 presents the materials and methods and its details; Section 3 discusses the results and the conclusion is in section 4.

2. 0 Materials and Methods

For this project task, LANDSAT 7 image of path 191 row 55 was selected which covers significant part of Lagos State with parts of it in Oyo, Osun and Ogun States in South-Western part of Nigeria. This is shown in Figure 1.

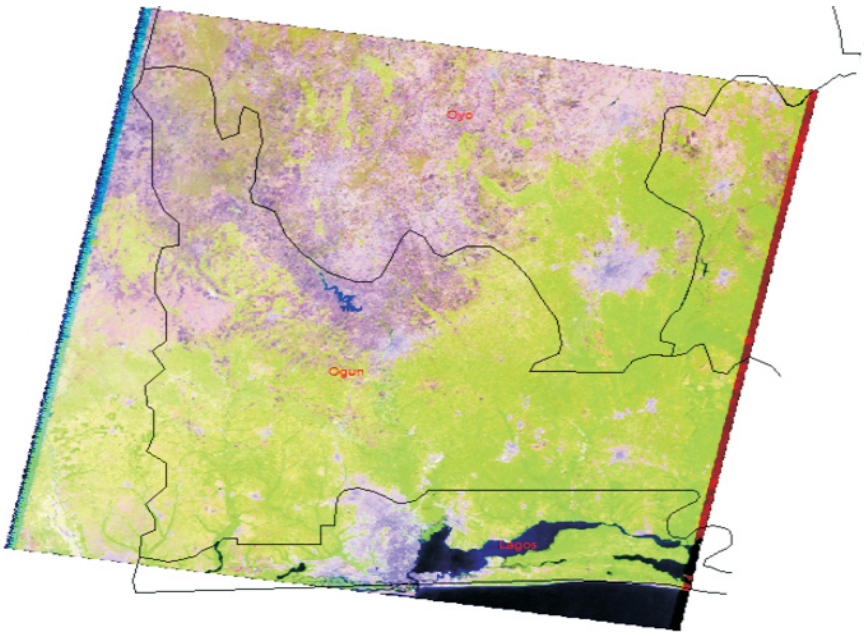

Figure 1 : Landsat Image (Bands 543 combination) used for this study. (www.landsat.usgs.gov/Landsat)

The LANDSAT 7 uses the Worldwide Reference System-2 (WRS) which index orbits (paths) and scene centers (rows) into a global grid system comprising 233 paths by 248 rows (Barsi *et al*., 2003). LANDSAT 7 has the capacity to collect and transmit up to 532 images per day. The main instrument on board Landsat 7 is the Enhanced Thematic Mapper Plus (ETM+). Figure 2 shows the WRS imposed on the Nigerian map. The entire procedure involved in executing this work is as shown in Figure 3.

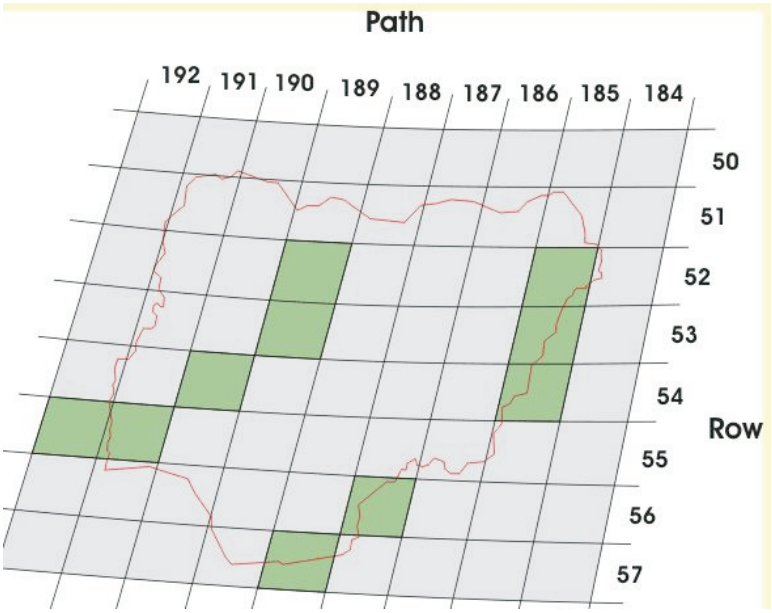

Figure 2 : World Reference System
(Source: http://www.yale.edu/ceo/DataArchive/nigeria.html)

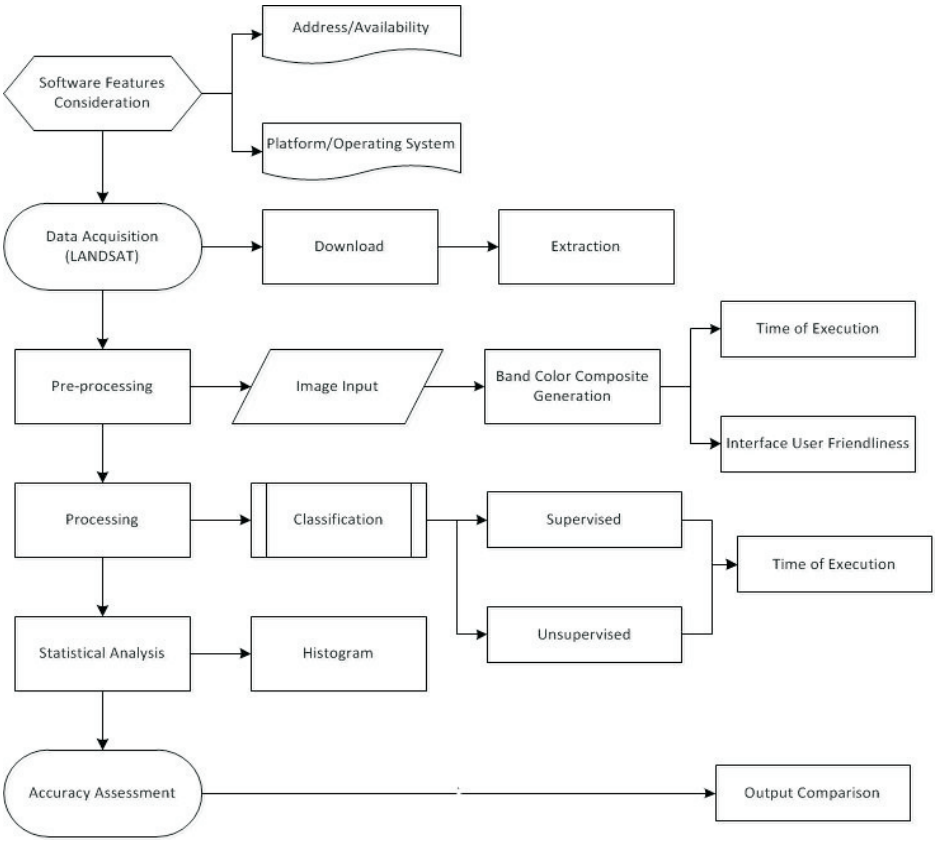

Figure 3 : Flow Chart of Methodology

2.1 Personal Computer's Configuration

A TOSHIBA personal computer with properties as described below was used in the processing of the LANDSAT 7 image.

Processor	intel Core i5-2410M CPU @ 2.30 GHz
Processor Rating	6.9 Calculations Per Second
Installed Memory (RAM)	4.00 GB
RAM Rating	5.9 Memory Operations Per Second
System Type	64-bit Operating System
Hard Disk Size	500 GB (465 GB)
System Operating System	Microsoft Windows 7 Ultimate

2.2 Software Features Consideration

The operating system requirements of each software were considered as documented on their website in some cases and in the software package. Table 1 shows the software features of each of the software considered.

2.3 Image Processing

All remotely sensed images are representations of the real world and the applications of certain processes on these images maximize the values of particular images to particular applications (Olaleye,1998). Image processing includes all processes involved in correction, enhancement and classification of images for easy interpretation and better analysis.

Table 1: Software Features

Features/Software	ENVI	IDRISI	ILWIS	MATLAB
Availability Type	Commercial	Commercial	Open	Commercial
Developer	Exelis VIS	Clarks University	ITC 52° North ILWIS community	MathWorks
Version	Version 5.0	Selva (15.0)	Version 3.3	R2013A
Operating System	Windows (32-bit or 64 bit), OSX, Linux	Windows XP and above (32 -bit and 64-bit)	Windows 98, Me, NT,2000, XP	Windows, Linux, Mac
Base Language	IDL, Python	Delphi, Visual C++, Visual Basic	C++	C++, java
Graphical Display Minimum	Minimum display of 1024 x 768 with 64,000 colors	Minimum display of 1024 x 768 with 64,000 colors	Minimum display of 1024 x 768 with 64,000 colors	Minimum display of 1024 x 768 with 64,000 colors
RAM, disk drive minimum	512 MB RAM, 2 GB	512 MB RAM, 1 GB	256 MB RAM, 1 GB	2048 MB RAM, 1 GB
Source (URL)	www.exelisvis.com	www.clarklabs.org	www.ilwis.org	www.mathworks.com

2.4 Image Classification

Based on a priori knowledge of the study area and reconnaissance survey with additional information from previous research in the study area, a classification scheme (after Anderson, 1976) was developed using a supervised classification method. The land-use types classified are: Dense urban, moderate urban, vegetation, water body, wetland and mangrove. Image classification assigns the decision making process to the computer. A satisfying and mathematically reliable classification theory mostly adopted by many researchers is the Maximum likelihood classification (Brito *et al*., 2006). Maximum likelihood classification was done by calculating the following discriminant functions for each pixel in the image as shown in Equation 1 (Paris, 2016):

$$g_i(x) - \ln p(\omega) - 1/2 \ln |\Sigma_i| 1/2 (x-m_i)^t \Sigma_i^{-1} (x-m_i) \quad (1)$$

Where: i = class
x = n-dimensional data (where n is the number of bands)
$p(\omega_i)$ = probability that class ω_i occurs in the image and is assumed the same for all classes
$|\Sigma|$ = determinant of the covariance matrix of the data in class wi
Σ_i^{-1} = its inverse matrix
m_i = mean vector

The maximum likelihood classification was used for processing image in ENVI, IDRRISI and ILWIS while K-means Clustering (partition n observations into k clusters in which each observation belongs to the mean of the cluster [David, 2004]) technique was adopted in the MATLAB environment. The classification scheme used for image processing is shown in Table 2.

2.5 Accuracy assessment of Processed Images

Accuracy of the processed image is very crucial because all results and analysis depends on image processing accuracy. Each class processed was superimposed on the original image to check the degree of agreement between original image and the processed image. Where disparity exists, available maps, experience acquired during reconnaissance and disparity observed were all compared before editing was carried out.

Table 2: The classification schemes used for the study

Class	Description
Water Body	Rivers, Streams, Creeks, Lagoons, etc. An example is Ogun River
Wetland	An area of land in which soil is saturated with moisture either permanently or seasonally featuring flooding of large areas of land by shallow bodies of water
Forest	Areas with a high density of trees and characterized by high rainfall
Woodland	Areas with low-density forest forming open habitats with plenty of sunlight and limited shade. Includes shrubs and grasslands.
Built Up	Urban and rural settlements as well as other man-made features e.g. roads, railway tracks etc.
Bare Land	Land undergoing transition from being covered by vegetation to being built up. They are currently stripped bare, that is empty.

Having done all necessary editing, the accuracy of the classification result was done by comparing the classification result with ground truth information, in this case ground truths are the Region of Interests (ROIs). Accuracy assessment of processed images were done in two ways: the overall accuracy and the Kappa Statistics. The overall accuracy of processed images was calculated using Equation (2).

$$p_0 = \frac{1}{N}\sum_{i=1}^{m} n_{ii} \qquad (2)$$

n_{ii} = the total number of correctly classified points by class along the diagonal of the error matrix

N = the total number of sampled points (Lo & Yeung, 2007).

Overall processing accuracy of 85% and above are considered suitable for urban expansion studies (Anderson et al, 1976). In the Kappa Statistics approach, the Kappa coefficient was computed using Equation (3)

$$KP = \frac{P_0 - P_c}{1 - P_c}$$

P_0 = Overall processing accuracy given in Equation (4)

P_c = Expected accuracy, where,

$$P_c = \frac{1}{N^2}\sum_{i=1}^{m}(n_{i+} \times n_{+i})$$

n_{i+} = row sum by class

n_{+i} = column sum by class

m = the total number of classes (Lo & Yeung, 2007).

3.0 Results

Here, the results of the processed LANDSAT image on the four (4) software applications are displayed, analyzed and discussed.

3.1 Image Classification Results

Image processing output for the four software packages are presented in Figure 4. MATLAB encountered an 'Out of Memory" issue in the course of processing the image for this study (Figure 4d). Several attempts to increase allocated virtual memory to MATLAB for task completion proved abortive. MATLAB processes image pixel-by-pixel which takes so much time as well as computational space. This operation poses huge computational burden when the area involved is very large. Hence, the same computer system whose configuration was stated earlier was inadequate for image processing of the study area using MATLAB.

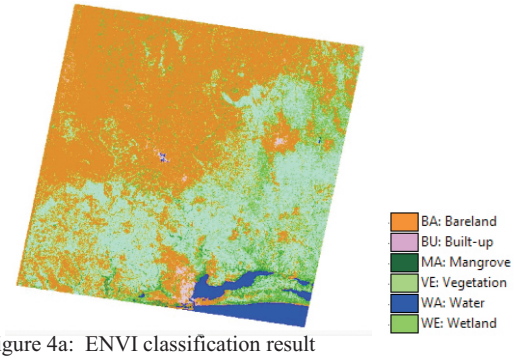

Figure 4a: ENVI classification result

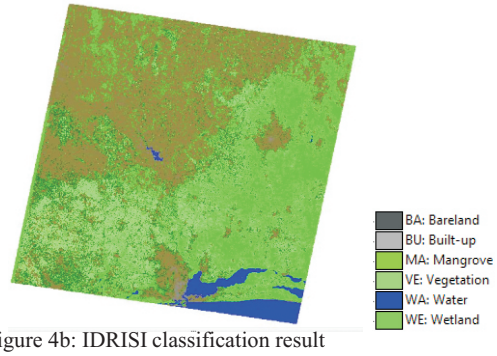

Figure 4b: IDRISI classification result

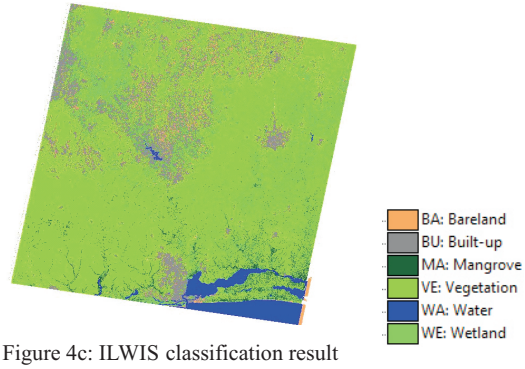

Figure 4c: ILWIS classification result

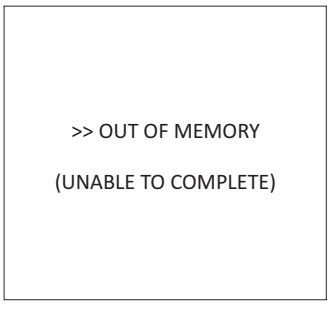

Figure 4d: MATLAB tering)

Figure 4: Classification output in software packages

3.2 Statistical Analysis

For each software package, there is a provision for statistical analysis. Statistical analyses such as Histograms, mean/average, minimum, maximum, total and standard deviation were done and compared among the four software, Band 5 of the LANDSAT image was used to compare the statistical analysis of the packages. Figure 5 is a graphic display of statistical result in each software package. No result is presented for MATLAB because MATLAB did not complete the processing. Although result could be obtained based on the level of processing before system ran out of memory, such result can misrepresent the actual results obtainable if the process had been completed. Table 3 is a summary of the statistical result in each of the software packages.

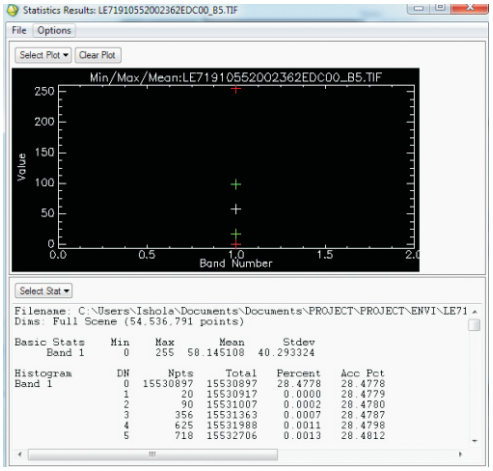

Figure 5a: Statistical result in ENVI

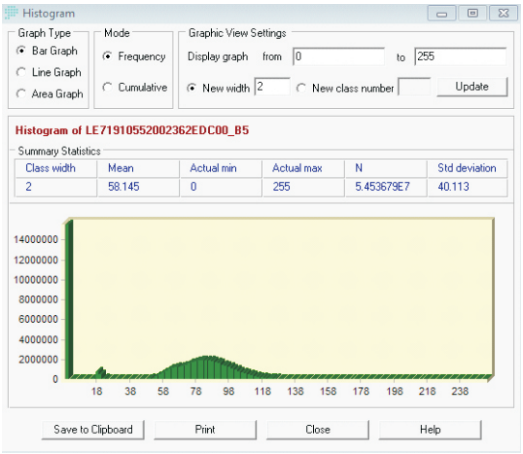

Figure 5b: Statistical result in IDRISI

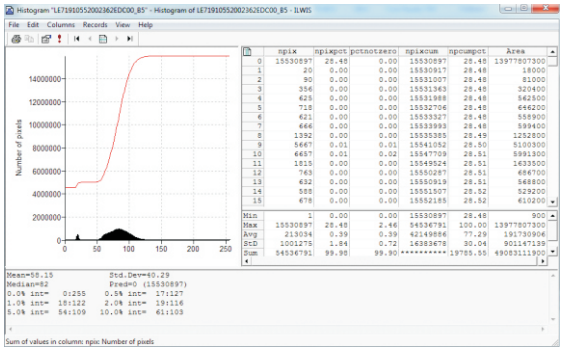

Figure 5c: Statistical result in ILWIS

Table 3: Histogram Statistics in each software package

	ENVI	IDRISI	ILWIS	MATLAB
Class width	1.00000	1.00000	-	-
Display minimum	0.000	0.000	-	-
Display maximum	116.000	116.000	-	-
Actual minimum	0	0	-	0
Actual maximum	255	255	-	255
Mean	58.145	58.145	58.145	58.145
Stand. Deviation	40.293	40.113	40.290	40. 154
Median	-	-	82.000	83.500
Total (N)	54536791	54536791	54536791	54536791

3.3 Discussion of Results

The results of the performance of each of the software package based on selected criteria are presented in this section. The image launch speed in each software, image input and software capability, colour composite generation software training for classification, classification and post classification are all the operations compared in each package and the results are as presented. The MATLAB results are those obtained before the operation stopped.

Launch speed was compared in each of the software packages and the results are shown in Table 4. With a time of approximately 1.23 seconds, ILWIS was the fastest to launch for the operator to perform image processing task.

Table 4: Launch Speed

General	Criteria	Image Processing Software Packages			
		ENVI	IDRISI	ILWIS	MATLAB
Launch Speed	Launch Time	8.15 secs	5.87 secs	1.23 secs	43.66 secs

In terms of the need to convert to a software specific format before processing can be performed, number of input steps of bands, number of interactive dialogue boxes and approximate time, results as presented in Table 5 shows that MATLAB software package is the easiest with six (6) steps to get all the bands on the software, no need for format conversion – works with the default file format – and no dialogue boxes used. However, the time it took to achieve this is approximately 17.39 seconds, more than time required by ILWIS and ENVI and less than the time required in IDRISI. ENVI followed in the ease to perform these tasks with time much less than those of MATLAB and IDRISI.

Table 5: Conversion to specific format

Pre-processing	Criteria	Image Processing Software Packages			
		ENVI	IDRISI	ILWIS	MATLAB
	Conversion to software format	NO	YES	YES	NO
	NO. of Input Steps for bands	6	10	8	6
	NO. Interactive Dialogue box	2	3	2	0
	Procedure repeated	NO	NO	YES	NO
	Input Time for the bands	13.39secs	19.71secs	10.88secs	17.39secs

Table 6 is the results obtained for colour composite generation in each package. The number of steps taken to generate a colour composite, number of interactive dialogue boxes used and the approximate time of execution were compared. The time required for this operation is very long in MATLAB although it has the least number of steps and does not use dialogue boxes, it took the longest time. ILWIS and IDRISI however performed better than ENVI in the number of steps and number of dialogue boxes involved while ILWIS used less time than IDRISI.

Table 6: Colour Composite Generation

Pre-processing	Criteria	Image Processing Software Packages			
		ENVI	IDRISI	ILWIS	MATLAB
Color Composite Generation	Steps	7	4	4	2
	NO. Interactive Dialogue box	2	1	1	0
	Time of Execution	3.12secs	24.63secs	16.24secs	973.89secs

In signature class training, the results are presented in Table 7. The number of steps, number of dialogue boxes, the bands used and flexibility of the four software packages to perform signature class training, ENVI is the easiest for use.

Table 7: Signature Class Training

Processing	Criteria	Image Processing Software Packages			
		ENVI	IDRISI	ILWIS	MATLAB
Signature Class Training	Steps	8	17	8	12
	Dialogue box	1	2	5	1
	Bands Used	Composite	Single/ Composite	Single/ Composite	Single/ Composite
	Flexibility	YES	NO	YES	YES

The classification time in each package is compared in Table 8. With an approximate time of 19.71 seconds in the performance of image classification, classification on ILWIS software package used the least time. The time for MATLAB could not be presented because MATLAB did not complete the processing operation.

Table 8: Classification

Processing	Criteria	Image Processing Software Packages			
		ENVI	IDRISI	ILWIS	MATLAB
Classification	Workflow Availability	YES	NO	NO	YES
	Time of Execution(Approx.)	199.96secs	47.36secs	19.71secs	-

Results of post-classification operations are presented in Table 9. With an accuracy of 99.557%, kappa coefficient of 0.9110, the use of three dialogue boxes and three steps, IDRISI could be the most preferred package in post-classification capability.

Table 9: Post-Classification

Processing	Criteria	Image Processing Software Packages			
		ENVI	IDRISI	ILWIS	MATLAB
Post – Classification	Steps	4	3	5	6
	No. of Dialogue Boxes	4	3	3	4
	Kappa Coefficient	0.8957	0.9110	0.8993	-
	Accuracy	98.879%	99.557%	92.630%	-

Summary of findings from the research are presented as follows:

- Availability Type: Out of the four image processing software used in this study, ILWIS is the only Open source package, that is, it is freeware software, which can be downloaded at www.ilwis.org
- Minimum RAM size: The minimum size (RAM) of the image processing software packages is 512mb except that of ILWIS & MATLAB which is 256MB and 2048MB respectively.
- Format Conversion: ENVI & MATLAB do not require conversion of original Image format to a software recognizable format. ENVI in particular has an automated routine to read image files and works with the file directly.
- Launch Time: Amongst the software, ILWIS takes the shortest time to start up.
- Image importation: No provision was made in ILWIS & MATLAB to import each image band and analyze required images needed in processing at once, the procedure had to be repeated for each band of image.
- Training of classes: To perform classification, signature classes were trained using a composite image. ENVI only uses a composite image in training classes. However in the three other packages, the classes could be trained on single/individual bands.
- Classification Workflow: There is availability of Classification Work-flow in ENVI and MATLAB.
- Classification Accuracy: IDRISI presented the highest overall accuracy of 99.557%.
- User Friendliness in Composite Generation: ENVI could be the preferred software in terms of user friendliness in generating a colour composite.
- Statistical Analysis: IDRISI is also the most preferred software in terms of statistical analysis, as it contain more statistical modules than other image processing software.
- Time of Execution in processing: From the four image processing software packages, ILWIS has the minimum overall time of execution in processing and analysis of images.
- Multi-tasking: Of all the four image processing packages, only IDRISI can perform other operations while other operations is still going on, which is a big advantage as one does not have to wait for one operation to finish before performing another, (this only happens if and only if the latter operation is independent or is not a function of the former operation).

4.0 Conclusion

The comparative study of the image processing software packages shows that although the packages were either comprehensive or interchangeable, each contained many useful features just depending on purpose, lead-time and need. Although, more than one package may be required to complete all processing operations and analysis, the following was obtained;

- ENVI software is most user-friendly in image processing operations.
- ENVI is also the best for visual interpretation especially with its multiple view and Geo-linking capabilities.
- For image processing tasks with short lead time, ENVI software package is recommended, however this depends on the grades of the computers.
- IDRISI software package is recommended for tasks involving image processing and analysis that emphasize more statistical results.

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ELECTROMAGNETIC PROFILING AND ELECTRICAL RESISTIVITY SOUNDINGS FOR GROUNDWATER INVESTIGATION IN A TYPICAL BASEMENT COMPLEX: A Case Study of part of Ijero-Ekiti, Southwestern Nigeria

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Abstract:
Integrated geophysical techniques involving Very Low Frequency Electromagnetic Method (VLF – EM) profiling and Electrical Resistivity method using the Vertical Electrical Sounding (VES) technique have been used to map College of Health Sciences Technology, Ijero Ekiti, Ekiti State, Southwestern Nigeria, with the aim of determining its groundwater potential. The qualitative interpretation of VLF – EM results identified areas of hydro-geologic importance and aid in the selection of specific points for VES. Thirty VES were carried out across the area using the Schlumberger electrode array configuration, with half-current electrode separation (AB/2) varying from 1 m to 65 m. The data acquired were interpreted qualitatively and quantitatively and were presented as table, maps, chart and section. The interpreted models revealed three to six geo-electric layers namely; topsoil, lateritic clay, weathered layer, fractured basement and the fresh basement. The weathered basement and the fractured basement are the potential aquiferous layers within the area. On the basis of the characteristics of geo-electric parameters the study area is zoned into good, intermediate and poor groundwater potential zones. However, the groundwater potential of the area is generally rated low.

Key words: Profiling, Electrical Resistivity, Sounding, Aquifer, Basement Complex.

INTRODUCTION

Water is one of the most important natural resources available on earth. Without it, there would be no life on earth. The extractable quantity of portable water for use is limited by nature.

Groundwater is the water held in the subsurface within the zone of saturation under hydrostatic pressure below water table (Ariyo and Banjo, 2008). Observation shows that groundwater comes from rain, snow, ice sheet and hail that percolate into the ground and become the groundwater responsible for the spring, wells and bore holes (Oseji *et al.,* 2005).

Ijero Ekiti is underlain by Basement Complex rocks of the southwestern Nigeria and groundwater in this environment is usually contained in the weathered and/or fractured basement rocks or alluvial deposits within flood plains as mentioned by some authors among whom are Wright (1992), Olorunfemi and Fasuyi (1993) and Ogungbemi *et al.,* (2014).

The availability of quality water resources has always been the primary concern of people within the basement complex region and Ijero-Ekiti is not an exception.

Groundwater is widely used as a source, for drinking supply and irrigation in food production (Zekster and Everett, 2004). Naturally, 53% of all population relies on groundwater as a source of drinking water (Alabi *et al.,* 2010). Surface water is not reliable and dependable; hence, the need for good quality groundwater in this area forms the basis for this research.

Geophysical survey involving electrical resistivity, gravity, seismic and electromagnetic methods constitutes the most reliable means, outside direct mechanical drilling, through which basement structures such as ancient river channels, basement depressions and fractured zones that are of hydrogeological significance can be mapped (Eaton and Watkins, 1970; Vanderberghe, 1982). However, the most commonly applied geophysical technique for groundwater

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exploration is the electrical resistivity method. This is a consequence of the usually significant resistivity contrast between the deposit within the channel and the underlying bedrock (Ako and Olorunfemi, 1989).

The Very Low Frequency Electromagnetic (VLF – EM) method has found useful application in groundwater investigation in basement terrain, most especially as a reconnaissance tool (Amadi and Nurudeen, 1990; Olorunfemi *et. al.,* 1995; Adiat *et. al.,* 2009).

In view of the above, integrated geophysical investigation involving very low frequency electromagnetic (VLF-EM) and electrical resistivity methods were conducted at College of Health Sciences Technology, Ijero Ekiti, Ekiti State, Southwestern Nigeria (Fig. 1), with a view to determine its groundwater potential.

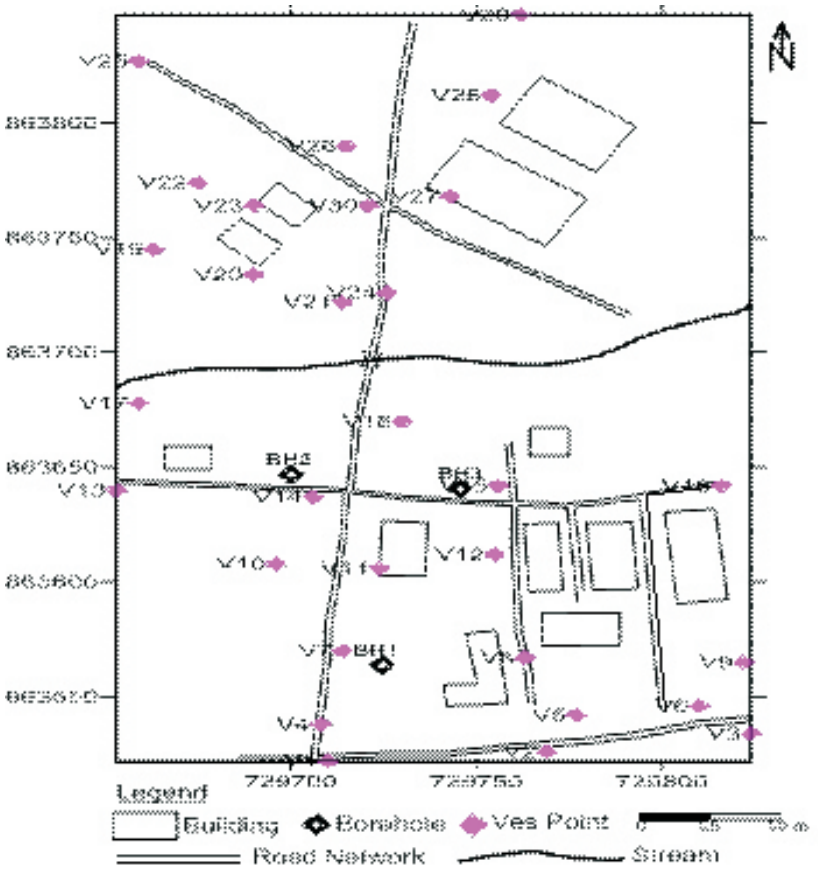

Figure 1: Location map of the study area showing VES points

Geology of the Study Area

The Ijero area is within the Basement Complex region of Southwestern Nigeria. The study area lies within latitudes 7º 46' - 7º 53' N and longitudes 5º 00' - 5º 07' E. The town is located at about 42 km northwest of Ado-Ekiti. Ijero-Ekiti area which is located around the eastern margin of Ife-Ilesha Schist belt is underlain by Precambrian Basement Complex rocks (Fig. 2). Systematic geological mapping carried out on the study area revealed rocks associated with mafic and ultramafic rocks, schists, gneisses, quartzites and granite pegmatite. Details of the lithological and petrographic characteristics of these associated rocks are contained in (Okunlola and Akinola, 2010). The study area is rugged with undulating terrain consisting entirely of gneissic and quartzite rocks. Most of the rocks in the study areas are well exposed in some places.

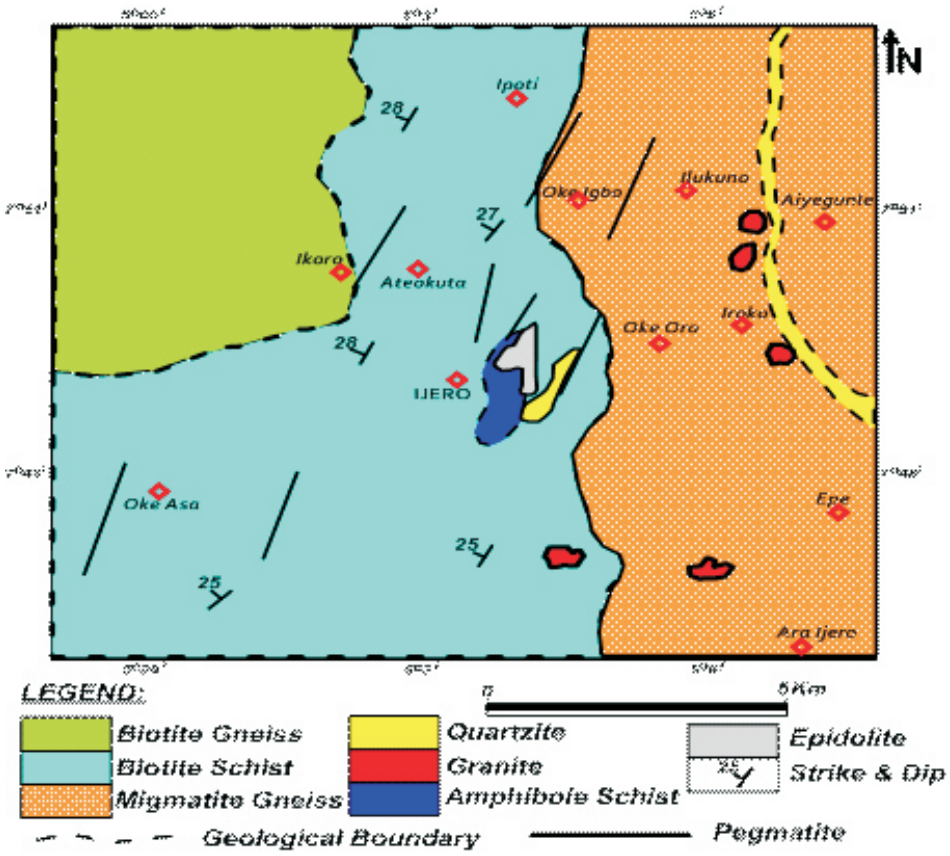

Figure 2: Geological map of Ijero-Ekiti (After Okunlola and Akinola, 2010).

Materials and Methods

Two geophysical methods involving the VLF-EM and the electrical resistivity methods were adopted for this survey. The VLF-EM method was carried out first due to its ability to provide extensive and qualitative information on the conductivities of different subsurface layers and also aid in the selection of specific points for the VES data acquisition.

Very Low Frequency Electromagnetic (VLF-EM) Method

The VLF-EM geophysical method is a quick and powerful tool for the study of shallow conducting lineament features in the near surface earth (Telford *et. al.,* 1977). The method is based on measurement of the secondary magnetic field induced in local conductors by primary electromagnetic fields generated by powerful military radio transmitter in the very low frequency range (15 – 25 Khz).

The instrument employed for this survey was the ABEM WADI, which measures the in-phase (Real) and quadrature (Imaginary) components of the induced vertical magnetic field as a percentage of the horizontal primary field. The VLF measurements were made along seven traverses, using the existing roads and footpaths with orientation at high angles to the direction of the transmitter, with station intervals of 10 m.

The raw real, R (in phase) and the imaginary, I (quadrature) components were measured on the field. The raw real VLF data were converted with the aid of an in-built filtering program provided in the ABEM WADI equipment as well as a software package (KHFfilt Version 1.0, Pirttijärvi, 2004), into filtered Real data in which anomaly inflections appear as peak positive anomalies and false VLF anomaly inflections as negative anomalies of the profiles (Reynolds, 1977).

The Electrical Resistivity Method

The electrical resistivity method utilized the Vertical Electrical Sounding (VES) techniques. The geophysical data were acquired with the SSR-MP1Resistivity Meter.

The resistivity meter is a high quality earth resistance meter capable of accurate measurements over a wide range of conditions. It contains both the transmitter unit, through which current enters the ground and the receiver unit, through which the resultant potential difference is recorded. Other materials include: two current electrodes and two potential electrodes, two black coloured connecting cables for current electrodes and two red coloured cables for potential electrodes, two reels of calibrated ropes, hammer for driving the electrodes in the ground, compass for finding the orientation of the traverses, cutlass for cutting traverses and data sheet for recording the field data. In the study area, the electrode spread of AB was varied from 1 to a maximum of 130 m (Fig. 3). The electrical resistivity data were processed by plotting the apparent resistivity values against the half of electrode spread (AB/2). This was subsequently interpreted quantitatively using the partial curve matching method and computer assisted 1-D forward modeling using Win-Resist 1.0 version software (Vander Velpen, 2004).

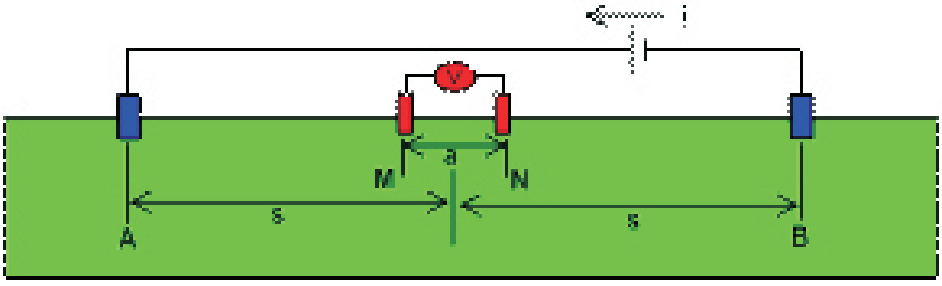

Figure 3: A sketch diagram of Schlumberger array

Second order geoelectric parameters called Dar Zarrouk parameters were determined from the iterated geoelectric parameters (Mallet, 1974). This second order parameters are derived using equations developed by (Zohdy *et al.,* 1974). For n layers, the total longitudinal unit conductance (S) and coefficient of anisotropy (λ) is given by:

$$S = \sum_{i=1}^{n} \left(\frac{h_i}{\rho_i} \right) \qquad (1)$$

$$\lambda = \left(\frac{\rho_T}{\rho_L} \right) \qquad (2)$$

where, S = longitudinal unit conductance, n is the number of layers, h_i is the layer thickness, ρ_i is the layer resistivity, ρ_T is the transverse resistivity, ρ_L is the longitudinal resistivity and λ is the coefficient of anisotropy

Results and Discussion

VLF – EM Profiles and Map

A typical plot of raw real (quadrature) measured on the field and the filtered real is presented as profiles (Fig. 4 (a)) and its corresponding Karous-Hjelt (K-H) pseudo sections is shown in Figure 4 (b) respectively. The interpretation of both the profiles and pseudo sections was basically qualitative or semi quantitative. Figure 4a shows the raw and filtered real profiles along profile 7. Several inflection points mapped as fractures (e.g., F1 and F2 at distances 45 m and 120 m respectively) on the filtered real is shown.

These points are zones of interest in groundwater abstraction in basement complex terrain. Figure 4 (b) shows the corresponding K-H pseudo section of the profile. The pseudo section is a measure of conductivity of the subsurface as a function of depth. The conductivity is shown as colour codes with conductivity increasing from left to right (i.e. from negative to positive). Different features of varying degree of conductivity trending in different directions were delineated on the section, for instance, within stations between 38 and 50 m, 90 and 135 m, a highly conductive body at an approximate depth of 10 m were shown.

Several other closures of conductive bodies are present on the section with each conductive body coinciding with the points already identified on the profile as fractures/joints.

The same process of qualitative interpretation was adopted for the remaining profiles and their corresponding pseudo sections. Based on the interpreted VLF-EM profile the points of interest marked as F1 and F2, etc. were among the points that were further investigated using the Vertical Electrical Resistivity Sounding technique.

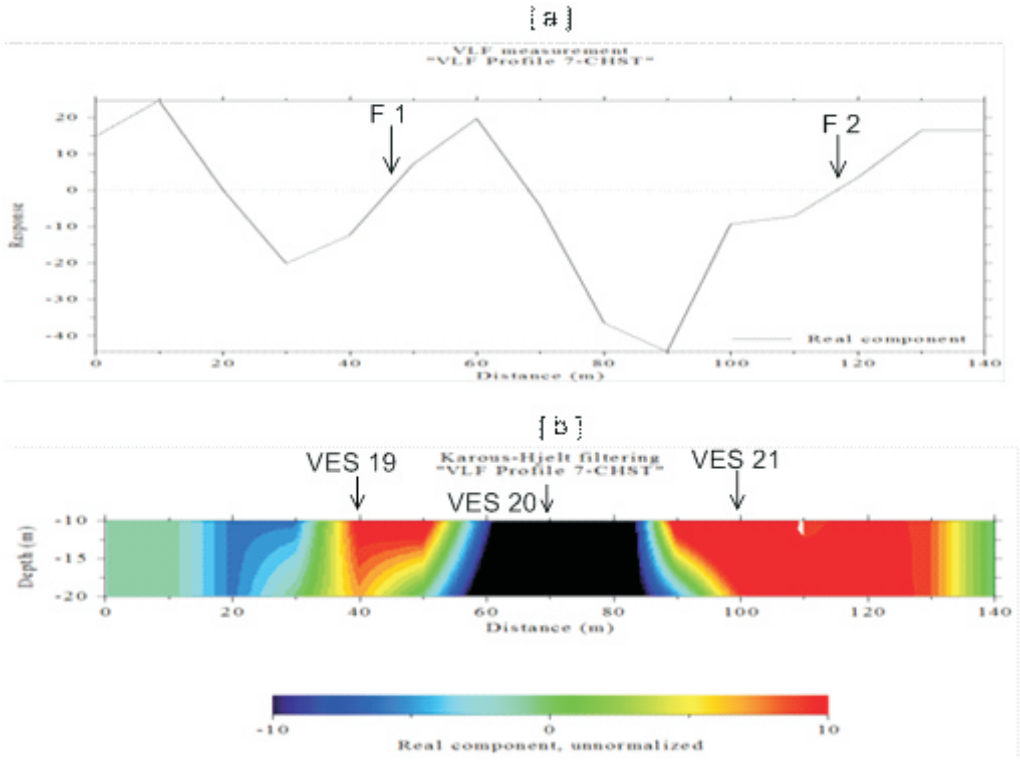

Figure 4: [a] VLF-EM profile along traverse 1, and [b] Karous and Hjelt Pseudo Section of the Inverted VLF-EM Real component of the Profile.

Resistivity Sounding Curves and Geoelectric Sections

Table 1 shows the summary of results obtained from the resistivity data inversion, while the pictorial statistical analysis of the result is presented in Fig. 5. Curve types identified were A, K, H, QH, KH, HA, KHK, KA, HK. The predominant curve type is A-curve type having percentage frequency of 46.7%. The high percentage recorded by the A curve type within this study area is an indication of a predominantly low ground-water potential of the study area.

Table 1: VES Curve types from the resistivity data

Curve Type	Frequency
QH	1
KH	3
H	5
HA	2
A	14
KHK	1
KA	1
K	2
HK	1

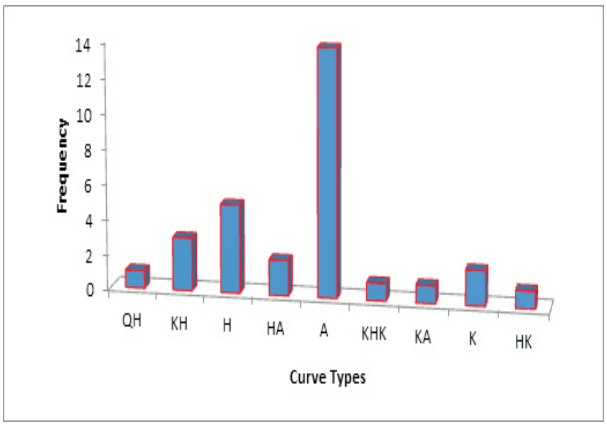

Figure 5: Frequency of curve types within the study area

The 2 Dimensional view of the geo-electric parameters (resistivity and depth) obtained from the inversion of the electrical resistivity sounding data are presented as geo-electric sections.

Figure 6 (a) and (b) are geo-electric sections drawn through VES locations 4, 7, 11 and 15 in the NE – SW and VES points 10, 11 and 12 in the W-E directions respectively.

In figure 6 (a), the top soil which is relatively thin, is characterized by resistivity values between 76 Ohm-m and 390 Ohm-m and thickness values between 0.6 m and 4.8 m. Based on the resistivity values, the top soil is presumed to be clayey to sandy soil. Under VES 4 and 15, the second layer resistivity value is presumed to be an indication of lateritic-clay soil, with resistivity value of 169 ohm-m and 484 ohm-m respectively. Beneath the topsoil under VES 7, the relatively high resistivity value of 1005 ohm-m observed indicate a resistive material within lateritic-clay layer. However, another layer recognized as weathered layer extends from VES 4 through VES 7, 11 and 15. This aquiferous unit is characterized with low resistivity values ranging from 13 Ohm-m to 120 Ohm-m with layer thickness ranging from 8.2 m to 16.5 m. Beneath this aquifer unit is another layer recognized as fractured basement, it occurred below VES 7 and VES 15 with resistivity 346 ohm-m and 206 ohm-m and layer thickness 29.7 m and 13.6 m respectively. The fresh bedrock with resistivity values ranging from 644 ohm-m to 1818 Ohm-m is observed under VES 4, 11 and 15 and is of infinite depth. Depth to the bedrock varies from 13.9 to 42.3 m.

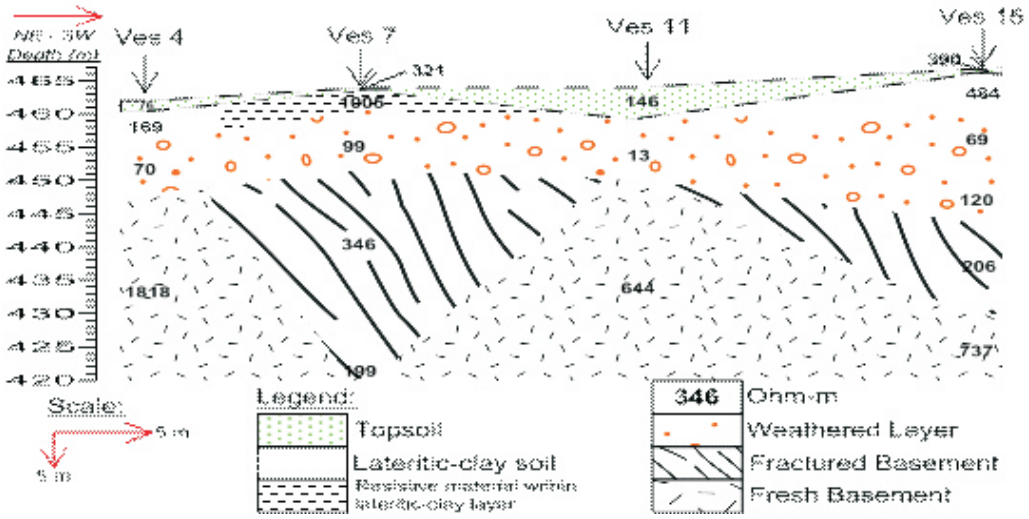

Figure 6 (a): Geo-electric section through VES points 4, 7, 11 and 15.

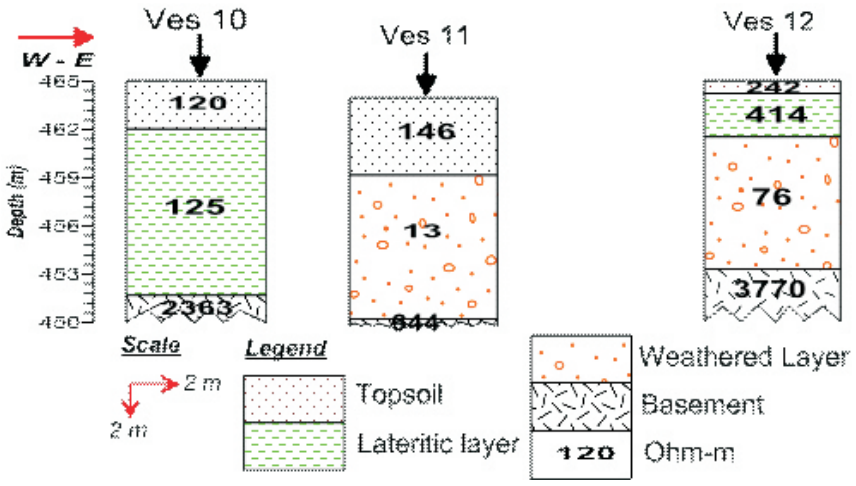

Figure 6 (b): Geo-electric section through VES points 10, 11 and 12

Overburden Thickness Map

The overburden thickness map (Fig. 7) shows that the overburden thickness of the area varies from 2 to 42 m. The northern and most of the central flanks have thin overburden (between 2 to 14 m thick), while the southern and some of the central flanks have relatively thick overburden (thickness between 16 to 42 m). Zones within the study area whose overburden thickness is less than 16 m are considered in this study to have low groundwater accumulation. On the other hand, zones identified as having overburden thickness $\geq$ 24 m are considered to have moderate to high groundwater accumulation potential. Such zones cover about 25% of the entire study area.

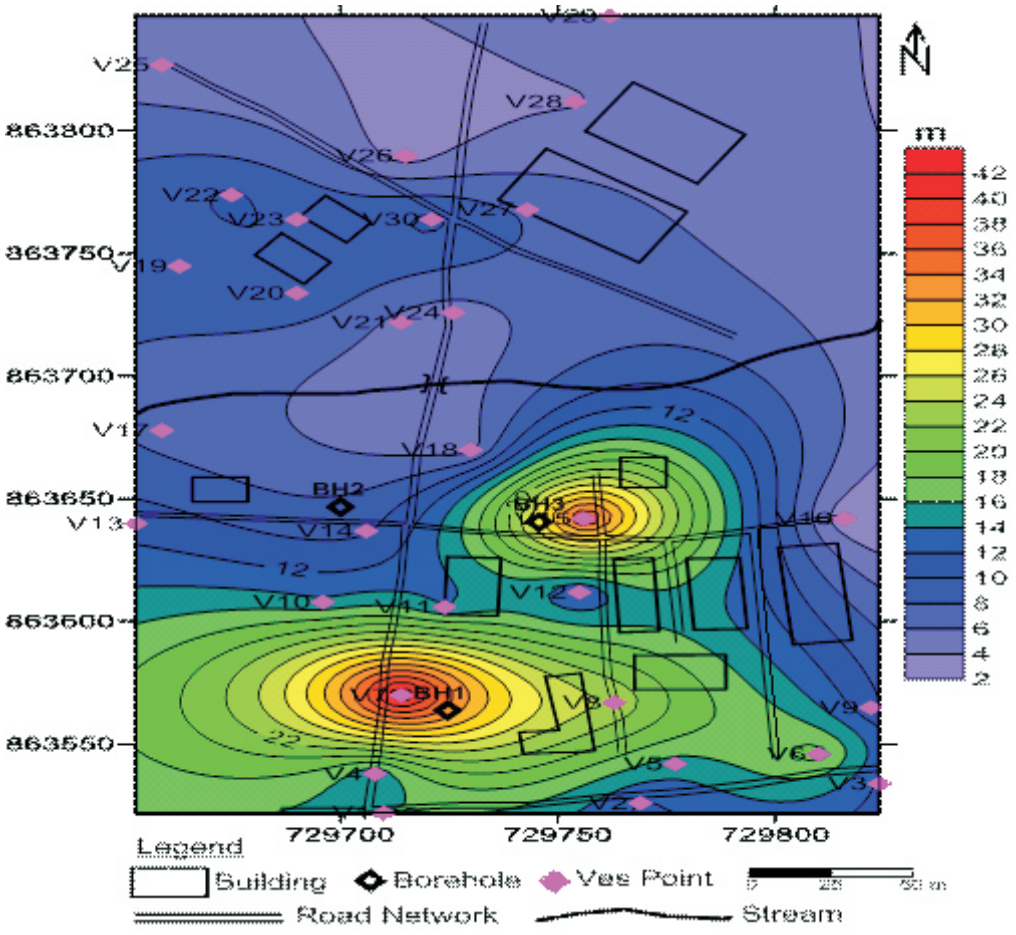

Figure 7: Overburden Thickness Map of the study area.

The longitudinal unit conductance (S) values obtained from the study area, ranges from 0.05 to 0.75 mhos. Clayey overburden, which is characterized by relatively high longitudinal conductance, offers protection to the underlying aquifer. According to the classification of Oladapo and Akintorinwa, (2007), the longitudinal unit conductance values from the study area enabled us to identify area with weak, moderate and good protective capacity and its transmissivity potential. Where the conductance is greater than 0.55 mhos are considered zones of good protective capacity. The portion having conductance values ranging from 0.15 to 0.35 mhos was classified as zone of moderate protective capacity; and area with values ranging from 0.05 to 0.15 mhos is considered to have poor protective capacity.

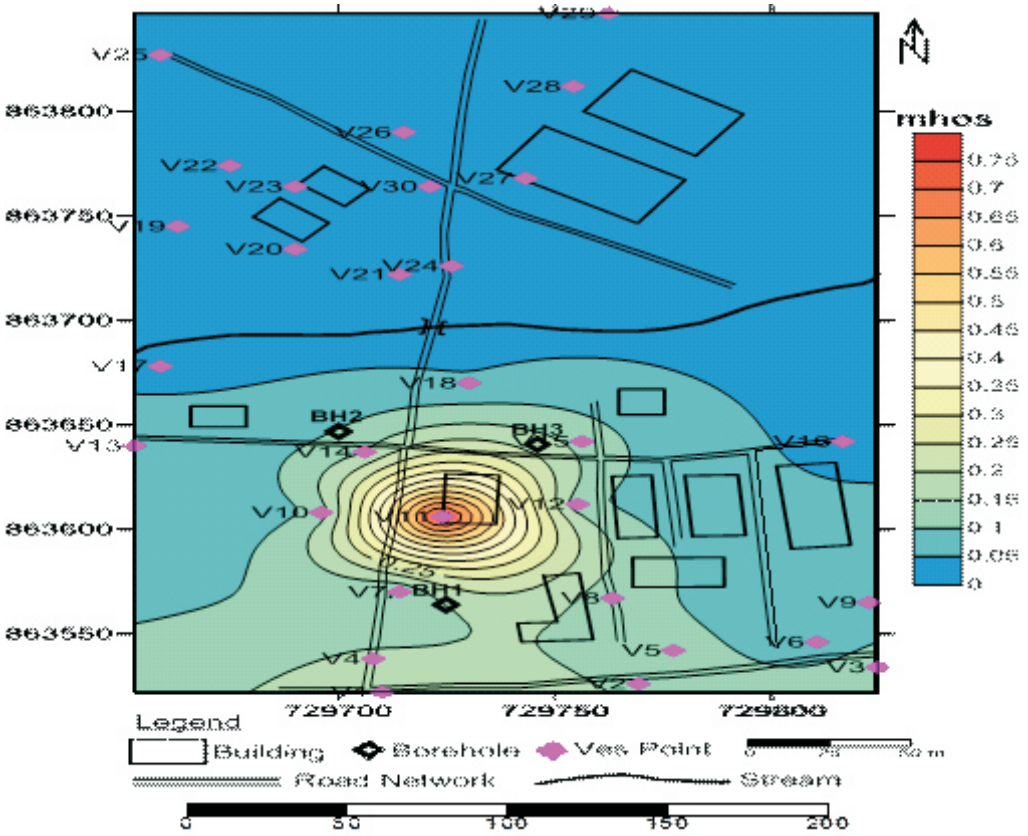

Figure 8: Longitudinal Unit Conductance of the study area.

Bedrock Relieve Map

The bedrock relief map of the study area was produced by removing the overburden thickness values from the elevation values . The map reflects the topography of the bedrock underlying the study area (Fig. 9). The map shows features of the basement structures within the study area to include basement ridges (R) and depressions (D). Naturally, groundwater flows from areas of high pressure (such as bedrock ridges) to area of low pressure (such as bedrock depressions). The bedrock ridges are oriented approximately North-south (N – S) with some isolated high-peak ridges at the western, eastern and Northeastern flanks of the study area. Also, depressions are seen around the central and southwestern region of the study area. The basement depressions constitute water collection zones and where it is overlain by high overburden thickness plays a significant role in groundwater development.

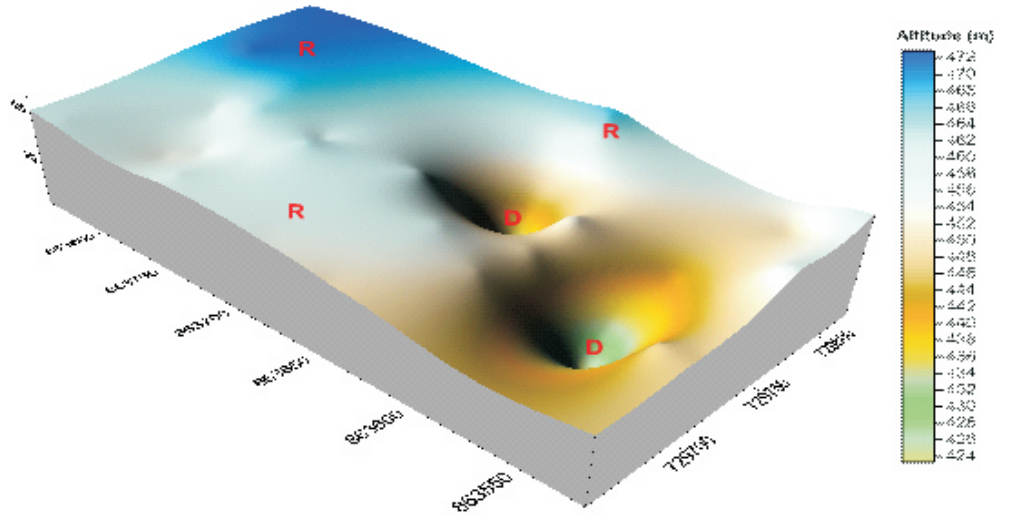

Figure 9: Bedrock Relieve Map of the study area.

Groundwater Potential Map

Fig. 10 shows the groundwater potential map of the study area. The groundwater evaluation of the area is based on various maps and sections most especially the overburden thickness, total longitudinal conductance and bedrock relief maps. The groundwater potential of the study area can be classified into high, moderate and low potentials.

Zones where the overburden is thick (thickness >24 m) with moderate *longitudinal conductance values* ranging from 0.2 to 0.75 mhos (Fig. 8), significantly thick weathered layer of resistivity values between 13 and 120 Ω-m are classified as high groundwater potentials zones. Zones with thin overburden (thickness between 6 and 14 m), near-surface basement ridges, high aquifer protective capacity (thick clay layer above the aquifer) and low values of total longitudinal conductance (0.05 – 0.1 mhos) are considered to have low groundwater potential. While zones having overburden thickness between 14 to 24 m with thin weathered layer of resistivity values ranging between 130 and 250 Ω-m are considered to have moderate groundwater potential.

Comparison between the groundwater potential map (Fig. 10) and the bedrock relief map (Fig. 9) revealed that the area categorized as moderate to high groundwater potential zones coincide with the areas of basement depression (D) on the relief map, with substantively thick overburden thickness. In the same way, areas identified to be associated with the basement ridges (R) are recognized as areas of poor groundwater potential, with characteristic thin overburden and low longitudinal conductance values.

The groundwater potential map shows that about 24% of the entire study area falls within zone rated as having high groundwater potential, while about 51% of the study area constitutes the low groundwater potential rating and the remaining 25% has moderate groundwater potential rating. The aquifer in this area occurs within a basement depression, highly localized and is protected against *infiltration of polluting fluid*.

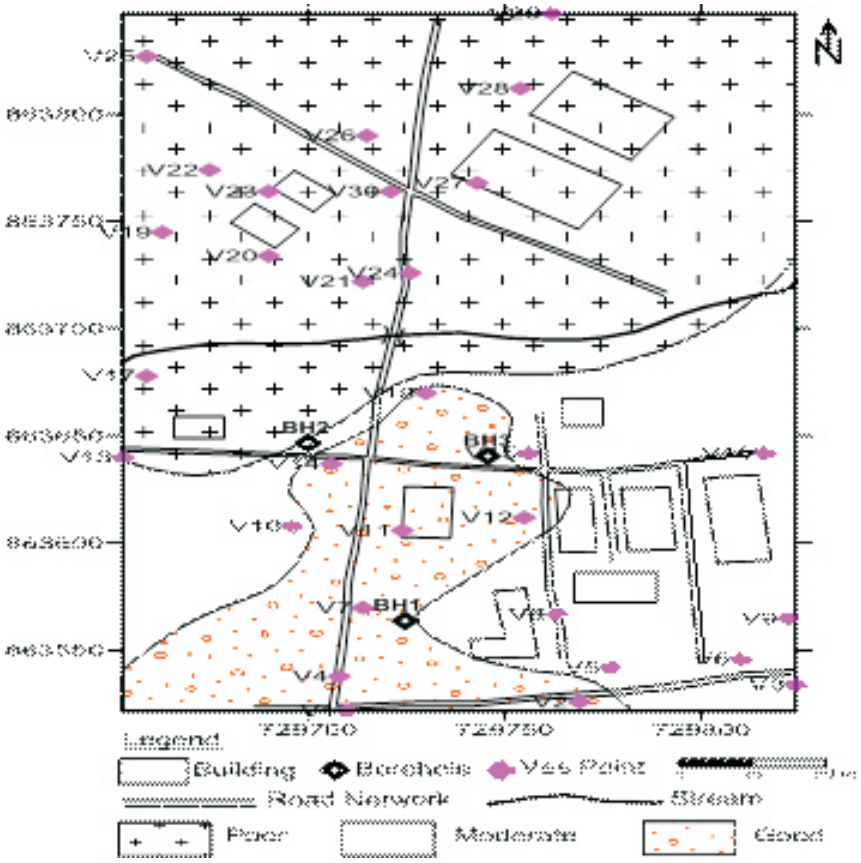

Fig. 10: Groundwater potential map of the study area.

Conclusions

The geophysical methods used in this study have greatly assisted in evaluating groundwater potential of College of Health Sciences Technology, Ijero-Ekiti, Ekiti State, Southwestern Nigeria. Both the VLF – EM and Electrical resistivity data over the area were inverted and interpreted in terms of the distribution of the geo-electrical parameters in the area. Interpretation of the EM profiles identified some areas of hydro-geologic importance in form of fractures and thick overburdens, which were probed further using the Electrical Resistivity survey.

About 24% of the area falls within the high groundwater potential rating, while about 25% constitutes the moderate groundwater potential rating and the remaining 51% constitutes low groundwater potential rating. Hence the groundwater potential of the area could be rated on the average as low. Other geologic feature delineated from the distribution of the subsurface resistivity is the bedrock depression, which is of significant hydro-geologic importance. The VES stations in the zones having high and medium groundwater potential are envisaged to be viable for groundwater development within the area. Thus, groundwater resource development and management can be effectively planned for in the study area.

Acknowledgment

No financial support or technical assistance or advice was received from any agency/body/individual. However the effort of Mr. Musa Bawalah for his assistance during data acquisition for this research is acknowledged.

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Appendix

Table 2: Summary of geo-electric parameters obtained from VES within the area

VES NO	?1	?2	?3	?4	?5	?6	h_1	h_2	h_3	h_4	h_5	Northing	Easting	Curve Types
1	523	163	65	2840	-----	-----	0.4	5.9	9.9	-----	-----	863522	729710	QH
2	161	278	63	2840	-----	-----	0.9	2.9	8	-----	-----	863526	729769	KH
3	278	80	4554	2712	-----	-----	1.1	10.5	-----	-----	-----	363534	729824	H
4	76	169	70	-----	-----	-----	1.5	4.5	8.2	-----	-----	863538	729708	KH
5	173	87	128	1818	-----	-----	3.7	4.9	6.5	-----	-----	863542	729777	HA
6	294	85	567	3592	54	-----	1.3	3.9	5.3	8.4	-----	863546	729810	HK
7	321	1005	99	390	199	-----	0.6	2.8	9.2	29.7	-----	863570	729714	KHK
8	227	72	191	346	3743	-----	4.4	5.5	5.1	8.8	-----	863567	729763	HA
9	81	272	4404	1008	-----	-----	5.3	5.1	-----	-----	-----	863565	729822	A
10	121	125	2363	-----	-----	-----	3	11.3	-----	-----	-----	863608	729696	A
11	146	13	644	-----	-----	-----	4.8	9.1	-----	-----	-----	863606	729724	H
12	242	414	76	-----	-----	-----	0.8	2.7	8.2	-----	-----	863612	729755	KH
13	107	151	1337	3770	-----	-----	1	10.2	-----	-----	-----	863640	729653	A
14	77	62	3557	-----	-----	-----	2.6	7.1	-----	-----	-----	863637	729706	H
15	390	484	69	120	206	737	1	5.9	8.3	8.2	13.6	863642	729756	KA
16	184	41	1081	-----	-----	-----	0.7	1.6	-----	-----	-----	863642	729816	H
17	81	737	2894	-----	-----	-----	2.4	4.9	-----	-----	-----	863678	729659	H
18	592	69	4484	-----	-----	-----	1.3	3.8	-----	-----	-----	863670	729730	A
19	63	818	415	-----	-----	-----	2	6.7	-----	-----	-----	863745	729663	K
20	423	517	9475	-----	-----	-----	1.9	8	-----	-----	-----	863734	729690	A
21	85	520	2132	-----	-----	-----	1.4	4	-----	-----	-----	863722	729714	A
22	350	1845	1534	267	-----	-----	0.8	3.6	5.9	-----	-----	863774	729675	K
23	131	595	6776	-----	-----	-----	1.4	8.3	-----	-----	-----	863764	729690	A
24	85	555	7747	-----	-----	-----	1.9	3.3	-----	-----	-----	863726	729726	A
25	71	202	302	-----	-----	-----	2.3	2.3	-----	-----	-----	863827	729659	A
26	73	513	24259.9	-----	-----	-----	1.4	1.6	-----	-----	-----	863790	729743	A
27	107	397	3477	-----	-----	-----	1.6	6.1	-----	-----	-----	863768	729743	A
28	92	199	24140	-----	-----	-----	2.2	1.7	-----	-----	-----	863812	729754	A
29	159	172	8361	-----	-----	-----	2.2	3.2	-----	-----	-----	863847	729762	A
30	179	691	4376	-----	-----	-----	1.7	8.8	-----	-----	-----	863764	729721	A

NUTRITIONAL AND ANTINUTRITIONAL ATTRIBUTES OF UNDER - UTILIZED TREE CROPS: ADANSONIA DIGITATA, ALBIZZIA LEBBECK AND DANIELLIA OLIVERI SEEDS

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Abstract:

The present study investigated the chemical compositions of Daniellia oliveri, Baobab (Adansonia digitata) and Albizia lebbeck seeds.The seeds have very high protein contents, which range from 33.40 in Daniellia oliveri to 48.32% in Adansonia digitata The crude fat varied from 8.32 - 6.93% while other proximate composition ranges were: moisture content, 3.23 - 4.20%. Crude fibre 3.56 - 6.35%. Ash 3.83 - 4.51% and carbohydrate 21.90 - 44.60%. The most abundant minerals were Ca (300 – 880) mg/100g, Mg (170 – 380) mg/100g and K (113 – 210) mg/100g. The level of Na/K ratio is desirable compared to the recommended value. The amino acid analysis revealed that all the samples contained useful quantities of most essential amino acids. Total essential amino acids (TEAA) with histidine ranged from 260.00 to 399.80g/kg of protein. The least concentrated amino acid was Cys (5.3 – 12.6 g/kg crude protein) and calculated isoelectric point (pI) ranged between 3.12 and 4.41. The low levels of anti-nutritional factors showed that the seeds may be recommended for human consumption.

Keywords: Daniellia oliveri, Adansonia digitata, Albizia lebbeck, seeds, proximate analysis, antinutritional factors

Introduction

Malnutrition is prevalent in Africa due to lack of sufficient animal protein in the diet, hence the search for alternative sources of protein from lesser-known tree crops to replace expensive and scarce animal protein. In view of this, efforts are geared at identifying and evaluating under-utilized plant protein sources. This development has stimulated research on the utilization of the seeds of some underutilized tree crops such as *Daniellia olivieri,* baobab (*Adansonia digitata*) and *Albizzia lebbeck*. Baobab (*Adasonia digitata*) belongs to the family Bombacaceae sub family of Malvaceae (Becker *et al.,* 1984).

The tree is widespread in the drier regions of Africa. The savannah is the natural habitat where the tree is planted or preserved. *Albizzia lebbeck* is of the family Mimosaceae. The tree is easily grown from seed and produces large straw-coloured and very persistent fruits hanging down in conspicuous clusters. It is found throughout the tropics, the foliage is commonly used as fodder in India for cattle, and in Sudan, goats eat fallen leaves and flowers (Lowry, 1989). *Daniellia oliveri* is grown widely in Benue State in the north-central part of Nigeria and evenly distributed in other parts of Nigeria. The pulp of *Adansonia* is already being used as seasonings in local drinks e.g. *(Fura - da - nono*) while the seeds are normally thrown away. Also, no part of *Albizzia* and *Daniellia* are known to be edible such that the rich harvest of seeds wastes from year to year.

Little information is available on these seeds and presently they constitute major wastes. The aim of the present work, therefore, is to determine the chemical compositions and so assess their nutritional values in diets.

Materials and Methods

The *Adansonia digitata* seeds were collected from Fulani women after they had removed the pulp for use in making *Fura – da – nono* drink while *Albizzia lebbeck* and *Daniellia oliveri* seeds were harvested from trees abundantly present in and around Ahmadu Bello University, Zaria and Federal University of Agriculture, Makurdi. The

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samples were sun-dried, de-shelled, powdered and stored in polythene bags. The moisture and ash contents were determined using the air oven and dry ashing methods (Pearson, 1981) The ashes were digested with 3M HCl and mineral contents were determined by atomic absorption spectroscopy (AAS) (Vogel, 1962). The samples were analyzed for fat, crude protein and crude fiber; and carbohydrate by difference according to the methods of the Association of Official Analytical Chemists (AOAC., 1995). Amino acid composition of the seed flour was determined as described by Fabian *et al.* (1990).

Estimation of iso electric point: Estimation of isoelectic point (pI) for a mixture of amino acids was carried out according to the equation:

$$IPm = \sum_{i=1}^{n} IPi \ \ Xi$$

where IPm is the isoelectric point of the mixture of amino acids, IPi is the isoelectric point of the ith amino acid in the mixture and Xi is the mass or mole fraction of the ith amino acid in the mixture and there are n amino acids in the mixture.

Sodium / potassium (Na/K) ratio was calculated for the samples (Nieman *et al.*, 1992). The fatty acid values were obtained by multiplying crude fat value of each sample with a factor of 0.8 (i.e. crude fat x 0.8 = corresponding fatty acids value) (Paul and Southgate, 1978).

The metabolizable energy value was calculated by using : carbohydrates x 17kJ+ crude protein x 17kJ + crude fat x 37kJ for each of the samples (Edem *et al.,* 1990). Errors of three determinations were computed as standard deviation for the proximate composition.

Bulk density: A 10 ml-graduated cylinder was gently filled with each sample. The bottom of the cylinder was gently tapped on a laboratory bench several times until there was no further diminution of the sample level after filling to the 10 ml mark. Bulk density was calculated as weight of sample per unit volume of sample (g/ml). All determinations were made in triplicates (Onuma and Bello, 1988).

Anti-nutritional factors

The method of Wheeler and Ferrel (1971) was employed for phytin determination. The tannin content of the seed flour was determined by modifying the procedure of Makkar (1994). The method described by Day and Underwood (1986) was used for oxalate analysis while total cyanide content was determined by the method described in AOAC (1995).

Protein Fractionation

Protein fractions were extracted according to their solubilities in different solvents as described by Landry and Moureax (1970). 3.5g portions of deffated *Adansonia digitata, Albizia lebbeck and Daniellia oliveri* flours were extracted twice with 50 ml distilled water for 30 mins at room temperature. The extract was centrifuged at 3000xg for 30 mins and the supernatant was used for the determination of the water soluble albumin. The residue was then extracted successively in a similar manner with 1.0M NaCl, 70% ethanol and 0.2% NaOH. The supernatant of each extract was collected separately and used to estimate the salt - soluble globulin, alcohol - soluble prolamin and alkali - soluble glutelin fraction. The weight of residue remaining after succesive extraction represented the insoluble proteins.

Results and Discussion

Table 1 presents the proximate composition, bulk density, calculated metabolizable energy and predicted fatty acid value of the samples. The moisture content at 2.85 to 4.20 % is low compared to most legumes but compares favourably with African yam bean (Adeyeye *et al.,* 1999). The low moisture content shows that the seeds will have a long shelf life (Oyenuga, 1968).The crude fat values are low and ranged from 8.32 to 16.9% which do not qualify these seeds as oil- rich compared to soybean 22.8 - 23.5% (Paul and Southgate, 1980; Salunkhe, 1998), pumpkin seed (47.0 - 49.2%) (Aiseigbu, 1989; Fagbemi and Oshodi, 1991) and conophor seeds (47.9 – 51.1%) (Ige *et al.,* 1984). The crude protein of the seeds ranges from 33.4 to 48.3% and is higher than some legumes, such as African yam bean (22.55%), lima bean (23.1%)

(Aremu *et al.,* 2006) and pigeon pea (21.6%) (Oshodi *et al.,* 1998) but slightly lower than that of groundnut (56.9%) (Conkerten and Ory, 1976) and soybean (61.4%) (Rackis *et al*., 1961). The values of ash and crude fibre compare favourably with those of cowpea and scarlet runner bean (Aremu *et al.,* 2006), however, the value of carbohydrate is lower.

The present results agree with the acceptable ash range values of legumes at 2. 4 - 5.0% (FAO, 1989). These seeds have high metabolizable energy ranging from (1634-1820) kJ /100g that compare favourably with some vegetables such as Utasi (*Marsidenia latifolium*) at 1, 695 kJ / 100g and Etinkene *(Piper guineense)at* 1,676 kJ / 100g (Udosen, 1995) but lower than that of bulma cotton seed at 2,129kJ /100g (Olaofe *et al*., 2006). Relatively high energy values in these seeds indicate that they are concentrated sources of energy and fall within the recommended energy dietary allowances for children (FAO, 1974). The bulk density of the seeds ranged from 0.41 to 0.45gcm^{-3}. The calculated fatty acid ranged between 6.66 and 13.5. These moderate values for the seeds suggest that the oils may be suitable for edible purposes and can also be utilized for industrial purposes.

Table 2 presents the mineral composition of the seeds. The most abundant mineral was calcium (300 – 880mg/100g) followed by magnesium (170-380 mg/100g) and potassium (113-210mg/100g). These values compare favourably with the values reported for some cowpea varieties and under - utilized legumes (Aremu *et al*., 2006; Aletor and Aladetiml, 1989; Olaofe *et al.,* 1993; Oke *et al.,* 1985; Padilla *et al*., 1996). *Albizzia lebbeck* has the highest value of calcium (880mg /100g) followed by *Adansonia digitata* (750mg /100g) while *Daniellia olivieri was* the least (300mg/100g). This suggests that, the seeds would probably provide minerals required for bone and teeth formation, more especially in children.

Calcium is also important in blood clotting, muscle contraction and in certain enzymes in metabolic processes. Magnesium is the third highest mineral component in the seeds. The values (170 – 380 mg/100g) are higher than grain and baby foods (Olaofe and Sanni, 1988), some cowpea varieties and some under-utilized edible legumes in Nigeria (Aletor and Aladetimi, 1989). High amount of magnesium in the blood is necessary because it is an activator of many enzyme systems and maintains the electrical potential in nerves (Shills, 1973). In all the seeds, the ratio of sodium to potassium is less than 0.6 suggesting that they will be very suitable for hypertensive patients who should consume less sodium. Sodium and potassium are also required in the body to maintain osmotic balance of the body fluids and the pH of the body to regulate muscle and nerve irritability and to control glucose absorption. The iron contents of these seeds (4.9 – 11.3 mg/100g) are higher than that reported for *Triticum durum* whole meal flour 4.9 mg/100g (Adeyeye and Aye, 2005) and an under utilized legume *Cassia floribunda* Cav. (3.6 – 5.7 mg/100g) (Vadivel and Janardhanan, 2001). The manganese contents (7.2-19.0 mg/100g) are higher than that of bulma cotton (*Bombcopsis glabra)* seeds (2.5mg/100g) (Olaofe *et al*., 2006). The zinc and copper contents agree with or are comparable to values reported for some Nigerian agricultural crops (Olaofe and Sanni, 1988).

Table 1: The proximate composition % of the flour obtained from *Albizia lebbeck, Daniellia oliveri and Adansonia digitata* seeds

Composition	*Albizia lebbeck*	*Daniellia oliveri*	*Adansonia digitata*
Moisture	3.23 ± 0.33	2.85 ± 0.23	4.20 ± 0.4
Crude Fat	13.4 ± 0.42	8.32 ± 0.42	16.9 ± 0.23
Crude Protein	42.8 ± 0.4.	33.4 ± 0.4	48.3±0.4
Ash	4.51 ± 0.24	4.30 ± 0.35	3.83 ± 0.26
Crude fibre	3.56 ± 0.32	6.35 ± 0.53	4.82 ± 0.16
Carbohydrate	32.5 ± 0.3	44.6 ± 0.3	21.9 ± 0.21
Bulk density g/cm^3	0.44 ± 0.33	0.41 ± 0.52	0.45 ± 0.33
[a]Fatty acid	10.7	8.66	13.5
[b]Energy (kJ/100g)	1776	1634	1820

Each value represents mean ± standard deviation of three replicate determinations.
[a]Calculated fatty acid (0.8 x crude fat). [b]Calculated metabolizable energy (protein x 17 + fat x 37 + carbohydrate x 17).

Table 2: Mineral contents (mg/100g) of the seeds

Mineral	*Daniellia oliveri*	*Adansonia digitata*	*Albizia lebbeck*
Ca	300	750	680
Mg	170	360	380
K	113	209	210
Na	6.94	7.51	9.53
Na/K	0.06	0.04	0.05
Fe	4.89	9.13	11.3
Mn	7.18	15.2	19.0
Zn	0.69	0.87	1.39
Cu	0.22	0.38	0.47

Table 3: Amino acid composition (g/kg crude protein) of the seeds

Amino acid	*Daniellia oliveri*	*Adansonia digitata*	*Albizia lebbeck*
Lysine[a]	26.6	46.4	39.5
Histidine[a]	17.9	31.0	28.2
Arginine[a]	37.4	56.2	47.7
Aspartic acid	62.2	82.3	97.9
Threonine[a]	20.3	26.1	30.5
Serine	14.3	30.5	25.9
Glutamic acid	82.7	155.7	120.7
Proline	10.6	30.8	28.7
Glycine	30.6	39.4	34.5
Alanine	22.8	27.0	23.2
Cystine	5.3	7.9	12.6
Valine[a]	32.5	38.0	40.1
Methionine[a]	7.3	22.4	18.8
Isoleucene[a]	27.9	41.4	33.3
Leucine[a]	51.9	85.9	71.9
Tyrosine	25.8	35.4	29.0
Phenylalanine[a]	38.0	52.4	50.7
Calculated isoelectric point (pl)[b]	3.12	4.96	4.41

[a]Essential amino acid. [b](pI) calculated isoelectic point and has no unit

Table 4: Analysis of amino acid data (g/ kg crude protein) of the seeds

Amino acid description	*Danielli a oliveri*	*Adansonia digitata*	*Albizia lebbeck*
Total amino acid (TAA)	514	309	733
Total non-essential amino acids (TNEAA)	255	409	373
%TNEAA	49.5	50.8	50.8
Total essential a. a (TEAA) with histidine	260	400	361
Without histidine	242	368	32.5
%TEAA with histidine	50.6	49.4	49.2
Without histidine	47.1	45.6	45.4
Essential aliphatic a a (EAAA)	112	165	145
Essential aromatic aa (EArAA)	38.0	52.4	50.7
Total neutral a a (TNAA)	287	437	399
%T.N.AA	55.9	54.1	54.5
Total acidic a a (TAAA)	145	238	219
%TAAA	28.2	29.4	29.8
Total basic a a (TBAA)	82.1	134	115
%TBAA	16.0	16.5	15.7
Total sulphur AA(TSAA)	12.6	30.3	31.4
% Cystine in TSAA	42.1	26.1	40.1

Table 5: Amino acid scores of the seeds

Amino acid		*Daniellia oliveri*		*Adansonia digitata*		*Albizia lebbeck*	
	Provisional AAS pattern[a]	EAAC	AAS	EAAC	AAS	EAAC	AAS
Isoleucine	40	27.9	0.70	41.4	1.04	33.3	0.83
Leucine	70	51-9	0.74	85.9	1.23	71.9	1.03
Lysine	55	26.6	0.48	46.4	0.84	39.5	0.72
Methionine+ Cystine	35	12.6	0.36	30.3	0.87	31.4	0.90
Phenylalanine+ Tyrosine	60	63.8	1.06	87.8	1.46	79.7	1.33
Threonine	40	20.3	0.51	20.1	0.65	30.5	0.76
Tryptophan	10	nd	nd	nd	nd	nd	nd
Valine	50	32.5	0.35	38.0	0.76	40.1	0.80

[a] Source: FAO /WHO, 1991; nd not determined ; EAAC (Essential amino acid composition (*g* /kg))

Table 6: Protein fractions g/100g of *Daniellia* oliveri, *Adansonia digitata* and *Albizia lebbeck* seeds

	Daniellia oliveri	*Adansonia digitata*	*Albizia lebbeck*
Albumins	13.7 ± 0.2	22.9 ± 0.3	14.3 ± 0.2
Globulins	18.3 ± 0.4	18.2 ± 0.1	25.7 ± 0.1
Prolamins	10.3 ± 0.2	12.5 ± 0.4	23.1 ± 0.3
Glutelins	25.6 ± 0.3	27.8 ± 0.1	17.7 ± 0.1
Insoluble protein	32.1 ± 0.2	18.6 ± 0.1	19.2 ± 0.4

Table 7: Anti-nutritional factors in *Daniellia oliveri*, *Adansonia digitata and Albizia lebbeck* seeds

Anti-nutritional factors	*Daniellia oliveri*	*Adansonia digitata*	*Albizia lebbeck*
Tannic acid (mg/100g)	1.22 ± 0.03	2.05 ± 0.02	0.65 ± 0.05
Polyphenols (mg/100g)	0.49 ± 0.05	0.32 ± 0.04	0.16 ± 0.04
Cyanide (mg/100g)	0.42 ± 0.04	0.32 ± 0.24	0.09± 0.23
Phytate (g/100g)	7.13 ± 0.02	6.66± 0.02	3.83 ± 0.04
Oxalate (mg/100g)	0.19 ± 0.04	0.33 ± 0.25	0.14 ± 0.03
Alkaloid (%)	7.48 ± 0.25	6.40 ± 0.04	1.37 ± 0.23
Saponin (%)	3.27 ± 0.33	2.06 ± 0.02	0.53 ± 0.04
Flavonoid (%)	0.86 ± 0.22	0.65 ± 0.32	0.22 ± 0.22

Table 3 presents the amino acid composition of the flour from the three seeds. The most abundant amino acid in all the seeds is glutamic acid which ranged between 82.7 to 155.7g/kg, followed by aspartic acid for *Daniellia oliveri and Albizia lebbeck* seeds and leucine in *Adansonia digitata*. Cysteine and methionine are the least amino acids in all the seeds; 5.3 and 7.3g/kg for *Daniellia oliveri* ,7.9 and 22.4g/kg for *Adansonia digitata and Albizia lebbeck at* 12.6 and 18.8g/kg. The observation that aspartic (Asp) and glutamic (Glu) acids are the major amino acids in the seed flour agree with Olaofe *et al.* (1993 ; 1994) and Oshodi *et al.* (1993) for some oil seeds. Leucine is the most concentrated (51.9 – 85.9 g/kg crude protein) essential amino acid in all the samples while the most

concentrated amino acid is glutamic acid (82.7 – 155. 7g/kg crude protein) (Oshodi *et al.,* 1998). The calculated isoelectric point (pI) varied between 3.12 – 4. 96. Its use is in determining the pH where protein would precipitate to obtain protein isolate from biological samples (Olaofe and Akintayo, 2000).

The nutritive value of a protein depends primarily on the capacity to satisfy the needs for nitrogen and essential amino acids (Oshodi *et al*., 1998). Table 4 shows the analysis of amino acids in the seeds. The total essential amino acid (TEAA) values (with Histidine) ranged from 49.2% in *Albizzia lebbeck* seed to 50.6% in *Daniellia olivieri* seed. These are comparable to values obtained for selected oil seeds at 33.3 to 53.6% (lge *et al*., 1984; Olaofe *et al*., 1994) and soybean at 46.5%(Aiseigbu, 1989), cream coat cowpea at 43.8% and red specks scarlet runner bean at 48.3% (Aremu *et al*., 2006). It suggests that these studied seeds which are readily available mainly in the northern states of Nigeria may be found useful as food supplements. The percentage of total acidic amino acid (TAAA) is greater than the percentage of total basic amino acids (TBAA) in all the samples indicating that the protein in these seeds is probably acidic in nature. The amino acid scores are shown in Table 5. The essential amino acid contents are lower than the FAO/WHO (FAO /WHO, 1991) recommended values. *Adansonia digitata* is rated highest followed by *Albizzia lebbeck* seeds while *Daniellia olivieri* is rated least in protein quality. Methionine + Cysteine and Lysine are the most limiting amino acid in Daniellia oliveri. The limiting amino acids in *Adansonia digitata* are threonine and valine while in *Albizia lebbeck* they are lysine and threonine.

Table 6 shows percentage protein fractions on the basis of solubility in water (albumin), alcohol (prolamin), salt (globulin) and alkanine (glutelin).

Daniellia oliveri, *Adansonia digitata* and *Albizia lebbeck contain* 13.7, 22.9 and 14.3% albumin, 10.3, 12.5 and 23.1% prolamin, 18.3, 18.2 and 25.7% globulin and 25.6%, 27.9% and 17.7% glutelin respectively. The results show that 67.9%, 81.4% and 82.3% total protein could be extracted by solvents from *Daniellia oliveri, Adansonia digitata* and *Albizia lebbeck* seed flours respectively. The remaining percentages probably account for the non – protein Nitrogen and insoluble protein. Idris *et al* (2003) also used different solvents (H_2O, NaCl, ethanol and NaOH) to extract protein content of wheat bran and found it to contain 23.5, 15.5, 18.5 and 25.5% albumin, globulin, prolamin and glutelin respectively. Bhattacharya *et al.* (1994) also obtained similar results for tamarind kernel.

Table 7 presents the anti-nutritional factors in the seed flours. The oxalate content of these seeds are low (0.14 – 0.33mg/100g) compared to Chinese gourd (1.48mg/100g) (Olaofe *et al.,* 2009). Oxalic acid has the ability to bind some divalent metals such as Ca and Mg and so can interfere with the metabolism of these minerals. Blood and Henderson (1974) had observed that the ingestion of an excessive amount of oxalate could cause gastro-intestinal irritation, blockage of the renal tubules by oxalate crystals, muscular weakness or paralysis.The oxalate levels in these seeds would not cause any nutritional discomfort.

Polyphenols and tannins inhibit the activities of digestive enzymes (Jambunathan and Singh, 1981) and the nutritional effects are mainly related to their interaction with protein and minerals. Tannin – protein complexes are insoluble thereby decreasing the protein digestibility (Carnovale *et al.*, 1991). The concentrations of polyphenols in *Daniellia oliveri*, *Adansonia digitata* and *Albizia lebbeck* are between 0.16 – 0.49%. These values are lower in mucuna species which range from 4.34 to 7.75% (Adebowale *et al*., 2005). The concentration of tannic acid at 0.65 - 1.22% are lower than in chickpea seed (4.88%) (Tarek, 2002). Phytates (hexaphosphate inositol) are common anti-nutrients in plant seeds. They chelate di – and

tri-valent mineral ions such as Ca^{2+}, Mg^{2+}, Zn^{2+} and Fe^{3+} resulting in reduced bioavailability of trace minerals (Duffus and Duffus, 1991). Phytate concentration of the seed flours ranges between 3.83 to 7.31% which are higher than in mucuna species (1.23 - 2.56%) (Adebowale *et al*., 2005) and sesbania seeds (1.89 - 2.37%) (Hossain and Becker, 2001).

The saponins are a diverse group of compounds containing a glycone linked to one or more biological effects in animals including erythrocyte haemolysis, depressed growth, reduced feed intake and effect on nutrient absorption and acid metabolism (Cheecke, 1996). The concentrations of saponin in the seeds range between 0.53 and 3.27% which are similar to mucuna seeds with 0.52 - 3.0% (Adebowale *et al*., 2005) but higher than in sesbania seeds 0.5 – 1.46% (Hossain and Becker, 2001). It has been known for a long time that a wide variety of plants are potentially toxic because they contain glycosides from which hydrogen cyanide may be released by hydrolysis (Conn, 1979). Hydrolysis occurs quite rapidly when the ground plant is cooked in water and most of the liberated hydrogen cyanide is lost by volatilization. The concentrations of cyanide in the seeds range between 0.09 – 0.42% which are lower than the values for kidney bean (2.0%) and garden pea (2.3%) (Montgomery, 1969). These results show that *Daniellia oliveri*, *Adansonia digitata* and *Albizia lebbeck* seeds contain minimum levels of anti-nutritional factors which the body can tolerate even as they can also be reduced by boiling. According to Fagbemi *et al* (2005), processing especially boiling can effectively reduce the anti-nutritional factors.

Conclusion: The seeds of *Daniellia oliveri, Albizia lebbeck and Adansonia digitata* are good sources of protein (33.4 – 48.3%). The seeds have high levels of amino acids and minerals while there are low levels of anti nutritional factors. These seeds have potentials in livestock nutrition and human diet as economic and alternative protein sources that could alleviate protein malnutrition in developing countries.

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STUDY ON THE PHYSICOCHEMICAL PROPERTIES OF OXIDIZED, ACETYLATED AND HYDROXYPROPYLATED CORN STARCH

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Abstract

Corn starch was extracted and modified through oxidation, acetylation with acetic anhydride and hydroxyl-propylation. The physicochemical properties and proximate content of the native starch (NS), oxidized starch (OS) acetylated starch (AS) and hydroxyl-propylated starch (HS) samples were carried out using standard methods of analysis. The results show that percentage protein and ash contents reduced after oxidation and acetylation, while the percentage fat contents increased with acetylation. The water absorption and oil absorption capacities of acetylated corn starch were 110% and 100.1% respectively in contrast to the WAC and OAC of the native corn starch which are 110 and 81.90% respectively. The pasting properties PP were improved by acetylation with pasting temperature. Peak viscosity increased from 276.17 to a maximum of 339.92 with modification in the other NS<AS<HS<OS.

1.0 Introduction

Starch makes up the nutritive reserves of many plants. Starches are good texture stabiizers and regulators in foods (Cousidine, 1992). Draw backs like low shear- stress and thermal resistance, proneness thermal decomposition and high degree of retro gradation have limited their uses in some industrial food applications (Reference).

These shortcomings can be overcome by chemical and physical modifications of starches (Fleche, 1985). The extent of change in different properties during modification depend on the starch (Singh et al., 2003). Cheh and Jane, 1994 observed that the granules of cold-water soluble corn starches prepared by alcoholic-alkaline treatment had indented appearance and were large than those of the original native granules. Singh and Singh, 2003 reported that physicochemical, thermal, rheological and retro-gradation properties of cold-water soluble corn starch depend on the native granule morphology. Acetylation of starch is an important modification method that has been applied to various starches that impact the thickening needed in food applications.

The degree of acetylation of starches depends upon factors such as starch sources, reactant concept ration, reaction time and pH. The extent of change in physicochemical properties in the acetylated starch compared to the native starch is proportional to the degree of acetylation (Philips et al., 2003). Acetylated starch with low degree of substitution is commonly obtained by esterification of native starch with acetic anhydride in aqueous medium in the presence of an alkaline catalyst (Aburto et al., 1999).Swelling occurs when starch water penetrates the granules of the starch. Each type of starch swells differently which indicates the differences into the molecules organization within the granules (Adebowale, et al., 2002).Swelling power is a useful parameter in the baking industry. The swelling power was reported to be directly proportional to temperature (Adebowale et al., 2002). There was however little information on the effects of oxidation, acetylation and hydro-propylation of corn starch on the proximate and physicochemical properties of the native and modified corn starches.

2.0 Materials and Method

2.1 Preparation of Starch Samples

2.1.1 Native Corn Starch

Industrial corn starch or Native corn starch (NS) was supplied by Pascal Scientific, Akure, Ondo State, Nigeria.

2.1.2 Oxidation of Corn Starch

A uniform slurry of starch was prepared by dispersing 100g of NS in 500 ml distilled water. The pH was adjusted to 9.5 with 2 M NaOH. 0.1g NaOCl was added to the slurry over a period of 30 minutes while the pH was maintained at 9.0 to 9.5 with constant stirring at 30 ± 2 °C. The reaction proceeded for 10 minutes. The pH was later adjusted to 7.0 with H_2SO_4 and the oxidized starch was filtered and washed four times with distilled water and the cake air dried 30 ± 2 °C for 48 hours.

2.1.3 Acetylation of Corn Starch

Using the method of Sathe and Salunkhe, (1981), 100g of corn starch was weighed and dispersed in 500 ml of distilled water. The mixture was stirred magnetically for 20 minutes. The pH of the slurry obtained was adjusted to 8.0 using 1 M NaOH. 10.2 acetic anhydride was added slowly over a period of one hour at an interval of 10 minutes and stirred while the pH was maintained at a range of 8.0 – 8.5. The reaction was left to proceed for 55 minutes after the addition of the acetic anhydride. The pH of the slurry was then adjusted to 4.5 using 0.5 M HCl. The slurry obtained was filtered and washed four times with distilled water. The filtered slurry was air dried at 30 ± 2 °C for 48 hours.

2.1.4 Hydroxy-propylation of Corn Starch

Using the method described by Perara et al., 1979, 200g of starch was weighed into 600 ml screw cap jar. A solution of NaOH (2.6g) and Na_2SO_4 (30g) in 240 ml distilled water was prepared at room temperature. The solution was added to the starch in the jar and placed in a water bath at 40°C and 10 ml propylene oxide was added to the mixture. The reaction was allowed to continue at 40°C for 24 hours with constant shaking. The starch suspension was then neutralized to pH 5.5 with 1 M H_2SO_4. The starch suspension was filtered and the cake was washed with distilled water until negative to sulphate ions when tested with $BaCl_2$. The hydroxyl- propylated suspension was air dried.

2.2 Proximate Analysis

Standard procedures recommended by Association of Official Analytical Chemists were used for Sample treatment and analysis. The fat content (FC) was determined using solvent extraction method with n-hexane/Petroleum ether (b.p. 40-60 °C) in a soxhlet extractor. The moisture content (MC) was determined using air oven as weight difference after oven-drying for 4-5 hours at 105 °C, divided by original eight of the sample. Crude Protein (CP) was determined by Kjeldahal's method as %N x 6.25. Total ash Content (TAC) was determined by weight difference after incinerating a known weight to ash in a muffle furnace, divided by the original weight of the sample. The Crude Fibre (CF) was determined according to Pearson, 1981. Carbohydrate was determined by difference as (100 - Σ FC, MC, CP, TA, and CF)%. The Proximate analysis was carried out in triplicates and the results are in % dry weight of flour (Ogundele and Oshodi, 2010) .

2.3.0 Determination of Functional Properties of

2.3.1 Determination of water absorption capacity (WAC)

1.00g of flour sample was mixed with 10.00cm^3 distilled water and centrifuged for 30mins at 3,500r/min. The supernatant was decanted into a 10.00cm^3 graduated measuring cylinders. The volume noted was used to determine the volume of water absorbed by difference and was converted to gram assuming the density of water to be 1.00 g/cm^3 (Beuchat, 1977).

2.3.2 Determination of oil absorption capacity (OAC)

0.5g flour sample was mixed with 10.00ml vegetable oil. The mixture was centrifuged at 3000r/min for 30 minutes. The excess oil was decanted into a 10.00cm^3 graduated measuring cylinders and the volume noted. The bonded oil volume was determined by difference and converted to grams. The percentage OAC was expressed as g/g % of the flour sample (Beuchat, 1977).

2.3.3 Determination of Pasting Properties

Starch pasting properties was evaluated by using a Rapid Visco Analyzer (RVA). 2.5g of starch sample was suspended in water and adjusted to a total weight of 28g. The sample was equilibrated at 50°C for 1 minute, heated to 30°C in 7.5 minutes at rate of 50°C/minute. From the resulting pasting curve, temperature at initial viscosity increase (TI), peak viscosity (P_v), time to peak viscosity (P_t), (time P_v – time at initial viscosity increased), hot past viscosity (HPV) breakdown viscosity (BV), (P_v - HP_v), Rate of shear thinning (Rst), (P_v – HP_v/13-5min – P_t), cooled pasting viscosity (CP_v) and break viscosity (SB_v), (CP_v - HP_v) were calculated.

2.3.4 Starch Paste Clarity

2.3.5 50mg of starch was suspended in 5 ml distilled water and heated to 95 °C in a boiling water bath while shaking thoroughly. The slurry was cooled to room temperature. 1 ml of the solution was diluted to 10 ml distilled water. Percentage transmittance of the 0.1% starch solution was determined against a water blank at 650 nm in a glass cuvette using a spectrometer.

2.3 .5 Effects of Temperature on Swelling and Solubility

Using the method of Adebowale et al., ((2002), this was employed for the determination of the effect of temperature on the starch solubility and swelling. The starch sample (0.2g to 1.0g) was weighed and quantitatively transferred into a clear dried test tube and reweighed (W_1). The starch was then dispersed in 50 cm^3 of distilled water using a blender. The resultant slurry was heated at the desired temperature of 55, 65, 75 and 85 (°C) for 30 minutes in water bath. The mixture was cooled to 30 ± 2 °C and centrifuged at 5,000 for 15 min. Aliquot (5ml) of the supernatant was dried to a constant weight at 110 °C . The residue obtained after drying the supernatant represented the amount of starch solubilized in residue. Solubility was calculated as 100g of starch. The residue obtained from the above experiment (after centrifugation) with the retained water was quantitatively transferred to a clean dried test tube used earlier and weighed (W_2) and swelling was calculated as:

Percentage swelling of starch =

$$\frac{W_2\text{-}W_1 x100}{\text{weight of starch}} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

2.3 .6 Determination of least gelation concentration (LGC)

2-20% sample –distilled water suspensions of the samples were prepared. Test tubes containing 5ml of each were heated in boiling water for one hour and rapidly cooled under running water. Further cooling was done at about 4°C for the next two hours. The least gelation concentration of the samples was determined as the concentration at which there was no slipping of the tube contents when inverted (Coffman and Garcia, 1977).

3.0 Results and Discussion

3.1 Proximate Content

Table 1 shows the results of the proximate analysis of native and modified corn starches. The moisture content of native, oxidized and hydroxypropylated starches were 12.04% , 12.40% and 12.47% respectively, while the moisture content of acetylated corn starch was a little higher with a value of 12.84%. There is however, no significant difference in the moisture contents of the native and the modified corn starches. Moisture content depends largely on the method, extent of drying and the humidity in the surrounding atmosphere (reference) … . The protein content of NS, OS, AS and HS are 0.37%, 0.29%, 0.28% and 0.26% respectively. The reduction in protein content due to modification may be due to degradation of protein at modification. This observation is similar to the observation made on new cocoa yam starch flour by Lawal, 2004. Hence modifications generally decreased the protein content, fat content and ash content of the corn starch. This may be due to degradation of some proteins and further washing on addition of chemical during modification.

Table 1: Proximate content of native and modified corn starch (%)

Parameter	Native Corn Starch	Acetylated Corn Starch	Oxidized Corn Starch	Hydropropylated Corn Starch
Crude protein	0.37	0.28	0.29	0.26
Moisture	12.04	12.84	12.40	12.47
Fat content	1.50	0.50	1.0	1.50
Total Ash	0.11	0.05	0.03	0.15
Carbohydrate	85.98	86.33	86.28	85.62

3.2 Functional Properties

Table 2 show the functional properties of native and modified corn starches. There was no significant change in the water absorption capacity (WAC) of the corn starches due to acetylation and hydropropelenation, but the WAC increased from 110.0% to 120.0% for oxidized corn starch. The oil absorption capacities (OAC) of the corn starches increased in the following other HS< NS<AS< OS with the values 72.80%, 81.90%, 100.10% and 108.00% respectively. Hence, the hydrophilic and hydrophobic properties of the corn starch increased most with oxidation from 110.0% to 120.0% WAC and 81.90 to 108.0% OAC. These observations are in agreement with the observation made by Desphande et al., 1982, who observed that oxidization improved the OAC of black gram starch by almost 2.5 times more than that of the native starch. The least gelation concentration of the modified corn starches are 16% (w/v), while at this concentration, native starch was viscose.

Table 2: Functional Properties of Corn Starch and Modified Starches (%)

Parameter	Native Corn Starch	Acetylated Corn Starch	Oxidized Corn Starch	Hydropropylated Corn Starch
Water Absorption Capacity	110.00	110.00	120.00	81.90
Oil Absorption Capacity	81.90	100.10	108.00	72.80
Starch Clarity Transmittance	38.00	30.20	37.00	69.30
Least Gelation Concentration		16.00	16.00	12.00

3.3 Pasting Properties

The past clarity in Table 3 shows reduction in past clarity after acetylation and oxidation of the corn starch. However, hydroxyl propylated corn starch had a higher past clarity of 9.30 compared with 38. 0 past clarity of native starch. This is 81.72% increase in the past clarity of the corn starch past clarity. Hydroxy-propylation increased pasting properties of the corn starch from 38.0% to 69.3%, Table 3. This is 82.37% improvement

on the pasting property due to Hydropropylation. The peak viscosity of hydroxyl-propylated starch was higher than the peak viscosity for NS. This is in agreement with the observation made Pal et al., 2002. The peak viscosity of the corn starches increased with modification with values 276.17, 282.25, 321.75, 339.92 for NS, AS, HS and OS respectively. This is in agreement with the result reported on native and acetylated sword beans (Akinbowale et al., 2006).The trough values which is the viscosity after isothermal (Hot past viscosity) were generally lower than the peak viscosity of the native and modified corn starches. The break down value (which is the difference between the peak viscosity and the viscosity after holding for 30 minutes at 95°C) of the native corn starch is higher (91.83) than that of the oxidized corn starch which is 73.92. The final viscosity for the native starch was lower than that of the oxidized corn starch with 288.67 and 330.08 respectively. Hydroxy-propylation increased the Break Down (BD) and Set Back (SB) vales of the corn starch from 91.83 to 209.83 and 104.00 to 156.42 % respectively. While on the other hand, Oxidation reduced the BD and SB to 73.92 and 64.08 respectively. The setback value (SB) is an index of retro-gradation tendencies in starch past (Ancona et al., 2001). Oxidation reduced the starch tendency to retrograde as indicated by the reduction in the set back from 104.33 of the NS to 64.08 for the OS. Similar result was reported for cocoyam starch (Lawal, 2004).

Table 3: Past Clarity and Pasting Properties of Native and Modified Corn Starches

Pasting Properties (RVU)	Native Corn Starch	Acetylated Corn Starch	Oxidized Corn Starch	Hydropropylated Corn Starch
Past Clarity	38.00	30.00	37.00	69.30
Pasting Temperature	76.65	76.41	76.15	70.05
Peak viscosity	276.17	282.25	339.92	321.75
Trough 1	184.33	188.08	266	112.42
Breakdown	91.83	94.17	73.92	209.83
Final Viscosity	288.67	305.25	330.08	268.83
Set back	104.33	117.17	64.08	156.42
Peak time	5.15	5.21	5.74	3.72

3.4 Effect of Temperature on Swelling Properties

The effects of temperature on swelling power of corn Table 4, shows that each type of starch swells differently, implying the differences in molecular organization within the granules. The swelling power of native and modified starch increased as the temperature increases. However, hydroxyl- propylated corn starch had the highest swelling capacity for all the temperature intervals noted, This result is similar to the observation made by several other researchers on starch swelling power with temperature (Adebowale and Lawal, 2002; Lawal, 2004).

Table 4: Effects of Temperature on Swelling of Native and Modified Corn Starches (%)

Temperature (^oC)	Native Corn Starch	Acetylated Corn Starch	Oxidized Corn Starch	Hydropropylated Corn Starch
55	105	120	115	235
65	365	475	460	940
75	660	645	685	915
85	730	765	810	955

Conclusion

Modifications by oxidation, acetylation and hydroxyl-propylation generally decreased the protein content, fat content and ash content of the corn starch. This may be due to degradation of some proteins and further washing on the addition of chemical during modification. The hydrophilic and hydrophobic properties of the corn starch increased most with oxidation from 110.0% to 120.0% WAC and 81.90 to 108.0% OAC. These observations are in agreement with the observation made by Desphande et al., 1982, Hydroxy propylation increased the past clarity, Break Down and Set Back of the corn starch than other modification processes, while oxidation reduced the BD and SB of the corn starches. Modification by Acetylation improved the pasting properties of corn starch

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GASTROINTESTINAL PARASITES OF DOGS IN IJURIN AND IKOSU COMMUNITIES, EKITI STATE, NIGERIA.

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Abstract

Epidemiological investigation of gastrointestinal parasites of dogs (Canis familiaris) was carried out at Ijurin and Ikosu communities in Ekiti State, Southwest, Nigeria. Two hundred faecal samples were collected using long forceps and processed by the Kato-Katz technique. The overall prevalence of gastrointestinal parasites observed was 69.2%. Seven gastrointestinal parasites were identified out of which Ancyclostoma caninum had the highest prevalence and intensity (39.1%; 44.2±27.7 epg) followed by Toxocara canis (21.0%; 24.5±17.8 epg), Taenea hydatigena (11.5%; 21.7±15.6 epg, Trichuris vulpis (7.0%; 7.5±4.3 epg), Toxascaris spp., (6.7%; 7.5±20.5 epg), Uncinaria stenocephala (5.4%; 5.2±2.3 epg), and Dipylidium caninum (4.1%; 10.5.2±8.1 epg). Infections with two to three parasites were observed in 35.5% of the infected dogs. Risk factors for gastrointestinal helminth infections were identified and highlighted. In conclusion, the high prevalence of gastrointestinal helminthes infection observed in these dogs is a clear indication of the occurrence of parasitic infection and there is urgent need to initiate control programme aimed at eliminating the parasites in these communities.

Keywords: Dog, gastrointestinal intestinal parasite, faecal samples, risk factors, zoonotic disease

Introduction

The association between dog and dog owners is increasingly becoming a major public health importance worldwide as a result of their adaptation to human habitation (Tannen, 2004). While dog owners derive several benefits ranging from physical, to social and emotional well-being from their dogs, (Robertson *et al*., 2000) they are equally at the risk of contracting zoonotic diseases from them (Craig & Macpherson, 2000). Zoonoses involving dog parasites have been found to be of public health importance as some can cause serious disease. For instance, *Toxocara* species are capable of infecting and inducing larva migrans syndromes in human beings who accidentally ingest the infective stages (eggs or larva respectively) (Daryani *et al*., 2009). Hookworm larvae can cause a disease called 'cutaneous larva migrans' or 'creeping eruption' when they penetrate the surface of a person's skin and migrate through it. In severe cases, the larvae may make their ways through the skin and enter deeper tissues. This may cause lung disease and painful muscles (Lefkaditis *et al*., 2006).

In Nigeria, gastrointestinal parasite of dogs is fast gaining recognition because of the ways in which the dogs are being reared. They roam the streets untended and in the process contract zoonotic infections and pollute the environment with helminth eggs and larvae and protozoan cysts in the process(Sowemimo and Asaolu, 2008). Previous studies from Nigeria showed that gastrointestinal parasites of dogs varied from one region to the other. For instance, Edosomwan reported an overall prevalence of 28.0% from a study conducted on dogs in Edo State (**Edosomwan and Chinweuba, 2012)**, while Umar (2009), reported a prevalence of 93.8% from Kaduna State, Nigeria. Also, Biu *et al*., (2012) reported a prevalence of 55.8% from Maiduguri from Northern Nigeria and Sowemimo and Asaolu (2008) reported a prevalence of 24.7% from Ibadan Nigeria. While much work has been done on epidemiology of dog parasites in different communities in Nigeria, little or no epidemiological study has been carried out on canine zoonosis in Ekiti State, Nigeria. This

study therefore aimed at determining the types of species and prevalence of gastrointestinal parasites, which could be of zoonotic importance in dogs in Ekiti State. It is hoped that the baseline epidemiological data collected would facilitate the development of effective interventions for controlling canine zoonotic infections.

Methodology

Study Area

The study was carried out in two Local Government Areas in Ekiti State namely Ijero and Moba Local Government Areas of Ekiti State. Communities that were selected for study were Ijurin and Ikosu. Ijurin is a town in Ijero Local Government Area of Ekiti State, located between Latitude 07º66′58′N and 07º88′70′N and Longitude 05 º11′33′E and 05º3′02′E while Ikosu is a town in Moba Local Government Area of Ekiti State, Nigeria. It is located between Latitudes 07 º59′37′N and 07º99′38′N and Longitude 05º10′40′E and 05º17′78′E. The two communities are predominantly civil servants, petty traders, few migrant and farmers.

Study procedure

A random house-to-house screening of dogs was carried out in the twocommunities. Structured questionnaires were pre-tested in Iloro-Ekiti which is also located in Ijero Local Government Area, six weeks prior commencement of the study. Consent was taken from dog owners and interviews were conducted using the pre-tested structured questionnaires to obtain information on the dog's approximately, age, sex, mode of life, occupation of dog owners, defaecation sites, awareness and knowledge about whether dog harbours worm, frequency of treatment with anthelminthics, canine parasite zoonoses and access to veterinary clinic. Dog age was determined using the dentition pattern, and classified as puppy (0≤ 6), young (6-24 months), and adult (>24 months).

Stool samples were collected from each dog through a direct rectal swab using long forceps. Faecal samples were collected into pre–labeled clean specimen bottles containing 10% aqueous formaldehyde for preservation and then transported to the parasitological laboratory of the Department of Zoology, Obafemi Awolowo University, Ile-Ife within 24 h of collections.

Parasitological procedure

Each faecal sample was mixed thoroughly with 10% aqueous formaldehyde for preservation. The samples were later processed for helminth eggs, presence and concentration of worm burden, using the Kato-Katz technique (WHO, 1994) and observed under a binocular microscope at 100× magnification. Observed helminths ova in 41.7mg of sieved stool were identified using known structural and morphometric features (Bowman, 1999), and multiplied by a factor of 24 to convert to eggs per gramme of faeces (Katz *et al*., 1994).

Statistical analysis

Statistical tests were applied using SPSS 16.0 (SPSS Inc.,Chicago llinois, USA).The prevalence of each parasite was calculated as the number of infected individuals over the total number of dogs examined and multiplied by 100 to get the percentage prevalence. Differences in parasite prevalence between the two communities were determined using the Chi-square test in two ways (Contingency tables). Chi-squared test was used to examine the relationship between parasite prevalence and host age and sex. Mann – Whitney U test was used to explore the relationship between the egg intensity (calculated as the mean egg count of all sampled individuals, both infected and uninfected) and sex, while Kruskal-Wallis test was used for variables with more than two levels, that is, egg intensity and host age. Multivariate logistic regression was used to analyze the association between parasite prevalence and each household, age, and sex variable after adjusting for other variables.

Results

A total of seven parasitic helminthes were recorded in this study and these include *Ancyclostoma caninum* (39.1%), *Toxocara canis (*21.1%*)*, *Dipylidium caninum* (4.3%), *Toxascaris spp.* (6.7%), *Taenea hydatigena* (11.9%), *Trichuris vulpis* (7.3%), and *Uncinaria stenocephala* (5.6%).Table 1 showed the summary of prevalence of the different parasites observed in the two communities. The overall prevalence of infection was 69.2%.

Table 1: Prevalence of Individual Parasite in 200 dogs in both Ijurin and Ikosu Communities

Parasite	Ikosu N=100 (%)	Ijurin N=100 (%)	Both Communities N=200 (%)
Ancyclostoma caninum	43.5	34.6	39.1
Toxocara canis	23.6	18.6	21.1
Dipylidium caninum	5.2	3.4	4.3
Toxascaris spp.	5.2	8.1	6.7
Taenea spp.	8.7	15.1	11.9
Trichuris vulpis	8.7	5.8	7.3
Uncinaria stenocephala	4.3	6.9	5.6

Risk factors associated with prevalence of intestinal parasites.

Table 2 showed the risk factors that were associated with prevalence of infection. There was a significance difference in prevalence of infection with regards to age of dogs ($P < 0.05$). The prevalence of infection was highest in dogs less than six months old (72.3%) and least (18.1%) in dogs older than 24 months. Table 3 showed the prevalence and intensity of infection with respect to age of dogs. All the eight parasites were present in all the age groups except *Dipylidium caninum, Toxascaris spp.,* and *U. stenocephala* that were absent in adult male and female dogs.

Table 2: Prevalence (%) of gastrointestinal parasites relative to age and sex of dogs

Age (Months)	Number examined	Number infected	Prevalence (%)
< 6	65	47	72.3
6-24	102	49	48.0
>24	33	6	18.1
		P < 0.05	
Sex			
Male	93	41	44.0
Female	107	61	57.0
		P>0.05	

Table 2 showed that prevalence and intensity of parasitic infections were significantly higher in females than in male dogs ($P < 0.05$). In both sexes, *A. caninum* has the highest prevalence and intensity of (39.1%; 44.2 ± **27.7 epg**) followed by *T. canis* (21.1%; 24.5±**17.8 epg**).

Logistic regression analysis

The responses to the questionnaires administered to dog owners showed that 86 (45.7%) were aware that dogs harbor worms but only 41 (22.5%) were aware of canine parasite zoonosis. Only 11 (6.8%) of the households owning dogs had access to veterinarian and they deworm their dogs once or twice in a year. Dogs aged 0-6 months were 6.7 times more likely to harbor hookworm species eggs (prevalence = 70.1%) than dogs of age 24 months and above (prevalence = 17.8%) ($2 = 26.389$, $df = 2$, $P=0.000$).

Monoparasitism and Polyparasitism

Monoparasitism accounted for 64.5% of total infections, while polyparasitism comprised of 27.3% double infection and 8.2% three parasites infection. Infection with *A. caninum* was the most important monoparasitism,

which alone accounted for 81(64.3%) of 126 single infections observed. *U. stenocephala* was found in only one dog (0.53%). Double infection combinations were observed in *A. caninum / T. canis, T. canis, / T. hydatigena,* and *A. caninum/T. hydatigena* while concurrent infections with three parasites were recorded between *T.canis/ T. hydatigena /T.vulpis, T. canis/ D. caninum/ A. caninum.* There were no cases of four or five parasites combination infections recorded.

Table 3: The Percentage Prevalence and Intensity (I) of gastrointestinal parasites in relation to age of dogs in Ijurin and Ikosu Communitie

Age (Months)	< 6		6-24		>24	
Parasite	**Prevalence[b] (%)**	**I (Mean±SEM)**	**Prevalence[b] (%)**	**I (Mean±SEM)**	**Prevalence[b] (%)**	**I (Mean±SEM)**
Ancylostoma caninum	61.5	166.9±27.3	37.2	77.4±19.9	9.0	10.6±4.8
Toxocara canis.	33.8	60.7±14.4	18.6	30.8±23.8	6.0	4.5±19.2
Dipylidium caninum	6.1	6.9±4.0	4.9	4.4±3.4	0	0±0
Toxascaris spp.	10.7	37.6±13.7	5.8	4.9±1.8	0	0±0
Taenea spp.	16.9	21.5±17.9	9.8	16.8±13.3	6.0	3.0±2.1
Trichuris vulpis	10.7	27.6±15.3	4.9	13.4±6.1	9.0	4.5±2.5
Uncinaria stenocephala	9.2	4.6±0.5	4.9	2.4±0.8	0	0±0
% of infected dogs	**72.3**		**48.0**		**18.1**	
Total		**65[a]**		**102[a]**		**33[a]**

[a]Total number of dogs examined in each age group; [b]Prevalence was calculated by dividing the number of dogs infected with individual parasite by the total number of dogs in each age group.

Table 4: The Percentage Prevalence, Intensity (I) and Range of parasites eggs in the faeces of dogs of different sexes

	Male (N=93)			Female (N=107)			Both Sexes (N=200)		
Parasites	**(%)**	**I (Mean±SEM)**	**R**	**(%)**	**I (Mean±SEM)**	**R**	**(%)**	**I (Mean±SEM)**	**R**
Ancyclostoma caninum	27.4	49.3± 21.7	0-2000	51.1	65.8±53.8	0-4000	39.1	44.2±27.7	0-4000
Toxocara canis.	11.6	30.6±12.6	0-1500	20.5	28.6±19.2	0-2500	21.1	24.5±17.8	0-2500
Dipylidium caninum	3.4	2.3±1.4	**0**	4.8	10.8±5.0	0-1500	4.1	10.5±8.1	0-1500
Toxascaris spp.	4.5	5.5±2.1	0-100	8.9	16.8±9.3	0-1000	6.7	7.5±5.0	0-1000
Taenea spp.	7.1	5.1±1.5	0-100	15.8	16.8±10.5	0-1500	11.5	21.7±15.6	0-1500
Trichuris vulpis	5.1	4.6±2.1	0-100	8.9	6.5±10.2	0-1000	7.0	7.5±4.3	0-1000
Uncinaria stenocephala	3.6	2.5±1.4	0-100	7.2	5.0±3.4	0-100	5.4	5.2±2.3	0-100

Discussion

The results obtained in this study showed that dogs examined in Ijurin and Ikosu communities in Ekiti State harbored several gastrointestinal parasites of which *A. caninum* and *T. canis* were the most prevalent with prevalence of 39.1% and 21.1% respectively making these parasites the most important parasites in this study. This is in agreement with reports from earlier authors in Nigeria who reported high prevalences of the two parasites, for instance, Anene *et al.,* 1996 recorded prevalence of 37.6% and 31.5% for *Ancylostoma caninum* and *Toxocara canis* respectively in Nsukka Area of Enugu State. Similarly, Biu *et al.,* (2012) recorded prevalence of 51.9% and 27.3% for *A. caninum* and *T. canis* respectively in Maiduguri.

The varying prevalence can be attributed to the differences in breeds, rearing conditions and health care received by dog population that the different authors worked with. Moreover, the double infection combination that was observed in *A. caninum / T. canis* is similarly consistent with report from Southeast Nigeria by Okoye *et al.,* 2010 who observed similar relationship between the two parasites. From the foregoing, the epidemiology and control of the diseases that these parasites cause may be better understood if the factors that drive the close association of the parasites are known. *A. caninum* and *T. canis* are pathogenic zoonotic parasites and are known to cause larval migrans (creeping eruption), chronic intestinal bleeding, abdominal pain and diarrhea in children ((Gavignet *et al.,* (2008), and Groese *et al.,* (1994)).

Other parasites that were encountered in this study include *Toxascaris spp.*, *T. hydatigena, D. caninum, T.vulpis*, and *U. stenocephala.* This is also in agreement with reports from other authors who have reported similar parasites thus, indicating that these parasites are cosmopolitan species in Nigeria (Sowemimo and Asaolu (2008), Malgor *et al.,* (1996), Katagiri and Oliveira-Sequeira (2008), Okoye *et al.,* (2010), Swai *et al.,* (2010), and **Biu *et al.,* (2012).**

The high prevalence of single infection observed in this study is not far removed from reports of other authors who also observed high prevalence in single worm infection than multiple infections in Benin city and Ibadan (Edosomwan and Chinweuba (2012), and Sowemimo and Asaolu (2008)). Furthermore, the pattern of mixed infections observed in this study compared well with the work of other authors who reported mixed parasitism involving two and three helminthes. However, there were no infections with four or more parasites recorded. This supports earlier reports from other authors who obtained similar results in Ibadan, South East Nigeria and Brazil ((*Odeniran and Ademola* (2013), Sowemimo and Asaolu (2008), Okoye *et al.,* (2010), and Katagiri and Oliveira-Sequeira (2008)).

The overall prevalence of parasitic infection of 69.2% in this study is consistent with reports from different ecological and epidemiological settings in South East and **Makurdi** in Nigeria and across the world in South Africa, **Mexico City,** Northern Belgium and Spain (Okoye *et al.,* (2010), Onyenwe and Ikpegbu (2004), Anene *et al.,* (1996), Omudu and Amutu (2007), Martinez-Moreno *et al.,* (2007), Eguia-Aguilar *et al.,* (2005), Claerebout *et al.,* (2009), and Minnaar *et al.,* (2002)**).** However, it is far higher than 24.7% recorded in Ibadan Nigeria ((Sowemimo and Asaolu (2008)) and 26.6% recorded in Spain (**Ortuño and Castellà, (2011)**). The difference may be due to the veterinary care received by dog population worked with in Ibadan by Sowemimo and Asaolu (2008) compared to local breeds of dogs that were involved in this study that seldomly received veterinary care. This further agrees with the report of Sowemimo and Asaolu (2008) who reported a high significant difference in prevalence of helminth parasites ($P < 0.05$) in the local breed (African shepherd) (41.2%) than in Alsatian dogs (16.2%) or in other exotic breeds (21.0%) (Sowemimo and Asaolu, 2008). High prevalence of parasitic infection has been attributed to non-adoption of the modern animal health care programmes by dog

owners, most of who are ignorant, uneducated and unable to provide their pets' daily needs ((Swai *et al.,* (2010), and Minaar and Krecek, (2001)).

The overall prevalence of gastrointestinal parasites of dogs observed in these communities thus indicates a potential public health problem that needs urgent intervention. Furthermore, the pattern of infection that is observed in this study with respect to age is consistent with reports from other authors who also recorded higher infection prevalence in puppies and young dogs than adult dogs (24 months) in South East and Jos, Plateau State Nigeria (Okoye *et al.,* (2010), Kutdang *et al.,* (2010)).

While the prevalence and intensity of infections recorded in these communities are not far removed from trends previously described in other parts of Nigeria, the results from this study showed the current status of gastrointestinal parasites in Ekiti State. The importance of dogs as reservoirs of gastrointestinal parasites have been confirmed by polyparasitism and these might have been attributed to poor nutrition and poor sanitary conditions which in turn predisposes the pet owners to the greatest risk of acquiring more than one zoonotic infections (Kutdang *et al.,* (2010)). This in addition to low awareness of canine zoonotic transmission by pet owners may contribute to increase in transmission risk of these parasites to humans in the two communities. Likewise, lack of functioning veterinary clinics in these communities may contribute to increase in worm burden.

In conclusion, this study has observed the high prevalence of gastrointestinal parasites infection among dogs in the study areas. The significance of these parasites in causing zoonotic diseases require that control programmes aimed at diagnosing, treatment and control of gastrointestinal parasites of dogs be embarked upon in these communities. In addition, dog owners should be educated on the public health importance of these parasites in causing zoonotic diseases and the need for them to provide veterinary care for their dogs.

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