

AFRICAN JOURNAL OF SCIENCE, TECHNOLOGY AND ENGINEERING (AJSTE)



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nanoschematic

DNA contains the genetic information that allows all known living things to function, grow and reproduce. However, it is unclear how long in the 4-billion-year history of the DNA has performed this function as it has been proposed that the earliest forms of life may have used RNA as their genetic material (hereditary) which may have acted as the central point of many cellular functions as it can both transmit genetic information and carry out catalytic as part of many processes. The ancient DNA world which began with would have been used for both catalysis and genetics may have facilitated the evolution of the complex genetic code based on their respective bases. "Information theory" shows the transfer of information from a source to a destination in a channel of information. A great number of bases in the DNA molecule are involved in the transfer of information. The transfer of information is a process of encoding the information into a digital form.



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Preamble

African Journal of Science, Technology and Engineering (AJSTE) is an academic multidisciplinary peer-reviewed yearly publication that seeks to publish original, innovative research and academic scholarship that contributes to the growth of knowledge in Science, Technology and Engineering and related fields. Her key audiences are: Scientists in academia and industry, researchers, students, government agencies/policymakers and citizens with a passion for “STEM”.

This second edition is aligned with the newest research, interspersed with contemporary concerns and latest global transposition in Science, Technology and Engineering. It carries original and full-length articles that reflect the latest research and developments in both theoretical and practical aspects of global science. It promotes research awareness and compatibility platform through a concise and methodical interface to cater for all categories of scholars in science, while encouraging innovativeness and quality research work.

The topical issues in this Journal include : investigation and prosecution of sexual offences in relation to forensic medical evidence ,attitudes of nurses towards pressure ulcer prevention guidelines, effects of exotic tree's litter quality on responses of the adjacent native grasses, properties of operators in norm-attainable algebras and their applications, effect of varying thickness on performance of titanium dioxide solar cell, investigating the effect of an IR emitting element to the time constant of solar energy harvesting device lifetime, and knowledge sharing using social media as strategy.

The Journal is both in print and online versions.

Chief Editor

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Investigation and Prosecution of Sexual Offences in Relation to Forensic Medical Evidence in Kiambu County, Kenya.

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Abstract

Kenya police annual reports show that sexual offences are escalating in Kenya. This study was done to find out the challenges the police officers within Kiambu County faced in the course of evidence collection, investigation and prosecution of sexual offences. The research involved conducting interviews and administration of Likert scale questionnaire for police officers trained on handling sexual offenses as the key informants, and use of data abstraction tool to collect data from the police record files in the year 2016. Analysis of P3 forms indicated that 50% of reported victims had hymen broken, 40.9% had genital lacerations and 9.1% had hymen intact. It was established common laboratory tests ordered in rape cases are: high vaginal swab (77.3%), HIV (95.5%), pregnancy (77.3%) and DNA analysis (13.6%). Great amount of evidence (77%) collected in rape investigation is not sent to forensic laboratories for analysis. The other setbacks included lack of collaboration between the police gender department and other government agencies like health facilities handling cases of sexual offences, and inadequate support for the gender offices to effectively handle cases of sexual offences. Only a third of reported sexual offence cases reach full trial. Inadequacies were observed in filling of the P3 and Post Rape Care (PRC) forms and there was lack of adherence to chain of custody in evidence handling. Challenges in investigation and prosecution of sexual offences adversely affects justice for the victims. Recommendation for continuous specialized training to clinicians on forensic medical evidence, infrastructural upgrade, modern tools for gender departments and a multidisciplinary approaches in handling sexual offences.

Keywords: Prosecution, Sexual Offences, Forensic Medical Evidence, Kiambu county, Kenya.

Introduction

Sexual violence crimes happen throughout the world with varying incidence in different countries. Areas like Latin America the study shows that among the sexually assaulted adults less than five percent report to law enforcing institutions. Sexual violence by partners reported by women, between the ages of 15-49 years was 59% in Ethiopia which was the highest in the country included in the survey, in majority of the countries the rate falls between 10% and 50% (WHO, 2012).

Kenya Demographic Health Survey (KDHS) findings was that one in every five or 21% of Kenya women between ages 15 and 49 years were exposed to various form of sexual violence. Moreover, KDHS found that 12% of women reported that their first encounter of sexual intercourse was against their consent. Further 40% and 44% of women and men respectively age between 5 and 49 years have experienced physical violence from the age of 15 years, of these 20% and 12% of women and men respectively have been physically abused within one year before the survey (KDHS, 2009).

According to the National Police Service (NPS), 2015 annual report, Kiambu County ranked third in crimes against morality at 238 cases after Nakuru and Bungoma Counties. There was 19% increase in offences against morality in 2015 compared to 2014 in Kiambu County. The report cited an increase of the same offences by 8% in the year 2014. Tigoni Police Station recorded 9 cases in 2015, but there was a sharp increase in 2016 recording 19 cases (NPS 2015).

Sexual assault offences are defined, outlined and stipulated in the Kenya Sexual Offences Act 2006. In Kenya, only 25% of sexual assault cases presented before a court of law leads to successful convictions. This poor outcome is as a result of insufficiency of health workers and law enforcement agent to gather evidence from victims promptly and effective way.

Examination of victims of suspected sexual assault requires a combination of skills in clinical history taking, thorough physical examination, collection and preservation of substantial physical evidence for forensic assessment. Clinicians' capacity in handling of sexual offences and through collection, preservation of physical evidence, analysis, reporting and conclusion are key for sexual offences cases.

In year 2006, Kenya successfully enacted policing laws to help curb Sexual and

Gender based Violence (SGBV), nevertheless these offences continue to be endemic in the country. Clinicians' capacity in handling of sexual offences by collection and preservation of physical evidence, analysis and reporting, and conclusion were among key aspect for conducting this research. Forensic medical evidence is vital in prosecution of sexual offences because of its utility in aiding determination of the cases in a court of law.

There is therefore need for a study to establish challenges in the investigation and prosecution of sexual offences in relation to forensic medical evidence in Kiambu County.

Methodology

The research involved interviews using a guide with specified questions that begins with *how* or *what* and Likert scale questionnaire for police officers trained on investigation and prosecution of sexual offenses. The police in Tigoni, Kikuyu and Thika police stations were the key informant. Information on challenges and experience in the probation and prosecution of sexual offence.

Triangulation was used during data collection as a data management tool. All the Police files on sexual offences for the year 2016 were examined. The files sample frame comprised of the files in the year 2016, involving sexual offences.

Research Design

It was descriptive cross sectional study, to assess challenges in the probation and prosecution of sexual offences in relation to forensic medical evidence in Kiambu County.

Study Area

Research was conducted within Kiambu County, Tigoni, Kikuyu and Thika police gender department. These police stations were selected for this study because they were considered to apply best practices in handling sexual offences in Kiambu County, their population density and were situated in main sub counties hence making outcomes of the study representative.

Study Population

Four police officers trained in trained on handling sexual offences and two senior most police officers were recruited from each of the three police stations. An interview was conducted on them and then Likert scale questionnaire was administered. Two senior police officers were not available due to other official engagements. One hundred and ninety-four files (NPS, 2016) on reported cases against morality in Kiambu County were perused. The reported cases included rape, defilement, sodomy, incest, indecent act, bestiality among others. In this, the accessible population to the study was in Tigoni, Kikuyu and Thika police gender departments. Each of the gender department reports an average of 20 cases in a year, comprising of 60 cases of accessible population.

Data Collection Methods and Procedures

The researchers conducted interviews to 16 key informant who were police officer trained and experienced in handling sexual offences. Likert scale questionnaire was administered to the same officers including their supervisors. The interviews were face to face and involved audio recording and taking notes lasting for 30-40 minutes followed by Likert scale questionnaires lasting for 8-12 minutes. The researchers accessed the police files involving sexual offenses for year 2016 and required information captured in the data capture tool. Each file perusal took 10-15 minutes.

The data was captured using a structured questionnaire, Likert skill and audio. The data was screened through frequency checks, physical count and double entry. Analysis was done using IBM statistics.

Ethical Considerations

Permission to conduct this study was obtained from Mount Kenya University (MKU) Research Ethics Committee and National Commission for Science, Technology and Innovation (NACOSTI). Permission from Tigoni, Thika and Kikuyu police gender departments was sort before commencement of data taking. Information obtained during the study was confidential and anonymity was observed as no names or any other personal identification was captured.

Results

i) *Qualitative results*

The study sought to establish the challenges that are encountered in obtaining forensic medical evidence for sexual offences during investigations. The use of descriptive study design was to find out facts without manipulation of data, seek opinions, analyse and interpret findings. Triangulation of information was used to aid in validation of the results, and helped to collaborate the themes identified from the manuscripts. The most noticeable themes were;

- i. Loss of vital evidence before reporting as most victims of sexual assault not being aware how to preserve evidence before reporting to police or visiting a health facility.
- ii. Clinicians lacking full insight on how handle victims of sexual offences, collect and preserve forensic medical evidence.
- iii. Lack of collaboration between the police gender department and health facilities in handling cases of sexual offences.
- iv. Inadequate support to the police gender department to effectively handle cases of sexual offences.

The study found out that the lack of awareness by the victim on the right thing to do after such incidences have taken place led to the interfering of evidence by the victims through taking showers and having a change of cloth. The delay of the victims in reporting of such cases leads to the degradation of evidence as time elapses. In addition, the study found out that the lack of adequate training of the medical personnel handling the victims was equally a challenge in obtaining the required forensic medical evidence. Thus, these challenges encountered had an effect on the prosecution of the sexual offences which in some cases led to the acquittal of the offenders and therefore justice is denied to the victims.

The study established the poor collaboration between the medical personnel and the police officers, the police stations and the government hospitals affected the processing and presenting forensic medical evidence during prosecution. The processing and presenting of this evidence is further impeded by the lack of proper

storage facilities for the exhibits. The analysis of DNA samples took unnecessarily long duration, but in majority of cases the DNA sample was not collected in the first place which would have served to place the offender at the scene of crime. Therefore, these challenges in processing and presenting of the forensic medical evidence affected the strength of prosecution of the sexual offences.

Triangulation used to assess the accuracy of the key informant interview confirmed most of the information gathered. There existed several inadequacies in regard to the police documents that are used in the gathering of evidence. Most of the documents did not capture all the necessary information, and were not accompanied by the evidence and specimens collected. In cases where exhibits were available, there was a generally poor preservation of the same. This therefore served to weaken the prosecution of offenders involved in sexual offences. There was glaring discrepancies between the P3 and PRC forms of the same victims.

In regard to the challenges in the chain of custody of forensic medical evidence, the study found that the chain of custody was not well established in most cases that were studied. Thus, the lack of a well-established chain of custody can affect the overall prosecution of sexual offences.

ii) Quantitative Results

Evidence Analysis in the P3 Form

From the findings, it was established that 11 (50%) respondents indicated that based on the evidence analysis carried out, the hymen was not intact, with the genitals having lacerations, 9 (40.9%) indicated there was no evidence analysis that was carried out, 2 (9.1%) reported that the evidence analysis revealed that the hymen was intact. The findings therefore indicate that evidence analysis revealed that there was actual offence committed as evidenced by the broken hymen and lacerations. However, the findings also show that there was no evidence analysis in a number of cases which serves to compromise the weight of evidence being presented during the prosecution of the cases Figure 1 below.

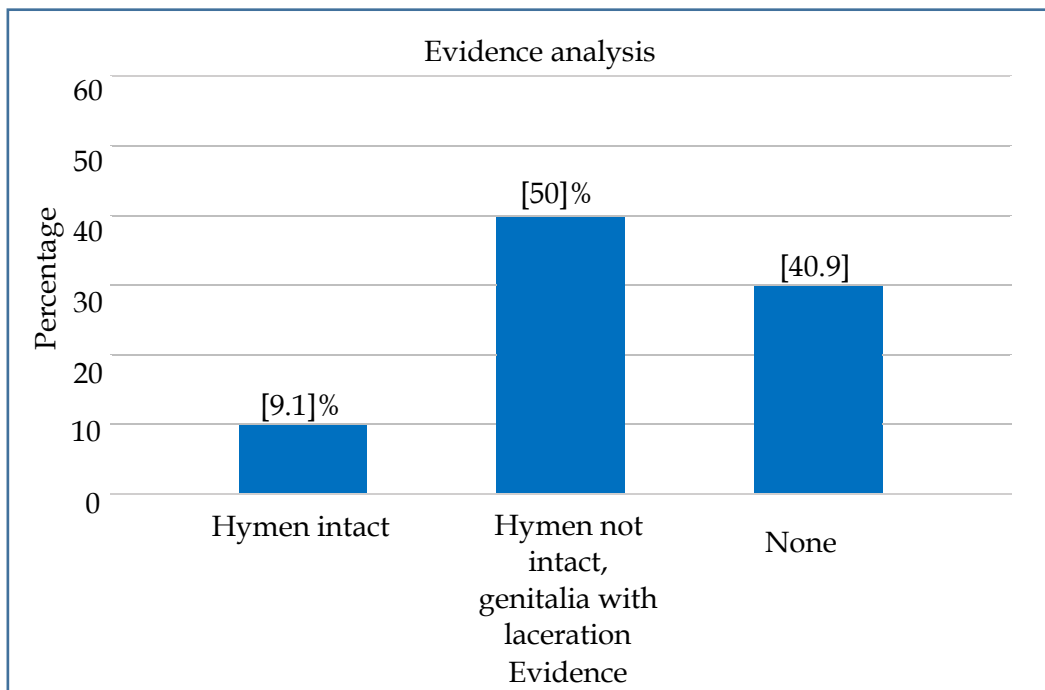
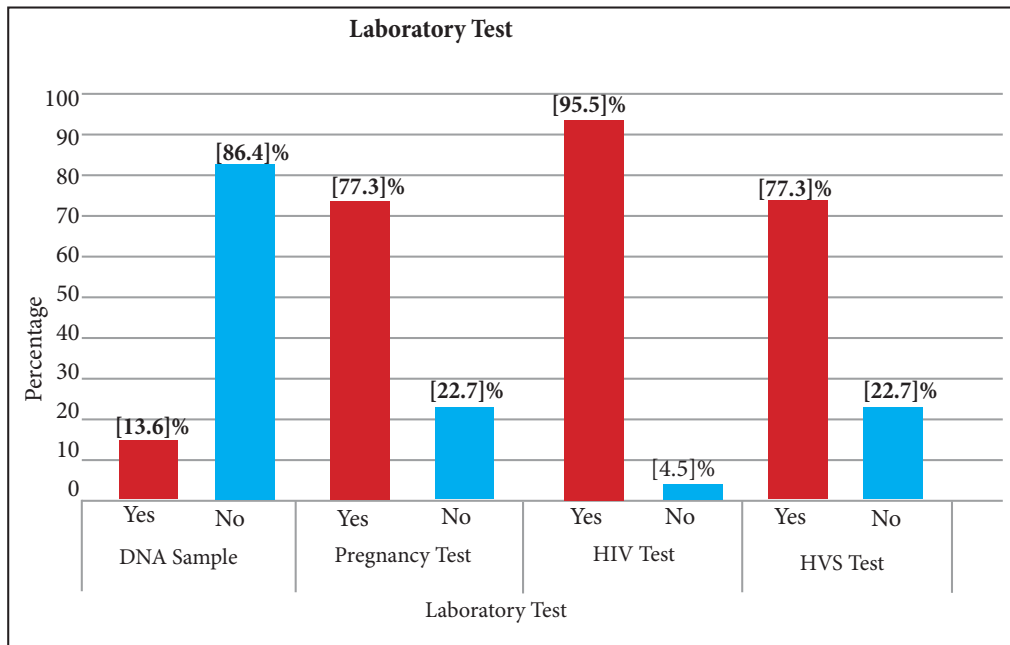


Figure 1: Clinical Assessment of Sexual Offences Victims

Laboratory Test and Results

Types of laboratory tests ordered on the victims as part of sexual offences investigation include: DNA, Pregnancy, HIV and HVS. It appears the forensic DNA which is deemed most crucial in evidential preparation was least requested by the investigators. The HIV test may have been requested for patient management, but utility is limited in proving sexual offences Figure 2 below.



The study sought to find out whether specimen obtained from the victims and perpetrators was sent to forensic laboratories for analysis.

From the findings, majority of the specimens, 77% collected from the victims and perpetrators were not sent to forensic laboratories for analysis, while 23% of the specimens were sent to forensic laboratories for analysis. However, even for the specimens that were sent for analysis, no results were received back. The findings therefore indicated that most of the collected evidence was not sent for further forensic analysis which otherwise would have provided more evidence in the prosecution of the cases Figure 3 below.

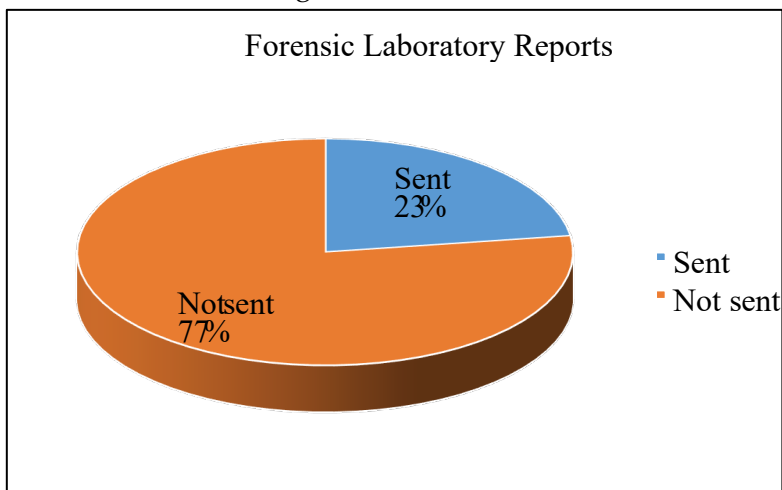


Figure 3: Frequency of Utility Forensic Laboratory in Processing Specimen from Sexual Offences

Likert Scale Questionnaire

The likert questionnaires were administered to the key informants with an expectation to respond how they agreed or disagreed with the statements. A three point Likert scale was used to rate the responses namely: (1) Agree, (2) Neutral and (3) Disagree.

Table 1: The Manner of Reporting Sexual Offence

Statements	Agree (%)	Neutral (%)	Disagree (%)	N
All sexual offences are usually reported to police station for action	12.5	6.25	81.25	16
Minors of less than 18 years need a parent/ guardian while reporting sexual offence against them	93.75	0	6.25	16
Most victims of sexual offences report incidences to police stations before going to seek medical attention	87.5	0	12.5	16
Most victims of sexual offences seek medical attention first before reporting incidence to police stations	18.75	6.25	75	16
Most victims of sexual offences report offence to police station before taking a bath or change of clothing	50	0	50	16

Statements	Agree (%)	Neutral (%)	Disagree (%)	N
Most victims of sexual offences report offence to police station after taking a bath or changing of clothing	50	0	50	16
Most victims of sexual offences report offences when it's too late to collect forensic medical evidence	81.5	0	18.5	16
Most victim of sexual offence report the offence early enough that aids gathering forensic medical evidence	25	0	75	16
Forensic medical evidence is very vital to corroborate victims of sexual offence allegation	100	0		16

The clinicians attending the victims of sexual offences are conversant with forensic medical evidence	25	0	75	16
The hospitals where the victims of sexual offences are first attended to are conversant on how to collect and preserve forensic medical evidence	37.5	0	62.5	16
The local facilities are well facilitated to collect and preserve forensic medical evidence	62.5	0	37.5	16

Table 2 above show that victims of sexual offences report to the police long after the incidence (81.5%). It was reported that the medical facilities receiving the sexual offence victims have limited capacity to collect forensic medical evidence (62.5%). but highly admitted (100%) that the forensic medical evidence is very important in corroborating sexual offences.

Table 3: Relationship between Agencies Dealing with Sexual Crimes

Statements	Agree (%)	Neutral (%)	Disagree (%)	N
There is good collaboration of the police and government health facilities in handling the victims of sexual offences.	62.5	0	37.5	16
There is poor collaboration between the police and government hospitals in collecting and preservation of forensic medical evidences in relation to sexual assault.	87.5	0	12.5	16
Forensic medical evidence is usually the main evidence the investigating officer is usually interested in sexual offences.	56.25	0	43.75	16
The police investigating officer usually encounter challenges in building a strong case due to poor collaborative forensic medical evidence.	93.75	0	6.25	16

Table 3 above indicates that there is poor collaboration between the police and public health facilities in collecting forensic evidence (87.5%). This affect the quality forensic evidence which is critical in the investigation and prosecution of the sexual violence offences (93.75%).

Table 4: Chain of Custody for the Specimen for Sexual Offences

Statements	Agree (%)	Neutral (%)	Disagree (%)	N
Chain of custody is important in handling forensic medical evidence.	31.25	12.5	56.25	16
All the cases of sexual offences there is strict adherence to the chain of custody in handling forensic medical evidence.	25	0	75	16
In your own opinion the clinician handling forensic medical evidence are conversant with the chain of custody in handling this type of evidence.	37.5	0	62.5	16
There is need to support the existing structure on chain of custody in handling forensic medical evidence.	100	0	0	16

The respondents observed that clinicians attending do not need chain of custody for forensic medical evidence (75%) and that it is not observed (56.25%). However, the respondents consider it necessary chain of custody is important for forensic medical evidence (100%), Table 4 above.

Discussion

The study identified the challenges the gender departments in Kiambu County faced in their investigation and prosecution of sexual offences in relation to forensic medical evidence, and in pursuit for justice to the victims of sexual violence.

Based on the key informant finding, most are proud working at the gender department since it assists in the enhancing the knowledge regarding gender based issues. It also provides an opportunity for those working there to learn about what happens in the communities they live in. Working at this particular department provides one with an opportunity to educate the public on gender based violence issues. Professionalism and integrity is a virtual for those working there. There should be a full informed consent of the victim when medico-legal evidence need to be collected and thereafter stored and analysed.

According to those interviewed, there are several problems that are encountered when dealing with sexual offences. Among these problems include: majority of the cases are not reported at the station, there is late reporting of the offences up to more than 72 hours or more when most of the evidence is lost or degraded, with some assault victims taking bath and change their clothing before attending a health facility before reporting the offences. Most victims are not conversant with the procedures of reporting such incidences. This may also explain as per the police report where the victims often not supported in coming forward and premature

prosecution of cases before investigations are complete which can result in wrongful acquittals.

There is poor documentation and capture of evidence in both PRC and p3 forms, poor storage facilities for specimens that will be used in analysis, failure of the victims providing full information on the incidences and there is a general fear of being exposed alongside the intimidation from the offenders together with their next of kin. With regard to the challenges that are encountered when gathering forensic medical evidence, the key informants pointed out that some clinicians were not conversant with what type of specimen to take for the forensic analysis. Evidence when collected promptly there is adequacy in recovery of microscopic evidence such as spermatozoa which can be lost in late examination.

It was also pointed out that there are several factors that prove to be a challenge in gathering of forensic medical evidence such as tampering of the crime scene, victimization of the victims, because of tribal or cultural norms and poor facilities and infrastructure at the police stations where confidentiality is needed in such cases. According to Amnesty International, in Kenya, only 25% of sexual assault presented before a court of law leads to successful convictions, this poor outcome is as a result of insufficiency of health workers and law enforcement agent to gather evidence from victims promptly and effective way.

Regarding how the challenges which are usually encountered in gathering of forensic evidence eventually affect the prosecution of these offences, the key informants pointed out that the forensic medical evidence provide more weight to the prosecution, but when this type of evidence is not collected and no clinician to act as medical expert. Thy suggested that in the P3 form, the clinician should state the degree of injury as required in column 5 of the P3 form, clearing indicating whether its harm, grievous harm or maimed. The P3 form should also have a section for DNA match.

In regard to how other working environments affect the investigations and prosecution of sexual offences, it was noted that storage of the forensic medical evidence was very poor at the police stations. This finding is contrary to other countries like Australia, Canada, United Kingdom and United States, where the evidence is secured in a sexual violence kit and may be frozen or stored while the victim decides whether they will pursue recourse in the legal system⁷. Some stations lack private rooms at the police stations for interrogation of the victims and where they can give their evidence in a free manner, lack of transport and facilitation to the Government Chemist and the inability of some officers to attend victims of sexual offences due to lack sensitization on how to handle such cases.

The officers interviewed seemed not to be so conversant with the chain of custody and how to go about it. According to WHO, creation of a secure chain of custody is key to effective processing of medico-legal evidence to avoid compromise before analysis and possible court use. This should be from specimen collection, sealing in separate containers to avoid cross-contamination, labelling, to signing by the person who gathered them.

Conclusion

There still exist challenges in investigation and prosecution of sexual offences and this is adversely affecting justice to the victims. There should be enhanced collaboration between police, health workers and other stake holders in forming multidisciplinary teams to investigate and prosecute sexual offences. There is also need for a community awareness of how report and preserve evidence after the ordeal. Regular special training to the police and clinicians in line to their roles in handling victims of sexual offences. More research need to be done on clinician knowledge in forensic medical evidence and their roles as medical forensic expert during prosecution.

Recommendation

The study recommends that necessary steps should be taken to improve the collaboration of the police gender departments, health facilities and other stake holders who handle victims of sexual assault through joint special training, workshops and sensitization programmes. This will enhance preservation of the evidence and seamless flow of investigation. There also need for national forensic DNA database.

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Attitudes of Nurses towards Pressure Ulcer Prevention Guidelines at a Level 5 Hospital in Kenya

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Abstract

Introduction

Pressure ulcers pose a major challenge to quality of life, and increase the risk for mortality and morbidity. Numerous guidelines have been developed to prevent them, yet the global prevalence is 4.7-18.7%. The main aim of the study was to determine the nurses' attitude towards Nursing Council of Kenya (NCK) guidelines on pressure ulcer prevention.

Methods

This was a descriptive cross sectional study, whose target population was 400 nurses in Embu County. The study population was 200 nurses working in Embu Level 5 Hospital. Two sampling methods, that is stratified random sampling followed by systematic random sampling were used. Sample size was 145 respondents and the tool for data collection was a questionnaire. Research permission was obtained from National Commission for Science Technology and Innovation (NACOSTI). Data was analysed using statistical package for social sciences version 21.

Findings

Majority (63.6%) of the nurses had a positive attitude towards the guidelines. Attitude had a significant association with knowledge on NCK guidelines at $p < 0.05$, but did not significantly influence adherence to NCK guidelines.

Conclusion

The researcher concluded that the attitude towards NCK guidelines was positive, and that nurse's knowledge of the guidelines influenced their attitudes positively.

Keywords: *Attitudes, Adherence, Knowledge, Pressure Ulcers, Prevention Guidelines*

Introduction and Background

Pressure ulcers, recently referred to as pressure injuries, are a breakdown of the skin continuity secondary to continuous pressure (Hinkle & Cheever, 2014). They are associated with morbidity and mortality even though they are preventable (NPUAP et al., 2014). Past studies have demonstrated that, the prevalence and incidence of pressure ulcers are still high globally. Prevalence ranges from 4.7%-18.7% and incidence 23%-27.5% in hospitals. However, the incidence of pressure ulcers among patients admitted in nursing homes is slightly lower compared to that of hospitals, and it ranges between 12% and 25% (Shrestha, 2016).

According to Dilie & Mengistu (2015), in a study done in Ethiopia, majority of the nurses (68.4%) expressed positive attitude in pressure ulcer prevention and management. Their attitude however did not reflect on their practice. A descriptive cross-sectional study done in Jordan demonstrated that, most of the nurses had a positive attitude towards pressure ulcer prevention. Female nurses were found to score better in attitude, compared to their male counterparts. Majority of them, however, felt that prevention of pressure ulcers was a time consuming affair. Majority of the nurses had a belief that patients in the intensive care unit were not at any risk of pressure ulcer development (Laila, 2018).

A small percentage of nurses did not consider pressure ulcer prevention as requiring any priority in the management of the bed ridden patients. This study revealed that nurses who had received training on pressure ulcer prevention and those with many years of working experience, generally had better attitude scores, compared to those without these attributes. Nurses' education level, their ages and whether or not they had read articles on pressure ulcer prevention previously, did not have any significant relationship with their attitudes (Laila, 2018).

Another study which was done in Nigeria showed that most of the nurses (82.29%) who were interviewed, demonstrated a positive attitude towards pressure ulcer prevention. This attitude, however, did not reflect on the level of practice of pressure ulcer prevention interventions. There was an attitude practice mismatch after correlating the results on attitude and those on practice of pressure ulcer prevention. This was better accounted for, due to other factors which included low levels of staffing, insufficient knowledge of the nurses, unavailability of devices to relieve pressure and limitation of the working time (Uba et al., 2015).

Justification

Guidelines have been developed over the years by organizations such as The National Institute for health and Care Excellence (NICE) and National Pressure Ulcer Advisory Panel (NPUAP). The Nursing Council of Kenya (NCK) has not been left behind, and has developed pressure ulcer prevention guidelines through a manual of clinical procedures. This manual is revised from time to time and the latest version is dated 2019 (NCK, 2019). It is justifiable to study these locally available guidelines, and assess the attitudes of nurses towards them. This is because, if they are adhered to, the pressure ulcer prevention practice is likely to improve by leaps and bounds, thus reducing the incidence and prevalence of pressure injuries.

Objectives

- i. To assess the relationship between demographic factors and nurses' attitude towards NCK pressure ulcer guidelines at Embu Level 5 Hospital.
- ii. To determine nurses' attitude towards NCK pressure ulcer prevention guidelines at Embu Level 5 Hospital.
- iii. To examine the association between attitude and adherence to NCK pressure ulcer prevention guidelines.

Methods

This study was conducted at Embu Teaching and Referral Hospital, a Level 5 County Referral facility, serving residents of Embu county and also referral cases from the neighbouring counties, such as Tharaka Nithi, Kirinyaga, Kitui and Machakos. The hospital had a 1000 bed capacity, serving specialized and general cases. Specialized units included ICU, and Renal units. The study utilized an institutional based descriptive cross-sectional research design. The study population totaled to 200 nurses, who were distributed in the various hospital departments and the calculated sample size was 145 nurses. The study utilized two sampling methods: First, utilized stratified random sampling method, with departments as the criteria for stratification, to ensure that the sample was representative of all the nurses. Secondly, systematic random sampling, to pick the respondents from each stratum.

The study included those nurses who were involved in day to day direct care of the patients, and those nurses who were willing to participate in the study freely. It also included those nurses who had worked for at least 2 months since their first appointments, because they had gone through the orientation process, and were familiar with the hospital protocols. The study excluded nurses in senior management positions, because they were not directly involved in care of the at risk patients. Nurses in horizontal specializations e.g. psychological counseling were excluded, because even if they were handling patients, their roles were more psychological than physical. Nurses who were not willing to participate in the

study, by declining to sign the informed consent form, were also excluded.

The researcher conducted a pretest of the tool on 15 nurses, which was 10% of the total respondents. The pretest was done in Consolata Hospital Kyeni, which was a level 4 hospital at that time. The nurses were drawn from the medical, surgical, pediatric and maternity wards of the facility. Cronbach's alpha reliability test was run on the tool based on the pretest results, and a reliability coefficient of 0.751 was found.

Permission to conduct the research was obtained from NACOSTI, Embu County Health Offices, Hospital Chief Executive Officer and nursing officers in charge of the respective wards. Respondents were required to sign a consent form, as an indication of consent to participate in the study. The researcher utilized a semi-structured self administered questionnaire to collect data. The questionnaire had Likert scales which were used to determine the nurses' attitude towards the NCK guidelines and the levels of adherence to the pressure ulcer prevention guidelines. The tool was administered after nurses completed their shifts, to ensure that they gave maximum attention to it, and those who were very tired were allowed to carry it home, and fill it once relaxed. The researcher ensured completeness of the tools before formally receiving them from the participants, and clarified any misconceptions concerning the questions. The tool required an average of 15 minutes to complete.

Finally, editing was done on those questionnaires with minor mistakes e.g. wrong departmental names, in preparation for data entry. Data was then entered into Statistical Package for Social Sciences version 23 for analysis. The computer for data analysis was password protected for privacy purposes. Quantitative data was organized then standardized before coding. Descriptive statistics were used to analyze data e.g. mean, and standard deviation, percentages, frequencies and range. The null hypotheses were tested using chi square, to determine if any statistical significance existed between the variables of the study at p value of <0.05 .

Results and Discussion

Demographic factors and nurse's attitude

The total number of questionnaires that qualified for data analysis was one hundred and eighteen which represented an average response rate of 81.4%. Most respondents came from the medical-surgical units and the maternity, i.e. 23.7% (28) came from the medical department, 17.8% (21) from maternity and 15.3% (18) surgical units, which collectively formed more than 50% of the respondents. The other departments contributed to less than 9% each. Results indicated that 36% (43) of the respondents had worked for less than one year, 22% (26) had worked for one to two years, while 42% (49) of the respondents had worked for more than two years in their respective departments. Majority of the respondents had a diploma in nursing with 62.7% (74) and those with a basic degree were 28% (33), while 8.5% (10) had a certificate in nursing. Majority of the nurses i.e. 71.2% (84) had high knowledge level of the NCK pressure ulcer prevention guidelines, while 28.8% (34)

had moderate knowledge level. The mean score was 87.4%, range 55-100% and standard deviation was 8.9.

Table 1: Demographic Factors

Variable	Frequency (n)	Percentage (%)
Department of work		
• Medical	28	23.7
• Maternity		
• Surgical	21	17.8
• Others	18	15.3
Total	51	43.2
	118	100
Duration of work		
• <1 year	43	36
• 1-2 years		
• >2 years	26	26
Total	49	42
	118	100
Academic qualification		
• Certificate level	10	8.5
• Diploma level		
• Degree level	74	62.7
Total	34	28.8
	118	100
Knowledge of NCK guidelines		
• High knowledge level	84	71.2
• Moderate knowledge level	34	28.8
Total	118	100

Out of these demographic factors namely, the department of work, duration worked in respective departments, academic qualifications and knowledge level of NCK pressure ulcer prevention guidelines, knowledge level of NCK guidelines was found to significantly influence nurses' attitudes at χ^2 (1, N=118)=4.296, $p=0.038$). There was weak positive relationship between knowledge and attitude at Cramers v 0.19, where those with high knowledge level were 2.9 times more likely to have a positive attitude (OR=2.944, CI=1.028-8.425). This finding was congruent with that of Laila (2018), who found that nurses with prior training in pressure ulcer prevention, demonstrated better attitude scores.

Table 2: Association between Knowledge of NCK Guidelines and Attitude

Variable	Category	Nurses' attitudes		Total
		Positive	Negative	
Knowledge of NCK pressure ulcer prevention guidelines	High knowledge	68	33	101
	Moderate knowledge	7	10	17
Total		75	43	118

$$\chi^2 (1, N=118) = 4.296, p=0.038)$$

A. Attitudes of Nurses Towards NCK Pressure Ulcer Prevention Guidelines

A five point researcher developed Likert scale, was used to assess the respondents' attitudes towards the guidelines. The scale had five statements to which nurses responded as: strongly agree, agree, not sure, disagree and strongly disagree. These responses were coded as 5,4,3,2 and 1 respectively. The fifth statement of the Likert scale i.e. "general knowledge of nursing can replace NCK guidelines on pressure ulcer prevention" was reverse coded before analysis.

Table 3: Responses Towards Likert Statements for Testing Attitude

Statement	SA	A	NS	D	SD	TOTAL
NCK guidelines are necessary for effective pressure ulcer prevention	55.1%	41.5%	0.8%	0.8%	1.7%	100%
Adherence to NCK pressure ulcer prevention guidelines can reduce prevalence of pressure ulcers	62.7%	30.5%	2.5%	3.4%	0.8%	100%

Nurses should lead in the adherence to NCK guidelines	62.7%	30.5%	3.4%	0.8%	2.5%	100%
Nurses bear greatest responsibility in pressure ulcer prevention	59.3%	34.7%	1.7%	2.5%	1.7%	100%
General knowledge of nursing can replace NCK guidelines	11%	16.9%	14%	35%	22%	100%

Key: SA-Strongly agree, A-Agree, NS-Not sure, D-disagree, SD-Strongly disagree
Table 3 above shows that majority of the nurses strongly agreed that, guidelines are necessary for pressure ulcer prevention, adherence to NCK pressure ulcer prevention guidelines can reduce the prevalence and incidence of pressure ulcers, nurses should be on the forefront in adherence to those guidelines, and that nurses bear the greatest responsible in pressure ulcer prevention. On the other hand, a great majority disagreed that general knowledge of nursing can replace the NCK pressure ulcer prevention guidelines.

A variable called “attitude score” was computed, based on the individual responses towards the Likert statements. The highest possible score was obtained by summing the codes for the different response categories. For instance, if someone strongly agreed with all the statements, their score would be (5 multiplied by 5), since the code for “strongly agree” was 5, and the statements were five in number, making the maximum possible score as 25. Those who scored ≥ 20 were considered to have a positive attitude, while those who scored below 20, were considered to have a negative attitude. Those with a positive attitude were 63.6% (75) while those with negative attitude were 36.4% (43).

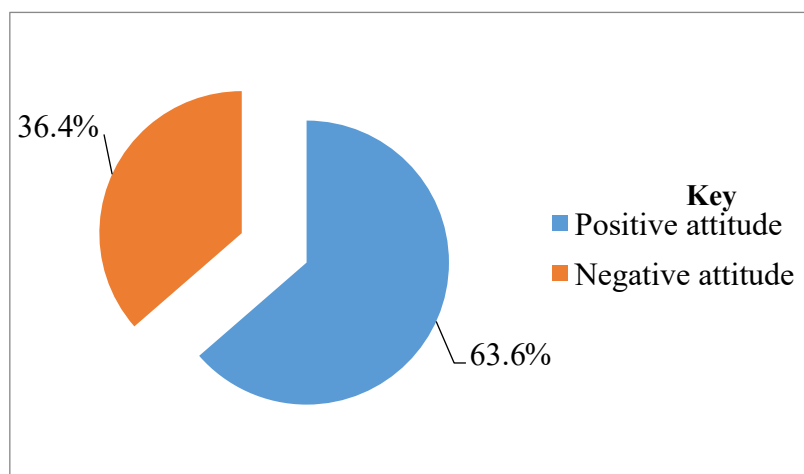


Figure 1: Attitudes of Nurses Towards NCK Pressure Ulcer Prevention Guidelines

Majority of the nurses (63.6%) had a positive attitude towards the NCK guidelines. This finding was different from that of Uba et al., (2015), whereby the nurses with positive attitude towards pressure ulcer prevention guidelines were 82.29%. However, this finding was close to that of a study done in Ethiopia by Dilie and Mengitsu (2015), which found 64% of nurses with a positive attitude.

Association between Attitude and Adherence to NCK Pressure Ulcer Prevention Guidelines

The attitude scores were correlated with adherence scores, which revealed a mild negative association between attitude and adherence. The association was not statistically significant at 95% confidence level. This agreed with Uba et al., (2015) that attitude did not reflect on the level of adherence.

Table 4: Correlation between Attitude and Adherence

		Attitude score	Adherence score
Attitude score	Pearson Correlation	1	-.037**
	Sig. (2-tailed)		.692
	N	118	118
Adherence score	Pearson Correlation	-.037	1
	Sig. (2-tailed)	.692	
	N	118	118

**Finding is insignificant at 95% confidence level

Conclusion

The researcher concluded that, majority of the nurses had a positive attitude towards NCK pressure ulcer prevention guidelines; knowledge level on NCK guidelines was significantly associated with attitude and that attitude was not a reliable predictor of adherence to NCK guidelines.

Recommendation

The hospital management should organize refresher trainings on pressure ulcer prevention.

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Effects of Exotic Tree's Litter Quality on Responses of the Adjacent Native Grasses

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Abstract

Tree litter falls is a major pathway of enhancing nutrients cycling to the understory grass vegetations adjacent to it. The main objective of the study was to evaluate the effects of exotic tree's litter quality on the responses of the adjacent native grass. A composite sample of freshly fallen leaves was collected. Leaf samples were homogenously mixed and put in nylon litter bags of 2mm mesh size and 25g weight. Each 7 marked points (1, 10, 20, 30, 40, 50 and 60m) had 3 samples litter bag weighing 25g. A total of 84 litter bags were collected from the adjacent pastures which include 21 litter bags from Eucalyptus, 21 litter bags from Acacia, 21 litter bags from Cypress and 21 samples litter bags from the control. They were taken to the laboratory for litter analysis and later reburied back to the points where they were collected. They were first retrieved from the points they were buried at the end of dry season and later at the end of wet season. Data was summarized using excel package and then analyzed using Statistical Package for Social Sciences (SPSS) for window version 23. All the hypotheses was tested at $\alpha=0.05$. The results of the study show that tree litter quality influences resource supply to the adjacent grass pastures. The findings is thought to provide valuable information to National Environmental Management Authority (NEMA), community leaders, Kenya Forestry Services (KFS), opinion leaders, extension officers, farmers and NGOs.

Keywords: Litter Quality, Decomposition Rates, Grass Biomass

Introduction

Plants litter decomposition is a vital ecosystem process. It is the key pathway to the transfer of above ground carbon to the soil as well as nutrients cycling process (Ibrahima & Halima, 2008). Climate and leaf chemical composition are major factors in determining decomposition rate (Bohra, Kumar & Singh, 2015). Plant exudates influence the microbial function as well as their structure (Verhoef & Gunadi, 2001).

Soil microbial organisms are highly influenced by amino acids, sugar, proteins and falconoid that a given species of plant excrete (Thébault et al.,2010). Microbial community structures are highly influenced by soil disturbance, allelopathic influence, local fauna and flora which impose selective pressure (Chawla, 2008). Soil microbial organisms are highly influenced by amino acids, sugar, proteins and falconoid that a given species of plant excrete (Wang et al., 2010). Litter quality alters of soil properties, microbial structure and function of soil roots which help to withstand stress and resilience to hatch environmental conditions (Mahmood et al., 2009). The composition and quality of litter substrate determine the abundance of selective mycorrhizal association

Materials and Methods

(i) Location of the Study

The study was conducted in Semi-arid South Marmanet forest in an area within 3km square. The area is approximately 300 kilometers from Nairobi. The area lies within the longitudes of 36°40" East to 37°20" East. The West and East point of the study area, just touches the equator (0°) and extends to 0° 15 South and North. The area had gently sloping hills with well drained clay-loam soils. The adjacent native grass areas consist of section of either Eucalyptus plantations (*E. Globules*), Cypress or Acacia tree stands.

(ii) Climatology

The study area had daily temperatures ranges between 14 to 25°C; Altitude - 2200 to 2400 m above sea level. On average, the warmest month(s) are January and February. Most rainfall (rainy season) is received between the month of April and June. The average rainfall ranges between 500 mm - 700 mm (Kenya Forestry Service, 2009).

iii) Marking of Plots Distance

Experimental marked points which start from the tree stand were made. A distance of 1, 10, 20,30,40,50 and 60m from each tree stand was marked. Each of the above marked points; a radial circle sampling method was used to get the litter and soil samples. This involves a radius of 1m all around the marked points in the direction of 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315°. This sampling method was adopted to ensure a collective litter and soil samples were taken from each marked point in different directions.

iv) Obtaining Ground Grass Biomass from Tree Stand

To obtain the above ground grass biomass sample from the tree stands. A distance of 1, 10, 20,30,40,50 and 60m from each tree stand was marked. Each of the above marked points; a radial circle sampling method was used to get collective litter samples. This involved a radius of 1m all around the marked points in the direction of 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315°. A quadrat 0.25m² was laid on each direction and litter samples were collected inside the quadrat. This was aimed at getting above ground biomass of vegetation away from the tree stand. Each marked points (1, 10, 20, 30, 40, 50 and 60m); a serrated knife was used to harvest the grasses

that grow near the surface of the soil. One grass biomass sample representing 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315° was obtained by dividing the number of quadrat made by 8 different directions. The harvested grass samples were put carefully in labelled bag that included quadrat number and the area collected.

v) Obtaining above Ground Grass Biomass from control

To obtain above soil sample from control (Open native grass without trees nearby), an experimental plot (10x70m) was identified. A distance of 1, 10, 20,30,40,50 and 60m from first marked point in an open native grass area was made. Each of the above marked points; a radial circle sampling method was used to get collective litter samples. This involves a radius of 1m all around the marked points in the direction of 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315°. A quadrat 0.25m² was laid on each direction and litter samples were collected inside the quadrat. This represented litter samples for the control experiment. All the grass that was within the framework of quadrant was harvested. A serrated knife was used to harvest the grasses that grow near the surface of the soil. The harvested grass samples were put carefully in labeled bag that includes quadrat number and the area collected.

(vi) Quantifying Species Composition

A taxonomist from Kenya Forest Service (KFS) South Marmanet Forest was contacted to determine grass species composition. The names of individual grass species within the quadrat was evaluated by identifying their taxonomical names (both scientific and common names). The frequency of the grass species was also evaluated by counting the number of individual grass species as they occur within the quadrat. Their frequency varied from 0% to 100%.

(vii) Determining percentage of Species Cover

After the taxonomist from the Forest Service (KFS) had established the individual grass species, the numbers of individual grass species within the quadrat were evaluated by counting the number of individual grass species and dividing them by area of the quadrat.

$$\frac{\text{Number of species in the quadrat} \times 100}{\text{Area of quadrat in m}^2}$$

(viii) Determining Percentage of Species Richness

After identification of individual species, the level of disturbance was evaluated by comparing relative abundance of species between along the adjacent pastures and the open grass pasture.

(xi) *Obtaining Grass litter Samples (Litter bag Experiment)*

A composite sample of freshly fallen leaves was collected at the start of experiment. The collected leaf litter was mixed thoroughly to get composite litter sample. Leaf samples were homogeneously mixed and put in nylon litter bag of 2mm mesh size and 25g mass. Each 7 marked point (1, 10, 20, 30, 40, 50 and 60m) had 3 samples litter bag weighing 25g. A total of 84 litter bags were collected from the adjacent pastures which include 21 litter bags from Eucalyptus, 21 litter bags from Acacia, 21 litter bags from Cypress and 21 samples litter bags from the control. They were labelled according to the distances from tree stand collected. During the initial analysis of the litter, a total of 28 litter bags from seven collected points were taken to the laboratory for litter analysis. The other 56 out of 84 not selected was taken back to the point where they were collected, reburied at a depth of 15cm at a distance of 1, 10, 20, 30, 40, 50 and 60m away from tree stand. At the end of dry season, a total of 28 litter bags were retrieved back from the point they will be reburied. At the end of wet season, the remaining 28 litter bags were retrieved back from point they were reburied. They were taken to the laboratory for physical and biogeochemical analysis. All the laboratory litter bags collected were put in plastic bags to prevent moisture loss and stored in temperature of 5°C before taken for analysis.

1) *Treatments*

(i) *Seasonal Treatments* The experiment had three season treatments: Dry season (DS), Wet seasons (WS), & Vegetation

Vegetation Treatment: The experiment consisted of four different vegetation types

(a) Eucalyptus Vegetation type (b) Cypress Vegetation type (c) Native Acacia vegetation types (d) Native grass Vegetation type (Control)

Distance Treatments: There was seven marked point distance from each tree stand measured in metres as follow: 1, 10, 20, 30, 40, 50 and 60m.

Data collection

(i) *Measurement of the Soil Porosity*

To determine soil porosity, soils from different adjacent pastures, sample soil was put in a beaker at the same level. The water was then poured into each of the beaker until it reached the top. The porosity was determined by dividing the volume of water that was able to be poured into the soil inside the beaker by total volume of the soil in the beaker. The result was expressed as percentage.

ii) Quantifying Soil N in the Sample

200g of soil was measured. It was sieved with 2mm sieve and stored with air tight jars at 20°C in the dark for 4 weeks. 70g of soil from the 200g soil was measured and shaken for one hour and filtered with a filter paper. Total soil N was measure by digestion with H₂SO₄, salicylic acid, H₂O₂ and selenium as described by Novozamsky et al. (1984) (Which has been 'reference' methods compared to other methods). The increase in mineral N between week 1 and week 6 was used to determine N mineralisation rates.

iii) Quantifying Microbial biomass Nitrogen (MBN)

After obtaining total soil N in the sample by digesting it with H₂SO₄, salicylic acid, H₂O₂ and selenium. Fumigation was done using chloroform to kill all the microbes in the sample. Samples were oven dried at 105 °C and weighed. The differences in mass before fumigation and after fumigation showed the Microbial Biomass Nitrogen (MBN) from total N in the sample

(iv) Quantifying Soil Carbon in the Sample

70g of Soil samples was oven-dried at 105 °C. Organic matter content was measured by loss-on-ignition (Ball, 1964). Samples were digested with H₂SO₄, salicylic acid, H₂O₂ and selenium as described by Novozamsky et al. (1984) (Which has been 'reference' methods compared to other methods). Total soil Carbon was then obtained.

(v) Quantifying Microbial biomass Carbon (MBC)

After obtaining total soil C in the sample by loss-on-ignition and then digesting them with H₂SO₄, salicylic acid, H₂O₂ and selenium. Fumigation was done using chloroform to kill all the microbes in the total soil C in the sample. Samples were later oven dried at 105 °C and then weighed. The differences in mass before fumigation and after fumigation showed the Microbial Biomass Carbon (MBC) from total C in the sample.

vi) Measurement of Total Soil Phosphorus (P)

30cm³ of soil extracts was pipette into 50 ml volumetric flasks with approximately 15 ml deionized water. Samples with high humic materials were precipitated before undergoing colorimetry. Three cm³ of extract was pipette into a centrifuge tube with 0.5 ml 0.9M sulfuric acid (H₂SO₄), centrifuged for five minutes at 8000 x g. The sample was then neutralized using phenolphthalein indicator (1%), 5M sodium hydroxide (NaOH) and 2M H₂SO₄. Following this, 4 ml of colour developing solution was added and the solution was made to up 50 ml with deionized water. After 1 hour (to allow for full colour development) the colour was assessed by absorbance at 880 nm with a UV spectrophotometer. Phosphorus content was then calculated using a standard curve ranging from 0-0.5 µg P/mL (Schenck & Pérez, 1988).

(vii) Quantifying Microbial Biomass Phosphorus (MBP)

After establishing total soil Phosphorus (P) in the samples, 5g of the samples were fumigated using chloroform. This was aimed at killing all the microbes in the total soil P in the sample. Samples were later oven dried at 105 °C and then weighed. The differences in mass before fumigation and after fumigation showed the Microbial Biomass Phosphorus (MBP) from total P in the sample.

(ix) Measurement of Soil pH and Soil Moisture

An appropriate amount of soil (10-20 g) was dried at 105°C for 24 hours (Blakemore et al., 1987). Soil moisture was calculated as the weight lost per gram after oven drying for 105°C. A 10 g (dry weight equivalent) sample of moist soil was dispersed in 20 ml of deionized water and the pH was measured after 30 minutes (Blakemore et al., 1987).

(x) Measurement of Decomposition of Leaf Litter and the Soil

After the initial litter and soil sample analysis, the leaf litter and soil samples was buried and retrieved during dry and wet season. They were brought back to laboratory for analysis. Samples were oven dried at 80°C. The loss in dry mass of leaf and soil samples were calculated from the initial converted oven-dry mass and remaining mass. The rates of decomposition were calculated from the percentage of mass loss divided by respective days of sample collection.

Results and Discussions

Stands Litter Quality and their Decomposition Rates

Average bulk depth, duff depth and total litter depth was measured in centimeters. The main aim was to compare different stand litter depth and the rate at which litter decomposes on the floor of the tree stand. The results are as shown in the Table 1 below

Table 2: Average Litter Bulk, Duff and Total Litter Depth.

	Bulk depth(cm)	Duff depth(cm)	Total litter depth (cm)
Eucalyptus	6.8 cm	6.3cm	13.1cm
Acacia	2.4cm	2.2cm	4.6cm
Cypress	3.1cm	2.9cm	6cm
Control	1.9cm	1.3cm	3.2cm

From the Table 1 Eucalyptus had the highest bulk depth (6.8cm) among the three and the control. The same stand had also the highest duff density and the total litter depth was 13.1cm. Cypress tree stand had the second highest bulk depth of 3.1cm and duff density of 2.9cm. the total litter depth was 6cm. Acacia had the least bulk depth among the three stand but higher than the control. Bulk depth was 2.4cm while the duff density was 2.2cm. The total litter depth was 4.6cm. The results indicated that Eucalyptus litter does not decompose easily and therefore higher total litter depth. The rate of litter conversion to soil is slow resulting to higher bulk and duff depth.

Comparison of Stand Litter Differences in Chemical Composition

Different common chemical analysis was carried out to determine differences in stand chemical compounds. The results is as shown in Table 3 below:

Table 3: Comparison of Stand Litter Differences in Chemical Composition

Source variation	of Lignin	Lignin : N ratio	Lignin : Pratio	Tannins	Polyphenols	Cellulose
Eucalyptus	37%	1:321	1:645	8.6%	4.7%	23%
Acacia	24%	1:127	1:211	2.1%	1.3%	31%
Cypress	29%	1:222	1:532	7.4%	1.9%	25%

From the Table 3 above, Eucalyptus had the highest (37%) lignin percentages across all the three stands. The ratio of lignin to Nitrogen was 1:321, while that of lignin to Phosphorus was 1.645. Under the chemical compound the percentages of litter chemical tannins, polyphenol and cellulose was 86%, 4.7% and 23% respectively. Cypress tree stand was the second with lignin ratio of 29% and lignin N ratio of 1:222, while lignin P ratio was 1:532. The percentages of tannins, polyphenols and cellulose was higher than Acacia with 7.4%, 1.9% and 25% respectively. Acacia had the least in lignin percentages (24%) and had closer lignin N and P ratio of 1:121 and 1:211 respectively. It also had a lower tannins, polyphenols and cellulose of 2.1%, 1.3% and 31% respectively. The study results shows that Eucalyptus litter had higher percentages of chemical compounds than the other two stands. These compounds may serve as a source of variations in decomposition level and release of nutrients.

Effects of Stand Litter Quality on Species Compositions, Richness and Cover

Table 4 below shows relationship between microbial biomass effect on species composition, richness and cover. In adjacent pastures next to Eucalyptus, species compositions were affected by litter quality that yields Microbial Biomass Nitrogen (MBN). Litter quality in Eucalyptus adjacent stand failed to release litter Nitrogen

hence denying the growing grass species enough Nitrogen. This created relative significant difference in species composition as some of the grass species failed to generate. Changes in season did not significantly affect species composition at ($P<0.05$) since mineralization of Nitrogen was still being affected by leaf composition and quality. The microbial biomass phosphorous did not significantly affect the adjacent pasture species composition at ($P<0.05$). However, Microbial Biomass Carbon (MBC) has an effect on species composition. This might have been possible because of litter carbon mineralization effect. Carbon mineralization in Eucalyptus leaf litter was slow due to its chemical composition. This delayed the release of minerals necessary for the growth of some species. Only grass species that were able to survive in such condition was able to survive. This significant affected the ration of grass species composition.

In Acacia, microbial biomass Nitrogen did not control species composition at ($P<0.05$). The species did not differ in composition. Other microbial factor such microbial biomass carbon (MBC), microbial biomass phosphorous (MBP) and MBN:C ration did not significantly affect species composition at ($P<0.05$). Season changes in Acacia adjacent pastures also did not affect the relative ratio of species composition.

Cypress adjacent pasture has a significant effect on species composition at ($P<0.05$). Failure of the leaf litter to release Nitrogen affected the species composition against control. Only grass species with perennial characteristic and unpalatable such as *cynbopogon nardus* were able to survive in relative to others. Season changes not however had significant effect on species composition at ($P<0.05$).

Species richness is another component of species abundance in adjacent pastures. Under the eucalyptus adjacent pasture, the amount of MBN production in the leaf litter significantly affect species richness at ($P<0.05$). The ability of leaf litter to yield Nitrogen, affect the number of species (richness) per unit quadrat. Other microbial Biomass such MBC, MBP and MBN:C ratio also control the species richness at ($P<0.05$). This was highly affected by the mineralization level of eucalyptus leaf that failed to release nutrient during grass establishment stages. Season however, did not significantly affect the species richness at ($P<0.05$). The decomposition level during wet seasons was still low delaying the release of the required nutrients to the adjacent soil.

Acacia tree stand had significant effects on adjacent pasture richness. The labile litter in Acacia leaf promoted the growth of species in number. This was significantly higher than the two exotic stand, but slight lower than control at ($P<0.05$). Changes in seasons in decomposition of MBN to release litter Nitrogen had a significant effect of species richness. Higher species numbers were observed during wet season than in dry season. The release of MBC at ($P<0.05$) also affect the number of species since the litter in Acacia leaf was able to decompose quickly enabling the adjacent pastures to acquire required nutrient as a result of carbon mineralization (Figure 1) Other microbial biomass such MBP and MBN:C ratio were also significant at ($P<0.05$). The

rate of decomposition to release required nutrients affected the number of species more against control.

Cypress just like in Eucalyptus, the MBC, MBN and MBN:C ratio had a significant effect at ($P < 0.05$). Litter decomposition was slow down, hence affecting the species richness. The number of species per unit 0.25m^2 quadrat was lower than that of Acacia and control. However, it was much higher than that of Eucalyptus.

Species cover was another component of species abundance. In Eucalyptus species, MBN was observed to affect the species cover at ($P < 0.05$) (figure 4.5) MBN had a significant effect in decomposition of litter Nitrogen. This probably affected the release of nutrient hence affected the species cover in relation to bare ground cover. Season had significant effects on species cover were obtained during wet season. Other microbial biomass such as MBC, MBN:C also found to control species cover.

In Acacia adjacent pastures, MBN, MBC as well as MBN:C were also found to affect species cover at ($P < 0.05$). Cypress just like in Eucalyptus, leaf litter also found to slow down release of Nitrogen, hence controlling microbial biomass such as MBN, MBC and MBN:C ratio at ($P < 0.05$). Simial finding were also found by Díaz-Pinés et al.(2011), Zhang et al.(2013)and Parton *etal* (2009).

Table 5 Means Treatment for Microbial Biomass Factor on Species Composition, Richness and Cover. Horizontally, *** means are significant ($p < 0.05$). * means are significant at ($p < 0.01$).

	Species composition			Species Richness				Species Cover				
	MBN	MBC	MBP	MBN ;C	MBN	MBC	MBP	MBN ;C	MBN	MBC	MBP	MBN ;C
Eucalyptus	134.2**	436.9**	413.2	321.7*	338.2**	356.9**	423.2**	333.2**	249.2**	326.9**	453.2**	363.2**
Seasons	231.4*	327.5	322.4	453.6	233.5	329.6	341.8	375.9	327.1	353.5**	422.7	366.7*
Acacia	45.3	42.3	43.7	36.4	39.7*	41.6*	41.8*	47.1*	46.1*	41.3*	44.1*	43.5*
Season	311.3	422.4	421.8	487.5	437.5	432.7**	433.5	422.6	437.1	462.9**	432.4**	466.1**
Cypress	39.6**	41.7*	42.8	39.3*	41.7*	42.1*	39.6*	43.2*	41.6*	46.7*	41.9*	46.3*
Season	222.1*	265.3	277.3	255.6	277.8	271.1**	282.8	277.8	263.2	253.1**	277.3	288.7
control	46.3*	43.3	51.3	42.9*	46.4*	43.9	51.1	44.8*	47.4*	46.8	54.3*	47.4*
Season	322.1*	344.5	369.1	341.7	364.1	322.6	366.7	322.7	322.7	321.8**	354.2**	354.2**

Table 5 Effect of Stand litter: P, N, C and NO₃⁻ on Species Composition, Richness and Cover

	Species composition				Species richness				Species cover			
	P	N	C	NO ₃ ⁻	P	N	C	NO ₃ ⁻	P	N	C	NO ₃ ⁻
Eucalyptus	235.1*	344.3**	211.4	324.5*	233.4*	235.5**	733.3	227.6**	349.7	443.3**	367.5	434.5**
Season	433.5*	322.5**	453.5	266.2**	344.2*	463.1**	633.2	644.3**	633.2*	533.3**	356.3	322.4**
Acacia	246.5	324.5	465.5	453.2	456.4*	364.3*	453.4	443.6	423.5	532.4*	644.3	543.4
Season	422.4	645.3**	564.3	433.6	244.5	356.4**	453.4	563.4**	432.4*	453.4**	432.4	534.4**
Cypress	432.3	433.5**	423.4	432.4*	453.3*	432.3**	542.4	643.3**	564.3	653.1**	543.3	463.5*
Season	325.5	456.3	543.5	453.5	543.2	567.3	345.5	453.6	453.2	543.2	564.5	453.2

		**	3	**	*	**	3	**		**	3	**
Control	342.5	344.2	453.2	456.3	543.5	544.5	432.4	533.3	543.2	636.6	643.1	432.5
Season	544.4	532.4	533.3	433.3	432.4	433.5	435.3	533.4	459.9	478.6	547.7	476.6
		*	3	*	*	*	3	*	*	*		*

Effect of Stand litter: P,N,C & NO-3 on Species Composition, Richness and Cover

Figure 5 shows responses of grass species in terms of composition, richness and cover in relation to P, N, C and NO₃ of the adjacent pastures. In eucalyptus, phosphorous (P) did not significantly affect species composition. However release of Nitrogen (N) to the leaf litter had a significant effect (Table 5) above. Carbon (C) and Nitrate (NO₃) did not also affect the species composition. Season had no significant effect in phosphorous (P) but had a significant effect on Nitrogen (N) and NO₃. No significant effect was observed in Carbon (C) at (P<0.05).

In Acacia adjacent pasture, no significant effect was observed at (P<0.05) on species composition on P, N, C and NO₃. The species composition relative ratio remained the same.

Cypress adjacent pastures had a significant effect on N and NO₃ release in the leaf litter and therefore affected the adjacent pasture (figure 4.7.3). The chemical composition in the litter, might have affected relative ratio of composition against control. The finding were also observed by Parton et al. (2009) that Some compounds such as polyphenolic substance inhibit the activity of micro-organism. Others may render N inaccessible to majority of decomposition microorganisms where by N mineralization may occur under the species richness, eucalyptus adjacent pastures were affected on P, N and NO₃ ratio at (P<0.05). Season had a significant effect as more species per 0.25m² quadrat were found. In Acacia adjacent pastures no significant effect in term of P, N and C but significant is NO₃ Faster mineralization of Nitrogen might have encouraged more species per unit quadrat.

Cypress adjacent pastures had significant difference in terms of N and NO₃. Higher species numbers were found. However, no significant difference were found to affect species richness in term of Carbon (C) and Phosphorous (P) at (P<0.05). Changes in seasons had no significant different (P<0.05).

Under the species cover, eucalyptus adjacent pasture had significance difference in terms of Nitrogen (N) and NO₃ release to the leaf litter at (P<0.05). Higher species covers were observed during wet season than in dry season. No significant effects in specific cover in term of Phosphorous (P) and Carbon (C) were found. In Acacia adjacent pastures, significant effects were observe during wet season and therefore season had a significant effects species cover. However, only Nitrogen and NO₃ were observed to have changes in species cover during different seasons. Cypress has the similar significance difference in term of Nitrogen and NO₃ just

like eucalyptus significance different ($P < 0.025$) were observed Nitrogen and NO_3 release but not in Phosphorous (P) and Carbon (C) season had significant difference as higher ground cover were observed during wet season forest. The findings were also observed by Lugo et al., (1995) that the rate of decomposition of litters depends on seasons and quality of lignin and phenolic compounds within the litter substrate.

Table 5: Effect of Stand litter: P, N, C and NO_3 - on Species Composition, Richness and Cover

	Species composition				Species richness			Species cover				
	P	N	C	NO_3	P	N	C	NO_3	P	N	C	NO_3
Eucalyptus	235.1*	344.3**	211.4	324.5*	233.4*	235.5**	733.3	227.6**	349.7	443.3**	367.5	434.5**
Season	433.5*	322.5**	453.5	266.2**	344.2*	463.1**	633.2	644.3**	633.2*	533.3**	356.3	322.4**
Acacia	246.5	324.5	465.5	453.2	456.4*	364.3*	453.4	443.6	423.5	532.4*	644.3	543.4
Season	422.4	645.3**	564.3	433.6	244.5	356.4**	453.4	563.4**	432.4*	453.4**	432.4	534.4**
Cypress	432.3	433.5**	423.4	432.4*	453.3*	432.3**	542.4	643.3**	564.3	653.1**	543.3	463.5*
Season	325.5	456.3**	543.3	453.5**	543.2*	567.3**	345.3	453.6**	453.2	543.2**	564.3	453.2**
Control	342.5	344.2	453.2	456.3	543.5	544.5	432.4	533.3	543.2	636.6	643.1	432.5
Season	544.4	532.4*	533.3	433.3*	432.4*	433.5*	435.3	533.4*	459.9	478.6*	547.7	476.6*

Horizontally, **means are significant ($p < 0.05$). * means are Significant at ($p < 0.01$) **Effect of Stand Litter Quality on Soil Temperatures**

5 Effect of Stand Litter Quality on Soil temperatures

Table 6: Effect of Stand Litter on Soil Temperatures

Treatments		Litter and Soil pH in Different Seasons				
Tree Species	Distance From the Tree	Initial	Dry Season		Wet Season	
		Soil Temperature	Litter Temp	Soil Temp	Litter Temp	Soil Temp
Eucalyptus	1m.	21°C	22°C	21°C	20°C	19°C
	10m	21°C	22°C	21°C	20°C	19°C
	20m	23°C	23°C	23°C	21°C	21°C
	30m	24°C	24°C	24°C	22°C	22°C
	40m	24°C	24°C	24°C	22°C	22°C
	50m	24°C	24°C	24°C	22°C	22°C
	60m	24°C	24°C	24°C	22°C	22°C
Acacia	1m.	23°C	24°C	23°C	23°C	21°C
	10m	23°C	24°C	23°C	23°C	21°C
	20m	23°C	25°C	23°C	24°C	21°C
	30m	24°C	25°C	24°C	24°C	22°C
	40m	24°C	25°C	24°C	24°C	22°C
	50m	24°C	25°C	24°C	24°C	22°C
	60m	24°C	24°C	24°C	24°C	22°C
Cypress	1m.	22°C	23°C	22°C	21°C	21°C
	10m	22°C	23°C	22°C	21°C	21°C
	20m	23°C	24°C	23°C	23°C	22°C
	30m	23°C	25°C	23°C	23°C	22°C
	40m	24°C	24°C	24°C	24°C	22°C
	50m	24°C	24°C	24°C	24°C	22°C
	60m	24°C	24°C	24°C	24°C	22°C
Control		24°C	24°C	24°C	24°C	22°C

From the above results Table 6, soil temperatures were significantly affected by the seasons across all stands and the control. Eucalyptus adjacent pastures recorded the lowest pH temperatures during wet season. This was much lower than the other stands (19°C-22 with a distance of 1-40m away from tree stand). A lower temperature was also recorded in litter during wet season ranging from 21-22°C. However, an average temperature was recorded during dry season that was equivalent to other stands and the control. There was a progressive increase in soil and litter temperatures as the distance increases. No significance difference of both soil and litter temperature recorded after a distance of 50m in verses the control. Cypress and Acacia adjacent pastures recorded almost the same temperature range. A distance of 1-30m away from tree stand recorded between 23-24°C in dry season and between 21-24 in wet season. A linear progression of soil and litter temperature was observed as the distance increased away from tree stand. Season had a significance effect in

both soil and litter temperatures. No significance soil and litter temperatures were observed after a distance of 40m in both Cypress and Acacia adjacent pasture verses the control.

Effect of Litter on Soil Moistures

Table 7: Effect of Litter on Soil Moistures

Treatments		Litter and Soil Moisture in Different Seasons				
Tree Species	Distance From the Tree	Initial Soil Moisture	Dry Season Litter Moisture	Soil Moisture	Wet Season Litter Moisture	Soil Moisture
Eucalyptus	1m.	17%	16%	12%	22%	20%
	10m	17%	16%	13%	23%	21%
	20m	18%	17%	13%	23%	20%
	30m	19%	17%	14%	24%	20%
	40m	20%	19%	16%	27%	25%
	50m	20%	19%	16%	27%	25%
	60m	20%	19%	16%	27%	25%
Acacia	1m.	21%	20%	17%	31%	28%
	10m	21%	20%	17%	31%	28%
	20m	19%	19%	17%	30%	28%
	30m	20%	19%	16%	29%	27%
	40m	20%	19%	16%	27%	25%
	50m	20%	19%	16%	27%	25%
	60m	20%	19%	16%	27%	25%
Cypress	1m.	17%	16%	14%	23%	21%
	10m	17%	16%	14%	25%	21%
	20m	17%	16%	14%	25%	23%
	30m	18%	17%	15%	26%	23%
	40m	19%	19%	16%	27%	24%
	50m	20%	19%	6%	20%	25%
	60m	20%	19%	6%	27%	25%
Control		20%	19%	6%	27%	25%

From the above study results, Table 7, soil moisture was significantly affected by the seasons across all stands and the control. Eucalyptus had the lowest soil moisture across all adjacent stands. A distance ranging from 1-40m recorded between 16-19% litter moisture content in dry season and 22–27% in litter in wet season. In soils the same distance recorded moisture content ranging from 12-14% in dry season and 22-25% in wet season. There was a progressive increase in moisture content as the distance increases. No significance difference of both soil and litter after a distance of 50m against the control. Adjacent pastures to cypress recorded the second lowest soil and litter moisture. A distance of 1-30m away from tree stand recorded moisture content ranging from 16-19% in litter during dry season and 23-26% in litter during wet season. In soil moisture content, the percentage moisture content was ranging from 14-16% in dry season and 21-25% in wet season.

Acacia recorded the highest soil and litter moisture across all the adjacent stands and the control. A distance of 1-30m recorded 20-19% in dry season and 31-27% in litter during wet season. In soil moisture content, the percentage moisture content was ranging from 17-19% in dry season and 28-25% in wet season. This was unlike other stand soil and litter content. Moisture decreased with increase in distance. Further increase in distance away from tree stand did not affect the moisture content verses the control.

Influence of Stand Litter on Ecto-Mycorrhizal Association

The initial and the final sample analysis of ecto-mycorrhizal (ECM) did not differ so much in seasons. Adjacent pastures next to cypress recorded higher ECM percentage than acacia and Eucalyptus. The percentage progressed positively as the distance increases away from the tree stand. Ecto-mycorrhizal (ECM) was founded to be in high in those regions with the deficiencies in nutrients. The adjacent pastures to cypress recorded higher mycorrhizal association as a compensation factor for mineral nutrient loss. As earlier reported by Fadil et al. (2006) exotic trees have higher associate to ectomycorrhizal than native species due substrate utilization and carbon assimilation efficiencies. This means that there is higher efficiency of mineralizing more carbon per unit substrate than without utilizing ecto-mycorrhizal. The effect of adjacent tree stand did not affect the adjacent pasture more than 30m away. No significance difference in percentage of ECM was found after 30m away the from tree stand. Eucalyptus recorded the second highest ECM after cypress, higher percentage 52 2.12 in dry season and 55 2.11% in wet season. The percentage was higher than acacia and the control at a distance of 1 – 50m away with percentage difference of 53 2.12 to 462.11 in dry season and 55 2.12 to 49 2.11 percent in wet season. There were no significant effects in percentages of Ecto-mycorrhizal after a distance of 50m away from the tree stand. Season was significant with higher percentage increase in of ECM.

Acacia adjacent pasture unlike in AM, the trend of ECM changed from high percentage at a closer distance away from the tree stand. The percentage recorded at a distance (1 – 30m) was lower that other stands and the control. The study indicates that number of mycorrhizal was

lesser in litter that is easy to decompose and high in litter that does not decompose easily. This was also demonstrated by the work of Bajad et al. (2017) that litter quality affects roots mycorrhizal association. Microbes surrounded by rich rhizospheres, produces signals that enhances plants fitness and growth to a given environment. It was also found to be influenced by inter- plant communication in undisturbed environment. It was further observed by Mahmood et al. (2009) that litter quality alters soil properties, microbial structure and function of soil roots. This help to withstand stress and resilience to hatch environmental conditions Ngoran, et al. (2006)

Effect of Litter on Arbuscular Mycorrhizal Association

Effect of Aburscular mycorrhizal association percentage was measured in both dry and wet seasons. Acacia had the highest percentage of Aburscular mycorrhizal (AM) at a closer distance from the tree stand. The percentages range from 57 3.17% to 41 2.37% from a distance of 1 – 60m. A significant downward trend in mycorrhizal association was noted as the distance increases. Seasons had a significant effect on mycorrhizal AM association with higher AM recording higher percentage in wet season.

Cypress adjacent pasture recorded the higher mycorrhizal association than Eucalyptus. The mycorrhizal association was lower in a distance of 1 – 30m away from the tree stand with (35 2.22% to 54 ±2.66% in distance of 1 – 30m during the dry season. In high moisture condition (Wetseason) the percentageincreased from 432.21% to 592.32% on distance of 1 – 60m away from the tree stand.

The effect of adjacent pasture on mycorrhizal was not significant after the distance of 30m away from the tree stand verses control. Adjacent pastures next to eucalyptus recorded relatively lower percentage than Cypress, but were significantly lower to that of Acacia and the control. Unlike the Acacia, Eucalyptus adjacent pastures AM percentages increases with the distance whereas in acacia it decreases with distance. The effect of mycorrhizal on the adjacent stand was only effective at a distance of 40 meters away. Season was significant in mycorrhizal association percentage with high moisture content recording higher percentage than in dry season. No significant AM association against control was recorded after a distance of 50 meters away from the tree stand. The findings on effects of season were also observed by Berg & Laskowski (2006) that various stages of decomposition may also be affected by season variations in temperature. Floor litter is likely to influence various biological processes and finally shift mycorrhizal association according to limited resources needed by plants.

Conclusion

- The type of litter has significant effects on the type of organic matter present. Eucalyptus leaf litter poses decomposition challenges to the micro-organism involved in decomposition.
- There is closer relationship on leaf litter of Cyprus and Eucalyptus in ability to decompose. Comparison of Nitrogen mass loss in Acacia and other exotic leaf litter, Acacia leaf litter is easier to decompose due to less chemical exudes that allow biogeochemical process involved in decomposition.
- The quality of litter also affects the carbon cycle as well as its cycling. Acacia tree stand recycle its carbon constituents more easily than that of eucalyptus and Cyprus. This is due to substrate quality that is easier to decompose to release mineral carbon.
- Different leaf litter significantly affects the N pools decomposition mainly because of leaf toughness especially in Eucalyptus. The leaf litter of Eucalyptus affects the adjacent pastures by slowing down the decomposition rate more than those of Acacia adjacent pastures.
- Climatic condition such as temperature, rainfall and micro-organism has significant effects on nutrient cycling in the adjacent grass pastures. The reason may be that climate and litter diversity affects the soil community activity during decomposition process.
- Association of mycorrhizal is affected by the plant litter quality. They also differ according to the type of litter in the adjacent pastures. Higher AM are found in Acacia than in Eucalyptus as a result of AM works better with organic matter with higher composition of bacterial community as oppose to ECM.
- Microbial biomass carbon (MBC) as well as MBN and MBP significantly dependant on the type of litter. This is evidenced by higher percentage of microbial biomass in Acacia adjacent pastures than those in the two exotic trees.
- Maintainers of primary production in adjacent pastures depend on mass loss of the available nutrient pools in the litter and soil organic matters. In addition, litter material added to the adjacent pastures constitute of a major factor in determining nutrients cycling in grass floor.

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Properties of Operators in Norm-Attainable Algebras and their Applications

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Abstract

Let H^n be a finite dimensional Hilbert space and $\delta_{P,Q}$ be a generalized derivation induced by the orthogonal projections P and Q . In this study, we have shown that $\delta_{P,Q}$ has a lower bound and is utmost equal to the sum of norms of P and Q and also that $\delta_{P,Q}$ is Hermitian and is bounded above by its numerical radius. Finally, the research gave power bounds for numerical radii of the $\delta_{P,Q}$.

Introduction

Studies on the norm of inner derivations lead [7] to introduce the idea of S -universal operators and criteria for the universality for subnormal operators i.e. an operator $T \in B(H)$ such that $\|\delta_T \mid \tau\| = 2d(T)$, for each norm ideal τ in $B(H)$ and $d(T) = \inf_{\lambda \in \mathbb{C}} \{\|T - \lambda I\|\}$. Bonyo [7] established the relationship between δ_T , δ_P and $\delta_{T,P}$ on $B(H)$ where the operators T and P are S -universal. To be precise; supposing that $T, P \in B(H)$ are S -universal, then $\|\delta_{T,P} \mid B(H)\| \leq \frac{1}{2}(\|\delta_T \mid B(H)\| + \|\delta_P \mid B(H)\|)$ and the norm of a generalized derivation implemented by two S -universal operators is less than or equal to half the sum of the norms of inner derivations implemented by each operator [7]. The norm of a derivation δ_T as a mapping of $B(H)$ onto itself is given by $\inf \|T - \lambda I\|$ [42]. Kadison, Lance and Ringrose [60] showed that if T is selfadjoint and δ_T maps a subalgebra of $B(H)$ into $B(H)$, then $\|\delta_T\| = \inf\{2\|T - A'\| : A' \in \theta'\}$ where θ' is the commutant of the subalgebra $\theta \subset B(H)$. McCarthy [42] used an example of a self-adjoint operator to show that the hypothesis that $(\delta(\theta) \subset \theta)$ is inessential, taking θ to be the subalgebra of diagonal matrices with $\theta' = \theta$. Later on, Bonyo [6] investigated the relationship between diameter of the numerical range of an operator $T \in B(H)$ and norms on inner derivations implemented by T on the norm ideal, and further considered the application of S -universality to the relationship. The

relationship in [6] determined using the fact that a generalized or inner derivation is an operator and as such, one can calculate its numerical range as well as the norm whenever applicable. Indeed, it was noted in [6] that for any operator $T \in B(H)$ and norm ideal τ in $B(H)$, $\text{diam}(W(T)) \leq \|\delta_T\| \tau$ where ' diam ' is the diameter. Furthermore, it was shown that if $T \in B(H)$ is S -universal, and τ a norm ideal in $B(H)$, then $\text{diam}(W(T)) \leq \|\delta_T\| \tau$. In [61], Rosenblum determined the spectrum of an inner derivation, $\delta_T = TP - PT$. Kadison, Lance and Ringrose [60] investigated derivations δ_T acting on a general C^* -algebra and which are induced by Hermitian operators. Stampfli [75] studied a derivation δ_T acting on an irreducible C^* -algebra $B(H)$ for all bounded linear operators on a Hilbert space H . The geometry of the spectrum of a normal operator T was used in [60] to show that the norm of a derivation is given by $\|\delta_T\| = \inf\{2\|T - \lambda\| : \lambda \in C\}$ using the geometry of the spectrum of normal operator T . Stampfli [75] raised the question on the ability to compute the norm of a derivation on an arbitrary C^* -algebra. Kaplansky [26] later used the density theorem to prove that the extension of derivations of a C^* -algebra to its weak-closure in $B(H)$ [26] is achieved without increasing norm. Gajendragadkar [26] computed the norm of a derivation on a von Neumann algebra. Specifically, it was shown that if φ is a von Neumann algebra of operators acting on a separable Hilbert space H and $T \in \varphi$ and δ_T is the derivation induced by T , then $\|\delta_T\|_{\varphi} = 2 \inf\{\|T - Z\| : Z \in C\}$ where C is the center of φ [19]. Given an algebra of bounded linear endomorphisms $\mathcal{L}(X)$ for a real or complex vector space X , it was shown that for each element $T \in \mathcal{L}(X)$, an operator $\delta_T(A) = TA - AT$ is defined on $\mathcal{L}(X)$ and $\|\delta_T\| \leq 2 \inf_{\lambda} \|T + \lambda I\|$. Furthermore if X is a complex Hilbert space then the norm equality holds [21]. Johnson [21] used a method which applies to a large class of uniformly convex spaces to show that this norm formula does not apply for ℓ^p and $L^p(0,1)$, $1 < p < \infty, p \neq 2$. For L^1 spaces, the formula was proved to be true in the real case but not in the complex case when the space has three or more dimensions. The derivation constant $K(\mathcal{A})$ has been studied for unital noncommutative C^* -algebra $\mathcal{A}$ [4]. Archbold [4] studied $K(M(\mathcal{A}))$ for the multiplier $M(\mathcal{A})$ for a non-unital C^* -algebra $\mathcal{A}$ and obtained two results; that $K(M(\mathcal{A})) = 1$ if $\mathcal{A} = C^*(G)$ for a number of locally compact group G and $K(M(\mathcal{A})) = \frac{1}{2}$ if G is (nonabelian) amenable group. Salah [67] showed that in both finite and infinite dimensional vector spaces, the norm of a generalized derivation is given by $\|\delta_{A,B}\| = \|A\| + \|B\|$ for a pair $A, B \in B(H)$. Okelo in [51] and [50], showed the necessary and sufficient conditions for a derivation δ_T to be norm-attainable. Several other results exists on the inequalities of derivations and commutators on C^* -algebras. For instance Kittaneh [31] used a polar decomposition $T = UP$ of a complex matrix T and unitarily invariant norm $\|\cdot\|$ to prove the inequality $\| |UP - PU|^2 \| \leq \| |T^*T - TT^*| \| \leq \|UP + PU\| \|UP - PU\|$. Williams [79] proved that if a commutator $TX - XA = \alpha I$ is such that A is normal, then the norm relation $\|I - (TX - XT)\| \geq \|I\|$ holds. Anderson [2], generalized Williams inequality and proved that $\|P - (TX - XT)\| \geq \|P\|$. Later, Salah [67] proved that if T and P are normal operators, then $I - (TX - XP) \geq \|I\|$. The norms of derivations implemented by S -universal operators have been shown to be less than or equal to half the sum of inner derivations implemented by each operator in [7] and in particular was proved that, $\|\delta_{T,P}\| \leq \frac{1}{2}(\|\delta_{T-\lambda}\| + \|\delta_{P-\lambda}\|)$ and $\|\delta_{T-\lambda, P-\lambda}\| \leq \frac{1}{2}(\|$

$\delta_{T-\lambda} \| + \| \delta_{P-\lambda} \|$). Using unitaries and non-orthogonal projections, Bhatiah and Kittaneh [5] determined max-norms and numerical radii inequalities for commutators. Some authors have used the concept of classical numerical range to study different classes of matrices of operators. For instance, many alternative formulations of (p, q) -numerical range $Wp, q(A) = \{Ep((UAU^*)[Q])\}$ for a unitary U where $1 \leq p \leq q \leq n$ for an $n \times n$ complex matrix X , with $q \times q$ leading principle submatrix $X[q]$ and the p th elementary symmetric functions of the eigen values of $X[q]$ [38]. Chi-Kwong Li [37] extended the results of these formulations to the generalized cases, gave alternative proofs for some of them like convexity and even derived a formula for (p, q) - numerical radius of a derivation as $r_{p,q}(T) = \max \{ \| \mu \| : \mu \in Wp, q(T) \}$. Mohammad [44] applied positive operators in the proof of a similar result. Orthogonal projections being bounded operators, have extensive uses on implementation of derivations and construction of underlying algebras of the derivations. Vasilevski [76] studied the applications of C -algebras constructed by orthogonal projections to aimark's ilation theorem. Spivack [74] used orthogonal projections to induce a derivation on von Neumann algebras. In [39] Matej used mutually orthogonal projections acting on a C -algebra to prove that any local derivation is a derivation.

Basic Definitions

Definition 2.2.0. An elementary operator $T \in B(H)$ is said to be norm-attainable if there exists a unit vector $x_0 \in H$, such that $\|Tx_0\| = \|T\|$

Definition 2.2.1. A Hilbert-Schmidt operator T with orthonormal basis $\{e_i : i \in I\}$ has a Hilbert-Schmidt norm $\| \cdot \|_2$ is defined by $\|T\|_2 = (\sum_{i \in I} \|Te_i\|^2)^{\frac{1}{2}}$

Definition 2.2.2. Let H_n denote the complex vector space of all $n \times n$ Hermitian matrices, endowed with the inner product $\langle A, B \rangle = \text{Tr}(B^*A)$, where $\text{Tr}(\cdot)$ is the trace on the positive matrices and B is the adjoint of B , then:

- (i). the trace norm of T , is defined by, $\|T\|_1 = \sum_{i=1}^n s_i(T)$.
- (ii). the spectral norm of T , also is defined by, $\|T\|_2 = \max\{s_i(T)\}$, where $s_i(T)$ are the singular values of T , i.e. the eigenvalues of $|T| = (T^*T)^{\frac{1}{2}}$.

Definition 2.2.3. A tensor product of H with K is a Hilbert space P , together with a bilinear mapping $\varphi : H \times K \rightarrow P$, such that

- (i). The set of all vectors $\varphi(x, y)$ ($x \in H, y \in K$) forms a total subset of P , that is, its closed linear span is equal to P ;
- (ii). $\langle \varphi(x_1, y_1), \varphi(x_2, y_2) \rangle = \langle x_1, x_2 \rangle \langle y_1, y_2 \rangle$ for $x_1, x_2 \in H, y_1, y_2 \in K$.

We refer to the pair (P, φ) as the tensor product.

Remark 2.2.4. Let X, X', Y and Y' be vector spaces over some fields and $P : X \rightarrow X'$, and $Q : Y \rightarrow Y'$ be operators. Then there is a unique linear operator $P \odot Q : X \otimes Y \rightarrow X' \otimes Y'$ defined by

$$(P \odot Q)(X \otimes Y) = P(x) \otimes Q(y), \quad \forall x \in X, y \in Y. \text{ The function } f : X \times Y \rightarrow X' \otimes Y'$$

Y' defined by $f(x, y) = P(x) \otimes Q(y)$ is bilinear and so by the universal property of tensor products, there exist a unique operator $P \odot Q$ for which the above equation holds. The map $P \odot Q$ is called the tensor product of P and Q .

Results and Discussion

Lemma 3.0.0. Given that $P, Q, X \in B(H)$ are matricial operator on a finite dimensional separable Hilbert space H^n then $PX - XQ$ is also matricial.

Proof.

Let $[p_{ij}]$, $[q_{ij}]$ and $[x_{ij}]$ denote the matrices of the operators P , Q and X respectively. Suppose that $v_i = v_1, \dots, v_n$ forms a basis of H^n over a field $\mathbb{K}$, then a simple computation shows that for

$$\begin{aligned} (P - Q)v_i &= P v_i - Q v_i \\ &= \sum_j p_{ij} v_j - \sum_j q_{ij} v_j \\ &= \sum_j (p_{ij} - q_{ij}) v_j \end{aligned}$$

which can also be written more compactly as $\sum_j \gamma_{ij} v_j$ where γ_{ij} is the finite difference $p_{ij} - q_{ij}$ for every i and j . For a given $\lambda \in \mathbb{K}$ then it is also clear that $\lambda[p_{ij}] = [\lambda p_{ij}]$. We adopt the order $v_i T$ (instead of $T v_i$) for the image of an arbitrary operator T which acts on H_n for $v_i \in H_n$. Thus, $v_i T X = (v_i T) X = (\sum_j p_{ij} v_j X = \sum_j p_{ij} (v_j X)$. But $v_j X = \sum_k x_{jk} v_k$ and so by substituting in the equation above yields $v_i (PX) = \sum_j p_{ij} (\sum_k x_{jk} v_k) = \sum_k (p_{ij} x_{jk}) v_k$ so that $[PX] = \alpha_{ij}$ where for each i and j , $\alpha_{ij} = \sum_k p_{ij} x_{jk}$. Thus, we can also find $\beta_{ij} = \sum_i x_{jk} q_{ki}$ so that $\gamma'_{ij} = \alpha_{ij} - \beta_{ij} = \sum_k p_{ij} x_{jk} - \sum_i x_{jk} q_{ki}$.

Theorem 3.0.1 Let $\delta : B(H) \rightarrow B(H)$ be a generalized derivation defined by $\delta_{P,Q}(X) = PX - XQ$ for orthogonal projections P and Q induced by q_n , then

$$\|\delta_{P,Q}\| = \{\sum |p_n|^2\}^{\frac{1}{2}} - \{\sum |q_n|^2\}^{\frac{1}{2}} \text{ and } \|\delta_{P,Q}(X)\| = \|P\| \|X\| - \|X\| \|Q\|$$

Proof.

Taking $\|f_n\| = 1$ for a fixed $P, Q \in P_0(H)$ then $\delta_{P,Q}(f_n) = p f_n - f_n q$. Suppose that p_n and q_n which induce P and Q respectively are bounded, then $\delta_{P,Q} f_n = p f_n - f_n q$ can take the form of a diagonal matrix and $\sum_n (p_n f_n - f_n q_n)$ is also bounded. Now

$$\begin{aligned} \|\delta_{P,Q}(f_n)\|_2 &= \|\sum_n (p_n f_n - f_n q_n)\|_2 \\ &\geq \|\sum_n p_n f_n\|_2 - \|\sum_n q_n f_n\|_2 \\ &= \sum_n |p_n|^2 \|f_n\|^2 - \sum_n |q_n|^2 \|f_n\|^2 \\ &= \{\sum_n |p_n|^2 - \sum_n |q_n|^2\} \{\sum_n \|f_n\|^2\} \end{aligned}$$

so that on taking the supremum over both sides of the inequality gives

$$\sup\{\|Pf_n - f_nQ\| : \|f_n\| = 1\} \geq \|\delta_{P,Q}(f_n)\|$$

$$\geq \{\sum_n |p_n|^2\}^{\frac{1}{2}} - \{\sum_n |q_n|^2\}^{\frac{1}{2}}$$

Conversely the following relation hold

$$\{\|\sum_n(p_nf_n - f_nq_n)\|\}^{\frac{1}{2}} \leq \left\{\{\sum_n |p_n|^2\}^{\frac{1}{2}} - \{\sum_n |q_n|^2\}^{\frac{1}{2}}\right\} \{\sum_n \|f_n\|^2\}^{\frac{1}{2}}$$

Which implies that the following also hold.

$$\begin{aligned} \{\|\sum_n(p_nf_n - f_nq_n)\|\} &\leq \{\sum_n |p_n|^2 \|f_n\|^2 - \sum_n |q_n|^2 \|f_n\|^2\} \\ &= \{\sum_n \|p_nf_n\|^2 - \sum_n \|q_nf_n\|^2\} \\ &\leq \{\|\sum_n(p_nf_n - f_nq_n)\|\} \end{aligned}$$

So

$\sup\{\|Pf_n - f_nQ\| : \|f_n\| = 1\} = \|\delta_{P,Q}(f_n)\|$ and for an arbitrary $X \in B(H)$, then for $X = \sum_n X_n f_n$

$$\begin{aligned} \|\delta_{P,Q}(X)\| &= \{\sum_n \|p_n\|\}^{\frac{1}{2}} \{\sum_n \|X_n f_n\|^2\}^{\frac{1}{2}} - \{\sum_n \|X_n f_n\|^2\}^{\frac{1}{2}} \{\sum_n \|q_n\|\}^{\frac{1}{2}} \\ &= \|P\| \|X\| - \|X\| \|Q\| \end{aligned}$$

The following is a discussion of the norms of derivations in the context of tensor product of operators. We show that indeed $\delta_{P,Q}$ is linear and bounded in this context.

Remark 3.0.2. Suppose that $H = \ell^2$ is infinite dimensional complex Hilbert space, then ℓ^2 is unitarily invariant to the Hilbert space tensor product $\ell^2 \otimes \ell^2$. Let $P \in$

(H^n, H_1) , $Q \in B(H^n, H_2)$ and an arbitrary $X: H^n \rightarrow H^n$ for $H^n = H_1 \oplus H_2 = H_{11} \oplus H_{22}$. There is a unique linear operator $P \odot X \in B(H^n \otimes H_1, H_1 \otimes H_1)$, called the tensor product of P and X satisfying $(P \odot X)(x \otimes y) = P(x) \otimes X(y)$ and similarly $(X \odot Q)(y \otimes x) = X(y) \otimes Q(x)$. Moreover, there is a unique injective linear operator $\theta: B(H^n, H_1) \otimes B(H^n, H_2) \rightarrow B(H^n \otimes H_1), B(H^n \otimes H_2)$ which satisfy $\theta(P \otimes X - X \otimes Q) = P \odot X - X \odot Q$.

Theorem 3.0.3 Let $P \in B(H^n, H_1)$, $Q \in B(H^n, H_2)$ and an arbitrary $X: H^n \rightarrow H^n$ for $H^n = H_1 \oplus H_2 = H_{11} \oplus H_{22}$ then $\delta_{P,Q}$ is linear and bounded.

Proof.

By the definition of derivations, the map $\delta_{P,Q}(X) = P \otimes X - X \otimes Q: B(H_1 \otimes H_{11}) \rightarrow (H_2 \otimes H_{22})$ is defined by

$$P \odot X(\sum_{i=1}^n x_i \otimes y_i) - X \odot Q(\sum_{i=1}^n y_i \otimes x_i) = \sum_{i=1}^n P(x_i) \otimes X(y_i) -$$

$\sum_{i=1}^n X(x_i) \otimes Q(y_i)$ for all $x \in H^n$. Let $\alpha, \beta \in \mathbb{F}$ and $\sum_{i=1}^n x_i \otimes y_i, \sum_{i=1}^n x'_i \otimes y'_i \in H_1 \otimes H_{11}$. Then

$$P \odot X - X \odot Q(\alpha \sum_{i=1}^n x_i \otimes y_i - \beta \sum_{i=1}^n x'_i \otimes y'_i) = (P \odot X - X \odot Q)(\alpha \sum_{i=1}^n x_i \otimes y_i) +$$

$$(\beta \sum_{i=1}^n x'_i \otimes y'_i)$$

$$= (P \odot X - X \odot Q)(\alpha \sum_{i=1}^n x_i \otimes y_i) + (P \odot X - X \odot Q)(\beta \sum_{i=1}^n x'_i \otimes y'_i) \\ = P \odot X(\alpha \sum_{i=1}^n x_i \otimes y_i) - X \odot Q(\alpha \sum_{i=1}^n x_i \otimes y_i) + P \odot X(\beta \sum_{i=1}^n x'_i \otimes y'_i) -$$

$$X \odot Q(\beta \sum_{i=1}^n x'_i \otimes y'_i)$$

$$= \alpha \sum_{i=1}^n P(x_i) \otimes X(y_i) - \alpha \sum_{i=1}^n X(x_i) \otimes Q(y_i) + \beta \sum_{i=1}^n P(x'_i) \otimes X(y'_i) \\ - \beta \sum_{i=1}^n X(x'_i) \otimes Q(y'_i)$$

$$= \alpha (P \odot X - X \odot Q)(\sum_{i=1}^n x_i \otimes y_i) - \alpha X \odot Q(\sum_{i=1}^n x_i \otimes y_i) + \beta (P \odot X - X \odot Q)(\sum_{i=1}^n x'_i \otimes y'_i) -$$

$$\beta X \odot Q(\sum_{i=1}^n x'_i \otimes y'_i)$$

$$\odot Q(\sum_{i=1}^n x'_i \otimes y'_i)$$

$$= \alpha (P \odot X - X \odot Q)(\sum_{i=1}^n x_i \otimes y_i) + \beta (P \odot X - X \odot Q)(\sum_{i=1}^n x'_i \otimes y'_i)$$

Now for the case of boundedness,

$$\| (P \odot X - X \odot Q)(\alpha \sum_{i=1}^n x_i \otimes y_i) \| = \| \sum_{i=1}^n P(x_i) \otimes X(y_i) - \sum_{i=1}^n X(x_i) \otimes Q(y_i) \|$$

$$\leq \| \sum_{i=1}^n P(x_i) \otimes X(y_i) - \sum_{i=1}^n X(x_i) \otimes Q(y_i) \|$$

$$\| Q(y_i) \|$$

$$\| Q(y_i) \|$$

$$\| X(y_i) \|$$

$$\| X(x_i) \| \| Q(y_i) \|$$

$$\sum_{i=1}^n \| x_i y_i \|$$

$$\leq \| \sum_{i=1}^n P(x_i) \otimes X(y_i) - \sum_{i=1}^n X(x_i) \otimes Q(y_i) \| \\ \leq \| \sum_{i=1}^n P(x_i) \otimes X(y_i) \| + \| \sum_{i=1}^n X(x_i) \otimes Q(y_i) \| \\ \leq \| \sum_{i=1}^n P(x_i) \| \| X(y_i) \| + \| \sum_{i=1}^n X(x_i) \| \| Q(y_i) \| \\ \leq \| \sum_{i=1}^n P \| \| X(y_i) \| + \| \sum_{i=1}^n X \| \| Q(y_i) \| \\ \leq \| P \| \| X \| \sum_{i=1}^n \| x_i y_i \| + \| X \| \| Q \| \sum_{i=1}^n \| x_i y_i \|$$

$$= (\|P\| \|X\| + \|X\| \|Q\|) \sum_{i=1}^n \|x_i\| \|y_i\|$$

Letting $(\|P\| \|X\| + \|X\| \|Q\|) = M$, thus M is the upper bound for $PX - XQ$

Theorem 3.0.4. Let $X \in B(H)$ and orthogonal projections $P, Q \in B(H)$ then $\|P \odot X - X \odot Q\| = \|P\| \|X\| - \|X\| \|Q\|$

Proof.

$$\begin{aligned} \|P \odot X - X \odot Q\| &= \sup \left\{ \left\| \sum_{i=1}^n (x_i \otimes y_i) \right\| = 1 \left\| P \odot X - X \odot Q \left(\sum_{i=1}^n x_i \otimes y_i \right) \right\| \right\} \\ &\leq \sup \{ \| \sum_{i=1}^n (x_i \otimes y_i) \| = 1 \| P \| \| X \| \| \sum_{i=1}^n x_i \otimes y_i \| \| \sum_{i=1}^n x_i \otimes y_i \| \} \\ &= \|P\| \|X\| - \|X\| \|Q\| \end{aligned}$$

Conversely,

$$\|P \odot X - X \odot Q\| = \sup \{ \|P \odot X(\sum_{i=1}^n x_i \otimes y_i) - X \odot Q(\sum_{i=1}^n x_i \otimes y_i)\| \mid \sum_{i=1}^n x_i \otimes y_i \in X \otimes Y, \sum_{i=1}^n x_i \otimes y_i \neq 0 \}$$

Then

$$\|P \odot X - X \odot Q\| \geq \left\{ \frac{\|P \odot X(\sum_{i=1}^n x_i \otimes y_i) - X \odot Q(\sum_{i=1}^n x_i \otimes y_i)\|}{\| \sum_{i=1}^n x_i \otimes y_i \|} \mid \sum_{i=1}^n x_i \otimes y_i \in X \otimes Y, \sum_{i=1}^n x_i \otimes y_i \neq 0 \right\} = \|P\| \|X\| - \|X\| \|Q\|$$

$$\text{Thus } \|P \odot X - X \odot Q\| \geq \|P\| \|X\| - \|X\| \|Q\|$$

In the sequel, the research will consider inequalities for the norms of derivation discussed. The inequalities considered will be on generalized derivations and the results generalize to the cases of inner derivations.

Theorem 3.0.5. Suppose that $P, Q \in P_0(H)$ are matricial operators, then

$$\|\delta_{P,Q}(X)\|^2 = \left(\sum_{i,j=1}^2 \sum_{i \neq j} |p_{ixij} - x_{ij}q_j|^2 \right)^{\frac{1}{2}} + \left(\sum_{i,j=1}^2 \sum_{i=j} |p_{ixij} - x_{ij}q_j|^2 \right)^{\frac{1}{2}} + \left(\sum_{j=1}^2 |q_j x_{3j}|^2 \right)^{\frac{1}{2}} \text{ on } \oplus H_3$$

Proof. Suppose that P and Q are positive diagonal $n \times n$ matrices with eigenbases p_n and q_n respectively for $n \geq 1$, with $p_n(1 - p_n^*) = 0$ and $q_n(1 - q_n^*) = 0$. Given arbitrary $X \in B(H)$, then,

$$P \text{ and } Q = \begin{bmatrix} p_1 & 0 & 0 \\ 0 & p_2 & 0 \\ 0 & 0 & 0 \end{bmatrix}, Q = \begin{bmatrix} q_1 & 0 & 0 \\ 0 & q_2 & 0 \\ 0 & 0 & 0 \end{bmatrix} \text{ an arbitrary } X = \begin{bmatrix} x_{11} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \end{bmatrix},$$

with

$p_1 \geq p_2 \geq 0$ then

$$\begin{aligned}
 PX - XP &= \begin{bmatrix} p_1x_{11} - x_{11}p_1 & p_1x_{12} - x_{12}p_2 & p_1x_{13} \\ p_2x_{21} - x_{21}p_1 & p_2x_{22} - x_{22}p_2 & p_2x_{23} \\ -x_{31}p_1 & -x_{32}p_2 & 0 \end{bmatrix} \\
 &= \begin{bmatrix} p_1x_{11} - x_{11}p_1 & 0 & 0 \\ 0 & p_2x_{22} - x_{22}p_2 & 0 \\ 0 & 0 & 0 \end{bmatrix} + \\
 &\quad \begin{bmatrix} 0 & p_1x_{12} - x_{12}p_2 & p_1x_{13} \\ p_2x_{21} - x_{21}p_1 & 0 & p_2x_{23} \\ -x_{31}p_1 & -x_{32}p_2 & 0 \end{bmatrix}
 \end{aligned}$$

So that for a commutative $B(H)$ then

$$\begin{aligned}
 PX - XP &= \begin{bmatrix} 0 & p_1x_{12} - x_{12}p_2 & p_1x_{13} \\ p_2x_{21} - x_{21}p_1 & 0 & p_2x_{23} \\ -x_{31}p_1 & -x_{32}p_2 & 0 \end{bmatrix}.
 \end{aligned}$$

Now

$$\begin{aligned}
 PX + XP &= \begin{bmatrix} p_1x_{11} + x_{11}p_1 & p_1x_{12} + x_{12}p_2 & p_1x_{13} \\ p_2x_{21} + x_{21}p_1 & p_2x_{22} + x_{22}p_2 & p_2x_{23} \\ x_{31}p_1 & x_{32}p_2 & 0 \end{bmatrix} \\
 &= \begin{bmatrix} p_1x_{11} + x_{11}p_1 & 0 & 0 \\ 0 & p_2x_{22} + x_{22}p_2 & 0 \\ 0 & 0 & 0 \end{bmatrix} + \\
 &\quad \begin{bmatrix} 0 & p_1x_{12} + x_{12}p_2 & p_1x_{13} \\ p_2x_{21} + x_{21}p_1 & 0 & p_2x_{23} \\ x_{31}p_1 & x_{32}p_2 & 0 \end{bmatrix}
 \end{aligned}$$

and

$$\begin{aligned}
 QX - XQ &= \begin{bmatrix} q_1x_{11} - x_{11}q_1 & q_1x_{12} - x_{12}q_2 & q_1x_{13} \\ q_2x_{21} - x_{21}q_1 & q_2x_{22} - x_{22}q_2 & q_2x_{23} \\ -x_{31}q_1 & -x_{32}q_2 & 0 \end{bmatrix} \\
 &= \begin{bmatrix} q_1x_{11} - x_{11}q_1 & 0 & 0 \\ 0 & q_2x_{22} - x_{22}q_2 & 0 \\ 0 & 0 & 0 \end{bmatrix} + \\
 &\quad \begin{bmatrix} 0 & q_1x_{12} - x_{12}q_2 & q_1x_{13} \\ q_2x_{21} - x_{21}q_1 & 0 & q_2x_{23} \\ -x_{31}q_1 & -x_{32}q_2 & 0 \end{bmatrix}
 \end{aligned}$$

Similarly, for a commutative $B(H)$ then

$$QX - XQ =$$

$$\begin{bmatrix} 0 & q_1x_{12} - x_{12}q_2 & q_1x_{13} \end{bmatrix}$$

$$\begin{bmatrix} q_2x_{21} - x_{21}q_1 & 0 & q_2x_{23} \\ -x_{31}q_1 & -x_{32}q_2 & 0 \end{bmatrix}.$$

Now

$$\begin{aligned} QX + XQ &= \begin{bmatrix} q_1x_{11} + x_{11}q_1 & q_1x_{12} + x_{12}q_2 & q_1x_{13} \\ q_2x_{21} + x_{21}q_1 & q_2x_{22} + x_{22}q_2 & q_2x_{23} \\ x_{31}q_1 & x_{32}q_2 & 0 \end{bmatrix} \\ &= \begin{bmatrix} q_1x_{11} + x_{11}q_1 & 0 & 0 \\ 0 & q_2x_{22} + x_{22}q_2 & 0 \\ 0 & 0 & 0 \end{bmatrix} + \\ &\begin{bmatrix} 0 & q_1x_{12} + x_{12}q_2 & q_1x_{13} \\ q_2x_{21} + x_{21}q_1 & 0 & q_2x_{23} \\ x_{31}q_1 & x_{32}q_2 & 0 \end{bmatrix} \end{aligned}$$

We obtain an operator

$$\begin{aligned} (PX - XQ) &= \begin{bmatrix} p_1x_{11} - x_{11}q_1 & p_1x_{12} - x_{12}q_2 & p_1x_{13} \\ p_2x_{21} - x_{21}q_1 & p_2x_{22} - x_{22}q_2 & 0 \\ -q_1x_{31} & -q_2x_{32} & 0 \end{bmatrix} \\ &= \begin{bmatrix} p_1x_{11} - x_{11}q_1 & 0 & 0 \\ 0 & p_2x_{22} - x_{22}q_2 & 0 \\ 0 & 0 & 0 \end{bmatrix} + \\ &\begin{bmatrix} 0 & p_1x_{12} - x_{12}q_2 & p_1x_{13} \\ p_2x_{21} - x_{21}q_1 & 0 & 0 \\ -q_1x_{31} & -q_2x_{32} & 0 \end{bmatrix} \end{aligned}$$

Now on introducing the norm function to the equality results into the norm inequality;

$$\begin{aligned} &\left\| \begin{bmatrix} p_1x_{11} - x_{11}q_1 & p_1x_{12} - x_{12}q_2 & p_1x_{13} \\ p_2x_{21} - x_{21}q_1 & p_2x_{22} - x_{22}q_2 & 0 \\ -q_1x_{31} & -q_2x_{32} & 0 \end{bmatrix} \right\| \leq \left\| \begin{bmatrix} p_1x_{11} - x_{11}q_1 & 0 & 0 \\ 0 & p_2x_{22} - x_{22}q_2 & 0 \\ 0 & 0 & 0 \end{bmatrix} \right\| \\ &+ \left\| \begin{bmatrix} 0 & p_1x_{12} - x_{12}q_2 & p_1x_{13} \\ p_2x_{21} - x_{21}q_1 & 0 & 0 \\ -q_1x_{31} & -q_2x_{32} & 0 \end{bmatrix} \right\| \\ &\left\| \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \right\| \end{aligned}$$

Application of Hilbert-Schmidt norm to this, gives us the following

$$\begin{aligned} &(\sum_{i,j=1}^2 \sum_{i,j=1}^2 |p_{ixij} - x_{ij}q_j|^2)^{\frac{1}{2}}_{(i=j)} + (\sum_{i,j=1}^2 \sum_{i,j=1}^2 |p_{ixij} - x_{ij}q_j|^2)^{\frac{1}{2}}_{(i=j, i \leftrightarrow j)} + \\ &(\sum_{j=1}^2 |q_jx_{3j}|^2)^{\frac{1}{2}} \end{aligned}$$

Lemma 3.0.6. Let $P \in P_0(H)$ and X is compact, then $s_j(PX) = s_j(XP) \leq \|X\| s_j(P)$

Proof.

$s_j(PX) = s_j(XP)$ is immediate from the commutativity of the singular values and $s_j(XP) \leq \|X\| s_j(P)$ follows from the correspondence $s_j(\cdot) \equiv \|\cdot\|$, and the inequality, $\|PX\| \leq \|P\| \|X\|$.

Theorem 3.0.7. Let $B(H)$ be a C^* -algebra, $P_0(H^n)$ a commutative subalgebra of $B(H)$ and a map $\delta_{P,Q}$, such that $\delta_{P,Q}: P_0(H^n) \rightarrow B(H)$. Let $\delta_{P,Q}: M_n(P_0(H^n)) \rightarrow M_n(H^n)$ be a linear map between matricial operator spaces $M_n(P_0(H^n))$ and $M_n(H^n)$. For n -tuples of $\delta_{P,Q}$, whereby $\delta_n: M_n[P_0(H^n)] \rightarrow M_n[B(H)]$, then $\delta_n[(P, Q)] = [\delta(P, Q)]$, $\forall P, Q \in M_n[P_0(H^n)]$ and $[P] = [P_1, P_2]$, $[Q] = [Q_1, Q_2]$. Moreover, $\|\delta_{P,Q}\| \leq \|\delta_{P,Q}\|_{CB}$ holds.

Proof.

We apply diagonal matrices $[P]$ and $[Q]$. For $n = 1$, then by definition of δ_n , δ_1 and δ are coincidental [20] hence, $\|\delta\| = \|\delta_1\|$. We now proceed to give proofs when $n = 2$ and when $n = 3$. For $n = 2$, let $[P], [Q] \in M_2[P_0(H^n)]$, $j, k = 1, 2$, then for $\delta_2: M_2[P_0(H^n)] \rightarrow M_2[B(H)]$, we now have,

$$\begin{aligned} \delta_2(P, Q) &= \delta_2 \left(\begin{bmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{bmatrix} \begin{bmatrix} Q_{11} & Q_{12} \\ Q_{21} & Q_{22} \end{bmatrix} - \begin{bmatrix} Q_{11} & Q_{12} \\ Q_{21} & Q_{22} \end{bmatrix} \begin{bmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{bmatrix} \right) \\ &= \begin{bmatrix} P_{11}Q_{11} - Q_{11}P_{11} & P_{11}Q_{12} - Q_{11}P_{12} \\ P_{12}Q_{11} - Q_{12}P_{11} & P_{12}Q_{12} - Q_{12}P_{12} \\ P_{21}Q_{11} - Q_{21}P_{11} & P_{21}Q_{12} - Q_{21}P_{12} \\ P_{22}Q_{11} - Q_{22}P_{11} & P_{22}Q_{12} - Q_{22}P_{12} \end{bmatrix} \\ &= \begin{bmatrix} \delta(P_1, Q_1) & 0 \\ 0 & \delta(P_2, Q_2) \end{bmatrix} \end{aligned}$$

$$\|([P_{11} \ P_{12}] [Q_{11} \ Q_{12}] - [Q_{11} \ Q_{12}] [P_{11} \ P_{12}])\| = \| [P_{11}Q_{11} - Q_{11}P_{11} \ P_{12}Q_{11} - Q_{12}P_{11}] \|$$

$$= \| \begin{bmatrix} \delta(P_1, Q_1) & 0 \\ 0 & \delta(P_2, Q_2) \end{bmatrix} \|$$

$= \left(\sum_{j=1}^2 \sum_{k=1}^2 \|\delta((P_j, Q_k))\|^2 \right)^{\frac{1}{2}}$ (Hilbert-Schmidt norm)

$$\begin{aligned} &= (\|\delta((P_1, Q_1))\|^2 + \|\delta((P_2, Q_2))\|^2)^{\frac{1}{2}} \\ &\geq \|\delta((P_1, Q_1))\|^2 \\ &= \|\delta((P_1, Q_1))\| \end{aligned}$$

$$= \| \delta_1((P_1, Q_1)) \|.$$

Therefore,

$$\| \delta_2 \| = \sup\{\| \delta_2(PQ) : [PQ] \in M_2[P_0(H^n)]\| \}$$

$$\geq \sup\{\| \delta_1((P_1, Q_1)) \| \} = \| \delta_1 \|$$

and hence $\| \delta_2 \| = \| \delta_1 \|$.

$$\begin{array}{ccccc} P_1X - XQ_1 & 0 & 0 & & \\ \text{When } n=3, \delta_3 \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} & P_2X - XQ_2 & 0 & P_3X - XQ_3 & \\ \delta_{(P_1, Q_1)} & 0 & 0 & 0 & 0 \\ & 0 & 0 & 0 & \delta_{(P_3, Q_3)} \end{array}$$

which implies that

$$\begin{aligned} & \begin{array}{ccccc} P_1X - XQ_1 & 0 & 0 & \delta_{(P_1, Q_1)} & 0 & 0 \\ \delta_3 \begin{bmatrix} 0 & P_2X - XQ_2 & 0 \\ 0 & 0 & P_3X - XQ_3 \end{bmatrix} & = & \begin{bmatrix} 0 & \delta_{(P_2, Q_2)} & 0 \\ 0 & 0 & \delta_{(P_3, Q_3)} \end{bmatrix} \end{array} \\ & = \left[\sum_{j=1}^3 \sum_{k=1}^3 \| \delta((P_j, Q_k)) \|^2 \right]^{\frac{1}{2}} \\ & = (\| \delta((P_1, Q_1)) \|^2 + \| \delta((P_2, Q_2)) \|^2 + \| \delta((P_3, Q_3)) \|^2)^{\frac{1}{2}} \\ & = \left[\sum_{j=1}^3 \sum_{k=1}^3 \| \delta((P_j, Q_k)) \|^2 \right]^{\frac{1}{2}} \\ & = \| \delta([\delta((P_j, Q_k))]) \| \end{aligned}$$

This implies that

$$\begin{aligned} \| \delta_3 \| &= \sup\{\| \delta_3[\delta((P_j, Q_k))] : [\delta((P_j, Q_k))] \rightarrow M_3[P_0(H^n)] \| \} \geq \sup\{\| \delta_2[\delta((P_j, Q_k))] : [\delta((P_j, Q_k))] \rightarrow M_2[P_0(H^n)] \| \} = \| \delta_2 \| \text{ and therefore,} \\ \| \delta_3 \| &\geq \| \delta_2 \|. \end{aligned}$$

Lastly, consider $\delta_{n+1} : M_{n+1}[P_0(H^n)] \rightarrow M_{n+1}[B(H)]$ defined by $\delta_{n+1}[\delta((P_j, Q_k))] = [\delta((P_j, Q_k))]$ for all $j, k = 1, \dots, n+1$.

We obtain,

$$\begin{aligned} \| \delta_{n+1}[(PQ)_{j,k}] \| &= \| [\delta(PQ)_{j,k}] \| \\ &= \left[\sum_{j=1}^{n+1} \sum_{k=1}^{n+1} \| \delta((P_j, Q_k)) \|^2 \right]^{\frac{1}{2}} \\ &\geq \left[\sum_{j=1}^n \sum_{k=1}^n \| \delta((P_j, Q_k)) \|^2 \right]^{\frac{1}{2}} \end{aligned}$$

$$= \| \delta_n [\delta (P_j, Q_k)] \|$$

Therefore, on taking supremum on both sides of the inequality above we get $\| \delta_{n+1} \| = \| \delta_n \|$. Application of the property of complete boundedness of the norm of δ , we further get $\| \delta \|_{CB} = \sup \{ \| \delta_n \| : n \in \mathbb{N} \}$ which implies that $\| \delta \|_{CB} = \| \delta_n \| \forall n \in \mathbb{N}$. Therefore, $\| \delta \| = \| \delta \|_{CB}$, this completes the claim.

Example 3.0.8. Let $\delta: M_2(\mathbb{C}) \rightarrow M_2(\mathbb{C})$ be a derivation defined by $\delta_{P,Q}(X) = PX - XQ$. Let an operator P , be defined by $P(e_j) = e_j$ on a finite dimensional Hilbert space H , for an orthonormal basis $e_j, j = 1, 2, \dots$

We can then set the matrix for an arbitrary operator X and that of P as,

$$X = \begin{bmatrix} a & a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} & a_{24} \end{bmatrix}, \quad P = \begin{bmatrix} e & 0 \\ 0 & 1 \end{bmatrix}.$$

It is clear by simple calculation that

$$PX - XP = \begin{bmatrix} e_1 x_{11} - x_{21} x_{11} & e_1 x_{12} \\ p_1 & 0 \end{bmatrix}.$$

Now suppose that H has a unique direct decomposition given by $H = \text{ran } P \oplus \ker P$ and e_1 is an identity in the range of P , then $PX - XP$ becomes $PX - XP =$

$$\begin{bmatrix} 0 & e^1 x_{12} \\ -x_{21} e_1 & 0 \end{bmatrix}. \text{ We can find a unitary } U = \begin{bmatrix} e_1 & 0 \\ 0 & e_2 \end{bmatrix} \text{ such that}$$

$$\frac{1}{2} \begin{bmatrix} -x_{021} e_1 & e^1 0 x_{12} \end{bmatrix} = (UX - XU)$$

$$= \frac{1}{2} (UX - XU^*)$$

By triangle inequality,

$$\frac{1}{2} \| (UX - XU) \| \leq \frac{1}{2} \| (UX + XU) \| \leq \frac{1}{2} \| UX \| + \frac{1}{2} \| XU \| = \| XU \| = \| X \|.$$

Now considering another operator Q similar to P , we can get another orthonormal

$$\text{basis } f_j, j = 1, 2, \dots \text{ such that } Q \text{ is defined by } Q = \begin{bmatrix} f^j & 0 \\ 0 & 0 \end{bmatrix}.$$

Let also $\frac{1}{2}$ $\frac{1}{2}$

$\| X \| = \{ \sum_n | \alpha_n |^2 \}^{\frac{1}{2}} = 1, \| PX \| = \{ \sum_j | e_j |^2 \}^{\frac{1}{2}} = P \| QX \| = \{ \sum_j | f_j |^2 \}^{\frac{1}{2}} =$
 $Q \text{ and so } \| PX - XQ \| \leq \| PX + XQ \| \leq \| PX \| + \| XQ \|.$

Lemma 3.0.9. Suppose that for an arbitrary $X \in B(H)$ and $P_1X, P_2X, XQ_1, XQ_2 \in C_2$ then, $n^{p-1} \sum_{i=1}^n \|P_i\|_p^p \leq \|\sum_{i=1}^n P_i X_i\|_p^p \leq \sum_{i=1}^n \|P_i X_i\|_p^p$ for $0 < p \leq \infty$ and the reverse inequalities hold for $1 \leq p < \infty$.

Proof. If a_1 and a_2 are nonnegative real eigenvalues for P_1 and P_2 , then $n^{p-1} \sum_{i=1}^n a_i^p \leq (\sum_{i=1}^n a_i)^p \leq \sum_{i=1}^n a_i^p$. The inequalities follow, respectively, from the concavity of the function $f(t) = t^p, t \in [0, \infty)$ for $0 < p \leq 1$, and the convexity of the function $f(t) = t^p, t \in [0, \infty)$ for $1 \leq p < \infty$.

Proposition 3.1.0. Let $P = P_1, P_2, Q = Q_1, Q_2 \in C_p$ and an arbitrary $X = X_1, X_2 \in B(H)$ for some $p > 0$. Then $\sum_{i,j=1}^2 \|P_i X_i - P_j X_j\|_p^p + \sum_{i,j=1}^2 \|X_i Q_i - X_j Q_j\|_p^p \geq$

$$\sum_{i,j=1}^2 \|X_i - X_j\|_p^p \geq (D_{P_X-XQ})^{\frac{p-2}{2}} \sum_{i,j=1}^2 \|P_i X_i - X_j Q_j\|_p^p + (D_{Q-X})^{\frac{p-2}{2}} \sum_{i,j=1}^2 \|X_i Q_i - X_j\|_p^p +$$

$$D_X^{\frac{p-2}{2}} \sum_{i,j=1}^2 \|X_i - P_j X_j\|_p^p - (\|\sum_{i,j=1}^2 (P_i X_i - X_j Q_i)\|_p^p + \|\sum_{i=1}^2 (X_i Q_i - X_i)\|_p^p + \|\sum_{i=1}^2 (X_i - P_i X_i)\|_p^p) \text{ for } 0 < p < 2.$$

Proof.

We define a constant D_P by $D_P = \sum_{i=1}^n \pi(P_i X_i)$ where

$$\sum_{i=1}^n \pi(P_i X_i) = \{1, 0, \dots, ((P_i X_i) \neq 0) \neq 0\};$$

and $D_Q = \sum_{i=1}^n \pi(X_i Q_i)$ where

$$\pi(X_i Q_i) = \{1, 0, \dots, ((X_i Q_i) \neq 0) \neq 0\};$$

We prove the case for $0 < p < 2$ and infer the result onto the other cases. We have

$$\sum_{i,j=1}^2 \|P_i X_i - X_j Q_j\|_p^p + \sum_{i,j=1}^2 \|X_i Q_i - X_j Q_j\|_p^p + \sum_{i,j=1}^2 \|X_i - X_j\|_p^p +$$

$$(\|\sum_{i=1}^2 (P_i X_i - X_i Q_i)\|_p^p + \|\sum_{i=1}^2 (X_i Q_i - X_i)\|_p^p + \|\sum_{i=1}^2 (X_i - P_i X_i)\|_p^p) =$$

$$2(\sum_{1 \leq i < j \leq 2} \|P_i X_i - P_j X_j\|_p^p + \sum_{1 \leq i < j \leq 2} \|X_i Q_i - X_j Q_j\|_p^p + \sum_{1 \leq i < j \leq 2} \|X_i - X_j\|_p^p) +$$

$$(\|\sum_{i=1}^2 (P_i X_i - X_i Q_i)\|_p^p + \|\sum_{i=1}^2 (X_i Q_i - X_i)\|_p^p + \|\sum_{i=1}^2 (X_i - P_i X_i)\|_p^p) =$$

$$2(\sum_{1 \leq i < j \leq 2} \|P_i X_i - P_j X_j\|_p^{\frac{p}{2}} + \sum_{1 \leq i < j \leq 2} \|X_i Q_i - X_j Q_j\|_p^{\frac{p}{2}} + \sum_{1 \leq i < j \leq 2} \|X_i - X_j\|_p^{\frac{p}{2}} +$$

$$\sum_{1 \leq i < j \leq 2} \|X_i - X_j\|_p^{\frac{p}{2}}) + (\|\sum_{i=1}^2 \|P_i X_i - X_i Q_i\|_p^{\frac{p}{2}} + \|\sum_{i=1}^2 \|X_i Q_i - X_i\|_p^{\frac{p}{2}} + \|\sum_{i=1}^2 \|X_i - P_i X_i\|_p^{\frac{p}{2}}) \geq$$

$$\|\sum_{1 \leq i < j \leq 2} \|P_i X_i - P_j X_j\|_p^2 +$$

$$\sum_{1 \leq i < j \leq 2} \|X_i Q_i - X_j Q_j\|_p^2 + \sum_{i=1}^2 \|(P_i X_i - X_i Q_i)\|_p^2 + \sum_{i=1}^2 \|X_i Q_i - X_i\|_p^2 +$$

$$\begin{aligned}
& \sum_{1 \leq i < j \leq 2} |X_i - X_j|^2 + \sum_{i^2=1} |X_i Q_i - X_i|^2 \|_{p/2}^{p/2} + \|\sum_{1 \leq i < j \leq 2} |X_i - X_j|^2 + \\
& \sum_{1 \leq i < j \leq 2} |P_i X_i - P_j X_j|_2 + \sum_{2i=1} |X_i - P_i X_i|_2 \|_{p/2}^{p/2} = \|\sum_{i,j=1}^2 |P_i X_i - X_j Q_j|_2 \|_{pp/22} + \\
& \|\sum_{2i,j=1}^2 |X_i Q_i - X_j|^2 \|_{p/2}^{p/2} + \|\sum_{i,j=1}^2 |X_i - P_j X_j|_2 \|_{pp/22} \geq D_{PX}^{-1} \sum_{i,j=1}^2 \|X_i Q_i - \\
& P_i X_i - X_j Q_j\|_{pp/2}^2 + D_{XQ-X}^{-1} \sum_{i,j=1}^2 \|X_i Q_i - X_j\|_{p/2}^2 + D_{X-PX}^{-1} \sum_{i,j=1}^2 \|X_i Q_i - \\
& P_i X_i - P_j X_j\|_{pp/22} = \\
& \sum_{i,j=1}^2 \|P_i - X_j Q_j\|_{pp,j=1}^2 + D_{X-QX}^{-1} \sum_{i,j=1}^2 \|X_i Q_i - P_j X_j\|_{pp,j=1}^2 + D_{X-PX}^{-1} \sum_{i,j=1}^2 \|X_i Q_i - \\
& P_i X_i - P_j X_j\|_{pp}^2 \\
& D_{PX}
\end{aligned}$$

Proposition 3.1.1. Let $P_1, P_2, Q_1, Q_2 \in C_p$ for some $p > 0$. Then $\sum_{i,j=1}^2 \|P_i X_i - P_j X_j\|_{pp} + \sum_{2i,j=1}^2 \|X_i Q_i - X_j Q_j\|_{pp} \geq 2.2^{p-2} \sum_{2i,j=1}^2 \|P_i X_i - X_j Q_j\|_{pp} - 2 \|\sum_{2i=1}^2 (P_i X_i - X_i Q_i)\|_p$ for $0 < p \leq 2$.

Proof.

$$\begin{aligned}
& \text{We set } D_Q^{-\frac{p-2}{2}} \sum_{i,j=1}^2 = 2 D_Q^{-\frac{p-2}{2}} \sum_{i=1}^2 \|X_i Q_i\|_{pp}, D_X^{-\frac{p-2}{2}} \sum_{i,j=1}^2 \|X_i - P_j X_j\|_{pp} = \\
& 2 D_P^{-\frac{p-2}{2}} \sum_{i=1}^2 \|P_i X_i\|_{pp}. \\
& \text{Now } 0 \leq \sum_{i,j=1}^2 \|P_i X_i - P_j X_j\|_p + \sum_{i,j=1}^2 \|P_j X_j - X_i Q_i\|_p - D_{PX-XQ}^{-1} \sum_{i,j=1}^2 \|X_i Q_i - P_i X_i - P_j X_j\|_{pp} \\
& = 2 \left(D^{-\frac{p-2}{2}} \sum_{i,j=1}^2 \|X_i Q_i - P_i X_i - P_j X_j\|_p \right) + \left(\sum_{i=1}^2 (P_i X_i - X_i Q_i)_p + \sum_{i,j=1}^2 \|P_i X_i - P_j X_j\|_p + \sum_{i,j=1}^2 \|X_i Q_i - P_i X_i - P_j X_j\|_p \right) \\
& = \sum_{i,j=1}^2 \|X_i Q_i - P_i X_i - P_j X_j\|_p + \sum_{i,j=1}^2 \|P_i X_i - P_j X_j\|_p \\
& = 2 D_{PX-XQ}^{-\frac{p-2}{2}} \sum_{i,j=1}^2 \|X_i Q_i - P_i X_i - P_j X_j\|_p + 2 \|\sum_{i=1}^2 (P_i X_i - X_i Q_i)\|_p + (D_{PX-XQ}^{-\frac{p-2}{2}} \sum_{i,j=1}^2 \|X_i Q_i - P_i X_i - P_j X_j\|_p)
\end{aligned}$$

$$\begin{aligned}
& \left(\sum_{i=1}^2 \|X_i Q_i\|_{pp} - 2D_{PX-XQ} \sum_{i=1}^2 \|X_i Q_i\|_{pp} \right) \cdot D_{PX-XQ}^{-2} \sum_{j=1}^2 \|P_i X_i - X_j Q_j\|_{pp} - \left\| \sum_{i=1}^2 (P_i X_i - X_j Q_j) \right\|_p \\
& \quad \leq D_{PX-XQ}^{-2} \sum_{i=1}^2 \|X_i Q_i\|_{pp}^2 - \left\| \sum_{i=1}^2 X_i Q_i \right\|_p^2 \leq 0.
\end{aligned}$$

Since $2D_{PX-XQ}^{-2}$ is greater than or equal to 1, we deduce from lemma 4.20 that

$$\sum_{i=1}^2 \|P_i X_i - X_j Q_j\|_p \leq \sum_{i=1}^2 \|P_i X_i\|_p + \sum_{j=1}^2 \|X_j Q_j\|_p.$$

Similarly, we have $\sum_{i=1}^2 \|X_i Q_i\|_{pp} \leq 2D_{PX-XQ}^{-2} \sum_{i=1}^2 \|X_i Q_i\|_{pp} + \sum_{i=1}^2 \|X_i Q_i\|_p$. It therefore implies that

$$\begin{aligned}
& \sum_{i,j=1}^2 \|P_i X_i - P_j X_j\|_p + \sum_{i,j=1}^2 \|X_i Q_i - X_j Q_j\|_p \geq 2D_{PX-XQ}^{-2} \sum_{i,j=1}^2 \|X_i Q_i - X_j Q_j\|_{pp} \\
& \quad \geq 2 \cdot 2^{p-2} \sum_{i,j=1}^2 \|X_i Q_i - X_j Q_j\|_p - 2 \sum_{i,j=1}^2 \|P_i X_i - P_j X_j\|_p \geq 0.
\end{aligned}$$

Conclusion

In this paper, the study has shown that the norm of a derivation, induced by orthogonal projections via tensor product is linear, bounded and continuous. Furthermore, there is inequalities of such a derivation induced by n-tupled orthogonal projections.

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Effect of Varying Thickness on Performance of Titanium Dioxide Solar Cell

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Abstract

The need for energy to drive economic development has increased tremendously, yet most energy sources lead to environmental pollution with consequences such as global warming and serious health complications. Global warming for instance, exacerbate problems of some energy source like hydro-generated energy due to climate variability. Alternative options have thus to be investigated. This study assessed the effects of varying solar cell thickness on its output. The study used a TiO_2 (the photo active layer) and the electronegative material layers on current voltage output of the fabricated solar cell. Various ratios of titanium dioxide: graphite /iodine/KI mixtures were prepared in each respective layer. Optimization involved varying the mass of the constituents of each layer, while maintaining other constants to obtain the highest current-voltage outputs. The mixtures at varying ratios were made into pellets and their electrical properties investigated. The presence of KI enabled solubility of iodine enhancing it to disperse evenly in graphite whose mass was constant at 0.01g in all the cells fabricated. The optimal thicknesses were found to be 2.00 and 1.00 mm respectively. The optimum electricity generation was observed at the ratio of $\text{TiO}_2/\text{C}_x:\text{I}_2:\text{KI}$ as 0.4: 0.3: 0.17: 0.01g, respectively. The highest open circuit voltage (V_{oc}) of 0.979V and a short circuit current density (J_{sc}/cm^2) of $12.037\mu\text{A}$ was observed, giving efficiency (η) of 0.006% and a Fill factor (FF) of 0.64. The study concludes that thicker cells resulted to higher voltage and current output. However, this variation was dependent on the ratio of $\text{TiO}_2/\text{C}_x:\text{I}_2:\text{KI}$. Industrial and scholarly recommendations are presented.

Keywords: *Varying Thickness, Performance, Titanium Dioxide Solar Cell.*

Introduction

The need for energy to drive industrial, domestic and other social economic projects increases with the population growth. Currently, most energy sources result to environmental pollution with consequences such as global warming and serious health complications. Factors such as global warming exacerbate the problem of some energy source like hydro-generated energy due to drought. Due to such challenges, alternative options of energy sources have to be investigated. This study sought to fabricate a non-corrosive cell with no toxic emissions. Besides

environmental friendliness, optimized solar cells can be used to bridge this energy gap.

Electrode Thickness

Thickness of solar cell electrodes dominantly influence its optics (Naqavi, 2013). When the thickness of electrodes is modified, it exerts impacts on the conduction band edges of the semiconductor material and the electron excitation is potentially improved. According to Kavita (2011), ordered configuration of particles in solar cells is attributed to photon energy diffusion dynamics and strain in the film. With three different thicknesses, Kavita revealed that the characterized fabricated samples had identical film properties. Kavita concluded that photon diffusion was affected by thicker layer interface. Thicker layers affect diffusion of photon energy in thin films resulting to low potential (Kavita, 2011; Zhang, 2013).

Grätzel (2009) indicated that coating graphite onto the conductive side is one of the crucial steps for making the dye-sensitized solar cells (DSSC). Therefore, the study tested the dependence of the thickness of graphite layer with the performance of the cell. Grätzel (2003) noted that graphite layer has potential influence on the efficiency of the solar cell. Graphite layer is necessary for cell functioning properly (O'Regan & Grätzel, 1991) and is controlled by manipulating the time over the candle flame. Difference in thickness of graphite can be tracked by the colour of the layer (O'Regan & Grätzel, 1991). However, graphite layer was necessary for the DSSC to produce voltage and bulky thickness would not improve the efficiency of the solar cell (O'Regan & Grätzel, 1991).

O'Regan and Grätzel (1991) fabricated titanium dioxide solar cell through a wet chemical process. Thicker layers of titanium dioxide potentially decrease the output of the cell by blocking the photon transfer (Grätzel, 2003). The development of the cell brought about the possibility of having an alternative to silicon based photovoltaic cell (Sundaram, 2009). The Grätzel cell (DSSC) is inexpensive, easy to develop and has an overall conversion efficiency at 12%. However, the cell suffers from corrosion due to action of oxygen on the material used (Sundaram, 2009). The current study exploited the same principles of the DSSC but without the aqueous media to minimize effects of corrosion.

Statement of the Problem

Climate change and variability has resulted to reduced precipitation hence affecting water levels and HEP production. Fossil fuel on the other hand has contributed to environmental pollution which has disastrous health effects (Herman, 2002). Domestic lighting is essential in many homesteads particularly in rural Kenya as most of them are not connected to the national grid (Ahmad & Mohammad, 2010) and use paraffin which on combustion results to respiratory ailments. Alternative sources of energy are therefore required and solar power offers the best alternative. The use of doped titanium dioxide activated by ordinary radiation and graphite as the conduit for the migration of electrons are suitable materials for making a solar cell (Ahmad & Mohammad, 2010). Due to the rising

cost of energy, alternative options of generation of electricity necessitated this study to be carried out. This study endeavoured to fabricate a solid solar cell using titanium dioxide (TiO_2), and iodine (I_2) with potassium iodide (KI/I_2) dispersed in graphite (C_x) for solar cell application. This was intended to be an alternative green source of energy which is renewable and not easily degraded.

Materials and Methods

The study adopted an experimental research design to investigate the performance of the fabricated solar cell. It was done by first obtaining the optimal values of the parameters under investigation. The best parameters were obtained by establishing the optimal values of each material constituent of the cell. These were TiO_2 , which was the photoactive material, the graphite which was the conducting medium and the Iodine/Iodide mixture which replenished the electrons conducted away after photo excitation. This process employed varying the weights of the component parts, and finally characterization of the fabricated solar cells under constant radiation intensity in clear daylight.

In the study, the following assumptions were made: The solar radiation was assumed to be constant at $100 \text{ mW}/\text{cm}^2$ irradiance (Hagfeldt *et al.*, 2010); the solar density on the solar cell was assumed to be uniform, and the voltage drop in the digital meter leads was assumed to be negligible. All reagents were of analytical grade and were sourced from Sigma Aldrich. The titanium dioxide (TiO_2), iodine (I_2), potassium iodide (KI) and graphite (C_x) in their powder form were used.

To fabricate the solar cell, different mass ratios of graphite (C_x) powder, titanium dioxide (TiO_2) powder, potassium iodide (KI) and iodine (I_2) were mixed and compressed to form a Solar Cell. Figure 1 below shows the schematic presentation of the fabricated cell.

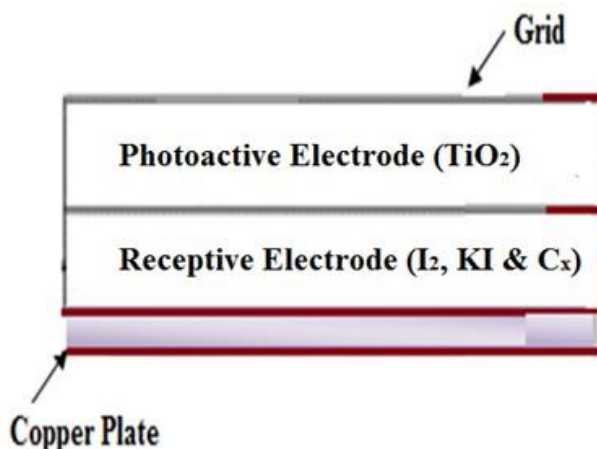


Figure 1: Schematic presentation of the fabricated solar cell

To provide the required dimensions, a copper plate was cut into 2.5 cm by 2.5 cm by the use of metal plate shears. An active cell of $\varnothing 1.3 \text{ cm}$ ($A=1.327 \text{ cm}^2$) was prepared, laid on the copper plate and covered with a transparent raising as a copper conductor

in contact with the upper electrode was drawn through the raisin for external connection.

The first cell electrode was made by placing the photo active measured sample separately in a circular dice and compressed thoroughly. The second electrode was made by disposing the mixtures of mass ratios of (graphite: iodine: I_2/KI) over the initial layer and the pressing procedure followed. The resultant was a circular pellet which served as the photo active cell. I-V characteristics of each of the resulting cells were monitored. The photo active (cathode) was prepared by varying masses of powdered TiO_2 ranging from (0.2-1) g. These masses were inserted in a moulding dice and pressed into a disc form with a diameter of 1.3 cm to form a circular pellet.

The receptive layer (anode) was prepared by varying masses of finely divided mixtures of mass ratios (graphite: I_2 : I_2/KI) ranging from (0.1: 0.1: 0.01) g to (0.6: 0.3: 0.01) g. These mixtures of mass ratios were then inserted in a moulding dice and pressed into a disc form with a diameter of 1.3 cm to form a circular pellet similar in size to the photoactive layer. The receptive layer (anode) was then placed on photo active (cathode) and pressed further to form a complete assembly of the solar cell. External conductors were then connected to the cell for I-V characterization. Figure 2 below shows the schematic cell presentation of the solar cell.

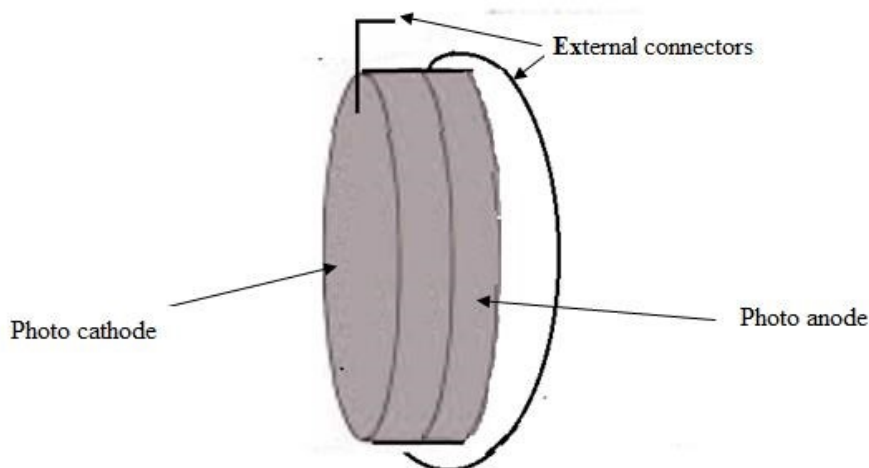


Figure 2: Photo Voltaic Cell Scheme

The optimum I-V characteristics were established using the circuit diagram of Figure 3 below:

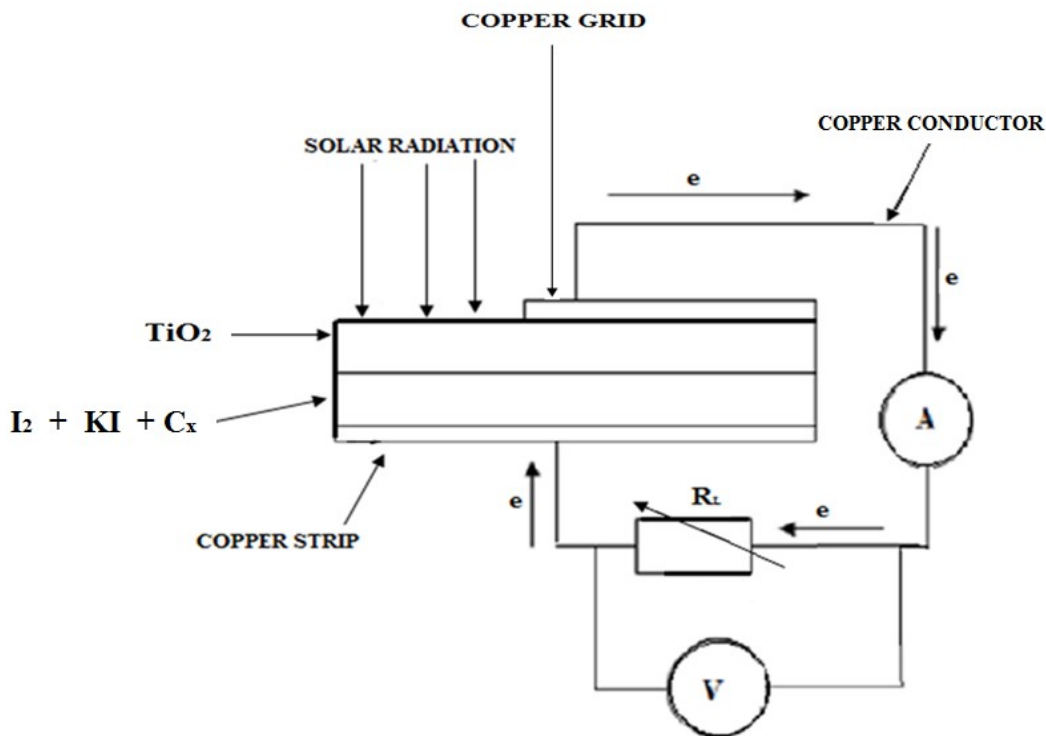


Figure 3: Assembly of the Circuit Diagram for the I-V Characterization

A high resolution micro-Ammeter (0-100 μA) was connected in series with the fabricated Solar cell to measure the current density output (J_{MP}) resulting from the generated charge carriers which migrated from the photo active cathode layer of the cell through external conductors and back to the cell through the anode. A high resolution galvanometer (0-250 mV) was connected in parallel with the arrangement of the $\varnothing$ 1.3 cm ($A=1.327 \text{ cm}^2$) active solar cell and the micro-Ammeter (0-100 μA) to measure the resulting open circuit voltage (V_{OC}) at the output terminals.

A high resolution graduated variable resistor (Ohmmeter) (0-34 Ω) was connected in series with the micro-Ammeter (μA) and in parallel with the galvanometer (0-250 mV). The variable resistor served the purpose of an external load and the ratio of the generated potential (V_{MP}) to the measured resistance at any particular instant, confirmed the amount of the current density (J_{MP}) through the external circuit and this was recorded to determine the maximum power (P_{MAX}) of the solar cell. The short circuit current density ($J_{\text{SC}}/\text{cm}^2$) values were determined at zero applied voltage and the open circuit voltage (V_{OC}) values were determined at zero current under solar radiation. The current generated against their corresponding potential for various cells were collected and tabulated. The voltage output for maximum power output (P_{MAX}) were taken at 5 minutes intervals and tabulated for analysis.

The fabricated solar cell parameters were calculated using equations as applied by Adegbenro (2016), while calculating parameters of different shapes and states of

solar cells. In his study, the cells were in 1cm² squared blocks, while the cell in this study had a diameter of (Ø) 1.3 cm giving an area (A) of 1.327 cm²:

$$\frac{V_{MAX}(mV/cm^2)}{V_{MP}} \times A$$

(1)

$$\frac{I_{MAX}(\mu A/cm^2)}{J_{MP}} \times A$$

(2)

$$P_{MAX} = V_{MP} \times J_{MAX}$$

(3)

$$\frac{I_{SC}(\mu A/cm^2)}{J_{SC}} \times A$$

(4)

$$\frac{V_{OC}^2(mV/cm^2)}{V_{OC}/cm} \times A$$

(5)

$$P_T = V_{OC}/cm^2 \times J_{SC}/cm^2$$

(6)

$$\frac{J_{MP} V_{MP}}{J_{SC} V_{OC}} \times \text{Fill Factor (FF)}$$

(7)

$$\text{Shunt Resistance (R}_{SH}) = \frac{\Delta Y}{\Delta X}$$

(8)

$$\text{Series Resistance (R}_S) = \frac{\Delta X}{\Delta Y}$$

$$\eta = \frac{J_{sc} V_{oc}}{p_{in} A} \quad (9)$$

(10)

'A' is the photoactive area of the cell; $A = 1.327 \text{ cm}^2$. In the study, the parameters were obtained by adopting expression 1-10 as applied by Adegbenro (2016) when he characterized different shapes and states of solar cells to obtain their parameter values.

Jain (2013) defines the open circuit voltage (V_{oc}) is the voltage delivered by the solar cell when the electrodes are isolated and no current is sourced under infinite load resistance. This voltage represents the maximum potential energy stored to initiate the flow of electrons which are yet to be dissipated. Jain also notes that the voltage of a unit area (V_{oc}/cm^2) delivered by a solar cell when the electrodes are isolated represents the maximum potential energy stored to initiate the flow of electrons which are yet to be dissipated.

Results and Discussions

Effect of the Cell Thickness on Potential (V_{oc}) and Efficiency ($\eta\%$)

The influence of photoactive layer thickness on the photocurrent density was a parameter of concern. This is because thickness has effects on the penetration of radiation that reaches the photo active material and as a consequence influences the resistivity of the cell (Wasiu, 2017; Zhang, 2013). As such, an optimum value had to be established for optimal results. The effect of (1, 2, 3 and 4) mm thickness of the photo active material (TiO_2) on the open circuit voltage and the efficiency of the solar cell was investigated and the results obtained were as presented in Table 1 below.

Table 1: Effect of Varying Thickness of the Optimized Solar Cells on V_{oc} (V) and $\eta\%$

Layer	Thickness (mm) of TiO_2	V_{oc} (V)	Efficiency (η) %
One layer	1	0.833	0.0034
Two layers	2	0.979	0.0060
Three layers	3	0.562	0.0040
Four layers	4	0.497	0.0038

From the information recorded in Table 1 above, graphical presentations of potentials and efficiency ($\eta\%$) against the thickness of the photo active material were made as presented in Figures 4 and 5 below.

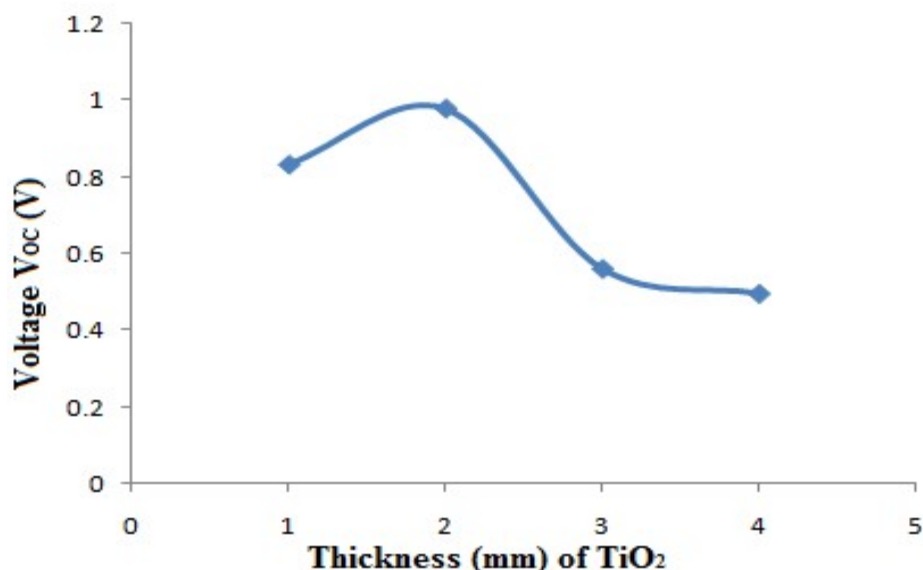


Figure 4: Variation of the cell thickness against V_{oc}

The results in Figure 4 show a gradual increase in potential until a thickness of 2.0 mm after which the optimal value of the photoactive cell yielded a potential of 0.979 V. A sudden decrease in potential was observed as the thickness of the photoactive material was increased. This can be concluded that thicker layers of titanium dioxide potentially decrease the output of the cell by blocking the photon transfer (Grätzel, 2003). Comparable observations were presented by Swapnil (2016) when he fabricated and characterized an organic solar cell. Another graphical presentation of efficiency ($\eta\%$) against the thickness of the photo active material was made from the information recorded in Table 1, as presented in Figure 5. A similar profile to that of Figure 4 was observed confirming that the optimum thickness found for maximum potential was also the one for maximum efficiency.

This shows that even if the thickness of the cell is enhanced thus to increase more charge carriers, there has to be agreement in the generated free electrons and the resistivity of the cell to enable the migration of the current (Calado *et al.*, 2016).

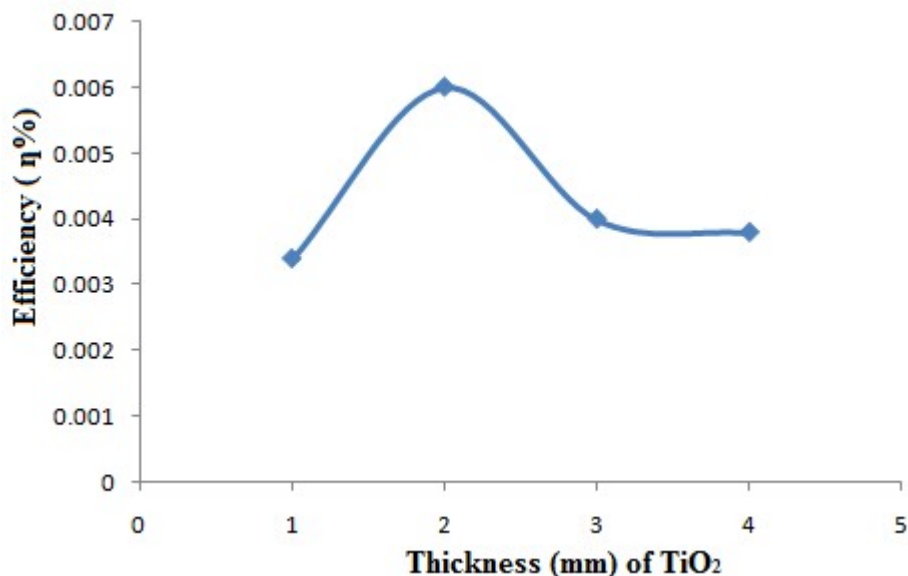


Figure 5: Variation of the cell thickness against efficiency η %

From Figure 5 above, it is observed that an increase in the number of TiO₂ layers from one layer to two layers raised the efficiency by 0.0026%. However, an increase from two layers to three layers contributed to a decrease in the efficiency by 0.002%. This change indicates that the thickness of TiO₂ photo anode layer made in this study has influence on the performance of the solar cell due to effects on the cell internal resistance (Imran, 2013). An increase in the thickness of both the conducting graphite medium – (C_x) and that the photo active material (TiO₂) contributed to a longer path for the photo-generated electrons to reach the working electrode thus delaying the electron recombination process. The thickness of the photoactive material was found to have a direct impact on the cell efficiency. The thickness of the cell made from a combination of the mass ratio of (0.4: 0.3: 0.17) of TiO₂: graphite: I₂ respectively was observed to give an open circuit voltage (V_{oc}) of 0.979 V as presented in Figure 4.

Conclusion and Recommendations

Based on the above findings, the study adopted the values for the optimized thickness of the photo active layer as 2 mm for the fabrication of solar cells for I-V characterization. Certain thickness of the photo active material (TiO₂) and graphite (C_x) were observed to affect the cells output since variation of TiO₂ generated varied potentials. A thickness of 2 mm and 1 mm of TiO₂ and graphite respectively yielded the highest potential of 0.979 V. This study concludes that thickness affects penetration of radiation and also increases the parasitic resistance to the migrating electrons. It is therefore recommended that further research work be done using TCO (transparent conducting oxide) as the cathode in addition to employing technologies that can reduce air packets in the solar cell.

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Investigating the Effect of an IR Emitting Element to the Time Constant of Solar Energy Harvesting Device Lifetime

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Abstract

Solar photovoltaic (PV) system is instrumental in provision of sustainable energy in the wake of social and environmental concerns. While research in solar cell efficiency has made great strides and achieved over 40% efficiency. Key concern is however, extending time constant of solar cell lifetime in minimum or no insolation. This emanates from the fact that most of solar cells have solid power storage which runs out under limited insolation reducing reliability of the cells. Improved in PVs high efficiency with flexible and lightweight thin films, would reduce on reliability which can guarantee longest time output in limited insolation. This paper investigated the effect of an infra-red generating element on time constant of a solar cell lifetime when the element is placed adjacent to solar cell. Using a dyesensitized (DSSC) TiO₂ solar cell electrode, maintaining topology, thermal escape mechanism, quantum structure and optical absorption of In(Ga)As quantum dots in a wide gap Al_{0.2}GaAs host material, the study investigated effect of attaching an emitting element on the solar cell lifetime whose findings showed a minimum of 27% increase in power output under low irradiation, while 14% increase in power output was recorded for high irradiation when an IR diode was mounted adjacent to solar cell. The study concluded that standardized IR element adjacent to a solar cell in a PV system significantly stretch a solar cell lifetime and power output.

Keywords: Solar Cell Efficiency, Time Constant, IR Emitting Element, Solar Cell Lifetime.

Introduction

The rapidly increasing energy demand (Madlener & Sunak, 2011; Wolfram, Shelef & Gertler, 2012) and the concerns over environmental degradation (Smil, 2015) resulted from the use of conventional energy sources have opened option for exploring more alternatives sources for energy production. Solar energy is considered as a major renewable sources of energy (Kabir et al., 2018) since it involves zero greenhouse gas emission and zero dependence on fossil fuels (Panwar, Kaushik & Kothari, 2011). The use of solar energy suffers from the challenge of ensuring steady flow of electric power (Li et al., 2011) particularly during the periods of low solar radiation. This has caused system designers to look into the reliability aspects of solar photovoltaic systems (Sharma & Chandel, 2013; Mustafa et al., 2020). One way of minimizing the impact of irregular power supply is by the inclusion of a storage unit so that the surplus energy generated during period of high solar radiation can be stored and utilized later during periods when solar radiation is low or absent. But, according to Schoenung (2011) storage systems

using batteries are an expensive proposition. It is of interest to system design engineers to examine just how much is gained in terms of reliability of power delivery at the cost of hardware failure of panel for solar PV systems operated with and without battery storage.

According to Chander et al. (2015), the change in the incident intensity on a solar cell causes change in all solar cell parameters, which include short circuit current (I_{sc}), open circuit voltage (V_{oc}), the fill factor (FF), efficiency (η), diode ideality factor (n), reverse saturation current (I_{rs}), series resistance (R_s) and shunt resistance ($R_{sh} = I/G_{sh}$). These parameters affect the efficiency of the solar cell (Chikate et al., 2015). Chegaar et al. (2013) found that the short circuit current, the photocurrent and the ideality factor increased linearly with the irradiation level intensity, while the open circuit voltage and efficiency increased logarithmically. According to the study, the fill factor increased slightly for low irradiation intensities, and then it decreased with higher intensities of irradiation. The saturation current increased exponentially, while the series resistance remained invariant and the shunt resistance decreased linearly. It is thus observed that at lower light levels, the shunt resistance impact becomes **increasingly essential**. With reduction in light intensity, the **bias point** and current through solar cell decrease as well, and the solar cell's equivalent resistance can start to approach the shunt resistance. If these two resistances are **equal**, the total current fraction flowing through shunt resistance **increases**, therefore increasing the fractional power loss from shunt resistance. These findings show the importance of taking into account the kind of application of solar cells under low and high illumination intensities.

However, with increased global reliance on solar energy (Solangi et al., 2011), there is need to come up with solar cells that not only have higher efficiency, but also have the ability to stretch their output beyond the irradiation period. Ordinarily, the time constant of a solar cell determines the quasi static condition (Pockett et al., 2015). The magnitude of the time constant depends on various parameters such as the operating point (voltage and current), temperature, irradiance level, minority carrier lifetime, and other semiconductor parameters only to mention the most important ones. This study thus sought to establish if placing an IR element adjacent to the solar cell can reasonably stretch the output life constant hence ensuring reliability of the solar cell under limited irradiation.

Operating solar photovoltaic at lower temperature will increase its lifespan (Siecker, Kusakana & Numbi, 2017). This will reduce module surface area by increasing overall output power. Researchers have proposed and tested several cooling techniques for the panel. One of the most common and effective way to cool PV module is used of water as coolant (Sharma et al., 2018). There are a number of means available to increase solar panel output and efficiency (Stritih, 2016). These factors include solar cell experimental technologies and highest efficiencies where multi-cell gallium arsenide has been found to have 44% efficiency; fill factor (utilization of available surface area); grade of the solar cell; **solar cells glazing** (optical transmissivity) and solar panel orientation. Of the most important according to this study is the **Maximum Power Point Tracking** (MPPT) controller (turns excess power in form of heat into additional charge current). In

this study, if this excess power is redirected to the IR emitting element so that the output of the solar cell can be stretched beyond the set period of production when the solar cell receives limited irradiation. This stems from the fact that even though research to increase the lifespan of a solar cell has been extensively done, information on extension of the output time of the solar cell after the irradiation is still scanty.

Methods and Materials

Using two dye-sensitized solar cells (DSSC) using TiO_2 electrodes and germanium (Ge) mid-wave infrared (MWIR) diode of wavelength $25\mu\text{m}$, with index of refraction (n_d) of 4.003, density of 5.33gcm^{-3} , coefficient of thermal expansion (CTE) of $6.1 \times 10^6/^{\circ}\text{C}$ and knop hardness of 780, the diode was mounted on the same chip board with one of the solar cell, while the other solar cell was left alone. The reason for choosing InGaP/InGaAs/Ge photovoltaic cells is that they are made to work in concentrated light and their structure is triple junction and the dimensions are $1\text{ cm}/1\text{ cm}$. The short circuit current measured at 190 suns is 2.67A and the open circuit voltage is 2.82 V . No-load voltage (maximum voltage the cell will produce under the current light conditions) and the short-circuit current (maximum current your solar cell can provide) were taken. Next, the load was swept, while recording voltage and current. For all the observations, resistance was kept constant (same as in the first observation) to enable track changes in the output of the solar cell at the same resistance at different times of day and with/without the IR diode.

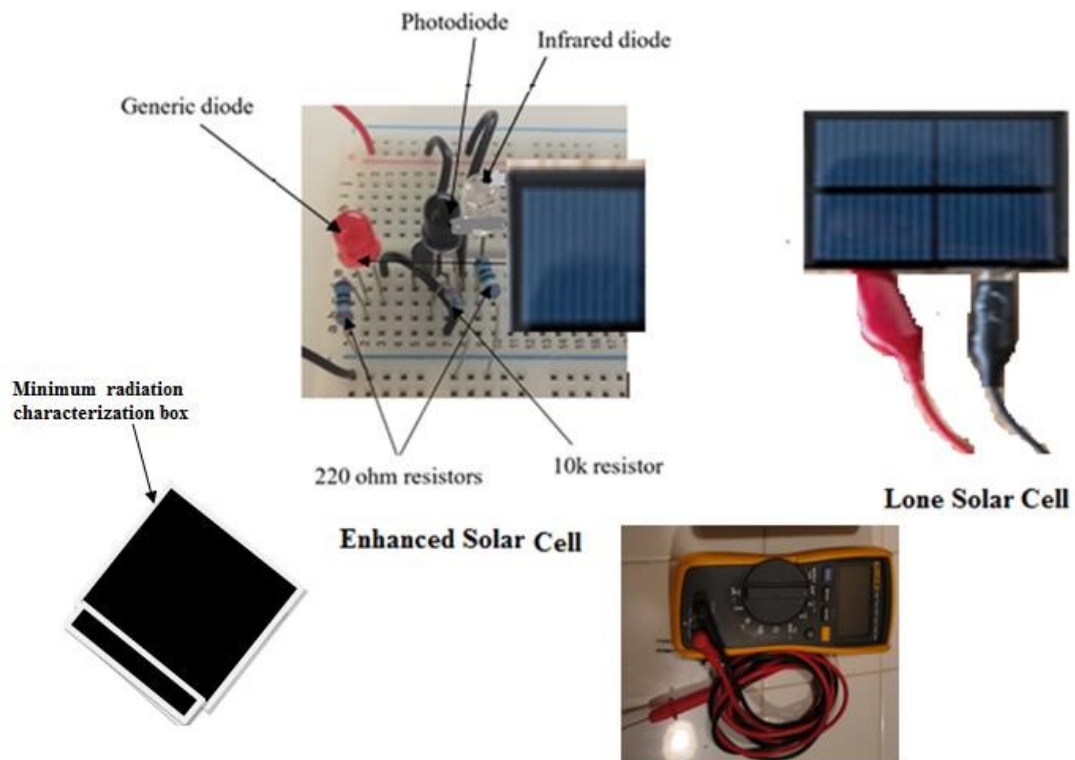


Figure 1: Solar Cell Circuit Assemblage and the Characterization Equipment

The two R_{SH} and single R_S were meant to characterize the solar energy harvesting device for short circuit current (I_{SC}) measured in a sunny day and the open circuit voltage (V_{OC}). For all the observations, resistance was kept constant to enable track changes in the output terminals at different seasons of the day, with and without the IR diode.

The circuit for the characterization is as presented in Figure 2 below

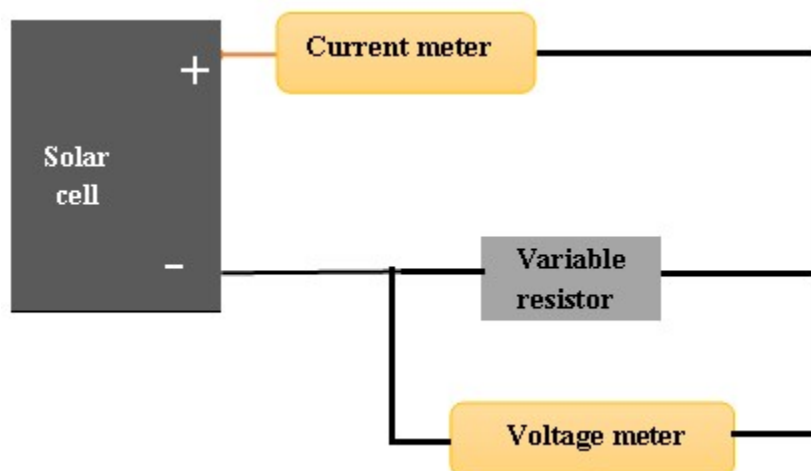


Figure 2: Characterization Circuit of the IR enhanced Solar Energy Harvesting Unit

Two sets of observations were recorded at varied sessions of the day take for comparison of different irradiance. The circuit was used to characterize the lone cell and that which was mounted adjacent to IR diode. The pair of the experiment conducted between 12 noon and 2 pm for full irradiance and between (5 – 7) pm (EAT) for minimum irradiance.

Results

The experiment was conducted to determine the voltage and current produced by the solar cell at different resistance levels for high irradiance level. The power output was then calculated for the high irradiance.

Table 1: T-I/V Characteristics of IR Enhanced Solar Cell

	Time/Minutes	V _{OC} (V)	I _{SC} (μ A)
0	30.21	2.29	
1	29.17	3	
	3	28.12	4.25
	5	27.09	4.51
	7	27.03	6.48
	11	26.99	10.5
	17	26.84	12.8
	27	26.77	14.5
	37	26.63	19.7
	51	25.44	21.4
	57	24.02	22.8
	60	20.99	29.2
	63	19.75	30.4
	67	18.41	31.3

69	18.36	32.5
73	17.22	35.8
77	16.19	36.1
81	13.15	36.9
87	10.09	37.6
93	8.06	37.9
97	9.74	38.3
101	7.12	38.5
107	5.61	39
111	4.09	39.2
115	3.32	39.5
121	2.71	42
125	2.56	42.9
129	2.11	43
137	2.96	45.2
143	2.48	45.9
157	2.37	56
180	0.8	57

From the results of Table 1, a graphical presentation of time against current (I_{sc}) and potential (V_{oc}) was made during the high irradiation with an IR diode

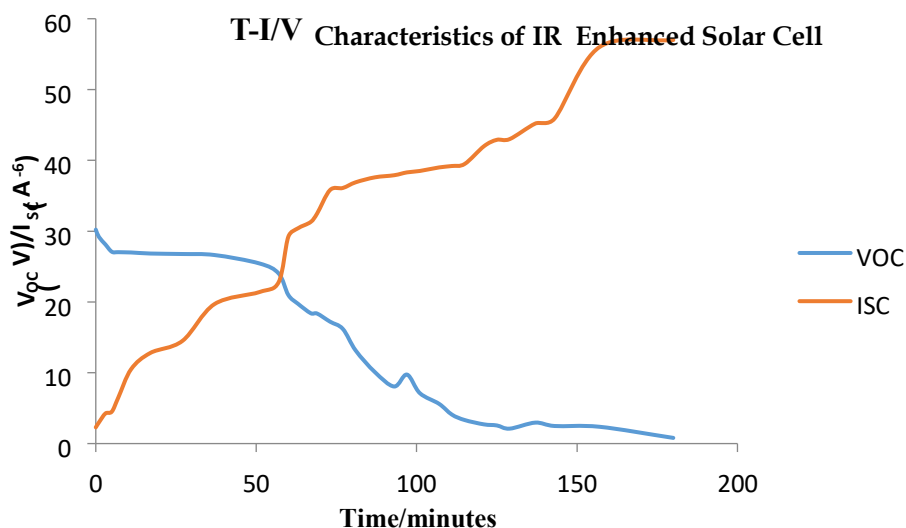


Figure 2: T-I/V Characteristics of IR Enhanced Solar Cell

Figure 2 shows variation of potential V_{OC} (V) and short circuit current (I_{SC}) (μA) with time (minutes). Potential was initially observed to built up to 30.21V, while the decay in gradually in minimum solar radiation for the three hours the cell was monitored under minimum radiation. Some residual potential were observed at 0.8V and some level of charge carriers generating a current of $57\mu A$. The residual power of $45.6\mu W$ which could sustain an LED within a duration of several minutes. Another experiment was conducted IR enhancing diode solar cell and the results were recorded in Table 2.

Table 2: T-I/V Characteristics of a Solar Cell Void of IR Enhancement Element

Time/Minutes	V_{OC} (V)	I_{SC}
0	10.16	0.29
1	10.07	0.3
3	9.48	0.5
5	9.35	0.71
7	9.22	0.8
11	9.18	1.5
17	9.11	1.8
27	9.09	2.23

37	8.52	2.35
51	8.4	2.4
57	7.18	2.6
60	6.98	2.62
63	6.62	2.74
67	5.41	2.83
69	5.12	2.95
73	4.32	3
77	4.19	3.1
81	3.4	3.39
87	3.11	3.46
93	2.76	3.69
97	2.35	3.8
101	1.6	3.98
107	1.27	4.19
111	0.6	4.2
115	0.2	4.5
121	0	4.72
125	0	4.72
129	0	4.7
137	0	4.69
143	0	4.68
157	0	4.5
180	0	4.42

From the results of Table 2, a graphical presentation of time against the current generated and potential decay were observed as shown in Figure 3.

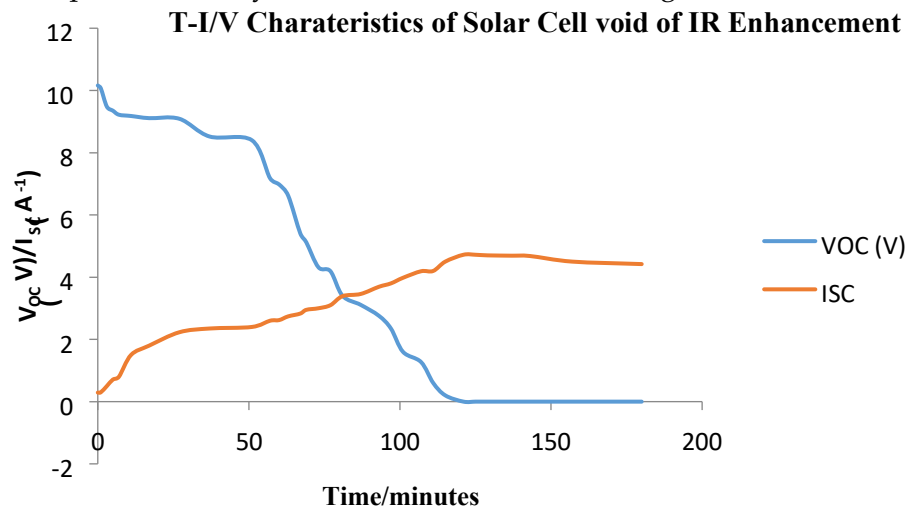


Figure 3: T-I/V characteristics of the solar cell void of IR enhancement element

The result of Figure 3 shows minimum potential (V_{oc}) of 0.2V and short circuit current (I_{sc}) of $4.42\mu A$ respectively observed within the duration of two hours power (P_{MAX}) generated was $0.38\mu W$.

Table 3: P_{MAX} (IR) and P_{MAX} (void) Characteristics of the Solar Cell.

Time/minutes	$P_{(IR)}$	$P_{(V)}$
0	69.1	2.95
1	87.5	3.02
3	119.5	4.74
5	122.2	6.64
7	175.2	7.4
11	283.4	13.8
17	343.6	16.4
27	388.2	20.3
37	524.6	20
51	544.4	20.2

57	547.7	18.7
60	612.9	18.3
63	600.4	18.2
67	576.2	15.3
69	596.7	15.1
73	616.5	12.9
77	584.5	12.9
81	485.2	11.5
87	379.4	10.8
93	305.5	10.2
97	373.04	8.9
101	274.1	6.4
107	218.8	5.3
111	160.3	2.5
115	131.1	0.9
121	113.8	0
125	109.8	0
129	90.7	0
137	133.8	0
143	113.8	0
157	132.7	0
180	45.6	0

From the results of Table 3, a characteristic plot was made of time against power generated by IR enhance solar cell to that void as shown in Figure 4.

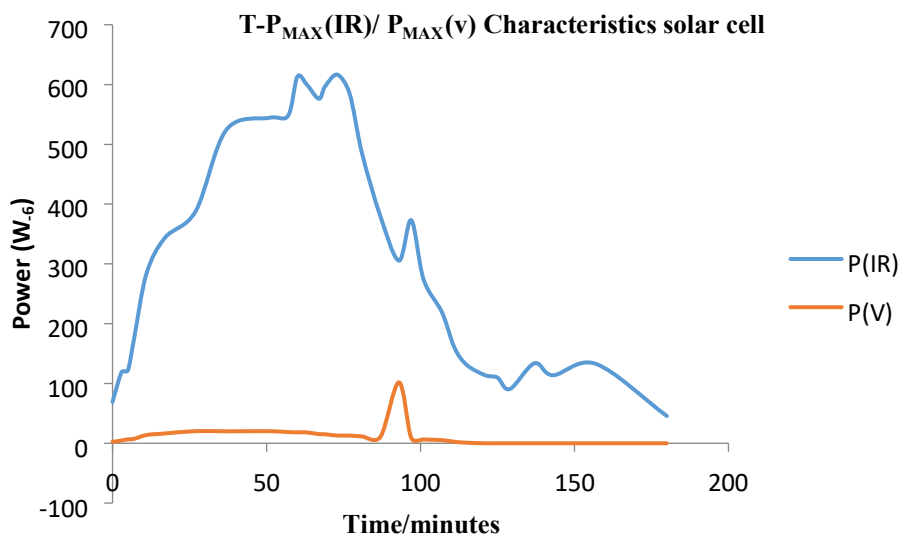


Figure 4: T- $P_{MAX}(IR)/P_{MAX}(v)$ Characteristics Solar Cell at Minimum Solar Radiation.

The result of Figure 4 shows that the IR solar cell generated energy of (612.9 μW) in minimum solar radiation and sustained to (45.6 μW) up to the end of the three hours void of natural solar radiation. The IR diode enhancement contributed to gradual decay of radiation since the P_{MAX} generated by that void was recorded at a negligible value (20.3 μW) which finally decayed to zero.

Discussion

The study revealed that at the IR enhanced contributed to a gradual delay in charge carrier generation which could support sensitive services in the absence of chemical stored grid energy for a longer duration. There was a wide in production between power and current from the two energy resources. At low irradiance, the IR enhanced solar cell sustained upto 0.8V with a current of 57 μA .

Finally, while there was a maximum difference in the sustained potential of 21.4% two hours after withdrawal of natural radiation the gap between the current generated was above 30%. The power of the cell void of IR enhancement was almost at negligible value after 111minutes.

Conclusion

Study showed that the IR diode increased the power output of the solar cell to more than 300%. An indication that it can support the life time of energy in emergency cases in regions of low solar radiation.

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Social Media: A Knowledge Sharing Strategy at Kirinyaga University Library

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Abstract

Social media platforms have transformed into tools that allow for interactive participation. These tools that have changed methods of communication include YouTube, My Space, LinkedIn, Twitter and Facebook. Many organizations have adopted various types of social media platforms as a means of sharing knowledge among its stakeholders. Several organizations in their vision to competitive and productive are adopting strategies of communication that enable both external and internal partnership. The emerging opportunities are provided by social media when knowledge is shared through them, enabling effective and efficient dissemination of knowledge by members of that organization. Academic libraries being among organizations influenced by technology and technological changes, have not been left behind. Academic libraries have in the 21st century adopted social media platforms as a means of sharing knowledge with its clientele. This paper investigated social media as a knowledge sharing strategy that has been adopted by Kirinyaga University library, identified specific social media platforms that were used in sharing knowledge, benefits of social media platforms in knowledge sharing, and challenges faced in sharing knowledge. Descriptive research design was adopted. The study targeted students and library staff resulting in a sample of 169. Data was collected using questionnaires. The study found that the participants were using Facebook, Twitter and WhatsApp to share library related knowledge. Social media was quicker in sharing information, convenient and faster. Some of the challenges they faced in sharing knowledge using social media were poor connectivity and low bandwidth. The study concluded that use of social media was a strategy academic libraries could use in sharing knowledge. The study recommends that academic libraries explore additional emerging and popular social media platforms that appeal to the users and offer more opportunities for sharing knowledge.

Keywords: Knowledge Sharing, Social Media, Academic Libraries.

Introduction/Background

The experience of social media cannot go unnoticed (Nielsen & Razmerita, 2014).

Methods of communication have been changed by social media platforms like YouTube, Twitter and Facebook. Organizations are adopting concepts of social media as a means of reshaping how knowledge is shared. According to Nelson (2015), various organizations have become competitive and productive by embracing communication strategies that increase the sharing of knowledge. Social media therefore provides the sharing of knowledge through platforms such as Twitter, Facebook and Wikis hence enabling knowledge dissemination amongst users and

library employees. Social media platforms therefore harness new opportunities within the organization by enabling the existing knowledge within the organizations to be shared. Some of the benefits provide by use of social media within an organization include enhanced services, increased income and reduction of business operations (Nielsen & Razmerita, 2014).

Knowledge sharing is a key aspect in the management of knowledge within institutions (Harden, 2012). It has become important in enabling the organization to convert an individual employee's knowledge into the knowledge of an organization. According to Brcic and Mihelic (2015), knowledge sharing results in knowledge generation, development of beliefs and problem solving. This knowledge in particular can be attributed to information on products, services and experience of clients. According to Chand and Chuang (2011), quality of sharing knowledge was being enhanced by social interactions. Gruber et al. (2015) opined that when academic libraries increased their presence on social media, communication and sharing of knowledge also increased within their social media platforms.

Academic libraries like other institutions have adopted social media platforms in different facets of their operations. The advent of social media and its relationship with academic library community has dynamically changed access and sharing information. Social media has emerged as a medium of communication with the use of internet leading to embracing of social communication within academic libraries. The various types of social media platforms that have found their use in academic libraries include Flickr, Digg, Mash Up, Wikis, Facebook and Twitter among others (Xie & Stevenson, 2014).

Materials and Methods

The study adopted descriptive research design. It allowed for the untampered studying of the participants in their natural environment. Kirinyaga University library was selected in this study, because it already utilizes social media platforms as a strategy in sharing knowledge. The study settled on a sample of 169 students and library staff. Self-administered questionnaire were used to acquire relevant data from participants. A statistical software SPSS v23 was used to analyze the collected data.

Results

The study attained a response rate of 83%. This being responses from 140 participants from the sampled 169. This sample size was therefore considered acceptable and credible considering recommendations Bailey (2010). The results showed male (60), while 40% were female respondents. The participants (45%) were mainly youthful (between 18-25 years) and most of them (40%) pursuing diploma courses. This was important for the study because this category of participants is considered to be high users of social media platforms for different purposes (Jolles & Crone, 2012). The demographic information for the participants is captured in Table 1.

Table 1: Participants' Demographic Information

Demographic Information	% (n)
Gender	
Male	60% (84)
Female	40% (56)
Age	
18-25 years	47% (66)
26-33 years	18% (25)
34-41 years	21% (29)
42 years and above	14% (20)
Education Level	
Certificate	29% (41)
Diploma	40% (56)
Undergraduate degree	31% (43)

Social Media Platforms used in Sharing Knowledge in Academic Libraries The participants were asked about the social media platforms they were using to access and share knowledge within Kirinyaga University library. The findings are presented in Table 2 below.

Table 2: Social Media Strategies

Social Media Platforms	Frequency	Percentage
Facebook	63	45
Twitter	28	20
WhatsApp	49	35

Most of the participants indicated that Facebook (69%) was the social media platform used in sharing knowledge, 49% choose WhatsApp and 28% indicated Twitter. This shows that there were more than one social media strategy that were being used to share knowledge at Kirinyaga University library. Facebook platform was the most used social media strategy

Benefits of Using Social Media Platforms as a Strategy of Sharing Knowledge The participants were asked to state the benefits of using social media platforms as a strategy of sharing knowledge at Kirinyaga University library. The findings are presented in Table 3 below.

Table 3: Benefits of using Social Media Platforms in Sharing Knowledge

Benefits	Frequency	Percentage
Quicker way of sharing knowledge	63	45
Easier knowledge sharing strategy	45	32
It is a convenient way of knowledge sharing	32	23

Most of the participants (45%) indicated that using social media as a strategy was a quicker way of sharing knowledge, 32% indicated it was an easier knowledge sharing strategy, while 23% stated that it was a convenient way of sharing knowledge. The results showed that social media was a strategy that was being utilized by the participants because of the benefits it came with.

Challenges of Using Social Media as a Strategy of Sharing Knowledge

The participants were asked about the challenges they were facing in sharing knowledge using social media. The findings are presented in Table 4 below.

Challenges	Frequency	Percentage
Poor connectivity to the internet	84	60
Low bandwidth	56	40

Most of the participants (60%) indicated that they were experiencing challenges of poor internet connectivity, while 40% indicated they were experiencing low bandwidth as a challenge of using social media as a strategy of sharing knowledge. The results implies that the strategy of using social media Kirinyaga University library as a means of sharing knowledge was being hampered by poor internet connectivity and low bandwidth.

Conclusion and Recommendations.

The study concluded that use of social media was a strategy academic libraries could use in sharing knowledge regarding the library services. Kirinyaga University library was benefiting from using social media as a strategy for sharing knowledge. It is recommended that academic libraries need to explore additional emerging and popular social media platforms that appeal to the users and offer more opportunities for sharing knowledge. Corrective measure of upgrading the Universities bandwidth were also necessary.

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