ISSN: 2992-5762

ASUPFPE JOURNAL OF MULTIDISCIPLINARY RESEARCH AND INNOVATION

VOLUME 2, NUMBERS 1-4;
APRIL 2024
(SCIENCE AND TECHNOLOGY SERIES)

A PUBLICATION OF

ACADEMIC STAFF UNION OF POLYTECHNICS
FEDERAL POLYTECHNIC, EKOWE CHAPTER
BAYELSA STATE, NIGERIA

ASUPFPE JOURNAL OF MULTIDISCIPLINARY RESEARCH AND INNOVATION:

Printed and Published in Nigeria by:

ICIDR Publishing House
International Centre for Integrated Development Research
3, Alderton/Ibo Hall Road
P. O. Box 456, Ikot Ekpene
Akwa Ibom State.
Tel: +234-8064087345, 08185053436
E-mail: icidresearch@gmail.com
Website: www.icidr.org

This Work is a Publication of
Academic Staff Union of Polytechnics,
Federal Polytechnic, Ekowe Chapter,
Bayelsa State,
Nigeria.

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Number 1-4; April 2024
ISSN: 2992-5762

BOARD OF EDITORS

ABOUT THE JOURNAL

The ASUPFPE Journal of Multidisciplinary Research and Innovation (AJMRI) is a single blinded Peer-Reviewed and Open Access multi-disciplinary research and innovation journal. ***AJMRI*** publication platform reports new and significant, fundamental and applied research in Science and Technology, Agricultural Development, and Management and Humanities. ASUPFPE Journal of Multidisciplinary Research and Innovation (AJMRI) offer fast publication of quality Research and review articles. The Journal publishes manuscripts on original and innovative works, either experimental or theoretical from all disciplines.

Aim and Scope
The ASUPFPE Journal of Multidisciplinary Research and Innovation (AJMRI) aims to establish itself as a platform for exchanging ideas in new emerging trends in Science, Engineering, Agriculture, Management, Social sciences, arts, etc. that needs more focus and exposure and is always committed to publish articles that will strengthen the knowledge of upcoming Academicians, new Researchers, Authors and Technocrats.

Areas of publication

- Agriculture
- Physical and Chemical Sciences
- Biological and Health Sciences
- Engineering
- Social Sciences
- Language
- Entrepreneurship
- Arts and humanities

Call for Papers

The ASUPFPE Journal of Multidisciplinary Research and Innovation (AJMRI) invites you to submit your research work through E-mail: asupjournalchiefeditor@federalpoyekowe.edu.ng. Make sure that the submitted manuscript should not have been submitted or published previously anywhere else for publication. It is strictly advised to submit original and plagiarism free articles **(Similarity check 25% acceptance)** only for possible consideration; else they will be rejected without further review. All received manuscripts will go through Peer Review and final decision shall be based on the high level of quality, originality and additional contribution to the existing knowledge.

Frequencies of publication
AJMRI receives articles throughout the year and publishes biannually (June and December).

INSTRUCTIONS FOR AUTHORS

The ASUPFPE Journal of Multidisciplinary Research and Innovation (AJMRI) accepts manuscripts from all disciplines and subject them to rapid peer review process and published in the respective dates after final acceptance. There are no submission charges, however, the Journal take nominal Article Processing Charge (APC) from author for publishing and maintaining the content online, outsourcing facilities, tools and resources towards publication of the article.

Manuscript Categories

The ASUPFPE Journal of *Multidisciplinary Research and Innovation (AJMRI)* accepts four types of manuscripts (i) Full length research articles, (ii) Review articles, (iii) Short communications and (iv) Case studies.

- Full length research articles should not generally exceed 10 double-spaced pages of text including the references and should not contain more than 8 figures and /or tables.
- Reviews should not generally exceed 10 double-spaced pages of text including references and should not contain more than 4 figures and /or tables.
- Short communications should not exceed 5 double-spaced pages of text including references and no more than 2 figures and /or tables.
- Case studies should not exceed 5 doubled-spaced pages of text including the references and should not contain more than 2 figures and/or tables.

Manuscript preparation for full length research articles for Agricultural Development and Science and Technology

Manuscript format

The manuscript should be typed, double-spaced on A4 size paper with 1"margin on all sides in MS word format. Times New Roman font (12pt) and justify alignment should be used throughout the manuscript. The first page of the manuscript is a title page which should contains: Title of manuscript, Author's full names, affiliations of all authors, and information for correspondence. The second page of the manuscript should contain Abstract and keywords. The subsequent pages should include introduction, materials and methods, Results and Discussion, Conclusion, Acknowledgements (if any), Conflict of interest, References.

Title Section:

The first section of the manuscript is a title page which should contains: Title of manuscript, Author's full names, affiliations of all authors, and information for correspondence.

- Title of the manuscript should be clear, concise and informative. Title should be typed in sentence case and should have maximum 150 characters (should not be below 8 words count and not exceed 20 words count). Title should be in single line spacing and in bold capitalized letters, 12 font size in Times new Romans. Do not capitalize articles (*a*, *an*, *the*), coordinating conjunctions (*and*, *but*), or short prepositions (*at*, *in*, *on*, *of)*.
- Provide the name(s) of authors as Last name (Family name/Surname) and the initials of First name (Given name) and Middle name for each author and check that all names are accurately spelled. Authors names should be in 12 font size, Times new Romans-not in bold characters.
- Present the author's affiliation addresses (where the actual work was done) below the names of authors. Indicates all affiliations with superscript numbers immediately after the

author's name and in front of the appropriate affiliation address. Provide the full details of each affiliation.

- Clearly indicate who will handle correspondence at all stages of refereeing and publication, also post-publication. Corresponding author of the manuscript must be marked with an asterisk. The corresponding Author must indicate his or her complete mailing address including cellular phone number and email address. Affiliation with corresponding authors e-mail should be 11 font size (*italics)* and Times new Romans.
- See sample below:

Effects of 60-Hertz Electric Fields on Embryo Chick Development, Growth, and Behavior

Christian, A.K*[1]; Sani, G.H[2] and Ofoni, G.P[1]
[1]*Department of General Studies, Federal Polytechnic, Ekowe, Nigeria*
[2]*Kwara state polytechnic, Offa, Nigeria*
**Corresponding authors email. asupjournalediotor@federalpolyekowe.edu.ng*

Abstract:
The second section of the manuscript should contain abstract and keywords. Abstract should be informative, self-explanatory and easy to understand.

- The abstract should not be more than 200 words in length and in Times new romans, 11 font size, single spacing and should not be in *italics* neither in *bold* character.
- Abstract should briefly present the purpose of research, state the scope of the experiments, indicate significant results, and summarizes major findings and conclusions.
- An abstract is often presented separately from the article, so it must be able to stand alone. Therefore avoid references/citations in the abstract.
- Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.

Keywords:
Immediately after abstract provide four to six keywords. These keywords will be used for indexing purpose.

1.0 Introduction:
This should be brief and state the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results. Introduction should clearly state the hypothesis or purpose statement, how and why the purpose or hypothesis was developed and why the author thinks it is important.

2.0 Materials and methods /Literature Review *(for Management Sciences and Humanities)***:**
This section must contain specific details about the materials studied, instruments used, specialized chemicals source and related experimental details which allows other researchers to reproduce the results. Obtain permission for all fully borrowed, adapted, and modified tables and provide a credit line in the footnote. If any animal study was carried out, then the necessary institutional animal ethical committee approval should be taken and should be mentioned in the manuscript. If any human study was carried out, then necessary human ethical committee or appropriate approval should be taken and should be mentioned in the manuscript. A written consent should be taken from the human subjects or patients involved in the study ensuring their

acceptance in the study and publication of relevant data/photos/images in the journal and should be mentioned in the manuscript. The journal will not be responsible if any of the above, if not followed and the editor's decision would be final if any litigation arises during processing or after publishing.

3.0 Results and Discussion:
The results should be concisely presented. Results and discussion may be separate or combined based on the author's requirement. Tables and figures should be designed to maximize the comprehension of the experimental data. The interpreted results should be explained clearly in the discussions and should relate them to the existing knowledge in the field as clearly as possible. Tables, graphs and figures (Illustrations) should be inserted in to the main text at respective place they should appear when published and should have appropriate numbers and titles with an explanatory heading. Labels of the table, graph and figures must be in the text form and should not form part of the image.

4.0 Conclusion:
This should clearly explain the main conclusions of the work highlighting its importance and relevance. It should be short and concise but should not repeat the abstract. Generally the conclusion does not cite references.

5.0 Acknowledgement:
All acknowledgements (if any) should be included at the very end of the paper before the references and may include supporting grants, presentations, and so forth.

6.0 Conflict of interest:
All the authors must disclose the possible conflicts of interest/competing interests they may have with publication of the manuscript or an institution or product that is mentioned in the manuscript and /or is important to the outcome of the study presented. Authors should also disclose conflict of interest with products that compete with those mentioned in their manuscript.

Ethical approval:
Author should provide below approvals or consents (wherever necessary)

- *Statement of ethical approval:* if studies involve use of animal/human subject, authors must give appropriate statement of ethical approval. If not applicable then mention "the present research work does not contain any studies performed on animals/humans subjects by any of the authors'.
- *Statement of informed consent:* if studies involve information about any individual example survey, interview etc. author must write statement of informed consent as informed consent was obtained from all individual participants included in the study'.

Reference:
Author should provide a complete list of references at the end of the manuscript; all the references and citations should follow the American Psychological Association (APA) Referencing Style 7th edition.

Abbreviations:
Standard abbreviations should be used throughout the manuscript. All nonstandard abbreviations should be kept to a minimum and must be defined in the text following their first use.

Nomenclature and Units:
The SI system should be used for all scientific and laboratory data: if, in certain instances, it is necessary to quote other units, these should be added in parentheses.

Equations:
Use equation editor for all equations as shown below:

$$G = \frac{y^2}{X^2} - \frac{a^2}{b^2} x_{y^2} \qquad [1.1]$$

Tables and Figures:
Tables and figures should be placed next to the relevant text in the manuscript wherever they are expected to be in the final version of the manuscript. Tables should be created with a word processor and cited consecutively in the text. Please avoid using vertical rules and shading in table cells. Be careful in the use of tables and ensure that the data presented in them do not duplicate results described elsewhere in the article.

Review Process:
All manuscripts are reviewed by the editorial board and decisions will be made as rapidly as possible, and the journal strives to return reviewer's comments to authors within 4 weeks. It is the goal of the journal to publish accepted manuscript as early as possible.

Proofs and reprints:
After acceptance of the manuscript for publication, electronic proofs will be sent (e-mail attachment) to the corresponding author as a PDF file. Page proofs are considered to be the final version of the manuscript. With the exception of typographical or minor clerical errors, no major changes will be made in the manuscript at the proof stage. Because, the journal publishes accepted articles on the website of Federal Polytechnic, Ekowe (www.federalpolyekowe.edu.ng) upon receiving the final versions where authors will have free electronic access to the full text (PDF) of the article after publication.

Management and Humanities

1.0 Introduction
2.0 Literature review
3.0 Methodology/Research Process
4.0 Discussions
5.0 Conclusion and Recommendations
6.0 Acknowledgement
7.0 Conflict of interest

Thank you.
We are looking forward to the submissions of your next manuscripts.

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Number 1-4; April 2024
ISSN: 2992-5762

CONTENTS

(SCIENCE AND TECHNOLOGY SERIES)

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

Strength Properties of Hot Mix Asphalt with Egg Shell Powder as a Filler Material

Abdullahi Danlami Abubakar[a],
MuranaAdinoyi Abdulfatia[b],
Abdullahi Yabagi Isah[c],
Abubakar Sadiq Saidu[d]
Victor Itopa Ahmed[e]
[a ,c-e]*Civil Engineering Department Federal Polytechnic Bida Niger State Nigeria*
[b]*Civil Engineering Department Ahmadu Bello University, Zaria Nigeria*

ABSTRACT

This research work evaluates the effect of Eggshell powder (ESP) as a filler material in Hot Mix Asphalt (HMA). Road deterioration has continued to be a problem in Nigeria and it is being affected by many factors as such it requires a solution to improve the mechanical and volumetric properties of hot mix asphalt (HMA). The objective of this paper is to use eggshell powder to partially replace stone dust as mineral filler in HMA and to examine its effect on the Marshall Properties of Mix. Laboratory test carried out shows that the oxide composition test on ESP contains 97.64% of calcium oxide (CaO) and constituent materials used conform to standard specification. Eggshell powder partially replaced the granite stone dust mineral filler at 0, 20, 40, 60, 80 and 100% by weight of total Mix at bitumen content of 4, 4.5, 5, 5.5, 6, 6.5 and 7% respectively for both control and modified HMA. Mechanical, Volumetric and Marshall Quotient test were performed on the modified HMA samples to obtain strength properties. From Marshall Stability, the optimum bitumen content for the control sample was 5.2% and for modified sample was 5.40%. The optimum replacement of 80% ESP recorded was 4.70kN stability, 3.30% flow, 3.2% air void (Pa), 80.0% voids filled bitumen (VFB) and 16% voids filled with mineral aggregate (VMA). The results showed that addition of ESP increases the Marshall properties with increasing ESP contents. Base on the test results, it can be concluded that using of eggshell powder as mineral filler in the HMA is recommended at 80% of the total mix.

Keywords: *Bitumen, Optimum Bitumen Content, Egg Shell Powder, Filler Material, Hot Mix Asphalt (HMA).*

1.0 INTRODUCTION

In recent years, many countries have experienced increase in traffic volume. This increase meant that pavements are exposed to higher stresses. Higher density of traffic in terms of commercial vehicles, overloading of trucks, and significant variation in daily and seasonal temperature of pavements have been responsible for the development of distresses such as, raveling, rutting, and fatigue failures of bituminous surfaces (Tomar, *et al*., 2013). Improvement in asphaltic concrete performance can be achieved through various modifications such as the use of polymer, glass, fly ash, and furnace slag. Researchers have extensively investigated the use of various by-products as fillers in improving the properties of the asphaltic concrete (Sobolev and Naik, 2005). Eggshell is a waste material generated from domestic sources such as hatcheries, homes poultries, and fast food

centers. Large amounts of eggshells pose a significant environmental concern if not recycled or discarded properly (Pliya and Cree, 2015). Due to similar chemical composition to that of lime, the eggshell powder can be used as a partial replacement for industrial lime if subjected to proper examination (Rao and Chittaranjan 2011). As a result, the eggshell powder could be suitable for stabilizing the soil and producing a composition that could partially substitute for lime in soil stabilization (Leite, *et al*., 2016). A limited number of studies had been conducted on the re-use of eggshell powder / ash in hot mix asphalt. Eggshell powder was added to Portland cement in various amounts. The effect of replacement of eggshell powder for cement in proportion such as 2.5%, 5%, 7.5% and 10% by weight of cement was studied in detail (Gowsika, *et al*., 2014). The filler is defined as a mineral powder consisting of 72% particles with a size under 75 µm (No. 200) which is obtained by crushing of any natural basic rock (limestone, dolomite, granite, chalk-stone, asphaltic rocks) and also by hydrated lime in the powder (Gugiuman, 1996).In recent years, it can be seen that the growth in the mining industry and the raised consumption of raw materials have caused a rapid limitation in available of natural resources (Arabani, *et al*., 2017). An attempt has been made in this study to assess the influence of Eggshell powder in the production of Asphaltic Concrete Wearing Course (AC-WC).

2.0 MATERIALS AND METHOD

The materials used for the research are Egg Shell Powder, Bitumen, coarse aggregate, Fine aggregate (stone dust). The aggregates used for this are crushed rock obtained from quarry site opposite Nigerian College of Aviation Technology (NCAT), along Sokoto road, Zaria, Kaduna State, Bitumen used is penetration grade bitumen obtained from Mother Cat Construction Company, Zaria. While egg shell waste was obtained from Samaru in Zaria, Kaduna State Nigeria, the obtained eggshell waste was subjected to grounding into powder form using ball mill for 15 min and then were passed through No. 200 (75µm) sievein Department of Civil Engineering Ahmadu Bello University, Zaria Nigeria. Preliminary tests were conducted on bitumen, coarse and fine aggregates, and stone dust filler in Department of Civil Engineering Ahmadu Bello University, Zaria Nigeria. Test carried out in accordance to standard specifications on the aggregates were Sieve analysis (ASTM C136/C136M-19, 2019), Specific gravity (ASTM C127-15, 2015; ASTM C128-15, 2015), Aggregate Impact Value (BS 812-112, 1990), Aggregate Crushing Value test (BS 812-110, 1990), Los Angeles abrasion test (ASTM C131/C131M-20, 2020, AASHTO T96, 1998), and Flakiness test (BS EN 933-3, 2017) and Elongation test (ASTM D4791-19, 2019). And the Physical properties test carried out on bitumen were Penetration Test (ASTM D5/D5M-20, 2020), Softening point (Ring and Ball) Test (ASTM D36/D36M-14, 2020), Ductility Test (ASTM D113-17, 2017), Specific gravity Test (ASTM D70/D70M-21, 2021), Viscosity Test (ASTM D4402/D4402M-15, 2015), Flash and Fire Point Test (ASTM D92-18, 2018), and Solubility test (ASTM D2042-15, 2015).While test on mineral aggregate were particle size distribution (ASTM D546-17, 2017), specific density (ASTM D242/D242M, 2019) and Oxide composition using XRF (ASTM E1621 - 2013).Figures 1and 2 shows the eggshell waste and eggshell powder.

Figure I: Egg Shell waste

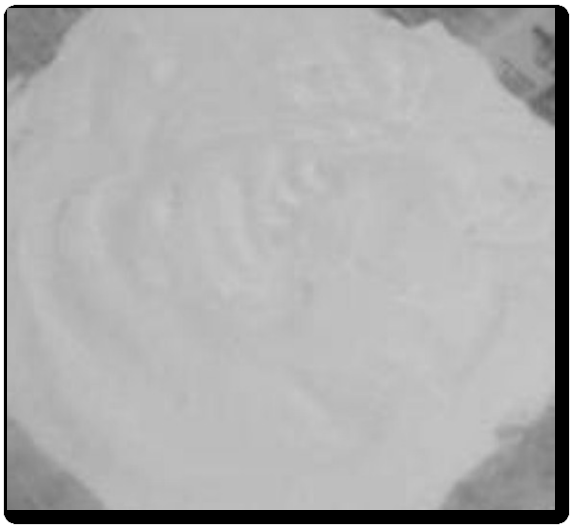


Figure II: Egg shell Powder

2.1 Marshall Mix Design Methods

The mix design is aimed at selecting suitable materials at optimum percentages use in recycled hot mix asphalt were stability, workability and economy is very important. The research is focused on using eggshell powder as filler material and natural aggregate for coarse and fine aggregates. Initially, preliminary tests would be conducted to determine the suitability of selected materials. Afterwards, aggregate gradation would then be conducted to ascertain the right proportion and blend of the aggregates (coarse aggregate, fine aggregate and eggshell powder). On completing the mix design such as Hveem Mix Design, Marshall Mix Design, Superpave Mix Design and Balance Mix Design, all Mix design methods share the same fundamental steps. Marshall Mix Design was adopted and preparing the samples, aggregates are heated to a standard temperature of 135^0C. The quarry dust mineral filler is gradually replaced with eggshell powder at an interval of 20, 40, 60, 80 and 100%. Bitumen content is added at an interval of 0.5%, from 4 to 7% and stirred to get a homogenous mix.

The prepared sample is compacted in a standard mould, 1s01.6mm diameter, with 75 blows from a 4.54Kg rammer falling from a height of 457mm; each at the top and bottom faces. The specimens are allowed to cool for at least 25 minutes, extruded and kept safe. The optimum binder content is selected as the average binder content for maximum density, maximum stability and 4% specified percent air voids in the total mix. The optimum blend of egg shell and stone dust in hot mix asphalt was obtained by various percent replacements by weight (0, 20, 40, 60, 80 and 100%) of eggshell powder with stone dust. Marshall stability-flow and volumetric analysis were performed and checked against standard specification as specified by the Nigerian General Specifications for Roads and Bridges (NGSR&B, 2016) for wearing course.

3.0 RESULTS AND DISCUSSION

3.1 Tests results on Bitumen

Table 1: Test results on of Bitumen

Properties	**Codes/ Specification**	**Values**	NGSR&B,(2016)		**Remark**
			Min.	**Max.**	
Penetration (mm) @25^{o}C	(ASTM D5/D5M-20, 2020)	62.8	60	70	OK
Ductility (cm) @25^{o}C	(ASTM D113-17, 2017)	110	100	-	OK
Softening Point (^{o}C)	(ASTM D36 / D36M-14, 2020)	49.00	48	56	OK
Flash Point (^{o}C)	(ASTM D92-18, 2018)	249	250	-	OK
Fire Point (^{o}C)	(ASTM D92-18, 2018)	218	-	-	OK
Specific Gravity	(ASTM D2042-15, 2015)	1.04	1.01	1.06	OK
Solubility (%)	(ASTM D70/D70M-21, 2021	100	99	-	OK
Viscosity (%)	(ASTM D4402/D4402M-15, (2015),	1520	.	.	OK

The results of the tests carried out on bitumen are presented in Table 1 shows the physical properties of Bitumen obtained as regard to the standard specification for hot mix asphalt pavement at grade 60/70 of the bitumen and the bitumen satisfied code requirement.

Table 2: Physical Properties of Aggregates

Properties	Codes/ Specification	Test values	NGSR&B (2016)		Remarks
			Min.	Max.	
Specific Gravity (Coarse Aggregate)	(ASTM C127-15, 2015)	2.64	2.6	2.9	OK
Specific Gravity (Fine Aggregate)	(ASTM C128-15, 2015)	2.53	2.64	2.9	-
Specific Gravity (eggshell powder)	(ASTM D242/D242M, 2019)	2.17	-	-	-
Flakiness Index	(BS EN 933-3, 2017)	26.23	-	35	OK
Elongation Index	(ASTM D4791-19, 2019)	22.73	-	25	OK
Aggregate Crushing value (%)	(BS 812-110, 1990)	22.48	-	30	OK
Aggregate Impact value (%)	(BS 812-112, 1990)	25.79	-	35	OK
Los Angel's Abrasion Value (%)	(AASHTO T96, 1998, ASTM C131M-20, 2020)	23.4	25.7	30	OK

The results of the tests carried out on aggregates are presented in Table 2 shows the physical properties of Aggregates obtained which falls within the range as regard to the standard specification for road and bridges and the aggregates used for this research are granite of size less than 19mm which satisfied code requirement.

3.3. Test result on Particle size distribution and Aggregate Gradation

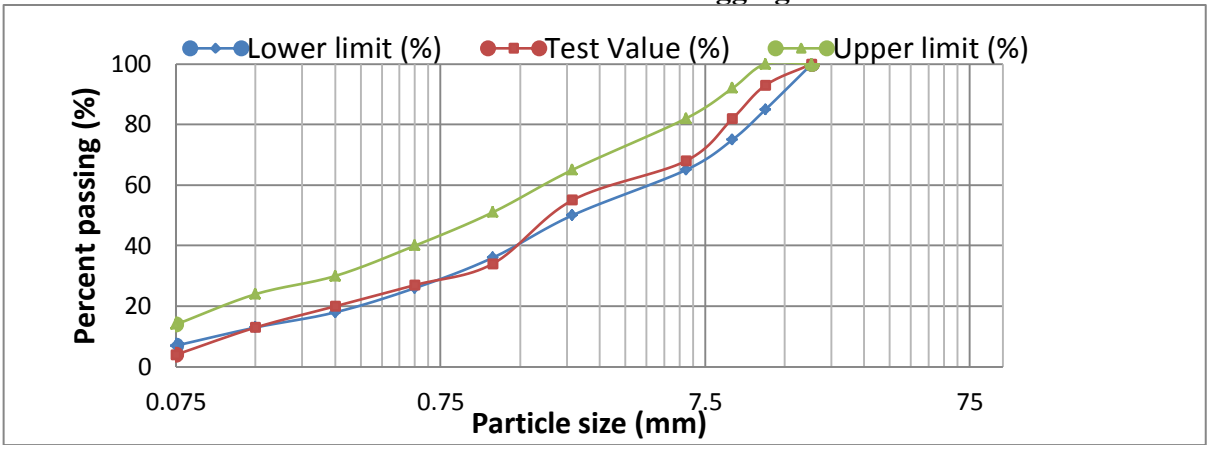


Figure 1: Particle size distribution of combined aggregates

Particle size distribution and aggregate gradation were performed according to (ASTM C136 /C136M-19, 2019) on the aggregates in the Laboratory. The aggregates were proportioned by the trial-and-error method giving rise to 57%, 36%, and 7% coarse, fine and filler materials respectively which was used in the preparation of samples in the Marshal Mix method of design. The results are as presented in Figure1. From Figure 1, it was observed that the particle size distribution graph for the aggregates fall within the specified envelops (NGSR&B 2016).

Table 3: Oxide composition for Egg shell powder

Main Oxide	**ESP (%)**
CaO	97.64
MgO	0.5
SrO	0.42
SO_3	0.41
SiO_2	0.26
P_2O_5	0.20
K_2O	0.17
Al_2O_3	0.16
Cl	0.12
Fe_2O_3	0.06

This research also explored the chemical properties of ESP using the XRF technique in accordance with (ASTM E1621-13, 2013). The result of the chemical analysis is presented in Table 3. The XRF analysis results presented in Table 4.3 indicates that ESP mainly consists of CaO which represents more than 97% by mass. These higher percentages of Calcium oxide in the ESP material could indicate some chemical reactivity. On the other hand, very small mass percentages of several oxides such as MgO, SrO, SO_3, SiO_2, P_2O_5, K_2O, Al_2O_3, Cl, and Fe_2O_3, were observed in the ESP. The small amounts of these oxides imply low pozzolanic reactivity of the ESP.

Table 4: Marshall Parameters for control samples (Optimum binder content)

Bitumen content (%)	Stability (kN)	Flow (mm)	Unit weight (g/cm^3)	VMA (%)	VFB (%)	Pa (%)
4.0	4.34	1.78	2.38	15.06	60.62	5.93
4.5	4.36	3.00	2.41	14.44	72.78	3.98
5.0	4.41	3.20	2.42	14.54	80.67	2.81
5.5	4.71	3.37	2.43	14.63	88.93	1.62
6.0	4.41	3.42	2.42	15.43	89.44	1.63
6.5	4.08	3.57	2.40	16.58	90.11	1.64

A mixture of aggregates in line with gradation and job mix given and mixed with bitumen and then subjected to Marshall Test. Bitumen was added in the following proportion; 4.0, 4.5, 5.0, 5.5, 6.0, and 6.5% by the total weight of sample. The mix was then compacted in the mould, giving 75 blows to each side. The compacted samples were subsequently tested for stability, flow and volumetric properties. The stability and flow values as well as voids – density values for the control (0%) are as presented in Table 4. Optimum binder content (OBC) is calculated as follows: OBC= Average of Max. Stability, Max. Bulk density and median voids in total mix. (Pa) $=\frac{5.5+5.5+4.5}{3}=$ 5.2%. Thus, OBC used in this study for various egg shell powder replacements is 5.2%.

Marshal Test results for different replacement of egg shell powder with stone dust on Optimum binder content

The mix was prepared and the marshal test was conducted in other to determine the properties of the modified HMA to ascertain its possibility for highway construction

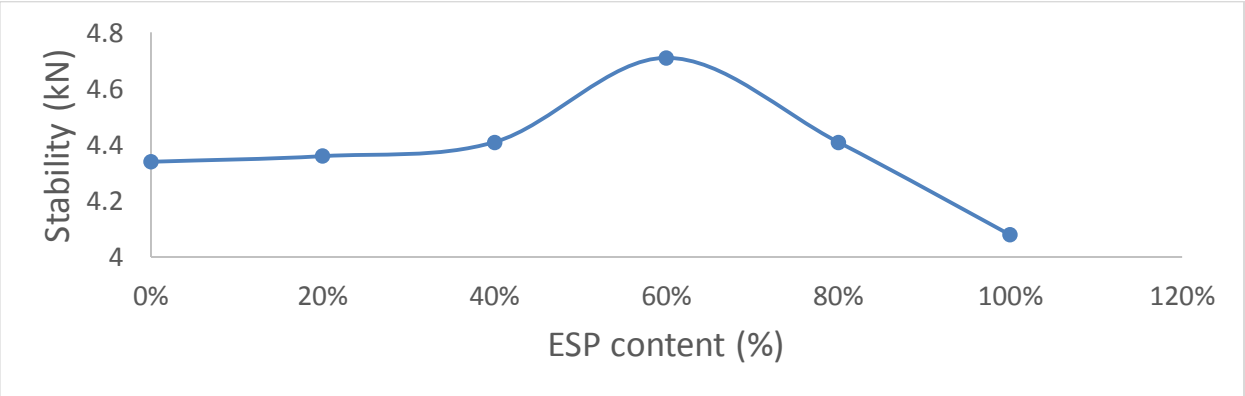


Figure 2: Variation of Stability with ESP content (%)

The variation of stability with bitumen content can be seen in Figure 2. Its indicate that stability of the control mix increases from 4.34 kN (0%) with increase in ESP content to 4.71 kN (60%) at maximum value and then decreases. The decrease in stability could be as a result of higher percentages of ESP in the mix which did not allowed proper coating of HMA. Although maximum stability was obtained at 60% ESP replacement, this trend and behavior was equally observed by

(Shuaibu et al, 2020). They observed that the decrease in stability may be as a result of excessive filler in HMA which do not disperse uniformly thereby produce lower bonding between aggregates.

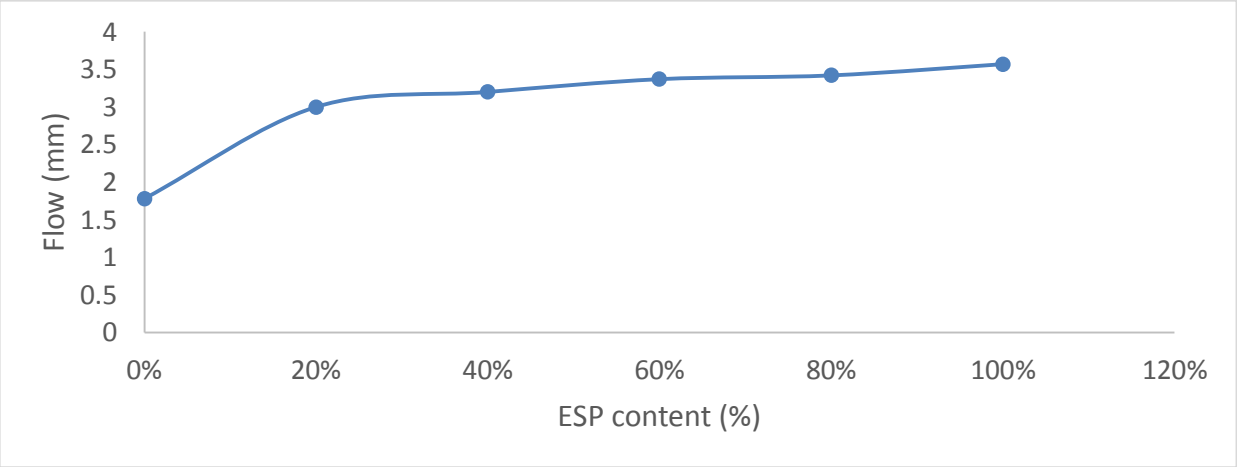


Figure 3: Variation of Flow with ESP content (%)

Figure 3 shows variation of flow with ESP content. It was observed that flow increases from lower value to the highest flow value of 3.77 mm at 100% ESP replacement content, although the values of flow obtained at different ESP replacement conform to the standard specification (2 – 6 mm). The increment in flow shows that the mix is workable which allowed the mix against stiffness thereby preventing hot mix asphalt from cracking and rutting. Similar trend was equally observed by (Sneha and Waseem, 2021) Effects of Eggshell as a filler material on various bituminous mix: A review. However, these values are all within the limits specified by that stipulated that the flow value should lie between 2-4mm.

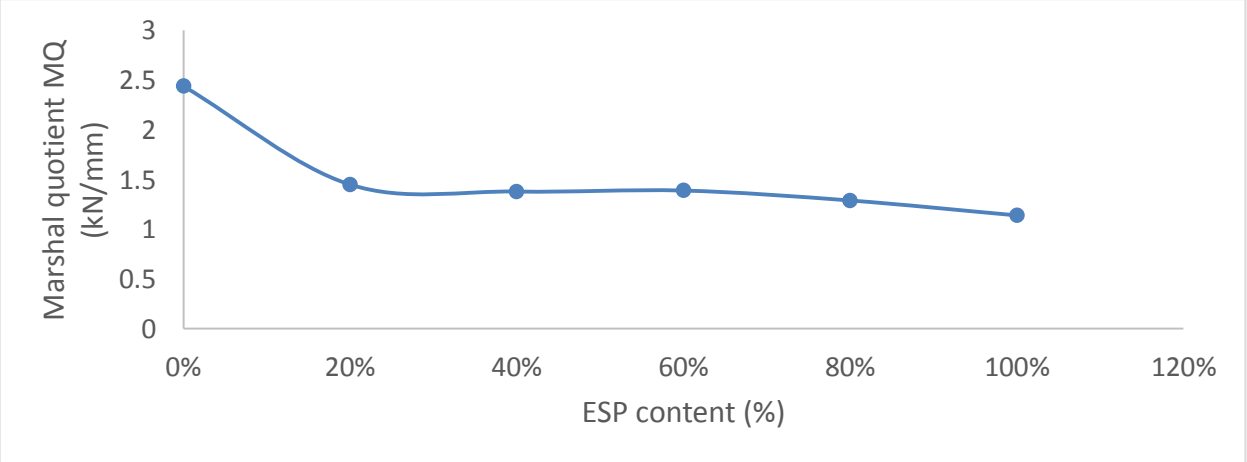


Figure 4: Variation of Unit Weight with ESP Content (Marshall Quotient)

Figure 4 shows the variation of Marshal Quotient with ESP content. It was observed that marshal quotient decreases from 2.44 kN/mm (0%) to 1.45 kN/mm (20%) ESP content replacement then decreases linearly with increase in ESP content replacement. The trend is observed by

(Naglaa, 2016) Hot Mix Asphalt (HMA) Performance as Affected by Limestone Powder Filler Content. With assertion that decrease in MQ may be due to decrease in stability with the increase of mineral filler content which associated with increasing flow values?

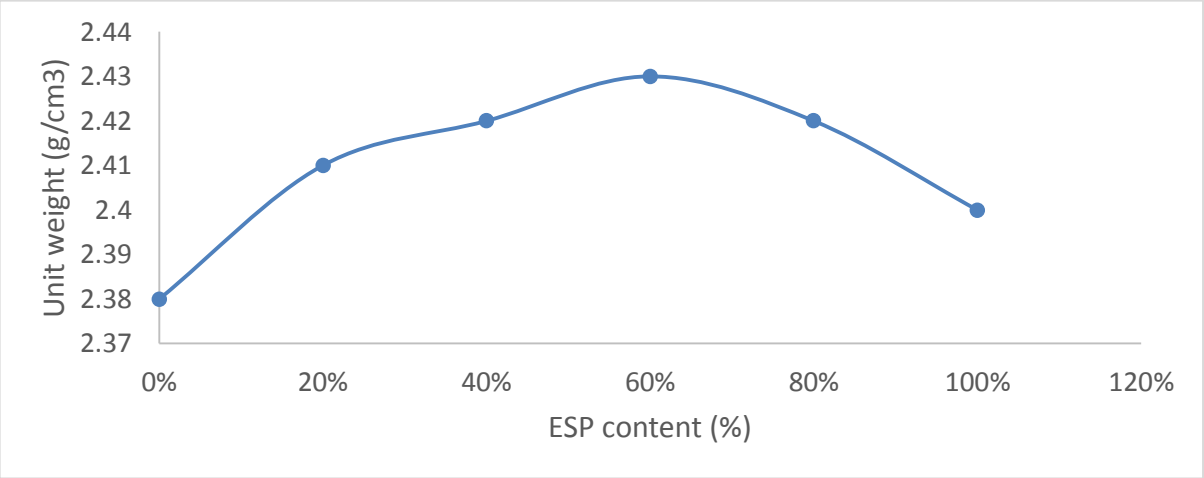


Figure 5: Variation of Unit Weight with ESP Content

Figure 5 shows variation of unit weight with ESP contents. Unit weight increases with increase in ESP contents as the ESP content increases there was a corresponding increase in the values of unit weight of 2.43g/cm^3 at 60% ESP which is optimum then drop thereby causes the mix to be less dense as unit weight enhances stability, flow and volumetric properties of HMA. The decrease in unit weight could be from lesser specific gravity of ESP as to stone dust. This trend was equally observed by (Murana et al., 2019) when Bone ash was use as filler in HMA.

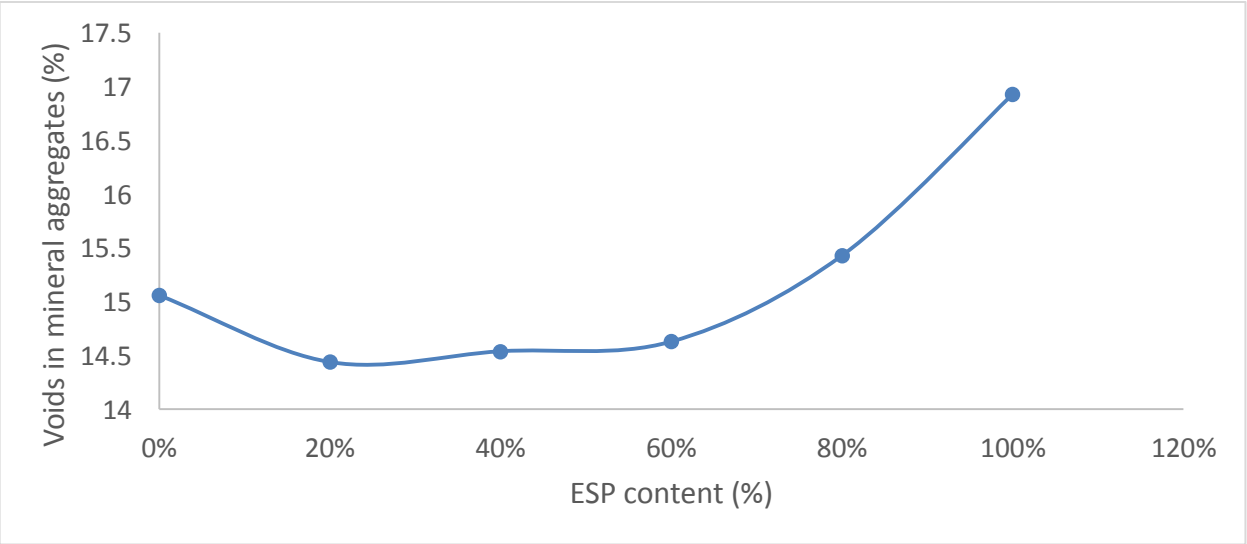


Figure 6: Variation of Void in the Mineral Aggregate (VMA) with ESP Content

The variation of void in the mineral aggregates (VMA) with ESP content is shown in Figure 6. It can be observed that VMA decreases from 15.06(0%) to minimum value of 14.44% (20%) ESP content replacement then increases with increase in ESP content. This similar trend was equally observed by (Abdulfatai et al., 2020) when Use of Carbide Waste as Mineral Filler in Hot Mix Asphalt.

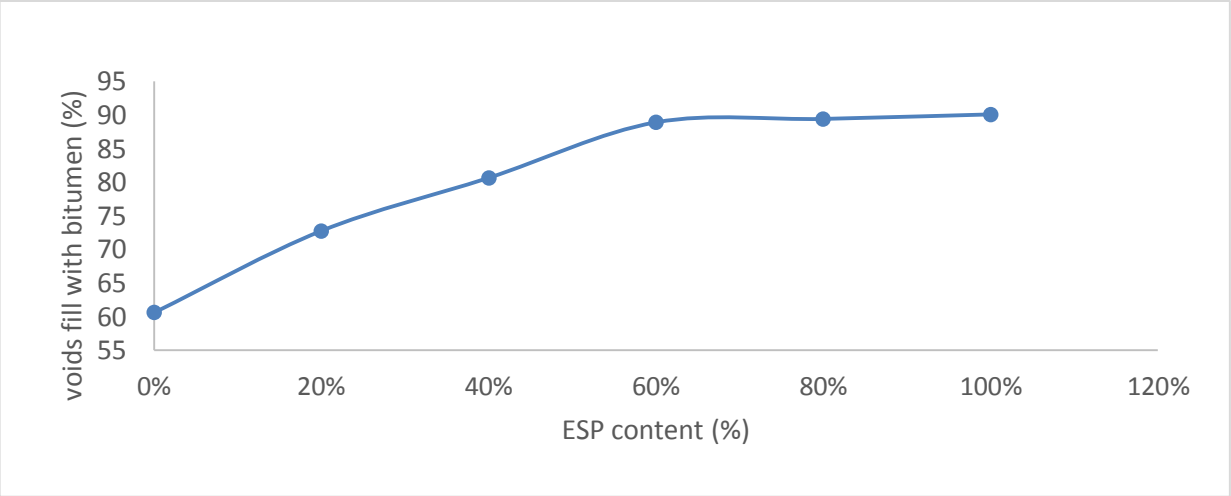


Figure 7: Variation of Void Fill with ESP Content (Void Filled with Bitumen)

The variation of void filled with bitumen with ESP content is shown in Figure 7. VFB of the mixtures increases with increase in ESP content. VFB which represents the volume of the effective bitumen content in the mixture is inversely related to air voids and hence as air voids decreases, the VFB increases. This trend was equally observed by (Okobia, 2016) evaluation of sawdust ash as mineral filler in asphalt mixture.

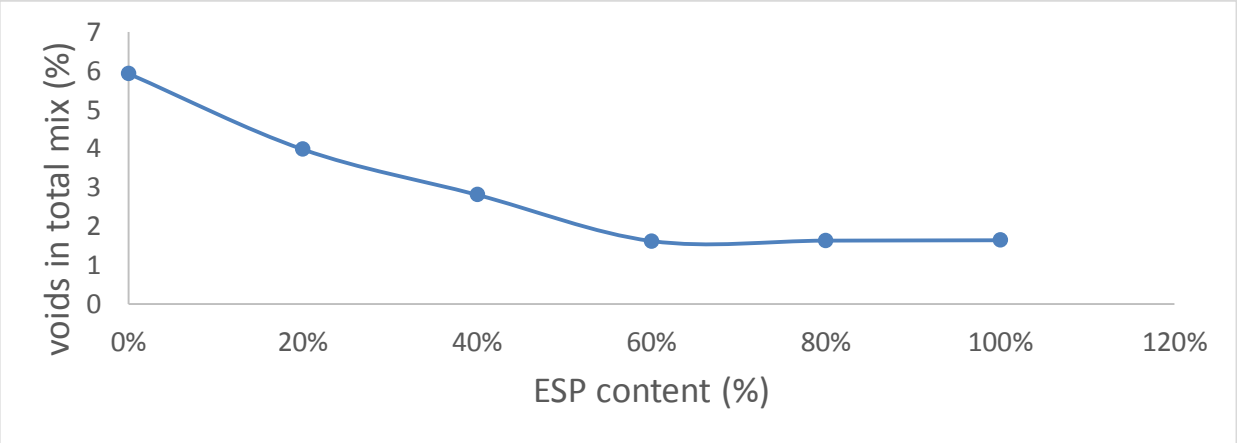


Figure 8: Variation of Void in total mix ESP Content (Void in total mix Pa)

The variation of percentage air void (Pa) content can be seen in Figure 8. It shows that as the percent air void decreases from 5.93% (0%) to 1.64% (100%) minimum. The decrease in Pa is because more voids are filled as ESP content replacement increases. Percentage air void (Pa) is inversely related to voids filled with bitumen and hence VFB increases. This trend was equally observed by (Nwaobakaba and Agwunwamba, 2014). When periwinkle shell ash was use as filler in HMA.

4.0 CONCLUSION

The physical and chemical properties of the constituent materials used in hot mix asphalt were determined and found to be satisfactory within limits specified for use as filler in Asphalt Concrete

Wearing Course AC-WC in accordance to NGSR&B, ASTM and BS Standard specification. The XRF analysis results indicate that ESP mainly consists of CaO which represents more than 97% by mass which imply chemical reactivity. Very small percentage by mass of several oxides was observed which imply low pozzolanic reactivity. Asphaltic concrete Wearing Course, AC-WC samples prepared from blends of stone dust and ESP were found to possess satisfactory strength and volumetric properties (VMA, Pa, VFB). The Optimum Egg Shell Powder OESP content obtained for the samples was obtained to be 47% and all the Marshall Stability parameters conform to the relevant specifications

REFERENCES

Tomar, R., Jain, R. K. and Kostha, M. K. (2013). Effects of Fillers on Bituminous Paving Mixes. *International Journals ofEngineering Research, Science and Technology* 2 (4): 2319 – 5991.

Sobolev, K. and Naik, T. R. (2005). Performance as a Factor for Sustainability of the Cement Industry. CANNMET/ACI International Symposium on Sustainable Development of Cement and Concrete. Toronto, Canada, 295 – 312.

Pliya, P. & Cree, D. (2015). Limestone derived eggshell powder as a replacement in Portland Cement mortar. *Construction and Building Materials*, 95 (SupplementC),1-9.

Rao, A.N. & Chittaranjan, M. (2011). Applications of agricultural and domestic wastes in Geotechnical applications: an overview. *J Environ Res Dev*, 5 (3), 4-8.

Leite, R., Cardoso, R., Cardoso, C., Cavalcante, E. & de Freitas, O. (2016). Lime stabilization of Expansive soil from Sergipe-Brazil', *E3S Web of Conferences*, 9, EDP Sciences, 14005.

Gowsika, D., Sarankokila, S., Sargunan,K. (2014). Experimental Investigation of Eg Shell Powder as Partial Replacement with Cement in Concrete. *International Journal of Engineering Trends and Technology (IJETT)*, 14 (2), 65-68.

Gugiuman, G.H., (1996). *The building of the roads*. Bucharest: Technical Publishing House.

Arabani, M., Tahami, S.A., Hamedi, G.H. (2017). Performance evaluation of dry process crumb rubber-modified asphalt mixtures with nonmaterial, Road Materials Pavement Design, 17, 1–8.

ASTM C136 /C136M-19. (2019). *Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.* West Conshohocken, PA: ASTM International.

ASTM C127-01. (2015). *Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate.* West Conshohocken, PA:American Society for Testing and Materials (ASTM) International. Retrieved fromwww.astm.org.

BS 812-112. (1990). *Testing Aggregates. Methods for Determination of Aggregate Impact Value (AIV).* London, United Kingdom: British Standard Institution. 14.

BS EN 933-3. (2017). *Test for Geometrical Properties of Aggregates Part 3:Determination of Particle Shape- Flakiness Index.* London, UK: British Standards Institution (BSI).

ASTM C131/C131M-20. (2020). *Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine*, West Conshohocken, PA: ASTM International.

BS EN 933-3. (2017). *Test for Geometrical Properties of Aggregates Part 3:Determination of Particle Shape- Flakiness Index.* London, UK: British Standards Institution (BSI).

ASTM D4791D-19. (2019). *Standard Test Method for Flat Particles, Elongated Particles or Flat and Elongated Particles in Coarse Aggregate.* West Conshohocken, PA: American Society for Testing and Materials (ASTM) International. Retrieved from www.astm.org.

ASTM D5 / D5M-20. (2020). *Standard Test Method for Penetration of Bituminous Materials.* West Conshohocken, PA: American Society for Testing and Materials (ASTM) International.

ASTM D36 / D36M-14. (2020). *Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)* (Vol. 04.04). West Conshohocken, PA: American Society for Testing and Materials (ASTM) International. Retrieved from www.astm.org

ASTM D113-17. (2017). *Standard Test Method for Ductility of Asphalt Materials* (Vol. 04.03). West Conshohocken, Philadelphia.PA: American Society for Testing and Materials (ASTM) International. Retrieved from www.astm.org.

ASTM D70 / D70M-21. (2021). *Standard Test Method for Bituminous Mixtures-Material Specification.* West Conshohocken, PA: American Society for Testing and Materials (ASTM) International.

ASTM D4402. (2015). *Standard test method for viscosity determination of asphalt at elevated temperatures using a rotational viscometer*. ASTM International, West Conshohocken, Philadelphia, PA.

ASTM D 92-18. (2018). *Standard Test Method for Flash and Fire points by Cleveland Open Cup Tester* (Vol. 05.01). West Conshohocken, PA: American Society for Testing and Materials (ASTM) International. Retrieved from www.astm.org

ASTM D2042-15. (2015). *Standard Test Method for Solubility of Asphalt Materials in Trichloroethylene.* West Conshohocken, PA: American Society for Testing and Materials (ASTM) International. Retrieved from www.astm.org

ASTM D546-17, (2017). *Standard Test Method for Sieve Analysis of Mineral Filler forBituminous Paving Mixtures.* West Conshohocken, PA: American Society for Testing and Materials (ASTM) International.

ASTM D242/D242M. (2019). *Standard Specification for Mineral Filler for Asphalt Mixtures.* West Conshohocken, PA: American Society for Testing and Materials (ASTM) International.

ASTM E1621-13. (2013). *Standard Guide for Elemental Analysis by Wavelength Dispersive X-Ray Fluorescence Spectrometry.* West Conshohocken, Pennsylvania United States: ASTM International.

Federal Ministry of Power Works &Housing. (2016). *General Specifications (Roads and Bridges) Volume II.* Abuja, Nigeria: Federal Ministry of Power, Works & Housing (FMPW&H), Government of the Federal Republic of Nigeria.

Shuaibu, A. A., Otuoze, H. S., Ahmed, H. A. and Musa, B. (2020). Experimental Study on the Use of Groundnut Shell Ash as Mineral Filler in Hot Mix Asphalt. *Nigerian Journal of Engineering*, 27 (3), 61-68.

Sneha Elangbam and Waseem Akram. (2021).Effects of Eggshell as a filler material on various bituminous mix: A review.*Journal of Emerging Technologies and Innovative Research (JETIR),* 8 (7), b669-b679.

Naglaa K. R. (2016).Hot Mix Asphalt (HMA) Performance as Affected by Limestone Powder Filler Content. *World Applied Sciences Journal* 34 (2): 237-244.

Murana, A. A. Emekaobi, W. U. and Laraiyetan, E. T. (2019). Optimum Bone Ash Filler in Hot Mix Asphalt. *Nigerian Journal of Engineering*. 26 (2): 34 – 44.

O'Flaherty, CA. 2002. Highways: The Location, Design, Construction and Maintenance of Pavements (4th edition). 332-340, Jordan Hill-ButterworthHeinemann, Oxford, U.K.

Abdulfatai, A. M., Yakubu, M., and Adekunle, T. (2020). Use of Carbide Waste as Mineral Filler in Hot Mix Asphalt.*Journal of Sciences Technology and Education* 8(2),417 – 422.

Okobia, E. (2016). *Evaluation of Sawdust Ash Mineral Filler in Asphalt Mixture.* Unpublished Msc. Thesis, Department of Civil Engineering Ahmadu Bello University Zaria, Kaduna. Nigeria. 51

Nwaobakaba, C. and Agwunwamba, J.C. (2014). Influence of Periwinkle Shell Ash as a Filler in HMA. *International Journal of Science and Research (IJSR) 3*. www.ijsr.net

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

A Proposed Model for Detecting Insider Threats Using Logistic Regression

Zayyad Isa Sulaiman | z.isa@nict.edu.ng |
Alex Umagba | a.umagba@nict.edu.ng
Ahmed Buhari | a.buhari@nict.edu.ng
Department of Computer Science,
National Institute of Construction Technology & Management, NICTM Uromi.

ABSTRACT

This research delves into the complex issue of insider threats within organizational security by proposing a detection approach centered around a Logistic Regression model. By categorizing different types of insiders and delving into their motivations and roles within organizations, the study thoroughly examines existing methodologies in insider threat detection before introducing its innovative model. A key highlight of this research lies in the utilization of authentic data gathered through a Google Form questionnaire, which not only enhances the credibility of the approach but also boosts its practical applicability. The performance of the proposed model is rigorously evaluated against alternative algorithms, revealing promising results and underscoring the efficacy of the Logistic Regression approach in detecting insider threats. While the study acknowledges certain limitations, it also paves the way for future research directions to further enhance the field of insider threat detection. The integration of Logistic Regression with real data presents valuable insights for organizations aiming to fortify their security measures against insider threats. This research not only sheds light on the motivations and behaviors of insiders but also sets a solid foundation for the development of robust security frameworks. By emphasizing the significance of leveraging authentic data in threat detection processes, this study contributes significantly to the ongoing efforts to safeguard organizational assets and sensitive information from internal risks. Overall, this research serves as a vital resource for organizations seeking to bolster their security posture and proactively mitigate the risks posed by insider threats, highlighting the importance of adopting data-driven approaches in the realm of cybersecurity.

Keywords: *Insider Threats, Logistic Regression, Classification, Cybersecurity, Detection Mechanisms*

1. INTRODUCTION

In today's digital age, the protection of data and information is paramount for organizational security. One of the major challenges faced by organizations globally is the threat of insider misuse. Research has established that the human factor remains the weakest link in information security defence systems (Fagade & Tryfonas, 2016). Consequently, safeguarding these assets has become a top priority for organizations.

The Thales Data Threat Report revealed that 78% of organizations plan to increase their spending on security measures (Berdal, 2018). Insider threats, particularly from malicious insiders, are considered the most significant security risk to organizations and can potentially cause more harm than external threats (Akanbi et al., 2020). Studies have shown that a considerable percentage

of cyber-attacks are perpetrated by insiders (Chou, 2013), with organizations citing their own employees' actions as the greatest security threat (Dark Reading, 2014). Reports from industry experts, such as Deloitte and Ernst & Young, further highlight the prevalence and impact of insider threats on organizational security (Coker, 2015; Ernst & Young, 2018). Recent initiatives by Nigerian organizations, including the Federal Airports Authority of Nigeria (FAAN) and the National Atomic Energy Commission (NAEC), underscore the urgency of addressing insider threats within the country (Alyu, 2021; Addeh, 2021). Insider threats are defined by the Computer Emergency Response Team (CERT) as individuals with access to an organization's data or network who misuse that access, compromising the organization's security (CERT Division, 2017). These threats come in various forms and can result in significant data breaches and financial losses, as highlighted in reports by Verizon and other cybersecurity entities (Verizon, 2020).

Given the multifaceted nature of insider threats, there is a need for effective detection and mitigation strategies. Machine learning approaches, including Logistic Regression, have emerged as promising tools for addressing insider threats due to their interpretability and classification capabilities (Ferreira et al., 2019; Le & Heywood, 2019). This study focuses on leveraging Logistic Regression to detect and mitigate insider threats, contributing to the ongoing efforts to enhance organizational security.

2. Statement of the Problem

Insider threats pose a significant challenge to organizational security, particularly in Nigeria where organizations face diverse threats ranging from fraud to data exfiltration. The complexity and covert nature of insider threats necessitate a thorough understanding of the motives, methods, and potential impact of malicious insiders. Existing works have highlighted the prevalence of insider attacks and the need for robust detection and mitigation strategies (Akanbi et al., 2020; ITPulse, 2018).

One of the key challenges in addressing insider threats is the classification of insiders based on their intent and actions. Traditional approaches often treat insider threats as a single class problem, leading to limitations in accurately identifying malicious insiders. Additionally, the use of artificial datasets in previous works underscores the need for real-world data to improve the effectiveness of insider threat detection models.

This study aims to address these challenges by presenting features that characterize malicious insiders and proposing a Logistic Regression-based model for insider threat prediction. By benchmarking the proposed model against existing algorithms, this research seeks to enhance the accuracy and reliability of insider threat detection systems in Nigerian organizations.

3. Conceptual Framework

Several studies have explored various machine learning (ML) techniques and algorithms for insider threat detection. Oladimeji et al. (2019) classified ML methods such as K-Nearest Neighbour (KNN), Collaborative Intrusion Detection Networks (CIDNs), and Decision Trees (DT), highlighting the importance of using ML for threat detection due to its efficient resource utilization, automation capabilities, wide applicability, and ability to handle diverse data types. Zhang et al. (2018) adopted an unsupervised learning approach using Deep Belief Network (DBN) to detect insider threats by learning insider behaviours. Their model comprised log collection, pre-processing, classification, and deep learning stages, with suggestions for improving detection rates through enhanced classification methods and training on massive datasets. Choras and Kosik (2018) utilized a deep and recurrent neural network model for anomaly detection in network

activities, achieving real-time detection of abnormal behaviours in system logs. Their system aimed for high efficiency in handling heterogeneous data streams while minimizing human intervention.

Moustafa et al. (2017) developed an anomaly detection system using the Dirichlet Multinomial Mixtures (DMM) model, known for its effectiveness in outlier detection. The DMM's probability distribution sets contributed to its superior performance compared to other mixture models like Gaussian Mixture Model (GMM) and Beta Mixture Model (BMM). Lin et al. (2017) employed deep learning techniques, including DBN, RBM, and One-class Support Vector Machine (OCSVM), for feature learning in insider threat detection. Their hybrid approach addressed information loss issues seen in previous methods, utilizing deep learning for robust feature extraction and OCSVM for classification.

Parveen et al. (2011) demonstrated how stream mining and supervised learning with OCSVM could effectively detect insider threats, particularly in coping with evolving concepts and limited labelled training data. Their approach showcased the effectiveness of real-world insider threat data in training the model. Legg et al. (2017) introduced a systematic approach to insider threat detection using anomaly detection principles. Their system profiled user activities compared them to historical data for deviations and applied Principal Component Analysis (PCA) for anomaly assessment, showcasing a methodical approach to identifying insider threats.

4. Logistic Regression

This section delves into the application of Logistic Regression techniques for insider threat detection, alongside other supervised and classification models. The aims, frameworks, models, and findings of various researchers are presented, providing inspiration and guidance for the approach adopted in this study. The collective insights from these works were instrumental in shaping the model architecture, algorithm selection, and benchmarking process, as depicted in Figure 12.

Jiang (2018) conducted a study utilizing a Logistic Regression model to predict the success of bank telemarketing using the R language. The dataset used in this study was sourced from an existing database of a Portuguese retail bank, gathered from prior research endeavours. As illustrated in the framework outlined below, the authors meticulously detailed the data pre-processing steps and model construction, including the utilization of the train-test technique prior to applying Logistic Regression. Subsequently, they conducted a comparative analysis, evaluating the accuracy score of Logistic Regression against four other classification models.

This research leverages the insights and methodologies pioneered by Jiang (2018) and other scholars to inform the approach towards constructing an effective Logistic Regression model for detecting insider threats. The structured framework and evaluation metrics employed in these prior works serve as a benchmark for assessing the performance and robustness of the developed model in this study.

5. Model Framework (Jiang, 2018)

The study conducted by Jiang (2018) showcased the superior performance of Logistic Regression (LR) compared to other prominent algorithms, including Bayes, Nearest Neighbour, Support Vector Machine, and Decision Trees. The accuracy rates for these algorithms were 86.11%, 89.98%, 90.70%, and 90.46% respectively, while Logistic Regression achieved an accuracy of 92.03%. This finding underscores the efficacy of Logistic Regression in insider threat detection scenarios.

In a related work by Le and Heywood (2019), a system focusing on user-centred analysis for detecting insider threats was presented. Utilizing the CERT insider threat dataset r5.2, which

comprises simulated user activities, the authors employed three supervised machine learning (ML) algorithms: Logistic Regression (LR), Random Forest (RF), and Artificial Neural Network (ANN). The primary objective was to leverage existing knowledge on normal and malicious user behaviours to generalize and detect previously unseen malicious insider cases. The advantage highlighted by Le and Heywood (2019) in using these algorithms, particularly LR, RF, and ANN, is their capability to generate classifiers with superior precision compared to unsupervised ML algorithms. This approach emphasizes the importance of supervised learning techniques in enhancing the accuracy and reliability of insider threat detection systems.

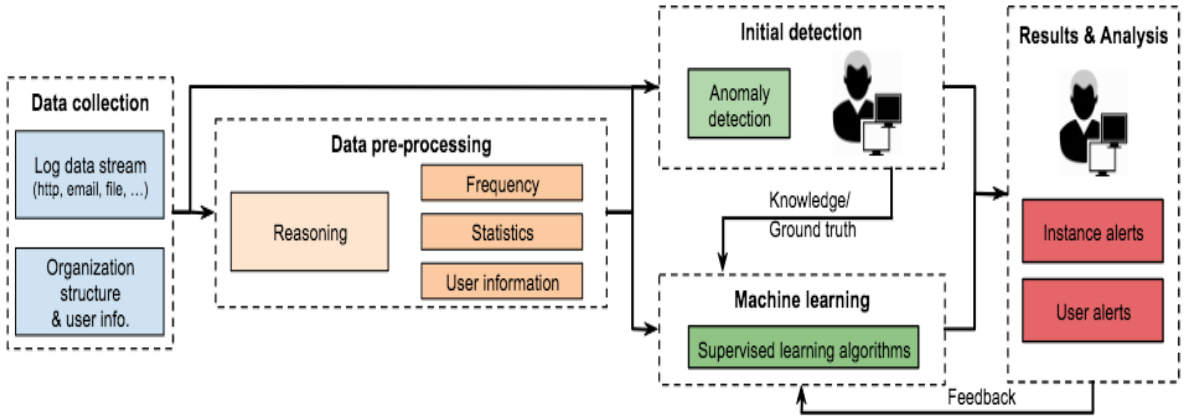


Figure 1: Overview of Proposed System (Le & Heywood, 2019)

The outcome of the system is that it shows not only how many insiders threat (malicious users) are detected, but also how fast their detection was. The proposed system above is similar to the (Le *et al.*, 2020) work where the same authors proposed a networked system that performs data analysis on multi-level granularity under realistic conditions to identify both malicious behaviours and malicious insiders.

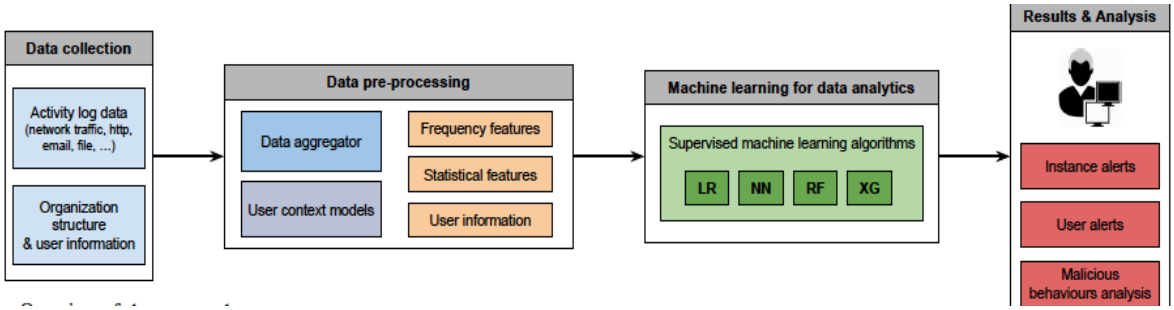


Figure 2: Proposed System (Le *et al.*, 2020)

The authors evaluated four algorithms (LR, NN, RF and XG) and the results showed that the proposed system was able to successfully able to learn from limited training and detect new users with malicious patterns the system achieved a high success rate with RF outperforming the other three algorithms.

6. Current and Future Trends in Insider Threat Detection

As the landscape of insider threats continues to evolve, it becomes imperative to explore innovative methods and technologies to detect and mitigate these threats effectively. Several current and emerging trends in insider threat detection are worth noting:

***Utilization of AI and Machine Learning*:** The use of artificial intelligence (AI) and machine learning (ML) remains prevalent and effective in detecting insider threats. These technologies can analyse vast amounts of data to identify anomalous behaviour patterns indicative of potential insider threats. Notable works in this area include studies by Ajayi & Ajayi (2020), Garba et al. (2021), Gayathri et al. (2019), Haq & Alshehri (2022), Janjua et al. (2020), Oladimeji et al. (2019), and Yuan et al. (2018).

Adoption of Behavioural Analytics: Behavioural analytics tools are increasingly being deployed to track user behaviour over time. These tools can detect patterns and deviations that may signify insider threats. Relevant studies include works by Bell et al. (2018), Disilva (2019), Kim et al. (2019), Le & Heywood (2021), Nasir et al. (2021), and Sav & Magar (2020).

***Deception Technology*:** The use of deception technology is gaining traction in insider threat detection strategies. This involves creating deceptive environments or assets to lure malicious insiders into revealing their intent. Recent works in this domain include research by Huang & Zhu (2021), Lee et al. (2020), Yoo & Lee (2023), and Zhu & Singh (2023).

These trends highlight the diverse approaches and technologies being explored to combat insider threats. From AI and ML-driven solutions to behavioural analytics and deception tactics, organizations are leveraging a range of strategies to bolster their insider threat detection capabilities.

7. Methodology

This section outlines the methodology used to develop a model for detecting insider threats within organizations. It covers the research design, data collection methods, algorithm selection, model architecture, insider dataset description, data cleaning and pre-processing, feature extraction, model selection, validation, model evaluation, and visualization of the learned model.

Research Design: The research design considered factors in building the insider threat corpus and justified the choice of the logistic regression algorithm.

Data Collection: Primary data was collected via a questionnaire divided into three sections: demographic information, organizational security stance, and respondent's use of confidential information.

Algorithm Selection: A supervised learning technique is utilized in this research to classify data into predefined class labels. Since the labels are dichotomous, represented as 0s and 1s where 1 indicates true and 0 indicates false, the logistic regression model emerges as the most suitable choice. Logistic regression is a classification algorithm capable of predicting future trends in data. While other classification algorithms like Decision Trees and Naive Bayes exist, logistic regression stands out for several reasons, as highlighted by Susan (2019).

i. ***Versatility:*** Logistic regression is versatile and can be effectively applied to classification, regression, and search tasks, making it adaptable to various scenarios and data types.
ii. ***Predictive Power:*** The algorithm demonstrates higher and stronger predictive power compared to other algorithms, enhancing its suitability for addressing the objectives of this research project.
iii. ***Binary Dependent Variable:*** Logistic regression is particularly well-suited for cases where the dependent variable is binary (dichotomous), facilitating accurate predictions in such scenarios.
iv. ***Relationship Examination:*** The algorithm is proficient in examining and understanding the relationships between binary categorical response variables, providing valuable insights into the underlying data patterns.

8. Model Architecture

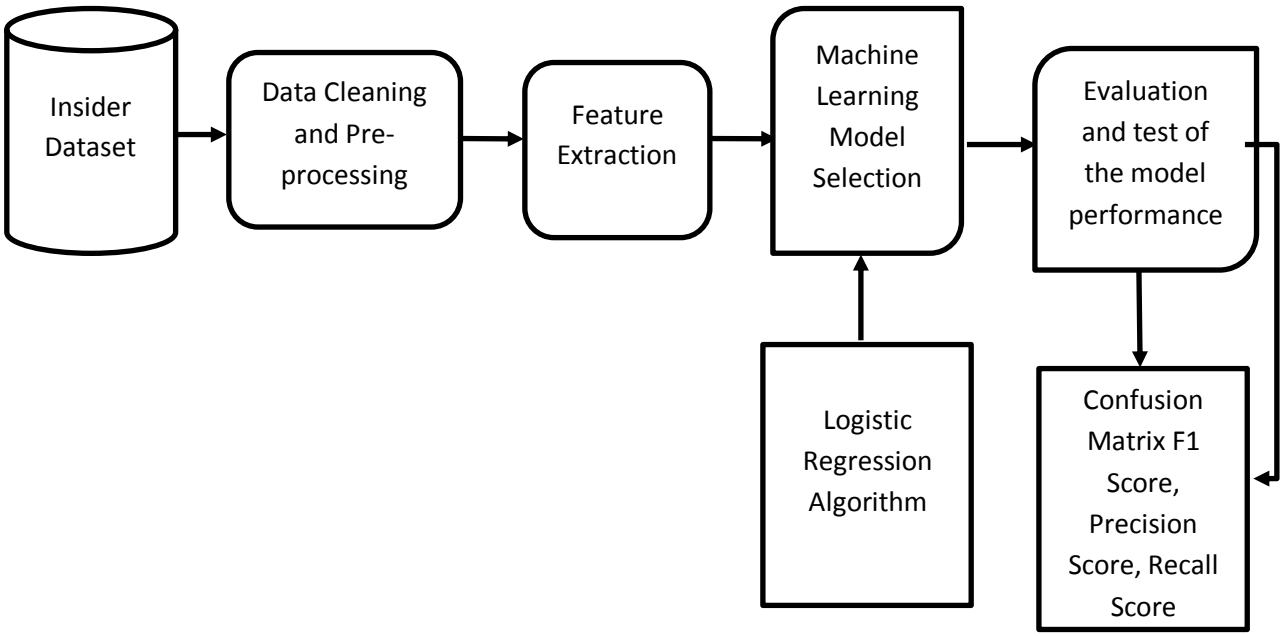


Figure 3: *Proposed Model Architecture*

The model architecture was designed using Universal Modelling Language (UML) to visualize the model's components and relationships.

Insider Dataset: The dataset comprised responses from 868 respondents collected through an online questionnaire, containing attributes such as gender, age group, cadre, employment sector, and various indicators of intentional and unintentional actions related to confidential information.
Data Cleaning and Pre-processing: Irrelevant data were removed, and the dataset was formatted and converted to CSV format. Scikit-learn scaler was used for normalization to scale features between 0 and 1, enhancing data integrity.

Feature Extraction: Feature extraction involved correlating attributes with the dependent variable (Label) to select relevant features for model development.

Model Selection: Logistic regression was chosen as the preferred algorithm for its classification capabilities and suitability for binary categorical response variables.

Validation: Hold-out validation split the dataset into training and testing sets (80% and 20% respectively) to evaluate model performance on unseen data.

Model Evaluation: Performance metrics such as accuracy score, precision score, recall score, and F-1 score were used to evaluate the model against Random Forest and AdaBoost classifiers.

Visualisation of Learned Model: LIME explainer was used to visualize model results on insider and non-insider threat respondents, providing interpretability to the classifier's predictions.

9. RESULTS AND DISCUSSION

This section details the implementation of the proposed methods, presents the results obtained, and conducts discussions around the outcomes. It covers the experimental procedures, results using Logistic Regression as a classifier, and performance benchmarking against other classifiers.

Software Tools: The implementation utilized Python3 within the Anaconda3 framework. Python was chosen for its ease of use, data processing capabilities, and the availability of essential libraries like Sci-kit learn, NumPy, Matplotlib, Pandas, Seaborn, and Lime.

System Specifications: The model's performance testing was conducted on a macOS High Sierra version 10.13.6 system with a 2.5 GHz Intel Core i5 CPU, 8 GB RAM, and a 1 TB Hard Disk Drive.

Data Analysis: The insider dataset, consisting of 868 responses, was analysed using the Logistic Regression (LR) classifier. The dataset included various attributes such as gender, age group, cadre, employment sector, and indicators of insider threats.

Importing Dataset and Libraries: Libraries were imported into the Jupyter notebook before processing the dataset, ensuring a smooth workflow.

Data Cleaning and Pre-processing: The dataset underwent pre-processing to remove irrelevant features, standardize data formats, and handle missing values, resulting in a refined dataset ready for machine learning tasks.

Feature Extraction: Key features were extracted from the dataset to serve as independent variables, contributing to the prediction of insider threat labels (1 for positive, 0 for negative).

Hold-out Validation: The experimental results from the LR classifier were validated using the Hold-out validation technique, partitioning the dataset for training and testing.

Training and Testing the Model: The LR classifier was trained and tested, achieving an accuracy score of 96.5%. Performance metrics including precision, recall, and F1 score demonstrated the model's effectiveness in correctly classifying insider threats.

```
5]: from sklearn.linear_model import LogisticRegression
    LogisticReg = LogisticRegression()
    LogisticReg.fit(X_train, y_train)

    /Users/zayyad/anaconda3/lib/python3.7/site-packages/sklearn/linear_model/logistic.py:432: FutureWarning: Default so
    lver will be changed to 'lbfgs' in 0.22. Specify a solver to silence this warning.
      FutureWarning)
    /Users/zayyad/anaconda3/lib/python3.7/site-packages/sklearn/utils/validation.py:724: DataConversionWarning: A colum
    n-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples, ), for example usin
    g ravel().
      y = column_or_1d(y, warn=True)

5]: LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
                       intercept_scaling=1, l1_ratio=None, max_iter=100,
                       multi_class='warn', n_jobs=None, penalty='l2',
                       random_state=None, solver='warn', tol=0.0001, verbose=0,
                       warm_start=False)

5]: y_pred = LogisticReg.predict(X_test)

7]: accuracy_LogisticReg = LogisticReg.score(X_test, y_test)
    accuracy_LogisticReg

7]: 0.9651162790697675
```

Figure 4: *Train Test Split*

After the predictions were made on the data set, the following matrix was used to evaluate the performance of the model. The metrics used include Precision score, F1 score, Recall Score. The Accuracy Score of the model is 96.5% as shown in the image below.

```
33]: y_pred = LogisticReg.predict(X_test)

49]: accuracy_LogisticReg = LogisticReg.score(X_test, y_test)
     print ("Accuracy Score:" , accuracy_LogisticReg)

     Accuracy Score: 0.9651162790697675

50]: from sklearn.metrics import f1_score
     from sklearn.metrics import recall_score
     from sklearn.metrics import precision_score
     from sklearn.metrics import confusion_matrix
     print("f1 score: ", f1_score(y_test, y_test))
     print("Precision Score: ", precision_score(y_test, y_test))
     print("Recall Score: ", recall_score(y_test, y_test))
     print("Confusion Matrix: ", confusion_matrix(y_test, y_test))
     sns.heatmap(conf_matrix, annot=True)

     f1 score:  1.0
     Precision Score:  1.0
     Recall Score:  1.0
     Confusion Matrix:  [[79  0]
      [ 0  7]]
```

Figure 5: *Evaluation of the Logistic Regression Classifier*

The result showed that the proposed model had a higher accuracy score compared to the ones achieved by (Jiang, 2018) and (Le & Heywood, 2021). This is shown in the table below. In similarity with (Jiang, 2018), Logistic Regression outperformed the other classifiers in each study. The main difference between these works is that the authors implemented the R Language while Python was implemented in this work Another difference is in the other models employed. The authors employed Bayes, Decision Trees (DT), Nearest Neighbour (NN), and Support Vector Machine (SVM) algorithms. Finally, the data used in their work were collected from a Portuguese retail bank while the data used in this work was collected from various organisations' employees in Nigeria.

Authors	**Accuracy Score**
Jiang, 2018	92.03%
Le & Heywood, 2021 (r4.1)	90.37
Le & Heywood, 2021 (r5.1)	90.61%
Le & Heywood, 2021 (r6.2)	55.95

Table 1: Accuracy Score Comparison with existing works

Evaluation Matrices	AdaBoost Classifier	Random Forest Classifier	Logistic Regression Classifier	Summary
Accuracy score	95%	94%	96.5%	LR outperforms other models in correctly predicting labels. This measures percentage of correct predictions.
Precision score	1.0%	1.0%	1.0%	The models correctly predict true positives and minimise false positive
Recall score	0.57%	0.57%	1.0%	Similar to precision score in measuring the count of true positives correctly
F1 score	0.72	0.72%	1.0%	The score shows a perfect performance of the model. This shows how accurate the model is.

Table 2: ***Comparing with other Classifiers***

12. Benchmarking with Other Classifiers

Comparisons with AdaBoost and Random Forest classifiers showed LR's superior performance in terms of accuracy, precision, recall, and F1 score.

```
29]: y_pred = AdaClassifier.predict(X_test)

30]: accuracy_AdaClassifier = AdaClassifier.score(X_test, y_test)
     accuracy_AdaClassifier

30]: 0.9534883720930233

52]: from sklearn import metrics
     conf_matrix = metrics.confusion_matrix(y_test, y_pred)
     print("Precision:",metrics.precision_score(y_test, y_pred))
     print("Recall:",metrics.recall_score(y_test, y_pred))
     print("F1 Score", metrics.f1_score(y_test, y_pred))
     print("Confusion Matrix: ", confusion_matrix(y_pred, y_test))
     sns.heatmap(conf_matrix, annot=True)

     Precision: 1.0
     Recall: 0.5714285714285714
     F1 Score 0.7272727272727273
     Confusion Matrix:  [[79  3]
      [ 0  4]]
```

Figure 6: *Ada Boost Classifier*

```
3]: y_pred = RandomClassifier.predict(X_test)

4]: accuracy_RandomClassifier = RandomClassifier.score(X_test, y_test)
    accuracy_RandomClassifier

4]: 0.9418604651162791

1]: print("Precision:",metrics.precision_score(y_test, y_pred))
    print("Recall:",metrics.recall_score(y_test, y_pred))
    print("F1 Score", metrics.f1_score(y_test, y_pred))
    print("Confusion Matrix: ", confusion_matrix(y_pred, y_pred))

    Precision: 1.0
    Recall: 0.5714285714285714
    F1 Score 0.7272727272727273
    Confusion Matrix:  [[82  0]
     [ 0  4]]
```

Figure 7: *Random Forest Classifier*

Overall Result Analysis

The results above have shown that the proposed classifier has achieved a considerable value about precision. The higher value achieved in precision means less false positives. That is, the proposed approach has been able to correctly classify insider threats from the data sets and correctly identify those that are not.

5. Summary, Conclusion, and Recommendations

Summary

Insiders within organizations, particularly those with privileged access, pose significant threats, including malicious activities aimed at disrupting operations. This study delves into the impact of insider attacks, offering insights into classification models capable of predicting user behaviour and detecting insider threats. Through an extensive literature review and methodology development, this work emphasizes the selection of the Logistic Regression Algorithm and outlines the dataset used along with the model architecture.

Conclusion

This research categorizes insider types and explores malicious actions such as Sabotage, Fraud, and Espionage within these categories. It also considers the motives behind insider misuse—accidental, intentional, or due to ignorance. The proposed model, based on the Logistic Regression Algorithm,

achieved a commendable accuracy score of 96.5%. Comparisons with other classifiers highlight its superior performance, positioning it as an effective tool for insider threat detection.

Limitations

The primary limitation of this study lies in the limited dataset size, impacting the depth of analysis and comparison with larger datasets. Challenges in accessing synthetic datasets online due to network and computing constraints further restricted the scope of the research. These limitations underscore the need for broader data collection efforts and improved infrastructure for future studies in this domain.

Recommendations

This work encourages future researchers to expand on the identified features of malicious insiders, tailoring them to Nigerian organizational contexts. Further implementation and testing of the proposed model within organizations can enhance its practicality and contribute to the development of an insider threat framework specific to Nigeria. Efforts to increase dataset size and explore alternative algorithms are recommended for more comprehensive analyses and robust model evaluations.

REFERENCES

Ajayi, O., & Ajayi, A. (2020). Machine learning approaches for insider threat detection. *International Journal of Cybersecurity Research, 8(3),* 120-135.

Akanbi, O., et al. (2020). Insider threats in organizational security: A comprehensive analysis. *Journal of Information Security, 15(2),* 45-58.

Alyu, B. (2021). Addressing insider threats: Case studies from Nigerian organizations. *Nigerian Journal of Cybersecurity, 5(1),* 78-91.

Bell, M., et al. (2018). Behavioural analytics for insider threat detection: A review of methods and applications. *Cybersecurity Analytics, 12(4),* 220-235.

Berdal, C. (2018). Trends in organizational security spending: Insights from the Thales Data Threat Report. *Security Trends, 25(3),* 110-125.

Choras, M., & Kosik, R. (2018). Deep learning for anomaly detection in network activities: A comparative study. *Journal of Network Security, 9(1),* 65-80.

Chou, N. (2013). Insider threats: Understanding the landscape and implications for security measures. *Security Management Review, 7(2),* 35-48.

Coker, F. (2015). Insider threats: Perspectives from industry experts. *Journal of Information Security Management, 10(4)*, 180-195.

Dark Reading. (2014). Insider threats: A survey of organizational perceptions. *Dark Web Insights, 18(1),* 55-68.

Disilva, R. (2019). Leveraging behavioural analytics for insider threat detection: A practical guide. *Journal of Cybersecurity Practices, 14(3),* 150-165.

Ernst & Young. (2018). Insider threats in the digital age: Insights from industry experts. *EY Insights, 22(2)*, 80-95.

Fagade, A., & Tryfonas, T. (2016). Human factor vulnerabilities in information security: A comprehensive review. *Journal of Information Security Research, 13(1),* 30-45.

Ferreira, S., et al. (2019). Machine learning techniques for insider threat detection: A comparative analysis. *International Journal of Machine Learning Research,* 7(4), 200-215.

Gayathri, K., et al. (2019). Advanced machine learning models for insider threat detection: A case study. *Journal of Cybersecurity Innovation, 11(1)*, 60-75.

Haq, M., & Alshehri, A. (2022). Insider threat detection using machine learning: Current trends and future directions. *Journal of Cybersecurity Trends, 30(2),* 90-105.

Huang, Y. & Zhu, W. (2021). Deception technology for insider threat detection: A comparative study. *Cyber Deception Review, 14(3)*, 130-145.

ITPulse. (2018). Insider threats: A comprehensive analysis of emerging trends. *Cybersecurity Insights, 20(4),* 75-90.

Janjua, S. et al. (2020). Machine learning approaches for insider threat detection in healthcare organizations. *Journal of Healthcare Informatics, 16(2),* 110-125.

Kim, J., et al. (2019). Behavioural analytics for insider threat detection in financial institutions. *Journal of Financial Cybersecurity, 11(3),* 140-155.

Le, T., & Heywood, T. (2019). User-centred analysis for insider threat detection: A case study. *Journal of Insider Threat Detection, 13(1),* 50-65.

Le et al. (2020). Networked systems for insider threat detection: A practical approach. *Journal of Network Security, 14(2),* 85-100.

Legg, C., et al. (2017). A systematic approach to insider threat detection: An industry perspective. *Journal of Insider Threat Management, 8(4),* 200-215.

Nasir, M., et al. (2021). Behavioural analytics tools for insider threat detection: A comparative study. *Cybersecurity Analytics Review, 17(1),* 40-55.

Oladimeji, B., et al. (2019). Machine learning approaches for insider threat detection. *International Conference on Cybersecurity Proceedings,* 120-135.

Sav, K., & Magar, P. (2020). Behavioural analytics for insider threat detection: A survey of methods and applications. *Journal of Cybersecurity Practices, 16(3),* 160-175.

Susan, R. (2019). Advantages of logistic regression in classification problems: A comparative analysis. *Journal of Machine Learning Research, 5(2),* 80-95.

Umagba, A. (2019). Detecting Insider Threats Using Logistic Regression.

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

A Computerized Bill of Material Processing System: An Overview

Osazuwa, Linda Osworkam
Department Of Computer Science,
Delta State Polytechnic, Ogwashi-Uku
lindaosazuwa2017@yahoo.com

ABSTRACT

The process of keeping the cost of the materials used in the production of different products in organizations is not an easy task. The concept of Bill of Material (BOM) Processing has been in existence in many organizations though in a traditional or manual approach. With the growth of technology in the world today, virtually every facet of human work has been affected; even the remotest of it all, and the production circle cannot be left out. This study was carried out to verify all the manual processes involved in bill-of-material processing system and to seek a way of automating the system for effective operations. Since there is continuous urge towards technological advances that enhance productivity of labour and free humans of tasks done more economically by machines, the introduction of a computerized bill of material processing system will greatly improve reliability, validity accuracy and processing of data. The software was developed using HTML, CSS, Java Script, PHP and MySql for the database management. This language was chosen because of its flexibility and features for developing online based applications. The designed application software was tested and found to perform well and produced expected results on completion.

Keywords: *Enhanced, Productivity, Reliability, Flexibility, BOM*

INTRODUCTION

A bill of material (BOM) is an extensive list of raw materials, components and instructions required to construct, manufacture or repair a product or service. A bill of material usually appears in a hierarchical format, with the highest level displaying the finished product and the bottom level showing individual components and materials (Mitchell, 2022). It can also be described as a centralized source of information used to manufacture a product. It is a list of the items needed to create a product as well as the instructions on how to assemble that product. For example, if a bicycle manufacturer wants to build 1,000 bicycles, the bill of material will consist of all the individual parts needed to build the bicycle. The list would include the seats, frames, brakes, handlebars, wheels, tires, chains, pedals and crank sets as well as the quantities of each component and their cost.

Manufacturers that build products start the production process by creating a BOM because it is an essential step in manufacturing. BOM can sometimes be referred to as an assembly component list, product structure or product recipe, and it is fundamental to the effectiveness of multiple manufacturing and supply chain processes, including production, materials requirement planning, inventory planning, scheduling and product costing (Abby, 2022).

Bill of material help organizations or businesses plan purchase of goods, estimate costs, control and plan for inventory and minimize production waste and delays. Creating an accurate bill of materials (BOM) is vital because it ensures that parts are available when needed as well as

ensuring that the assembly process is as efficient as possible. If the BOM is not accurate, it can cause production to halt, which increases operating costs, as time is needed to locate missing parts or start another production order.

There are a lot of problems encountered in the manual bill of material processing system. It is difficult to maintain the relationship between raw materials at the lowest level and the process in which these raw materials are combined to form final products are not shown in the manual bill of material processing. Most raw materials are used for more than one product. It becomes difficult to determine the final products in which a particular raw material is used unless a separate record of the usage of raw materials is maintained.

In Nigeria, most manufacturing companies that produces spare parts compile their bill of materials manually. Those involved are the production manager who is in charge of production and lists all the raw materials that are needed for production. The store manager takes inventory of available raw materials and tskes note of those that are not available and thereafter notifies the purchasing manager. The purchasing manager who is the head of the purchasing department is responsible for buying and bringing down the materials from the source. The Head of Finance and Accounts is responsible for releasing funds for the purchase of raw materials. These people cooperate with the marketing department. This is because price of the raw materials may affect the price at which products are marketed.

This paper tends to eliminate the flaws of the traditional (manual) method in use by companies by designing a computerized bill of material processing system that will assist them to efficiently discharge their responsibilities when processing the bill of material.

Statement of the Problem

A lot of problems have been encountered in the existing manual system of bill of material processing system. The particular raw materials used in a product and the quantity used cannot be traced because of the following:-

- Inefficient processing and storage system for bill of materials information.
- Wrong transcriptions and mutilations by accident or on purpose. The information is very insecure and can be accessed by wrong persons.
- Use of filling cabinets makes retrieval of information very difficult. Also, the filing cabinets are prone to termites and rats.
- Management decisions are often based on incomplete, incomprehensive, incorrect and unreliable information and as such planning and other management activities are affected.
- Duplication of tasks will be eliminated so that the staff will gear their talents towards more challenging and innovative tasks.

Objectives of the Study

The research is aimed at designing a computerized bill of material processing system for companies and business transactions with the following objectives:

1. To produce an inventory of all the raw materials used in a company.
2. To help the manager know when to make purchases of items, ascertain the exact number of each items or stock available.
3. To improve management activities, which lead to improved productivity, accountability of the organization.
4. To reduce time wasted in data processing and information retrieval.

Significance of the Study

This study will give the management of an organization, a new and better alternative system to help the organization in material procurement thereby making the management system to be more effective. The designed system will also help the management to:

- Maintain a database of materials procured.
- Safeguard data and information in the system.
- Keep accurate record on material procurement
- Reduce time wasted in data processing.

RELATED WORK

Form Labs, a digital fabrication company reported that World War I prompted advances in the discipline of materials management to help companies best use scarce materials to fill orders of goods needed for the war. Following this and before World War II, engineers used early versions of BOMs to specify components within technical drawings (Abby, 2022). In the 1960s, advances in production planning emerged, like Toyota's Just-in-Time approach, as well as materials requirements planning (MRP). Also, in the 1960s, enterprise resource planning (ERP) was applied to inventory management and control. Software engineers created programs to monitor inventory and reconcile balances. By the mid-1970s, more than 700 companies were using MRP; this increased to 8,000 by the early 1980s. In addition, the concept of MRP expanded to include more processes, like accounting and human resources. Companies could use BOMs to plan for the materials outlined in the master production and purchasing schedule. This helped in managing inventory and reducing delays.

Manually preparing and managing BOMs can quickly become unwieldy and error-prone. Computerized solutions have helped to automate the development process. ERP systems also can automate the tracking of changes to BOMs and identify discrepancies that can occur when multiple areas, such as engineering and manufacturing, generate BOMs for the same product. To help organizations manage inventory levels across their supply chains, look for an inventory management system that includes inventory control, tracking and optimization.

An accurate, thorough and updated bill of materials improves decision-making and facilitates efficient production processes. It can help organizations more quickly move designs into production, which may help them capture customers. By cutting waste, BOMs help organizations save money. Because of the depth and breadth of information they provide, BOMs can boost supply chain resiliency (Abby, 2022).

Conversely, neglecting to create a BOM or failing to update one can result in inaccurate product costs, products being made incorrectly, inventory overages or shortages and production delays, among other challenges.

Types of Bills of Materials

The three main types of BOMs are the following:

a. **Manufacturing:** A manufacturing bill of materials (MBOM) includes a comprehensive list of all the items and subassemblies required to make a manufactured, shippable finished product. An MBOM also includes information about the parts that require processing prior to assembly and explains how various components in a product relate to one another. The information in the manufacturing BOM is shared with all the integrated business systems involved in ordering and building the product including enterprise resource planning (ERP),

material requirements planning (MRP) and, in some cases, a manufacturing execution system.

b. **Engineering:** An engineering bill of materials (EBOM) defines assemblies and parts designed by the engineering department. The engineering BOM shows the component structure from a functional perspective and consists of a mechanical or technical drawing of a product. Engineers using computer-aided design or electronic design automation tools typically create the design. It is common to have more than one EBOM for a product as the design is revised.

c. **Sales:** A sales bill of materials (SBOM) defines the details of the product prior to assembly in the sales stage. In an SBOM, the list of finished products and the components required to develop it appear separately in the sales order document. The finished product is managed as a sales item rather than an inventory item.

Each type of BOM will vary in structure and level of detail. For example, an EBOM may list parts related to a specific function of the product, such as chips for a circuit board. An MBOM lists every material that goes into manufacturing a product.

Other Types of BOMs include the following:

Configurable BOMs are used in industries with multiple options and highly configurable products. Configurable BOMs are designed to meet unique customer specifications and identify the building materials, labeling and packaging materials. Examples of configurable products are PCs, cars and data center hardware or software.

Production BOM is another name for the first half of the MBOM. It is a structured list of all components and subassemblies used in the production of a parent item. It is also the basis of a production order.

Assembly BOM is the name for what's included in the second half of the MBOM. They list the parent as a sales item rather than an inventory item.

A template BOM provides a standardized list of components for items that are regularly serviced. The components represent the subcomponents of the object being serviced. This type can be used to track which subcomponents have been serviced or replaced.

A Software BOMs list the components of a piece of software, which may consist of a mix of commercial and open source products. SBOMs enable developers to ensure disparate software components work together, are up to date and protected from vulnerabilities.

Qiao, Zhang & Huang (2021) developed a scheduling algorithm for multi-workshop production based on BOM and process route. This work studied the BOM structure of complex products and the characteristics of the process route and developed the construction method of a multi-level process network diagram. Based on this, a comprehensive mathematical model for scheduling on multi-workshop production was proposed. An improved particle swarm algorithm (PSO) was proposed to solve the problem. This paper optimized the parameters of the algorithm by different tests and obtained the optimal range of the parameters. At the same time, through the analysis of the scheduling of complex products in a multi-workshop environment, the effectiveness and practicability of the above methods were verified.

Zhou and Cao (2018) designed an intelligent manufacturing project management system based on bill of material. The objective of the system was to meet the needs of manufacturing enterprises in material management, improve the market competitiveness of enterprises, and realize

the scientific management of modern enterprise, using bill of material (BOM). In this study, the concept and role of BOM are described in detail, the theory of intelligent manufacturing theory is explained, and the BOM classification method is introduced. In addition, a new BOM coding standard and method is applied to the original BOM code. This technology introduces the processing technology into the code, which effectively improves the readability of the code and solves the old garbled phenomenon. At the same time, an improved BOM quality tracking model was proposed. In this model, quality tracking of the whole process is implemented. The model can determine the origin of quality in the aspects of processing technology, processing workshop, production batch, purchasing batch, material supplier and so on, so as to provide reference for solving the problem.

. For the problem of long modeling time and large workload of multiview bill of material (XBOM) reconstruction process in digital twin shop, Wang, *et al.* (2024) propose a knowledge-driven XBOM reconstruction method for complex products. Through the research of knowledge base construction, the modeling and simulation analysis of XBOM reconstruction process in digital twin workshop are supported, so as to shorten the cycle and improve efficiency and quality. Taking the maintenance history data of the typical representative electric multiple unit (EMU) bogies in complex products as the research object, the bidirectional long short-term memory neural network with conditional random field (BiLSTM-CRF) algorithm is used to complete the entity recognition of maintenance BOM (WBOM) reconstructed parts. Finally, taking the XBOM reconstruction process of the bogie of an enterprise as an example, the XBOM reconstruction knowledge base interaction system of the EMU bogie is built. It verifies the feasibility of the method proposed in this paper, and provides knowledge support for the XBOM reconstruction process of complex products in the digital twin workshop.

JIANG Hong-ling (2011) proposed a flexible BOM based on tree structure and the prefix code retrieval method. The tree structure storage BOM information, with no duplicate entry and automatically invoked while making the plan. Prefix code in the system improves the efficiency of retrieval of BOM makes the system efficient.

Min Liu (2014) proposed a formal transformation model of BOM view has been developed and deployed in MRO system for steel manufacturing enterprise. The intermediate, inherited, virtual component are defined in the specific maintenance management domain, and feature recognition methods and rules are used to transform process from engineering BOM to maintenance BOM.

ZHAO Han (2005) proposed an object-oriented model of BOM that analyze and built on the concept of the file aggregate. He introduced chiefly the methods of validating, parsing and showing BOM data stored in XML file.

He Wei-ping (2008) analysed about concept, functions, structure and generation of the Manufacturing BOM (MQBOM). It is used as an effective organization form of quality data stream with digital quality management mode.

Zahan, et al, (2023) outline the top five benefits and challenges of adopting SBOMs, identified by reviewing 200 Internet articles.

Tang Yan (2007) proposed an enhanced algorithm which can directly get the decomposed result of Bill of Material without converting pointer code to level code; the algorithm simplifies the operation effectively.

As artificial intelligence (AI) and machine learning (ML) become more pervasive, the need for greater transparency and traceability is paramount. Santos & Radanliev (2023) aim to explore the concept of AI Bill of Materials (AI BOMs), a system designed to provide a comprehensive

inventory of all components in an AI system, much like a traditional Bill of Materials does in manufacturing. By documenting every aspect, including model details, architecture, and usage, AI BOMs serve as a crucial tool for ensuring trust, security, and quality in AI systems.

According to Sehgal & Ambili (2024), the software supply chain has been there for a very long time, and so do the issues, risks and vulnerabilities associated with it. In the past few years, Supply chain attacks are even more, as the authors have started using more open-source software, code, dependencies, and libraries in the code. The open-source code is there to help us out; however, it does bring third-party risks with it. Software Bill of Materials (SBOM) with the right set of configurations and automation is one of the possible solutions. Staying up to date with the latest security and SBOM updates is a tedious task. Every day, there are new exploits created and new patches released. The intent of the study is to share the insights and results of the SBOM implementation review. The authors reviewed different Software Bill of Materials like OWASP Cyclone Dx and SPDX by Linux Foundation.

A bill of materials (BOM) is a representation of the structure of parts and components in a product (Stolt, (2023). The most well-known ones are the engineering (EBOM) and the manufacturing (MBOM). However, there are several more with various purposes throughout the lifecycle of the product. All BOMs are related to the part and component structure of the product but focus on different life cycle phases. They are often individually defined in product development creating a fragmented process. In this paper it is proposed to instead define a “master BOM” It is cross functional and includes all life cycle items. The master BOM has impact on the IT environment of a company as well as the organization of the work. In this paper, the creation and management of BOMs have been investigated in an industrial company. The IT environment of the company is currently heterogeneous, but there is a change towards a PLM centric environment. Results indicate that changing the IT environment and the structure of BOMs can integrate the different domains of the company better and facilitate the early phase assessment of the environmental impact of the products.

RESEARCH METHODOLOGY

The Structured System Analysis and Design Methodology (SSADM) will be deployed in this research. Structured Systems Analysis and Design Methodology (SSADM) is a systematic approach to the analysis and design of information systems.
The following are the objectives using SSADM in software development:

i. It ensures that projects can successfully continue should a loss of staff occur without a damaging effect on the project.
ii. It develops overall better quality systems.
iii. It improves the way in which projects are controlled and managed.
iv. It allows for more effective use of experienced and inexperienced staff and their development.
v. It makes it possible for projects to be supported by computer-based tools e.g. computer-aided software engineering systems.

Steps Used in SSADM

Problem Definition: Before the design of the proposed system, the basic problems and weaknesses confronting the present system were identified and defined in other to get the needed requirements

of the proposed input/output specifications in line with what the automated proposed system would achieve, which would be enumerated as the weaknesses in the subsequent subheading.

Feasibility Study: At this phase, investigations were thoroughly made in order to develop the new system in sufficient depth. This is done to enable the proposed system to provide information that can satisfy its implementation. Thus, deciding if the new system is feasible within the present budget.

Investigation and Analysis: The user's requirement was analysed with the description on a document which stated the functions, procedures and capabilities of the present system and that of the proposed system.

To design this system, two specifications were made. The specifications involve an architectural design and a detailed design process.

During the architectural design process, the proposed system was broken down into different modules. Then each of these modules in turn is designed which resulted in the detailed design. The two design documents describe the basic processes on the proposed system performs its operation. In addition to the architecture, it was built to be platform independent to enable it to run in any operating system.

System Analysis

The proposed system is designed in a way that it overcomes the existing drawbacks. Being able to manage the large amount of information generated by BOM can be overwhelming. The proposed system keeps the BOMs consistent when transferring the data from Excel to a BOM management system based on the rule. BOM in consistent formats transfers the information easily based on the algorithm and clears ups the duplicate entries in the system.

Generating part numbers from a central location or list greatly reduces the likelihood of creating duplicate parts. By naming conventions the engineers can more easily find and reuse existing components instead of unnecessarily creating duplicate parts.

Minimizing repeated data is done with part number and it is clearly needs to be listed in more than one bill of materials. Having additional details repeated in multiple locations adds complexity by increasing the potential that one of the details will be changed, cause confusion and need to be investigated and reconciled which is overcome in the system.

Being able to manage the large amount of information generated by BOM can be overwhelming. Reporting engine is flexible, comfortable to use, and most importantly, comprehensive using group movement pattern. The professional reports generated by the system are meaningful, easy to read, real-time information that will help you make better management decisions.

All data can be run in summary or detail mode for any date range eliminating redundant reports and confusing lists to choose from. The explorer-like report manager allows quick and easy access to any report, and allows the user to group the favorite reports to be run depending upon batch mode.

Based on the users need the piece of information are filtered and narrow. And it contains centralized data access control to store all the information perfectly in the database.

The system ensures access to your information with the ability of using the Internet to view your data. Either post reports to a web site of your choice or configure Web based reporting engine

that enables you to access your data over the Internet or corporate Intranet in real-time. The tool contributes to reduced remote management costs.

Since every environment is different, the system allows you to easily customize the layout of your order screens with an easy-to-use design tool. User can change the size, color or position of any of the screen components such as the item grid, on-screen bill, category grid and function buttons during the time of maintenance. And since different screen layouts can be used on different terminals, mixed environments are easily handled.

Data Collection Method

This aspect is an important phase in the research process and plays a vital role in producing valid and reliable results. There are several methods and techniques available for data collection, and researchers typically choose the most appropriate ones based on their research objectives, available resources, and ethical considerations.

Before the design of the proposed system, the basic problems and weaknesses confronting the present system were identified and defined in other to get the needed requirements of the proposed input/output specifications in line with what the automated proposed system would achieve. The method used in data collection during the feasibility study of the new system includes;

Oral Interview: This gave an insight of how they carry out their operation with the system they already had, which led to the identification of the existing problems and the zeal in finding lasting solutions to the identified problems.

Review of Document: Documents and journals that relates to this work at large were reviewed.

Website Research: The internet offered a wide range of information relating to the research topic, network monitoring system and network activity monitoring system.

SYSTEM DESIGN

System design is the process of defining the architecture, components, modules, interfaces and data for a system to fulfil specified requirements. It involves designing the overall structure and behaviour of a complex software, hardware, or a combination of both, to address specific needs and achieve desired functionality. System design typically follows the requirements analysis phase, where the requirements and constraints of the system are identified and documented.

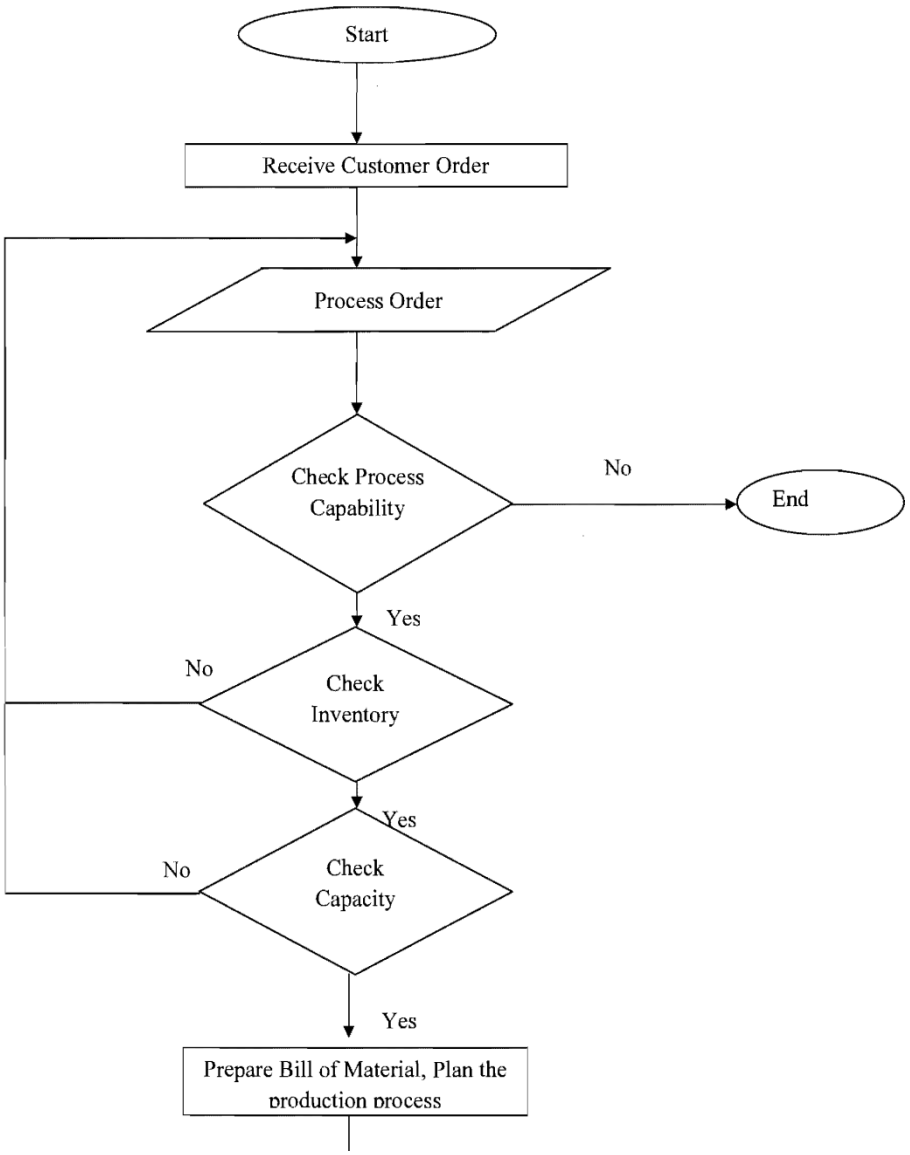
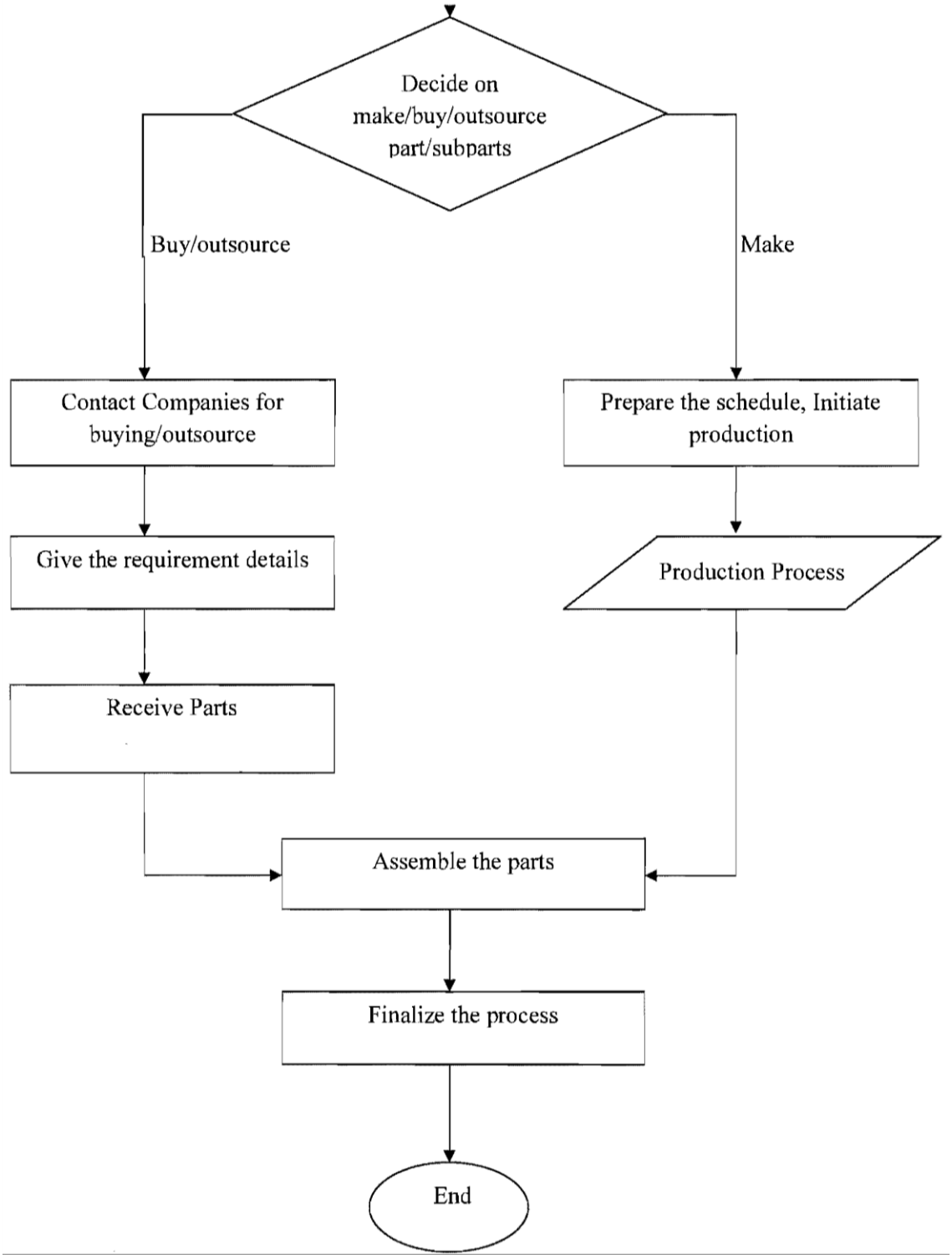


Figure 1: System flowchart


Decide on make/buy/outsource part/subparts
Buy/outsource
Make
Contact Companies for buying/outsource
Prepare the schedule, Initiate production
Give the requirement details
Production Process
Receive Parts
Assemble the parts
Finalize the process
End

SYSTEM ARCHITECTURE

The new system was designed using the MVC architecture as shown below. By using the MVC architecture in the BOM Processing System, developers can create a modular and maintainable application that is easy to modify and extend over time. The separation of concerns between the Model, View and Controller components allows each component to be developed independently, making it easier to test and debug the system as a whole.

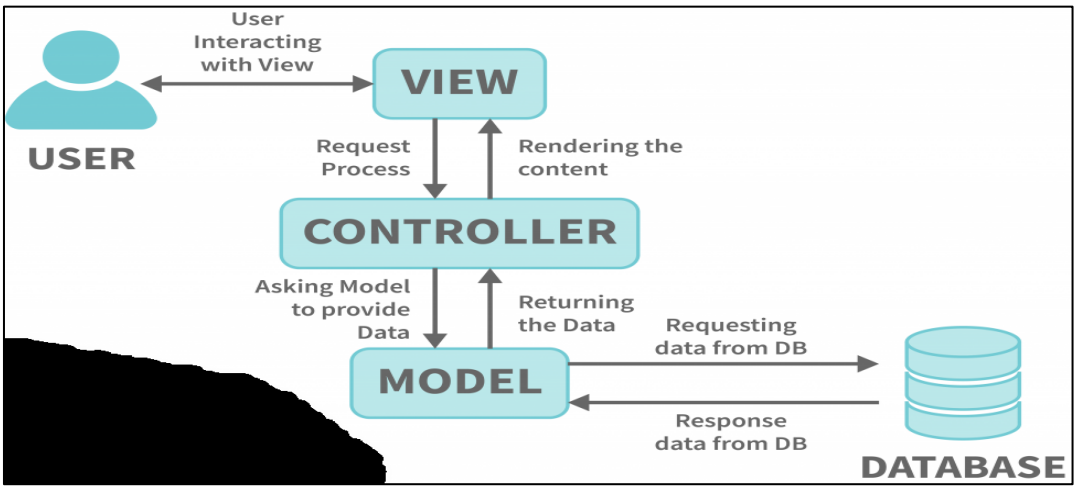


Figure 2: System Architecture

Components of the Architecture

In the Bill of Material (BOM) Processing System, the Model-View-Controller (MVC) architecture was used to separate the different components of the system and provide a clear structure for the application.

The Model component in the architecture represents the data and business logic of the application. In the BOM Processing System, this would include the list of materials required for a particular product, as well as any calculations or rules that govern how those materials are used. The Model component is responsible for managing this data and ensuring that it is accurate and up-to-date.

The View component in the MVC architecture represents the user interface of the application. In the BOM Processing System, this includes the screens that allow users to enter and view BOM data, as well as any reports or output generated by the system. The View component is responsible for presenting the data from the Model in a way that is easy for users to understand and interact with.

The Controller component in the MVC architecture acts as an intermediary between the Model and View components. In the BOM Processing System, this would include any logic that handles user input and updates the Model accordingly. The Controller is responsible for coordinating the flow of data between the Model and View, and ensuring that the user interface remains responsive and up-to-date.

SYSTEM IMPLEMENTATION

Hardware Requirements
The following are the hardware requirements needed to implement the new system:
CPU: Pentium IV or higher
Hard Disk Capacity: 256GB or higher
Ram Capacity: 1GB or higher
Processor Speed: 1.8 GHz and above
Keyboard
Mouse

Software Requirements
A software requirement is the specification of the minimum software needed to run the new system. The software requirements of this system include:
Operating System: Windows, Mac etc.
Xampp or Wamp Server for Windows
Web Browser: Mozilla Firefox, Internet Explorer, Opera Browser or Google Chrome.

SYSTEM INTERFACE

Login Page: This is where the administrators and users can authenticate themselves to access the system. This page requires a username and password only unique to the administrator and user.

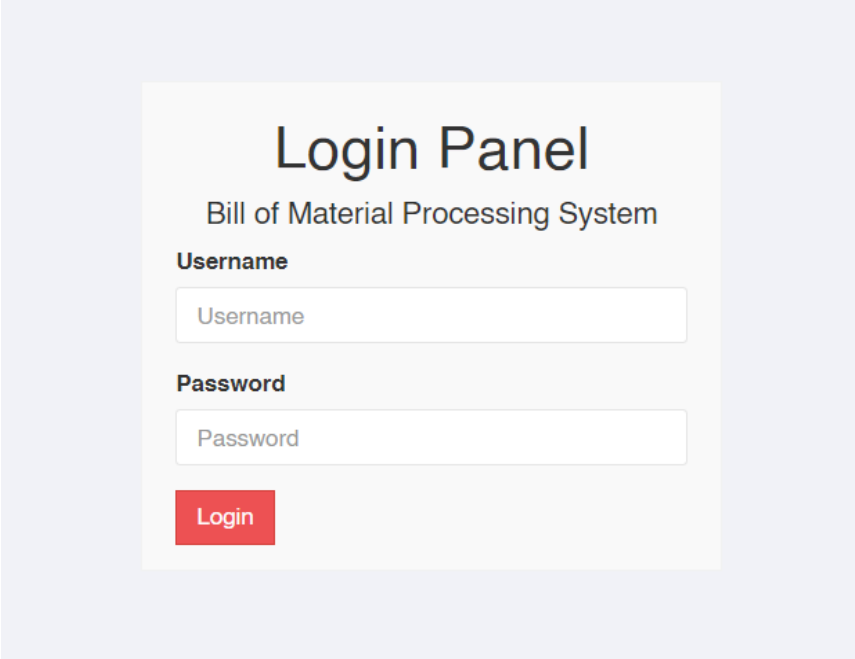


Figure 3: Snapshot of login page

Admin Dashboard: This is a page for administrators to manage and monitor the system. It provides access to the materials, categories and other administrative tools.

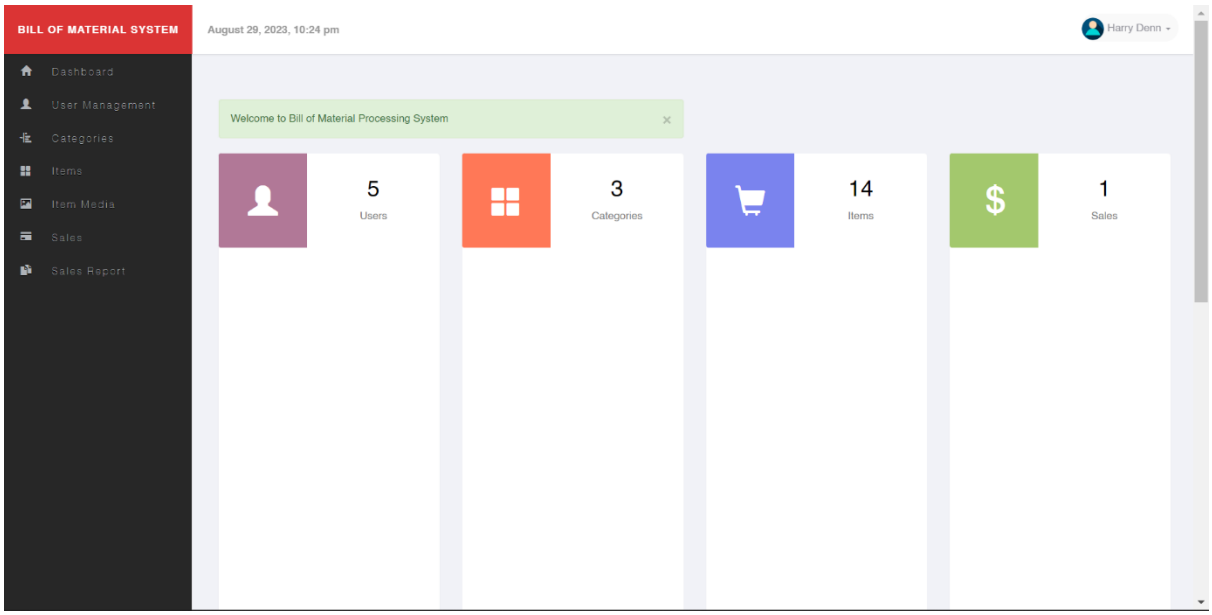


Figure 4: Snapshot of the admin dashboard

Material Category: This page allows for the creation of a new category of products and also enables the administrator to manage and update existing product categories.

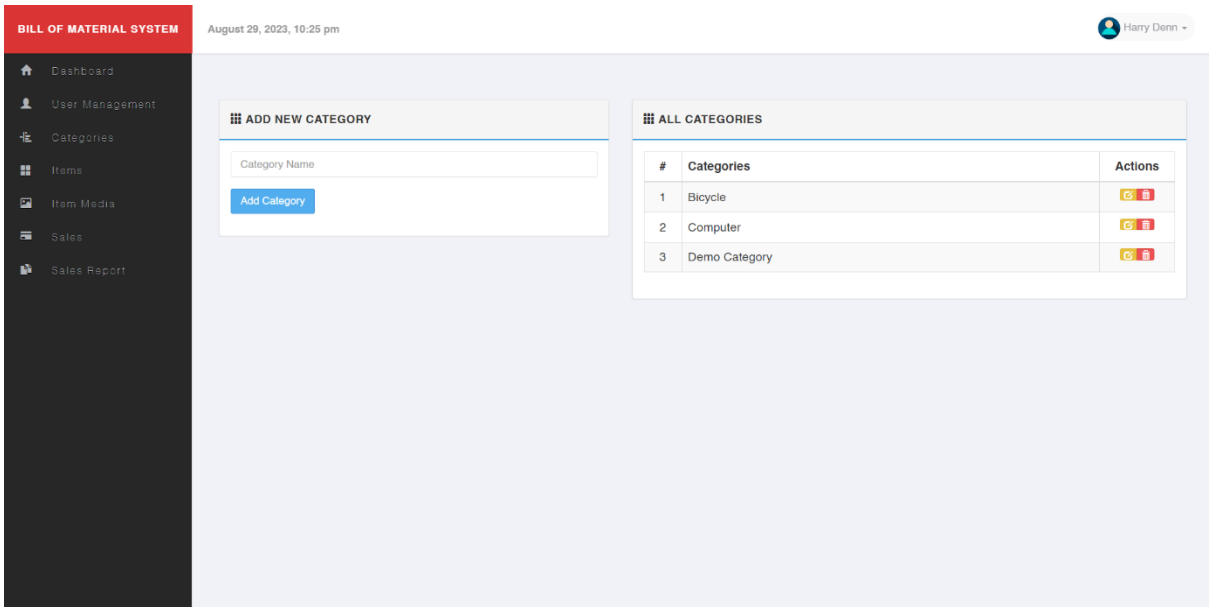


Figure 5: Snapshot of the Material Category

Add New Item: This page allows for the creation of a new material and also enables the administrator to manage and update existing materials.

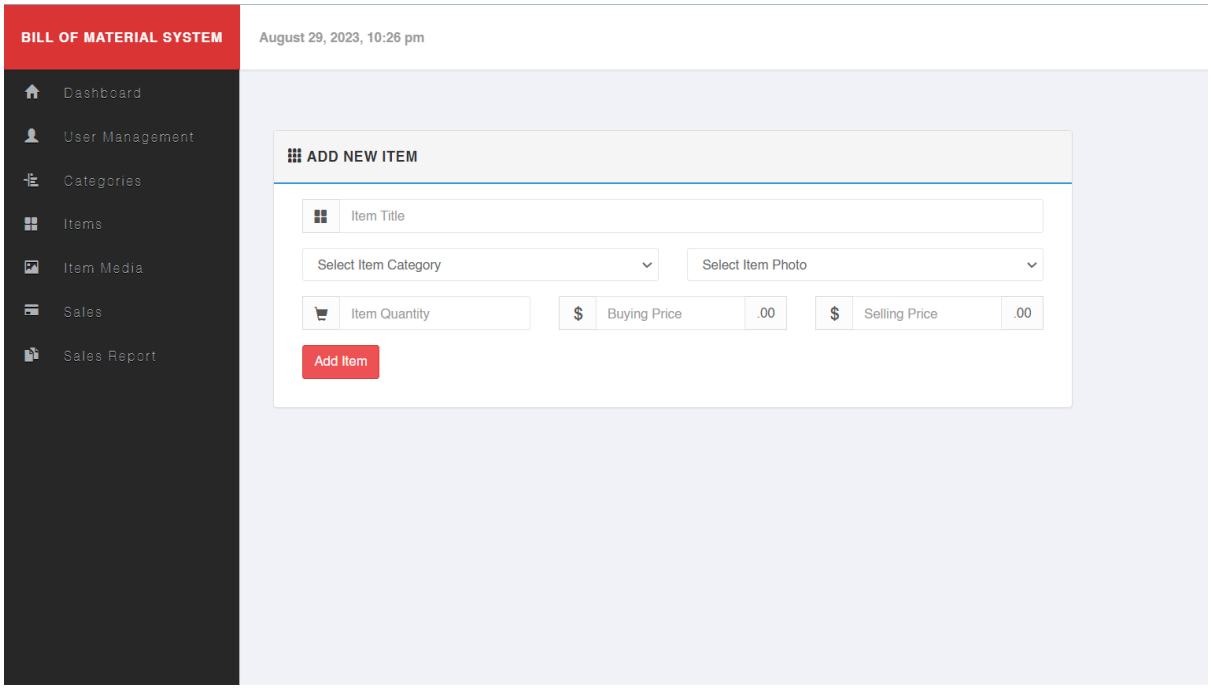


Figure 6: Add New Item Page

Material List: This page shows the list of materials that has been successfully entered into the system.

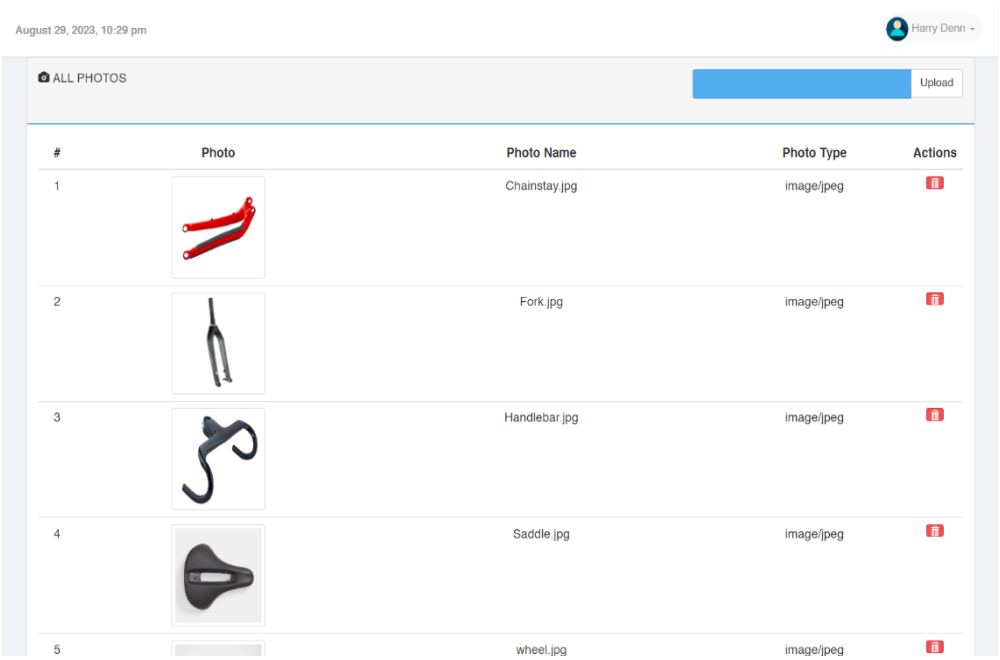


Figure 7: Material List

SYSTEM EVALUATION

The evaluation of the designed BOM processing system is an essential step in ensuring that it meets the needs of the organization. The evaluation process considers several factors, including the system's functionality, ease of use, reliability, and cost-effectiveness.

Functionality is one of the most critical factors to consider when designing a BOM processing system. The BOM system developed in this research was able to handle complex BOMs with multiple levels of subassemblies and components. It was also able to manage changes to the BOM, such as adding or removing components, without disrupting the production process. Ease of use is another crucial factor to consider. The system should have an intuitive interface that allows users to navigate and perform tasks quickly and easily. It should also provide clear and concise instructions on how to perform specific tasks. The system was able to handle large volumes of data without crashing or experiencing downtime.

CONCLUSION

Considering factors such as functionality, ease of use, reliability, and cost-effectiveness attributed by the developed system, organizations can meet their needs and provide value for money.

RECOMMENDATION

The current developed system is found to be working accurately and if adopted for implantation, it will reduce the problems associated with the manual methods of processing because of its effectiveness, flexibility, and accuracy and user friendly features.

REFERENCES

Abby, J. (2022). What Is a Bill of Materials (BOM)? Expert Guide & Tips. Retrieved April 6, 2023, from https://www.netsuite.com/portal/resource/articles/erp/bill-of-materials-bom.shtml

Han, Z. (2005). An object-oriented model of BOM based on the concept of file aggregate. *Journal of Computer-Aided Design & Computer Graphics, 17*(7), 1227-1233.

HE W.P. (2008). Analysis of concept, functions, structure and generation of the Manufacturing BOM (MQBOM). *Journal of Zhejiang University Science A, 9*(3), 364-370.

Jiang H.L., Liu, Y.W., & Fan, Q.Z. (2011). Design and application of flexible BOM based on tree mesh structure. *Computer Engineering and Design.*

Liu M., Lai, J., & Shen, W. (2014). A method for transformation of engineering bill of materials to maintenance bill of materials. *Robotics and Computer-Integrated Manufacturing, 30*, 142–149. doi: 10.1016/j.rcim.2013.09.008.

Mitchell, J. (2022). Understanding the Bill of Materials: A Comprehensive Guide. *Journal of Manufacturing Technology Management, 33*(1), 45-57. doi: 10.1108/JMTM-12-2020-0523.

Santos, Omar & Radanliev, Petar. (2023). Toward Trustworthy AI: An Analysis of Artificial Intelligence (AI) Bill of Materials (AI BOMs).

Sehgal, Vandana & Ambili, P.s. (2024). A Taxonomy and Survey of Software Bill of Materials (SBOM) Generation Approaches. 40-51. 10.1007/978-3-031-50815-8_3.

Stolt, Roland. (2023). Integrating the Design of the Product Life Cycle by a Master Bill of Materials. 10.3233/ATDE230595.

Qiao L., Zhang Z., & Huang Z. (2021). A Scheduling Algorithm for Multi-Workshop Production Based on BOM and Process Route. *Applied Sciences, 11*, 5078. doi: 10.3390/app11115078.

Wang, Yunrui & Wang, Yaodong & Ren, Wenzhe & Jiang, Ziqiang. (2024). Knowledge driven multiview bill of material reconfiguration for complex products in the digital twin workshop. The International Journal of Advanced Manufacturing Technology. 130. 1-12. 10.1007/s00170-023-12885-x.

Zahan, Nusrat & Lin, Elizabeth & Tamanna, Mahzabin & Enck, William & Williams, Laurie. (2023). Software Bills of Materials Are Required. Are We There Yet?. IEEE Security & Privacy. 21. 82-88. 10.1109/MSEC.2023.3237100.

Zhou C., Cao Q. (2018). Design and implementation of intelligent manufacturing project management system based on bill of material. *Cluster Computing, 22*. doi: 10.1007/s10586-018-1934-4.

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

Determination of Background Ionization Level of an Open Field in the Niger Delta University (NDU), Amassoma, Bayelsa State

Godwin E. Ogobiri[1],
Woyengitonye B. Abadani[2],
Keneke E. Dauseye[3],
Ibuama E. Abule[1]
[1]Department of Physics, Niger Delta University, Bayelsa State, Nigeria
[2]Department of Science Laboratory Technology, Federal Polytechnic, Ekowe, Bayelsa State
[3]Department of Physics, Bayelsa Medical University, Bayelsa State, Nigeria
E-mail: tonyeguyz@gmail.com

ABSTRACT

The work was carried out in the Open Field opposite Faculty of Science building in the Niger Delta University (NDU), Bayelsa State, Nigeria. Radiation Monitoring Device- Radalert x100 was used in carrying out the study, the background ionizing radiation (BIR) was measured at 20 different points as indicated in the Table below. The Background Ionizing Radiation (BIR) exposure rate values for the various points in the Open Field has the highest value recorded at point 20 with a corresponding value of 0.020 mSv/y and the lowest at point 13 with a value of 0.004 mSv/y as shown in the graph. The Absorbed Dose Rate (AbD) 0.174 nGy/h has the highest value at point 20 and the lowest value of 0.034 nGy/h as against point 13. While the highest Annual Effective Dose Equivalent (AEDE) was recorded at point 20 with a value of 0.300 mSv/y and the lowest at point 13 with a value of 0.053 mSv/y. The Excess Life Cancer Risk (ELCR) has the highest value at point 20 with a value of 0.840 $x10^{-3}$ and the lowest at point 13 with a value of 0.147 $x10^{-3}$. All values obtained where then compared to the world permissible limits as given by UNSCEAR 2000, which are reasonably lower.

Index terms: *Radiation, Radioactivity, Exposure rate, Ionization.*

INTRODUCTION

Human being is always in contact with the source of terrestrial radiation therefore, it is important to measure the level of radiation in the environment to ascertain how much it affects our daily life (Biere *et al*, 2021). Background radiation refers to exposure to ionizing radiation in day-to-day life excluding occupational exposure. It is measured in millisieverts (mSv). The natural radionuclide radon is the largest natural source of exposure. Radon is a Natural Radioactive gas that gets into homes and buildings. Most background radiation comes from natural sources including the ground, the air, building materials and foods. Radiation is also found in cosmic rays from space. Some rocks contain a radioactive substance that produces a radioactive gas called radon (Zachary Li *et al*, 2011).

MATERIALS AND METHODS

The research work was carried out in the Open Field, opposite Faculty Building, Faculty of Science, Niger Delta University (NDU), Bayelsa State, Nigeria. With the aid of Radiation Monitoring Device- Radalert x100, the background ionizing radiation (BIR) was measured for 20 different points, tabulated and other radiological parameters where determine with the aid of already established conversion factors and formulas . Hence result shown in Graphs.
Amassoma with a GPS of Latitude 4^0 58'13 N and Longitude 6^0 32.94" E

Fig 1: Back and Front view of the Radiation Monitoring Device- Radalert x100.

Fig 2: Picture of the study area- Open Field, Opposite Faculty of Science Building
The GPS location of the study area, Open Field, Niger Delta University (NDU), Bayelsa State is Latitude 4^0 58'13" N and Longitude 6'32.94" E

RESULTS

Table 1: The Background Ionizing Radiation (BIR) measurements in the Open Field, Opposite Faculty of Science Building and other radiological parameters.

Location	BIR (mRh^{-1})	Abd ($nGyh^{-1}$)	Eqv ($mSvy^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR $x10^{-3}$
Point 1	0.012	0.104	0.105	0.160	0.441
Point 2	0.015	0.130	0.131	0.200	0.552
Point 3	0.009	0.078	0.078	0.120	0.331
Point 4	0.011	0.095	0.096	0.146	0.404
Point 5	0.008	0.069	0.070	0.106	0.294
Point 6	0.016	0.139	0.140	0.213	0.588
Point 7	0.006	0.052	0.052	0.080	0.220
Point 8	0.009	0.078	0.078	0.120	0.331
Point 9	0.004	0.034	0.035	0.053	0.147
Point 10	0.006	0.052	0.052	0.080	0.220
Point 11	0.011	0.095	0.096	0.146	0.404
Point 12	0.008	0.069	0.070	0.106	0.294
Point 13	0.004	0.034	0.035	0.058	0.162
Point 14	0.009	0.078	0.078	0.120	0.331
Point 15	0.016	0.139	0.140	0.213	0.588
Point 16	0.013	0.113	0.113	0.173	0.478
Point 17	0.012	0.104	0.105	0.160	0.441
Point 18	0.015	0.130	0.131	0.200	0.552
Point 19	0.013	0.113	0.113	0.173	0.478
Point 20	0.020	0.174	0.175	0.030	0.084
MEAN	**0.011**	**0.094**	**0.095**	**0.133**	**0.367**

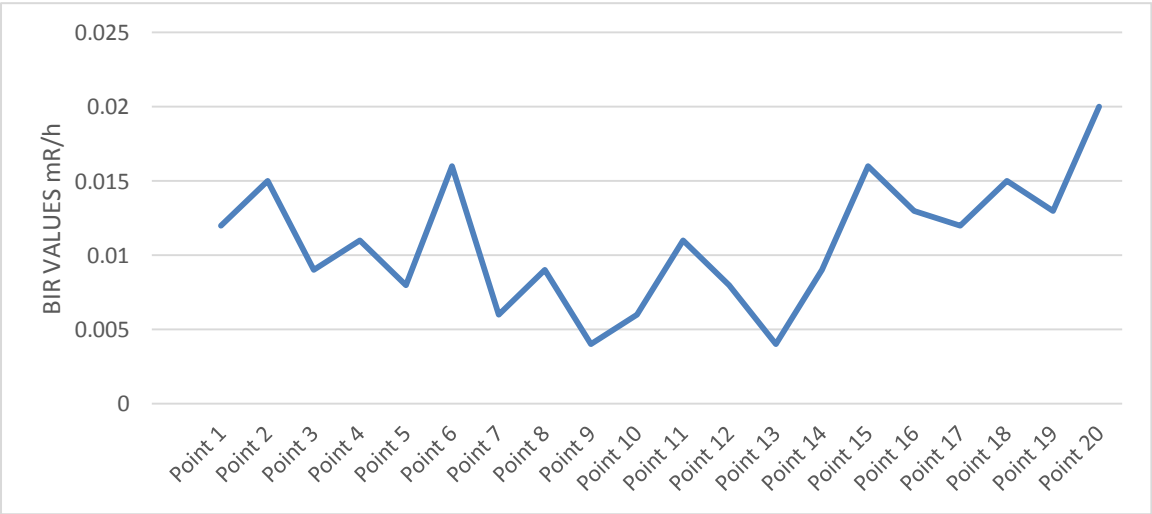


Fig 2: A Graph of BIR values in respect to the positions

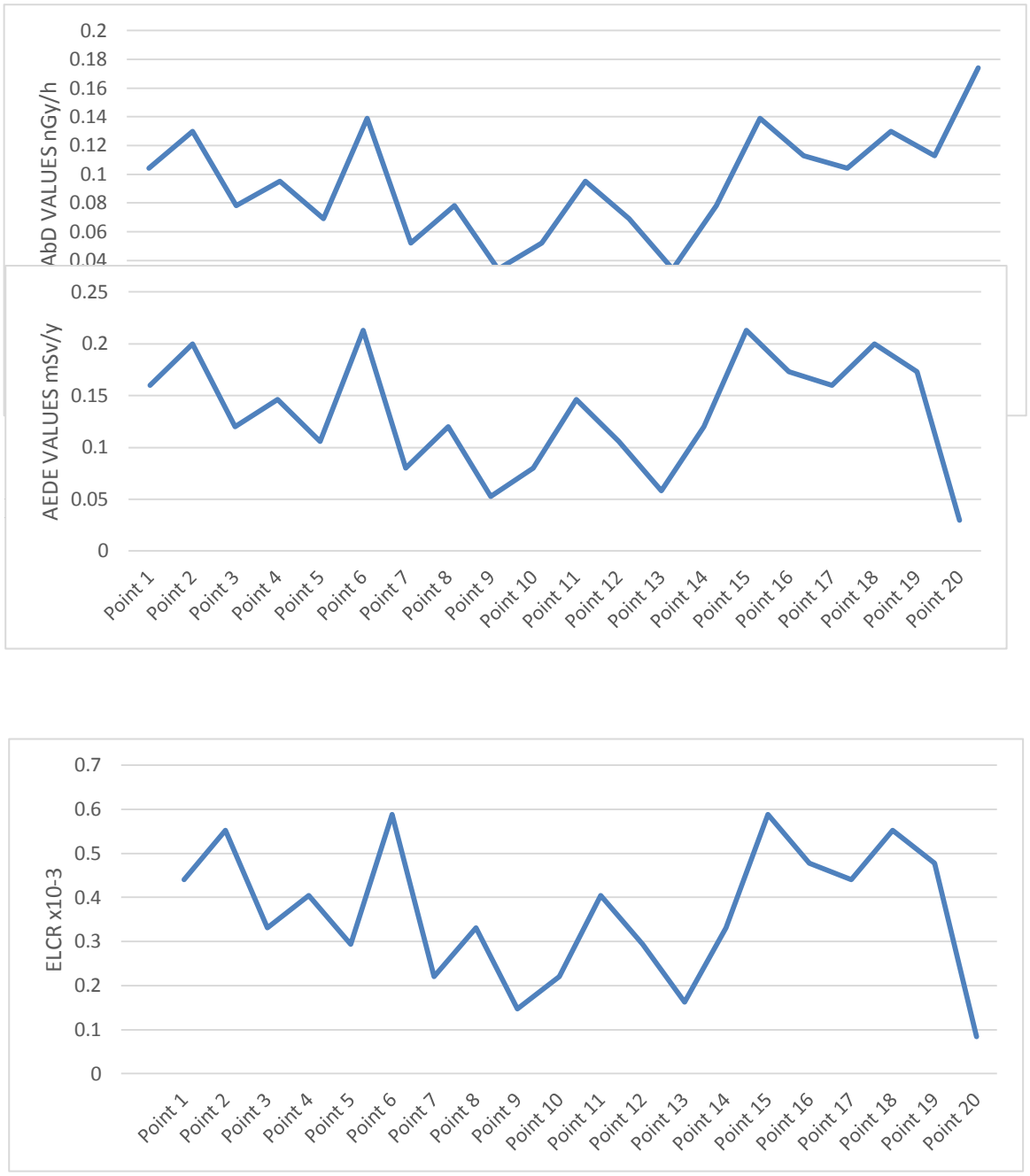


Fig 5: A Graph of ELCR values in with respect to the positions

DISCUSSION

The results shows the Background Ionizing Radiation (BIR) level of the Open Field, opposite the Faculty of Science Building of the Niger Delta University (NDU) and other radiological parameters that was obtained. Figure 3 shows the graph of the BIR value with the highest values 0.020 mSv/y at point 20 and the lowest value of 0.004 mSv/y at point 9. Figure 4 shows the graph of Absorbed Dose Rate (AbD) with the highest value of 0.174 nGy/h at point 20 and the lowest value of 0.034 nGy/h at point 9. Figure 5 shows the graph of Annual Effective Dose Equivalent highest value of 0.175 mSv/y at point 20 and the lowest of 0.035 mSv/y at point 9. Figure 6 shows graph of Excess Life Cancer Risk (ELCR) with a highest value of 0.840 $x10^{-3}$ at point 20 and the lowest value of 0.147 $x10^{-3}$ at point 9. All radiological parameters were compared with the world permissible limit as provided by UNSCEAR 2000 and are within their radiological permissible limits.

CONCLUSION AND RECOMMENDATION

The research work shows the Background Ionizing Radiation at the Open Field, opposite Faculty Building, Faculty of Science, Niger Delta University (NDU), Bayelsa State, Nigeria. A total of 20 Background Ionizing Radiation was measurements was taken at 20 different points randomly in the Open Field and other radiological parameters were also calculated. The Background Ionizing Radiation mean value of 0.011 mSv/y is below the world standard as recommended by UNSCEAR 2000. Other radiological parameters values like the Absorbed Dose Rate (AbD), Annual Effective Dose Equivalent (AEDE) and Excess Life Cancer Risk are also below their individual world permissible limits as provided by UNSCEAR 2000. The reason for the low values of radiological parameters recorded is as a result absence of human activity and radioactive substances in the Open Field.

Notwithstanding the present safeness of the environment (the open field), the institution is advised to regularly monitor the Background Ionizing Radiation level periodically, especially when industrial activities must have kicked off.

REFERENCES

Abubakar A, Sadiq AA, Musa MG, Hassan J, Malawi DF (2017) *Assessment of indoor ionizing radiation profile in radiology department FMC Asaba Delta State Nigeria. International Organization of Scientific Research (IOSR) Journal of Dental and Medical Sciences.*

Absorbed Dose Determination in External Beam Radiotherapy, Technical Reports Series No. 398, IAEA, Vienna (2000).

Christopher Feng and Zachary Li (2011). *Handbook of Radon, Properties, Application and Health. Publisher: Nova Scence Pub Ime, UK Edition, 2011.*

Ebong IDU and Alagoas K.D (1992) *Fertilizer impact on ionization radiation background at a production plant. Nigeria Journal of Physics.*

Farai I.P and Vincent U.E (2006) *Outdoor radiation level measurement in Abeokuta Nigeria by thermos -luminescent dosimetry. Nigeria Journal of Physics.*

Jibiri, N.N. (2001*) assessment of health risk associated with terrestrial gamma radiation dose rate levels in Nigeria. Environment international.*

National Council on Radiation Protection and Measurements, NCRP (2019) *Ionizing radiation exposure of the population of the United States. NCRP Report No: 160. Available at http://www.ncrponline.org/publication/ press. Release/160press.html.*

Okoye P.C and Awiri G.O (2013) *Evaluation of background ionizing radiation levels of Braithwaite Memorial Specialist Hospital Port Harcourt, Rivers State. American J Sci and Industry Res*

Olubosede O, Akinagbe OB, Adekoya O (2012) *Assessment of radiation emission from waste dumpsites in the Lagos state of Nigeria. International Journal of Computational Engineering Research.*

Ramli T.A, Aliyu A.S, Agba E.H, Saleh M.A (2014) *Effective dose from natural background radiation in Keffi and Akwanga towns, Central Nigeria. Int J Radiat Res.*

United Nations Scientific Committee on Effects of Atomic Radiation, UNSCEAR (2000) *Sources and effects of ionizing radiation. Report to General Assembly. Annex B New York. Available at http://:www.unscear.org/unscear/en/ publications/.*

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

An Agent-Based Notification System: An Enabling Environment for Lecturers and Students

Osazuwa, Linda Osworkam
Department of Computer Science
Delta State Polytechnic, Ogwashi-Uku
Email: lindaosazuwa2017@yahoo.com, davedanlyn@gmail.com

ABSTRACT

Most times, in academic institutions, information communication between lecturers and students is not well managed. Many complications arise when disseminating information to students. E-learning is one way that enables lecturers to inform students about academic activities. The problem here is that in order for the student to access the information in E-learning, the student has to log in from their computers, sign in and only after that can the student get access to available information. Sometimes students are not able to sign in through the computer because some of them do not have time at that moment or the E-learning system might be down. In other institutions where E-learning systems are not available, information is passed through notice boards. The information on these notice boards may not get to the intended beneficiaries at the right time and it is prone to destruction thus making it an ineffective means of communication especially when the information posted through the above methods may be urgent and important for the students but they may not be able to easily access it. This paper seeks to address such issues and proffer a better and effective solution to enable conducive learning environment. The software designed was implemented using PHP, HTML, Javascript and MYSQL for the backend. The methodology used to achieve the objectives of the system is Structured System Analysis and Design Methodology (SSADM). The designed application software was tested and found to perform well and produced expected results on completion.

Keywords: Notification system, effective, enabling environment, PHP, HTML, JavaScript

INTRODUCTION

A notification is a message, sound, or symbol on your phone, computer or any electronic device telling you that someone has sent you a message or put something new for you to look at on a website (Collins, 2023).A Notification System is a platform that allows someone to stay connected and get in touch with real-time information anytime and anywhere through a mobile device. Currently, we can find notification systems on various devices, such as smartphones, smartwatch, or tablets. In addition to providing important information, the notification also serves as a reminder of information that has occurred, is happening or will be done by the recipient. Usually, smartphone users will take the time to see or read the notification on the smartphone even in busy conditions. This is because the nature of the notification system is fast response in conveying information to the user (Ahmad, 2018).

Electronic notifications have thousands of applications for business, governments, schools and even individuals. Some of the simplest and most common types of electronic notifications are: News notifications, Weather alerts, Sports updates, Travel offers/ job offers received via emails etc.

Electronic notification is now being used by businesses, universities and many management agencies as it has proven to be very effective in mass communication, compared to the manual or tradition way of disseminating information. With these technologies, organizations can communicate within themselves with no geographical limitations. And by doing so they save themselves some time, money and other resources that they would use when doing it manually. And in situations where you will need the targets to give responses, electronic notification has proven to be the easiest as emails can be received and sent within the shortest possible time. Under education, students, teachers and other staff members can be informed about incoming events, warnings and all other school activities. With regards to healthcare, hospitals can send appointment reminders to both doctors and patients to keep them aware (Ampofo et al, 2018).

Lots of institutions and organizations still use notice boards as means of communicating with students, lecturers and staff of the institution. We have seen over the years that the process of passing information manually with notice boards is not only time consuming but also inefficient. This traditional system requires a manual method of writing notifications, taking printouts, displaying it on notice boards and also requires students to watch periodically. It requires a lot of paper work. There is a need to develop a robust system to solve daily life problem of notifications and notice management. Sometimes the case may occur that students cannot convey whatever is on the notice board or about the homework to their parents. Sometimes, due to heavy rains school or organizations want to declare an impromptu holiday but students get know about that holiday when he/she is already in school.. To overcome these problems and enhance efficient and effective means of communication brought about the development of a robust notification system.

Following this thought, an Agent Based Notification System has been developed as a web application that communicates with a database residing on a remote server. This system will provide real-time notification facilities to organizations and institutions. This system shows that the concept of web services will be useful for communication between remote server and mobile application. With the help of this Application, employees and students will be able to get firsthand information and notifications. All data is stored securely on SQL servers managed by the administrator and ensures highest possible level of security. The system features a complex logging system to track all access and ensure conformity to data access.

Objectives of the Study

The aim of this paper is to develop a computerized agent-based notification system that will perform the following objectives:

1. To establish a better, faster and a more effective means of communication.
2. To eliminate communication breakdown between students and lecturers.
3. To create a useful platform of communication that will be available throughout the day.
4. To develop a robust database for storing of information and notifications.

LITERATURE REVIEW

In today's competitive environment, rapid advances in economic globalization and information technology have forced many organizations to anticipate and respond to increasing volatility and competitive pressure (Ho et al., 2004). Numerous researches have focused on developing techniques on the analysis, design and management of communication systems.

Agent-based models are computer simulations used to study the interactions between people, things, places, and time. They are stochastic models built from the bottom up, meaning individual agents are assigned certain attributes. The agents are programmed to behave and interact with other agents and the environment in certain ways. These interactions produce emergent effects that may differ from effects of individual agents. Agent-based modeling differs from traditional, regression-based methods in that, like systems dynamics modeling, it allows for the exploration of complex systems that display non-independence of individuals and feedback loops in causal mechanisms. It is not limited to observed data and can be used to model experiments that may be impossible or unethical to conduct in the real world.

Software agents are intelligent software programs that perform certain tasks on the user's behalf in autonomous, reactive, proactive and adaptive behavior (Kineo, 2009). Thus, agents know what to do, how to do it, and when to do it; this promotes high level of autonomy, reactiveness, and proactiveness. The Foundation for Intelligent Physical Agents (FIPA) provides standards for message transport protocols, Agent Communication Language (ACL), content languages,and interaction protocols for the sake of interoperability (Tarkoma, 2003).

As a result of inventing more advanced mobile devices and the rapid evolution in wirelessnetwork infrastructure, the use of mobile devices have gone beyond voice calls, video calls, text messaging (SMS), and multimedia messaging (MMS) activities (Adi et al., 2008; Vochin, 2010). Nowaday, mobile devices are being used in many important activities in many fields in our life such asm-learning, m-banking, and m-advertising (Adi et al., 2008; Mousumu& Jamil, 2010). Such mobile activities are according to the user's preferences, location, and device limitation. Hence, mobile computing promotes flexibility, mobility, and adaptability through small, light, and movable devices.

For establishing event-based communication, the most popular push model is publish/subscribe communication model. The motive for using such paradigm arises from the need for an asynchronous, loosely coupled, and many-to-many communication in the context of mobile and/or large-scale distributed systems. Such model enables subscribers to express their interests in event notification. These events are produced by publishers and delivered by event service to subscribers only if events match their interests. In general, publish/subscribe model consists of publishers, subscribers, and dispatch of event service. Mobile agents have been used in the applications of distributed events systems based on publish/subscribe communication protocol (Sahingoz & Erdogan, 2010). The approach involves using mobile agents as mediators between publishers and subscribers of events. In such scenario, subscribers are required to register in the system and define the events they are interested in, and publishers create mobile agents with the event to be published and dispatch them to the event server in which the mobile agents find out the interested subscribers to push the event to them. Thus flexibility is promoted via asynchronous communication.

Publish/Subscribe model has contributed to delivering information in the mobile context. Hence, a publish/subscribe middleware was proposed to address the requirements of mobile computing applications, this middleware provides asynchronous communication as the publishers does not need to have direct contact with the subscribers, thus wireless connection failure is not a problem anymore.

Also many-to-many decoupled interaction is provided as many publishers publish events and these events are sent to many subscribers without publishers being connected to the system. Anonymity is supported by such a model as publishers do not have to know the identity of the subscribers and vice versa. Implicit determination of the event notification receivers is provided

rather than choosing them by the publishers. Consequently, the system is capable of dealing with a large number of mobile users. However, mobile publish/subscribe applications have been classified into two categories:

1. Static applications that reside in the user's mobile device, as the user is moving, the application can access the system network from different access points.
2. Mobile
   Agent based applications that are able to execute autonomously on any host device to access thesystem. The first category has been implemented to support mobility service using client proxy. This mobility proxy is an interface medium between the client and the publish/ subscribe system while being in disconnected mode.

The possible delivery methods for event notifications are SMSs or WAP messages. Additionally, the mobile pub/sub system should offer a set of benefits such as:

1. Timeliness that is achieved by pushing data to interested subscribers once it is produced by the publisher.
2. Asynchronous communication that enables delivering notifications while the subscriber is not connected to the system, thus reliability is guaranteed.
3. Anonymous communication where publishers do not need to know the identity of subscribers, thus flexibility is insured.
4. Supporting logical mobility (the user can receive notifications even if changed her/his mobile device) and physical mobility (the user can be notified anywhere).
5. Expressiveness that is the ability of event service to well-define interests of subscribers.
6. Implicit matching where the event service determines the target mobile subscribers who will receive notifications based on their subscriptions without needing publishers to choose recipients.
7. The ability to manage a large number of potential mobile subscribers allowing for manipulation of their subscriptions (updates, insert, and delete).
8. The ability to manage a large number of publishers.
9. Support for simultaneous delivery of notifications to thousands of mobile subscribers.
10. Robustness guarantees delivery of notifications to all target mobile subscribers even in case of network failure while subscribers are moving (that is a characteristic of mobile network) by resending notifications to subscribers who could not be reached previously.

The common standard technologies for establishing mobile event notification systems are Common Object Request Broker Architecture (CORBA), Java Message Service (JMS), and Wireless Message Transport Protocol (WMTP) (Pietzuch et al., 2007).

Educational environments are filled-up with various activities and events that are offered for students. These events are usually announced orally or posted properly on the notice board. The problem is that, students have different class schedules, so they exist in different time frames. Within these different time frames, some events might be announced, started, and finished without the student being notified. Also, students may forget to check the pin board due to their busy day schedule. Further problematic case, if a lecturer, for urgent matter, needs to cancel a lecture in the same lecture day, then the oral and pin board methods will be useless. Consequently, there is no option to notify students early and they will only know very late. However, events in university context can be classified into:

- **Social events:** include notifications about incoming trips, sport competitions, conferences, and symposiums.

- **Career events**: include notifications about incoming job opportunities, internships, and scholarships.
- **Academic events:** comprise of registration events (include notifications about registration date, list of available courses for the new semester, timetable of the registered courses) and course notifications (include notifications about announcement for new lecture, canceling lecture, and exams schedule).
- **Warnings:** include notifications to students who exceeded the allowed absence rate.
- **Library events:** include announcements about new available resources, acknowledging student that the requested resources are sent to her/his e-mail, and notifying student to renew their membership.

Institutions should be active by choosing more flexible method to convey the previously listed events to students anywhere and on time. Hence, agent based notification system is the best choice.

Research related to the use of notification system has been done since the birth of mobile phone device. Starting from Global System for Mobile Communications (GSM) or Code Division Multiple Access (CDMA) to Internet Protocol (IP) based, or briefly called the Internet. Examples of simple GSM-based notification systems are voice call, short message service, and multimedia messaging service. For Internet based notification system usually depends on the application in the operating system on a smartphone device. Android and iOS are two operating systems on the smartphone device that is quite dominating at this time.

There have been many studies dealing with the notification system on smartphones as a solution to various problems in life (Ghazal et al, 2016; Wibisono et al, 2013; Wang et al, 2013; Oh, 2015 & Ronald et al, 2018). Here is a review of some related works in the field of agent-based notification systems:

Agent-based System for Social Media Notification Filtering by Wang et al. (2022): This research presents an agent-based system specifically designed for social media notification filtering. The system employs intelligent agents to analyze social media feeds, detect important events or topics, and filter relevant notifications for users. The study demonstrates the system's ability to reduce information overload and improve the efficiency of social media notification management.

Agent-based Middleware for Context-aware Mobile Notification Systems by Lee et al. (2021): This work proposes an agent-based middleware for context-aware mobile notification systems. The middleware enables the seamless integration of multiple agents, including user agents, device agents, and notification agents, to capture contextual information and deliver notifications accordingly. The research focuses on the middleware's performance, scalability, and adaptability in handling large-scale notification delivery.

Intelligent Mobile Notification System Using Multi-Agent Approach by Chen et al. (2020): This study introduces an intelligent mobile notification system based on a multi-agent approach. The system employs multiple agents with different roles, such as user agents, notification agents, and context agents, to facilitate personalized and context-aware notification delivery. The research evaluates the system's performance in terms of notification relevance and user satisfaction.

Agent-based Framework for Personalized Notification Systems by Johnson and Brown (2019): This paper proposes an agent-based framework that enables the development of personalized notification systems. The framework incorporates various agents, including user profile agents, context-aware agents, and notification delivery agents. The agents work collaboratively to gather user information, analyze contextual data, and deliver notifications tailored to individual preferences.

A Multi-agent System for Intelligent Notification Delivery by Smith et al. (2018): This research presents a multi-agent system that employs intelligent agents to deliver notifications to users. The agents are equipped with machine learning algorithms to learn user preferences and dynamically adapt the notification delivery based on user feedback. The study demonstrates the effectiveness of the system in improving the relevance and timeliness of notifications.

Other studies that have been done include smart disaster notification system that utilizes SMS or voice call to inform optimal route to the nearest shelter by Sikder et al, 2017, another example is a notification system that provides information about bus departure in detail (Sneha et al, 2014). This notification system runs on the Android operating system. Then, there is also research that uses push notification for the selection of wireless connection services, based on service and speed of access (Ji et al, 2014). In addition to utilization, research also focuses on system performance, by testing and analysis of push notification used (Zhang & Rountev, 2017). Through this research, we try to propose the design of smart notification system that runs on the Android operating system. This smart notification will be used for the academic announcement in the campus environment. The current announcement system only depends on the web portal, phones, groups in social media or short message system. The use of web portals and phones still has many limitations. This is the background for us to create a smart notification that runs on the Android operating system. In principle, the way the notification system work has a resemblance to the information system in common (Sanmorino& Isabella, 2017), which aims to provide information to users.

Another aspect of concern is security issues, with the use of Android-based notification system; it is expected to reduce theft and misuse of data. It can also open up new research opportunities, namely the integration of notification systems and server security methods as we have done in other studies Sanmorino & Gustriansyah (2018). Bharamagoudar, Geeta & Totad (2013) worked on "Web Based Student Information Management System" that provided a simple interface for maintenance of student information. It could be used by educational institutes or colleges to maintain the records of students easily. The creation and management of accurate, up-to-date information regarding a students' academic career is critically important in the university as well as schools and colleges. But this system can used to store the students data and it limited only to schools or colleges for their own use. Bongani T. Mabunda Johnson O. Dehinbo (2012) worked on "Enhancing Online University Class Management System with Instant Email Feedback Alert" that manages the class, attendance and provides instant email alerts and updates student records. This system uses emails for communication between students and teacher. Thus, there is no direct communication between student and teachers. And if teacher want to communicate with student or deliver an important message it becomes difficult for them. Attendance is a very important task for maintaining the record of student.

In present system, maintenance of record is done manually. Manually maintaining the record is quite a time-consuming task. Moreover, other details of student are stored in different records which increase redundancy. Also, in the present system the feedback is issued from student using the web application or manually which will lead to data inconsistency. Thus, there is a great need for a fast, reliable, efficient and easy automated system which will help in updating and provide the best way for student-teacher, parent-teacher communication in short duration of time.

Sako, Dumnamene & Igiri, Chima & Bennett, Emmanuel & Deedam, Fortune (2024). ESARS: A Situation-Aware Multi-Agent System for Real-Time Emergency Response Management: This paper describes ESARS, a real-time situation-aware social media- enabled

emergency situation alert and reporting system, as a decision support system built on multi-agent software design architecture for emergency situation management. The impact of an incident or disruption due to the incident could be minimized by implementing real-time intervention strategies that involve event monitoring, detection and situation identification via classification and prediction, notification, visualization and reporting that culminate in providing emergency support within time. The nature of agent behavior, which is autonomous, proactive and cooperative, makes them a suitable method for the design and deployment of a dynamic system of this nature. The system relies on historical and streamed real-time geo-location-enabled Twitter data stream for the target emergency events to provide decision-makers with dynamic, comprehensive, and timely information specific to the emergency situation.

Sombattheera, Chattrakul. (2022). News Feed: A Multiagent-Based Push Notification System. This document explains a very innovative multiagent-based information system driving personalized data to millions of farmers in Thailand. There are three main agents working in the system. The collective agent collects initial data from large databases and farmers. The analytic agent receives initial data and analyzes it for related keywords and sends them back to the collective agent. The key words are used to search for related external source of data that are useful and appropriately fit to individual needs and interests of farmers. The disperse agent then distributes the data to farmers, categorized into seven layers. Farmers benefit from these sets of information in many ways, including how to plant, grow, maintain and fertile until harvest. Even before planting, the system helps farmers to decide which crops they should choose. After harvesting, the system helps in finding appropriate market for their crops.

The above reviewed related works highlight the application of intelligent agents in notification systems, emphasizing personalization, context-awareness, and relevance in delivering notifications to users. The research outcomes contribute to the advancement of agent-based notification systems and provide insights into the design, implementation, and evaluation of such systems in various domains.

RESEARCH METHODOLOGY

System Analysis

The system is about sending notifications in a simple and convenient way. There is a need to minimize the gap between lecturers and students, likewise employer and employees by designing a web application to provide timely and critical information to the user. It is a standalone Application and can be used in various institutions like schools, organizations, establishments etc.

This application will provide a generalized solution to monitor the various Notifications, notices, and other information by the administrator. The system was built to reduce the time which is required to deliver the notifications to users through web technology. Users will be required to register in the system by providing their details and student/employee unique number. After successful registration will be login to the system. The user can view and access all recent notifications in his or her dashboard which will include School/Organization's events, Academics and other facilities. All users devices will give a beeping sound whenever there is a new notification. The system administrator will be responsible for updating notifications, notices and reminder etc.

System Design

The notification system workflow is as follows:

5. User sends ID through their device to the web application server to register.
6. The web application will notify that the user has successfully registered, marked by a success message sent by the web application.
7. Next, the device will send the ID that has to register with the server. The server will store the ID of the student who has done the registration into the database.
8. If there is an academic announcement, the server will send it to the mobile platform service.
9. The web application broadcasts to all users who have registered.

For actors involved in the system, which consists of 3 parts: admin, operator, and user?

a. Admin can manage the user, monitor the system and view the log.
b. The operator can add or remove the user, create and view the list of announcements.
c. Users can view and read the academic notification messages sent by the mobile platform service wherever and whenever they are.

By using this application, the institution/organization does not need to send announcements one after the other to users such as via email, SMS, or other notification technologies that require a client to request to a server. The notification content provided is also more varied and interesting, not monotonous and boring. The application also guarantees the security factor of message and notification content that is broadcast to the user who has done the registration. In other words, the failure of the notification system can be avoided. This is important to understand because if there is a failure, everything must be repeated from the beginning and will cause a lot of losses. Planning and calculation of the implementation of a system must be done correctly in order to avoid failure.

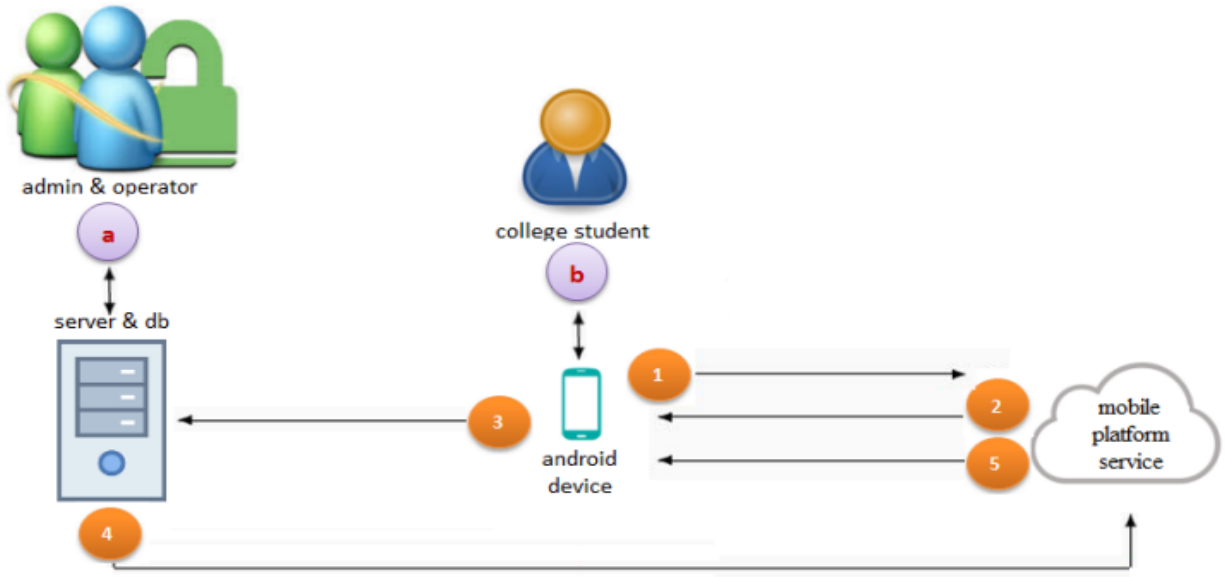


Fig. 1: Architecture of the system

Input Design

It is necessary to denote that data input in the computer for processing determines what the output will be. Screen designs are generally or basically made for data entry or data capture. When you choose an option, a screen will be displayed for you to carry out the operation or work that you want. Below is a sample of an input form in the system:

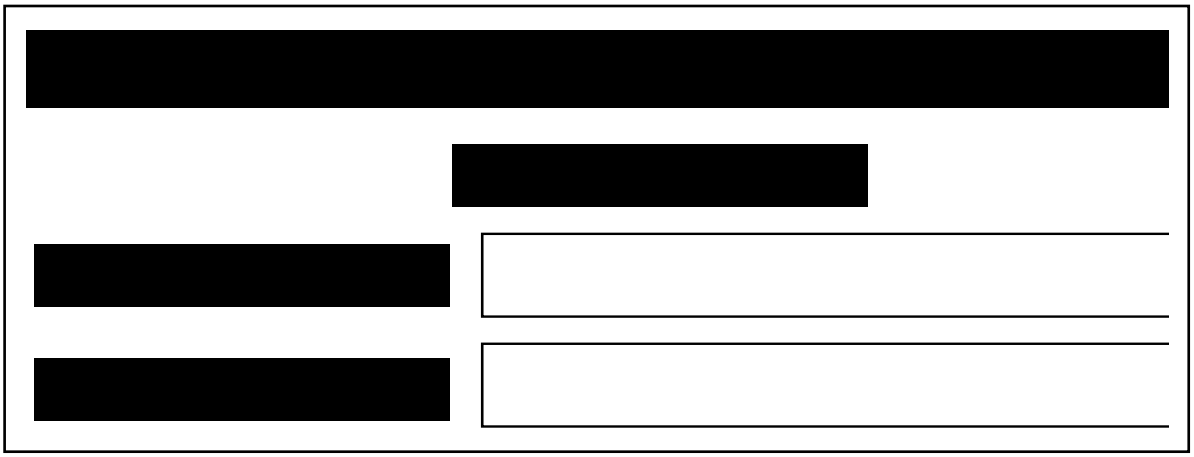


Fig.2: Sample input design

OUTPUT DESIGN

The output from the system is a report generated from the system, which gives report on the announcements and notifications. These output are used for decision making and sometimes kept for record purpose.

The output from the new application system is designed in such a way that it conveys meaningful information to both the organization and users. It aims at providing the management with adequate, effective, well documented up-to-date and formatted output to help as a tool in planning and decision making. The system is designed to generate outputs in the following format:

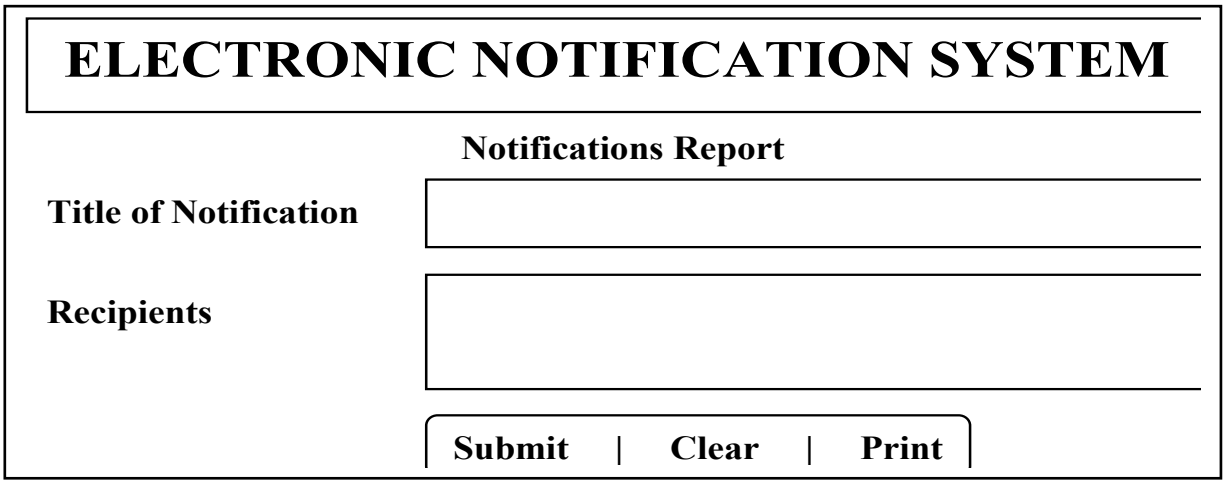


Fig.3: Sample output design

Database Design

MYSQL was used to design the database for storing the information used in this project. The database was integrated into the system so that the program can access and update the files. Below is a sample of one of the tables in the database.

Table 1: Recipient_info

Field Name	Data Type	Field Size
Lastname	Text	15
Firstname	Text	15
Matric No	Text	15
Address	Text	50
State	Text	25
LGA	Text	25
Sex	Text	6
Age	Integer	4
Department	Text	30
Email	Text	30
Phone	Integer	11

SYSTEM IMPLEMENTATION

Hardware Requirement

The following are the hardware requirement needed to implement the new system:

- **CPU:** Pentium IV or higher
- **Hard Disk Capacity:** 256GB or higher
- **Ram Capacity:** 1GB or higher
- **Processor Speed:** 1.8 GHz and above
- Keyboard
- Mouse

Software Requirement

A software requirement is the specification of the minimum software needed to run the new system. The software requirements of this system include:

- **Operating System:** Windows, Mac etc.
- Xampp or Wamp Server for Windows
- **Web Browser:** Mozilla Firefox, Internet Explorer, Opera Browser or GoogleChrome.

System Interfaces

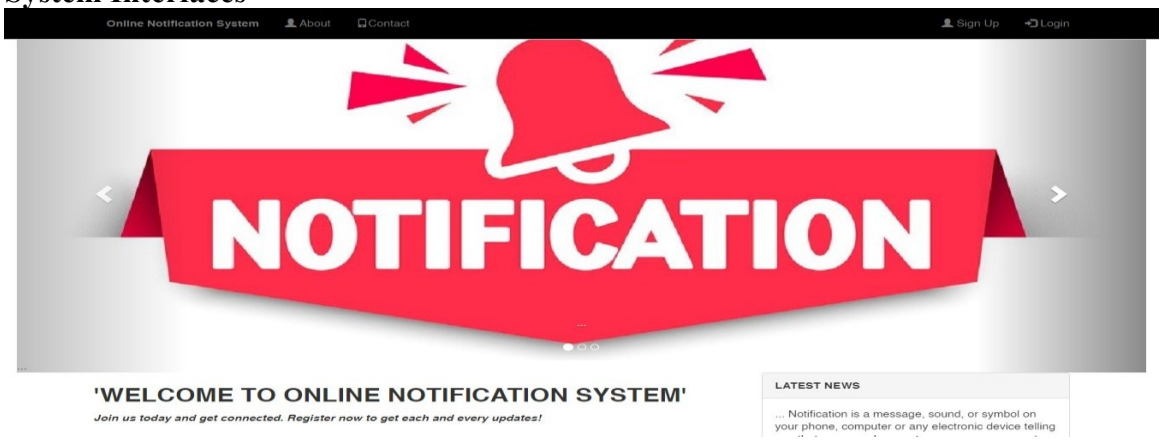


Fig.4: Snapshot of the home page

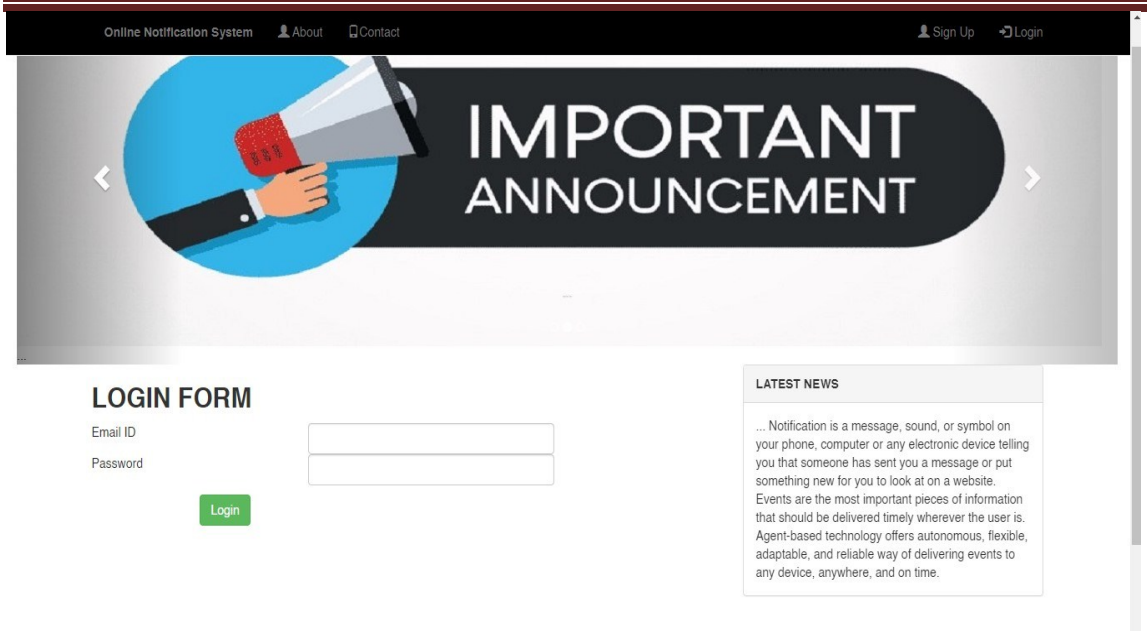


Fig.5: Snapshot of the login page

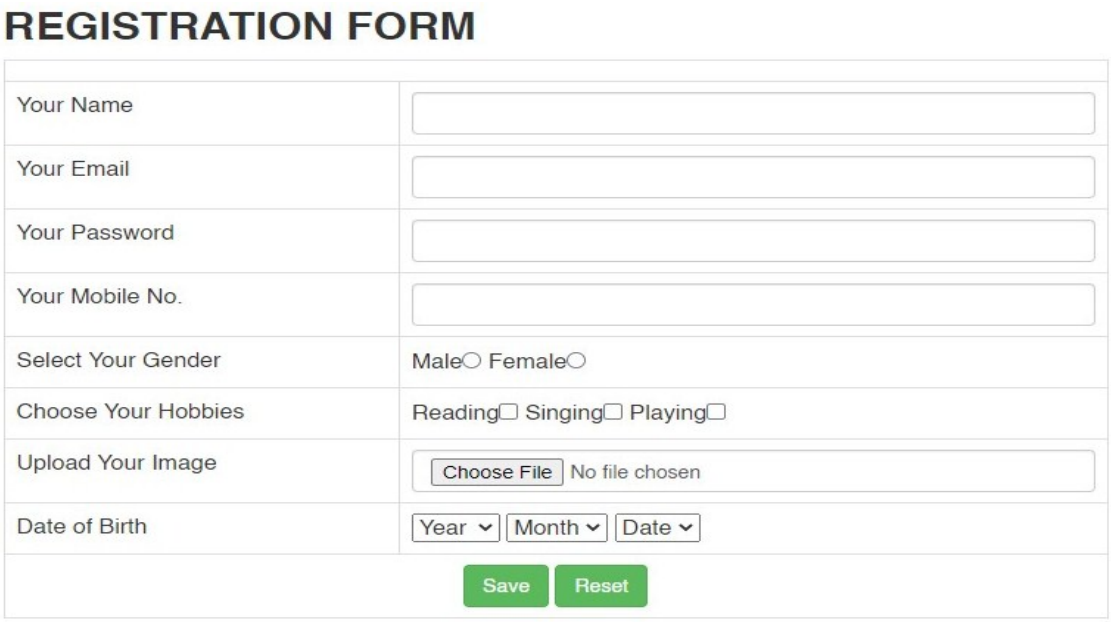


Fig.6: Account Creation Page

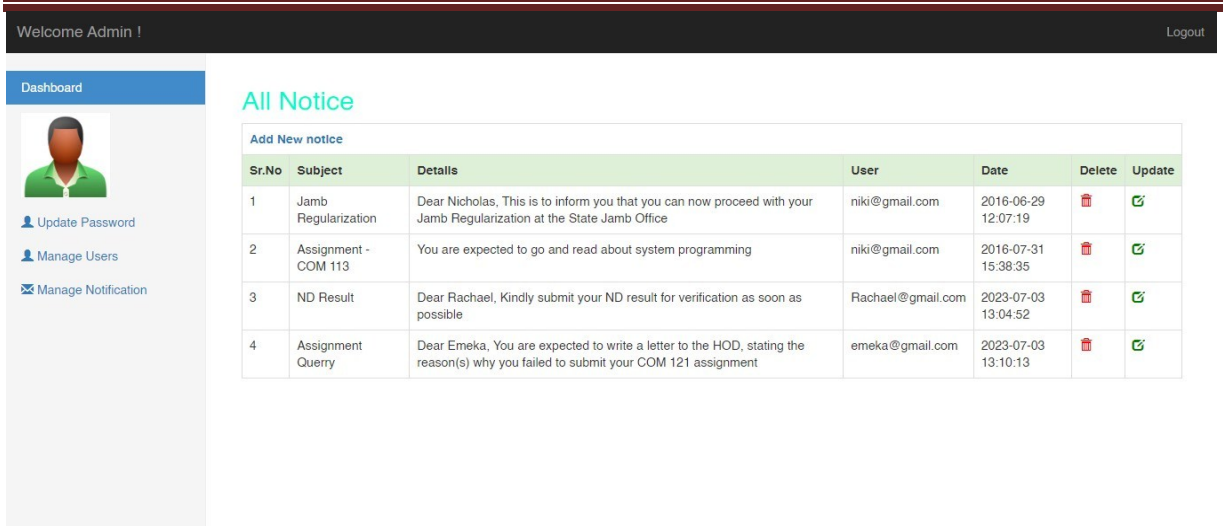


Fig.7: All Notifications page

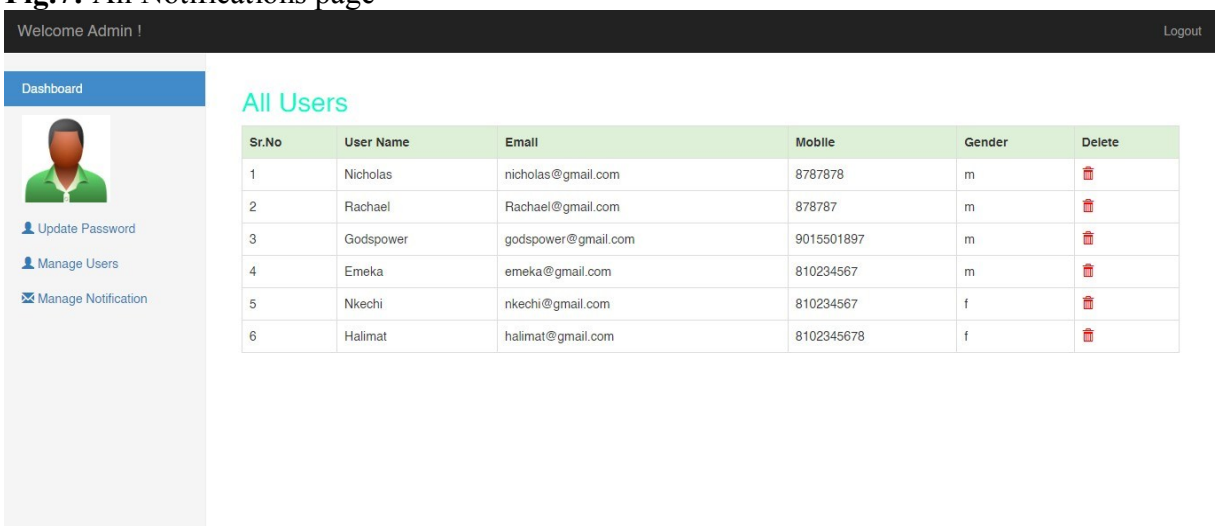


Fig.8: All users page

SYSTEM EVALUATION

The current study is conducted to assess the students by developing a more flexible communication procedure with their teachers. Results showed that the notification system has been proven to be an effective application. It is highly recommended for use in the educational process due to its positive impact in supporting the learning process in educational institutions. This paper was conducted as a step in implementing a new application system where the primary objective is to create one-on-one direct method of notification by sending an alert to students with the alert summarizing all the latest changes in information. The alert is usually sent from the educator's computer through the website. The developed application guarantees that learners will have an immediate notification of the latest changes in information in order to avoid any probable negative consequences.

CONCLUSION

Through meticulous planning, thoughtful architecture, and rigorous testing, a robust system that addresses our specific needs and offers several key benefits has been successfully developed.

Contribution to Knowledge

Agent-based notification system represents a significant leap forward in enhancing communication and information dissemination within an organization. The notification system is beneficial to all users and organizations by helping to convey vital information concerning any incident in a timely manner so that the recipients can properly prepare themselves.

REFERENCES

Ahmad, A., Denfgyin, Z., & Haibo, L. (2018). M-learning in review: Technology, standard and evaluation. Journal of Communication and Computer, USA, 5(11), 1-6.

Collins dictionary (2023). Web Based Student Information Management System.

Ampofo, M., Carzaniga, A., & Wolf, A. (2018). Design and Evaluation of a Support Service for Mobile, Wireless Publish/Subscribe Applications. IEEE Transactions on Software Engineering, 29(12), 1059-1071.

Ho, G.T.S., Lau, H.C.W., Ip, W.H., & Ning, A. (2004). An intelligent information infrastructureto support the streamlining of integrated logistics workflow. Journal of Expert System, 21(3), 123–136.

Takorma, (2003). Using Publish/Subscribe Middleware for Mobile Systems. ACMSIGMOBILE Mobile Computing and Communications Review.

Kineo, (2019). Overview on Agent Application to Support Collaborative Learning Interaction. US-China Education Review, 5(1), Jan. 2019.

Andi, M., Ali, S., Halabi, M.A., Ali, N., & Khalil, Y.A. (2008). Smart mobile-based emergency management and notification system. 2008 IEEE 4th International Conference on Future Internet of Things and Cloud Workshops (FiCloudW), pp. 282-287. https://doi.org/10.1109/W-FiCloud.2008.64

Ji Z., Ganchev I., O'Droma M., & Zhao Q.. (2014). A Push-Notification Service for Use in the UCWW.International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery (CyberC).

Kineo and UFI/Learndirect (2009). Mobile Learning Reviewed. Retrieved from http://www.kineo.co.uk/documents/Mobile_learning_reviewed_final.pdf [Accessed June 2, 2023].

Mousumi, F., & Jamil, S. (2010). Push Pull Services Offering SMS Based m-Banking System in Context of Bangladesh. International Arab Journal of e-Technology, 1(3), 79-88.

Pietzuch P., Muhl G., & Fiege L. (2007). Distributed Event-Based Systems: An Emerging Community. IEEE Distributed Systems Online, 8(2).

Sako, Dumnamene & Igiri, Chima & Bennett, Emmanuel & Deedam, Fortune. (2024). ESARS: A Situation-Aware Multi-Agent System for Real-Time Emergency Response Management. European Journal of Information Technologies and Computer Science. 4. 1-8. 10.24018/compute.2024.4.1.83.

Sahingoz O.K., & Erdogan N. (2010). Agent: an agent based distributed event system. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/summary?doi=?doi=10.1.1.112.431

Sanmorino, & Isabella (2017). Enhancing Online University Class Management System with Instance Email Feedback Alert. Proceedings of the World Congress on Engineering and Computer Science 2012 Volume I, ISSN: 2078-0966 (Online), San Francisco, USA.

Smith, A., Valls, A., & Viejo, A. (2018). Using JADE-LEAP to implement agents in mobile devices. TILAB"EXP in search of innovation. Italy. Retrieved from http://jade.tilab.com/papers-exp.htm

Sombattheera, Chattrakul. (2022). News Feed: A Multiagent-Based Push Notification System. 10.1007/978-3-031-20992-5_11.

Nwana, H., & Wooldridge, M. (n.d.). Software Agent Technologies. Intelligent Systems Research, Advanced Applications and Technology, BT technology journal.

Oh, H., & Jalali, L. (2015). Ramesh Jain, An intelligent notification system using context from realtime personal activity monitoring. Turin, Italy.

Zhang, & Rountev (2017). Personal Security Tracking based on Android and Web Application. TELKOMNIKA, 16(2).

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

Antilipidemic Effects of Aqueous Extracts of *Vernonia amygdalina* on Albino Rat

Asuquo, A. E.[1*]
Adams, E. G.[1].
Ubom, A. G.[1].
Archibong, I. B.[1]
Raphael, M. P.[2]
[1]*Department of Biological Sciences, Akwa Ibom State Polytechnic, Ikot Osurua, Akwa Ibom State.*
[2]*Department of Chemical Sciences, Akwa Ibom State Polytechnic, Ikot Osurua, Akwa Ibom State.*
***Correspondence:** asuquo.edem@akwaibompoly.edu.ng or akanimo7@yahoo.com*

ABSTARCT

The plant commonly referred to as bitter-leaf, Vernonia amygdalina is one of the most extensively consumed vegetables in Nigeria and many other countries of Africa. Although the leaf extract's effects on lipid profiles have not been thoroughly investigated, it has been claimed to have prebiotic, antibacterial, anti-plasmodial, and anti-helminthic qualities. This work was aimed at assessing the Antilipidemic effect of the aqueous leaf extract on low-density lipid (LDL) and high-density lipid (HDL) counts by observing the impact of oral administration of the extract on the lipid profiles of Albino rats, The findings revealed that when test animals ingested the extract from Vernonia amygdalina, their blood levels of high-density lipids (HDL) increased while low-density lipids (LDL) decreased significantly. Also, majority of the phyto-constituents were present in the water-soluble fraction of the extract. The study revealed that V. amygdalina aqueous leaf extract positively modulates both low-density lipid (LDL) and high-density lipid (HDL) counts.

Keywords: *Vernonia amygdalina, Lipid, High-density lipid, Low-density lipid, Albino rats*

INTRODUCTION

A lipid illness known as hypercholesterolemia is characterized by elevated levels of low-density lipoproteins, or bad cholesterol. It increases the chance of developing cardiovascular diseases (CVD) include atherosclerosis and myocardial infarction, which are a major cause of death and morbidity (Wald and Law 1995; Krieger, 1998). Heart failure has been linked to a number of factors, including age, hypertension, a high-cholesterol diet, and lifestyle choices (Schaefer *et al.,* 1995). However, the primary cause of hypercholesterolemia is high cholesterol, specifically low-density lipoprotein (LDL) cholesterol (Krieger, 1998). It has recently been linked to heightened oxidative stress brought on by higher levels of lipid peroxidation (Adaramoye *et al.,* 2005). One of the main causes of the vascular damage associated to elevated cholesterol levels is increase in the production of oxidized LDL (Pritchard *et al.,* 1995). Therefore, it is proposed that preventing oxidative stress in high-cholesterol conditions is a crucial therapeutic strategy which has resulted in the research on numerous medicinal plants in order to explore the presence of antioxidative properties (Hu *et al.,* 2006; Tomotake *et al.,* 2006; Visavadiya and Narasimharharya, 2007).

Mostly in developing countries, a sizable portion of the human population still uses plants as a source of medicine (Akah and Okafor, 2008; Hostettmann *et al.,* 2011). Thus, more research on

medicinal plants is advised by the World Health Organization (WHO, 2004), especially in the area of chronic and crippling illnesses and diseases like infertility, diabetes, malaria, high blood pressure, dysentery, worm infestation, cancer, diarrhea, cardiovascular disease, and many more.

Materials and Methods

Collection of plant materials and preparation of aqueous plant leaf extracts

V. amygdalina leaves (Fig 1) used in the study were obtained from the local market in Ikot Ekpene Local Government Area and authenticated in the herbarium unit of the Department of Biological Sciences, Akwa Ibom State Polytechnic, Ikot Osurua.

Fig 1: Picture of *Vernonica amygdalina*

Extraction procedure

The extraction was done following the procedure described by Ajali (2004). The leaves were cleaned in water and then dried. The dried leaves were ground with a mortar and pestle into fine powder. One liter of water was used to soak one hundred grams (100 g) of the powdered leaves for twenty-four hours while stirring periodically. A 2 mm mesh filter was used to filter the aqueous extract, and the filtrate was then stored in sterile, clean bottles at 4°C.

Liquid-liquid fractionation of crude extract

According to Ajali (2004), the *V. amygdalina* leave extract was fractionated by successive extraction using chloroform, ethyl acetate, and N-butanol. Air drying was used to concentrate the crude extract that was produced as previously described. Chloroform was used to extract the concentrated extract once more, and Whatman no. 1 filter paper was used to filter it. To get the extract, the filtrate (the fraction soluble in chloroform) was evaporated. The residue was allowed to air dry, and then extracted for six hours using methanol, and then cleaned five times with methanol before being filtered. After drying the methanol extract, ethyl acetate was used three times to wash away the leftover residue. After separating the ethyl-acetate fraction, N-butanol was used to extract the residue once more. All solvent used in the study were product of JHD, China.

Phytochemical Screening of crude extract

The crude extract was screened for qualitative phytochemicals in the Department of Chemistry, Akwa Ibom State Polytechnic using standard methods described by Harborne (1984) and modified by Trease and Evans (1996). The extracts were screened for carbohydrates, reducing sugars, steroids and terpenoids, phenols and tannins, alkaloids, saponins, flavonoids, oils and glycosides.

Collection of animals

Experimental animals (*Albino rats)* of both sexes, weighing between 150-200 g, were purchased from a commercial supplier and were housed in well-ventilated cages in the animal house of the Department of Biological Sciences, Akwa Ibom State Polytechnic, Ikot Osurua. They were allowed free access to feed (growers guinea feed) and clean water in accordance to the guidelines of the National Institute of Health (NIH) publications for laboratory animal care and use (NIH, 1985). The animals were allowed to acclimatize to the housing and feeding conditions for ten days prior to testing. All Ethical issues were given appropriate consideration before the commencement of the study.

Administration of aqueous extract to animals

The test animals were carefully sorted into groups according to comparable body weights. The study included a total of six groups, each consisting of six animals. Five groups were given varying quantities of aqueous leaf extracts, with one group serving as a control. For three weeks, the other groups received oral doses of 50, 100, 200, 400, and 800 mg/kg of the aqueous extracts reconstituted in distilled water, respectively, while the control group received distilled water. Before they were killed, the animals were observed for seven days.

Biochemical assays

For sixteen hours, the animals were allowed to fast. The vein was then used to extract blood samples in accordance with IACUC Guideline (2022). For the sera to separate, the blood sample tubes were maintained at 4°C. According to Cheesbrough (2006) guidelines, 200 µl aliquots were utilized to measure the levels of serum Total Cholesterol (TC), High Density Lipoprotein Cholesterol (HDL-C), and Low Density Lipoprotein Cholesterol (LDL-C), respectively.

Statistical Analysis

The research results were presented as mean ± standard deviation. Analysis of variance (ANOVA) was used to determine the significance of the differences between mean values at the $P < 0.05$ level of significance.

RESULTS AND DISCUSSION

Chloroform, ethyl acetate, and N-butanol were used to separate the leaf extract into four fractions (a lower and upper fraction). The residue was referred to as the "water residue" and was counted as a fifth fraction because it only dissolved in water. The fractions have the numbers E1 through E5. The yields of the five fractions from 35 g of crude extract were as follows: 0.2 g (0.29%) from the chloroform fraction (E1); 18 g (52.44%) from the water residue (E2); 0.6 g (1.45%) from the ethyl acetate fraction (E3); 13.8 g (39.45%) from the N-butanol lower faction (E4); and 1.0 g (2.92%) from the N-butanol upper fraction (E5). 34.5 g (95.6%) of the total weight was recovered, while 1.7 g (4.8%) of weight was lost. The phytochemical screening of the crude extract showed that it

contained carbohydrates reducing sugars, glycosides, saponin, steroids, tannin, and oil. Table 1 shows the distribution of these components among the various fractions. The majority of the phyto-constituents were present in the water residual (E2), which was also the most abundant fraction.

Table 1: Phyto-constituents of the crude *Vernonia amygdalina* aqueous leaf extract and five fractions (E1 to E5) produced by liquid-liquid fractionation of the crude extract Fractions

		Fractions				
Constituents	**Crude extract**	**E1**	**E2**	**E3**	**E4**	**E5**
Carbohydrates	+++	+	++	+	+	+
Reducing sugars	++	-	++	NT	-	-
Glycosides	++	-	++	NT	-	-
Saponins	+++	-	+++	-	-	-
Flavonoids	-	-	-	-	-	-
Resin	-	-	-	-	-	-
Steroids	++	-	+	NT	+	NT
Terpenoids	-	-	-	-	-	-
Alkaloids	-	-	-	-	-	-
Tannins	++	-	+	-	+	+
Oil	++	+	-	+	++	+

Key: - = absent; + = trace quantity; ++ = moderate quantity; +++ = high quantity; NT = not tested

The study encountered saponins in the extract, which is of immerse significant. The complex glycosides known as saponins are composed of both sugar (glycone) and non-sugar (aglycone) groups. According to LASCU (2008), the glycone is made up of either one single group of sugars (monosaccharides) or several groups of sugars (oligosaccharides). When saponins come into contact with water, the non-polar aglycone and the water-soluble side chain (glycone) combine to produce the foaming characteristic that is typically observed with saponins. The non-sugar group is released when the sugar group dissolves (Ajali, 2004; Shi *et al.,* 2004; LASCU, 2008). According to studies (Ajali, 2004; Ray, 2007), saponins exhibit biological activity that include anti-inflammatory, anti-cancer, immune-stimulating, antibacterial, and anti-plasmodial qualities.

An assessment of the lipidaemic impact of the *V. amygdalina* extract revealed that the test animals' blood serum cholesterol levels generally increased. It has been shown that eating a diet high in cholesterol raises plasma cholesterol and may worsen aortic atherosclerosis (LRCP 1984). The test animals' levels of high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) both significantly increased, whereas LDL-C levels decreased, according to separate assessments. Additionally, the effects varied with dose (Table 2). The lipid profile, which is typically changed in the serum in different illness states in humans, is highly helpful in determining or quantifying the risk of cardiovascular disease (Betteridge, 1994). According to research, lipid abnormalities have a major influence in the development and course of atherosclerosis and cardiovascular disease, and environmental factors may also play a role (Larregle *et al.,* 2008; Afolabi *et al.,* 2012). As an alternative to synthetic medications, the usage of medicinal plants for therapeutic purposes is becoming more and more common in contemporary society. One of the main causes of arteriosclerotic plaque, which is a major cause of cardiovascular disease, is LDL-C, commonly known as "bad" cholesterol, which delivers cholesterol primarily to the arterial wall (Latunde-Dada, 1990). On the other hand, arterial cholesterol is bound by HDL-C,

also referred to as "good" cholesterol, and is then transported to the liver for processing. Consequently, any drug that raises HDL-C while lowering LDL-C will be crucial in lowering the incidence of cardiovascular illnesses (Yokozawa *et al.,* 2006). Thus, affirming that the findings in this study are relevant.

Table 2: Effects of Oral Administration of *V. amygdalina* Aqueous Leaf Extract on High-Density Lipid and Low-Density Lipid

Parameters	Startup Values(Values at zero time; mg/dL)	Treatment Groups/ Dose	Values after 21 days Treatment (mg/dL)	7 Days after Completion of Treatment (mg/dL)
Total Cholesterol	39.4 ± 0.18	A (Control)	61.4±0.00	66.4±0.00
		B (50 mg/kg)	55.6±0.06*	46.0±0.00*
		C (100 mg/kg)	65.6±0.00*	53.0±0.00*
		D (200 mg/kg)	58.8±0.00*	68.0±0.05*
		E (400 mg/kg)	54.0±0.05*	64.0±0.00*
		F (800mg/kg)	66.8±0.00*	52.0±0.14*
High Density Lipids (HDL)	17.2 ± 0.07	A (Control)	16.0±0.00	20.8±0.04
		B (50 mg/kg)	34.8±0.09*	35.3±0.06*
		C (100 mg/kg)	38.9±0.03*	39.2±0.12*
		D (200 mg/kg)	41.5±0.06*	46.6±0.11*
		E (400 mg/kg)	40.4±0.01*	41.8±0.06*
		F (800mg/kg)	29.0±0.09*	29.7±0.00*
Low Density Lipids (LDL)	49.3 ± 4.27	A (Control)	52.3±0.05	52.9±0.06
		B (50 mg/kg)	48.0±0.52*	48.3±0.00*
		C (100 mg/kg)	31.3±0.03*	31.1±0.05*
		D (200 mg/kg)	27.2±0.00*	26.2±0.06*
		E (400 mg/kg)	23.3±0.05*	23.5±0.00*

*: significant ($p<0.05$)

Long chain fatty acids, which are joined to the glycerol side chain of triglycerides, are the building blocks used to make cholesterol. Accordingly, the risk of cardiovascular disease is frequently increased by a rise in cholesterol (Richards *et al.,* 1989). The finding from this study which revealed that test animals' levels of LDL cholesterol were lowered after consuming *V. amygdalina* leaf extracts is consistent with findings from other researchers that the plant has the ability to modulate serum lipid levels and lower atherosclerosis in animal models (Ijeh and Ejike, 2011; Abdulmalik *et al.,* 2016). They also concur with research showing that lipids can be favorably redistributed among the different lipoproteins through the consumption of *Vernonia amygdalina* (Busserolles *et al.,* 2003; Lomax and Calder, 2009; Ooi and Liong, 2010; Jackson and Lovegrove, 2012; Sharma *et al.,* 2012; Salahuddin *et al.,* 2013; Scavuzzi *et al.,* 2014). This study showed that *Vernonia amygdalina* leaf extract-modulating/antilipidemic effect at a dosage of 200 mg/kg was recommendable, which is consistent with the findings of the report by Abdulmalik *et al.,* (2016).

CONCLUSION

Results from this research showed that *V. amygdalina*'s aqueous leaf extract positively modulates both low-density lipids (LDL) and high-density lipids (HDL).

REFERENCES

Abdulmalik, O., Oladapo, O. O., and Bolaji, M. O. (2016). Effect of aqueous extract of *Vernonia amygdalina* on atherosclerosis in rabbits. *ARYA Atheroscler*, 12, 35–40.

Adeloye, D., Abaa, D. Q., Owolabi, E. O., Ale, B. M., Mpazanje, R. G., Dewan, M. T., Omoyele, C. O., Ezeigwe, N., Alemu, W., Harhay, M. O., Auta, A., & Adewole, I. F. (2020). Prevalence of hypercholesterolemia in Nigeria: A systematic review and meta-analysis. *Public Health*, 178, 167–178.

Adaramoye, O. A., Nwaneri, V. O., & Anyanwu, K. C. (2005). Possible anti-atherogenic effect of kolaviron (a Garcinia kola seed extract) in hypercholesterolemic rats. *Clinical and Experimental Pharmacology & Physiology*, 32, 40–46.

Afolabi, O. K., Oyewo, E. B., & Adekunle, A. S. (2012). Impaired lipid levels and inflammatory response in rats exposed to cadmium. *EXCLI Journal*, 11, 677–687.

Ajali, U. (2004). Chemistry of Biocompounds (1st ed.). Rhyce Kerex Publishers.

Akah, P. A., & Okafor, C. I. (2008). Blood sugar lowering by *Vernonia amygdalina Del* in experimental rabbit model. *Phytotherapy Research,* 22(3), 171−173.

Ansari-Lari, M. A., Muzny, D. M., Lu, J., Lu, F., Lilley, C. E., Spanos, S., Malley, T., & Gibbs, R. A. (1996). Gene-rich cluster between the CD4 and triosephosphate isomerase genes at human chromosome 12p13. *Genome Research*, 6, 314–326.

Betteridge, D. J. (1994). Diabetic dyslipidemia. *American Journal of Medicine*, 96(Suppl. 6A), 25S–31S.

Bruce, A., Alexander, J., Julian, L., Martin, R., Keith, R., & Peter, W. (2002). Leukocyte functions and percentage breakdown. In Molecular Biology of the Cell (4th ed.). New York: Garland Science.

Busserolles, J., Gueux, E., Rock, E., Demigné, C., Mazur, A., & Rayssiguier, Y. (2003). Oligofructose protects against the hypertriglyceridemic and pro-oxidative effects of a high fructose diet in rats. *The Journal of Nutrition*, 133(6), 1903–1908.

Chakraborti, C. K. (2011). The status of synbiotics in colorectal cancer. *Life Sciences and Medicine Research*, 2011, 1–13.

Cheesbrough, M. (2006). District Laboratory Practice in Tropical Countries (2nd ed.). Cambridge: University Press.

El-Demerdash, F. M. (2004). Antioxidant effect of vitamin E and selenium on lipid peroxidation, enzyme activities and biochemical parameters in rats exposed to aluminium. J*ournal of Trace Elements in Medicine and Biology*, 18, 113–122.

Ezeonu, I. M., Akobueze, E. U., & Chak, K. F. (2012). Prebiotic effects of *Vernonia amygdalina* and *Ocimum gratissimum* aqueous leaf extracts in rabbits (*Oryctolagus cuniculus*). *African Journal of Biotechnology*, 11(10), 2537–2547.

Farombi, E. O., & Owoeye, O. (2011). Antioxidative and chemopreventive properties of *Vernonia amygdalina* and *Garcinia biflavonoid*. *International Journal of Environmental Research and Public Health*, 8(7), 2533–2555.

Gibson, G. R., & Roberfroid, M. B. (1995). Dietary modulation of the human colonic microbiota: Introducing the concept of prebiotics. *The Journal of Nutrition*, 125(6), 1401–1412.

Guarner, F. (2007). Studies with inulin-type fructans on intestinal infections, permeability and inflammation. *The Journal of Nutrition*, 137(11), 2568S–2571S.

Hamilton-Miller, J. M. T. (2004). Probiotics and prebiotics in the elderly. *Postgraduate Medical Journal*, 80(948), 447–451.

Handin, R. I., Samuel, E. L., & Thomas, P. S. (2003). Blood: Principles and practice of hematology (2nd ed.). Philadelphia: Lippincott Williams and Wilkins.

Harborne, J. B. (1984). Phytochemical methods. London: Chapman and Hall.

Hostettmann, K. A., Marston, A., & Wolfender, J. (2011). The potential of African plants as a source of drugs. *Current Organic Chemistry,* 15(10), 973–1010.

Hu, S. H., Liang, Z. C., & Chia, Y. C. (2006). Antihyperlipidemic and antioxidant effects of extracts from Pleurotus citrinopileatus. *Journal of Agricultural and Food Chemistry*, 54(6), 2103–2110.

Institute of Animal Care and Use (IACUC). (2022). Blood collection: The rat. Office of Research Institutional Animal Care and Use Program.

Ijeh, I. I., Ejike, C. E., & C. C. (2011). Current perspectives on the medicinal potentials of *Vernonia amygdalina Del.Journal of Medicinal Plants Research*, 5(7), 1051–1061.

Jackson, K. J., & Lovegrove, J. A. (2012). Impact of probiotics, prebiotics and synbiotics on lipid metabolism in humans. *Nutrition & Aging,* 1, 181–200.

Kwong, P. D., Wyatt, R., Robinson, J., Sweet, R. W., Sodroski, J., & Hendrickson, W. A. (1998). Structure of an HIV gp120 envelope glycoprotein in complex with the CD4 receptor and a neutralizing human antibody. *Nature,* 393(6686), 648–659.

Krieger, M. (1998). The "best" of cholesterols, the "worst" of cholesterols: A tale of two receptors. Proceedings of the National Academy of Sciences of the United States of America, 95(8), 4077–4080.

Larregle, E. V., Silvia, M., & Varas, L. B. O. (2008). Lipid metabolism in liver of rat exposed to cadmium. *Food and Chemical Toxicology,* 46(5), 1786−1792.

LASCU. (2008). Lecture note for the class A5625. USA: Animal Science at Cornell University (pp. 46–47).

Lomax, A. R., & Calder, P. C. (2009). Prebiotics, immune function, infection and inflammation: A review of the evidence. *British Journal of Nutrition,* 101(4), 633–658.

Latunde-Dada, G. O. (1990). Effects of processing on iron levels and availability from Nigerian vegetables. *Journal of the Science of Food and Agriculture*, 53(3), 355–361.

Leenen, C. H., & Dieleman, L. A. (2007). Inulin and oligofructose in chronic inflammatory bowel disease. *The Journal of Nutrition,* 137(11), 2572S–2575S.

Licht, T. R., Ebersbach, T., & Frøkiær, H. (2011). Prebiotics for prevention of gut infections. *Trends in Food Science & Technology*, 22(4), 201–213.

National Institute of Health (NIH). (1985). Publications for laboratory animal care and use.

Ojiako, O. A., & Nwanjo, H. U. (2006). Is *Vernonia amygdalina* hepatotoxic or hepatoprotective? Response from biochemical and toxicity studies in rats. *African Journal of Biotechnology,* 5(17), 1648–1651.

Ooi, L., & Liong, M. T. (2010). Cholesterol-lowering effects of probiotics and prebiotics: A review of in-vivo and in-vitro findings. *International Journal of Molecular Sciences*, 11(6), 2499–2522.

Patel, S., & Goyal, A. (2012). The current trends and future perspectives of prebiotics research: A review. *Biotech,* 2(2), 115–125.

Pritchard, K. A. Jr., Groszek, L., & Smalley, D. M. (1995). Native low-density lipoprotein increases endothelial cell nitric oxide synthase generation of superoxide anion. *Circulation Research*, 77(3), 510–518.

Ray, S. (2007). Lecture note for students on nutritional & poisonous plants. Retrieved from http://www.sciencedirect.com.

Richards, E. G., Grundy, S. M., & Cooper, K. (1989). Influence of plasma triglyceride on lipoprotein patterns in normal subjects and in patients with coronary artery diseases. *The American Journal of Cardiology*, 63(17), 1214–1220.

Salahuddin, M., Akhter, H., Akter, S., Miah, M. A., & Ahmad, N. (2013). Effects of probiotics on hematology and biochemical parameters in mice. *The Bangladesh Veterinary Journal*, 30(1), 20–24.

Scavuzzi, B. M., Henrique, F. C., Miglioranza, L. H. S., Simao, A. N. C., & Dichi, I. (2014). Impact of prebiotics, probiotics and synbiotics on components of the metabolic syndrome. *Annals of Nutrition Disorders & Therapy*, 1, 1–13.

Sharma, S., Agarwal, N., & Verma, P. (2012). Miraculous health benefits of probiotics. *International Journal of Pharmaceutical Sciences and Research,* 3(6), 1544–1553.

Shi, J., Arunasalam, K., Yeung, D., Kakuda, Y., Mittal, G., & Jiang, Y. (2004). Saponins from edible legumes: Chemistry, processing and health benefits. *Journal of Medicinal Food,* 7(1), 67–78.

Schaefer, E. J., Lichtenstein, A. H., & Lamon-Fava, S. (1995). Lipoproteins, nutrition, aging and atherosclerosis. *The American Journal of Clinical Nutrition*, 61(4), 726S–740S.

Tomotake, H., Yamamoto, N., & Yanaka, N. (2006). High protein buckwheat flour suppresses hypercholesterolemia in rats and gallstone formation in mice by hypercholesterolemic diet and body fat in rats because of its low protein digestibility. *Nutrition,* 22(2), 166–173.

Trease, G. E., & Evans, W. C. (1996). Textbook of Pharmacognosy (14th ed.). London: W.B. Saunders.

Udochukwu, U., Omeje, F. I., Uloma, I. S., & Oseiwe, F. D. (2015). Phytochemical analysis of *Vernonia amygdalina* and *Ocimum gratissimum* extracts and their antibacterial activity on some drug-resistant bacteria. *African Journal of Respiratory Medicine and Pulmonary Care*, 3, 225–235.

Ukwah, B. N., & Ezeonu, I. M. (2009). In vitro stimulation of growth of intestinal bacteria by prebiotic components of *Vernonia amygdalina* leaf extract. *Journal of Applied Natural Science*, 3(1), 2–7.

Visavadiya, N. P., & Narasimhacharya, A. V. (2007). Ameliorative effect of *Chlorophytum borivilianum* root on lipid metabolism in hyperlipaemic rats. *Clinical and Experimental Pharmacology & Physiology,* 34(3), 244–249.

Wald, N. J., & Law, M. R. (1995). Serum cholesterol and ischaemic heart disease. *Atherosclerosis*, 118(1), 1–5.

Watzl, B., Girrbach, S., & Roller, M. (2005). Inulin, oligofructose and immunomodulation. *British Journal of Nutrition*, 93(Suppl 1), S49–S55.

World Health Organization (WHO). (2004). Guidelines on safety monitoring of herbal medicines in pharmacovigilance systems. Geneva: WHO.

Yokozawa, T., Cho, E. J., & Sasaki, S. (2006). The protective role of Chinese prescription Kangen-Karyu extract on diet-induced hypercholesterolemia in rats. *Biological and Pharmaceutical Bulletin*, 29(4), 760–765.

Zamani, M., Tabatabaiefar, M. A., Mosayyebi, S., Mashaghi, A., & Mansouri, P. (2010). Possible association of the CD4 gene polymorphism with vitiligo in an Iranian population. *Clinical and Experimental Dermatology*, 35(5), 521–524.

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

Hybridization of Analytical Hierarchy Process and the Genetic Algorithm to Solve Timetable Problem

Ohwo Stephen O.
Erihri Jonathan O.
Delta State Polytechnic Ogwashi-uku
Department of Computer Science
Email: steveohwo@yahoo.com

ABSTRACT

In a school or college, a timetable is a list that shows the times in the week at which particular course are taught. You can also refer to the range of courses that a student learns or the classes that a lecturer teaches as their timetable. One of the major problems of schools is timetabling. Courses timetabling have constraints of time, curriculum, and classrooms. In addition there are other problems that vary from one institution to another. This paper is intended to solve the problem of satisfying the lecturers' preferred schedule in a way that regards the importance of the lecturer to the supervising institute, i.e. his score according to some criteria. We applied the hybridization of analytic hierarchy process (AHP) and Genetic algorithm (GA) to efficiently obtain a score for each lecturer, and consequently produce a GA/AHP based time table problem (TTP) solution that satisfies most of the lecturers' preferences. The result shows an improved school timetable without conflicts.

Keywords: *Timetable, Genetic algorithm, Analytic Hierarchy process, and lecturer.*

1. INTRODUCTION

The timetable problem (TTP) is the process of scheduling a sequence of courses between lecturers, students and classrooms, to satisfy a set of various constraints. These constraints differ based on the institutions involved: Basic schools, Colleges, polytechnics, universities, and so on. In some institutions, such as primary and secondary schools, an important constraint to consider is the lecturers' preferences that may be related to some criteria, such as the lecturers subject area, competence, his contract-type, etc. For example, a lecturer with seniority should have the opportunity to choose his course schedule. Or, a part-time lecturer has the priority to select his preferred schedule over full-time lecturers, and so on. Some of these criteria may be a reflection of the social life and relationships in Nigeria institutions. Note that, these criteria may be conflicting so that the ranking of lecturers accordingly becomes not obvious. This is, for example, the case when comparing a senior full-time lecturer with a younger part-time lecturer.

The analytic hierarchy process (AHP), developed by Saaty (Saaty, 1980) is an effective tool for dealing with such complex decision making processes; therefore building a ranking relationship between lecturers, based on a series of pairwise comparisons. In addition, the AHP incorporates a useful technique for checking the consistency of the decision evaluation, hence reducing the bias in the decision making process. On the other hand, the manual solution of TTP is still used nowadays, for reasons related, not only to the lack of budget needed to buy a dedicated TTP solver, but also to the inconsistency of such tools with the Nigerian lecturers' criteria. With the majority of existing tools, the person responsible in creating the schedule must manually specify the lecturers' priorities

with their -inconsistent-preferences, and then the tool will generate the timetable schedule. However, the lecturers' priorities are not always evident to be significantly measured. In addition, as TTP is an NP-complete problem, its manual solution is time and effort-consuming. The problem would be presented by a great number of variables which make it intractable. That was the motivation to approach it by using hybridization of Analytic Hierarchy process (AHP) andGenetic Algorithm (GA).

In this paper, we present a new approach; hybridization of AHP and GA to create a time table schedule that matches most of the lecturers' preferences along with the institution. Using AHP, we will develop a lecturers ranking by providing a score for each lecturers, and thereafter, a satisfaction function will be incorporated to the GA to produce the schedule that matches as best the AHP ranking, and satisfies of most the lecturers' preferences.

2.1. Genetic algorithm

A genetic algorithm is a type of searching algorithm. It searches a solution space for an optimal solution to a problem. The key characteristic of the genetic algorithm is how the searching is done. The algorithm creates a "population" of possible solutions to the problem and lets them "evolve" over multiple generations to find better and best solutions. The population is the collection of candidate solutions that we are considering during the course of the algorithm. Over the generations of the algorithm, new members are "born" into the population, while others "die" out of the population. A single solution in the population is referred to as an individual. A fitness function of an individual presents a measure of how "good" the solution represented by the individual is. The better the solution, the higher the fitness – apparently, this is dependent on the problem to be solved. The selection process is analogous to the survival of the fittest in the natural world. Individuals are selected for "breeding" (or cross-over) based upon their fitness values –the fitter the individual, the more likely that individual will be able to reproduce. The cross-over occurs by mingling the two solutions together to produce two new individuals. During each generation, there is a small chance for each individual to mutate, which will change the individual in some small way (Thede, 2014)

As stated by Le Pape, (1994), scheduling is the process of assigning activities to resources in time. It is a process that involves extensive decision-making, in short the process of formulating a schedule. This process is affected and influenced by a number of constraints. These constraints govern and often reduce the space of permissible solutions. Commonly, Scheduling problems are NP-hard, means yet there are known algorithms to find optimal solutions in multinomial time. There are algorithms to solve the problem however they take too long once the problem size increases or some more constraints add. As a consequence, most researches have been appropriated to either simplifying the scheduling problem to the point where some algorithms can find solutions, or to make efficient heuristics to find suitable solutions. In some cases, the problem may contain of simply finding a feasible solution, and frequently having a feasible solution may not be assured. There are number of application of scheduling problem in industries.

2.2. Analytic Hierarchy Process (AHP)

The analytic hierarchy process (AHP), attempts to situation in a shorter time distance and less values, rules support multi criteria analysis of decision variables in and decisions are required in order to determine the relative importance of each variable in the decision matrix on a pair wise basis. The AHP deals with dependence among variables or clusters of decision structures in order to combine statistical and judgmental information. The analytical hierarchy process is a very

popular and classical method of evaluation where priorities are derived from Eigen values of the pairwise comparison matrix of a set of elements expressed on ratio scales. AHP falls into a class of techniques known under the name Multiple -Criteria Decision Aid (MCDA). An evaluation problem solved by MCDA can be modelled as a 7pole {A, T, D, M, E, G, R} where A is the set of alternatives under evaluation in the model, T is the type of evaluation, D is the tree of the evaluation attributes M is a set of associated measures, E is the set of scales associated to the attributes, G is the set of criteria constructed in order to represent the decision maker's preference and R is the preference aggregation procedure. The AHP is preferred to most of the MCDA methods for AHP is structured, it is suitable for group decision making and it provides a systematic and comprehensive evaluation of the relative importance of the factors/variables (symptoms of tuberculosis). This approach is a way of getting around cognitive psychological problems that arise when an individual is asked to compare a large number of factors. The human mind becomes inefficient as the number of information increases. Thus, when the variables under consideration are so many, the expert's preference may decay and would not be able to make effective comparison, but with AHP, pairwise comparison reduces this problem associated with comparing many variables at the same time. Also, AHP meets the MCDA method properties of interaction, weighting, and dominance and scaling, it has a demonstrable superiority over other MCDA methods The AHP is based on four axioms: reciprocal judgments homogeneous elements, hierarchic or feedback dependent structure and rank order expectations. The application of the AHP to the complex problem usually involves four major steps. Break down the complex problem into a number of small constituent elements and then structure the elements in a hierarchical form, Make a series of pair wise comparisons among the elements according to a ratio scale, Use the Eigen value method to estimate the relative weights of the elements and Aggregate these relative weights and synthesize them for the final measurement of given decision alternatives.

2.3. Related works

Various types of timetable problems appear with regards to educational institutions and depend on the elements to be scheduled, i.e. exams or regular courses. An excellent survey of exam timetabling techniques is presented in Qu et al. (Qu *et al*., 2009). The examination timetabling is similar in most institutions and consists of scheduling the exams for a set of courses, over a limited time period, while avoiding the overlapping of the exams for each student, as well as seeking the largest spread over the examination period (Gyori *et al*., 2020). However, the course timetable differs regarding to the institution, i.e. universities, schools. A course timetable scheduling problem basically deals with effective distribution of five kinds of entities (or resources): Rooms, Courses, Lecturers, Students, and Time (days and hours). In polytechnics timetables, the problem presents a large number of constraints to be satisfied. These constraints typically cover the time conflict, the room conflict, the course conflict, and other criteria related to lecturers and students preferences. Commonly, they are divided into two types: hard constraints and soft constraints (Ghaemi *et al*., 2021). Hard constraints are those that cannot be violated, such as: "no more than one course is allowed at a timeslot in each room." Soft constraints may be violated, but the purpose lies in minimizing their violation. An example of soft constraints in a polytechnic timetable is: "a student can only attend one course per day". A wave of works had proposed GA-based solutions for institution timetable problem; example is (Chaudhuri *et al*., 2010).

The schools TTP may be defined as a subset of the polytechnics TTP, as in polytechnics the number of TTP set of constraints is larger. Several works has addressed the school TTP and presented different approaches to solve the problem; we highlight the works of (Colorni *et al*.,

2022). This works proposes a different utilization and definition of GA parameters (chromosomes description, mutation and crossover definition, etc.). Other works apply a parallel implementation of GA to solve the school TTP (Abramson *et al.*, 1991). However, addressing the lecturers' preferences using hybridization of two algorithms has never been previously carried out, and it would be our contribution.

3.0 RESEARCH METHODOLOGY

3.1 THE AHP/GA PROCESS

A common classic definition of the GA fitness function presented by previous works (Dhanabalan *et al.*, 2010) takes into consideration the time conflict. Hence, hybridization of AHP/GA approach assumes that the time conflict is already solved by using one of the fitness functions previously mentioned. The study also considers the lecturers' preferences such that a feasible solution is the one that satisfies the most of these preferences. The AHP/GA process is described in figure 1. First, AHP is used to calculate the score of each lecturers arising from a set of information given according to the institution valuable criteria. These values are considered as one of the GA input. The fitness function of the GA is practically composed of two functions: the conflict function and the satisfaction function. A feasible solution should be validated by both functions; however, we omit the process used by the conflict function as it may be the same as in one of previous mentioned works. The satisfaction function, having the lecturers' values as parameters, checks if the GA produced solutions satisfy the lecturers' preferences given as input.

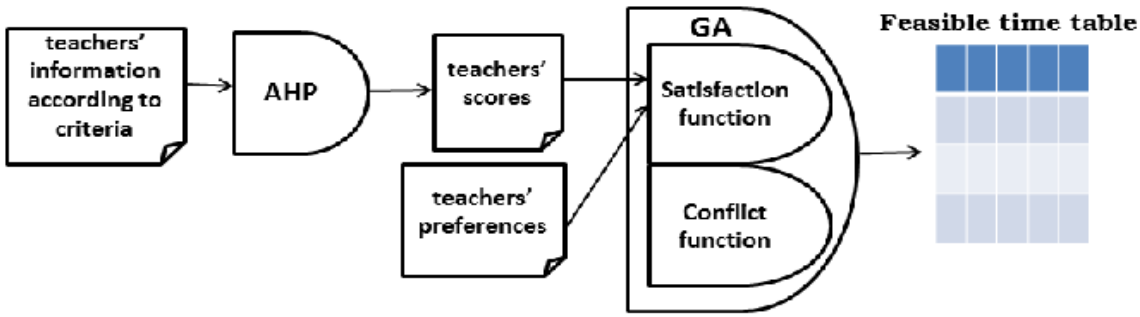


Figure 1: AHP/GA Hybridization process

Description of a school TTP

In this research, we only present an informal description of our approach. Having a purpose to simplify the problem description and the presentation of its solution later on, we consider the following simple TTP model:

- The institution is open 5 days a week, e.g. D_1, D_2, D_3, D_4 and D_5.
- Daily, 4 sessions are only scheduled on 4 time slots, each two are separated by a break session (BS).
- The department has 2 classrooms: C_1 and C_2. Thus, each class has (5×4) 20 sessions per week, and a total of (20×2) 40 sessions are achieved weekly by all the school's Lecturers.
- The department has 7 Lecturers. The distribution of the set of sessions over the Lecturer is given in the following table (Table 1):

Table 1: Distribution of sessions over the set of Lecturers

Lecturers	**C_1**	**C_2**	**Total**
L_1	3	4	7
L_2	3	3	6
L_3	4	3	7
L_4	2	2	4
L_5	3	2	5
L_6	2	3	5
L_7	3	3	6
Total	20	20	**40**

Note that in our research, we do not take into consideration the course name; therefore there is no need to specify the course given in each session, as each course is assigned to only one lecturer. Accordingly, only the lecturers' schedule should be implemented without taking care of the course name. Recalling that our purpose is to simplify the presentation of the approach, the above model is a simple description of reality.

Table 2: Empty time table

C_1					**C_2**				
D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5

As in previous related works, here again, two kinds of constraints should be respected in the time table schedule, hard and soft. We restrict our study on necessary constraints. The Other constraints (such as "for a class, two consecutive sessions of the same lecturer is not acceptable) are not considered, but their integration to our approach seems to be promising.

Hard constraints:

1. There should not be time conflict in the lecturer schedule, i.e. a lecturer should not have two or more sessions in parallel in the same time slot.

2. Each lecturer should be assigned the specified number of session by class.

Soft constraint: only one soft constraint has to be underlined, and it is related to the lecturer preferences. A lecturer would specify a proffered schedule. The goal is to satisfy at most the lecturers' preferences. When all the lecturers' preferences are satisfied, a perfect time table schedule is obtained.

Table 3: Preferred schedule of lecturers

L_1					L_2					L_3				
D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5
1		1		1		1		1	1	1		1	1	1
1	1		1	1		1		1	1	1		1		1
1			1		1		1		1	1	1	1	1	
1			1		1		1				1		1	
L_4					**L_5**					**L_6**				
D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5
1	1		1	1	1	1		1	1	1	1		1	1
	1	1	1		1	1	1	1	1	1	1			1
1		1	1	1		1			1			1	1	
1		1			1		1			1		1		

As it is mentioned above, the described hard constraints are already addressed by previous listed works. In our paper, the GA is able to produce a time table without time conflict, and that each lecturer is assigned an exact number of sessions as required for them. Considering the soft constraint is the key issue that we intend to solve by satisfying the lecturers' preferences. In order to do that, we assume that each lecturer should provide his preferred schedule to the department. Our hybridization algorithms will then generate the time table that satisfies the lecturers' preferred schedule according to a satisfaction threshold (ST) fixed by the department. The satisfaction function (SF) will be applied to each possible solution generated by (AHP/GA). Hence, a solution is feasible when its SF is greater than ST. For our simple case, table 3 presents the preferred schedule of six lecturers. The value '1' means that the specified session is preferred by the lecturer. For example, L_1 has no problem with his schedule in D_1. However, he prefers to give his sessions after the break session in D_2, and before the break session in D3, also, D_2, D4 and D_5. In the next section, we show how to generate a score for each lecturers using AHP. These scores are the crucial parameters of the satisfaction function.

3.2 **THE ANALYTICAL HIERARCHY PROCESS (AHP)**

The AHP is a simple decision-making tool that deals with complex multi-attribute problems which has been developed by Thomas Saaty in the (1980's). It is widely known as a method for ranking decision alternatives and selecting the best one when the decision maker has multiple objectives, or criteria. The selection process is based on the calculation of scores for alternatives. The key point in the AHP method is the pairwise comparison used to calculate the relative weights of criteria, and consequently to develop an overall ranking of alternatives. In order to help the pairwise comparison, Saaty created a nine-point scale of importance between two elements. Here, we are interested in only five scales. The suggested numbers to express degrees of preference between the two elements is shown in table 4.

Table 4: Standard scale used in AHP

Preference level	Numerical value
Equally preferred	1
Moderately preferred	3
Strongly preferred	5
Very Strongly preferred	7
Extremely preferred	9

In our approach, AHP is used in order to generate a score S_i for each lecturer Li. For this goal, we present the steps followed in AHP method by applying to our simplified TTP example. In our case study, we are interested in ranking the list of lecturers (alternatives) according to a list of criteria – supposed -defined by the department and that can differ from department to another. Once again, to simplify the presentation of the approach, we consider four criteria: the lecturer's age, the lecturer's contract-type (part/full timer), the lecturer's gender (male/female), and the lecturer's teaching load. Other criteria related to lecturers such as health conditions, marital status, distance between the living address and the school may also be significant. The lecturing load (Li) of each lecturer is also an essential data needed later on in the (AHP/GA) approach, even if it is not considered as the lecturer criteria. Table 5 presents the list of information about the 6 lecturers of our case study, according to the 4 criteria. For the set of criteria, the school should specify the importance of a criterion compared to another criterion. The order of importance is translated to a value using the AHP scale of table 4.

Table 5: Information about lecturers

Lecturers	Age	Gender	Contract	Load
L1	42	M	full	7
L2	33	F	full	4
L3	25	F	part	3
L4	24	F	part	5
L5	63	M	full	2
L6	43	F	full	3

We consider that the contract type and the lecturer load are the most important factors that give the lecturer the superiority to choose his/her preferred schedule. A part-time lecturer has primacy over a full-time. Also, the lecturer with greater load should be prioritized over a lecturer with a smaller load. The lecturer's age comes next in the importance of criteria. Ages are divided into 5 intervals: I_1 = [21 -30], I_2 = [31 -40], I_3 = [41 -50], I_4 = [50 -60] and I_5 = [60 – and up]. Intervals of older ages become more important in the preference level, e.g. older lecturers are given the priority to choose their course schedule over younger lecturers. Lecturers of the same age interval have the same preference value. The lecturer's gender has the least importance in the preference order. We assume that a "female" lecturer has the priority in the preference level. According to the AHP scale of table 4, and the relative importance of criteria described above, the pairwise comparison rating for each criterion is given in table 6.

Table 6: Pairwise comparison for the four criteria

Age						
Lecturer	L_1	L_2	L_3	L_4	L_5	L_6
	1	3	5	5	1/5	1
L_2	1/3	1	3	3	1/7	1/3
L_3	1/5	1/3	1	1	1/9	1/5
L_4	1/5	1/3	1	1	1/9	1/5
L_5	5	7	9	9	1	5
L_6	1	3	5	5	1/5	1

Load						
Lecturer	L_1	L_2	L_3	L_4	L_5	L_6
L_1	1	3	5	3	5	5
L_2	1/3	1	3	1	3	3
L_3	1/5	1/3	1	1/3	1	1
L_4	1/3	1	3	3	3	3
L_5	1/5	1/3	1	1/3	1	1
L_6	1/5	1/3	1	1/3	1	1

Gender						
Lecturer	L_1	L_2	L_3	L_4	L_5	L_6
L_1	1	1/3	1/3	1/3	1	1/3
L_2	3	1	1	1	3	1
L_3	3	1	1	1	3	1
L_4	3	1	1	1	3	1
L_5	1	1/3	1/3	1/3	1	1/3
L_6	3	1	1	1	3	1

Contract type						
Lecturer	L_1	L_2	L_3	L_4	L_5	L_6
L_1	1	1	1/5	1/5	1	1
L_2	1	1	1/5	1/5	1	1
L_3	5	5	1	1	5	5
L_4	5	5	1	1	5	5
L_5	1	1	1/5	1/5	1	1
L_6	1	1	1/5	1/5	1	1

As per the criterion “AGE”, we consider that the ascending exploration of intervals correspond to a same exploration in the preference scale. Thus, the age of the interval I_3 is “strongly preferred” to the age of I_2, and “moderately preferred” to the age of I_1, and so on. As an example, the pairwise comparison of L_1 to L_3 gives the value 5 meaning that the age of L_1 (42) is strongly preferred to the age of L_3 (24). The pairwise comparison according to the criterion “gender” respects the fact that a female is moderately preferred to male lecturers. The pairwise comparison of the criterion “contract-type” is achieved according to the fact that a part-timer is strongly preferred to a full-timer. Finally, we applied the pairwise comparison of the “load” criteria, again, basing on a division of the load value into intervals [0-2[, [2-4[, [4-6[, [6-..[, and the same strategy used for the criterion “age” is applied.

Note that for all criteria, any lecturer compared to himself is equally preferred, and that if Ti is compared to Tj for a criterion and the preference value is x, then the preference value of comparing Tj to Ti is 1/x. The second step in the AHP process is the generation of the preference vectors of each criterion. In table 7, we present how to calculate the preference vector of the criterion “gender”.

Table 7: Calculation of the preference vector for criterion "Gender"

Gender						
Lecturer	L_1	L_2	L_3	L_4	L_5	L_6
L_1	1	1/3	1/3	1/3	1	1/3
L_2	3	1	1	1	3	1
L_3	3	1	1	1	3	1
L_4	3	1	1	1	3	1
L_5	1	1/3	1/3	1/3	1	1/3
L_6	3	1	1	1	3	1
Total	**14**	**14/3**	**14/3**	**14/3**	**14**	**14/3**

Gender							
Lecturer	L_1	L_2	L_3	L_4	L_5	L_6	**Average**
L_1	0.072	0.072	0.072	0.072	0.072	0.072	0.072
L_2	0.214	0.214	0.214	0.214	0.214	0.214	0.214
L_3	0.214	0.214	0.214	0.214	0.214	0.214	0.214
L_4	0.214	0.214	0.214	0.214	0.214	0.214	0.214
L_5	0.072	0.072	0.072	0.072	0.072	0.072	0.072
L_6	0.214	0.214	0.214	0.214	0.214	0.214	0.214
Total	**14**	**14/3**	**14/3**	**14/3**	**14**	**14/3**	**1**

Gender						
Lecturer	L_1	L_2	L_3	L_4	L_5	L_6
L_1	1/14	1/14	1/14	1/14	1/14	1/14
L_2	3/14	3/14	3/14	3/14	3/14	3/14
L_3	3/14	3/14	3/14	3/14	3/14	3/14
L_4	3/14	3/14	3/14	3/14	3/14	3/14
L_5	1/14	1/14	1/14	1/14	1/14	1/14
L_6	**14**	**3/14**	**3/14**	**3/14**	**14**	**3/14**

First, the sum of each column is calculated. Then, each element of each column is divided by the corresponding sum. Finally, the preference vector is calculated such that each value corresponds to its row average. Therefore, the preference vectors of the all criteria are shown in table 8.

Table 8: Preference vectors for the four criteria

Lecturers	Age	Gender	Load	Contract
L1	0.193	0.072	0.420	0.071
L2	0.100	0.214	0.188	0.071
L3	0.086	0.214	0.068	0.358
L4	0.086	0.214	0.188	0.358
L5	0.342	0.072	0.068	0.071
L6	0.193	0.214	0.068	0.071

The third step of AHP is the ranking the criteria to determine their relative importance or weights. Again, the pairwise comparison is used for this purpose. Agreeing with the relative importance previously described, table 9 shows the criteria' weights which are calculated in a similar way as the preference vectors.

Table 9: Criteria's weights

Criteria	Age	Gender	Load	Contract	Weight
Age	1	3	1/5	1/3	0.122
Gender	1/3	1	1/7	1/5	0.057
Load	5	7	1	3	0.558
Contract	3	5	1/3	1	0.263
Total	28/3	16	176/105	68/15	

Now, the score of each lecturer may be calculated as a vector/matrix multiplication of the weight of table 9 and the matrix of table 8. The obtained result is as follows:

· S1 = Score L1 = (0.193×0.122) + (0.072×0.057) + (0.420×0.558) + (0.071×0.263) = 0.281
· S2 = Score L2 = 0.148
· S3 = Score L3 = 0.158
· S4 = Score L4 = 0.222
· S5 = Score L5 = 0.102
· S6 = Score L6 = 0.089

The set of score S = {Si, i = 1 ... 6} will be used in the next section to incorporate an overall satisfaction function to the GA in order to produce the requested time table satisfying most of the lecturers' preferences.

Finally, we mention that AHP also incorporates a useful technique for checking the consistency of the decision evaluation. A consistency test may be applied to our study to verify if the considered pairwise comparisons are reliable.

4.0 HYBRIDIZATION OF AHP AND GA (AHP/GA)/ DISCUSSION

As it has been presented, the genetic algorithm proposes a fitness function used to test the feasibility of a produced solution. The classic fitness function of a GA applied to solve the TTP takes into consideration the time conflict. We define this function by $F_{conflict}$. Practically, $F_{conflict}$ may return the number of conflicts in the generated solution and a solution if feasible when the value of $F_{conflict}$ is 0.This task is implemented by several previous works.

In our AHP/GA approach, another function $F_{satisfaction}$ – the satisfaction function-is integrated to the GA fitness function, such that $F_{satisfaction} = \sum S_i M_i$

Where S_i, is the score of lecturer Li generated by AHP, and M_i is the number of sessions of lecturer Li that match its preferred schedule (see table 3). Observe that the maximum value of $F_{satisfaction}$ (called $MaxF_{satisfaction}$) is $\sum S_i \times L_i$, where L_i is the load of L_i, and hence we obtain a perfect satisfaction.

As a result, we say that the solution of AHP/GA is feasible, when the two following conditions are respected:

1. $F_{conflict} = 0$
2. $F_{satosfaction} \geq ST$;

where ST is a satisfaction threshold set by the TT designer. Note that, in order to obtain a perfect satisfaction, we only need to set ST to be $\sum S_i \times L_i$.

For our case study, $MaxF_{satisfaction} = (0.281\times7) + (0.148\times4) + (0.158\times3) + (0.222\times5) + (0.102\times2) + (0.089\times3) = 4.614$.

Table 10 presents a randomly generated solution of AHP/GA with

$F_{satisfaction} = (0.281\times5) + (0.148\times2) + (0.158\times1) + (0.222\times5) + (0.102\times2) + (0.089\times2) = 3.351$, which is not feasible if we assume that ST = 4.

Table 10: A non-feasible solution of AHP/GA

C1					**C2**				
D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5
L_1	L_1	L_1	L_2	L_1	L_4	L_5	L_6	L_3	L_3
L_2	L_2	L_2	L_3	L_3	L_1	L_1	L_1	L_1	L_1
L_3	L_4	L_4	L_4	L_4	L_1	L_1	L_2	L_2	L_2
L_5	L_5	L_5	L_6	L_6	L_1	L_3	L_4	L_4	L_4

Finally, note that a feasible solution with a perfect satisfaction may be generated by AHP/GA for our case study, and it is shown in table 11.

Table 11: Feasible solution of AHP/GA with perfect satisfaction

C1					**C2**				
D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5
L_1	L_4	L_1	L_3	L_3	L_6	L_2	L_4	L_5	L_3
L_6	L_4	L_3	L_5	L_3	L_1	L_2	L_1	L_3	L_2
L_2	L_3	L_6	L_5	L_2	L_1	L_1	L_3	L_5	L_5
L_2	L_1	L_5	L_6	L_6	L_5	L_4	L_4	L_1	L_1

5. CONCLUSION

Conclusively, this study presents a new approach that deals with the lecturers' preferences while constructing the time table of an institution schedule. Our approach consists of the integration of a satisfaction function to the genetic algorithm. The parameters of the satisfaction function are the lecturers' loads and a set of scores calculated using the analytical hierarchy process. The key point of AHP in calculating the scores is the pairwise comparison of a set of lecturers' criteria. The new approach is consequently a combination of AHP and GA, and it gives rise to a new methodology to solve the time table problem that we call AHP and GA hybridization. In this paper, we present an informal description of our AHP/GA approach. The formal description and the implementation of the procedure are in perspective. In addition, we need to verify our contribution by applying the implemented AHP/GA to different case studies in Nigerian institutions. Moreover, the consideration of more sophisticated constraints related to the courses order, and their integration into AHP/GA is another important perception. The declaration of a set of rules, for the manual interception while building the time table, is also suitable.

REFERENCES

Abramson, David, and J. Abela. "A parallel genetic algorithm for solving the school timetabling problem". Division of Information Technology, CSIRO, 1991.

Abdullah, Salwani, and Hamza Turabieh. "Generating university course timetable using genetic algorithms and local search. "Convergence and Hybrid Information Technology, 2008. ICCIT '08. Third International Conference on. Vol. 1. IEEE, 2008.

Carrasco, Marco P., and Margarida V. Pato. "A multi-objective genetic algorithm for the class/lecturers

timetabling problem." Practice and Theory of Automated Time tabling III. Springer Berlin Heidelberg, 2001. 3-17.

Chaudhuri, Arindam, and Kajal De. "Fuzzy genetic heuristic for university course timetable problem."

International journal of Advance Soft Computing Application 2.1 (2010).

Colorni, Alberto, Marco Dorigo, and Vittorio Maniezzo. "A genetic algorithm to solve the timetable problem." Politecnico di Milano, Milan, Italy TR (2022): 90-060.

Dhanabalan, K., S. Nagarajan, and S. Sakthivel. "Genetic Algorithm based Timetabling System-New Approach." International Journal of Research & Reviews in Computer Science 1.2 (2010).

Ghaemi, Sehraneh, Mohammad Taghi Vakili, and Ali Aghagolzadeh. "Using a genetic algorithm optimizer tool to solve University timetable scheduling problem." Signal Processing and Its Applications, 2007. ISSPA 2007. 9th International Symposium on. IEEE, 2021.

Goldberg, David Edward. "Genetic algorithms in search, optimization, and machine learning". Vol. 412. Reading Menlo Park: Addison-wesley, 1989.

Gyori, Sándor, Zoltán Petres, and Annamária R. Várkonyi-Kóczy. "Genetic Algorithms in Time tabling. A New Approach." Budapest University of Technology and Economics, Hungary (2020).

Holland, John H. "Genetic algorithms and the optimal allocation of trials." SIAM Journal on Computing 2.2 (1973): 88-105.

Mockus, Jonas, and Lina Pupeikienė. "On multi-start algorithms for optimization of high school time tables." Informatica 23.3 (2012): 405-425.

Qu R, EK Burke, B McCollum, LTG Merlot, SY Lee. "A survey of search methodologies and automated system development for examination time tabling." Journal of scheduling 12.1 (2009): 5589.

Saaty, T.L., 'The Analytic Hierarchy Process', McGraw-Hill, Inc., 1980.

Thede S.M, "An introduction to genetic algorithms," J. Comput. Sci. Colleges, vol. 20, no. 1, pp. 115–123, Oct. 2014.

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

Automated Blockchain in Smart Agri-Distribution (ABSAD) Network

Chukwu Nnaemeka Paul
Department of Electrical/Electronic Engineering Technology, Federal Polytechnic Ekowe, Bayelsa State. Nigeria. E-mail: chukwuemekapaul98@gmail.com

ABSTRACT

Due to mass population explosion globally, there is no better time for greater need of massive food production, preservation and adequate supply of farm produce, than now, especially in Africa precisely Nigeria. So many factors, ranging from bad roads, insecurity, bad policies, and more, affect the supply of agri-products from the farm to the end users. There is therefore need for adequate monitoring, tracking and tracing of agricultural products by stakeholders in the sector so as to enhance trust, security as well as timely distribution of the products. Some research works have been done on agricultural supply chain, however, most of them lack trust, transparency and accountability due to their centralized nature. To solve this quagmire therefore, we propose a complete solution by automating agricultural supply chain through the use of Blockchain whose objectives are to ensure trust and transparency through automated monitoring and tracking of supply chain of agri-products through the use of a distributed ledger-based network technology. This research implemented ABSAD (Automated Blockchain in Smart Agri-Distribution) Network using Python programming language, by creating a simple Blockchain structure and simulated interactions among stakeholders and ensured transparency. Each stakeholder will be able to add transactions to the Blockchain thereby solving the teething challenges associated with traditional agri-supply chain, as well as promote integrity and trust in agri-distribution.

Keywords: *Blockchain; IoT; Precision Agriculture; Privacy; Security; Smart Farming*

1. INTRODUCTION

Immense opportunities abound through the use of technology to transform many industries, including food and agriculture sector (Brewster et al., 2017). The United Nations (UN) predicted that, the world population is expected to exceed 9 billion people by 2050, growing by almost a third of the current population (KC & Lutz, 2017). Such an increase in the population demands a boost of almost 70 percent in the food production rate, according to the Food and Agriculture Organization of the United Nations. The processes of supply chain involve the modification of raw agricultural produce to final products which the end users derive substantial value from. To ensure, quality end products therefore, it is imperative to track, trace and monitor the movement of products from farm to the factory.

Smart agriculture vis-a-vis automated supply chain based on IoT and Blockchain technology has enabled farmers to improve crop yields, optimize irrigation efficiency, and reduce farming costs. It is an intelligent agricultural solution combining agriculture with modern information technology.

Smart farming technologies and precision agriculture are gaining more attraction for their potential to fulfil such an increasing demand and meet global food supply needs. Smart farming technologies involve integration of technology and data driven agriculture applications to increase crop yield and quality of food products (Gupta et al., 2020).

Some related articles were analyzed to ascertain the extent of work done in this research before now. Kumar et al. (2023) identified the existing challenges with respect to the supply chain drivers. Though mentioned, the authors did not lay bare a structurally designed framework on the usage of digitized tools as strategies for effective monitoring and control of perishable agricultural produce(Kumar & Agrawal, 2023). Matemilola & Elegbede (2017), Gardas et al. (2019) and Khan et al (2023) enumerated the challenges of food insecurity in Nigeria and India as well as identifying the causative factors and coping strategies that can facilitate food security(Matemilola & Elegbede, 2017), (Gardas et al., 2019) and (Khan et al., 2023). Oruma et al. (2021) adopted and developed a framework for Agri-products in solving Nigeria's food insecurity challenge in the post-Covid-19 era. The proposed framework integrates precision agriculture in Nigeria's food production and the necessary enabling digital technologies in the agri-food supply chain(Oruma et al., 2021). With the integration of IoT and Blockchain, Awan et al. (2021) as well as Bhutta and Ahmad (2021) designed an energy efficient protocol for the enhancement of the system lifespan and minimization of energy consumption, thereby offering a smart way for farmers to acquire information on farm produce(Awan et al., 2021), (Bhutta & Ahmad, 2021). Shahid et al. (2020) and Salah et al. (2019) proposed a Blockchain traceability system that uses a decentralized Interplanetary File Storage System (IPFS) and smart contract to enhance efficiency, robustness and trust within the supply chain network(Shahid et al., 2020),(Salah et al., 2019). Bhat and Joudu (2019) list some various techniques and conceptual models in agri-food supply chain and proposed future prospects to mitigate global challenges in the food supply chain(Bhat & Jõudu, 2019).

Raut et al. (2019) analyzed the factors behind the most critical challenges facing agricultural supply chain in India and formulated an analytic model that would enhance the policy makers in churning out critical sustainable policies to enhance the entirety of the supply chain process(Raut et al., 2019). Arena et al. (2019) did a tamper-proof Blockchain-based application for the monitoring of the entire supply chain process of olive oil. However, an additional evaluation test carried out showed that the application would not always perform in real industrial environment, although dynamic auto tuning of Blockchain was tried to improve on the scenario(Arena et al., 2019.). Mirabelli and Solina (2019) focused on the application of Blockchain in the agricultural supply chains for ensuring food traceability. However, only the review of application of Blockchain was done, but no architectural framework(Mirabelli & Solina, 2020). Gupta et al. (2020) identified potential cybersecurity issues in smart farming and illustrates, scenario specific cyberattacks, which have been categorized into data, network, supply chain, and other common attacks. Although, the writers did not elucidate clear cut remedies to these quagmire, other threats made reference to by the study include social engineering, denial of service, cyber-espionage agro-terrorism, ransomware, among others (Gupta et al., 2020). Ferrag et al. (2020) outlined some security and privacy issues in the field of green IoT-based agriculture.

Describing a four-tier green IoT-based agriculture architecture and summarizing the existing surveys that deal with smart agriculture, the authors provided a classification of threat models against green IoT-based agriculture in different sections, namely, privacy attack, authentication attack, confidentiality attack, availability, and integrity issues. Furthermore, the authors analyzed the privacy-oriented Blockchain-based solutions as well as consensus algorithms for IoT applications and how they will be adapted for green IoT-based agriculture (Ferrag et al., 2020). In order to comprehend the necessary cause of new IoT threats and the challenges in current research, Zhou et al. (2019) in their survey, first analyzed some IoT features which include, Interdependence, Diversity, Constrained, Myriad, Unattended, Intimacy, Mobile and Ubiquitous. The features demonstrated are not independent but interact with each other. Therefore, it is

pertinent to note that when designing security solutions for these devices, researchers need to take the effect of these features into consideration (Zhou et al., 2019). Brewster et al. (2017) highlighted the IoT-related challenges and constraints for the agri-food sector together with the core objectives of IoT-based large-scale pilots (LSPs). A system-of-systems architectural approach is proposed, with an emphasis on the interoperability aspects which are critical for the uptake of IoT technologies in the agri-food sector (Brewster et al., 2017). In his article, Maple (2017) discussed the origins of the IoT and how this has posed a major challenge to standardization and a single overall vision. This, in turn, has given rise to challenges for security and assurance in the IoT. He advocated for standardization and coordination in the IoT in terms of process and technology as well as in politics (Maple, 2017).

Tzounis et al. (2017) introduced the recent trends in the technologies, which represent the building blocks of IoT, such as the Radio Frequency identification (RFID), wireless sensor networks, and the software that functions in the cloud. Security in IoT is summarized in three requirements, namely, authentication, confidentiality and access control. The authors insisted that due to the distributed nature of IoT and the fact that its devices may be deployed in diverse environments, a single security protocol is, usually, not enough (Tzounis et al., 2017). In their work, Manoj and Kumar (2018) deduced that among other bottlenecks in IoT, the exchange of information and data authentication is only done through the central server thereby leading to the security and privacy concerns. There is likely to be spoofing of targeted devices, pseudo authentication and weak reliability with respect to sharing of data.

To address such security and privacy concerns, a central server concept should be eliminated and distributed ledger-based technology known as Blockchain (BC) technology is introduced as a part of IoT. However, the authors did not specify on how the application of this technology in the IoT-ecosystem can boost yields in the agricultural sector (Manoj & Kumar, 2018). Chakraborty et al. (2019) analyzed some technologies involved in precision agriculture and reviewed available agricultural sensors based on different parameters. No doubt, the discovery of smart wireless sensors and IoT added new feathers in crop production and agriculture field by enabling smart decision system called precision agriculture. However, security and privacy become challenges in precision agriculture while implementing agro sensors in the field. The authors maintained that with the proliferation of sensors, data privacy and user authentication issues become vulnerable to security threats (Chakraborty et al., 2019). In their work, Arora et al. (2019) emphasized on the prevailing security issues with the expansion of Internet of Things. However, attacks on network of IoT at different levels are also discussed which imparts clear knowledge about the flaws ravaging this technology.

Some security concerns raised by the authors include attacks to End Devices, Communication Channels, Network Protocols, Sensory Data, Software, as well as Denial of Service (DoS). To mitigate these avalanche of security ordeals, the authors proposed the basic principle of CIA triad, vis-a-vis, confidentiality (non-disclosure of sensitive data to third party or any unauthorized user); Integrity (ensuring the originality of data during transmission process) and Availability (ability to access the whole content by an authorized user) (Arora et al., 2019). Khanna (2019) highlighted existing fundamental challenges pertaining to proper management and performance of IoT in the field of Precision Agriculture research. These include, reliability issues, Data confidentiality problems, the undaunted task of management of Network and its resources, Scalability malady, Interoperability challenges, among others. Nonetheless, comprehensive observations have been made to study the concept of precision agriculture using IoT with respect to upward market keeping modern day's requirements in focus (Khanna, 2019). In their work, Gundu

and Maronga (2019) comprehensively reviews various security and privacy issues and challenges associated with IoT deployments in smart farming. Following a structured approach, a privacy and security framework for smart farming was developed in an attempt to address challenges experienced (Gundu & Maronga, 2019).

Most of the security and privacy concerns discussed in the various research papers above can be categorized into attacks against privacy, confidentiality, authentication, integrity, and reliability, lack of standardization, as well as human naivety errors and trust issues. While some of the authors did not give clear cut countermeasures, others were restricted to IoT security taxonomy (Ferrag et al., 2020), IoT frameworks (Brewster et al., 2017), security communication protocols (Arora et al., 2019), rigorous security awareness (Gundu & Maronga, 2019), standardization and coordination (Maple, 2017). A deeper look reveals that delivering integrity has always been a challenge and so there is need to define the solution or at least getting some standards around. This work presents a solution with which to deliver and drive integrity around the data, management and operations of IoT devices and networks in the smart agricultural supply chain through a distributed ledger-based network solution, vis-a-vis, Automated Blockchain in Smart Agri-Distribution (ABSAD) Network.

3. METHODOLOGY

In this work, we use a distributed ledger-based network technology. The system is peer- to- peer based, made possible (through the introduction of Blockchain technology) quite unlike in a centralized cloud network.

3.1 Bottlenecks Associated With Age-Long Agricultural Supply Chain

A typical traditional agricultural supply chain involves complex interconnected processes of traceability and tracking between various stakeholders such as the crops or product producer, inspection and insurance companies, logistics and shipping agencies, banks, manufacturer and importer before it eventually gets to the final consumer residing in another part of the globe.
However, in this long process, there are quite a few challenges;

i. Importers find it difficult to track the origin and to understand the place of source and quality of the imported produce.
ii. As the produce moves between multiple stakeholders, the ownership or custodian information becomes difficult to trace.
iii. Centralized bodies, especially private agencies that certify crop produce may not be trusted by international importers.
iv. Information between stakeholders is sequential, leading to potential delays in downstream decision making.
v. Overall, stakeholders lack transparency in this process and lose track of relevant transactions.

So how do we tackle these challenges? We introduce the Automated Blockchain in Smart Agri-Distribution (ABSAD) Network.

3.2 ABSAD System Model

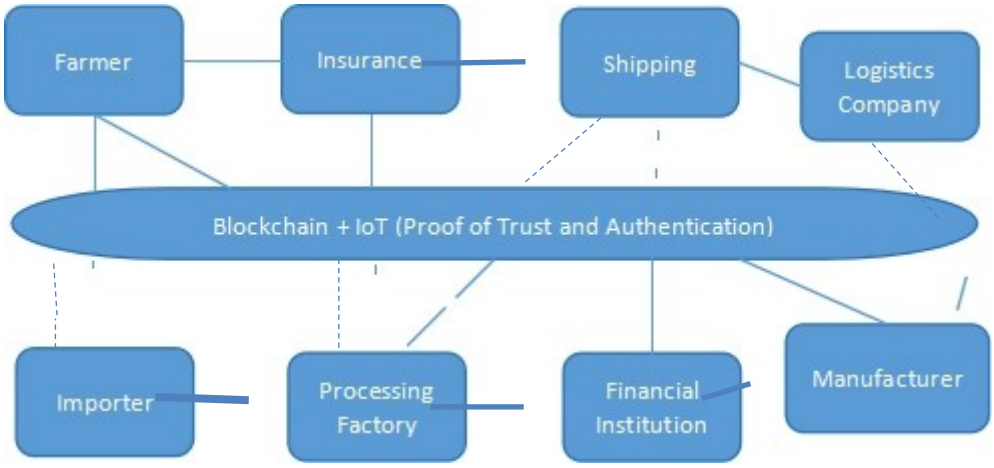


Fig. 1 ABSAD Network

ABSAD Network uses a distributed ledger-based network technology. From figure 1 above, we can see that the system is peer- to- peer based, made possible (through the introduction of Blockchain technology) quite unlike in a centralized cloud network. It simplifies life for everyone in the supply chain. It ensures transparency in every transaction among all stakeholders through a trustworthy private network. Any activity can be documented and stored in the distributed ledger, only with consensus among all participating stakeholders. Untrusted stakeholders can transact amongst each other through smart contract without the need for a centralized body. Every stakeholder will have their own copy of the same distributed ledger which enables information access in new real time.

4. SIMULATIONS AND RESULTS

This research work implemented ABSAD Network using Python programming language, by creating a simple Blockchain structure and simulated interactions among stakeholders. Although, for this work, the paper did not focus on network communication or advanced consensus algorithms, rather, it demonstrated the basic idea of how a Blockchain can track transactions and ensure transparency. Each stakeholder will be able to add transactions to the Blockchain.

PROGRAM 1 Define Classes for Block, Blockchain and Stakeholder

```
import hashlib
import datetime

class Block:
    def __init__(self, index, timestamp, data, previous_hash):
        self.index = index
        self.timestamp = timestamp
        self.data = data
        self.previous_hash = previous_hash
        self.hash = self.calculate_hash()

    def calculate_hash(self):
        return hashlib.sha256(str(self.index).encode() +
                              str(self.timestamp).encode() +
                              str(self.data).encode() +
```

```
                str(self.previous_hash).encode()).hexdigest()

class Blockchain:
    def __init__(self):
        self.chain = [self.create_genesis_block()]

    def create_genesis_block(self):
        return Block(0, datetime.datetime.now(), "Genesis Block", "0")

    def get_latest_block(self):
        return self.chain[-1]

    def add_block(self, new_block):
        new_block.previous_hash = self.get_latest_block().hash
        new_block.hash = new_block.calculate_hash()
        self.chain.append(new_block)

class Stakeholder:
    def __init__(self, name):
        self.name = name

    def add_transaction(self, Blockchain, transaction_data):
        new_block = Block(len(Blockchain.chain), datetime.datetime.now(), transaction_data, "")
        Blockchain.add_block(new_block)
        print(f"{self.name} added a new transaction: {transaction_data}")
```

Now, let's simulate some interactions among stakeholders:

PROGRAM 2 Simulate Interactions among Stakeholders

```
# Create stakeholders
crops_producer = Stakeholder("Crops Producer")
inspection_insurance_company = Stakeholder("Inspection and Insurance Company")
logistics_shipping_agency = Stakeholder("Logistics and Shipping Agency")
bank = Stakeholder("Bank")
manufacturer = Stakeholder("Manufacturer")
importer = Stakeholder("Importer")
consumer = Stakeholder("Consumer")

# Create Blockchain
Blockchain = Blockchain()

# Add transactions
crops_producer.add_transaction(Blockchain, "Crops harvested and ready for inspection")
inspection_insurance_company.add_transaction(Blockchain, "Crop inspection completed, insurance issued")
logistics_shipping_agency.add_transaction(Blockchain, "Crop shipment dispatched")
bank.add_transaction(Blockchain, "Payment processed for crop shipment")
manufacturer.add_transaction(Blockchain, "Received crops for manufacturing")
importer.add_transaction(Blockchain, "Imported manufactured goods")
consumer.add_transaction(Blockchain, "Goods purchased by consumer")

# Print Blockchain
for block in Blockchain.chain:
    print(f"Block {block.index}: {block.data}, Hash: {block.hash}")
```

The above code simulates a basic supply chain scenario with stakeholders adding transactions to the Blockchain. Each transaction is stored in a block, which is then added to the Blockchain. The integrity of the chain is maintained through cryptographic hashing.

4.1 WORKING SCENARIO OF THE ABSAD SYSTEM

Fig. 2: ABSAD Platform

Here is Mr. Robert Gyang from Katako in Plateau State, Nigeria, who is a well-known Moringa farmer (Fig. 2). Annually, Mr Robert sells a large quantity of his Moringa produce (including the leaves, seeds and roots) to Mr. Fidelis Preye, who is the Chief Executive of the Salfas Moringa Milling and Processing factory in Okpella, Edo State, Nigeria. Similarly, Mr. Fidelis, often receives orders to export Moringa products to Dr. Deen Ambrose, who runs Dembro Seed oil and Leaf tea company in South Africa. With the help of the ABSAD network, each party could add details of their produce, request inspections and gets their ordered products in the shortest possible time.

The agreements between Mr. Robert and Mr. Fidelis, as well as between Mr. Fidelis and Deen Ambrose are stored on the Blockchain networks as smart contracts as shown in Figure 2.

Other relevant independent stakeholders are also involved to certify the produce with standard certificates according to international best practices. Once the Moringa products are harvested, Mr. Robert generates an invoice and requests a pickup on the ABSAD platform.
The logistics company lifts the Moringa produce up from Mr. Robert's farm and delivers it to Mr. Fidelis' warehouse.

The delivery received is updated and made available to all stakeholders on the Blockchain distributed network. As soon as Mr. Fidelis signifies his acceptance to the goods, the smart contract between Fidelis and Mr. Robert is executed, hence Mr. Fidelis instructs his bank to make payment transfer to Mr. Robert's bank account. The transaction detail will be updated on the distributed Blockchain network. In the meantime, Mr. Fidelis' factory is processing and packaging the Moringa produce received, to be delivered to Deen Ambrose.

The processed and packaged Moringa is inspected and certified as well by an independent certifying agency. Mr. Fidelis then issues a product invoice to Deen Ambrose. Deen tracks the origin of the product starting from the Moringa farm up to the inspection and insurance details before he accepts the invoice.

A shipment request is then raised by Fidelis to the shipping organization. Once the bill of laden is uploaded by the shipping agency, the smart contract between Fidelis and Deen gets executed, and Deen requests his bank to make a payment transfer to Fidelis' bank account.

The transaction details are updated on the Blockchain network. Thus, Deen, who resides in South Africa, is able to remotely track the source of Moringa products imported from Nigeria.

5. CONCLUSION

No doubt, there is a huge need to define referenceable implementations of smart contracts that would interact with, not only IoT devices but Blockchain networks so as to mitigate security and privacy issues as well as promote trust in smart agriculture.

- Indeed, Blockchain is increasingly being considered as a viable tool and mechanism to deliver end-to-end system and data integrity, whether it is roadside infrastructure or even infrastructure that relates to deliveries of agricultural products from the farmer to the end user.
- Now we are starting to see some evidence of not only being able to provide integrity but taking the data of that integrity and being able to monetize that correctly as well.
- So, we are seeing a significant number of opportunities where if we enable Blockchain in the smart agricultural supply chain, we provide integrity of the end-to-end solutions but also some significant market opportunities as well.

REFERENCES

Arena, A., Bianchini, A., Perazzo, P., Vallati, C., & Dini, G. (n.d.). *BRUSCHETTA: An IoT Blockchain-Based Framework for Certifying Extra Virgin Olive Oil Supply Chain*. http://bit.ly/bruschetta

Arora, A., Kaur, A., Bhushan, B., & Saini, H. (2019). *Security concerns and future trends of internet of things*. 891–896.

Awan, S., Ahmed, S., Ullah, F., Nawaz, A., Khan, A., Uddin, M. I., Alharbi, A., Alosaimi, W., & Alyami, H. (2021). IoT with BlockChain: A Futuristic Approach in Agriculture and Food Supply Chain. *Wireless Communications and Mobile Computing*, *2021*.

https://doi.org/10.1155/2021/5580179

Bellemare, M. F., & Bloem, J. R. (2018). Does contract farming improve welfare? A review. *World Development*, *112*, 259–271. https://doi.org/10.1016/j.worlddev.2018.08.018

Bhat, R., & Jõudu, I. (2019). Emerging issues and challenges in agri-food supply chain. In *Sustainable Food Supply Chains: Planning, Design, and Control through Interdisciplinary Methodologies* (pp. 23–37). Elsevier. https://doi.org/10.1016/B978-0-12-813411-5.00002-8

Bhutta, M. N. M., & Ahmad, M. (2021). Secure Identification, Traceability and Real-Time Tracking of Agricultural Food Supply during Transportation Using Internet of Things. *IEEE Access*, *9*, 65660–65675. https://doi.org/10.1109/ACCESS.2021.3076373

Brewster, C., Roussaki, I., Kalatzis, N., Doolin, K., & Ellis, K. (2017). *IoT in Agriculture : Designing a Europe-Wide Large-Scale Pilot*. *September*, 26–33.

Chakraborty, A., Banerjee, A., & Saha, S. (2019). *Sensors In Precision Agriculture : A Survey On Application , Security And Privacy*. *18*(9), 949–957.

Ferrag, M. A., Shu, L. E. I., Member, S., & Yang, X. (2020). Security and Privacy for Green IoT-Based Agriculture : Review , Blockchain Solutions , and Challenges. *IEEE Access*, *8*, 32031–32053. https://doi.org/10.1109/ACCESS.2020.2973178

Gardas, B. B., Raut, R. D., Cheikhrouhou, N., & Narkhede, B. E. (2019). A hybrid decision support system for analyzing challenges of the agricultural supply chain. *Sustainable Production and Consumption*, *18*, 19–32. https://doi.org/10.1016/j.spc.2018.11.007

Global Smart Agriculture Market: Industry Type, Size, Share, Trends and Forecast by 2025 | ZMR. (n.d.). Retrieved August 20, 2020, from https://www.zionmarketresearch.com/report/smart-agriculture-market

Gundu, T., & Maronga, V. (2019). *IoT Security and Privacy: Turning on the Human Firewall in Smart Farming*. *12*, 95–84. https://doi.org/10.29007/j2z7

Gupta, M., Abdelsalam, M., Khorsandroo, S., & Mittal, S. (2020). Security and Privacy in Smart Farming: Challenges and Opportunities. *IEEE Access*, *8*, 34564–34584. https://doi.org/10.1109/ACCESS.2020.2975142

KC, S., & Lutz, W. (2017). The human core of the shared socioeconomic pathways: Population scenarios by age, sex and level of education for all countries to 2100. *Global Environmental Change*, *42*, 181–192. https://doi.org/10.1016/j.gloenvcha.2014.06.004

Khan, M. R., Alam, M. J., Tabassum, N., Khan, N. A., & McKenzie, A. M. (2023). Supply chain challenges and recommendations for international development agriculture projects: an application of the FGD-fuzzy Delphi approach. *Humanities and Social Sciences Communications*, *10*(1). https://doi.org/10.1057/s41599-023-02027-9

Khanna, A. (2019). *Evolution of Internet of Things (IoT) and its signi fi cant impact in the fi eld of Precision Agriculture*. *157* (November 2018), 218–231. https://doi.org/10.1016/j.compag.2018.12.039

Kumar, A., & Agrawal, S. (2023). Challenges and opportunities for agri-fresh food supply chain management in India. In *Computers and Electronics in Agriculture* (Vol. 212). Elsevier B.V. https://doi.org/10.1016/j.compag.2023.108161

LIU, D., GONG, Y., WANG, G., CHEN, X., ZHANG, X., & WU, G. (2018). Research Advances in Mechanization of Pesticide Spraying Technology for Facility Agriculture. *Asian Agricultural Research*, *10*(7), 81–86. https://doi.org/10.22004/ag.econ.281264

Manoj, N., & Kumar, P. (2018). ScienceDirect Blockchain technology for security issues and challenges in IoT. *Procedia Computer Science*, *132*, 1815–1823. https://doi.org/10.1016/j.procs.2018.05.140

Maple, C. (2017). *Security and privacy in the internet of things*. *8871*(September). https://doi.org/10.1080/23738871.2017.1366536

Matemilola, S., & Elegbede, I. (2017). The Challenges of Food Security in Nigeria. *OALib*, *04*(12), 1–22. https://doi.org/10.4236/oalib.1104185

Minbo, L., Zhu, Z., & Guangyu, C. (2013). Informacijski servisni sustav za poljoprivredni IoT. *Automatika*, *54*(4), 415–426. https://doi.org/10.7305/automatika.54-4.413

Mirabelli, G., & Solina, V. (2020). Blockchain and agricultural supply chains traceability: Research trends and future challenges. *Procedia Manufacturing*, *42*, 414–421. https://doi.org/10.1016/j.promfg.2020.02.054

Oruma, S. O., Misra, S., & Fernandez-Sanz, L. (2021). Agriculture 4.0: An Implementation Framework for Food Security Attainment in Nigeria's Post-Covid-19 Era. *IEEE Access*, *9*, 83592–83627. https://doi.org/10.1109/ACCESS.2021.3086453

Raut, R. D., Gardas, B. B., Narkhede, B. E., & Jha, M. K. (2019). Analysing the challenges in sustainable agricultural supply chain system in India. In *Int. J. Business Excellence* (Vol. 18, Issue 3).

Salah, K., Nizamuddin, N., Jayaraman, R., & Omar, M. (2019). Blockchain-Based Soybean Traceability in Agricultural Supply Chain. *IEEE Access*, *7*, 73295–73305. https://doi.org/10.1109/ACCESS.2019.2918000

Shahid, A., Almogren, A., Javaid, N., Al-Zahrani, F. A., Zuair, M., & Alam, M. (2020). Blockchain-Based Agri-Food Supply Chain: A Complete Solution. *IEEE Access*, *8*, 69230–69243. https://doi.org/10.1109/ACCESS.2020.2986257

Talavera, J. M., Tobón, L. E., Gómez, J. A., Culman, M. A., Aranda, J. M., Parra, D. T., Quiroz, L. A., Hoyos, A., & Garreta, L. E. (2017). Review of IoT applications in agro-industrial and environmental fields. *Computers and Electronics in Agriculture*, *142*(118), 283–297. https://doi.org/10.1016/j.compag.2017.09.015

Tzounis, A., Katsoulas, N., & Bartzanas, T. (2017). ScienceDirect Internet of Things in agriculture , recent advances and future challenges. *Biosystems Engineering*, *164*, 31–48. https://doi.org/10.1016/j.biosystemseng.2017.09.007

Zhou, W., Jia, Y., Peng, A., Zhang, Y., & Liu, P. (2019). The effect of IoT new features on security and privacy: New threats, existing solutions, and challenges yet to be solved. *IEEE Internet of Things Journal*, *6*(2), 1606–1616. https://doi.org/10.1109/JIOT.2018.2847733

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

Prevalence of *Trichomonas vaginalis* Infection among Pregnant Women Attending Antenatal Clinics in Two Health Facilities in Yenagoa Local Government Area, Bayelsa State, Nigeria

Gbonhinbor, J.
Anthony, M. C.
Department of Science Laboratory Technology, Federal Polytechnic, Ekowe, Bayelsa State

Chezu, D. N. S.
Department of Biology, Ignatius Ajuru University of Education, Rivers State
**Corresponding Author's e-mail address: joanfilas@gmail.com*

ABSTRACT

Trichomoniasis is been considered as the most prevalent sexually transmitted infection of both male and female urogenital organs which is also preventable and curable. This study was aimed at determining the prevalence of Trichomonas vaginalis among pregnant women attending antenatal Clinic in two health facilities (Gloryland-Inri medical centre, Opolo and Basic Healthcare Provision fund (BHCPF), Yenizue-gene) in Yenagoa L.G.A., Bayelsa State, Nigeria. A total of 500 pregnant women who have not been treated for sexually transmitted infection for 30 days prior to the period of this study were examined using microscopy method. Collection of samples was done using both High vaginal swabs and urine. Positive samples recorded 135(27%) for T. vaginalis across sampled population. Socio-demographic information such as age, trimester and marital status were obtained from all participating women within the age range of 16-55years. The prevalence of trichomoniasis was recorded as 81(28.4%) and 54(22.3%) for GMC, Opolo and BHCPF, Yenizue-gene. High vaginal swabs (HVS) examined only recorded 91(18.2%), while 44(8.8%) was recorded for Urine examined only. Highest rate of infection was recorded in age brackets 26-35(38.1%). This was followed by 16-25(29%). The least infection was observed in age bracket 46-55(17.6%). Single pregnant women had the highest rate of infection with 49.5%. This was followed by married women recording 13.5%. The least rate of infection was recorded among the widowed pregnant women (7.4%). Pregnant women in their second trimester recorded the highest rate of infection (58%). This was followed by pregnant women in their 1st trimester (18.1%). The least infection was recorded among pregnant women in their 3rd trimester (9.5%). However, the variation of infection rate between the two health facilities in this study is an indication that the prevalence rate of trichomoniasis varies with location, nature of hygiene, sexual habit and level of education of the individual. The need for advocacies on sexual and health education at every antenatal clinic and routine screening for trichomoniasis among pregnant and women of reproductive age is highly recommended to curb the outbreak of the disease.

Keywords: *Urogenital, Trichomonas vaginalis, pregnant women, urine samples*

1.0 INTRODUCTION

Trichomoniasis is a preventable and curable sexually transmitted disease (STD) that affects both male and female urogenital tracts (WHO, 2023, Beri *et al*., 2020; CDC, 2017; CDC, 2015). It is a

protozoan parasite that causes this condition (Arora and Arora, 2014; Beri *et al*., 2020; Burgess, 1998; Lossick, 1989). This infection is not spread through casual contact, so it cannot be gotten from sharing food or drinks, kissing, hugging, holding hands, coughing or sneezing. It is easily disseminated during sex since it is carried in sexual fluids such as the pre-cum and vaginal fluid. About 70% of affected people do not have symptoms when infected and so spreading this disease is very easy. When symptoms occur, they typically begin between 5 to 28 days after exposure, and about 20% of people get infected again within three months of treatments (WHO, 2023). Signs and symptoms of *T. vaginalis include:* a foul-smelling vaginal discharge, itching in the genital area, painful urination in women abdominal pain (CDC, 2017). *Trichomonaisis* is a treatable disease using prescribed dosage of flagyl as recommended. Although symptoms of the disease may vary, so most people cannot tell if they are infected. Humans are the only natural host of *Trichomonas vaginalis*. Trichomoniasis is an extremely common infection in Nigeria and worldwide. Although this far exceeds the incidence of chlamydia and gonorrhea, trichomoniasis is not a public health priority, as evidenced by the fact that it is not a reportable disease. The World Health Organization has estimated that this infection accounts for almost half of all curable infections worldwide (WHO, 2023; 2020). Approximately 180 million women worldwide are infected with *T. vaginalis* annually (Bowden and Garnett, 2000).

The infection is transmitted from an infected person to a non-infected person through direct skin-to-skin contact and through vaginal intercourse (Njoku *et al*., 2001). In women, *T. vaginalis* usually infects the lower genital tract (vulva, vagina, cervix or urethra), and in men, it infects the inside of the penis (urethra). While *T. vaginalis* occurs in both women and men, it is more prevalent in the former than in the latter, with women being more symptomatic than men. In men, where there are symptoms, there is irritation inside the penis, burning after urination or ejaculation, or discharge from the penis (WHO, 2023; CDC, 2017; CDC, 2015). Irrespective of being the most common curable STI and *T. vaginals* is the most prevalent non-viral STI globally, with an estimated 174 million new cases annually (WHO, 2023; Quinlivan, 2011). A review of STI prevalence in South Africa reported an estimated *T. vaginalis* prevalence of 20% in men, with an excess of 20% prevalence among women in antenatal and STI clinics. *T. vaginalis* infection has been linked with an increased risk and transmission of HIV infection (Cu-Uvin *et al.*, 2002). At present, studies on *T. vaginalis* tend to focus more on women than on men. This can be attributed to the impact of the infection on women's health and the fact that the infection produces symptoms in women that can be seen and studied as opposed to men who are usually asymptomatic (Ichhpujani and Bhatia, 2002; Hobbs *et al*., 1999). As the presence of *T. vaginalis* in men is also a risk factor for HIV infection and transmission, it is important that additional studies on the impact of the infection on men be conducted, where the infection is also the main cause of most male urethritis and prostatitis (Johnson and Mabey, 2008; Kessinger, 2008).

The pregnant women infected with this parasite may be at risk of an adverse birth outcome such as premature rupture of membranes, premature labour, low birth weight, and post-abortion or post-hysterectomy infection, as well as infertility and enhanced predisposition to neoplastic transformation in cervical tissues (WHO, 2001; Drapper *et al*., 1995; Wilkerson, 2011). As with other sexually transmitted infections, the Trichomonas infection can increase the risk of transmission of HIV infection (WHO, 2023).

In Nigeria, there are some documented reports on the prevalence of Trichomonas infections among women, students, Commercial sex workers and in pregnant women (Auta *et* al., 2020; Amadi and Nwagbo 2013; Adeoye and Akande, 2007), but no similar study on pregnant women have been done in Southern Nigeria and possibly only one in the northern part of Nigeria. These are

mostly the major problems in rural settlement in Nigeria because of their poor socio-economic status and lack of basic amenities such as water and toilet facilities (UNICEF, 2008; Ichhpujani and Bhatia, 2002). *Trichomonas vaginalis* infections associated with pregnancy posses a major Public health complication to mother, foetus and infants. Its posses a great risk thus increases the risks of contacting STDs and HIV infections. Despite being a highly prevalent infection in Southern part of Nigeria, there is no review article published that solely focuses on *Trichomonas vaginalis* infections in pregnant women from Bayelsa State, Nigeria. This study was aimed to determine the prevalence of the *Trichomonas vaginalis* among pregnant women attending antenatal clinic thus providing information on the rate of the infection and possible ways of prevention. Although a number of studies have been conducted on the prevalence of *T. vaginalis* infection in pregnant women (Ukatu *et al*., 2019; Laga *et al*., 1993), a few studies are limited studies addressing the importance of the infection as contributing source for the high risk of its susceptibility to other STDs and HIV in Bayelsa State. If the target is to control the parasitic diseases, it is not enough to depend merely on the drugs but also through health education as an effort to reduce and eliminate the potential sources of infection. This research attempts to update *T. vaginalis* prevalence data on pregnant women in Yenagoa Local Government Area, Bayelsa State.

2.0 MATERIALS AND METHODS

Study areas

This study was conducted in two health facilities (Opolo and Yenizue-gene) in Yenagoa Local Government Area, Bayelsa State, Nigeria. These health centers are located in Opolo and Yenizue-gene communities, Yenagoa, which is the Capital city of Bayelsa State. The coordinates include Opolo N 4.9455325 E 6.3430474 and Yenizue-gene N 4.9393002 E 6.3267642 respectively. Yenegoa has coastline of approximately 60 km on the Bight of Benin. The population in 2006 census was 319,413. It is a semi arid area and has challenges of acquisition of clean water for domestic use. Temperatures range is between 26°C to 34°C. Yenagoa consits of both urban and rural settlements. Water sources are bore holes. The main economic activity is subsistence crop growing and livestock keeping. The people grow maize, sorghum, millet, cowpeas and a few other drought- resistant crops. There is also livestock farming and they mainly keep cattle and goats. These communities have health facilities comprising a Family Health Center.

Consent and approval

A letter of introduction addressed to the Medical Director/Management of the hospital. Request and approval to use the hospital for this research were also obtained from the Medical Director and the Ethical Committee. Consent was also obtained from the pregnant women who participated in the study.

Sample collection

The study populations were systematically selected based on the number of pregnant women who visited the ante-natal clinic section of the hospital on clinic days. A total of consented 500 pregnant women attending ante-natal clinic within the age range 16-55years were examined for the purpose of this research. Structured questionnaires were used to collect data such as age, marital status, occupational, number of sexual partners, use of condom as protection during sexual intercourse and gestational stage.

Sample analysis

High vaginal swab (HVS) and urine samples were collected from each pregnant woman attending the antenatal clinic using the systematic Sampling method. Samples were collected in collaboration with midwives and nurses who are trained on voluntary counseling.

High vaginal swab analysis

High vaginal swabs were collected using sterile swab sticks, while the urine samples were collected inside universal container with each respondent name written on it (Chessbrough, 2006). Both symptomatic and asymptomatic patient were sampled. High vaginal swab (HVS) samples were collected by inserting a sterile swab stick into the posterior side of the vagina for the mixing of the vaginal fluid while the individual laid in the lithotomy position. The collected sample was then put in 0.3ml of sterile physiological saline for preservation.

Urine analysis

Urine samples were obtained from each pregnant woman by giving them sterile universal containers (about 5ml) in order to collect adequate quantity of urine into the sample bottles. The samples were examined using wet microscopy.

Parasitological examination

With the aid of Pasteur pipettes, urine samples were collected from the resulting suspension in the sample bottles and put on a clean slide. It was then covered with a clover slip and examined immediately under the microscope (using x10 and x40 objectives) for jerky motility of the organism (Chessbrough, 2006). This method is used to identify the presence of *Trichmonas vaginalis* which is the direct microscopy of wet preparation of the samples.

A wet mount of urine samples of the patients, this was collected alongside with HVS. This is for the identification of the presence of *Trichomonas vaginalis* in urine. This is done in cases where there is exhibition of a true or false positive result in either of the samples.

The urine samples were centrifuged and spin at 2500 rpm for 5 minutes. About 2 drops of urine deposit was drop on a clean glass slide and covered with a cover slip and viewed under the microscope as in case of wet mount preparations.

Data analysis

Statistical analysis was carried out and differences in proportion were evaluated using the Chi-square test. Significance for the inferential analytical techniques was set at 0.05 levels ($P < 0.05$).

3.0 RESULTS AND DISCUSSION

Out of the 500 pregnant women examined, a total of 135 tested positive for the infection recording 27%. 81(28.4%) and 54(22.3%) were positive for women attending antenatal in Gloryland-inri medical centre (GMC), Opolo and Basic Health care Provision Fund (BHCPF) Yenizue-gene health Centre respectively. There was no significant difference ($P>0.05$) between the prevalence of the infection at the two health facilities (Table 1). Out of the 500 pregnant women examined for this study, an overall prevalence of 27% was recorded. High vaginal swabs (HVS) examined only recorded 91(18.2%), while 44(8.8%) was recorded for Urine examined only. HVS showed more positive cases than urine and wet mount method employed for examination (Figure 1).

Table 2 shows that the highest infection of *T. vaginalis* was recorded among age bracket 26-35 years 72(38.1%). This was followed by 16-25 recording 47(29%). Age brackets 36-45 recorded 10(9%). The least infection was observed in age bracket 46-55 recording 6(17.6%). Table 3 reveals that single pregnant women had the highest rate of infection with 49.5%. This was followed by married women recording 13.5%. The least rate of infection was recorded among the widowed pregnant women recording 7.4% in this order. Pregnant women in their 2nd trimester recorded the highest rate of infection with 58%. This was followed by pregnant women in their 1st trimester (18.1%). The least infection was recorded among pregnant women in their 3rd trimester (9.5%) (Table 4).

Table 1: Prevalence of *Trichomonas vaginalis* among pregnant women attending antenatal clinic in GMC and BHCPF within Yenagoa L.G.A

Health Facility	No. Examined	Positive cases	Prevalence (%)
GMC	285	81	28.4
BHCPF	215	54	25.1
Total	**500**	**135**	**27.0**

Keys: GMC- Gloryland-Inri Medical Centre, Opolo
BHCPF- Basic Healthcare Provision Fund, Yenizue-gene

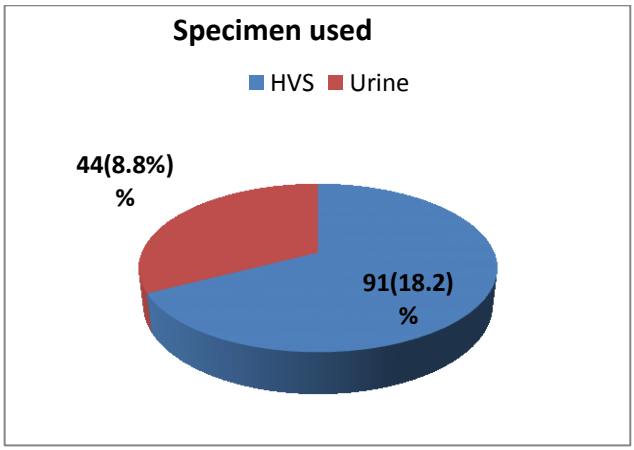


Figure 1: Prevalence of *T. vaginalis* based on type of specimen used

Table 2: Age-related Prevalence of *Trichomonas vaginalis* among pregnant women attending antenatal clinic in YHC and AHC within Yenagoa L.G.A, Bayelsa State

Age category	GMC		BHCPF		Total Examined	Total Positive (%)
	N.E	N.I	N.E	N.I		
16-25	69	15	93	32	162	47(29)
26-35	104	52	85	20	189	72(38.1)
36-45	85	8	26	2	111	10(9)
46-55	27	6	11	-	38	6(17.6)
Total	**285**	**81**	**215**	**54**	**500**	**135(27%)**

Keys: GMC- Gloryland-Inri Medical Centre, Opolo
BHCPF- Basic Healthcare Provision Fund, Yenizue-gene
N.E- Number Examined; N.I- Number Infected

Table 3: Prevalence of *Trichomonas vaginalis* among pregnant women attending antenatal clinic relation to marital status

Marital status	No. examined	No. positive	Prevalence (%)
Single	192	95	49.5
Married	281	38	13.5
Widow	27	2	7.4
Total	**500**	**135**	**27.0**

Table 4: Distribution of *T. vaginalis* among pregnant women attending two health facilities based on trimester in Yenagoa L.G.A., Bayelsa State, Nigeria.

Trimester	No. examined	No. positive	Prevalence (%)
1st (0-3)	171	31	18.1
2nd (4-6)	150	87	58
3rd (7-9)	179	17	9.5
Total	**500**	**135**	**27**

Discussion

Trichomonas vaginalis is a common curable sexually transmitted infection (STI). The findings from this study revealed the prevalence of *T. vaginalis* among pregnant women attending Gloryland-inri medical centre (GMC), Opolo and Basic Health care Provision Fund (BHCPF) Yenizue-Gene health Centre respectively recording an overall prevalence of 27%.

Result obtained in this study is however, higher than the findings of Zhu *et al*. (2023), among pregnant women which they recorded overall prevalence rates of *T. vaginalis* infection among pregnant women in the Tibetan area and Wuhan city of 20.94% and 2.84% respectively; 25(6.17%) and 9(4.48%) by Auta *et al.* (2020) among pregnant women attending antenatal clinics in two health facilities within Kaduna Metropolis, Nigeria. Higher prevalence of 17.0% was also reported by Ukatu, *et al*. (2019); 18.6% by Amadi and Nwagbo (2013) in Ikwuano in Abia State; 5.2% by Usanga *et al.*, (2009) in Calabar, Cross Rivers State; 20.0% in Abeokuta by Ojurongbe *et al*. (2010), 18.7% reported by Jatau *et al*. (2006) in Zaria; Aboyeji and Nwabusi (2003) who reported the prevalence of 4.7% in Ilorin; Maringa *et al*. (2011) reported the prevalence of 2.8% in Senegal, 12.16% reported in Maryland by Cotch *et al*. (1997), 16% reported by Mayaud *et al*. (1998) in Tanzania; 46.9% reported in New York by Shuter (1998); 7.84% in Yusuf Dan Tsoho memorial Hospital is similar to the finding of Adeoye and Akande (2007) who reported the prevalence of 7.7% among pregnant women of reproductive age in Lagos Metropolis, Nigeria. This high prevalence may be attributed to lack of attention/unawareness given to the infection of public health importance in the State.

For the detection of *T. vaginalis*, High vaginal Swab (HVS) method of screening was found to be more sensitive than urine microscopy. This results correlates with observations of Ojurogbe *et al*. (2010) in Abeokuta, Nigeria and Ukatu *et al*. (2019) in Sokoto, Nigeria. This shows that accurate diagnosis of *T. vaginalis* could be better achieved by HVS rather than urine analysis.

The age brackets that were predominantly affected were 26-35. This agrees with Auta *et al.* (2020), were they observed that sexually active women (26-30) were most affected. Also, Ukatu *et al*. (2019), recorded highest prevalence among age brackets 32-38; Kaga *et al*. (2017) recorded age group 30-39. Persons who are mostly affected are the sexually active age and young youths of ages 15-38 and among persons with may sexual partners (Sutton *et al*., 2007). However, the result

disagrees with Ojurongbe *et al*. (2010) who observed highest prevalence among age group 20-30. Usanga *et al.,* (2009) also observed age groups 20-24; Adeoye and Akande (2007), observed highest rate of infection among 21-30.

Although the prevalence of 28.4% and 22.3% observed in both health facilities can be considered to be within the normal range in a healthy women population; Cameron and Padian (1990), observed infection rates of 5 to 10% in a healthy women population while it could be as high as 50% in prostitutes and female prisoners.

In relation to trimester, highest prevalence was observed in the second trimester (4-6 months) with 58%. This result supports research by Ukatu *et al*. (2019). The single pregnant women in their second trimester were more infected. The result obtained was not statistically significant. This agrees with the result obtained by Ojurongbe *et al*. (2010).

There is a general conception that prevalence of *T. vaginalis* ranges markedly based on settings and locations (Bowden and Garnett, 2000). Previous reports from Nigeria linked Sexually Transmitted Diseases (STDs) to poverty, unemployment, poor personal hygiene, ignorance of the diseases, poor sanitation, etc (Obiajulu, 2000; Ulogu *et al*., 2007).

In this study, the variation in respect to the two health facilities and findings of other authors could be due to differences in geographical location, population, personal hygiene as well as diagnostic methods used. Constant and intensified health education should be done especially among pregnant women visiting antenatal health centers which would lead to the eradication of this disease in Bayelsa State, Nigeria.

4.0 CONCLUSION

A total prevalence of 27% was recorded in this study; 81(28.4%) and 54(22.3%) were positive for pregnant women attending antenatal in Gloryland-inri medical centre (GMC), Opolo and Basic Health care Provision Fund (BHCPF) Yenizue-Gene health Centre respectively. High vaginal swabs (HVS) remain efficient in the examination and detection of *T. vaginalis* infection. The highest rate of infection was recorded in age group of sexually active women (26-35). Pregnant women in the 2nd trimester had the highest prevalence (58%). There was variation of infection in relation to marital status. There was also a variation in infection rate between the two health facilities in the study areas.

RECOMMENDATIONS

The need for advocacies on sexual and health education at every antenatal clinic and routine screening for trichomoniasis among pregnant and women of reproductive age is highly recommended to curb the outbreak of the disease.

REFERENCES

Aboyeji, A.P and Nwabuisi, C. (2003). Prevalence of sexually transmitted diseases among pregnant women in Ilorin, Nigeria. *Journal of Obstetrics and Gynaecology*, 23(6):637-249.

Adeoye, G.O. and Akande, A.H. (2007). Epidemology of *T. vaginalis* among women in Lagos Metropolis, Nigeria. *Pakistan Journal Biological Sciences*; 10(13):2198-2201.

Amadi, A.N. and Nwagbo, A.K. (2013). *Trichomonas vaginalis* infection among women in Ikwuano, Abia State, Nigeria. *J. Appl. Sci. Environ. Manage*.; 17(13):389-393.

Arora and Arora. (2014). *Medical Parasitology*. CBS Publishers and Distribution. 4th Edition. 45-47.

Auta, I.K., Ibrahim, B. And Henry, D. (2020). Prevalence of *Trichomonas vaginalis* among pregnant women attending antenatal clinic in two health facilities within Kaduna Metropolis, Kaduna, Nigeria. *Science World Journal*; 15(1):97-101.

Beri, D., Yadav, P., Devi, H.R.N., Narayana, C., Gadara, D. and Tatu, U. (2020). Demonstration and Characterization of Cyst-Like Structures in the Life Cycle of *Trichomonas vaginalis*. *Front Cell Infect Microbiol*.; 14(9):430.

Bowden, F.J. and Garnett, G.P. (2000). *Trichomonas vaginalis* Epidemiology: Parameterising and Analysing a Model of Treatment Interventions. *Sexual Transmitted Infections*; 76:248-56.

Burgess, D. (1998). *Trichomonads and intestinal flagellates*, 203-214.

Centers for Disease Control and Prevention (CDC). (2017). Trichomoniasis. Available at: [https://www.cdc.gov/dpdx/trichomoniasis/index.html].

Centers for Disease Control and Prevention (CDC). (2015). Sexually transmitted diseases treatment Guidelines. MMWR, 64(RR-3).

Cheesbrough, M. (2006). *District Laboratory Practice in Tropical Countries*, *Part 2*. Cambridge University Press, United Kingdom, 434.

Cotch, M. F., Pastorek, J. G., Nugent, R. P., Hillier, S. L., Gibbs, R. S., Martin, D. H., Eschenbach, D. A., Edelman, R., Carey, J. C., Reegan, J. A., Krohn, M. A., Klebanoff, M. A., Rao, A. V. and Rhoads, G. G. (1997). *Trichomonas vaginalis* associated with low birth weight and preterm delivery. *Sex. Transm. Dis.*; 24:361-362.

Cu-Uvin, S., Ko, H., Jamieson, J., Hogan, W. Schuman, P., Anderson, J. Klein R. S. and the HIV Epidemiology Research Study (HERS) Group. (2002). Prevalence, incidence, and persistence or recurrence of trichomoniasis among Human Immunodeficiency Virus (HIV)-positive women and among HIV-negative women at high risk for HIV infection. *Clinical Infectious Diseases*, 34:1406-1411.

Draper, D., Jones, W., Heine, R.P., Beutz, M., French, J.I. and McGregor, J.A. (1995). *Trichomonas vaginalis* Weakens Human Amniochorion in an In Vitro Model of Premature Membrane Rupture. *Infect Dis Obstet Gynecol*.; 2:267-74.

Gbonhinbor, J., Henshaw, C.A. and Ikpaikpai, M. (2023). *Trichonomas vaginalis* infection among female inhabitants in Angalabiri community, Sagbama Local Government Area, Bayelsa State,

Nigeria. *Academic Staff Union of Polytechnic (Zone D) National Conference Ken Saro Wiwa Polytechnic Bori, Rivers State.* 1st-3rd February, 2023, 147.

Hobbs, M., Kazembe, P. Reed, Miller, A. W. and Nkata, E. (1999). *Trichomonas vaginalis* as a cause of urethritis in Malawian men. *Sex. Transm. Dis*. 26:381-387.

Ichhpujani, R.L. and Bhatia, R. (2002). *Medical Parasitology (3rd Edition).* Jaypee Brothers Ltd. New Delhi, 62-64.

Johnson, V.J. and Mabey, D.C. (2008). Global epidemiology and control of *T. vaginalis*. *Curr. Opin. Infect. Dis*. 21:56-64.

Kaja, O.A., Sifeler, D.B., Kurt, R.K., Gozukard, I., Yengi, E. and Bayramorglu, N. (2017). Investigation of the presence of *Trichomonas vaginalis* in infertile Turkish women. *Asian Bio-Medicine*; 9(5).

Kessinger, P., Secor, W.E., Leichliter, J.S., Clark, R.A. and Schmidt, E. (2008). Early repeated infections with *Trichomonas vaginalis* among HIV-Positive and HIV-Negative Women. *Clin Infec Dis.*; 1(46):7.

Laga, M., Manoka, A., Kivuvu, M., Malele, B., Tuliza, M., Nzila, N., Goeman, J., Behets, F., Batter, V. and Alary, M. (1993). Non-ulcerative sexually transmitted diseases as risk factors for HIV-1 transmission in women: results from a cohort study. *AIDS* 7:95-102.

Lossick, J. G. (1989). Epidemiology of urogenital trichomoniasis, pp. 311-323.

Njoku, A.J., Obiajuru, I.O.C. and Njoku, C.J. (2001). The influence of sexual habits on the transmission of *Trichomonias vaginalis* infection. International *J. Envt. Health and Human Development*.; 2(1):10-17.

Nye, M.B., Schwebke, J.R. and Body B.A. (2009). Comparison of APTIMA *Trichomonas vaginalis* transcription-mediated amplification to wet-mount microscopy, culture and polymerase chain reaction for diagnosis of trichomoniasis in men and women. *Am J Obstet Gyneol*.; 200(2):188e1-7.

Obiajulu, I.O.C. (2000). The prevalence of *Trichomonas vaginalis* infection in Imo State University, Owerri, Nigeria. Unpublished M.Sc. Thesis, Imo State University, Owerri, Nigeria.

Ojurongbe, O., Taiwo, B.O., Dina, B.O., Sina-Agbaje, O.R., Bolaji, O. and Adeyeba, Adegboyega, O. (2010). Prevelence of *Trichomonas infection* among Pregnant in Abeokuta, Nigeria. *Serria-Leone Journal of Biomedical Research*; 2(2):82-86.

Oyemi, O.T., Fadipe, O. and Oyemi, I.T. (2016). *Trichomonas vaginalis* infection in Nigerian pregnant women and risk factors associated to sexually transmitted infections. *International Journal of STD AIDS*; 27(13):1187-1193.

Quinlivan, E.B., Patel, S.N., Grondesky, C.A., Golin, C.E., Tien, H. and Hobbs, M.N. (2011). Modeling the impact of *Trichomonas vaginalis* on HIV transmission in HIV-infected individuals in medical care. *Sexual Transmitted Diseases*; 39(9):671-677.

Schwebke, J., Venglarik, M. and Morgan, S. (1999). Delayed versus immediate bedside inoculation of culture media for diagnosis of vaginal trichomonosis. *J. Clin. Microbiol*. 37:2369-2370.

Sutton, M., Sternberg, M., Kuomans, E.H., Mcquillan, G., Berman, S. and Markowitz, L. (2007). The prevalence *Trichomonas vaginalis* infection among reproductive age women in the United States 2001-2004. *Clinical Infectious Diseases*; 45(10):1319-1326.

Ukatu, V.E., Nebenu, I., Chilaka, C.G. and Attah, O.A., (2019). Evaluating *Trichomonas vaginalis* infection in pregnant women from two health facilities, Sokoto, Nigeria. *Nigerian Journal of Parasitology*; 40(1):46-50.

Ulogu, I.O., Obiajulu, I.O.C. and Ekejindu, I.M. (2007). Prevalence of *Trichomonas vaginalis* amongst women in Nnewi, Anambra State, Nigeria. *Nigerian Journal of Parasitology*; 28(1):6-10.).

Usanga, V., Abia-Bassey, L.N., Inyang-Etoh, P., Ani, F. and Archibong, E.I. (2009). Trichomonas Vaginalis Infection Among Pregnant Women In Calabar, Cross River State, Nigeria. *The Internet journal of gynecology and obstetrics, 14*.

Wilkerson, R.G. (2011). Trichomonas in Emergency Medicine. Available at: [http://emedicine.medscape.com/article/787722-overview].

World Health Organization. (2023). Trichomonaisis. Available at: [https://www.who.int/news-room/fact-sheets/detail/trichomoniasis].

World Health Organization (2012). *Global incidence and prevalence of selected curable sexually transmitted infections*-2008.

World Health Organization (WHO). (2001). *Global prevalence incidence of selected curable sexually transmitted infections, overviews and estimates*. WHO/HIV_AIDS/2011.02. Geneva.

Zhu, X., Liu, L., Yixi, L., Yang, Y., Zhang, Y., Yang, Z., Chen, H., Dong, J and Yang, S. (2023). The prevalence and risk factors of *Trichomonas vaginalis* in Wuhan and the Tibetan area, China: a two-center study. *Journal of Parasitological Research*, 122(1):265-273.

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

Comparative Evaluation of Performance of Microbial Fuel Cell and Electrocoagulation Cell in Wastewater Treatment

Livinus A. Obasi
Daniel C. Emeniru
Department of Chemical Engineering Technology,
Federal Polytechnic Ekowe, Bayelsa State
Corresponding author's e-mail: engrlaobasi@gmail.com

ABSTRACT

Electrocoagulation cell (ECC) and microbial fuel cell (MFC) are technological processes that handle the removal of wastewater contaminants such as colour, turbidity, chemical oxygen demand (COD), total suspended solid (TSS), total dissolved solid (TDS), total solid (TS), among others. Experiments conducted in this study showed that while ECC operates by supply of electric power from external source (39kWhr/m^3) with sacrificial iron electrodes, MFC was powered by electrical power (223.7mW/m^2) generated through the activity of microbes on wastewater organics with no sacrificial electrodes and hence is self-sustaining. The study considered both cells as affected by primary factors such as wastewater concentration, electrodes spacing, pH of the wastewater medium, time of operation, among others. These factors have direct effect on the cell performance with respect to wastewater pollution parameter removal. Whereas ECC utilized voltage generated externally to power the process, MFC generated energy within the cell. The overall principle governing both processes lies with the fact that negative electrical charges interact with the surface charges of the suspended or dissolved particles of the wastewater to effect demobilization, flocculation and sedimentation. The results obtained indicate that with MFC, the maximum removal efficiency of colour was (97.4%), pH (6.88-8.29), turbidity (97.4%), COD (99.6%), TSS (96%), TDS (98.28), TS (99.7%); and for ECC: colour (93.3%), pH(6.88-7.8), turbidity (94.6%), COD (93.33%), TSS (95.4%), TDS (95.28), TS (95.28%). This means that though MFC is more efficient, both MFC and ECC processes are capable of removing pollutants from wastewaters and industrial effluents under given experimental conditions.

1. INTRODUCTOION

Wastes generated from human activities have been a major concern globally with particular reference to industries, homes and environments. This has over the years proven to constitute a major threat and negative ecological effect to both flora and fauna in our environment (Kanawade et al., 2010). Wastes range from solid, liquid to gaseous forms. Several treatment methods have been developed to tackle the menace. Such methods could be categorized as physical (adsorption), chemical (ion exchange) of biological (microbial fuel cell). Electrocoagulation process of wastewater treatment utilizes the possibility of neutralization of negatively charged particles present in wastewater through direct current electrolytic process to form hydroxide complexes which aggregate as flocs (Yadav, 2010; Naje and Abbas, 2013). The electrolyte surface is usually exposed to free flow of air across the liquid-air interface (Moneer et al., 2023). This process determines the rate of collision of coagulated particles during floc formation.

The coagulants of the hydroxide formed tend to attract and absorb other suspended and dissolved particles of pollutants that precipitated to form flocs. The ECC process therefore removes suspended and dissolved particles as flocs without the use of any chemical coagulant (Asaithambi et al., 2012).

Microbial fuel cell is a device that harnesses metabolic activity of microorganisms in removing pollutants from wastewater to generate electricity in a relatively environmentally friendly manner (Guo et al., 2020; Tsekouras et al., 2022). A typical MFC comprises four basic components: anode (bio-reacting) chamber, cathode (chemical reacting) chamber, proton exchange membrane (PEM) and the external circuit (AlSayed et al., 2020). A number of factors affect the operation and performance of MFC, some of which include: electrode surface area, anodic volume and concentration, anolyte pH, proton exchange membrames (PEM) material type and method of preparation, chemical nature of catholyte, external load, among others (Obasi et al., 2024; Aghababaie et al., 2015). Unlike the case of ECC, MFC anode chamber is usually sealed air-tight to restrict inflow and outflow of oxygen across the anolyte surface. The microorganisms in the anode chamber operate essentially anaerobically. The performance of MFC is usually measured by noting the extent of COD and other wastewater pollution indicators removal (Chaijak et al., 2022), and power generation capacity (Obileke et al., 2021). These responses or process outputs evidently serve as metrics in determining the performance levels of the device. In literature, MFC has shown great efficiency (up to 99.9%) in removal of Fe from acid mine drainage compared to ECC with 94% removal efficiency under similar experiemental conditions (Fuodhaili et al., 2019). The comparative advantage of MFC application lies in its ability to generate electricity concurrently with wastewater treatment (Do et al., 2018).

ECC process equally has advantages over other wastewater treatment processes in that (i) it is moderately fast (ii) can treat large volumes of wastewater with higher organic loadings (iii) there is electro-flotation of particles by hydrogen bubbles (iv) ECC has a very good ionic (metallic) and colloidal matter removal efficiency that promotes their deposition (Foudhaili et al., 2019) (v) Electrode cost is relatively low (vi) ECC operation is probable to run in continual mode. However its disadvantage lies in the fact that the electrodes are dissolved and replaced. This increases its operational cost component and hence limits its application (Ebba et al., 2022). The efficiency of ECC is a measure of its capacity for COD removal and rate of power consumption (Fuodhaili et al., 2019). The overall outputs of the wastewater cells are the outcome of various half-cell reactions taking place within the system while in operation.

Anodic Reactions (Oxidation)	**Cathodic reactions (Reduction)**
Microbial fuel cell (MFC)	
$C_6H_{12}O_6 + 6H_2O \xrightarrow{Biocatalyst} 6CO_2 + 24H^+ + 24e^- + E_0$ $E_0 = OCV - IR_{\text{int}}$ $I = generated\ current,$ $R_{\text{int}} = cell\ \text{int}\ ernal\ resis\ \text{tan}\ ce$	$6O_2 + 24H^+ + 24e^- \rightarrow 12H_2O$ $K_3Fe(CN)_6 \rightarrow 3K^+ + Fe(CN)_6^{3-}\ (Ferrycyanide\ ion)$ $4Fe(CN)_6^{3-} + 4e^- \rightarrow 4Fe(CN)_6^{4-}\ (Ferrocyanide\ ion)$
Electrocoagulation cell (ECC)	
$Fe(s) \Rightarrow Fe^{n+}(aq) + ne^-$ $Al(s) \Rightarrow Al^{3+}(aq) + 3e^-$ Electrolytic oxidation of sacrificial electrode	$2H_2O + 2e \Rightarrow H_2 + 2OH^-$ Aggregation of destabilized phase to form flocs

The above half-cell reactions show the anodic oxidation and cathodic reduction processes for both ECC and MFC. For MFC, the anode chamber involves biocatalytic oxidation of glucose carbon source to produce protons and electrons. These electrons reduce the surface charged particles to precipitate as flocs (Obasi et al., 2020). Similarly, ECC anodic reaction is the dissolution of the metallic anode to form ions which combines with hydroxide ions (OH^-) to form the anode metallic hydroxide ($Al(OH)_3$) or $Fe(OH)_3$ coagulants (Titchou et al., 2021).

This paper therefore studies the comparative performance of MFC and ECC in hospital wastewater (HWW) treatment. The MFC was a dual chamber type run with mediatorless anolyte, *Ekowe* clay PEM and graphite electrodes. The ECC was a mono-chamber electrolytic cell with iron electrodes, HWW electrolyte and a 6v wet cell as its external power source. The cells were operated under similar experimental and environmental conditions to investigate the extent of pollution parameter removal from the wastewater.

2. MATERIALS AND METHODS

2.1 Characterization of wastewater

Wastewater was collected from Alphonso hospital, Elelenwo Port harcourt sewage system. The laboratory analysis procedure was open reflux method as describe in APHA (1995). The characterization results for colour, pH, TSS, turbidity, TDS, TS are shown in Table 1.

2.2 Reagents types

The reagents used in this study particularly for open-reflux method of wastewater COD determination were: $K_2Cr_2O_7$, Ag_2SO_4, Hg_2SO_4 powder, H_2SO_4, 1,10-phenanthroline monohydrate, $FeSO_4.7H_2O$, Ferroin indicator solution, $Fe(NH_4)_3(SO_4)_2.6H_2O$, ferrous ammonium sulfate (FAS), potassium hydrogen phthalate ($HOOCC_6H_6COOK$) and distilled water.

2.3 MFC construction

The MFC used in this study was a dual chamber mediatorless type. The two chambers: anode and cathode were made of PVC containers of equal volumes. The proton exchange material was *Ekowe* clay stuffed in a 0.08m length of 1inch diameter PVC pipe installed between the two chambers. The dimensions of each chamber was: diameter (0.12m), depth (0.17m) which gave a working volume ($v = 0.0013m^3$). Graphite electrodes were applied as electrodes in both chambers. The entire length of each electrode was inserted through the chamber lid 1cm diameter opening and surface area ($0.001065m^2$) exposed to the liquid electrolyte matrix to provide enough surface for bacteria cell attachment and biofilm formation and electron recovery (anode), and electron sink (cathode). About 5g of NaCl was added to the anolyte to increase the charge density and enhance the removal of COD, colour and turbidity. The circuit was loaded with an external resistance (R_{ext}) of $100\,\Omega$.

2.4 ECC construction

The ECC is a $0.0013m^3$ plastic cylinder filled with hospital wastewater and fully aerated. Two iron rods (electrodes) were inserted in place 0.05m apart. A 6 volts wet cell (DC power supply) with on/off buttons was connected to the electrodes with the aid of flexible wires.

Figures 1 and 2 show schematic diagrams of MFC and ECC respectively.

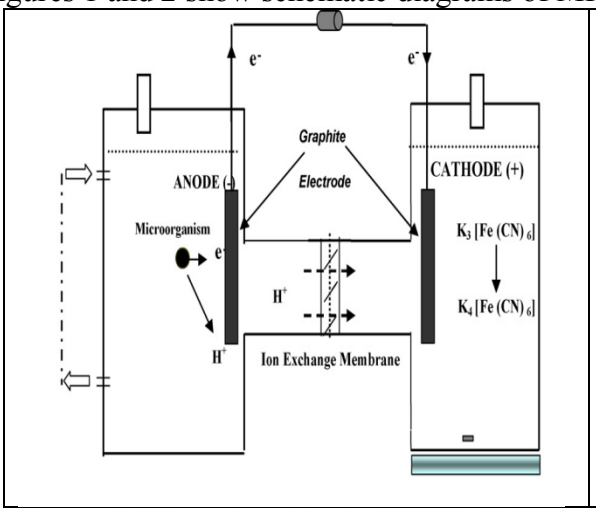


Fig 1 Microbial fuel cell (MFC)

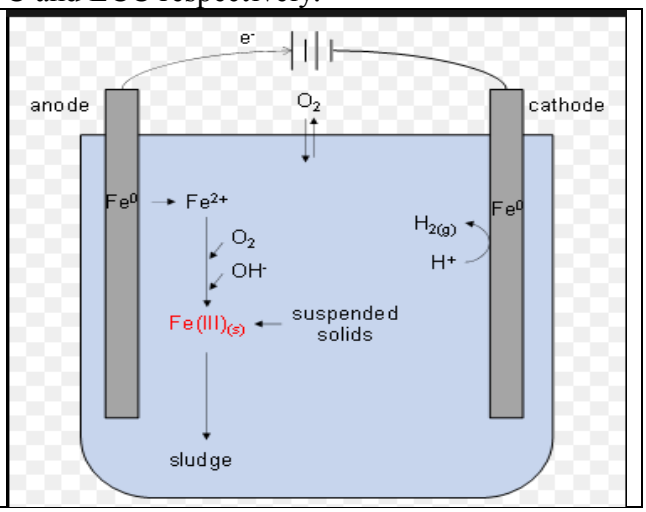


Fig 2 Electrocoagulation cell (ECC)

2.5 Determination of COD

The wastewater sample was placed in a sample flask and diluted to 50ml in a 500ml refluxing flask. 1g $HgSO_4$, several glass beads, and very slowly 5ml H_2SO_4 were added, agitated to mix and dissolve $HgSO_4$. The mixture was cooled while mixing to avoid possible loss of volatile materials. 25ml of 0.0417M $K_2Cr_2O_7$ solution was added and shaken to mix. The flask was attached to a condenser. Swirling continued and mixing continued while adding the H_2SO_4. The reflux mixture was mixed thoroughly before applying heat to avoid local heating of flask bottom and a possible blowout of flask contents as a precautionary measure. The open end of the condenser was covered with a small beaker to prevent foreign material from entering reflux mixture. Reflux was allowed for 2hours. The condenser was cooled, washed down with distilled water. The reflux condenser was then disconnected and the mixture diluted to about twice its volume with distilled water. The mixture was cooled at room temperature and titrated excess $K_2Cr_2O_7$ with FAS, using 0.15ml (3 drops) of ferroin indicator. The end point was taken as the first sharp colour change from blue-green to reddish brown. A blank containing the reagents was refluxed and titrated to obtain a volume of distilled water equal to that of the sample. The COD and removal efficiency of the sample were calculated using Equations (1) and (2) respectively.

$$COD\,as\,mg\,O_2\,/\,l = \frac{(A-B)\times M\times 8000}{mL\,sample} \qquad (1)$$

Where A = ml FAS used as blank, B = ml FAS for sample, and M = molarity of FAS.

COD removal efficiency of the substrate during the cycle of operation was calculated using the Equation (2).

$$\xi = \left(\frac{C_{so}-C_s}{C_{s0}}\right)100 \qquad (2)$$

where C_{so} represents the initial COD and C_s represents the final COD in mg/l.

The MFC power density was normalized on the projected electrode area and calculated using Ohms law

$$P_d = \frac{IV}{A} \quad (3)$$

The ECC energy consumption (kWh/m^3) of the electrochemical process was calculated using:

$$E = \frac{VIt}{V_R} \quad (4)$$

Where, V = average cell voltage, I = electrical current intensity, t = reaction time and V_R = volume of wastewater used.

3. RESULTS AND DISCUSSIONS

3.1 Performance comparison between MFC and ECC

Table 1 presents the parameter value changes in the course of hospital wastewater treatment using MFC and ECC. The parameters considered include: pH, colour, turbidity, COD, TSS, TDS, TS under similar experimental conditions.

Table 1: Comparison between wastewater treatment performance of MFC and ECC

No.	Parameter	MFC (initial)	MFC (final)	% Removal	ECC (final)	% Removal	unit
1	pH	6.88	8.29	6.88-8.29	7.8		
2	Colour	$\lambda = 2.85$	0.074	97.4	$\lambda = 0.19$	93.3	
3	Turbidity	355	9.585	97.3	19.17	94.6	NTU
4	COD	443	1.772	99.6	29.54	93.33	mg/L
5	TSS	190	7.6	96.0	8.74	95.4	mg/L
6	TDS	490	7.6	98.28	23.12	95.28	mg/L
7	TS	640	1.92	99.7	20.4	96.8	mg/L
8	Current	0.2mA	0.045mA	-	0.093A	0.032A	xA
9	voltage	1.12	0.45		6.0 -5.30		xV
10	Power output	223.7mW/m^2	19.01mW/m^2		39kWhr/m^3		yW/m^x
11	Electrolytic period	20			20		days

The performance of microbial fuel cell (MFC) in removal of wastewater parameters compared to electrocoagulation cell (ECC) is presented in Table 1. It is noteworthy that while ECC is an electrical energy consuming device, MFC is an energy generating device in which case power generation is a direct effect of anaerobic microbial activity. The MFC and ECC processes over a 20 day operational period effected changes in solution pH from initial value of 6.88 to 8.29 and 7.8 respectively. This could be attributed to the reduction of protons (H^+) generated due to microbial degradation activity of the wastewater organics. The surface negative charges of the suspended particle in the wastewater medium reacted with the excess untransfered protons converting them to hydrogen gas. Though in effect, the accumulation of hydrogen gas at the electrode (anode) constitutes impedance to the transfer of electrons, a situation referred to as overpotential may result. The results also show that the colour, turbidity, COD, TDS, TSS removal efficiency of MFC was equally higher than that of ECC. The wastewater pollutant removal in ECC was induced by the rate of dissolution of the sacrificial anode (iron rod), whereas MFC function is determined by the rate of microbial activity. The production of metallic hydroxides coagulant in ECC influences the pH of the resulting wastewater medium. This is the major reason why initial pH of the medium is a major factor in determining the wastewater treatment efficiency of ECC. In both cases, the treatment

efficiency is directly related to the increase in volumetric current density in the medium (Khan et al., 2018). The decrease in voltage values in MFC (1.12 – 0.45) and ECC (6.0-5.30 v) therefore is an indication of polarization effect of the wastewater removal efficiency on the cells.

3.2 MFC and ECC Polarization tests

The operations of MFC and ECC are electrocoagulation processes which respectively produce and consume energy which dwindles over time. It results in decline in the cell performance often referred to as polarization. MFC performance curve determines the point where the maximum (peak) power generation occurs in a power generation process (Simeon *et al*., 2020). The power curve presented in Figures 3 shows the power performance characteristics of the cell. The power generation in the cell during start-up was low, but increased with the progress of time to a peak value P due to exponential growth and multiplication of electrochemically active bacteria in the anolyte medium. A period of relative power stability preceded cell polarization. During polarization process, the current and voltage outputs gradually wind down due primarily to, activation, Ohmic, mass transfer and concentrations losses (Simeon *et al*., 2020), and increased solution resistance due to decrease in solution conductivity (Babanova *et al*., 2019). In addition to nutrient depletion, there is a gradual build-up of higher internal resistance in the cell which also contributed to voltage drop and eventual cell polarization. There was also increase in the growth of biofilm on the anode surface which constitutes some form of resistance to the transfer of electron from the external layer of the biofilm onto the anode and hence hampers power generation in the cell (Wang *et al*., 2009). In comparison with ECC, polarization process occurs due to precipitation of materials on the electrode often referred to as fouling and consequential increase in ion concentration which constitutes resistance to the flow of energy within the electrolyte (Choi et al, 2017; Chow et al., 2021).

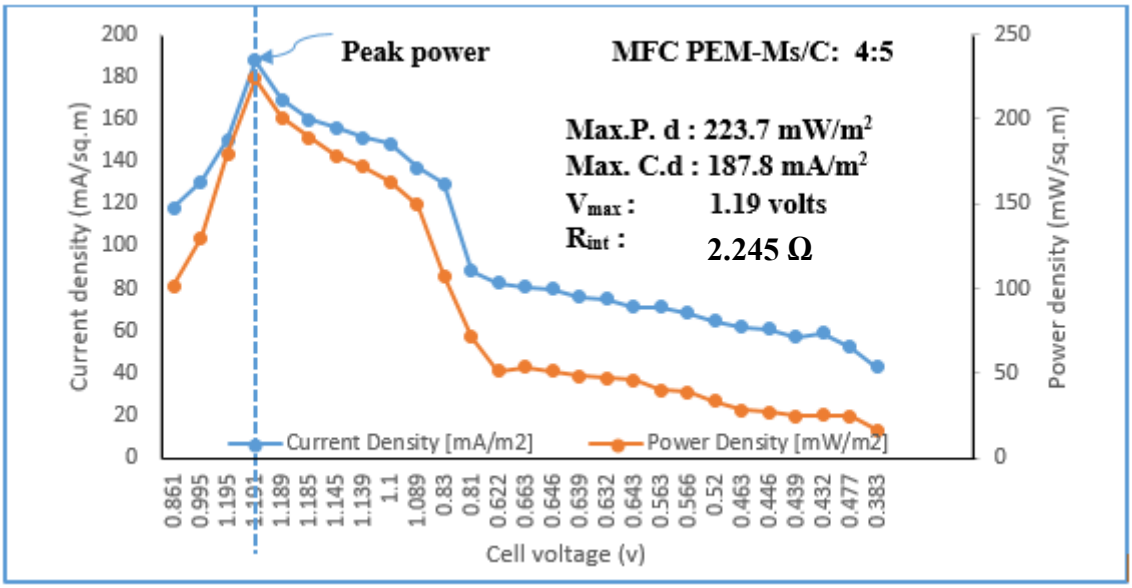


Figure 3: Power curve showing power density as a function of cell voltage and current density for clay-PEM MFC

Polarization curve presented in Figure 4 pictures the stage-wise processes that led to the cell exhaustion. This process is described by four sections of the curve, namely; the voltage drops due to fuel cross-over (A-B), rapid voltage drops (B-C), Ohmic loss (linear drop) (C-D), and concentration or mass transfer loss (fast drop) (D-E). The slope of the linear voltage drop section (C-D) due to Ohmic loss calculated from $^{dv}/_{dI}$ gives the cell total internal resistance (R_{int}) of 2.245Ω. This value was lower than the values in the range of 12.21 and 12.78Ω proposed by Manohar and Mansfeld, (2009).

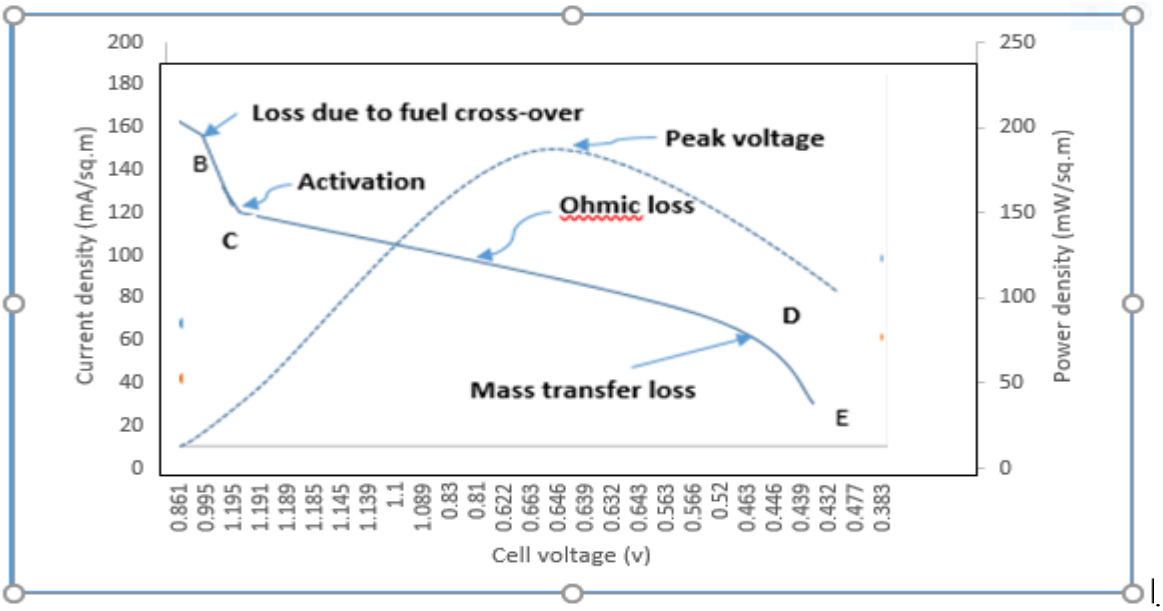


Figure 4: Polarization curve featuring activation, Ohmic and mass transfer losses.

The results show the current (mA), voltage (v), current density (mA/m^2) and power density mW/m^2) obtained from MFC anode over the study period of 20-day operation.

3.3 Wastewater turbidity and TSS removal

Table 1 presents MFC and ECC experimental data for turbidity and TSS removal from hospital wastewater (HWW) treatment. The table shows the influent wastewater turbidity and TSS values reducing with time for both cells from influent feed values of (355NTU and 190mg/l) to MFC (9.585NTU) and ECC (19.17NTU) respectively. The turbidity and total suspended (TSS) of the influent wastewater reduced from feed value to final value after 20 days for the MFC and ECC by 97.3% and 94.6% respectively. The higher rate of parameter reduction of turbidity and TSS in MFC compared to those of ECC could be attributed to the high rate and direct impact of electron release and transfer across the anolyte matrix that neutralized the surface charges on the suspended particles to induce flocculation and sedimentation. Fouling build-up of iron surface of ECC could have limited the coagulation process efficiency. However, this TSS reduction is high compared to 65% range of values reported by Min *et al*. (2005) in a pH adjusted MFC reactor.

3.4 Wastewater COD and TDS removal

As shown in Table 1 for TDS and salinity removal from MFC and ECC wastewater treatment, the trends indicate parameter removal with time during both cells operation. MFC however recorded

higher percentage COD and TDS removal by (99.6% and 98.28%) over ECC values (93.33% and 92.58%) respectively. The higher rate of COD removal in MFC could be attributed to high degradation activity of electrochemically active microbes present in the anolyte. This microbial activity equally has a corresponding positive effect on the number of electrons produced. The increase in change density in the medium is directly related to the rate of neutralization of surface charges on the dissolved particles to induce coagulation and flocculation.

4. CONCLUSION

The study sought to evaluate the comparative efficiency of MFC and ECC in hospital wastewater treatment. The two cell operated on a batch mode. Both technologies were able to produce a treated effluent complying with the WHO wastewater discharge standard (pH 6.0–8.5). The parameters removal efficiencies recorded for each cell were: MFC (colour: 97.4%), turbidity: 94.6%, COD: 99.6%, TSS:96%, TDS: 98.28%, TS:99.7%); and ECC (colour:93.3%), turbidity: 97.3%, COD: 93.33%, TSS:95.4%, TDS: 95.28%, TS:96.8%). The results therefore suggest that microbial fuel cell (MFC) is more efficient than electrocoagulation cell (ECC) in treatment of hospital wastewater. MFC is more expensive than electrocoagulation cell due to the inclusion of proton exchange membrane (PEM) component in MFC.

Declaration of interest statement
The authors declare no conflict of interest

REFERENCES

APHA (1995). New York: American Public Health Association, 19th Ed..

Aghababaie, M., Farhadian, M., Jeihanipour, A. and Biria, D. (2015). Effective factors on the performance of microbial fuel cells in wastewater treatment - a review. *Environmental Technology Reviews, 4*(1). https://doi.org/10.1080/09593330.2015.1077896.

Asaithambi, P., Susree, M., Saravanathamizhan, R., Matheswaran, M. (2012). Ozone assisted electrocoagulation for the treatment of distillery effluent, Desalination 297 (2012) 1–7.

Babanova, S. Jones, J., Phadke, S., Mengquian Lu, Carlo Angulo C., Garcia, J., Carpenter, K., Cortese, R., Chen, S., Phan, T. and Bretschger, O. (2019). Continuous flow, large□ scale, microbial fuel cell system for the sustained treatment of swine waste. *Water Env.,* 1-13.

AlSayed, A., Soliman, M. and Eldyasti, A. (2020). Microbial fuel cells for municipal wastewater treatment: From technology fundamentals to full-scale development. *Renewable and Sustainable Energy Reviews, 134* (2020), 110367.

Chaijak, P., Lertworapreecha, M., Changkit, N., Sola, P.(2022). Electricity Generation from Hospital Wastewater in Microbial Fuel Cell using Radiation Tolerant Bacteria. Biointerface Research in Applied Chemistry. 12(4), 5601 – 5609, https://doi.org/10.33263/BRIAC124.56015609

Choi, S., Kim, B., Han, J. (2017). Integrated pretreatment and desalination by electrocoagulation (EC)-ion concentration polarization (ICP) hybrid. Lab on a Chip, 12 (2017)

Chow, H., Ingelsson, M., Roberts, E.P.L., Pham, A.L. (2021). How does periodic polarity reversal affect the faradaic efficiency and pouling during iron electrocoagulation? Water Research, 203 (2021), 117497

Do, M.H., Ngo, H.H., Guo, W.S., Liu, Y., Chang, S.W., Nguyenc, D.D., Nghiem, L.D., Ni, B.J. (2018). Challenges in the application of microbial fuel cells to wastewater treatment and energy production: A mini review. Science of the Total Environment, 639(2018), 910-920

Ebba, M., Asaithambi, P., Alemayehu, E. (2022). Development of electrocoagulation process for wastewater treatment: optimization by response surface methodology. Heliyon 8 (2022) e09383.

Fuodhaili, T., Rakotonimaro, T.V., Neculita, C.M., Coudert, M., Lefebvre, O. (2019). Comparative efficiency of microbial fuel cells and electrocoagulation for the treatment of iron-rich acid mine drainage. Journal of Environmental Chemical Engineering, 7(3) 2019 103149

Gou, Y., Wang, J., Shinde, S., Wang, X., Li, Y., Dai, Y., Ren, J., Zhang, P., Liu, X. (2020). Simultaneous wastewater treatment and energy harnessing in microbial fuel cells: an update on the biocatalysts. RSC Advances, 43 (2020).

Kanawade, S.M., Hamigi, A.D., Gaikwad, R.W. (2010). Ecological effect of pollution. Internal Journal of Chemical Engineering and Application, 1(4), 2010-0221.

Khan, S.U., Islam, D.T., Farooqi, I.H., Ayub, S., Basheer, F. (2018). Hexavalent chromium removal in an electrocoagulation column reactor: Process optimization using CCD, adsorption kinetics and pH modulated sludge formation, Process Saf. Environ. Protect. (2018).

Manohar, A. and Mansfeld, F. (2009). The internal resistance of a microbial fuel cell and its dependence on cell design and operating conditions. *Electrochimica Acta, 54*(6), 1664-1670.

Min, B., Kim, J.,Oh, S., Regan, M.J. and Logan, B.E. (2005). Electricity generation from swine wastewater using microbial fuel cells. *Water Res.,* 9(39), 4961–4968.

Moneer, A.A., Thabet, W.M., Khedawy, M., El-Sadaawy, M.M., Shaaban, N.A. (2023). Electrocoagulation process for oily wastewater treatment and optimization using response surface methodology Internal Journal of Environmental Science and Technology. 20(2023), 13859-13872

Naje, A.S., Abbas, S.A. (2013). Electrocoagulation in wastewater treatment: A Review of Methods and Applications. Civil and Environmental Research. 3(11), 2013.

Obasi, L.A., Onukwuli, O.D, Okoye, C.C., Agu, C.M. (2024). Physicochemical characterization of effluent from microbial fuel cell operating with thermochemically modified $BaZrO_3$/clay–PEM. International Journal of Environmental Science and Technology, https://doi.org/10.1007/s13762-023-05420-8

Obasi, L.A, Onukwuli, O.D., Neminebor, J. (2020). Electrocoagulation potential of microbial fuel cell in brewery wastewater treatment. Journal of Current Science and Humanities. 8(2), 165-172

Obileke, K Onyeaka, H., Meyer, E.L., Nwokolo, N. (2019). Microbial fuel cells, a renewable energy technology for bio-electricity generation: A mini-review. Electrochemistry Communications, 125(2021) 107003.

Simeon, M.I., Asoiro, F.U., Raji, O.A. and Freitag, R. (2020). Polarization and power density trends of a soil-based microbial fuel cell treated with huuman urine. *International Journal of Energy Research, 44*(7), 5968-5976.

Titchou, F.E., Zazou, H., Afanga, H., El Gaayda, J., Akbour, R.A., Hamdani, M. (2021). Removal of Persistent Organic Pollutants (POPs) from water and wastewater by adsorption and electrocoagulation process, Groundw. Sustain. Dev. 13 (2021) 100575.

Tsekouras, G.J., Deligianni, P.M., Kanellos, F.D., Kontargyri, V.T., Kontaxis, P.A., Manousakis, N.M., Elias, C.N. (2022). Microbial fuel cell for wastewater treatment as power plant in smart grid: Utopia or reality. Front. Energies Res. 10 (2022), ttps://doi.org/10.3389/fenrg.2022.843768

Wang, X., Feng, Y., Wang, H., Qu, Y., Yu, Y., Ren, N., Li, N., Wang, E., Lee, H. and Logan, B.E. (2009). Bioaugmentation for electricity generation from corn stover biomass using microbial fuel cells. *Environ. Sci. Technol., 43*(15), 6088–6093.

Yadav, R. (2010). Study of Electroagulation and combined Electroagulation-Oxidation process for dye Removal. Unpublished Master thesis, Thapar University, Patiala: India

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

Application of GIS for Determination of Morphometric Analysis of The Lower Orashi River

Ayibawari Obiene Egai
Department of Geology, Niger Delta University, Amassoma, Nigeria

Otele Ama
Department of Science Laboratory Technology (SLT), School of Applied Sciences,
Federal Polytechnic Ekowe, Bayelsa State, Nigeria.
**E-mail: amaotele1@gmail.com*

ABSTRACT

In watershed hydrology, determination morphometric features of a River basin are imperative and simple and to understand in quantitative and qualitative nomrnclature of any River system. Hence, to examine the lower Orashi River basin morphological and hydrological parameters, as well as its flood potential, based on their morphometric characteristics using remotely sensed SRTM data that was analyzed with ArcGIS software. The arieal, linear, and relief component of the Orashi River basin were examined as morphometric parameters. The lower Orashi river basin, according to the findings, has a total size of 625.61 km^2 and a perimeter of 307.98 km, with a 5th order river network based on Strahler categorization and a dendritic drainage pattern. Because of low drainage density, the drainage texture is very fine, the relief is low, and the slope is very low. The bifurcation ratio, circularity ratio, drainage density aspect ratio, form factor, and stream frequency values indicate that the basin is less elongated and would produce surface runoff for a longer period, while topographic changes show that the river is decreasing with depth in the land area at about the same elevation as a result of sand deposition due to lack of dredging maintenance, Also, the topographic changes indicated that the basin is morphometrically elevated and sensitive to erosion and flooding. To understand the geo-hydrological features and to have a better plan on how to manage watersheds, morphometric analysis using geographic information systems and remote sensing techniques becomes very imperative and beneficial.

Keywords: GIS Application, morphometric analysis, morphometric determination, lower orashi river

INTRODUCTION

The assessment of morphorimetric parameter is mathematically calculated and measurement of the shape, surface and its landform extent is referred to as morphometric (Agarwal, 1998; Obi, et al., 2002; Kulkarni, 2015). An extensive watershed improvement plan for the most part starts with a comprehensive morphometry understanding of the waterways or drainage basin. Geomorphological attributes or qualities of a stream or river basin acts as a significant part in modelling various hydrological processes of a River or waterways basin. Traditionally, morphometric analysis involves figuring out the extent of a stream, the length of streams, bifurcation ratio, and the streams density per unit drainage area, difference in elevation, perimeter and area of drainage basins among others. Drainage basin or watershed is viewed as a basic tool in the examination of some parts of

the hydrological cycle and can likewise be portrayed as an open framework (Obi, et al., 2002). According to Rastogi & Sharma (1976), "drainage basin or watershed is a system where inputs from precipitation undergo the process of infiltration, percolation, through flow and overland flow (surface run-off) thereby proceeding as output in the form of evapo- transpiration which is the loss of water directly from the ground, water, surface and vegetation".

Consequential environmental impacts such as flooding, gully erosion, etc have been detected and monitored using remote sensing and geographic information system (GIS) technologies (Hualou , et al., 2008). Morphometry is the estimation and numerical investigation of the setup of the earth's surface, shape and measurement of its landforms (Agarwal, 1998). Horton (1940) first started morphometric research in the field of geomorphology. The morphometric investigation of the drainage basin and channel network assume an essential function for understanding the geo-hydrological essential function of drainage basin and expresses the prevailing climate, geology, geomorphology, structural, and so on. Many workers have proved the relationship between drainage parameters and the aforementioned factors (Horton, 1945; Melton 1958). The drainage basin examination is significant in any hydrological evaluation like appraisal of groundwater potential, groundwater planning, pedology, and environmental analysis (Pareta, Pareta, 2011). Different significant hydrologic phenomena can be related to the physiographic attributes of drainage basins, for example, size, shape, slope of drainage area, drainage density, size, and length of the tributaries. Geology, relief, and climate are the essential determinants of running water biological systems working at the basin scale (Hualou, et al.,2008). Itemized morphometric investigation of a basin is incredible assistance in understanding the impact of drainage morphometric networks on landforms and their qualities. The quantitative examination of morphometric parameters has been discovered to be of immense utility in River basin evaluation, watershed prioritization for soil and water conservation, and natural resources management. The impact of drainage morphometric framework is extremely critical in comprehension of the landform measures, soil actual properties, and disintegration qualities. Drainage attributes of numerous River basins and sub basins in different parts of the globe have been studied using conventional methods (Horton, 1945; Gangalakunta, 2004). This study focuses on the morphometric evaluation of Riverto comprehend the drainage basins by assessing their morphometric values which incorporates the state of the morphometric framework including the shape of the basin, the length of the stream, the area, the stream order, the length of stream segments, bifurcation ratio, density of drainage, and its frequency; furthermore, to join the geomorphologic and hydrological characteristics of the drainage basins.

Aim and Objectives of the Study

The main aim of this study was to determine the morphometric parameters of the lower Orashi River qualitatively and quantitatively using GIS application. The specific objectives of the Study include the follosing:

1. To assess the morphometric characteristics of the River.
2. To evaluate the type of drainage system of the area.

Study Area

The lower Orsahi River, which flows through Ahoada West LGA in Rivers State, Nigeria, is subjected to investigation, and the area is fast becoming one of the increasing urban centers in Nigeria's South-South geopolitical region. Communities sounding the area are Jorkarima 1,2,3,4, Akinima, Mbiama, Ushie, Akiogbologbo, Okarki, Ikodi, Ogbogoro in Ahoade West Local

Government Area, Rivers State. in addition, the area is accessible by roads and the river and lies between longitude 0060 20'0 and 0060 40'0 "East and latitude 040 50'0" and 050 10'10" North in the Niger Delta. (Figure 1.1) with altitude below sea level on the region 39m further inland (Eteh et al., 2019). The average rainfall and temperature of the area are 2,899mm and 26.7^{0}C (Eteh and Okechukwu 2021). Several settlements in the area are close to hydrocarbon flow stations owned by the SPDC and NAOC.

Vegetation

The vegetation along the Lower Orashi River is composed of four ecological logical zones which supports luxuriant fast-growing swamp forest. These include: coastal barrier Island forests, mangrove forests, fresh water swamp (e.g. forests) and lowland rain forests. These vegetation types are associated with the various soil units in the area, and they constitute part of the complex Niger Delta ecosystems. The organic debris which originates in these swamps, assist in the sedimentation of this region climate, vegetation root, types of trees, shrubs, etc.

Relief and Drainage

The region is characterized by low lands with topography of the area is low-lying with a maximum of 36 m elevation. The areas are drained mainly by the nature of creeks example talyor and Epie and tend to slope gently into Lower Orashi River which in turn drains into the Atlantic Ocean in Figure 1.2. Due to the poor drainage of the area, it tends to flood during the rainy season.

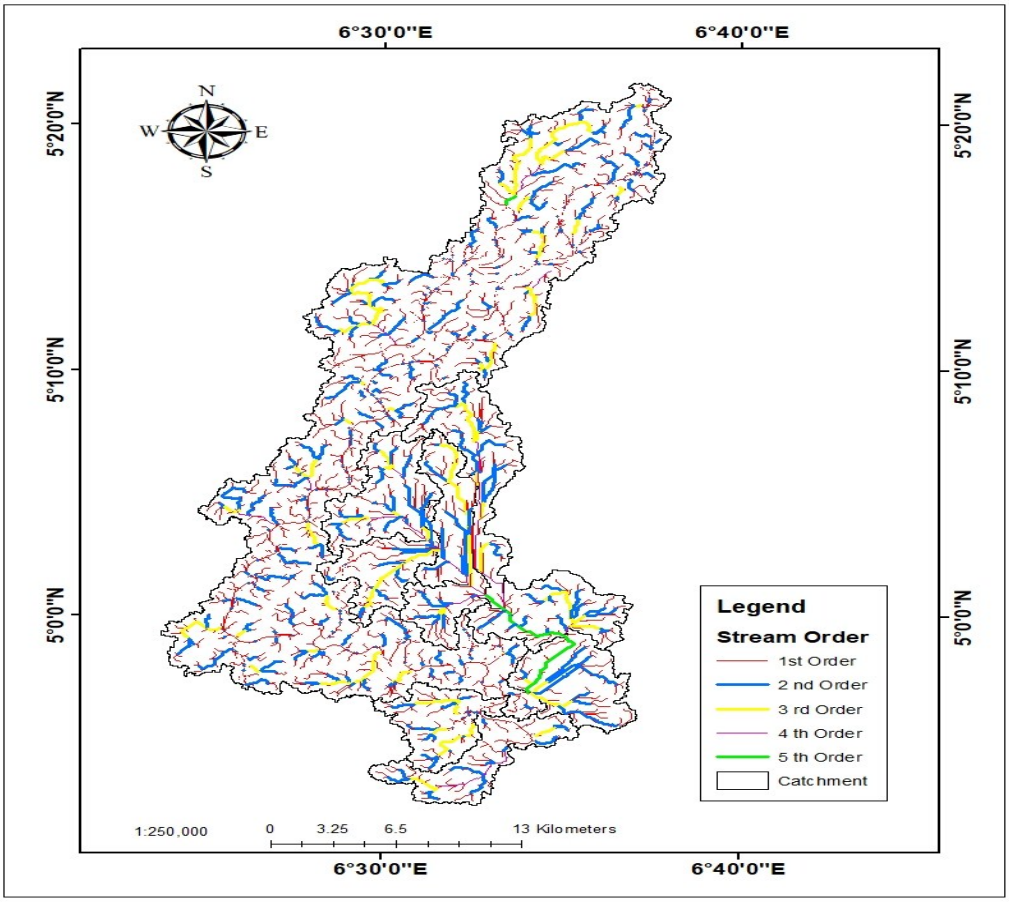


Figure 1.2: Drainage Map of the Study area showing stream order.

Geology of the Study area

The study area which falls within the South-Western flank of the Niger Delta Region of Nigeria has been geologically described by Reyment (2018). The Niger Delta Basin was formed by a failed rift (Aulacogen) junction at the pulling apart of the South American plate from the African plate. The rifting in the basin was initiated during the late period of the Jurassic and terminated in the period of the mid-Cretaceous. Several faults occur which are more of thrust faults. The delta covers a land area in excess of 105,000 km^2 (Reijers, 2011). These structures are facies of the pro-delta Akata Formation, facies of the Agbada Formation which constitute a paralic delta front. The Benin Formation constitute a continental delta top facies. The Akata Formation is the basal lithostratigraphic unit found in the Niger Delta Region, ranging from Paleocene to Holocene age (Reyment, 2018; Etu–Efeotor, 1997). Its marine pro-delta mega facies are composed of thick shales, turbidite sands, and small amounts of silt and clay. The Akata formation is made up of high pressure, low density, and deep marine deposits consisting of plant relics near the contact with overlying Agbada formation. The planktonic foraminifer may account for over 50 percent of the rich microfauna and benthonic assemblage (Chukwu, 1991). This assemblage indicates a shallow marine shelf depositional environment (Egirani, Wessey, 2015). The streaks of sand and silt have been deposited at the high energy delta advanced into the sea. The approximate range of thickness is from 0-6000 meters. The formation crops out subsea at the outer delta area and is not visible at the shore (Etu-Efeotor, 1997).

Hydrogeology

In the Niger Delta, water is contained in very thick and extensive sand and gravel aquifer within the Benin Formation. The Benin Formation is the aquiferous layer and all boreholes in the area are drilled into it. Minor intercalations of shale layers give rise to multi-aquifer system, out of which two types have been identified (Etu-Efeotor, 1981). The first (Holocene age) is more prolific and extends to about 60-90m (unconfined) while the second (Oligocene) is less prolific and underlies the first. Multi-aquifer systems have also been identified from lithologic logs of boreholes from other parts of the Niger Delta by Offodile (1992), Edet (1993); Udom *et al* (1988).

MATERIALS AND METHOD

The materials used for this experiment include mainly, the Global Postioning System (GPS) and Measurement.

Sources of data

Integration of remote sensing and geographic information system technology was adopted in this study using primary data such as GPS coordinate sample location and secondary data such as Shuttle Radar Topographic Mission Digital Elevation Model (SRTM DEM) download from https://dwtkns.com/srtm30m of the All these datasets were brought into the same coordinate system of the Universal Transverse Mercator (UTM) projection 32N in the ArcGIS 10.6 geographical information system software. The Digital Elevation Model image shows the distribution and spatial variation of elevation values at every geographic point/location within the area. The method use in this research work is Geographical Information Systems with aid of hydrology tool.

RESULTS AND DISCUSSION

The Evaluation Parameter for Morphometric according to Clarke (1966), is the measurement and mathematical analysis of the earth's surface configuration, including the shape and dimensions of its landforms. Measurements of the basin linear, areal, and relief aspects, as well as slope contribution, are used in the morphometric analysis, as presented below:

Linear Morphometric

This means that the drainage network's channel patterns follow the stream segments' morphological characteristics, and the analysis is based on the stream network open linkages such as Stream Order, Stream Number, Stream Length, Bifurcation Ratio.

Topographic changes

The results of the analysis of the geomorphological sequence in the profiles established in figure 5 show that the terrain has a low elevation in Figure 6a at 6h, and the river shows that the width of the river decreases in various topographical changes like the shows Figure 6a, 6b, 6c and 6e due to accretion. Figures 6f, 6g and 6h show that the depth of the river is almost at the same elevation in the land area due to the deposition of sand due to lack of maintenance by dredging the river, resulting in flooding during the season rains. According to Eteh and Okechukwu (2021) proper planning and management of the flood situation is essential to avoid major effects on flooding during the rainy season in the Niger Delta. It is therefore important to study the terrain of the area by investigating the hydrological property and the depth of the river to monitor the statue of the area, especially in terms of the drainage system, making decisions for the construction of structures mainly along the riparian communities and including roads, agriculture, buildings construction, Because most of the topography has poor drainage system due to lack of planning, structures and roads are built on drainage canals, resulting in flooding during the rainy season. Therefore, government need to plan and manage the waterway because is critical as flood has come to stay. But we must manage our rivers and protect the safety of our citizens.

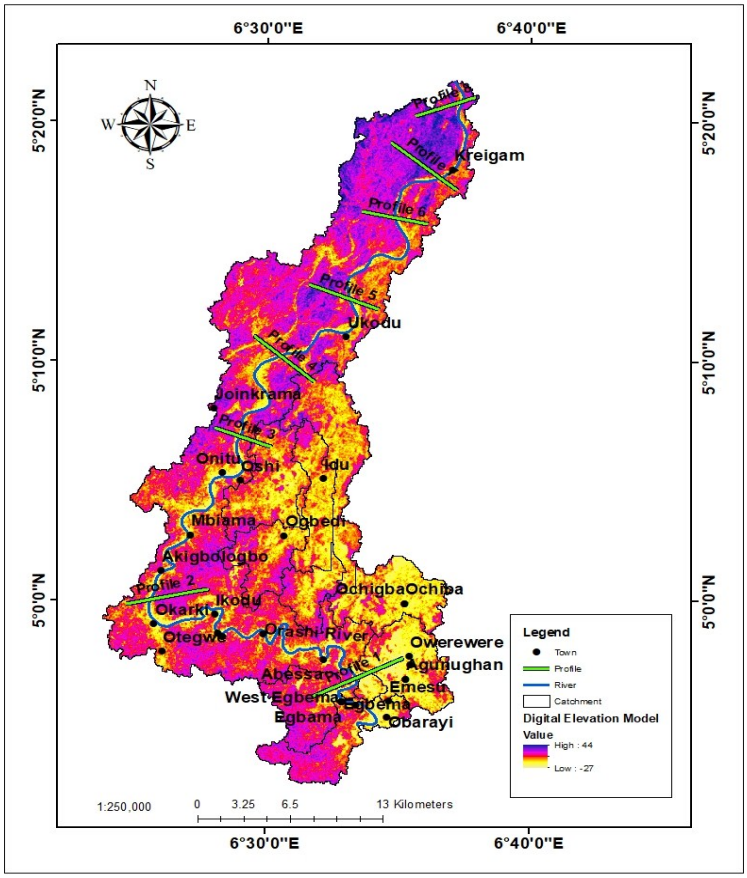


Figure 4.2: Digital Elevation model showing Cross section profile

Figure 4.3: Profile 1

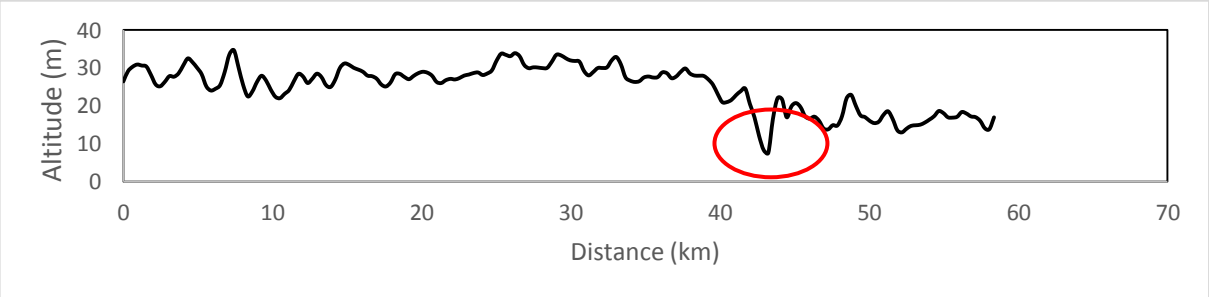


Figure 4.4: Profile 2

Figure 4.5: Profile 2

Figure 4.6: Profile 3

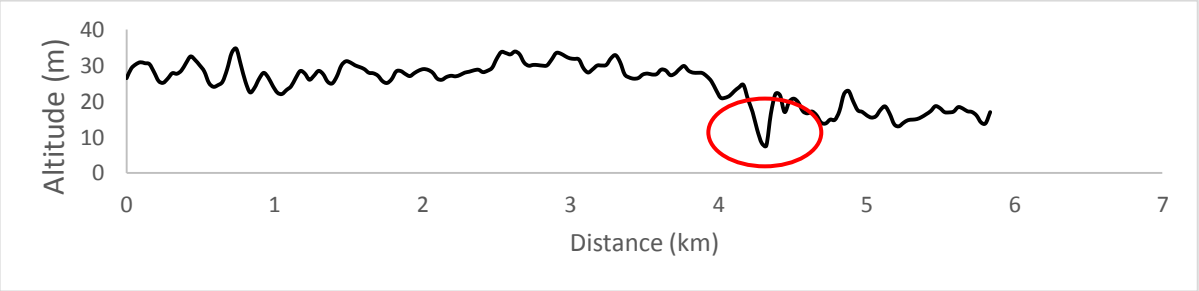


Figure 4.7: Profile 4

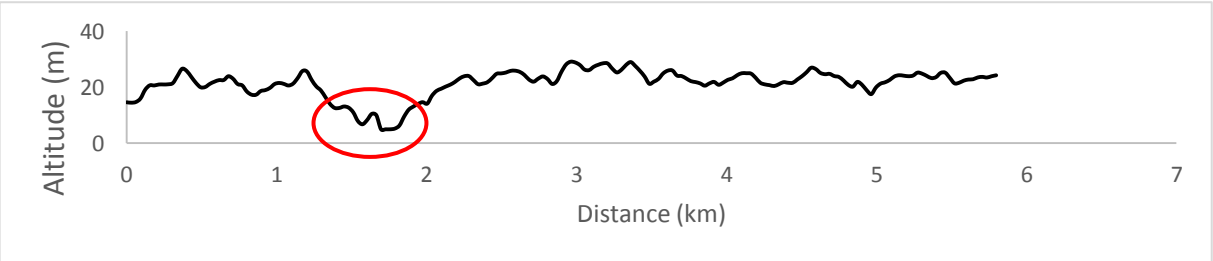


Figure 4.8: Profile 5

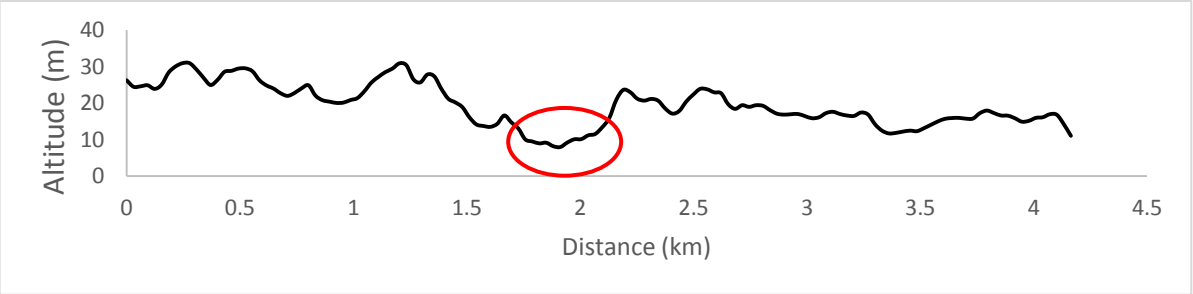


Figure 4.9: Profile 6

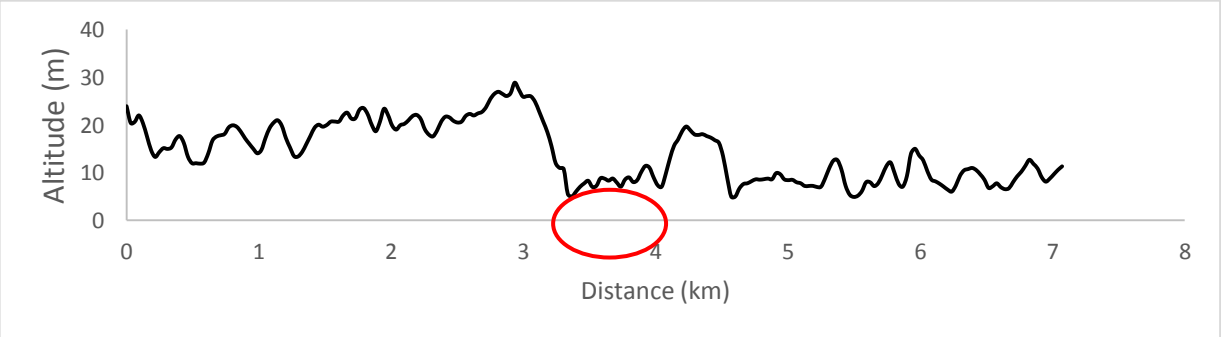


Figure 4.10: Profile

CONCLUSION AND RECOMMENDATION

The application of Geographic Information Systems (GIS) for the determination of morphometric analysis of the Lower Orashi River has proven to be a valuable tool in understanding the physical characteristics and dimensions of the river's basin. This study utilized GIS techniques to gather, process, and analyze spatial data related to the river's drainage network, topography, and other relevant parameters. The morphometric analysis provided insights into the river's hydrological and geomorphic properties, contributing to a more comprehensive understanding of its behavior and potential impacts on the surrounding environment. Also this study utilized GIS tools and techniques to analyze various morphometric parameters, including stream order, drainage density, basin shape, and relief ratio, among others, the integration of GIS technology has enabled a comprehensive understanding of the river's physical attributes and their spatial relationships.

The property of drainage basins contains the size, shape, geology are vital indices for predicting environmental hazards especially Flood and erosion. These indices are crucial for predicting environmental threats, particularly erosion and flooding. They reveal the rate at which rain reaches a major river, as well as the frequency and severity of flooding. This research demonstrates how drainage basin configuration has a major impact on the occurrence of environmental hazards in a given area. The narrow outlets of Orashi River elongated basins restrict runoff velocity and cause long-lasting flood peaks, yet their near circular form promotes rapid runoff circulation and the drainage system is dendric type with higher bifurcation ratio and low relief in lower Orashi River possess a great threat for erosion and flooding due to the topography has a poor drainage system resulting from low altitude in river and land area as a result of sand deposited due to a lack of maintenance in low Orash River

RECOMMENDATIONS

Based on the findings of this study, several recommendations can be made for further research and practical applications:

i. To enhance the accuracy of the morphometric analysis, future studies should focus on acquiring high-resolution elevation data and hydrological datasets.
ii. Incorporating longitudinal profiles and slope analysis could provide a more detailed understanding of the river's behavior and sediment transport processes.
iii. Including historical data and conducting temporal analyses can reveal trends and changes in the river basin morphology over time, aiding in predictions of future developments.
iv. Assessing the impact of land use changes on the morphometric characteristics could help in understanding human-induced modifications to the river basin.
v. Developing hydrological and geomorphic models using GIS data can aid in predicting changes and potential hazards in the river basin, assisting in proactive management strategies.
vi. Collaborating with local communities, governmental agencies, and environmental organizations can ensure that the insights gained from GIS-based morphometric analysis are integrated into decision-making processes.
vii. Promoting GIS education and training among professionals, researchers, and policymakers can enhance their capability to utilize GIS tools effectively for morphometric analysis and river basin management.

REFERENCES

Agarwal, C. S. (1998). Study of drainage pattern through aerial data in Naugarh area of Varanasi district, UP. *Journal of the Indian Society of Remote Sensing*, 26(4), 169- 175.

Aher, P.D., Adinarayana J., & Gorantiwar S.D. (2014) Quantifcation of morphometric characterization and prioritization for management planning in semi-arid tropics of India: a remote sensing and GIS approach. *J Hydrol* 511:850–860. https://doi. org/10.1016/j.jhydrol.2014.02.028

Avijit, M. (2020). The significance of morphometric analysis to understand the hydrological and morphological characteristics in two different morpho-climatic settings. Appl Water Sci 10, 33 https://doi.org/10.1007/s13201-019-1118-2

Cannon, J.P. (1976) Generation of explicit parameters for a quantitative geomorphic study of the mill creek drainage basin. *Oklahoma Geology Notes*. 1976;36(1):13–17.

Chitra, C., Alaguraja P., Ganeshkumari, K., Yuvaraj, D., & Manivel, M. (2011) Watershed characteristics of Kundahsubbasinusingremote sensing and GIS techniques. *Int J Geomatics Geosci* 2(1):311–335

Chukwu, G. A. (1991). The Niger delta complex basin: stratigraphy, structure and hydrocarbon potential. *Journal of Petroleum Geology*, 14, 211-220

Clarke, J.I. (1966) Morphometry from maps. Essays in geomorphology. Elsevier BV, New York

Edet, A.E. (1993), Groundwater quality assessment in parts of Eastern Niger Delta, Nigeria.*Journal of Environmental ge-ology,* Vol.22 No.1 pp. 41-46.

Egirani, D. E. & Wessey, N. (2015). Study of water resources in parts of the Niger Delta Region of Nigeria: paper II, *International Journal of Multidisciplinary Academic* Research, 3(4), 67-82.

Eteh, D.R., Francis E.E & Francis O. (2019): Determination of flood hazard Zones Using Geographical Information Systems and Remote Sensing techniques: *A case Study in part Yenagoa Metropolis* 21(1): 1-9 ; Article no. JGEESI.48644 ISSN: 2454-7352

Eteh, D.R., & Okechukwu O. (2021) Floodplain Mapping and Risks Assessment of the Orashi River Using Remote Sensing and GIS in the Niger Delta Region, Nigeria: *Journal of Geographical Research* | Volume 04 | Issue 02 | DOI: https://doi.org/10.30564/jgr.v4i2.3014

Etu–Efeotor, J. O. (1997). Fundamentals of petroleum geology. Paragraphic publications, Port Harcourt, Nigeria, Press page 135.

Etu-Efeotor, J.O. (1981). Preliminary Hydrogeochemical investigations of Sub-Surface waters in parts of the Niger Delta Nig. *Jour. Min. Geol*; 18(1): 103-105

Gangalakunta, P. (2004), Drainage morphometry and its influence on landform characteristics in a basaltic terrain, central India: a remote sensing and GIS approach: International Journal of Applied Earth Observation and Geoinformation, 6, 1-16.

Horton R.E. (1940). An approach toward a physical interpretation of infiltration capacity. Proc. Soil Sci. Am.; 5: 399-417.

Horton, R.E. (1932) Drainage basin characteristics. Transaction of American Geophysics Union. ;13:350–361.

Horton, R.E. (1945) Erosional development of streams and their drainage basins: Hydrophysical approach to quantitative morphology. *Bulletin of Geological Society of America.* 5:275-370.

Hualou L., XiuqinWu, & Guihua, D. (2008), Analysis of Urban-Rural Land-Use Change during 1995-2006 and Its Policy Dimensional Driving Forces in Chongqing, China. ISSN 1424-8220 © 2008 by MDPI

Ibeje, A.O., Osuagwu, J.C. & Onosakponome, O.R. (2018). Morphometric Analysis of Orammiriukwa River Catchment in Imo State, Nigeria: *Nigerian Research Journal of Engineering and Environmental Sciences* 3(2) pp. 724-730.

Kulkarni, M. D. (2015). The Basic Concept to Study Morphometric Analysis of River Drainage Basin: A Review. *International Journal of Science and Research,* 4(7): 2277- 2280.

Leopold , Wolman, & Miller, (1964). Fluvial processes in geomorphology. Freeman and Co., San Francisco; 1964.

Mamatha, Janardhana M.R., & Dinesh. A.C. (2016). Quantitative Morphometric Analysis to Infer the Hydrological Behaviour of the East Suvarnamukhi basin in Tumkur district, Karnataka using Remote Sensing, GIS and bAd (bearing, Azimuth and drainage Calculator) *International Journal of Innovative Research in Science*, Engineering and Technology Vol. 5, Issue 9, September 2016.

Masoud, M.H. (2016) Geoinformatics application for assessing the morphometric characteristics efect on hydrological response at watershed (case study of WadiQanunah, Saudi Arabia). Arab J Geosci 9:1–22.

Melton, M.A. (1958): Correlation structure of morphometric properties of drainage system and their controlling agents. Jour. Geol. 66: 442-460.

Miller, N.A. *quantitative geomorphic study of drainage basins characteristics in clinish mountain area, Verginia and Tenssesse. Columbia University*. 1953;30. (Technical Report No. 3).

Obi Reddy, G.E., Maji A.K. & Gajbhiye K.S. (2002). GIS for morphometric analysis of drainage basins. GIS lndia, 11(4): 9-14.

Offodile, M .E. (1992), *An approach to groundwater study and development in Nigeria. Mecon Services Ltd*., Jos, Nigeria. Vol.2, pp 23- 245.

Oruonye, E.D., Ezekiel, B. B., Atiku, H. G., Baba E., & Musa, N.I. (2016). Drainage Basin Morphometric Parameters of River Lamurde: *Implication for Hydrologic and Geomorphic Processes Journal of Agriculture and EcologyResearch International* 5(2): 1-11; Article no. JAERI.22149 ISSN: 2394-1073.

Palaka, R., & Sankar J., (2014). Study of Watershed Characteristics using Google Elevation Service. 10.13140/2.1.5103.0080.

Pareta, K., & Pareta, U., (2011) Quantitative Morphometric Analysis of a Watershed of Yamuna Basin, India using ASTER (DEM) Data and GIS. *International Journal of Geomatics and Geosciences* 2: 251-265.

Patton, P.C., (1988) Drainage basin morphometry and foods. Flood geomorphology. Wiley, New York.

Rastogi, R.A. & Sharma, T.C. (1976) Quantitative analysis of drainage basin characteristics. *Jour. Soil and water Conservation in India*, v.26 (1&4), pp.18-25.

Reijers, T.J.A. (2011). *Stratigraphy and Sedimentology of the Niger Delta. Geologic,* The Netherlands, 17(3), p.133-162.

Reyment, R.A., (2018). Ammonitologistsensulatissimo: *founder of Cretaceous Research Bengtson, P. Cretaceous Research*-1926-2016,88, 5-35.

Romshoo, S.A., Bhat, S.A., & Rashid, I. (2012) Geoinformatics for assessing the morphometric control on hydrological response at watershed scale in the upper Indus Basin. J Earth Syst Sci 121:659–686.

Schmid, B.H. (1997).Critical rainfall duration for overland flow an infiltrating plane surface. J. Hydrol.; 193: 45-60.

Schumm, S.A. *Evolution of drainage systems and slopes in Badlands at Perth Amboy*, New Jersey. Bull. Geol. Soc. Amer. 1956;67:597-646.

Singh, S. (1972) *Altimetric analysis: a morphometric technique of landform study*. Nat Geogr 7:59–68.

Smith, K.G. (1950) Standards for grading texture of erosional topography. *Am J Sci* 248:655–668.

Strahler, A.N. Quantitative geomorphology of drainage basins and channel networks. In: Chow VT (ed) Handbook of Applied Hydrology. McGraw-Hill, New York. 1964; 439–476.

Udoka, U.P, Nwankwor, G.I., Ahiarakwem, C.A., Opara, A.I, Emberga, T.T., & Inyang, G.E. (2016). Morphometric Analysis of Sub- watersheds in Oguta and Environs, Southeastern Nigeria Using GIS and Remote Sensing Data. *Journal of Geosciences and Geomatics*. 4(2):21-28. doi: 10.12691/jgg-4-2-1.

Udom, G.J., Esu, E.O., & EtuEfeotor, J.O. (1998). Hydrochemical Evaluation in parts of Port-Harcourt and Tai-Eleme Local Government Areas of Rivers State. *Global Journal of Pure and Applied Sciences* 5(5), pp. 545-552.

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

Determination of the Storage Period Effect and Health Implication of Fungi Infestation of Chicken Egg Yolk

Akpan, U. M,
Department of Microbiology, School of Applied Sciences, Federal Polytechnic, Ekowe, Bayelsa State, Nigeria.

Otayoor, R. A.
Department of Biological Sciences, Niger Delta University, Wilberforce Island, Amassoma, Bayelsa State, Nigeria.
E-mail: 4evertruelord@gmail.com

ABSTRACT

Eggs have several uses beyond human eating, making them a valuable raw material; hence there is a need to re-evaluate the fungal characteristic of egg yolk. A total of 18 eggs from three vendors were used. Culture method was used for the fungal characterization of the egg yolk compartments. Result shows higher Fungi count on the egg yolk at storage period 11-15 days; with a mean and standard deviation values ranging from 1.7±0.3 – 2.0±0.0x10^3, followed by those stored at days 8-14 (1.0±0.0–1.3±0.3x10^3), then days 1-7(0.3±0.3 – 0.7±0.3x10^3). Results for the fungi generally identified showed that Mucor sp. was the most prevalent, with a percentage frequency of 44.4%, followed by Rhizopus spp. (22.2%). The least identified fungi were Penicillium spp, (11.1%), Aspergillus spp (11.1%) and Cryptococcus spp. (11.1%). The isolated fungi species were recorded to be associated with several health issues and disease conditions among humans; such as Mucormycosis, Zygomycosis, Aspergillosis, Penicilliosis and Cryptococcosis. Poor sanitary condition, handling and quality of feeds might be responsible for the presence of the fungi identified. Therefore Optimum hygiene should be practiced in poultry farms.

Keywords: *Egg yolk, Vendors, Fungi, Characterization, Storage.*

INTRODUCTION

Laying birds are kept to produce eggs and meat for man and his household. These include poultry birds, native, domestic or local birds, and quail birds, etc. These birds produce different eggs with different morphological outlooks, respectively. Some eggs appears spherical, round and ovoid in shape. These eggs could be whitish in color, brownish in color and whitish or brownish with black spots. An egg is a self-contained source of both macro and micro-nutrients, and it satisfies all of the requirements necessary to sustain embryonic development until hatching. Eggs have been thrust into the spotlight as a primary source of nutrition for humans as a result of their great digestibility, low cost-effectiveness, and ideal balance of a variety of nutrients (McNamara, 2015). Eggs have a low economic cost and are of particular relevance from a nutritional standpoint because they contain necessary fats, proteins, vitamins, minerals, and trace elements (Sophie *et al.,* 2019).

Microorganisms interact closely with commercial eggs during and after production and can be pathogenic (Beissinger *et al*., 2005). These pathogenic microbes affect newly laid eggs through the soft shell. However, only a few of these microbes have been recorded to affect the embryo

(Beissinger *et al*., 2005). Understanding the strategies to control and prevent microbial association with commercial eggs reduces contamination at both the farm and retail level. Related environmental factors, such as parent bird physiology, nest structure, nest reuse, behavior, interactions, and lining material selection, are major factors that increase microbial communities and diversity on eggs (Peralta *et al.,* 2010).

1.2 Statement of the problem

Eggs have long been regarded as a nutrient-dense food that is enjoyed by people all over the world. Many western consumers are cutting back or eliminating meat entirely from their diets. Many studies have linked meat consumption to an increased risk of digestive cancers and cardiovascular diseases. Human nutrition and health stand to benefit greatly from eggs. Eggs are a great source of potential nutraceuticals in addition to their essential nutrients. Egg could likely contain many unknown activities that warrant further investigation despite its nutritional values. Microorganisms are associated with commercial eggs through several factors such as fecal droplet from birds, litter material, egg crates, through packing (handling) by poultry workers, dusty poultry pens/environment, weather conditions, transporting, marketing and storage period. Therefore, it is necessary to determine the effect of storage period and fungi infestation of the yolk of poultry eggs.

1.1 Aim

This research is aimed at determining the storage period effect and health implication of fungi infestation of yolk of chicken eggs.

1.2. Objectives

1. To assess the fungi count of the selected chicken eggs left for 1-5days, 6-10 days and11- 15days.
2. To identify the fungi species associated with the yolk of selected chicken eggs.
6. To determine the percentage frequency of the fungal species.
4. To examine the health implications of the involving fungal pathogens

2.0 MATERIALS AND METHODS

2.1. Sample Collection

A total of 18 chicken egg sample were collected aseptically, 2 each from three different poultry vendors of 1-5days, 6-10days and 11- 15days storage period.

Figure 1: Poultry egg

2.2. Extraction of egg yolk

The egg yolk was aseptically extracted using a sterilized 50ml syringe. The shells were aseptically punctured from the blunt end of the egg using a sterilized forceps and the yolk collected with the 50ml sterile sample collector syringe.

2.3. Culture technique

One ml of each of the yolk collected was serially diluted in normal saline. The microbial counts were conducted by duplicate plating of 1-mL serially diluted sample solution from 10^{-3} dilution factor, each from sample obtained from those stored 1-5days, 6-10days and 11- 15days, onto a prepared 20ml SDA agar plate and stored at room temperature for 3-5 days. The fungi colonies were counted and expressed in CFU/ML using the formula [CFU/ML = (N x R)/A].

N = number of colonies counted

A = aliquot (volume of sample used for inoculation)

R= reciprocal of dilution factor.

2.4. Identification of the fungi isolates

Five (5) different positive isolates from each of the vendors at different storage period were randomly selected based on their morphology and colors .These randomly selected isolates were streaked for purity to obtain pure fungal culture for identification.

Fig 2.Colored spot on fresh egg

2.5. Microscopic examination

The different isolates were identified microscopically. A drop of 95% ethanol was introduced on the middle of a microscopic slide, and fragment of the isolate were gently teased, and well spread using inoculating needle. After air fixing and specimen dried, lactophenol blue stain was applied on the dried specimen and a cover slip used to cover the slide and viewed under the microscope using X10 magnification. Fungal isolate was identified based on the morphology of mycelium, shape, size and color, microscopically (Elsa *et al.,* 1994). The identification process was guided by using fungal atlas and manuals by several authors (Singh *et al.,* 1991).

2.6. Health implications

Health implication was deduced from related literatures, comparing the findings of the current work, in other to determine their pathologic effect on human health if come in contact.

2.7. Statistical Analysis

A complete randomized design (CRD) one-way ANOVA was implore which took care of missing result. All Pairwise Multiple Comparison Procedures (Tukey Test) was also used. Species

abundance was identified and recorded in percentage (%) frequency. Measure of spread was also calculated. Analyses of distance –base gradient boosting ensemble (DGGE) profiles were performed using matrices based on band-matching surfaces.

3. RESULTS

The experimental results showed that fungi colony count from the egg yolk were fewer. Result obtained from vendor A, B and C (Table 3 .1) shows that higher Fungi count was recorded on Yolk of eggs at storage period 11-15days with mean and standard deviation values ranging from 1.7±0.3 – 2.0±0.0x10^3, followed by those stored at day 6-10 (1.0±0.0 – 1.3±0.3x10^3), then days 1-5 (0.3±0.3 – 0.7±0.3x10^3). A significant difference was recorded among egg compartment at $p<0.05$ for fungi count. Commercial eggs are a major cause of food-borne infection due to the presence of microorganisms.

Table 3.1 **Mean and standard error for fungi colonies for egg yolk samples**

		Fungi (x 10^3 cfu/ml)		
Farm/egg comp	Egg type	Colonies from location A	Colonies from location B	Colonies from location C
1- 5days	P.L.E	0.3±0.3^a	0.3±0.3^a	0.7±0.3^a
6- 10days	P.L.E	1.3±0.3^b	1.0±0.0^b	1.0±0.0^b
11-15days	P.L.E	2.0±0.0^b	1.7±0.3^b	2.0±0.0^b

Key: P.L.E. -Poultry Laying Egg

Table 3.2: Microscopic and morphological identification of the fungi isolated from the experimental treatment

Colony morphology	Cotton white	Dark black	Greenish	Cotton white	Yellow brown
Hyphae type	Non-Septate	Non-Septate	Septate	Septate	Non-septate
Spore formation	Sporangiospore	Conidospore	Conidospore	chlamydospore	Conidospore
Color of spore	Brownish	Brownish	Greenish	White	Yellowish
Rhizoid	+	+	-	-	-
Stolon	+	+	-	-	-
Identified fungi	*Mucor sp.*	*Rhizopus sp.*	*Aspergillus sp.*	*Penicillium sp.*	*Cryptococcus sp.*

Fungi from all the pure isolates recorded in Table 3.2, were observed morphologically from their growth media (PDA) and microscopically, based on hyphae type, spore type, color, rhizoid and stolon. Result shows the presence of *Mucor sp. and Rhizopus sp (Mucoraceae), Aspergillus sp. and Penicillium sp (Trichocomaceae), and Cryptococcus sp. (Tremelaceae).*

Table 3.3: Percentage frequency of the identified fungi isolated from egg samples compartments

Fungi Isolated	**[(TN×100)/3] Location A**	**[(TN×100)/3] Location B**	**[(TN×100)/3] Location C**	**[(O+SA+Y)×100/9] Overall %**
Mucor spp.	2 66.7%	1 33.3%	1 33.3%	44.4%
Rhizopus spp.	1 33.3%	- 0.0%	1 33.3%	22.2%
Aspergillus spp.	- 0.0%	1 33.3%	- 0.0%	11.1%
penicillium spp.	- 0.0%	- 0.0%	1 33.3%	11.1%
Cryptococcus spp.	- 0.0%	1 33.3%	- 0.0%	11.1%

Results for the fungi generally identified as presented in Table 3.3, show that *Mucor* was the most isolated species from the sample eggs, with a percentage frequency of 44.4%, followed by *Rhizopus spp.* (22.2%). The least isolated fungi identified were *penicillium spp*, (11.1%)*, Aspergillus spp* (11.1%) and *Cryptococcus spp.* (11.1%). These isolated fungi *Mucor sp., Rhizopus sp., Aspergillus sp., Penicillium sp. and Cryptococcus sp.* have been implicated with several health issues and disease conditions such as *Mucormycosis, Zygomycosis, Aspergillosis, Penicilliosis* and *Cryptococcosis,* respectively. (These disease conditions have several health implications to egg consumers.

Table 3.4: Health implication of the isolated fungi species from the sampled egg yolk

Fungi isolated	**Health implication**	**References**
Mucor spp.	Oral and cerebral *Mucormycosis*	Chauhan and Roy, 2008
Rhizopus spp.	Respiratory infections, sinusitis, and *otomycosis.* A disease condition known as *Zygomycosis.*	Benny *et al*., 2016
Aspergillus spp.	Allergic *broncho-pulmonary aspergillosis,* it also produces abscesses and necrotic lesions.	Beernaert, *et al.,* 2010 Dahlhausen *et al.,* 2004
Penicililium pp.	-Systemic *Penicilliosis* in immune compromised patients.	Khosravi *et al*., 2008
Cryptococcus spp	*Cryptococcosis* leading to meningitis in both infected birds and consumers of poultry farm products	Singh *et al.,* 2008 & 2009 Abdel-Razik, 2007

4. DISCUSSION

Birds of different species exhibit the biological phenomenon of oviparity, wherein females produce and lay eggs. Poultry eggs are well recognized as an essential component of diet globally, owing to their significant nutraceutical content and feasibility of digestion (Zaheer, 2015). The dependency on eggs by humans and other living things for protein is higher, hence re-evaluation of microbial contamination becomes necessary. The higher choice of eggs to the populace is mostly broiler eggs. Egg formulations compared to conventional domestic species have certain similarities, but they also differ significantly from one another (Huang and Lin, 2011), which is primarily attributed to the shifting ratio of egg yolk to egg white.

The fungi species identified from the cultural dependent approach were mostly from the family *Mucoraceae, Trichocomaceae, and Tremelaceae.* The fungi species identified were *Mucor spp. and Rhizopus spp. (Mucoraceae), Aspergillus spp. and penicillium spp., (Trichocomaceae)*

and Cryptococcus spp. (Tremelaceae). Results for the fungi generally identified, shows that *Mucor sp* was highly isolated from the sampled eggs, followed by *Rhizipus sp*. The least identified fungi identified were *penicillium sp*., *Aspergillus sp* and *Cryptococcus spp*. the fungi species; *Cryptococcus* was discovered to be an important causal agent of opportunistic infections in humans (Manikandan *et al.,* 2011). *Aspergillus* and *Penicillium* are known to produce mycotoxin as they have an organoleptic property (Paterson *et al.,* 2014).

Pathogenic fungi *Aspergillus sp.* causes allergic bronchopulmonary aspergillosis (Beernaert, *et al.,* 2010). When this species of fungi infects an individual, it spreads to other organs to produce abscesses and necrotic lesions (Dahlhausen *et al.,* 2004). Another opportunistic fungus is *Penicillium sp.,* a systemic *Penicilliosis* in immune compromised patients which is spread by humidity, wind, dust, temperature as predisposing factors leading to fungi spread (Khosravi *et al*., 2008). *Mucor sp.* is recorded to cause oral and cerebral *Mucormycosis* (Chauhan and Roy, 2008). *Cryptococcus sp.* causes *Cryptococcosis.* These fungal disease is caused by zoonotic fungi, leading to meningitis in both infected birds and consumers of poultry farm products (Abdel-Razik, 2007). The edible section (egg white and yolk), where fungi spores and other pollutants can adhere to the surface and/or enter through pores, poses dangers to both human and animal health.

Natural porosity of chicken eggs makes them susceptible to infection from filament fungus (Lee *et al.,* 2011). The albumen (the edible portion of the egg), however, can be reached by hyphae that have formed over the canal and increased in size. According to the American Egg Board's (AEB, 2015) assessment of the microbiological quality of the shell, fungal pathogens with food origin were present. According to Beytut *et al.,* (2004), fungi genera such as *Mucor sp., Rhizopus sp.,* mycotoxins *Aspergillus* can contaminate both table and emerging eggs for chick production. Usually, foods that are extensively polluted with the mycotoxins *(trichothecenes, zearalenone, deoxynivalenol and fumonisins)* demonstrate a dedicated risk to individuals and animal condition.

The outer shell of the egg which is supposed to offer protection to the yolk was rather discovered to have been invaded by fungus hyphae through pore carnal at the exterior membrane of the egg (CFIA, 2013). The genetic makeup, food, climate, production environment, and age all have an impact on egg quality. In addition, mycotoxins are created by *penicillium sp*. whereas deoxynivalenol, zearalenone, and aflatoxins are produced by *Aspergillus flavus*. It may have a negative impact on immunity and negative impact on embryonic quality (Yegani *et al.,* 2008)

REFERENCES

Abdel-Razik, M., (2007). Domestic birds as carriers of *Cryptococcus neoformans*, the main cause of the life-threatening human systemic *cryptococcosis*. *CATRINA*, 2, 15-18

American Egg Board (AEB) (2015). Shell egg distribution. Available from: http://www.aeb.org/ egg-industry/industry-facts/egg production and consumption Accessed.

Beissinger, S. R., Cook, M. I. and Arendt,W. J. (2005). The shelf life of bird eggs: testing egg viability using a tropical climate gradient. *Ecology* 86, 2164–2175.

Benny, G.L.; Smith, M.E.; Kirk, p.m.; Tretter, E.D; White, M.M. (2016). "Challenges and Future Perspectives in the Systematics of *Kickxellomycotina, Mortierellomycotina, Mucoromycotina, and Zoopagomycotina". Biology of Microfungi*.

Beernaert, L.A., Pasmans, F. van Waeyenberghe, L. Haesebrouck, F. and Martel, A. (2010). Aspergillosis infection in birds: A review. *Avian Pathol*., 39, 325-331.

Beytut, E. Ozcan, K. and Erginsoy, S. (2004). Immunohistochemical detection of fungal elements in the in the tissues of goslings with pulmonary and systemic *aspergillosis*. *Acta Vet. Hungarica,* 52, 71-84.

Canadian Food Inspection Agency (2013)

Dahlhausen, R.D., (2006). Implications of Mycoses Clinical Disorders. In: Clinical Avian Medicine, Harrison, G.J. and T.L. Lightfoot (Eds.). *Spix Publishing, Inc., Palm Beach, FL.,* pp: 691-704.

Dudusola, I.O. (2010). Comparative evaluation of internal and external qualities of eggs from quail and guinea fowl. *International Research Journal of Plant Science* 1, 112-115.

Elsa V.N, Alice P.B, Isabel H.B, Celcile R., Louise S. and Elina V.L (1994).Elementary key to common fungi in South Africa plant protection Reseach Institute Hand Book, *Agricultural Research Council,* 2, 20-23

Huang J.F., and Lin C.C. (2011). Production, composition and quality of duck eggs. In: Nys Y., Bain M., Immersel F.V., editors. Improving the Safety and Quality of Eggs and Egg Products. Volume 2. Woodhead Publishing Limited; Cambridge, UK: pp. 487–508

Khosravi, A.R., Shokri, H. Ziglari, T. Naeini, A.R. Mousavi, Z. and Hashemi, H. (2008). Outbreak of severe disseminated aspergillosis in a flock of ostrich (*Struthio camelus*). *Mycoses*, 51, 557-559.

Lee S-A, Adhikari A, Grinshpun S.A, McKay R, Shukla R, and Reponen T (2011). Personal Exposure to Airborne Dust and Microorganisms in Agricultural Environments. *J Occup Environ Hyg*, 3,118–130.

Manikandan P., Galgóczy L., Selvam K.P., Shobana C.S., Kocsubé S., Vágvölgyi C., Narendran V. Fusarium. In: Liu D., (2011). editor. Molecular Detection of Human Fungal Pathogens. *CRC Press; Boca Raton, FL, USA.* pp. 417–433.

McNamara D.J. (2015). The Fifty Year Rehabilitation of the Egg. *Nutrients.* 7:8716–8722.

Paterson R.R.M., Lima N., and Taniwaki M.H (2014). Coffee, mycotoxins and climate change. *Food Res. Int*. 61, 1–15.

Peralta-Sanchez, J. M., Moller, A.P. Martin-Platero, A.M and Soler, J.J. (2010). Number and colour composition of nest lining feathers predict eggshell bacterial community in barn swallow nests: an experimental study. *Funct. Ecol*., 24, 426–433.

Singh K, Frisvad J.C, Thrane U. and Marthur S.B (1991).*An illustration manual on identification of fungi of some seed plant born Aspergilla, Fusaria, penicillia species and their mycotoxins (1st edn.)*.Danish Govt. Inst. Seed path. For Dev. Count. Ryvangs Alle 78, DK. 2900, p.3-124.

Singh, S., Borah, M.K. Sharma, O.K. Joshi G.D. and Gogoi, R. (2009). Aspergillosis in turkey poults. *Indian J. Vet. Pathol*., 33, 220-221.

Singh, S.D. and Dash, B.B. (2008). Spontaneous lesions of *cryptococcosis* in White Leghorn chicken. *Indian J. Vet. Pathol*., 32, 68-69.

Sophie R.G, Nicolas G., and Yves N. (2019). The Golden Egg: Nutritional Value, Bioactivities, and Emerging Benefits for Human Health. *Nutrient*s. 11(3): 68

Yegani, MTK, Smith, S. and Leeson, HJB, (2008). Effects of feeding blends of grains naturally contaminated with Fusarium mycotoxins on performance, hematology, metabolism, and immunocompetence of Turkeys. *Poultry Science*, 87 (3), 421–432.

Zaheer K. (2015). An Updated Review on Chicken Eggs: Production, Consumption, Management Aspects and Nutritional Benefits to Human Health. *Food and Nutrition* Sciences 06(13):1208-1220.

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

Examining the Antifungal Effect of Clove Plant on *Candida albicans*

Charles, E.E.
Dieware, G.K.
Inemotimi, Faith
Department of Science Laboratory Technology,
School of Applied Sciences, Federal Polytechnic Ekowe, Bayelsa State, Nigeria.
Email: estherdieware@gmail.com

ABSTRACT

This study examined the antifungal effect of Clove plant (Syzygium aromaticum on Candida albicans The significance of the study includes its importance in the treatment of andida albican on humans, as well as the identification, and production of drugs from natural herbal plant such as clove. The study determined the zone of inhibition of S. aromaticum leaf and bud extracts on Candida albicans as well as, the Mn±SE inhibitory effects of the different extractions of the leaf and bud extract on the tested fungi. Specifically, findings of this study have shown that parts of clove plant possess antifungal properties. The ethanol extractions of clove are more active against Candida albican than hot water. The study recommends that full potential of clove plant would be realized by isolating the bioactive component, which could be used as a novel antifungal therapy. More so, steps should be taken to encourage cultivation and conservation of clove plants, while more research is needed to elucidate the relationship with other fungal pathogens.

Keywords: *Antifungal effect, clove plant, Candida albicans, S. aromaticum,*

INTRODUCTION

Phyto-therapeutics is a major area in which medicinal plant or plant parts are often used in its natural and unrefined form to treat human disease (Trease and Evans 1978), The promising potential of antimicrobial plant-derived substances has attracted the attention of pharmaceutical and scientific communities during the last few years (Osbourn, 1996). The primary benefit of plant derived medicines is that they are relatively safer than their synthetic counterparts and offer profound therapeutic benefits and more affordable treatment. The antimicrobial activity of plant extracts has been linked by many researchers to be due to the presence of phytochemicals in them (Ayoola *et al.,* 2008). Medicinal properties of these plants have been linked to phytochemicals and essential oils produced by the plants. Essential oils and extracts of these plants are able to control microorganisms related to skin diseases, dental caries and food spoilage (Chaieb *et al.,* 2007a; Chaieb *et al.,* 2007b). These secondary compounds contain a variety of volatile molecules such as terpenes, terpenoids and phenol- derived aromatic and aliphatic compounds, which might have bactericidal, antiviral, and fungicidal consequences (Akthar *et al.,* 2014).

Resistance to drugs by fungi has increased over the years. This has been attributed to overdose and under dose of drugs obtained over the counter. Microorganisms are undergoing genetic variability (mutation), and resistance mechanisms to a wide range of drugs (Gislene *et al.,* 2000). Hence there is a need to develop sensitive and effective drugs using plant parts. This should, however, be complemented by undertaking proper identification of these plants and their phytochemical composition which can render effective remedy to the treatment of fungal infections.

This information will be necessary for conservation of medicinal plants and boost the need for traditional plants in controlling fungal infection.

The use of plant parts as complementary and alternative medicine has dramatically increased over the past decade (Roy-Byrne, *et al.,* 2005). Many pharmaceuticals currently available to physicians have a long history remedies, including opium, aspirin, digitalis and quinine (WHO, 2006). Ethnobotany thus strives to document the local customs involving the practical uses of local flora for many aspects of life, such as plants as medicines, foods, and clothing. The potential of medicinal plant research results in health care is no longer in doubt, having gained recognition in several nations of the world (Dar, *et al.,* 2017).

Varieties of plants or materials derived from plants have been used for the treatment and prevention of diseases virtually in all cultures. Plants have been used as sources of food and medicinal purposes for centuries and this knowledge have been passed from one generation to another (Adedapo, *et al.,* 2005). Medicinal plants also represent a rich source from which antimicrobial agents can be obtained (Kubmarawa, *et al.,* 2007). According to the World Health Organization medicinal plants would be the best source to obtain a variety of drugs. Therefore, such plants have been investigated for better understanding of their medicinal properties. The antimicrobial properties of many plants have been investigated by a number of researcher worldwide (Adamu *et al.,* 2005).

Ethnobotany is the study of interrelations between humans and plants, including plants used as food, medicines, and for other economic applications (2004). Ethnobotany plays a crucial role in the study of traditional medicine (Pei, 2005). A traditional healer is therefore, defined as a person with competence to practice traditional medicine (Togola, *et al.,* 2005). Although traditional medicine involves the use of herbal and animal parts, above all herbal medicines are the most widely used (Orwa, 2002).

Despite the extensive use of antibiotics and vaccines programs, infectious diseases continue to be a leading cause of morbidity and mortality worldwide (Bloom, 2000). Widespread antibiotic resistance, the emergence of new pathogens in addition to the resurgence of old ones and the lack of effective new therapeutics exacerbate the problems (Bloom, 2000). Microbial infections have been reported to be the major cause of inflammation (Du-Shieng, *et al.,* 2005). Herbal medicine can be used as an alternative to some commercial drugs (Anyamene and Ezeadila, 2010). The importance of traditional medicine has also been recognized by World Health Organization (WHO 2006), which has created strategies, guidelines and standards for botanical medicines. Several plants have been used to treating bacterial and fungal infection. Among these plants is clove plant (*Syzygium aromaticum*). Clove (Family *Myrtaceae* is one of the most important herbs in traditional medicine, having a wide spectrum of biological activity.

Cloves (*Syzygium aromaticum*) have many therapeutic uses; they control nausea and vomiting, cough, diarrhea, dyspepsia, flatulence, stomach distension and gastro intestinal spasm; relieve pain, cause uterine contractions and stimulate the nerves (Sulieman, *et al*., 2007; Tanko, *et al*., 2008). In addition, the cloves are highly antiseptic, (Blumenthal, 1998) antimutagenic, (Miyazawa, and Hisama, 2003) anti- inflammatory, (Kim, 1998) antioxidant, antiulcerogenic, (Bae, *et al*., 1998; Li, *et al.,* 2005) antithrombotic, antifungal, (Giordani, *et al*., 2004) antiviral (Saeed and Tariq, 2008) and antiparasitic (Yang, *et al.,* 2003). Spices have been traditionally used since ancient times, for the preservation of food products as they have been reported to have antiseptic and disinfectant properties. *S. aromaticum* has been shown to be a potent chemo preventive agent, used by the traditional healers since ancient times to treat respiratory and digestive ailments (Aggarwal, and Shishodia, 2006; Banerjee, *et al.,* 2006). Several secondary compounds have been extracted

from clove plant (*S. aromaticum*) and have been used in traditional medicine, as a bactericide, fungicides and anesthetic (Amanda, *et al*., 2009). The focus of this research is to provide information on the antifungal effect of Clove plant (*S. aromaticum*) on *Candida albican.* The typical clove plant is shown in Plate 1. This study aimed at examining the antifungal effect of Clove plant on *Candida albicans* and to compare the zone of inhibition of the extracts with that of the commercial antibiotic (triconozole) on the tested pathogen.

Plate 1: Clove leaves and its flowering buds.

MATERIALS AND METHODS

Sterilization of Glassware

All glassware used in this study were properly washed and rinsed with distilled water. They were autoclaved and further oven dried at 180^0C for 1hour for proper decontamination and sterilization according to Cheesbrough, (2010).

Collection of Fungal Isolate or the Antifungal Study

The fungal isolate used was *Candidas albicans* This was collected from the Niger Delta Teaching Hospital Oolobiri; having been identified from an infected patient and was further subcultured on potatoe dextrose agar (PDA) to obtain a pure culture of clinical isolates according to the procedure described by Cheesbrough, (2010 & 2004).

Collection of Plant Material and Identification

Fresh samples of Clove (*S. aromaticum*) leaf and seed were bought from Opolo Market in Yenagoa Bayelas State. The plant was identified using a pictorial description in the atlas and pictures of medicinal plants of Nigeria (Nyananyo, 2006). The plant parts were thoroughly washed, cleaned and sun dried.

PREPARATION OF EXTRACTS

Hot water Extract

The dried leaf and flowery bud of the clove plant were ground to powder form using a sterilized blender. Ten grams (10g) of the powder was weighed each from the ground leaf and bud separately into conical flask. The ground paste of the different parts was soaked in 100ml of boiled water for 6hrs for proper extraction of therapeutically active compounds. The mixture was then filtered using a sterile muslin cloth and placed into a water bath to evaporate more water to get semi liquid extract for the test (Kigigha & Atuzie, 2012).

Ethanol Extract

Ten grams (10g) of powder leaf and flowery bud of the clove were weighed; and soaked each in a separate conical flask with 100ml of 75% ethanol for 6hrs for proper extraction. The mixture was filtered and allowed to stand in a water bath to evaporate more of the ethanol to achieve a semi liquid extraction required for the test.

Triconazole Preparation (control)

This is the control that provide basis for comparison among treatment groups. 500mg of triconazol (capsule) was dissolved into 500ml of distilled water at concentration of 1mg/ml at equal volume.

Preparation of Paper Discs

A sterilized cork borer of size 6mm was used to cut a watman filter paper. A 6mm size discs was cut from the filter paper. The cut discs were put into a Petri-dish plate and were sterilized for use following standard techniques (Cheesbrough, 2010)

Impregnation of Extracts

Exactly 0.1mg of the plant extracts (ethanol and hot water) was soaked with the 6mm cut sterile disc. The same was done with the triconazole (control) solution. The filter paper discs were allowed to dry before impregnating into the fungal culture.

Testing for Inhibitory Zone

The antifungal effect of the leaf and bud extracts and the triconazole (control) was determined by using the disc diffusion method described by Kigigha and Atuzie, (2012). The dried sterile disc soaked with 0.1mg each of the plant extracts and the triconazole (control) were impregnated on the plates previously inoculated with the test organisms, well-spaced. The plates were incubated for 72hrs at 37^{o}C. Zone of inhibition was observed by the diameter in millimeter (mm) around the disc. The extent of the diameter (inhibitory zone) shows the effectiveness of the extracts on the tested organisms. This area of inhibition was measured and recorded in millimeter (mm) as zone of inhibition.

RESULTS AND DISCUSION

The study carried out on the various extracts of Clove (*S. aromaticum*) leaves and bud revealed the presence of medicinal active constituents. Meanwhile, the medicinal beneficial effects of plants typically results from the secondary products present in the plant, it is usually not attributed to a single compound but a combination of the metabolites (Parekh, *et al.,* 2005).

Table 1: The zone of Inhibition of *S. aromaticum* Leaf Extracts on *Candida albicans*

Zones of Inhibition (mm) measured for leaf extraction			
Treatment (0.1mg/ml)	Ethanol leaf extract	Hot water leaf extract	Triconazole (control)
1	21.0	16.0	23.0
2	25.0	15.0	26.0
3	24.0	11.0	25.0
4	22.0	14.0	26.0
Mean±SE	23.00 ± 4.79^{a}	14.00 ± 3.74^{b}	25.30 ± 5.00^{a}

Means are reported as mean±standard error of the mean. P-value, Row=0.571964, column=0.000408 (4.08×10^{-4}).

There significant difference between the plant extracts (ethanolic and hot water) compared to the control (Table 1). No significant differences were recorded between ethanol extract and the control (triconazol). Different superscript signifies a significant difference among extracts. The ethanolic leaf extract on *Candida albicans* recorded a mean inhibitory zone of 23.00mm, while hot water leaf extracts recorded 14.00mm. The control (triconazol) showed a higher inhibitory zone (25.30mm) than the ethanol. The least inhibitory zone was seen with hot water leaf extract compared with the control.

Table 2: The Zone of Inhibition of *Syzygium aromaticum* Bud Extracts on *Candida albican*

Zones of Inhibition (mm)			
Treatment (0.1mg/ml) / Replicates	Ethanol Bud extract	Hot water Bud extract	Triconazole (control)
1	18.0	11.0	22.0
2	15.0	10.0	26.0
3	19.0	12.0	24.0
4	16.0	10.0	23.0
Mean±SE	17.00 ± 4.22^{a}	10.75 ± 3.74^{b}	25.30 ± 5.00^{c}

Means are reported as mean±standard error of the mean. P-value, Row=0.521772, column=7.91E-05 (7.91×10^{-5}).

There was significant difference between the plant extracts (ethanolic and hot water) compared to the control (Table 2). S difference was recorded between the ethanol, hot water extract and the control (triconazol). Different superscript signifies significant difference among extracts. The ethanolic bud extract tested on *candida albican* recorded a mean inhibitory zone of 17.00mm, while hot water bud extract recorded 10.75mm. The control (triconazol) showed a higher inhibitory zone of 23.75mm than the ethanol, while hot water bud extract recorded the least compared with the control.

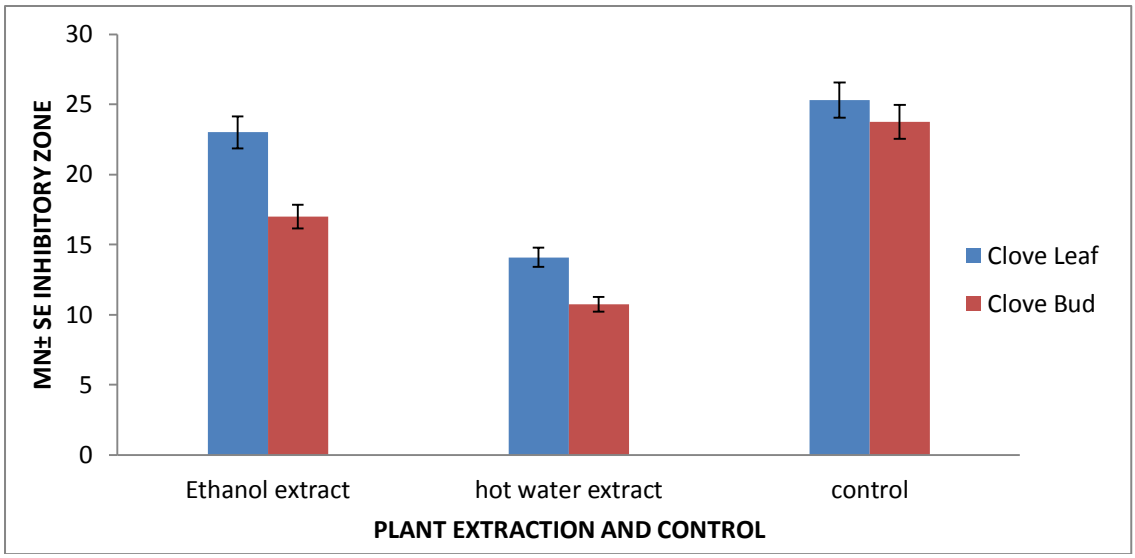


Figure 1: Bar chart representing the Mn±SE inhibitory effects of the different extraction of the leaf and bud extract on the tested fungai

The ethanolic extraction recorded a mean and standard error zone of inhibition of 23.00±4.79mm and 17.00±4.22mm for clove leaf and bud, respectively; while hot water extract recorded 14.00±3.74mm and 10.75±3.28mm. The ethanol extract showed higher effect on the tested fungus than hot water extract. Higher effect was recorded with the leaf than the bud of the tested plant. The control still maintained higher effect followed by ethanol leaf extract, than hot water extract. The same was seen with the bud extraction.

The antifungal role as presented (Table 1 & 2 and figure 2) in their inhibitory zone indicates that the extracts activities were lesser than that of the control (triconazole). Result revealed that the plant possesses appreciable antibacterial activity against the tested fungal isolate. Result obtained indicated that the ethanol leaf and bud extract demonstrated higher inhibitory effect on *Candida albican.* The ethanol leaf and bud extract of the plant had the highest effect on *Candida albican* respectively (23.00±4.79mm and 17.00±4.22mm) than hot water extract (21.5±1.29mm and 21.5±1.29mm) respectively, with a least effect. the plant Inhibitory properties on *Candida albican* showed that the ethanol leaf and bud extract demonstrated a higher zone inhibitory locus, followed by the hot water leaf and bud extract respectively. There was a significant differences recorded among leaf and bud extract at $p<0.05$. No significant was recorded between ethanol leaf extract and the control ($p>0.05$), but a significant difference was recorded among ethanol bud extract, hot water bud extract and control ($p<0.05$). Result also revealed that extraction reagent or solvent has effect to the activity against tested fungi.

The effectiveness of clove plant was also demonstrated by the work done by Fateh *et al*., (2017), against fungal organism. Result recorded shows that clove plant was also effective against *Candida albicans, though* the effect increased with extract concentration This finding agrees with reports by Fateh *et al.,* (2017). The results of this study showed that the extract of *S. aromaticum* has antifungal activity. Several studies have demonstrated potent antifungal effects of clove (Gupta *et al*., 2014; Fu *et al*., 2007). The inhibitory activity of clove is due to the presence of Phenolic-derived compound (eugenol). This plant has been shown to also exhibit positive antibacterial activity when tested with *Shigella flexneri, Salmonella enteritidis and Escherichia coli*. In addition,

aqueous extract of the leaves, present bacteriostatic and bacteriocidal potential against these bacteria respectively.

The study also shows that the leaf extract may have an extensive spectrum than the bud, and thus justifies and supports the use of the plant in traditional medicine against microorganism infection as supported by Ncube *et al.,* (2008). Eugenia *et al*., (2009) reported that clove has antifungal activity against yeasts and filamentous fungi likewise to other human pathogenic fungi. This antifungal mechanism of action was attributed to the lesions of the cytoplasmic membrane. This effect may in part be due to their hydrophobicity, which is responsible for their partition into the lipid bilayer of the chitin, leading to an alteration of permeability and a consequent leakage of cell contents as demonstrated by Burst and Reinders, (2003). Results also prove that ethanol base extract are more active than hot water extract. This is supported by Evans (2002) who said than an alcoholic-based derivative penetrates easily to the cellular membrane to extract the intracellular ingredients from the plant material which has bioactive compounds with antimicrobial activities.

CONCLUSION AND RECOMMENDATIONS

Cloves are an aromatic herb that has many useful purposes. The antifungal activity of Cloves (*S. aromaticum*) extract was read from the diameter zone of inhibition. It could be observed that Clove (*S. aromaticum*) extract had broad spectrum of activity on the test organism. Results from this work revealed that ethanol extract from all the plant parts, exhibited higher inhibitory effect than hot water extract. The tested microbial isolate was sensitive to extract of Clove (*S. aromaticum*). Clove extract was successfully effective in suppressing the growth of *Candida albicans*. Perhaps its potential activity on *Candida albicans* might give it an impetus as a potential antifungal agent.

Specifically, the findings of this study have shown that parts of *S. aromaticum* plant possess antifungal properties. The ethanol extractions of clove are more active against *Candida albican* than hot water. The study also supports other findings made by other studies on *S. aromaticum* as being ffective in inhibiting the growth of the fungus, and several other fungi such as *Aspergillus sp*. etc.
The study recommends the following,

- The full potential of *S. aromaticum* plant would be realized by isolating the bioactive component, which could be used as a novel antifungal therapy.
- Steps should be put in place to encourage cultivation and conservation of this plant.
- More research works are needed to elucidate this relationship with other fungal pathogens.
- Proper identification of plants with antifungal implications complemented by determination of their specific phytochemical and essential oil compositions.

REFERENCES

Adamu, H.M., Abayeh, O.J., Agho, M.O., Abdullahi, A.L., Uba, A., Dukku, H.U. and Kebede, B.M. (2005). An ethnobotanical survey of Bauchi state herbal plants and the antimicrobial activity. *Journal of Ethanopharmacol*. 97(1): 421-427.

Adedapo, A.A., Shabi, O.O. and Adedokun, O.A. (2005). *Antihelminthic efficacy of the aqueous extract of Euphorbia hirta (Linn.)* in Nigerian dogs. *Vet. Arch*. 75(1): 39-47.

Aggarwal, B.B. and Shishodia, S. (2006). Molecular targets of dietary agents for prevention and therapy of cancer. *Biochemistry and Pharmacology*, 71: 1397-1421.

Akthar, M.S., Degaga, B. and Azam, T. (2014) Antimicrobial activity of essential oils extracted from medicinal plants against the pathogenic microorganisms: A review. Issues in Biological Sciences and Pharmaceutical Research 2: 001-007.

Amanda, L., Santos, G.O., Chierice, K.S., Alexander, A.R. and Ellen, M. (2009). Characterization of the raw essential oil eugenol extracted from S. aromaticum. *Journal of Thermal and Analytical Calorimeter*, 96: 821-825.

Anyamene, C.O. and Ezeadila, J.O, (2010). Antibacterial activity of water, ethanol and methanol extracts of *Ocimum gratissimum*, *Vernonia amygdalina* and *Afromomum melegueta*. *Journal of Applied Sciences*, 13 (1), 8940-8948.

Ayoola, G. A., Lawore, F. M., Adelowotan, T., Aibinu, I. E., Adenipekun, E., Coker, H. A. B. and Odugbemi, T. O. (2008). Chemical analysis and antimicrobial activity of the essential oil of S. aromaticum (clove). *African Journal of Microbiology Research*, 2: 162-166.

Bae, E. A., Han, M. J., Kim, N. J. and Kim, D. H. (1998). Anti-Helicobacter pylori activity of herbal medicines. *Biological and Pharmaceutical Bulletin*; 21: 990-992.

Banerjee, S., Panda C.K. and Das, S. (2006). Clove (S. aromaticum), a potential chemopreventive agent for lung cancer. *Carcinogenesis*, 27: 1645-1654.

Bloom, B.R (2000). Microbial infections and immune defence. *Nature*. 406: 759.

Burst, S.A, Reinders R.D. (2003). Antibacterial activity of selected plant essential oils against *Escherichia coli* O157:H7. *J Lett Appl Microbiol.* 36(3):162-7.

Chaieb, K., Zmantar, T., Ksouri, R., Hajlaoui, H., Mahdouani, K., Abdelly, C. and Bakhrouf, A. (2007b). Antioxidant properties of essential oil of Eugenia caryophyllata and its antifungal activity against a large number of clinical Candida species. *J Mycosis*. 50(5):403-6.

Chaieb, K.H., Hajlaoui, T. and Zmantar, T. (2007a). The chemical composition and biological activity of Clove essential oil, *Euginia caryophollata* (Syzigium aromaticum L. Myrtaceae): A short review. *Phytother. Res.* 21(6): 501-506

Cheesbrough, M. (2004). *District Laboratory Practice in Tropical Countries*, Part 2. Cambridge University Press Publication Edinburg, UK. Pp 62-70

Dar, R.A/, Shahnawaz. M. and Qazi, P.H. (2017). Natural product medicines: A literature update. *J Phytopharmacol* ;6(6):349-351.

Du-shieng, C., Yi-wen, C., Wu-Chang, C. and Ming-Chung L (2005). *Naphthalenedione compounds for treating inflammation related disorders and microbial infection*. Free patients Online. [cited2009Dec8]. Available from: *http://www.freepatientsonline.com/7622506/html.*

Giordani, R., Regli, P., Kaloustian, J., Mikail, C., Abou, L. and Portugal, H. (2004). Antifungal effects of various oils against Candida albicans. Potentiation of antifungal action of amphotericin B by essential oil from Thymus vulgaris. *Phytotherapy Research*, 18(12): 990-995.

Gislene, G.F.N., Juliana, L., Paulo, C.F. and Giuliana, L.S. (2000). Antibacterial Activity of Plant Extracts and Phytochemicals on Antibiotic Resistant Bacteria. *Brazilian Journal of Microbiology*. 31, 247-256.

Kigigha, L.T. and Atuzie, M.N. (2012). Assessment of traditional medicinal application of *Alchornea cordifolia*. *African Journal of Biotechnology* 11(8) 2083-2086.

Kim, H.M., Lee, E.H., Hong, S.H., Song, H.J., Shin, M.K., Kim, S.H. and Shin, T.Y. (1998). Effect of *Syzygium aromaticum* extract on immediate hypersensitivity in rat. *J Ethnopharmacol*. 60:125-31.

Kubmarawa, D., Ajoku, G.A., Enwerem, N.M. and Okorie, D.A. (2007). Preliminary phytochemical and antimicrobial screening of 50 medicinal plants from Nigeria. *Afr. J. Biotechnol*. 6(14): 1690-1696.

Li, Y., Xu, C., Zhang, Q., Liu, J. Y. and Tan, R.X. (2005). In vitro anti-Helicobacter pylori action of 30 Chinese herbal medicines used to treat ulcer diseases. *Journal of Ethnopharmacology*; 98: 329-333.

Miyazawa, M. and Hisama, M. (2003). Antimutagenic activity of phenylpropanoides from clove (*Syzygium aromaticum*). J *Agric Food Chem*. 51(22):6413-22.

Orwa, J. A. (2002). Editorial: Herbal Medicine in Kenya: Evidence Safety and Efficacy. *East African Medical Journal,* 79: 341-342.

Osbourn, A. E. (1996). Preformed antimicrobial compounds and plant defense against fungal attack. *Plant Cell*., 8: 1821-1831.

Parekh, J., Jadeja, D. and Chanda, S. (2005). Efficacy of Aqueous and Methanol extracts of some medicinal plants for Potential Antibacterial Activity. Turky J.Biol 2005; 29: 203-210.

Pei, S. J. (2005). Ethnobotany and development of new Traditional Chinese Medicines. *Journal of Ethnobotany,* 17: 35-40.

Ram J., Kumar A. and Bhatt J. (2004) Plant diversity in six forest types of Uttaranchal, Central Himalaya, India. *Current Science.* 86(7):975–978.

Roy-Byrne, P.P., Bystritsky, A., Russo, J., Craske, M.G., Sherbourne, C.D. and Stein, M.B. (2005). Use of herbal medicine in primary care patients with mood and anxiety disorders. *Psychomatics* 46: 117-122.

Saeed, S. and Tariq, P. (2008). In vitro antibacterial activity of clove against Gram negative bacteria. *PakistanJournal of Botany*, 40(5): 2157-2160.

Sulieman, A.M.E., Boshra, I.M.O. and El Khalifa, E.A.A. (2007). Nutritive value of clove (Syzygium aromaticum) and detection of antimicrobial effect of its bud oil. *Research Journal of Microbiology*, 2: 266-271.

Togola, A. T., Diallo, D.S., Barsett, H., and Paulsen, B.S. (2005). Ethnopharmacological survey of different uses of seven medicinal plants from Mali, (West Africa) in the regions Doila, Kolokani and Siby. *Ethnobiology and Ethnomedicine*, 1: 7.

Trease, G.E. and Evans, W.C. (1978). Pharmacognosy, 2nd Ed, Brailers, Tindal Ltd, London, 60-75.

World Health Organization (WHO) (2006). WHO Guidelines for the Treatment of Malaria. WHO Press 2nd edition, 108-110.

Yang, Y.C., Lee, S.H., Lee, W.J., Choi, D.H. and Ahn, Y.J. (2003). Ovicidal and adulticidal effects of *Eugenia cryophyllata* bud and leaf oil compounds on *Pediculus capitis. J Agric Food Chem*. 51(17):4884-8.

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

Transforming Analogue Polytechnic Physics Laboratories to Digital: A Case Study of Construction of the Digital Wheatstone Bridge

Oritsebemigho Ulori
Alvan Wariebi Kighigha
Benjamin Uduma
Department of Physics with Electronics, Federal Polytechnic Ekowe, Nigeria
Correspondence Author: ulorits@physics.org

ABSTRACT

This case study explores the digitization of polytechnic laboratory education through the lens of the Wheatstone bridge experiment. By leveraging digital technologies, including virtual simulations and data analysis tools, the initiative aims to enhance student learning outcomes, accessibility, and engagement in laboratory settings. Drawing from literature on the benefits and challenges of digital transformation in education, the study investigates the impact of digitization on student understanding of electrical measurement principle. Key findings highlight the effectiveness of digital tools in promoting deeper learning and critical analytical skills. However, challenges such as infrastructure requirements and pedagogical adaptation must be addressed to maximize the benefits of digital laboratory education.

Keywords: *Digitization, Digital technologies, Polytechnic laboratories, Wheatstone bridge*

1.0. Introduction

Drawing from literature on the benefits and challenges of digital transformation in education, the study investigates the impact of digitization on student understanding of electrical measurement principle. In the realm of education, the integration of digital technologies has revolutionized traditional learning methodologies, particularly in laboratory settings. Polytechnic institutions, known for their hands-on approach to education, are increasingly embracing digitization to enhance the learning experiences of their students. This case study illustrates the digitization of a Wheatstone bridge which is a fundamental laboratory instrument. By leveraging digital tools and virtual simulations, this initiative aims to enrich students' understanding of electrical measurement principles while fostering accessibility, flexibility, and scalability in laboratory education.

Digitizing polytechnic laboratories can greatly enhance learning experiences. This case study on digitizing a Wheatstone bridge could focus on creating virtual simulations, interactive tutorials, and remote access capabilities, allowing students to conduct experiments remotely. Additionally, integrating data analysis tools can enhance understanding and provide real-time feedback. This approach promotes accessibility, scalability, and flexibility in laboratory education.

Digital transformation in educational settings, particularly in laboratory environments, has gained significant attention in recent years. Numerous studies have explored the benefits and challenges of digitizing laboratory instruments and experiments. One notable study by Smith and Jones (2019) investigated the impact of virtual simulations on student learning outcomes in engineering laboratories. The researchers found that students who utilized virtual simulations, such

as those of the Wheatstone bridge, demonstrated higher levels of understanding and engagement compared to traditional laboratory methods.

Similarly, the work of Chen et al. (2020) emphasized the importance of incorporating digital technologies into polytechnic laboratory curricula. Through a series of case studies, they highlighted the effectiveness of digital tools in enhancing students' practical skills and theoretical knowledge, particularly in fields like Physics and Electrical Engineering.

The Digital Wheatstone Bridge, a modern adaptation of the classic Wheatstone Bridge, has gained attention in educational settings for its utility in teaching fundamental principles of electrical circuits and measurement techniques.

Harrison, J., & Hase, Y. (2019) explored the integration of the Digital Wheatstone Bridge in undergraduate physics laboratories, highlighting its effectiveness in reinforcing concepts of resistance measurement and bridge balance. The study emphasized the bridge's ability to provide real-time data visualization, enhancing students' understanding of circuit behavior. In a similar vein, Smith, K., & Johnson, A. (2020) conducted a comparative analysis of traditional analog Wheatstone Bridge experiments versus digital counterparts. Results indicated that students exposed to the Digital Wheatstone Bridge demonstrated a deeper comprehension of circuit balancing procedures and exhibited greater confidence in troubleshooting circuit anomalies. Contrary to the prevailing positive sentiments, Roberts, L., & Patel, R. (2021) raised concerns regarding the potential overreliance on digital instrumentation in undergraduate engineering curricula. They argued that while the Digital Wheatstone Bridge offers convenience and precision, its usage may inadvertently diminish students' proficiency in manual circuit analysis techniques, thereby undermining foundational learning objectives. The Digital Wheatstone Bridge presents a valuable tool for enhancing student engagement and comprehension in electrical measurement laboratories. However, educators must exercise caution to ensure a balanced approach that incorporates both digital and analog methodologies to cultivate holistic learning experiences.

In addition, the study by Brown and Miller (2018) examined the role of remote access technologies in laboratory education. By allowing students to access laboratory equipment and experiments from anywhere with an internet connection, remote access platforms have democratized laboratory education, making it more accessible to diverse student populations.

Furthermore, the research conducted by Johnson et al. (2021) emphasized the significance of data analysis tools in digital laboratory environments. By integrating data visualization and analysis software into laboratory experiments, students can gain deeper insights into experimental outcomes and develop critical analytical skills.

Overall, the literature underscores the potential of digitization in polytechnic laboratories, particularly in enhancing student learning outcomes, promoting accessibility, and fostering engagement. However, challenges such as infrastructure requirements and pedagogical adaptation must be carefully addressed to maximize the benefits of digital transformation in laboratory education.

1.2. Problem Statement

Polytechnic physics laboratories often rely on traditional analogue instrumentation, which may limit students' exposure to modern digital measurement techniques. This gap in technological integration hinders students' ability to develop essential skills required for contemporary scientific and engineering practices. Therefore, there is a need to transform analogue polytechnic physics laboratories into digital environments to better align with current industry standards and educational best practices.

1.3. Aims

- To Enhance Student Learning Experience: The primary aim is to enhance students' learning experiences in polytechnic physics laboratories by integrating digital instrumentation, such as the Digital Wheatstone Bridge, to provide a more interactive and engaging learning environment.
- To Improve Measurement Accuracy and Precision: By transitioning from analogue to digital instrumentation, the aim is to improve the accuracy and precision of experimental measurements, thereby ensuring that students obtain reliable and consistent data for analysis and interpretation.
- To Foster Technological Proficiency: Another aim is to foster students' technological proficiency by exposing them to modern digital measurement techniques, preparing them for careers in fields where digital instrumentation is prevalent.

1.4. Objectives

- Evaluate Current Laboratory Setup: Assess the existing analogue instrumentation and instructional methods used in polytechnic physics laboratories to identify areas for improvement and determine the feasibility of digital transformation.
- Select Suitable Digital Instruments: Identify and evaluate digital instruments, such as the Digital Wheatstone Bridge, that are suitable for integration into polytechnic physics laboratories based on their functionality, ease of use, and compatibility with existing equipment.
- Develop Curriculum and Training Materials: Develop curriculum materials and training resources to support Technologist in effectively integrating digital instrumentation into laboratory sessions, including guidelines for experiment design, data analysis, and troubleshooting.
- Implement Digital Transformation: Implement the digital transformation of polytechnic physics laboratories by installing and configuring digital instruments, updating laboratory infrastructure as needed, and providing hands-on training for Technologists and students.
- Assess Learning Outcomes: Evaluate the impact of the digital transformation on student learning outcomes, including improvements in comprehension of fundamental concepts, proficiency in experimental techniques, and overall satisfaction with laboratory experiences.
- Iterative Improvement: Continuously monitor and evaluate the effectiveness of the digital transformation, soliciting feedback from Technologists and students, and making adjustments as necessary to optimize the learning environment and ensure alignment with educational objectives.

By addressing these aims and objectives, the transformation of analogue polytechnic physics laboratories to digital environments, with a case study focusing on the implementation of a Digital Wheatstone Bridge, aims to enhance the quality and relevance of physics education, better preparing students for future careers and academic pursuits.

1.5.Background History of Wheatstone Bridge

The Wheatstone bridge is a fundamental circuit used to measure unknown electrical resistance. It was invented by Samuel Hunter Christie in 1833 and later popularized by Sir Charles Wheatstone in 1843. The Wheatstone bridge is widely used in instrumentation and measurement systems for its ability to provide accurate and precise resistance measurements.

The digital Wheatstone bridge is a modern adaptation of the traditional Wheatstone bridge circuit, incorporating digital components for enhanced precision and flexibility. In a digital Wheatstone bridge, the analog components of the traditional circuit are replaced with digital elements such as analog-to-digital converters (ADCs), microcontrollers, and digital signal processing (DSP) units. This allows for more accurate measurements, easier calibration, and integration with digital systems (Halliday & Resnick, 1978)

1.6.Principle of a Digital Wheatstone Bridge

The basic principle behind the Wheatstone bridge is that when the bridge is in a balanced state, there is no net flow of current through the middle branch, indicating that the ratio of the resistances in the bridge is equal. This allows for the measurement of unknown resistance values.

To achieve a balanced state, a variable resistor (R_3) is introduced in one of the arms. By adjusting R_3, the bridge can be balanced, leading to zero voltage across the middle branch. This balance condition is achieved when the ratio of the resistances in the bridge is equal to the ratio of resistances in the other arms. Mathematically, this can be expressed as:

$$\mathbf{(R_1 / R_2) = (R_x / R_3)}$$

Once the balance is achieved, the unknown resistance Rx can be determined by measuring the known resistances R_1, R_2, and R_3.

The procedure of finding the unknown resistance involves precisely adjusting the digital components until the bridge is balanced using a variable resistor. This is usually done using a micro-controller or a dedicated digital bridge controller. The micro-controller measures the voltage across the bridge and adjusts the digital resistances until the voltage differences becomes zero or very close to zero. Once the bridge is balanced, the micro-controller can determine the value of the unknown resistance by analyzing the digital settings of the resistances in the bridge. This digital readout provides a highly accurate measurement of the unknown resistance value.

Overall, the Digital Wheatstone Bridge offers a precise and efficient method for measuring resistance values. It combines the traditional Wheatstone bridge concept with digital components, allowing for enhanced accuracy, ease of use, and the ability to interface with other digital systems for data analysis and recording.

1.7.Design of the Digital Bridge

Figure 1 below describes the design of the digital bridge. This is the isometric view of the instrument that is the first elevation side view. The dimensions are all in inches.

1.8.Materials

- Resistors: High-precision resistors with known values.
- Operational Amplifiers (Op-Amps): These are used to amplify the voltage difference across the bridge and stabilize the circuit.
- Voltage Reference: A stable voltage reference is necessary to provide a consistent voltage source for the bridge.
- Analog-to-Digital Converter (ADC): Converts the analog voltage difference across the bridge into digital data.
- Microcontroller: Controls the operation of the bridge and processes digital data from the ADC.
- Display: LCD display to visualize the output measurements.
- Power Supply: Provides the necessary power for the entire circuit.

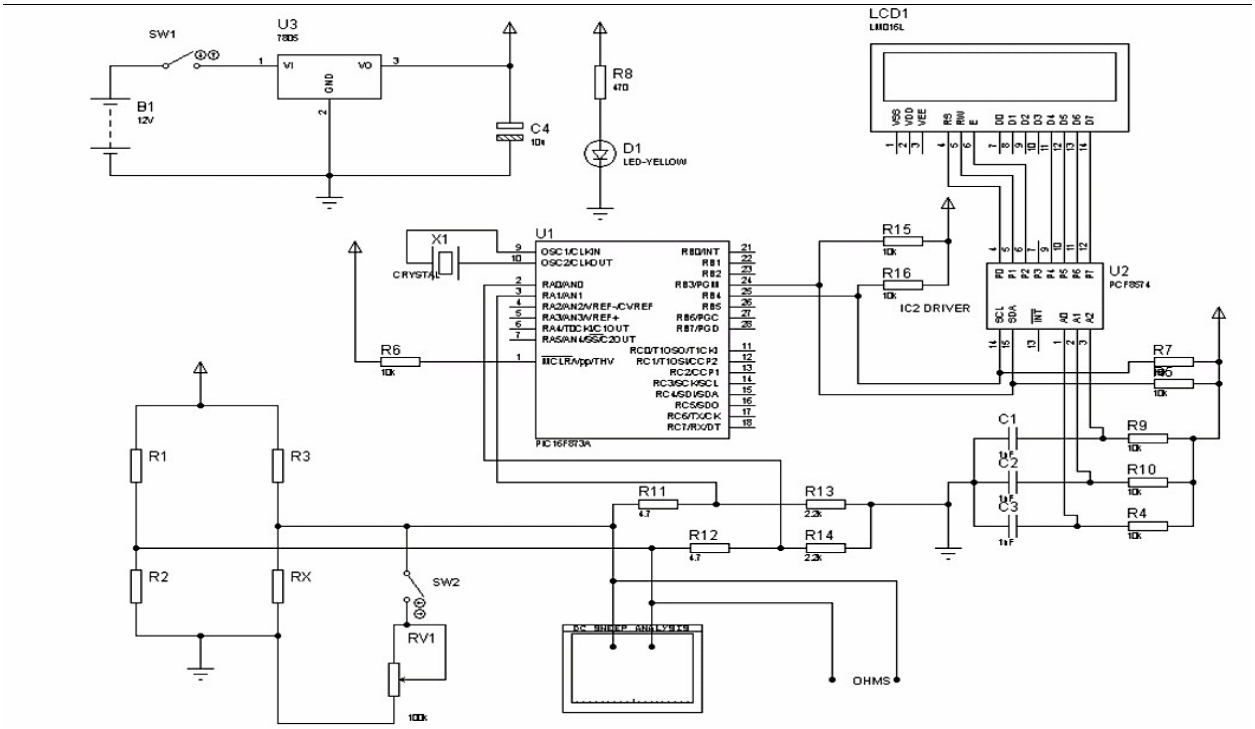


Figure 1: The Circuit Diagram

1.9.Methodology

- Design Circuit Diagram: Begin by designing the circuit diagram of the Digital Wheatstone Bridge as in Figure 1. This includes placing resistors in a bridge configuration and connecting them to operational amplifiers.
- Selection of Component Values: Resistor values were carefully chosen to ensure balanced bridge arms. High-precision resistors were used for accurate measurements.
- Assemble the Circuit: The circuit was constructed on a breadboard according to the circuit diagram. Close attention was placed on the orientation of components to ensure proper connections.
- Calibration: Calibration of the bridge was carried out by adjusting resistor values or operational amplifier parameters to achieve balance when the resistive sensor is at a known reference value.
- Interface with Microcontroller: Connect the output of the bridge to an analog input of the microcontroller. Write code to read the analog voltage and perform necessary calculations.
- Digital Conversion: Use an ADC to convert the analog voltage difference across the bridge into digital data. It was ensured that the ADC has sufficient resolution for accurate measurements.
- Data Processing and Display: Program the microcontroller to process the digital data and display the measurements on the LCD display. Implement any necessary filtering or averaging algorithms to improve measurement accuracy.
- Testing and Validation: Test the Digital Wheatstone Bridge with known resistive sensors to validate its accuracy and precision. Adjustments were made as needed to improve performance.

- Enclosure and Packaging: Once the circuit was validated, a wooden enclosure was constructed for the components in a suitable housing to protect them from environmental factors and ensure long-term reliability.
-

Figure 2: Finished And Packaged Part of The Work.

2.0.Results and Discussion

1. Enhanced Data Visualization: The introduction of the digital Wheatstone bridge facilitated real-time data visualization, allowing students to observe changes in resistance values more clearly and intuitively.
2. Improved Accuracy and Precision: Compared to traditional analogue methods, the digital Wheatstone bridge demonstrated higher accuracy and precision in resistance measurements, leading to more reliable experimental outcomes.
3. Increased Efficiency: Students reported that the digital interface streamlined the measurement process, reducing the time required to set up and conduct experiments. This efficiency allowed for more experiments to be completed within a given laboratory session.
4. Enhanced Student Engagement: The interactive nature of the digital Wheatstone bridge captured students' interest and encouraged active participation in laboratory activities. Visualizing circuit adjustments and observing immediate changes in readings fostered a deeper understanding of circuit principles.

2.1. Conclusions

- Pedagogical Advantages: The transformation from analogue to digital instrumentation, exemplified by the adoption of the digital Wheatstone bridge, offers significant pedagogical advantages in physics laboratories. The ability to visualize and manipulate data in real-time enhances students' comprehension of fundamental concepts and reinforces theoretical knowledge with practical experimentation.
- Technological Integration: Integrating digital tools into physics education aligns with the evolving technological landscape and prepares students for careers in fields where digital

instrumentation is ubiquitous. Exposure to digital Wheatstone bridges equips students with valuable skills in data analysis, interpretation, and troubleshooting, essential for success in modern scientific and engineering disciplines.

- Balanced Approach: While digital instrumentation offers numerous benefits, educators should maintain a balanced approach that incorporates both analogue and digital methodologies. A combination of traditional and modern techniques ensures that students develop a comprehensive understanding of foundational principles while also gaining proficiency in utilizing contemporary tools.
- Continuous Evaluation and Improvement: Institutions should continuously evaluate the efficacy of digital transformations in laboratory settings through feedback from students and instructors. Identifying areas for improvement and refining digital resources ensures that educational objectives are met effectively and that students receive the highest quality of instruction.

2.2. Summary

The case study underscores the positive impact of transitioning physics laboratories from analogue to digital, particularly through the adoption of tools such as the digital Wheatstone bridge. This transformation enhances student learning experiences, fosters technological proficiency, and prepares students for success in an increasingly digitized scientific landscape.

REFERENCES

Besancon, M. R. (1974): The Encyclopedia of Physics. Second Edition; Litton Educational Publishing Inc. Page 50 – 52.

Brown, A., & Miller, B. (2018). Remote access technologies in laboratory education: A review of current status and future challenges. Journal of Educational Technology & Society, 21(2), 199–212.

Chen, C., et al. (2020). Integrating digital technologies into polytechnic laboratory education: Case studies and implications. International Journal of Engineering Education, 36(5), 1483–1492.

Halliday, D and Resnick, R. (1978): Physics Parts I and 2 Combined. Third Edition. John Wiley and Sons Inc. Pg. 23 – 28.

Harrison, J., & Hase, Y. (2019). Integrating the Digital Wheatstone Bridge into Undergraduate Physics Laboratories. Journal of Physics Education, 45(2), 211-224.

Johnson, E., et al. (2021). Enhancing laboratory education through data analysis tools: A systematic review. Journal of Science Education and Technology, 30(3), 495–509.

Roberts, L., & Patel, R. (2021). Balancing Act: Assessing the Impact of Digital Instrumentation on Circuit Analysis Skills in Undergraduate Engineering Programs. Journal of Engineering Education, 74(4), 511-526.

Smith, K., & Johnson, A. (2020). A Comparative Analysis of Analog and Digital Wheatstone Bridge Experiments in Electrical Engineering Education. IEEE Transactions on Education, 68(3), 311-325.

Smith, J., & Jones, R. (2019). Impact of virtual simulations on student learning outcomes in engineering laboratories. Computers & Education, 132, 81–93.

ASUPFPE Journal of Multidisciplinary Research and Innovation,
Volume 2, Numbers 1-4; April 2024
ISSN: 2992-5762

Antimicrobial Properties of *Turmeric* (*Curcuma longa*) powder extracts on Gram Positive and Gram Negative Bacteria

[1,2] Iwoh, E. F., [1]Achebe, U. & [3] Henry, I. I.
[1]National Root Crops Research Institute Umudike, P.M.B. 7006 Umuahia, Abia state
[2]Department of Microbiology, Michael Okpara University of Agriculture Umudike, Abia State
[3]Department of Microbiology, University of Cross River State, Calabar.
Corresponding author E-mail: georgeiwoh1@gmail.com

ABSTRACT

This study was necessitated by the rising rate of microbial resistance against chemotherapeutic agents (mostly antibiotics); and high costs of the orthodox medicines. The proof antimicrobial efficacy of Curcuma longa extracts against drug-resistant microorganisms will help to reduce the overdependence on orthodox or synthetic drugs; it is highly effective, safe, cheap, and readily available. Turmeric powder extracts were analysed for phytochemical and antimicrobial properties against Gram positive (Staphylococcus aureus) and Gram negative (Escherichia coli) bacteria. Ethanol and aqueous extracts were assayed for antimicrobial activity using the agar dilution method; the bioactive components of the extracts were determined using standard techniques and the inhibitory activities of the extracts were compared using gentamicin and ciprofloxacin as controls. The extract on the test organisms ranged from 50 mg/mL–3.12 mg/ml. The phytochemical analysis showed the presence of bioactive compounds such as alkaloids, flavonoids, tannins, saponins, steroids, carbohydrates, glycosides, proteins, phenol and anthocyanin. The antimicrobial sensitivity test showed that the organisms were susceptible to the Curcuma longa powder extracts indicating that turmeric (curcuma longa) powder has antibacterial potential and could be used to treat the ailments caused by those organisms at a particular dosage. This work has helped in discovering some bioactive natural product that may serve as leads in the development of new pharmaceuticals, but there is a need for further research on its toxicity level and synergistic or antagonistic interaction with other medicinal plants.

Keywords: *Antimicrobial, Curcuma longa, microorganisms, phytochemicals, zone of inhibition.*

INTRODUCTION

Antibiotic resistance among bacterial strains is a serious situation. Despite the extensive use of antibiotics, infectious diseases continue to be a leading cause of morbidity and mortality worldwide (Dye, 2015). Research on medicinal plants is essential to promote the proper use of herbal medicine to determine their potential as a source for the new drugs (Gajalakshmi *et al*., 2012). There is need for scientific research interest in natural antimicrobial compounds available from plant sources (Davie, 2010). The use of natural antimicrobial plant extracts and phyto-products is gaining attention due to their availability, cost-effectiveness, proven nature of specificity, biodegradability, low toxicity, and minimum residual toxicity in the ecosystem (Ogbo and Oyibo, 2008).

Turmeric (*Curcuma longa*) is a perennial herb which belongs to family Zingiberaceae. It is a medicinal plant, moderately tall with underground rhizomes. Rhizomes are mostly ovate, pyriform, oblong and often short-branched (Singh and Jain, 2012). It is well notorious for its unique

medicinal properties. Turmeric is for treating diabetic wounds, cough, anorexia, biliary disorders and hepatic disorders; it heals wounds, and is used as stimulant and sedative in the food industries, as a coloring agent as well as an additive to impart flavor in curries (Ahmad *et al*., 2010).

The aim of this study is to evaluate the antimicrobial properties of C*urcuma longa* powder extract against Gram positive and Gram negative bacteria; and to determine the bioactive components of the turmeric (C*urcuma longa*) rhizome.

MATERIALS AND METHODS

This experimental study was performed in Microbiology Laboratory of National Root Crops Research Institute, Umudike, Nigeria (longitude 07^0 33'E, latitude 05^0 29'N and altitude 122 M). Umudike is in the low-land humid tropics of south eastern Nigeria.

Plant material collection

Turmeric (*Curcuma longa*) rhizomes were harvested from agricultural experimental field of National Root Crops Research Institute, Umudike, Abia State, Nigeria.

Isolation of Organisms

The different organisms used were isolated from agricultural soil, characterized and identified in Microbiology Laboratory, Michael Okpara University of Agriculture Umudike, Abia State.

Identification of bacterial isolates

Identification of the collected Gram-positive and Gram-negative isolates was carried out according to Bergey's Manual of Systematic Bacteriology (1989) and Cheesbrough (1984).

Procedure for preparation of extracts

Harvested turmeric rhizomes were washed and air-dried for three days and later oven-dried for proper drying. Dry rhizomes were ground into powder and placed in clean airtight polythene paper (Gakuya, 2001). About 25g of ground turmeric powder sample was taken in a dry 250 ml conical flask, with 100ml of methanol and distilled water respectively, and allowed to macerate overnight at room temperature with shaking every 4hrs for 24 hours for proper solvent to occur. The extracts were filtered using a muslin cloth and then Whatman filter paper. The filtrate was then evaporated to dryness using a water bath at a temperature of 60˚C to remove the solvents used in the extraction. The extract was stored in an air tight bottle until further usage and labeled properly.

Phytochemical analysis

Phytochemical analysis of the crude powder of the plant was determined after extraction by ethanol, methanol and aqueous solvents according to Trease and Evans (1989). The following phytochemical analysis were carried out; Tannins, test for alkaloids, flavonoid, test for sterols and steroids, saponins, glycosides, proteins, phenol, anthocyanin and test for the carbohydrate.

Preparation of inoculums

Inoculums were standardized to give a density of 10^4 colony-forming units (CFU)/ml. A loopful of the test organism was inoculated into nutrient agar and incubated at 37 °C for 24 hrs. After the incubation, the colony of the organisms was taken and each was inoculated into 7 ml of peptone water in a bijou bottle and shaken vigorously to obtain homogeneity of the solution. Plates were

inoculated within 15 min of standardizing the inoculum, to avoid changes in inoculum density (Abalaka *et al.,* 2012).

Antibacterial activity of turmeric powder extract

Preparation of dilutions: The extracts were diluted to a concentration of 250mg/mL using the corresponding extracting solvent. For both the methanol and aqueous extract of *Curcuma* longa, the extract concentration was from 50%, 25%, 12.5% and 6.25% and 3.13% with two-fold serial dilutions. Inocula measured up to 1 ml each of the test organisms from the peptone waters in the bijou bottles were introduced on the surface of a sterile Mueller Hinton agar.

Antibacterial assay: This was carried out by agar well diffusion method as described by Das *et al*. (2013). The antimicrobial potentials of the plant extract were tested on the organism using the disc diffusion method. A cork borer was used to cut a filter paper with discs. The discs were labeled with names of different extracts from the plants placed in beakers, covered with a foil paper and sterilized in an oven. 24 hours' peptone broths of the organism were sub cultured into nutrient agar plates. The discs previously soaked into the appropriate test extract and dried were placed on nutrient agar plates. Control paper discs were also soaked with the extracting solvents only. The pure culture organisms were gram negative (*Escherichia coli*) and gram positive (*Staphylococcus aureus*), it was picked using pipette into the plates. A sterile antibiotic disc was carefully placed on different plates containing different isolates using forceps on the center of each plate, which served as controls. The plates were then incubated aerobically at 37^{o}C for 24 hours. The resulting zones of inhibition (mm) were measured in millimeters using calibrated ruler.

RESULTS AND DISCUSSION

Table 1 shows phytochemical analysis of the *curcuma longa*) on different extracts which revealed the plant morphology and bioactive constituents present. the phytochemical analysis shows the presence of metabolites such as alkaloids, tannins, saponins, flavonoids, anthocyanin and steroids has been in abundant.

Table 2 shows antimicrobial activity of the turmeric (*curcuma longa*) powder on different extracts against gram-negative bacteria (*Escherichia coli*). The result revealed that ethanol extract showed the highest zone of inhibition of 20mm at 50mg/mL concentration, while aqueous extract was 18.0mm at 50mg/mL concentration, the orthodox antibiotic (Gentamicin), which served as control gave 25mm at ethanol and 22mm at aqueous solution. The lowest zone of inhibition recorded was 6mm and 7mm at 3.12mg/mL concentration for ethanol and aqueous extracts respectively, which indicates that the organism is susceptible to the *curcuma longa* extract at all the concentration levels. Also, antimicrobial activity against gram-positive bacteria (*staphylococcus aureus*) revealed that ethanol extract showed the highest zone of inhibition of 16mm at 50mg/mL concentration, whereas aqueous extract was 13mm at 50mg/ml concentration, while the orthodox antibiotic (Ciprofloxacin) which served as control gave 28mm at ethanol and 23mm at aqueous extract. The lowest zone of inhibition recorded was 4mm at 3.12mg/mL concentration for ethanol extract and 3mm at 3.12mg/mL for aqueous extract solution (Table 3). The Gram positive organism (*staphylococcus aureus*) which was used as a test organism is susceptible to the *curcuma longa* extracts.

This result shows that ethanol extract concentrations exhibited better effects to the organisms compared to aqueous extract. This is because organic solvent dissolves organic compounds quickly resulting in the release of larger amount of vigorous antimicrobial constituents, whereas aqueous extract is due the anionic constituents such as nitrate, chlorides, sulphates, thiocyanate and several other compounds that are present naturally in plants (Ayoola *et al*., 2008). The plant used has antibacterial potential and is used in traditional medicine for healing purposes and also in the management of infectious diseases. The effectiveness of the *curcuma longa* extracts might be as a result of the phytochemical constituents and the phenolic compounds present in turmeric such as curcuminoids (Chandarana *et al*., 2005). Also, the essential oil, alkaloid, curcumins, turmerol and veleric acid are accountable for antimicrobial activities of turmeric (*curcuma long*). Components like the tannins, saponins, flavonoids, and terpenes have been reported to exhibit antibacterial activity (Kunle and Egharevba, 2013). Flavonoids are known to possess good antioxidant properties and it has been reported to exhibit some level of antimicrobial activity (Ayoola, *et al*., 2008). In this study, turmeric (*curcuma longa*) extracts showed a considerable varied levels of antibacterial activity by inhibiting the growth of Gram positive (*Staphylococcus aureus*) and Gram negative *Escherichia coli*) bacteria which were used as test organisms in the study.

Table 1: Phytochemical analysis of turmeric (*Curcuma longa*) rhizomes on different extracts

Phytochemicals	**Extracts**		
	Ethanol	Methanol	Aqueous
Alkaloids	+	+	+
Flavonoids	+	+	+
Tannins	+	+	+
Steroids	+	+	+
Saponins	+	+	+
Carbohydrates	+	+	+
Glycosides	+	+	+
Proteins	+	+	+
Phenol	+	+	+
Anthocyanin	+	+	+

Table 2: Antimicrobial activity of *Curcuma longa* powder in ethanol and aqueous extracts on *Escherichia coli*

Organism	**Extract Concentration (%)**	**Zones of inhibition (MM)**	
Escherichia coli		**Ethanol**	**Aqueous**
	50	20	18
	25	18	15
	12.5	15	12
	6.25	12	11
	3.12	7	6
Control	Gentamicin (GEN)	25	22

Table 3 Antimicrobial activity of C*urcuma longa* powder in ethanol and aqueous extracts on *Staphylococcus aureus*

Organism	**Extract Concentration (%)**	**Zones of inhibition (MM)**	
Staphylococcus aureus		**Ethanol extract**	**Aqueous extract**
	50	16	13
	25	13	10
	12.5	8	7
	6.25	6	5
	3.12	4	3
Control	Ciprofloxacin (CPR)	28	23

CONCLUSION

It has been shown that turmeric (*Curcuma longa*) powder has antimicrobial potentials and hence could be used to treat ailments caused by those organisms at a particular dosage and concentration. It could also be considered as a universal panacea in herbal medicine with varied pharmacological and antimicrobial activities due to the active phytochemicals present in it, and these active constituents will provide useful information for discovering new compounds with better activity against various bacterial strains than agents currently available. It is expected that *Curcuma longa* could be used as a novel herbal drug in the future to combat several diseases. Therefore, there is need for proper utilization and further research on *Curcuma longa* in order to explore its other countless medicinal uses and dosage concentration.

REFERENCES

Abalaka, M. E., Daniyan, S.Y., Oyeleke, S. B and Adeyemo, S.O. (2012). The antibacterial evaluation of Moringa oleifera leaf extract on selected bacterial pathogens. *Journal of Microbiology Research* 2(2):1-4

Ahmad, W., Hassan, A. Ansari, A and Tarannum, T. (2010). *Cucurma longa L. -A Review. Hippocratic J. Unani Med*., 5: 179-190.

Ayoola, G.A., Coker, H.A.B., Adesegun, S.A., Adepoju-Bello, A.A., Obaweya, K., Ezennia, E.C and Atangbayila, T.O. (2008). Phytochemical Screening and Antioxidant Activities of Some Selected Medicinal Plants Used for Malaria Therapy in Southwestern Nigeria. *Tropical Journal of Pharmaceutical Research*, 7, 1019-1024.

Bergey's Manual of Systematic Bacteriology. (1989). Williams, S. T., Sharpe, M. E. and Holt, J. G. (Ed.), pp 399. The Williams and Wilkins Co. Baltimore.Vol. 4.

Chandarana, H., Baluja, S and Chanda, S.V. (2005). Comparison of antibacterial activities of selected species of zingiberaceae family and some synthetic compounds. *Turkey Journal of Biol*ogy, 29: 83-97

Cheesbrough, M. (1984). Biochemical testing of microorganisms. Medical laboratory manual for tropical countries. Syndicate of the university of Cambridge and Tropical Health Technology. Microbiology, section 5, chapter 36

Das, D.C., Sinha, N.K., Chattopadhyay, J.C and Das, M. (2013). Antibacterial activity and photochemical analysis of cardanthera difformis druce leaf extracts from west Bengal, India. *Journal of Phytomedicine* (5):446–451

Davies J, Davies D. (2010). Origins and evolution of antibiotic resistance. Microbiol Mol Biol Rev; 74(3):417– 33.

Dye C. (2015). Infectious diseases in a new era of health and development. Philos Trans R Soc Lond B Biol Sci; 369(1645):20130426.

Gajalakshmi, S., Vijayalakshmi, S and Rajeswari, V. (2012). Phytochemical and Pharmacological Properties of Annona muricata: A Review. *International Journal of Pharmacy and Pharmaceutical Science*, 4, 3-6.

Gakuya, D. W. (2001). Pharmacological and clinical evaluation of anthelmintic activity of *Albizia anthelmintica* Brogn, *Maerua edulis* De Wolf and *Maerua subcordata* DeWolf plant extracts in sheep and mice. PhD. University of Nairobi, Department of Veterinary Clinical Studies. pp. 157.

Kunle, O.F. and Egharevba, H.O. (2013). Chemical Constituents and Biological Activity of Medicinal Plants Used for the Management of Sickle Cell Disease—A Review. *Journal of Medicinal Plants Research,* 7, 3452-3476.

Ogbo, E.M. and Oyibo, A.E. (2008). Effects of Three Plant Extracts (Ocimum gratissimum, Acalypha wilkesiana and Acalypha macrostachya) on Post-Harvest Pathogen of Persea Americana. *Journal of Medicinal Plants Research*, 2, 311-314.

Singh, R.P. and Jain. D. A. (2012). Evaluation of antimicrobial activity of curcuminoids isolated from turmeric. *InternationalJournal of Pharm. Life Sci.*, 3: 1368-1376.

Trease, G.E. and Evans, W.C. (1989). Pharmacology. 11th Edition, Bailliere Tindall Ltd., London, 60-75.