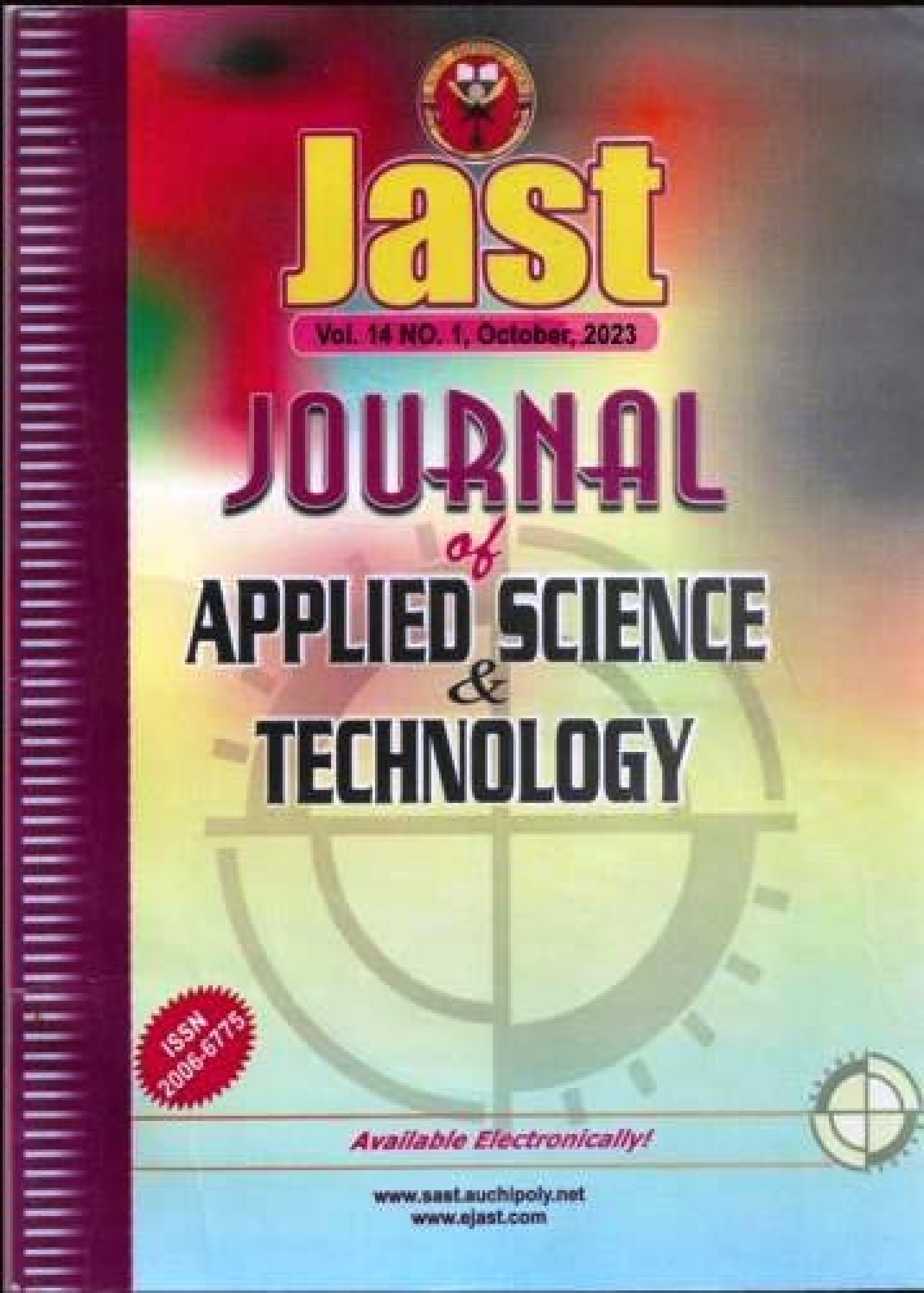
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EVALUATION OF THE LEVELS OF POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) IN SOME SELECTED GRILLED, ROASTED AND SMOKED DELICACIES IN NORTHERN PART OF EDO STATE

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ABSTRACT

Polycyclic aromatic hydrocarbon (PAHs) are carcinogenic and mutagenic pollutants which get into foods during processing in spite of this, only a few studies have been carried out on some Nigerian delicacies. Therefore, this study investigated the levels of PAHs in some selected food samples which included roasted maize, roasted yam, roasted unripe plantain, roasted ripe plantain, smoked cat fish, mackerel fish, smoked herring fish, grilled chicken and grilled beef. The analysis was carried out using the Gas chromatography (GC) with Flame Ionization Detector (FID) for identification and concentration levels of PAHs in various samples. The result revealed the presence of PAHs in different food samples with varying concentrations. The result showed that roasted yam, unripe plantain and grilled chicken had the least trace of PAHs of 3.62, 0.19 and 4.91mg/kg respectively. Also, the roasted maize, roasted ripe plantain and grilled leaf had some quantity of total PAHs of 7.85, 9.28 and 9.88mg/kg respectively while the smoked cat fish, mackerel and herring had the highest concentration of total PAHs of 79.62, 69.95 and 99.04 respectively. Higher values were found in benzo (a) pyrene (BaP) for smoked herring and catfish as 10.13 and 9.20mg/kg respectively. The BaP is highly carcinogenic and with higher total PAHs concentration for the smoked fish; the food samples may pose some heath risk on humans. This study therefore compliment monitoring information on the levels of Polycyclic Aromatic Hydrocarbons (PAHs) occurrences in the different food samples under study.

KEYWORDS: Polycyclic Aromatic Hydrocarbons (PAHs), delicacies, carcinogenic, pollutants, Gas chromatography, concentrations

INTRODUCTION

Most of this stable food enjoyed by the populace are prepared by either roasting, grilling, or smoking method. The health risk associated with the use of these methods in food preparation, especially meat prepared amines (HCAs) which are formed when amino acids, sugars and creatine (a protein) react at high temperatures and polycyclic aromatic hydrocarbons (PAHs) which are formed when fat and juices from meat grilled directly over an open fire drip onto the fire which then causes flames. The flames contain PAHs that can then adhere to the surface of the meat (Cathy, 2017). Hence, PAHs are formed as a result of thermal decomposition of the organicaterials. This result to pyrolysis of the fats (AmosTautua *et al.*, 2013).

at high temperature is that it can generate carcinogenic chemicals (Eze *at al.*, 2019). The two process that are thought to be responsible are the formation of heterocyclic

Chemically, the term PAHs refers to compounds consisting of two or more benzene rings bounded in linear, cluster or angular arrangement (Silva *et al.*, 2011) or compound that have two or more fused aromatic rings with a pair of carbon atoms shared between rings in their molecules. PAHs containing up to six fused aromatic rings are often known as "small" PAHs, and those containing more than six aromatic rings are called "large" PAHs (IARC *et al.,* 2010).

In general, PAHs are not present individually but in mixtures. Sixteen PAHs that have been extensively monitored are the compounds included in the United States Environmental Protection agency (USEPA) list of priority organic pollutant (USEPA, 1994). Of these 16 PAHs, benzo (a) pyrene is probably the most studied and has been described by the International Agency for Research on cancer (IARC) as probable human carcinogen in 1987 (IARC 1987). Thus, the determination of benzo (a) pyrene (BaP) has been widely used in environmental analysis as a marker for the entire PAHs content. These compounds show clear evidence of mutagenicity and carcinogenic effect in various types of bioassays in experimental animals (SCF, 2002).

Polycyclic aromatic hydrocarbons (PAHs) are pollutants which get into foods during processing. One of the major routes of human exposure to PAHs in non-smoking people is food. It has been found that raw food does not usually contain high level of PAHs (plaza-Bolanos *et al*, 2010). Presence of PAHs uncooked foods such as vegetables, seeds and grains have been found to accumulate on the waxy surface of many vegetables and fruits. On the other hand, PAHs are found in foods as a result of certain industrial food processing methods such as smoke curing, boiling, roasting and grilling over open fire or charcoal, which permit the direct contact between foods and combustion products (silva *et al*, 2011). Therefore, the analysis of PAHs in food is a matter of concern.\

MATERIALS AND METHODS

Collection of Materials

Samples of food for study were collected from three randomly selected sales spots in northern part of Edo state of Nigeria. The samples were obtained at Uchi market. The samples were immediately taken to the laboratory for analysis

Preparation of Samples

The maize, yam, unripe and ripped plantains were peel to remove the bark and roasted by the open charcoal pot flame method. Cat fish, mackerel and herring fish were smoked in an open fire drum method as used by the traditional people by placing the fish over a grid of flame from firewood, while the chicken and the beef were grilled by placing them on grill over a smoky flame of firewood (Amos-Tautua *et al,* 2013).

Extraction of Food Samples for PAHs Analysis

2g of each of the homogenized food samples was thoroughly mixed with anhydrous Na_2So_4 salt to absorb moisture and then extracted with a quantity of analytical grade dichloromethane(CH_2Cl_2).Thedichlorometha ne extract was cleaned up by passing

through a column packed with anhydrous Na_2SO_4 salt. The resulting extract was concentrated on a rotatory evaporator to give an oily residue which was again dissolved in 1ml CH_2Cl_2 to be used for analysis. (Amos-Tautua *et al,* 2013)

Analysis of Sample Extract for PAHs Concentration

The gas chromatography (GC) used was Hewlett packed 589 O series 11, coupled with flame ionization detector (FID) (Hewlett Packard, Wilmington DE USA). INL was injected into the G C for analysis. The Identification of PAHs was based on comparison of the retention times of the peaks with those obtained from standard mixture of PAHs (Standard are supplies by g) instrument manufacturer). Quantification was based on external calibration curves prepared from the standard solution of each of the PAHs (Amos-Tautua *et al,* 2013)

RESULTS AND DISCUSSION

Results

The result of the study is showed in the table 1 below:

Table 1: concentration level of PAHs in some selected delicacies (mg/k

PARAMETER	SAMPLE								
	Roasted unripe	Roasted yam	Grilled chicken	Roasted maize	Roasted ripe plantain	Grilled beef	Smoked mackerel	Smoked catfish	Smoked
Napthalene	——	0.62	——	1.73	——	0.02	1.11	1.13	1.72
Acenaphthylene	——	——	——	0.70	0.50	0.02	4.26	4.30	15.60
Acenaphthene	——	——	0.12	1.12	——	0.05	6.84	2.12	0.95
Flourene	——	1.51	0.24	0.85	0.78	——	4.84	0.34	3.02
Phenanthrene	——	0.14	——	0.16	0.26	——	1.64	1.29	1.46
Anthrancene	0.11	0.35	0.87	——	0.66	1.03	12.94	1.21	16.7

									2
Fluoranthene	——	——	——	O.61	0.67	——	3.73	22.08	6.89
Pyrene	——	0.45	——	0.35	0.65	2.15	7.39	12.40	16.77
Benzo(a)authrancene	——	0.16	0.89	0.07	0.61	0.01	5.78	4.43	2.62
Chrysene	——	0.07	——	0.05	0.61	5.12	1.42	6.94	6.25
Benzo(b)fluoranthene	0.08	0.31	0.63	0.37	1.31	0.06	6.63	2.48	6.73
Benzo(K)fluoranthene	——	——	0.71	0.28	0.67	0.02	1.91	5.60	1.45
Benzo(a)pyrene	——	——	0.53	——	——	——	2.90	9.20	10.13
Dibenzo(a,h) anthrancene	——	——	——	1.56	1.40	0.01	1.81	2.01	1.44
Benzo(g,h,i)pyrene	——	——	0.74	——	0.56	1.19	2.43	2.33	2.73
Indeno(1,2,3cd) pyrene	——	——	0.18	——	0.60	1.20	5.04	1.76	4.56
TOTAL PAHs	**0.19**	**3.61**	**4.91**	**7.85**	**9.28**	**9.88**	**69.95**	**79.62**	**99.08**

Discussion

A summary of the occurrence of various PAHs present in all the food samples is shown in table **1.** It showed the 16 PAHs and the total PAHs for all the samples. They were reasonably detected in the fish samples, while trace quantities were found in roasted yam, roasted unripe plantain and grilled chicken and some quantities were found in roasted maize, roasted ripe plantain and beef (suya). After thorough research, we found that these observations agreed with other inference made by other researchers that these PAHs are formed during the processing of food (Amos-Tantua *et al.*, 2013).

In table **1**, the concentration of the PAHs in the smoked fishes ranged between 69.95mg/kg and 99.08mg/kg, while the grilled chicken and beef ranged between

4.91mg/kg to 9.88mg/kg. From the observation, the average total PAHs level of suya (9.88mg/kg) was far lower than that of smoked herring fish (99.08mg/kg). This could be ascribed to the high fat content of the fish samples as compared to the chicken and the beef. Akpan *at al.,* (1994) reported that strong correlation exists between fish liquid and PAHs compounds; since the PAHs compounds are stored in the fatty fish tissue. The PAHs with the maximum concentration, flourathene (22.08mg/kg) was detected in catfish. As for the other food samples; roasted maize, roasted yam, roasted unripe plantain and ripe plantain were having lower PAHs values of 7.85, 3.61 ,0.19 and 9.28mg/kg respectively.

Benzo(a) pyrene (BaP) is the most studied carcinogenic PAHs (Collins *et al*, 1991). The levels of BaP found in smoked cat fish, mackerel and herring with the concentration 9.20, 2.90 and 10.13mg/kg were for higher than the recommended maximum permissible concentration of 5.0µ/kg or 0.005mg/kg fixed for BaP in smoked meat, fish and fishery products (JECFA, 2005).

ii. Indirect cooking methods should be used with foods placed in a chamber heated from the outside.
iii. Direct cooking methods can be done with heat from a clean combustion.
iv. Moderate cooking temperature of about 80-100°C should be used in other to avoid pyrolysis.
v. Public enlightenment should be used to sensitize people about the potential risks of PAHs.
vi. Further studies should be carried out on these pollutants.

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Surprisingly, BaP was not detected in other samples including the beef (suya) in our study. This, the smoke fish may pose some health risk to the people of Edo state North of Edo state Nigeria

CONCLUSION

From this study, since benzo (a) pyrene which is considered as a marker of carcinogenic PAHs is not detected in many of the food samples, it can be assumed that those foods do not represent health risk for human. However, it should be noted that the benzo (a) pyrene of the fish samples and the total PAHs concentrations are relatively too high. This call for some concern that they may pose some health risk.

RECOMMEDATION

Considering the carcinogenic potential of the PAHs and there is the need to reduce the levels of PAHs in foods; the following recommendation are made:

i. Special attention must be given to smoked, roasted and grilled foods.

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EFFECTS OF RIPENING STAGES ON THE LEVEL OF POLYCYCLIC AROMATC HYDROCARBONS (PAHs) OF LOCALLY ROASTED PLANTAINS

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ABSTRACT

Polycyclic aromatic hydrocarbons (PAHs) are carcinogenic pollutants which get into foods during processing. Roasted food samples of green ripe plantain (sample A), fairly ripe plantain (sample B) and fully ripe plantain (sample C) are seasonal delicacies in Auchi Polytechnic, Auchi and her environs and therefore were evaluated for PAHs. The values of the total PAHs concentration of the samples ranged from 10.28 – 40.33ppm with the fully ripe plantain having the highest concentrate of PAHs while the green ripe plantain had the least PAHs level. In fact, the PAHs levels were found to vary with the ripening stages of the plantain samples. Benzo(a)pyrene that is widely used as a marker of carcinogenic was not detected in the three samples. Though, not up to permissible limit, 7.56ppm was the highest concentrate recorded for the individual PAH Anthracene for the fully ripe plantain. This study showed that fully ripe plantain has the tendency to absorb or form more of PAHs than the other samples. These results can be used to determine any potential risk associated with the ingestion of these foods. It is therefore recommended that a low polycyclic aromatic hydrocarbons (PAHs) improved plantain roaster should be developed.

KEYWORDS: Polycyclic aromatic hydrocarbons (PAHs), Benzo (a) pyrene, Gas chromatography, carcinogenic, Plantain.

INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) constitute a large class of organic compounds that are composed of two or more fused aromatic rings. They are a class of ubiquitous environmental pollutants which can be generated during the preparation of food (Agerstad and Skog, 2005). A number of PAHs have been found to have carcinogenic and mutagenic effects while some of them may act as synergists. One of the major routes of human exposure to PAHs for non-smoking people is food. These compounds can reach the food chains by different ways as they have been found in different food products, such as dairy products, vegetables, fruits, oils, coffee, tea, cereals and smoked meat, therefore the analysis of PAHs in food is a matter of concern (Plaza-Bolanuos *et al.,* 2010). Also, PAHs are found in foods as a result of certain industrial food processing methods such as smoke curing, broiling, roasting and grilling over open fires or charcoal, which permit the direct contact between food and combustion products (Silva *et al.,* 2011).

In general, PAHs are not present individually but in mixtures. Sixteen PAHs that have been extensively monitored which are the compounds included in the United States Environmental Protection Agency (USEPA) list of priority organic pollutants (USEPA, 1994). Of these 16 PAHs,

Benzo(a)pyrene (BaP) is probably the most studied and has been described by the International Agency for Research on Cancer (IARC) as probable human carcinogen in 1987 (IARC, 1987). Thus, the determination of BaP has been widely used in environmental analysis as marker for the entire PAH content (Otahen, 2021). In 1964, the presence of benzo(a)pyrene (BaP) and other related PAHs were first reported to be present in charcoal broiled beef. PAHs have been detected at different concentrations in liquid fatty matrices e.g. edible oils (Barranco *et al.*, 2004), olive oil (Bogusz *et al.*, 2004) and milk (Kishikawa *et al.*, 2003), liquid non fatty matrices e.g. coffee (García- Falcón *et al.*, 2005) and tea (Lai *et al.*, 2004), solid fatty matrices e.g. smoked meat (Chiu *et al.*, 1997), fish (Pensado *et al.*, 2005; Silva *et al.*, 2011) and infant milk and cereal (Rey-Salgueiro *et al.*, 2009) as well as solid non fatty matrices e.g. fruits and vegetables (Rojo and Toledo, 2003) and tea leaves (Lin and Zhu, 2004).

Plantain (*Musa paradisiaca*) is an important source of carbohydrate to man; cooked or roasted green is one of the most staple food in South-south region of Nigeria. Plantain is cultivated in the tropics and is an important staple food in sub-Saharan Africa. About 63 million tonnes of the crop are produced annually, of which as much as 90% is consumed locally in the producing countries, allowing only a meagre 10% for foreign financial earnings through exportation (Awodoyin, 2003; Baiyeri *et al.,* 2011). Plantain are usually processed by roasting. The commonest mode of roasting plantain in our environment is by open flame roasting. This work seeks to identify and quantify the levels of PAHs in these commonly consumed plantain delicacies in Nigeria. The carcinogenic nature of some PAHs is well established and their occurrence in foods is not a matter of debate. A thorough search of the literature reveals that there is limited information on the level of PAHs in roasted plantains even though this food is consumed by many people. Hence, this work was embarked on to investigate the levels of PAHs in three samples of plantains which are prepared through direct exposure to fire and are widely consumed in Auchi Polytechnic, Auchi and her environs and Nigeria at large.

MATERIALS AND METHODS

Collection of Materials

Samples of green ripe, fairly ripe and fully ripe (*Musa paradisiaca*) were bought from the Uchi market in Auchi, Edo state, South-South of Nigeria. The charcoal used in the generation of heat were sourced from a local seller while the traditional charcoal basin for roasting with the grid placed on top was at the Department of Food Science and Technology, Auchi Polytechnic Auchi.

Roasting of Plantain Samples

Raw plantain samples (green ripe, fairy ripe and fully ripe) were roasted by open flame roasting method where a grid was placed over a pot/basin of lighted charcoal and the sample were roasted with occasional fanning to regulate the flame with temperature ranging between 140 – 200^{o}C. The position of the plantain were continuously changed at interval of 1 or 2 minutes such that every part of the food is exposed to heat until the plantain is completely roasted.

Preparation of Samples

The plantain were divided into three samples A (green ripe), B (fairly ripe) and C (fully ripe). The roasted samples were ground, blended and stored in the refrigerator at 4^{o}C prior to analysis.

Analysis of PAHs

Extraction: The samples were each pulverized using a manual grinding machine

to ensure homogenization. Five grams (5g) of the pulverized sample was thoroughly mixed with 10g of anhydrous sodium sulphate in a mortar (Amos-Tautua *et al,* 2013) to absorb moisture. The homogenate was placed into an extraction thimble and covered with a Whatman filter paper (125 mm diameter).This was then inserted into a Soxhlet extraction chamber of the Soxhlet extraction unit. Extractions were then carried out with 50mL mixture of redistilled n-hexane and dichloromethane in the ratio 3:1 for effective recovery. Subsequently, the crude extract was filtered through a layer of anhydrous sodium sulphate. The obtained filtrate was evaporated to near dryness.

Clean up: The clean-up of the extract was carried out using activated silica gel and anhydrous Na_2SO_4. The silica gel column was prepared by loading an activated silica gel (12g) onto a chromatographic column (id =1cm). About 1g of anhydrous Na_2SO_4 was added to the top of the silica gel in the column. After conditioning the columns with 20mL hexane the sample was applied and eluted with 200ml of mixture of Dichloromethane : Hexane (3:1).The eluate was collected into an evaporating flask and rotary evaporated to near dryness. The dry eluate was then dissolved in 1mL *n*-hexane for Gas Chromatographic analysis (Amos-Tautua *et al.,* 2013).

Instrumental analysis: The polycyclic aromatic hydrocarbon analysis was carried out using gas chromatograph system. The system consisted of a Hewlett Packard Model 5890 gas chromatography (GC) equipped with a flame ionization detector (FID) and a data processor (Hewlett Packard, Wilmington, DE, USA). The column used was HP-1932530, a non-polar, fused-silica capillary column (30m length × 25µm inner diameter × 0.25µm film thickness). The oven temperature was set initially at 60°C (5min hold), increased to 250°C at 15°C/min. (4min hold) and a final temperature of 320°C at 10ºC/min (4min hold). Nitrogen gas was used as the carrier gas at a flow rate of 1mL/min at a pressure of 30psi. The injector temperature was set at 250°C, injection volume was 1mL and the detector temperature was set at 320°C. Verification of peaks was carried out based on retention times compared to those of external PAHs standards (Amos-Tautua *et al.,* 2013).

RESULTS

Table 1: Concentration of PAHs (ppm) of roasted plantain (*Musa paradisiaca*) samples

	Samples		
Parameters	A	B	C
Naphthalene	ND	2.73	3.49
Acenphthylene	0.50	1.70	3.01
Acenaphthene	ND	1.00	1.70
Fluorene	0.78	0.85	4.94
Phenanthrene	0.26	0.16	2.25
Anthracene	0.66	0.09	7.56
Fluoranthene	0.67	0.61	5.66
Pyrene	0.65	0.35	1.34
Chrysene	0.61	0.05	2.77

Benzo(a)anthracene	0.61	4.07	4.53
Benzo(b)fluoranthene	1.31	0.37	1.10
Benzo(k)fluoranthene	0.67	0.19	ND
Benzo(a)pyrene	ND	ND	ND
Dibenzo(a,h)anthracene	2.40	1.56	0.54
Benzo(g,h,i)perylene	0.56	ND	ND
Indeno(1,2,3-cd)pyrene	0.60	ND	0.55
TOTAL PAHs (µg/g)	**10.28**	**13.85**	**40.33**

KEY
A = Green ripe plantain
B = Fairly ripe plantain
C = Fully ripe plantain
ND = non-detectable

DISCUSSION

PAHs were analysed with the results shown in table 4.1. The level of PAHs in the samples were found to be highest in the fully ripe plantain samples with a concentration of 40.33ppm. There is no limit yet for PAHs in plantain, but the result showed that benzo(a)pyrene (BaP), the most bio-indicator was not detected in the three roasted samples. BaP is the most studied carcinogenic polycyclic aromatic hydrocarbon and one of the most potent and it is often used as a toxicological prototype or surrogate for all carcinogenic polycyclic aromatic hydrocarbon (Collins *et al.*, 1991). The EU has established a maximum permissible level for BaP of $5\mu gkg^{-1}$. The value of the total PAHs for the roasted food samples ranged from 10.28 – 40.33ppm with the fully ripe plantain having the highest concentrate of PAHs while the green ripe plantain hat the lowest PAHs level. Individual concentration of the carcinogenic PAHs ranged from non-detectable (ND) in several of the food samples to 7.56ppm in roasted fully ripe plantain. The PAHs levels were found to vary with the ripening stages of the plantain samples.

The maximum permissible level weight for smoke meat and smoked meat products, although a legal limit of $1.0\mu gkg^{-1}$ had previously been adopted by some European countries. The EU has also set a maximum limit for BaP present in food stuffs as a result of the use of smoking-flavouring agents at $0.03\mu gkg^{-1}$ (Lorenzo *et al.,* 2011). These results can be used to determine any potential risk associated with the ingestion of these foods.

CONCLUSION AND RECOMMENDATION

From the study, it can be assumed that the roasted foods do not represent a health risk for human, since benzo(a)pyrene is mostly considered as a marker of carcinogenic PAHs. But, it should be stated that these food products are contaminated in the total PAHs after roasting which can be bio-accumulated overtime. Since it is obvious that the concentration of the total PAHs increased due to this roasting method, and for this reason an alternative process should be introduced. Considering the carcinogenic potential of the PAHs, the reduction of these contaminants in the delicacy is highly desirable and special attention must be given to the intake of roasted foods.

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NANOTECHNOLOGY IN ENVIRONMENTAL CONSERVATION: INNOVATIONS FOR SUSTAINABLE RESOURCES MANAGEMENT

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ABSTRACT

Our planet faces a complex challenge: meeting the ever-growing demands for essential resources (food, water, energy), consumer goods (electronics, vehicles), and social services (housing, healthcare, jobs) while simultaneously minimizing humanity's environmental footprint. Nanotechnology presents a promising path forward, offering efficient, cost-effective, and environmentally friendly solutions to these global sustainability challenges. This journal is dedicated to exploring the applications of nanotechnology in achieving sustainable development. We showcase recent advancements and discuss the potential of nanotechnology in addressing critical areas like water purification, clean energy technologies, greenhouse gas management, responsible material use, and green manufacturing processes. Recognizing the importance of a holistic approach, we also delve into the societal considerations surrounding nanotechnology, emphasizing its role in fostering the convergence of knowledge, technology, and social progress towards a sustainable future.

Keywords: Nanotechnology, Sustainability, Natural resources, Societal needs

INTRODUCTION

As the global population surges, ensuring adequate resource availability becomes increasingly crucial. To achieve sustainable growth, developing pollution-free technologies for environmental remediation and clean energy sources is paramount. Nanotechnology offers a transformative opportunity in this regard. Its potential to create "cleaner" and "greener" technologies promises significant health and environmental benefits. Researchers are actively exploring how nanotechnology can address air, water, and land pollution through innovative solutions for management, mitigation, and clean-up. It can also enhance the effectiveness of existing environmental remediation technologies.

Thriving on Earth requires access to fundamental needs like food, water, energy, shelter, clothing, and healthcare. As the global population is projected to reach 8-10 billion by 2050 (Diallo et al., 2013), one of the greatest societal challenges of the 21st century lies in elevating living standards for all while minimizing our environmental impact. Currently, a critical tension exists between fulfilling the growing demands for basic resources (food, water, energy), consumer goods (vehicles, electronics), and essential services (housing, healthcare, jobs) and mitigating greenhouse gas emissions and the environmental footprint of our agricultural and industrial activities (Godfray et al., 2010).

The National Nanotechnology Initiative (NNI) recognized the potential of nanotechnology to offer more sustainable solutions to global challenges from its very inception. In a 2000 presentation at the Cornell Nanofabrication Center, Roco (2001) highlighted how nanotechnology

could address critical areas like improving agricultural yields, developing more efficient water treatment and desalination technologies, and enabling the creation of clean, renewable energy sources like highly efficient solar cells. As the field advances, the research agenda for the next 10-20 years increasingly focuses on two key sustainability questions:

- Can nanotechnology address challenges in global sustainability across energy, water, food, shelter, transportation, healthcare, and employment?
- Can we develop nanotechnology in a sustainable manner, maximizing societal benefits while minimizing the impact on Earth's environment and climate?

Nanotechnology for sustainable development

Nanotechnology has become a powerful tool in the fight against global sustainability challenges (Diallo & Brinker, 2011; Brinker & Ginger, 2011). Nanomaterials possess unique physicochemical properties that make them ideal for developing sustainable technologies. They boast a significantly larger surface area compared to bulk materials, offering more active sites for interaction on a mass basis. Additionally, nanomaterials can be customized with various chemical groups, enhancing their affinity towards specific compounds like dissolved pollutants or gases. This tailored functionality can even target specific biological components or signaling pathways in harmful bacteria and viruses. Furthermore, nanomaterials pave the way for the development of novel functional materials with superior electronic, optical, catalytic, and magnetic properties. These innovative materials can then be processed into various forms, including water-soluble supramolecular hosts, particles, fibers, and membranes.

Water purification

Securing clean water has become a defining challenge of the 21st century, impacting both society and the global economy (Savage & Diallo, 2005; Shannon et al., 2008). Many regions struggle to sustainably supply clean water for human consumption, agriculture, food processing, energy production, and various industrial activities (Shannon et al., 2008; Diallo & Brinker, 2011). This growing demand coincides with a stressed water supply due to increasing contamination and salinization of freshwater sources like lakes, rivers, and aquifers. Further complicating the issue, a report by the Intergovernmental Panel on Climate Change (Bates et al., 2008) suggests climate change will negatively impact global freshwater resources in several ways:

- Increased frequency and intensity of droughts and floods.
- Reduced water stored in snowpack and glaciers.
- Decreased overall water quality due to rising salinity and increased sediment, nutrient, and pollutant transport in watersheds worldwide.

To meet the ever-growing global demand for clean water in the coming decade, significantly more water will need to be purified from currently unusable sources

like wastewater, brackish water, and seawater. This challenge presents a unique opportunity for the convergence of nanotechnology with water science and technology. This synergistic approach is leading to revolutionary advancements in water treatment, desalination, and reuse technologies (Savage & Diallo, 2005; Shannon et al., 2008; Diallo & Brinker, 2011).

Membrane processes driven by pressure, like reverse osmosis, nanofiltration, ultrafiltration, and microfiltration, are rapidly becoming the cornerstone of advanced water treatment, reuse, and desalination systems globally (Savage & Diallo, 2005; Shannon et al., 2008). This focus on membranes is highlighted by Swaminathan et al. (2012) in their article "Ionic transport in nanocapillary membrane systems." Their work reviews the state-of-the-art in nanocapillary array membranes (NCAMs) as valuable models for studying ion and particle transport through nanopores. These pores have characteristic sizes ranging from 1 to 100 nanometers and are fabricated by etching techniques using base polymers like polycarbonate, allowing for tunable pore size control.

Swaminathan et al. (2012) investigated how pore shape, surface electrical charge, and interactions between these factors influence the movement of ions and charged particles through nanopores less than 100 nanometers wide. Their study on nanocapillary array membranes (NCAMs) highlights how fundamental research in this area can inform the design of innovative technologies for sustainability. These include biomimetic membranes for desalination and 3D microfluidic/nanofluidic systems for applications like chemical separations, sensor analysis, and even energy conversion. Park et al. (2012) took a step towards such advancements by describing a new type of ion-selective nanofiltration (NF) membrane. This novel membrane is a composite structure built from polyvinylidene fluoride (PVDF) nanofibers and hyperbranched polyethyleneimine (PEI). The researchers created these nanofibrous composite (NFC) membranes by electrospinning a network of crosslinked PEI onto a commercially available PVDF microfiltration (MF) membrane.

Large surface area and unique optical and electronic properties make metal oxide nanoparticles highly promising for water purification catalysts (Savage & Diallo, 2005). In recent years, titanium dioxide (TiO_2) nanoparticles have emerged as particularly attractive photocatalysts for water treatment. These versatile nanoparticles can act as either oxidative or reductive catalysts, breaking down both organic and inorganic pollutants. Kuvarega et al. (2012) investigated the photocatalytic activity of nanocomposites made by combining multi-walled carbon nanotubes (MWCNTs) with nitrogen-doped and palladium co-doped TiO_2 (MWCNT/N, Pd co-doped TiO_2). To assess the effectiveness of these catalysts, the researchers measured the photodegradation of Eosin Yellow dye under simulated solar and visible light irradiation.

Further research into photocatalysis highlights its potential for water purification. Mahlambi et al. (2012) demonstrate this in their article "Synthesis and characterization of carbon covered alumina (CCA) supported TiO_2 nanocatalysts with enhanced visible light photodegradation of Rhodamine B." They successfully synthesized TiO_2

nanocatalysts supported on carbon-covered alumina (CCA) and showed these catalysts exhibited greater reactivity under visible light compared to unsupported versions. Metal oxide nanoparticles are also opening doors for more efficient water purification through magnetic separations technology.

Clean energy technologies

The 21st century faces a critical challenge: global climate change, primarily driven by rising greenhouse gas emissions, particularly carbon dioxide (CO_2) released from burning fossil fuels like coal and oil (Solomon et al., 2007). As the world population surges towards 8-10 billion by 2050 (Brinker &

Ginger, 2011; Fromer et al., 2011; Diallo et al., 2013), meeting our growing energy demands while drastically reducing CO2 emissions necessitates a large-scale shift to clean and renewable energy systems. Nanotechnology presents a game-changing opportunity to accelerate the development of these very technologies (Fromer & Diallo, 2013). Among renewable energy sources, solar photovoltaics stands out for its abundance, versatility, and minimal environmental footprint in terms of water usage and land use, making it the most attractive option for the future.

Highlighting the potential of solar energy for wastewater treatment, Choi et al. (2012) investigated hydrogen production through a process called solar water splitting. Their approach utilizes organic contaminants within wastewater as electron donors. This research is particularly significant because solar energy is intermittent, and large-scale solar power implementation requires efficient systems that convert sunlight into storable chemical fuels like hydrogen. The authors successfully demonstrated the feasibility of a scaled-up rooftop prototype for a hybrid photovoltaic electrolysis system. This system employs semiconductor nanoparticles coated onto metal substrates as electrodes to generate hydrogen while simultaneously oxidizing organic pollutants in the wastewater.

Chung et al. (2012) explores the convergence of nanotechnology with clean energy generation in their article "Nanotechnology Convergence and Modeling Paradigm of Sustainable Energy System Using Polymer Electrolyte Membrane Fuel Cell as a Benchmark Example." They propose a novel multi-scale modeling paradigm using the fuel cell system as a benchmark. This approach delves into understanding and modeling complex physical phenomena occurring at various time and length scales. Additionally, they introduce an optimization framework to guide application-driven research in nanotechnology for clean energy. The new modeling paradigm emphasizes a holistic integration, encompassing phenomena from the atomic/molecular level all the way up to the meso/continuum scale. Furthermore, the authors discuss system optimization strategies, including the use of reduced-order parameters for efficient multi-scale model integration, ultimately aiming to optimize fuel cell design.

Greenhouse gases management

Despite the development of alternative energy sources, fossil fuels still dominate global energy consumption, accounting for roughly 80% according to the IPCC (2005). In the near to mid-term future, we will likely continue to rely on fossil fuels to some extent. Therefore, capturing and storing carbon emissions (CO2 capture and storage or CCS) is emerging as a crucial strategy to reduce human-caused CO2 released into the atmosphere (IPCC, 2005). Nanotechnology offers exciting possibilities for developing efficient, cost-effective, and environmentally friendly solutions for CO2 separation, capture, and storage (Diallo & Brinker, 2011). Highlighting this potential, Kim and Lee (2012) reviewed recent advancements in CO2 separation technologies, focusing on membranes like thermally rearranged (TR) polymers containing nanocavities specifically designed for CO2 capture. Their research suggests that these new TR polymer membranes exhibit high gas permeability alongside exceptional selectivity, particularly for separating CO2 from post-combustion flue gases.

Zeolitic imidazolate frameworks (ZIFs) are a promising class of materials for capturing and storing carbon dioxide (CO2) efficiently and selectively (Wang et al., 2008; Banerjee

et al., 2008). To understand how ZIFs interact with CO2 on a molecular level, Park et al. (2012b) used density functional theory (DFT) calculations in their article "Local inter-molecular interactions for selective CO2 capture by zeolitic imidazole frameworks: energy decomposition analysis." Their goal was to explain why certain ZIFs capture more CO2 than others, based on experimental data. The DFT calculations revealed that the main attraction between CO2 and ZIFs comes from local electronic interactions, particularly those involving frozen density and polarization, with minimal charge transfer. However, Park et al. (2012b) also found that electron correlation effects can play a significant role depending on the specific arrangement of atoms and the functional groups within the ZIF.

Materials supply and utilization

The next generation of sustainable technologies hinges on innovation in how we source and utilize materials. Metals are the backbone of countless products, from airplanes and cars to smartphones and medical devices (NRC, 2008; Diallo & Brinker, 2011). Similarly, carbon-based materials derived from petroleum are essential for a wide range of products like plastics, solvents, and pharmaceuticals (Diallo et al., 2013). Sustainable development requires us to rethink how we obtain and use these materials to minimize environmental impact.

The article "Nanotechnology and Clean Energy: Sustainable Solutions for Critical Materials" by Fromer and Diallo (2013) explores how nanotechnology can revolutionize the materials we use in clean energy generation, conversion, and storage. As we transition towards clean energy technologies, a critical challenge emerges: securing a sustainable supply of the essential metals needed for these systems (Diallo & Brinker, 2011; Fromer et al., 2011; Diallo et al., 2013). The authors propose a two-pronged approach using nanotechnology:

vii. Developing nanostructured materials: These advanced materials boast enhanced electronic, optical, magnetic, and catalytic properties, potentially improving the efficiency of clean energy technologies.
viii. Recovering critical materials: Nanotechnology-based separation systems can extract these essential metals from unconventional sources like mine tailings, industrial wastewater, and electronic waste, minimizing environmental impact.

Electronic waste, or e-waste, is a growing environmental concern. Liou (2012) explored a promising solution in the article "Recovery of silica from electronic waste for the synthesis of cubic MCM-48 and its application in preparing ordered mesoporous carbon molecular sieves using a green approach." This research focused on recovering valuable materials from e-waste, a complex mixture that includes epoxy resin, phenolic resin, silica, and additives. Liou successfully utilized resin ash, a byproduct of e-waste processing, to create high-purity (99.87 wt%), high surface area (1317 m^2/g) mesoporous silica known as MCM-48, with a mean pore size of 3.0 nm. By transforming e-waste into valuable materials like MCM-48, this research paves the way for a more sustainable approach to electronic product lifecycles and waste management.

Beyond e-waste, nanotechnology offers a powerful tool for broader materials sustainability challenges. For instance, research by Scott and Chen (2003) and Diallo and Brinker (2011) explores how nanotechnology can be harnessed in agriculture to develop "smart" systems for the controlled and precise release of nutrients, fertilizers, and pesticides.

Green manufacturing and chemistry

Manufacturing forms the backbone of a healthy global economy, driving innovation and creating valuable jobs across developed and developing nations (Liveris, 2012). However, traditional industrial manufacturing processes often come at a high environmental cost. These processes are resource-intensive, requiring vast amounts of materials, energy, and water. Additionally, they generate significant waste products, including gaseous, liquid, and solid waste, often containing harmful byproducts that require special disposal or treatment. Nanotechnology is emerging as a game-changer, offering a path towards green manufacturing and chemistry across various sectors, including semiconductors, chemicals, petrochemicals, materials processing, pharmaceuticals, and many more (Diallo & Brinker, 2011).

Busnaina et al. (2013) examine the cutting edge of nanomanufacturing in their article "Nanomanufacturing and sustainability: opportunities and challenges." They propose that rapid, room-temperature, and pressure-independent assembly techniques could significantly reduce manufacturing equipment costs and promote long-term sustainability. This approach would achieve this by minimizing material use, water consumption, energy demands, and overall waste generation. Beyond these advancements, the convergence of nanotechnology and biotechnology offers exciting possibilities. Mohanpuria et al. (2008) point to the development of environmentally friendly "green chemistry" methods that utilize bacteria, fungi, and plants to synthesize functional nanomaterials, paving the way for non-toxic and sustainable production strategies.

Bhargava et al. (2013) explored a green method for synthesizing iron oxide nanoparticles (IONPs) in their article "Synthesis, characterization and mechanistic insights of mycogenic iron oxide nanoparticles." Their approach leverages a fungus called Aspergillus japonicus (AJP01), isolated from iron-rich soil. The researchers found that AJP01 could transform a mixture of potassium ferricyanide and ferrocyanide salts into IONPs measuring between 60 and 70 nanometers. Interestingly, they observed that extracellular proteins produced by the fungus play a crucial role in both the synthesis and stabilization of these nanoparticles. This bio-inspired method holds promise for the development of an eco-friendlier approach to producing not only IONPs, but potentially other nanomaterials as well.

Nanotechnology for sustainable development: societal perspectives

Societal perspectives

Achieving sustainable development on a global scale requires two key goals: fostering inclusive economic and social progress that benefits everyone, and minimizing the environmental impact of human activity on Earth's climate and ecosystems (UN, 2012; Diallo et al., 2013). However, the current focus of nanotechnology research for sustainability might be overlooking broader considerations, according to Wiek et al. (2012) in their article "Nanotechnology for sustainability—what does nanotechnology offer to mitigate complex sustainability problems?" The authors argue that much of the research prioritizes "end-of-pipe solutions" like water purification and energy efficiency technologies. They call for a more critical approach that weighs nanotechnology solutions against existing alternatives and carefully considers any potential negative side effects of these new technologies.

True sustainability requires a holistic approach that considers social, economic, and environmental impacts (Diallo & Brinker, 2011; Diallo et al., 2013). To achieve this, fundamental science (like materials creation, analysis, and modeling) must be integrated from the outset with engineering (system design, fabrication, and testing), commercialization (new products with market potential), and societal benefits (new jobs and environmental improvements). Therefore, funding sustainable nanotechnology solutions can't solely rely on small, individual research grants. Sustainable R&D needs to be woven into broader research goals and tackled by interdisciplinary teams within large-scale programs. These programs can be spearheaded by collaborative research teams or dedicated government-funded research and development centers (Diallo & Brinker, 2011; Diallo et al., 2013).

CONCLUSION AND RECOMMENDATION

Nanotechnology presents a transformative platform with immense potential to address global challenges and contribute to a more sustainable future. As highlighted throughout this review, research in this field is rapidly developing new materials, processes, and devices that can improve energy production, water treatment, waste management, and manufacturing practices. Furthermore, advancements in bio-inspired synthesis methods offer more environmentally friendly approaches to nanomaterial production.

However, achieving true sustainability requires careful consideration beyond just the technical feasibility of nanotechnology solutions. A holistic approach that integrates social, economic, and environmental factors is crucial. This necessitates strong interdisciplinary collaboration between fundamental scientists, engineers, commercialization experts, and social scientists from the beginning of the research and development process. Additionally, moving beyond small, individual research grants towards large-scale, interdisciplinary programs funded by both public and private entities will be critical for realizing the full potential of nanotechnology for sustainable development.

For future research directions in this field, the following recommendations are made:

- Expand research efforts on life-cycle assessment: Alongside the development of new nanotechnologies, a critical focus should be placed on thoroughly assessing their environmental and social impact throughout their entire life cycle, from material extraction and production to use and disposal.
- Develop responsible governance frameworks: As nanotechnology continues to evolve, proactive measures are needed to establish responsible governance frameworks that ensure the safe and ethical development and use of these technologies. Open communication and public engagement are essential in this process.
- Prioritize education and workforce development: To fully harness the potential of nanotechnology for sustainability, a skilled workforce is necessary. Investing in educational programs at all levels will prepare future generations to develop, implement, and manage these innovative technologies responsibly.

By following these recommendations, the field of nanotechnology can continue to play a vital role in creating a more sustainable and equitable future for all.

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Applications of Genetic Engineering in Environmental Conservation: Engineering Resistance in Threatened Species

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Abstract

Human actions, whether unintentional or intentional, have caused the endangerment or complete extinction of several species of animals and plants. The aforementioned losses were not a result of intentional actions, but rather the inadvertent introduction of forest illnesses or insect pests from other parts of the globe by humans. Efforts have been made to stop the spread of pests or pathogens and to find ways to combat them. However, progress has been limited and slow. This paper emphasises the use of genetic engineering (transgenics) as a tool to aid in the preservation of endangered species.

Keywords: Applications, Genetic Engineering, Environmental Conservation, Engineering Resistance, Threatened Species

Introduction

In recent years, there has been a substantial rise in the genetic modification of animals. However, the application of this technology raises ethical concerns, particularly those pertaining to animal welfare. Animal welfare, as defined by the World Organisation for Animal Health, refers to the overall well-being of an animal and its ability to adapt to its living conditions. Due to the additional difficulties posed by genetically modified animals, regulatory authorities have begun to formulate appropriate rules, which often include heightened surveillance and monitoring of possible effects on animal welfare. Various words are used to denote animals that have been genetically engineered, including genetically modified, genetically changed, genetically manipulated, transgenic, and biotechnology-derived, among others. (MacArthur and colleagues, 2006). The world population has had a growth rate of more than 25% in the last twenty years and is projected to reach around 10 billion by the year 2050, up from 7.7 billion in 2019. The current major difficulty is providing a sufficient quantity of nourishing and wholesome food to the rapidly growing global population. However, the global increase in population has not been matched by a corresponding increase in grain production (Lenka et al., 2020).

Aside from limited arable land and water supplies, global food production is also constrained by insect pests and disease-causing microorganisms. The annual economic losses resulting from plant virus infection may amount to as much as 60-80 billion dollars. The reason for this is that chemical pesticides are effective in controlling bacterial and fungal diseases, but they are not effective against viruses (Oerke and Dehne, 2004).

Advancements in biotechnology and a better understanding of the molecular mechanisms involved in plant-virus interactions have opened up new possibilities for genetically engineering plants to resist viruses. The references used are Mahas and Mahfouz (2018) and Yin and Qiu (2019). Considering this context, significant focus has been placed on the potential of transgenic technology to expedite the creation of disease- and pest-resistant variations of

endangered forest trees. This can be achieved by directly incorporating genes from other organisms, or even synthetic genes, which could provide resistance against the pathogen or pest. (Merkle et al., 2006). Transgenic technology offers several advantages over conventional breeding methods. It allows for faster genetic modification, especially for forest trees. Additionally, it enables the transfer of only the desired gene(s) into a desirable tree genotype, rather than transferring entire sections of the genome from another parent. This eliminates the need to breed out any unwanted traits. Genetic Engineering, a biotechnological technique, may produce enduring and inheritable modifications to the genetic code, allowing for targeted achievements. This technology offers several benefits compared to traditional breeding techniques (Abudayyeh, et al. 2017).

PLANT VIRUS

The global agricultural industry faces threats from both abiotic factors such as cold, drought, salt, and heat, as well as biotic pressures including bacteria, fungus, viruses, insects, and nematodes. Phytopathogenic viruses, often known as plant viruses, result in an annual decrease of around 10-15% in worldwide agricultural production (Mahy and van Regenmortel, 2009). Plant viruses account for about 50% of plant pathogens, which are responsible for both emergent and recurring plant diseases on a global scale. This has unforeseen ramifications for the natural ecosystems and food security. Nevertheless, the management of plant viral infections is more challenging as a result of the ongoing impact of global climate change and the expanding human population (Baltes, et al. 2015).

Plant viruses are obligate intracellular parasites composed of nucleoprotein complexes. Plant viruses are the second most significant plant pathogens, behind fungi. They result in annual losses of 60 billion dollars globally in agricultural and horticulture crops (Karavina and Gubba, 2017). The majority of plant viruses are spread by vectors that consume plants, such as insects (whiteflies, plant hoppers, jassids, thrips, etc.), mites, nematodes, and plasmodiophores (Whitfield et al., 2015). According to the categorization suggested by the International Committee on Taxonomy of Viruses (ICTV), viruses are divided into 7 orders, 111 families, 30 subfamilies, 610 genera, and 3705 species. Out of these, about 1407 species of plant viruses are found in 73 different genera and 49 families (Matthews, 2002). Baltimore (1971) has divided these viruses into seven types based on their viral genome and synthesised mRNA.

- *Class I*: dsDNA viruses: mRNA is synthesized normally using -ve strand as a template.
- *Class II*: ssDNA viruses: mRNA is synthesized by double-stranded DNA intermediate.
- *Class III*: dsRNA viruses: mRNA is synthesized by a complementary strand (template strand).
- *Class IV*: ssRNA viruses: RNA directly functions as mRNA.
- *Class V*: sense (-) ssRNA viruses: mRNA is synthesized by the synthesis of +ve strand.
- *Class VI*: (+) strand RNA viruses: virus genome is synthesized by reverse transcription (RT).
- *Class VII*: DNA reverse transcribing viruses with RNA intermediates.

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Utilising genetic resistance in agricultural plants to enhance plant cellular immunity against phytopathogenic viruses is the most effective option in comparison to traditional methods, which are labor-intensive, time-consuming, and often ineffectual (Whitham and Hajimorad, 2016).

Genome Engineering

Genome engineering has emerged as a new method for genetically enhancing agricultural plants by selectively modifying the genome to provide desired features (Sovova et al., 2016). Emerging genomic methodologies, such as novel breeding techniques (NBT) and genetic engineering (GE), have the capacity to modify the genetic makeup of plants and enhance their ability to withstand microbial diseases.

Genome engineering utilises site-specific enzymes (SSNs) that may selectively bind and cleave a particular nucleic acid sequence by producing double-stranded breaks (DSBs). The double-strand breaks (DSBs) that are formed may be repaired by either non-homologous end joining (NHEJ) or homologous recombination. The repair of double-strand breaks (DSBs) by non-homologous end joining (NHEJ) often results in the creation of tiny insertions or deletions (INDELs), which may cause loss-of-function mutations. Repair by homologous recombination is a complicated process that requires the simultaneous delivery of a DNA repair template with the required alteration to be integrated into the repaired location (Stella and Montoya, 2016).

Engineering RNA silencing-based resistance

RNA silencing, also known as RNA interference (RNAi), is triggered by the presence of double-stranded RNA molecules (dsRNAs) and causes particular inhibition or reduction of gene expression in a nucleotide sequence-specific manner. RNA interference (RNAi), also known as gene silencing, is a significant mechanism for plant antiviral immunity. It is activated by double-stranded RNAs (dsRNAs) and is considered a process that is conserved throughout evolution in most eukaryotes (Zhan, et al. 2019).

The double-stranded RNAs (dsRNAs) undergo processing by DCL (DICER-like ribonuclease III-type) enzymes, resulting in the formation of short nucleotide RNAs (sRNAs). These sRNAs are then integrated into the RNA-induced cytoplasmic silencing complex (RISC). The RISC complex consists of AGO (Argonaute) and other proteins. In this complex, small RNAs (sRNAs) are coupled with their target mRNA, leading to the cleavage of the mRNA. Approximately 30 crop species have been genetically modified to consistently produce short RNAs that specifically target certain viruses. Several countries have granted approval for the commercial distribution of dozens of these genetically modified crops.

Engineering ZF Nor TALEN-based resistance

Zinc finger nucleases (ZFNs) and transcription activator-like effector nucleases (TALENs) were the first instruments used in genome editing technologies. Genome editing methods function as a novel tool in the fight against plant viruses. ZFNs and TALENs are chimeric proteins created by combining a DNA-binding domain (DBD) with a non-specific cleavage domain from the FokI enzyme. The DNA-binding domain (DBD) identifies a particular nucleotide sequence in the DNA target, while the cleavage domain cuts the DNA to create double-strand breaks (DSB) at the intended location (Zaidi et al., 2017). Zinc finger nucleases are artificial proteins created by combining the DNA-binding domain (DBD) of a zinc-finger protein with the DNA cleavage domain of

the FokI restriction enzyme (Urnov et al., 2010).

TALEN is a combination of a transcription activator-like effector with the non-specific cleavage domain of the restriction enzyme FokI. Transcription activator-like effectors (TALEs) are proteins produced by Xanthomonas spp., a kind of bacterium that causes diseases in plants. These proteins are transported into the cells of the host plant to manipulate plant processes and facilitate the development of the pathogen (Schornack et al., 2013). After being transported into the plant cells, these proteins migrate to the nucleus and attach themselves to the specific DNA they are targeting.

Engineering CRISPR/Cas9 based resistance

CRISPR-Cas9, a technique based on clustered regularly interspaced short palindromic repeats and the CRISPR-associated protein Cas9, has revolutionised agricultural research by demonstrating its ability to modify the genetic makeup of plant species and opening up new avenues of exploration. The CRISPR-Cas9 strategy is both cost-effective and user-friendly, making it a popular technique in comparison to other genetic engineering approaches like as zinc-finger nucleases (ZFNs) and transcription activator-like effector nucleases (TALENs) (Cheng et al., 2015). Each time an experiment employing ZFNs and TALENs is conducted, a new protein must be obtained and validated. This need adds complexity and cost to the process. However, CRISPR-Cas9, in contrast, is very cheap and straightforward to use.

The CRISPR-Cas9 technology has been extensively used to change the genetic makeup of over 20 different agricultural plants. This technique allows for the alteration of several characteristics, including increased yield, improved growth, and enhanced resilience to both abiotic and biotic challenges (Kis, et al. 2019). This technology consists of two components: a CRISPR array and Cas9 nucleases. The destruction of DNA is facilitated by the Cas9 nuclease, which is encoded by the Cas genes located on each side of the CRISPR array. The CRISPR-Cas9 system's capacity to induce double-strand breaks (DSBs) in the genome has rendered it an exceptional tool for genome editing, sometimes likened to genomic scissors (Liang, et al. 2018).

Multiple studies have shown the capacity of the CRISPR system to modify the genetic makeup of many types of plants, such as monocots and dicots, resulting in enhanced resistance to a variety of plant infections. Furthermore, there exists a perpetual trade-off among plant genes, wherein modifying the S gene may result in a reduction in the plant's overall fitness (Kis, et al., 2019). The limitation of CRISPR-Cas9 tools, in the form of "off-target mutation," involves the introduction of one or two mutations that may affect a vulnerable gene from the host. Furthermore, these alterations exhibit greater durability compared to the R gene mutation, since the pathogen may undergo mild selection pressure in order to counteract the plant defence mechanism. In order to tackle these issues, it is necessary to develop novel S variants101 and incorporate them into the plants. Alternatively, the base editing approach may be used, or the particular promoter of desired genes/alleles can be targeted. An off-target mutation refers to an unintended or non-specific alteration that occurs in the genome as a result of genetic engineering. These alterations may take the form of point mutations, insertions, or translocations (Sampson, et al. 2013). Undesirable mutations may impact the system's competence and modify gene function and structure, perhaps leading to cell changes depending on the type of the mutation.

Conclusion

Ultimately, the use of contemporary biotechnology holds immense promise in surpassing the constraints of traditional viral resistance breeding. Both RNA interference (RNAi) and genome editing methods are especially suitable for crops with low genomic sequence data. These technologies do not need the bridging of distinct boundaries. Modern genome-editing methods have arisen as effective tools for introducing desired characteristics into certain agricultural plants. The primary antiviral methods, RNA silencing and genome editing, have been extensively used. The CRISPR/Cas9 method has become more popular because to its straightforwardness, effectiveness, and ability to be replicated. The comprehension of these molecular interactions between plants and pathogens has presented a chance for genetic engineering scientists to create crop types that are resistant to diseases or have reduced susceptibility, thereby promoting sustainable agriculture.

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Carbon Capture and Utilization: Biotechnological Strategies for Mitigating Climate Change and Promoting Sustainable Development

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Abstract

Carbon emissions are intricately intertwined with the world economy. All industries contribute to pollution, but the energy and transport sectors are particularly known for their high carbon emissions. The exponential increase in carbon dioxide emissions has resulted in global climate change and has emerged as one of the foremost environmental issues on a global scale. This challenge offers a unique chance to protect our future by implementing economically viable carbon capture and utilisation (CCU) technology. In order to achieve this goal, this assessment highlights effective practices and develops a sustainable method for capturing and using CO_2. This analysis examines the potential economic and environmental advantages of various applications to emphasise the significant and positive influence of CCU on sustainable development.

Keywords: Carbon Capture, Biotechnological Strategies, Mitigating Climate Change, Sustainable Development, Utilisation

Introduction

Carbon Capture and Utilisation (CCU) refers to a collection of technologies designed to capture carbon dioxide (CO_2) from industrial and atmospheric sources and transform it into useful goods. Biotechnological approaches are leading the way in these endeavours, providing creative ways to reduce the impact of climate change and support sustainable development (Kumar et al. 2017).

Environmental issues arising from the release of pollutants during the burning of solid, liquid, and gaseous fuels in different stationary and mobile energy systems, as well as emissions from manufacturing facilities, have emerged as significant global concerns. These problems involve not only pollutants like NOx, SOx, and particulate matter, but also greenhouse gases (GHG) such as carbon dioxide (CO_2) and methane (CH_4). There is a growing global worry about climate change, leading to a heightened interest globally in lowering greenhouse gas (GHG) emissions, especially carbon dioxide (CO_2) (Song, 2006).

The process of burning carbon-containing material often results in the production of carbon dioxide (CO_2). The current energy consumption in contemporary cultures relies on the burning of carbon-based fuels, mostly consisting of three fossil fuels: coal, petroleum, and natural gas. The complete oxidation or burning of any carbon-based organic matter results in the production of carbon dioxide (CO_2). However, until recently, CO_2 gas was often believed to be innocuous. CO_2 is a vital component in the carbon cycle of the Earth and is essential for the life cycle of animals and plants (Fawzy et al., 2020).

Anthropogenic activities, such as changes in land use patterns, deforestation, industrialization, transportation, and modern lifestyles, are causing an increase in the

concentration of carbon dioxide (CO_2). This which is a significant environmental challenge currently faced by the world. The current atmospheric CO_2 concentration is at 408 parts per million (ppm) according to Kumar et al. (2017). CO_2, a powerful Global Warming Gas (GWG), has had a 43% increase during the industrial revolution and is projected to rise to 60% by 2100 if the present trend continues (Kumar et al., 2017). The fundamental concerns of GHG management include energy economics, legislative restrictions, environmental preservation, and global climate change. The primary source of human greenhouse gas emissions is the use of fossil fuels.

To address this situation, it is crucial to implement creative techniques that may reduce the effect of these emissions on the environment. Carbon Capture and Utilisation (CCU) is a crucial technology that provides a versatile solution to tackle the issues related to carbon emissions. CCU refers to a collection of technologies and procedures that are specifically developed to capture carbon dioxide emissions from different sources, so avoiding their release into the atmosphere (Metz et al., 2005).

Unlike traditional carbon capture and storage (CCS) techniques, carbon capture and utilisation (CCU) go farther than just storing carbon, with the goal of transforming collected carbon into useful goods. This approach aims to establish a circular and sustainable carbon economy (Leung et al., 2017). Carbon emissions, which mostly come from industrial operations and energy production, greatly contribute to the greenhouse gas effect, worsening global warming and climate change (Hartmann et al., 2013).

Carbon capture and utilisation (CCU) offers a promising opportunity to not only decrease emissions, but also convert carbon into a valuable resource, promoting a more sustainable and circular approach to managing carbon (Rogelj et al., 2018). Biotechnology is experiencing rapid growth compared to other scientific and technological fields, and it is increasingly being applied in industries. This growth has been facilitated by advancements in genetics, bioinformatics, biochemistry, data sciences, chemical engineering, and genetic engineering. Biotechnological techniques have the potential to turn atmospheric CO_2 into valuable goods. various processes include biological reactions that have particular rates, resulting in the production of various compounds. Biotechnological reactions may take place under many settings, and a broad spectrum of microorganisms that use CO_2 can be engaged. These microorganisms have the ability to adapt to different environments and enhance the effectiveness of biotechnological processes (Zahed et al., 2021).

Microbial Carbon Capture

Autotrophic biota and certain microorganisms, such as algae, cyanobacteria, chemoautotrophic bacteria, and chemolithoautotrophic bacteria, have the ability to store and utilise captured CO_2. They achieve this through a CO_2 fixing mechanism supported by key enzymes like Ribulose-1,5-bisphosphate carboxylase/oxygenase (RuBisCO) and facilitated by enzymes like carbonic anhydrase (CA). This process is considered as one of the options for mitigating CO_2 emissions (Bharti et al., 2014; Kumar et al., 2017).

Photosynthetic organisms, particularly microalgae, have a crucial role in the process of CO_2 sequestration. The process of prokaryotic photosynthesis, which emerged

billions of years ago and later led to the development of eukaryotic photosynthesis, had a crucial role in transforming the Earth's atmosphere. By eating carbon dioxide and releasing oxygen, it effectively altered the composition of the atmosphere (Zhang et al., 2020). These microorganisms, which have a wide range of characteristics, are used to transform inorganic carbon (Ci) into organic carbon-based molecules via the process of photosynthesis. Microalgae, which include eukaryotic green algae, diatoms, euglenoids, and prokaryotic cyanobacteria, use CO_2 to produce a range of biological substances such as lipids, proteins, carbohydrates, pigments, and phenols. The carbon inside the CO_2 molecule is therefore attached to the molecular framework of these compounds, where it carries out various biological tasks. Therefore, the use of microalgal carbon capture is a revolutionary approach to capitalise on challenges, finally achieving sustainable reduction of CO_2 emissions by transforming it into marketable value-added products (Zhu et al., 2019).

Bioenergy carbon capture and storage

Bioenergy carbon capture and storage (BECCS) is a well-known method for removing carbon dioxide from the atmosphere, often mentioned in scientific literature as a significant approach for achieving negative emissions. The IPCC placed significant reliance on bioenergy carbon capture and storage (BECCS) as a viable means to achieve temperature targets in its assessments (IPCC 2018). The technique is a combination of biopower and carbon capture and storage technologies.

The fundamental concept behind the technique is rather simple. Biomass collects atmospheric CO_2 via photosynthesis while growing, and then uses it for energy generation by burning. The carbon dioxide emissions produced during burning are subsequently absorbed and stored in appropriate geological reservoirs (Pires 2019; Royal Society 2018). This technique has the potential to greatly decrease the amounts of greenhouse gases by extracting carbon dioxide from the environment. The carbon dioxide removal potential of this technique exhibits variability in the literature.

The primary obstacle linked to this technique is the substantial quantity of biomass feedstocks needed to effectively mitigate emissions. During extensive implementation, the use of specialised crops would result in a substantial demand for resources, including land, water, and nutrients, putting severe strain on these resources. An important concern arises from the direct conflict between this activity and the cultivation of food and feed crops for resources such as land, freshwater, and nutrients (Royal Society 2018; GNASL 2018).

Soil carbon sequestration

Soil carbon sequestration refers to the process of absorbing carbon dioxide from the atmosphere by using land management measures that enhance the amount of carbon stored in the soil. The carbon content in the soil is governed by the equilibrium between inputs, such as residues, litter, roots, and manure, and the carbon losses caused by respiration, which is primarily impacted by soil disturbance. The process of soil carbon sequestration is driven by practices that enhance inputs and/or decrease losses, as stated by the Royal Society in 2018 and Fuss et al. in 2018. Carbon sequestration enhances soil fertility and health by accumulating organic carbon in soils, leading to improved agricultural yields (Fuss et al., 2018). Several land management

practices that enhance the sequestration of carbon in soil include intensifying and rotating cropping systems, implementing

zero-tillage and conservation tillage practices, managing nutrients, using mulching and crop residues, incorporating biochar, utilising organic fertilisers, and implementing water management strategies (Royal Society 2018; Srivastava 2012; Farooqi et al. 2018). Although soil carbon sequestration is prepared for widespread implementation, obstacles to scaling have been found, including limited understanding, reluctance to adopt new methods, and insufficient legislative and financial incentives.

Direct air carbon capture and storage

Direct air carbon capture and storage (DACCS) is an emerging technology that has the ability to remove manufactured CO_2 from the atmosphere. The fundamental concept behind this technique is using chemical bonding to directly extract atmospheric CO_2 from the air and then either storing it in geological reservoirs or utilising it for other uses, such as chemical manufacturing or the formation of mineral carbonates. The process of capturing CO_2 from the air involves exposing ambient air to certain compounds called sorbents (Fawzy et al., 2020).

In addition, the sorbents are subsequently regenerated by the application of heat or water, which allows for the release of CO_2 for storage or utilisation purposes. Sorbents primarily function through two processes: absorption and adsorption. In absorption, CO_2 dissolves in the sorbent material, usually employing liquid sorbents like potassium hydroxide or sodium hydroxide. In adsorption, CO_2 sticks to the sorbent, typically utilising solid materials such as amines (Pires 2019; GNASL 2018; Gambhir and Tavoni 2019; Liu et al. 2018). Both procedures need heat energy for the regeneration of the sorbent and the release of CO_2. Nevertheless, it is crucial to acknowledge that the adsorption pathway demands less energy (Gambhir and Tavoni 2019).

Mineral Carbonation

Mineral carbonation is a chemical process in which carbon dioxide (CO_2) reacts with minerals to create stable carbonates. These carbonates may be securely stored underground or used in various applications (Olajire 2013; Wang et al. 2020). It closely mirrors the natural process of weathering, when silicate rocks are converted into carbonates, but it occurs at a much accelerated pace. Rock formations rich in calcium (Ca), magnesium (Mg), and iron (Fe) are the optimal candidates for reacting with CO_2 and producing stable carbonates. Moreover, industrial wastes that possess high concentrations of components like slag from steel factories and fly ash from coal combustion facilities are suitable ingredients for the carbonation process (Galina et al. 2019).

Emerging Applications of Carbon Capture and Utilization (CCU)

Carbon Capture and Utilisation (CCU) is an innovative method for reducing carbon emissions. It involves trapping carbon dioxide (CO2) and using it for different purposes. An area where CCU shows great potential is in agriculture and the improvement of soil quality. Carbon dioxide (CO_2) that is collected using carbon capture and utilisation (CCU) technology may be used to improve agricultural output. Carbonaceous compounds obtained from collected carbon dioxide, such as carbonates or biochar, may be integrated into soils to enhance their fertility and structure. Not only can this process effectively store carbon in a stable manner, but it also improves the soil's capacity to retain water and make nutrients more accessible (Raji et al., 2023).

Furthermore, the use of carbon dioxide in controlled environment agriculture, such as greenhouse horticulture, has shown potential. Higher concentrations of carbon dioxide (CO_2) may augment the process of photosynthesis and accelerate the development of plants, resulting in higher agricultural productivity and improved food yields. Research is focused on improving the use of CO_2 in agriculture by examining issues such as concentration levels, methods of administration, and the combination of CCU technologies with conventional farming techniques (Zhang et al., 2017; Long et al., 2006).

CCU has the capacity to effectively enhance renewable energy systems. Carbon dioxide (CO_2) obtained from industrial operations or straight from the atmosphere may be transformed into synthetic fuels using techniques such as Power-to-Liquid (PtL) or Electrofuels. Synthetic fuels provide a sustainable substitute for traditional fossil fuels, aiding in the decarbonisation of the transportation industry. The research investigates the effectiveness, scalability, and ecological consequences of synthetic fuels produced by CCU technology. The goal is to smoothly include these fuels into current energy infrastructures (Fasihi et al., 2021; Hafner et al., 2018). Moreover, CCU may also contribute to energy storage. Carbon dioxide (CO_2) may undergo chemical conversion into high-energy molecules and be stored for future use, offering a solution to the issue of intermittent renewable energy production. The research in this field concentrates on the advancement of efficient and economical energy storage technologies based on CCU (Carbon Capture and Utilisation) to enhance the dependability and consistency of renewable energy systems (Schiebahn et al., 2019). CCU has the capacity to amalgamate with other sectors, hence expanding its range of uses beyond energy and agriculture. Within the industrial industry, carbon dioxide (CO_2) that has been collected may be used as a raw material for the creation of chemicals and materials, so supporting the concept of a circular economy. For example, carbon dioxide (CO_2) may be transformed into polymers, plastics, or construction materials, thereby decreasing the dependence on conventional fossil fuel-derived raw materials. The research investigates the technological feasibility, economic viability, and environmental advantages of integrating CCU (Carbon Capture and Utilisation) into industrial processes (Jiang et al., 2020; Centi et al., 2019).

CCU-derived synthetic fuels may be used in several forms of transportation, such as aviation and shipping, within the transportation industry. The possibility of establishing a complete carbon loop, in which CO_2 released during combustion is caught and reused, offers a route towards sustainable and carbon-neutral transportation. The investigations in this field concentrate on the development and enhancement of CCU technologies to fulfil the rigorous requirements of various transportation fuels (Zhu et al., 2019; Spath et al., 2019). The growing use of CCU offers several potential advantages in terms of both the economy and the environment.

Utilising CO_2 as a valuable resource instead of a mere waste product may significantly help to the diversity and resilience of the economy. CCU has the capacity to substantially decrease carbon emissions from an environmental standpoint. CCU, or carbon capture and utilisation, helps combat climate change and supports the goal of reaching carbon neutrality by absorbing and effectively using CO_2 in many applications. Integrating CCU into industrial processes might result in a decrease in the total environmental footprint of certain industries.

Moreover, CCU may contribute to carbon removal and the long-term storage of carbon. Through the process of turning carbon dioxide (CO_2) into stable and useful products, such as mineralized carbonates or solid materials, as shown by Zhu et al. in 2019, carbon capture and utilisation (CCU) provides a means to securely store carbon for long periods of time. The research in this field investigates the possibilities of carbon-negative technologies within the context of CCU, offering an extra instrument in the battle against climate change (Zakkour et al., 2021). The growing uses of CCU demonstrate its adaptability and potential benefits to promoting sustainable development.

Conclusion

Biotechnological approaches for carbon collection and utilisation are essential in tackling climate change and advancing sustainable development. Through the use of microbes, enzymes, and bio-based processes, these novel methods may effectively absorb CO_2 and transform it into valuable commodities. This not only mitigates the release of gases that contribute to the greenhouse effect, but also generates economic prospects in the field of bio-based industries, therefore promoting a more sustainable future.

Implementing Carbon Capture and Utilisation (CCU) technology encounters a range of obstacles, including technological, legislative, and social constraints. It is crucial to acknowledge and tackle these problems in order to ensure the universal acceptance and efficacy of CCU tactics. Attaining optimal effectiveness and expandability in CCU procedures continues to be a significant technological obstacle.

The potential of Carbon Capture and Utilisation (CCU) to revolutionise carbon management, mitigate climate change, and promote sustainable industrial practices is very promising, as shown by current research and development endeavours. Engaging in the exploration of possible prospects and forecasting future developments is crucial for optimising the beneficial effects of CCU technology.

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THE STUDY OF SPACE CHARGE LIMITED CURRENT MEASUREMEMTS ANALYSIS OF SCREEN PRINTED ELECTRONIC DEVICES

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Abstract

This research work presented the study of space charge limited current analysis in screen printed electronic device. Space charge limited current measurements were carried out on the printed metal – silicon nano-composite – metal structures. The graph of In I – In V characteristics of the printed electronic devices were plotted and employed to determine the nature of transport through the device. It was observed that all the printed electronic samples displayed sub linear transport is dominated by direct tunnelling and field emission. The experimental results of this research work revealed that as the value of the effective mass of the charge carrier increases, the amount of the minimum energy required to free the charge carrier will increase in direct proportion. Also the conductivity increases, in direct proportion to the mobility of the charge carrier. Printed electronic device E has the highest conductivity and mobility. The investigation as shown that space charge limited current measurement analysis help to determine the mobility and electronic trap density as reveal by this research

Keywords: Silicon nano-composite based conductive ink, mobility, electronic trap density, and printable electronics

Introduction

Worldwide research on materials that can be employed for the printing of electronic devices is at a high level. This new technology of printing electronic systems on substrate poised to enter the market. One of the appealing characteristics of this technology is that the formulated ink can be deposited on substrates via printing techniques. Silicon nano-composite is a promise material for future flexible and low cost electronics (Cui, 2019)(Gao,2019).

There is the urgent need to investigate its ability to transport or allow charge carriers through it. Charge carrier transport is the process by which charged particles (electrons and holes) move in conducting media. In different conducting media, such as metal, plasma, electrolyte, vacuum and semiconductor material different particles serve to carry charge. Any motion of free charge carriers in a semiconductor leads to a current. This motion can be caused by an electric field due to an externally applied voltage, since the carriers are charged particles and its transport mechanism is termed as carrier drift. In addition, charge carriers also move from regions where the carrier density is high to regions where the carrier density is low and this carrier transport mechanism is due to the thermal energy and the associated random motion of the carriers. This transport mechanism is referring to as carrier diffusion. The total current in a semiconductor equals the sum of the drift and the diffusion current (Okpanachi et *al*, 2021).

Space charge limited current is one of the common methods used for investigation of intrinsic transport properties (charge carrier mobility) and electronic trap density of a semiconductor material. One of its vital merits over other techniques is that the charge extraction is by linearly increasing voltage, optical pump terahertz probe photoconductivity, microwave conductivity, lies in the facts that both mobility and electronic trap density can be probe independently (Vincent et *al*, 2021)

Experimental Methods

Experimental Materials and Instruments

The experimental materials used in this research process are N-type extrinsic semiconductor wafer, styrene acrylic, distilled water, ceramic substrates, silver paste, and milled silicon nano-particle.

The experimental instruments used in this experiment were an electronic balance (JY5002), designed stencil, source meter (Keithley's Series 2400), an XPERT-PRO diffractometer 7000, a DHG9109 laboratory dry oven, glass rod, mechanical milling machine and rubber squeegee (Okpanachi et *al*, 2021).

Deposition Method

A modified screen printing method was carried out using a glass rod and a rubber squeegee to force the silver paste on the ceramic substrate via stencil pattern. The printed silver pastes served as metallic terminals or electrodes and were heated to temperature of 150℃ in DHG9109 laboratory dry oven.

Silicon nano-composite based inks were printed in between two silver paste electrodes on the ceramic substrate via screen printing technique.

Sintering and Post-printing processes

Printed electronic devices A, B, C, D, and E on substrates were attained via screen printing method in order to measure the space charge limited electron and hole currents. And to optimism electron injection, a thin layer of formulated and developed silicon nano-composite was introduced in between the two metallic electrodes (silver)(Ye, 2015).

Sintering of the Printed Electronic Devices

The silver paste electrodes or contacts were then heated up to the temperature of 150℃ with the aid of a DHG9109 laboratory dry oven for about 30 minutes to ensure proper sintering of the contacts. After the period of 30 minutes of curing the printed contacts were allowed to cool.

Then the silicon nano-composite Based inks formulated and developed based on the different ratios were now printed in between the silver paste contacts.

Post Printing of the Printed Electronics Devices

The entire printed electronic devices were heated in a DHG9109 laboratory dry oven to a temperature of 250^0C for 15 minutes to convert the formulated and developed silicon nano-composite based inks into silicon nano-composite based conductive electronic inks.

Voltage Bias and Measurement of Current

In this research, a Keithley's Series 2400 source meter was employed to supply voltage of range (0-10V) across the printed electronic devices and to measure the currents through them. Each of the printed

electronic devices was biased with the aid of the source meter and the corresponding current through it was measured.

Result and Discussion

Result

In this section, the experimental results for analysis of space charge limited current in printed electronic devices were presented and analysed.

Performance Test of Printed Electronic Devices

Measurement of Space Charge Current Limited

If the rate at which charges are injected from silver electrode to the formulated and developed silicon nano-composite equal to the rate of motion, then the charges do not accumulate. But if the rate of mobility through the bulk is low, which is the case for many dielectric systems then there is existence of accumulations at the interface and in the bulk. The electric field due to the accumulated charges will influence the conduction process.

Deductions

Current transport will be limited by space charge:
$I \infty V^m$

i. When $m < 1$ sub-linear current transport dominated by direct tunneling and field emission.
ii. When $m = 1$ linear current transport is purely ohmic.
iii. When m approximately 2,space charge limited transport
iv. When $m >> 2$ super linear ballistic transport

In I versus In V Graph for Printed Electronic Device A (50:50)

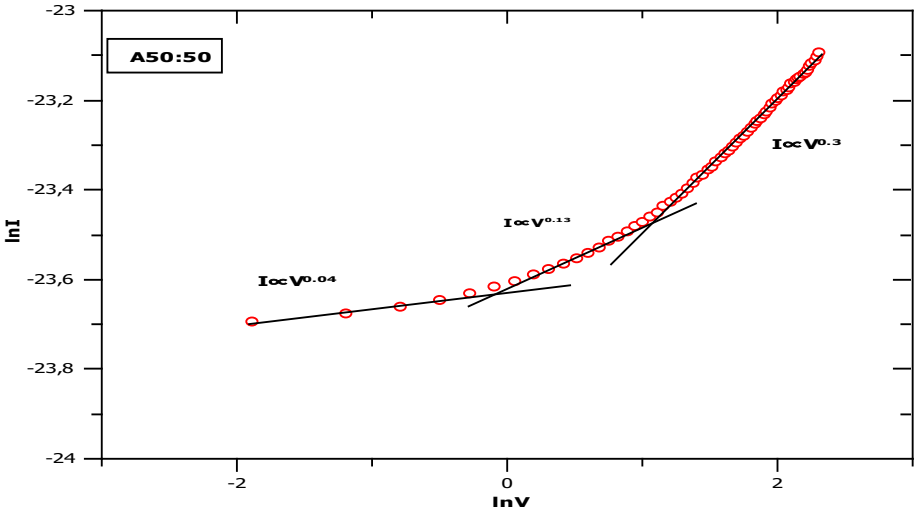

Figure 3 In I versus In V Graph for Printed Electronic Device A (50:50)

Deductions from In I versus In V

- When m < 1 sub linear current transport dominated by direct Tunneling and Field emission.

In I versus In V graph for Printed Electronic Device Sample B (40:60)

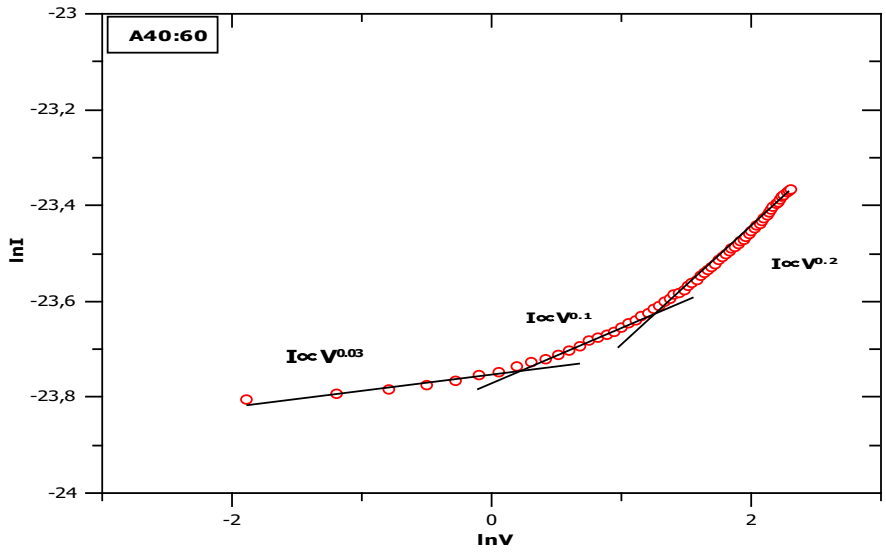

Figure 4. In I versus In V graph for Printed Electronic Device Sample B (40:60)

Deductions from In I versus In V

- When m < 1 sub linear current transport dominated by direct Tunneling and Field emission.

In I versus In V graph for Printed Electronic Device C (30:70)

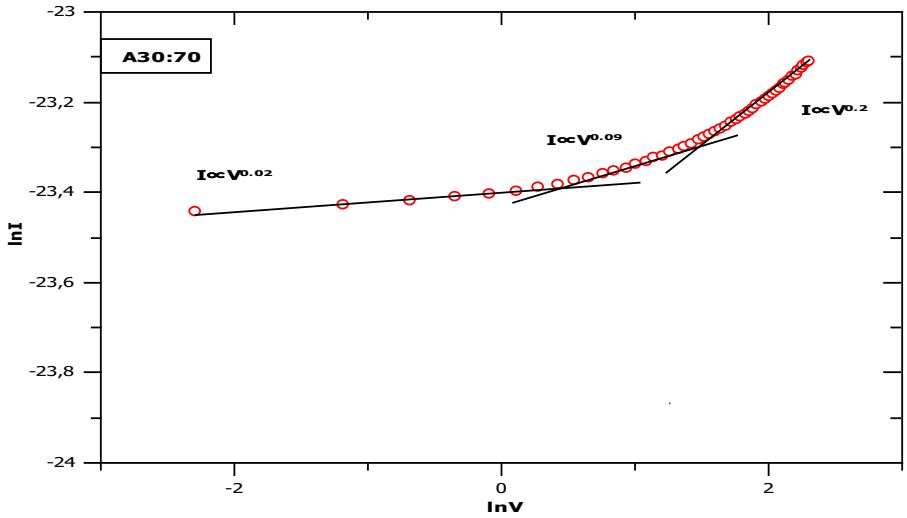

Figure 5. Ln I versus In V graph for Printed Electronic Device C (30:70)

Deductions In I versus In V

- When m < 1 sub linear current transport dominated by direct Tunneling and Field emission.

In I versus In V graph for Printed Electronic Device D (20:80)

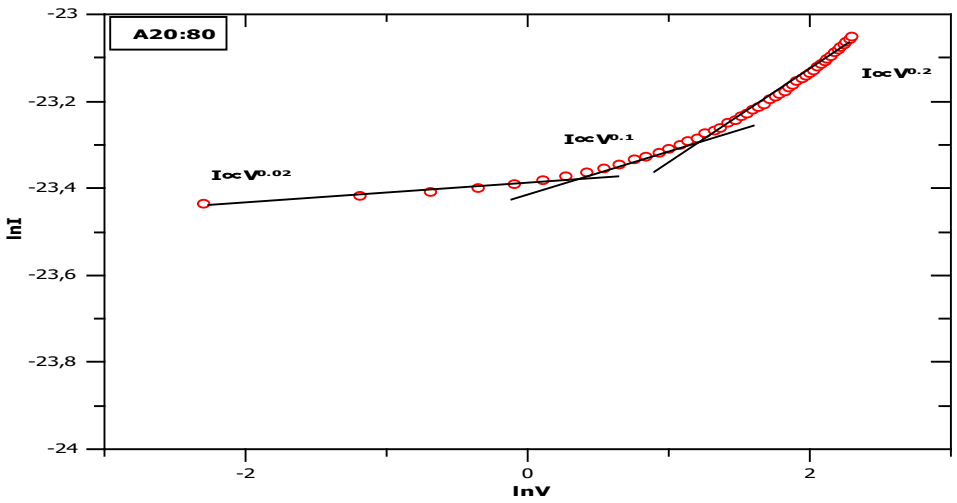

Figure 6 In I versus In V graph for Printed Electronic Device D (20:80)

Deductions In I versus In V

- When m < 1 sub linear current transport dominated by direct Tunneling and Field emission.

In I versus In V Graph for Printed Electronic Device E (10:90)

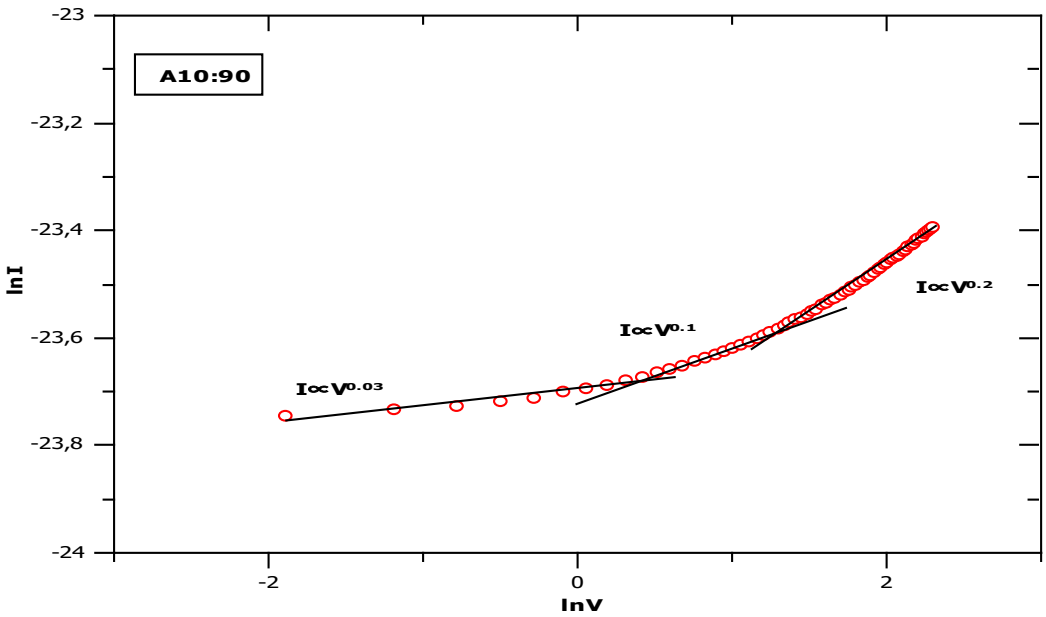

Figure 7 . In I versus In V Graph for Printed Electronic Device E (10:90)

Deductions from In I versus In V

- When m < 1 sub linear current transport dominated by direct Tunneling and Field emission

Determination of Charge Carrier Mobility

We used this equation 4 to calculate the charge carrier mobility of the printed electronic devices and data are recorded in Table 1

At low electric field the drift velocity, V_d is proportional to the electric field strength, E, and the proportionality constant is called the mobility, μ (Sze, 1985).

$\mu \frac{= V_d}{E}$

Where V_d the drift velocity of the electron, E is the electric field intensity, and μ is the mobility of the electrons and holes.

$$\mu = \frac{\sigma V_d A}{l}$$

$$\mu = \sigma V_d b$$

Where V_d the drift velocity of the electron, σ is the conductivity of the electron, A is the area of the printed electronic device on the ceramic substrate, and μ is the mobility of the electrons and holes.

The drift velocity of the charge carrier is proportional to the current, and can be estimated if the length of the printed electronic device and time taken by the electron to travel throughout the length of the printed electronic device is known. Hence the drift velocity is calculated as thus:

$$V_d = \frac{\Delta x}{\Delta t} \quad 2$$

Substituting equation 5 in equation 4 yields

$$\mu = \sigma \frac{\Delta x}{\Delta t} b \quad 3$$

It is obvious from the Table 1 that as the conductivity of the printed electronic device increases and the mobility equally increases. It showed that the printed electronic device with composition of 10:90 had the highest conductivity and mobility of the charge carrier through it. The actual values of resistivity, conductivity, and mobility of

Table 1 Resistivity, conductivity, and Mobility of printed electronic device

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Printed Electronic Device	Resistivity (Ωm)	Conductivity (S/m)	Mobility (m^2/Vs)
A(50:50)	13.15	0.076	6.35×10^{-7}
B(40:60)	11.50	0.086	7.18×10^{-7}
C(30:70)	10.76	0.093	7.63×10^{-7}
D(20:80)	10.30	0.097	8.10×10^{-7}
E(10:90)	10.90	0.099	8.27×10^{-7}

Determination of Electronic Trap Depth

We calculate for the value of electronic trap depth in order to determine the minimum energy required to free a charge carrier from the trap. The trap depth is defined by

$$E_T = \frac{1}{2} m v_x^2$$

Where v_x is the maximum velocity that may

be imparted to an electron initially at trap centre for it remain trappe

d, m is the effective mass of the electron, E_T is the trap depth.

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It can be seen from the table that the bigger the value of the effective mass of the charge carrier, the larger the amount of minimum energy needed to free the charge carrier from trap. Also the smalle

r the effective mass, the smaller the amount of energy required to free the carrier from the trap

Table 2 shows the results of effective mass of the charge carrier and trap depth

Printed Electronic Device	Effective Mass of Electron (kg)	Trap Depth (J)
A(50:50)	1.42×10^{-13}	1.97×10^{-21}
B(40:60)	1.39×10^{-13}	1.93×10^{-21}
C(30:70)	9.64×10^{-12}	1.34×10^{-19}
D(20:80)	2.07×10^{-12}	2.88×10^{-20}
E(10:90)	1.40×10^{-12}	1.94×10^{-20}

Table 2 the results of effective mass of electron and trap d Determination of Trap Densities

We calculate for the value of electronic trap density in order to determine the density of electronic trap states within the styrene acrylic that captured and released charge carriers

$$d = \frac{E_T}{A} \qquad 5$$

Where d is the trap depth, and A is the area of the styrene acrylic

Table 3 the results of Trap Densities

It can be seen from the table that as the trap depth increases then the electronic trap density decreases which shows that trap states within the styrene acrylic that captures and releases charge carrier is small.

Printed Electronic Device	Trap Depth (J)	Electronic Trap Density(J/m^2)
A(50:50)	1.97×10^{-21}	7.88×10^{-15}
B(40:60)	1.93×10^{-21}	7.72×10^{-15}
C(30:70)	1.34×10^{-21}	5.36×10^{-15}
D(20:80)	2.89×10^{-21}	1.16×10^{-15}
E(10:90)	1.94×10^{-21}	7.76×10^{-15}

Discussions

Space Charge Current Limited Measurement Analysis

The graph of In I versus In V had helped to understand that m < 1 sub linear current transport is dominated by direct Tunneling and Field emission. The In I- In V characteristics plotted for the printed electronic devices are shown in figure 3 to figure7.We observed that when the silver contacts were brought into intimate contact with silicon nano-composite based ink, a barrier was formed at the metal-semiconductor interface. The conduction and valence bands of the silicon nano-composite are brought into a definite energy relationship with the Fermi level in the metal. The Fermi levels in the two materials coincided at the establishment of thermal equilibrium when the experimental printed electronic device was connected to a source meter.

These In I- In V characteristics plotted in this research were typically shown that the transport of charge carrier through the devices were due to built up of space charges, indicative of a depletion layer with trapped charges in the developed silicon nano-composite inks.

We observed that the larger the value of the effective mass of the charge carrier , the bigger the amount of minimum energy needed to free the charge carrier from the trap

The nature and majority charge carrier in this silicon based conductive ink are basically electrons since the interface is of metal-semiconductor.

Conclusion

Space charge limited current is one of the common methods used for investigation of intrinsic transport properties (charge carrier mobility) and electronic trap density of a semiconductor material.

Therefore, the experimental results of this research work revealed that as the value of the effective mass of the charge carrier increases, the amount of the minimum energy required to free the charge carrier will increase also. Also the conductivity increases, in direct proportion to the mobility of the charge carrier. Printed electronic device E has the highest conductivity and mobility.

The investigation as shown that space charge limited current measurement analysis help to determine the mobility and electronic trap density as reveal by this research.

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SERO-PREVALENCE OF TRYPANOSOMIASIS IN RUMINANT ANIMALS IN IBADAN, OYO STATE.

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ABSTRACT

Trypanosomiasis is a worldwide infection caused by *Trypanosoma* species. They are economically devastating diseases and a major constraint to livestock health and productivity. Various prevalence studies have revealed the status of the diseases in some regions in Nigeria. However, limited reports on trypanosomiasis have been generated in South-West. The study is aimed at determining the prevalence of trypanosomiasis in ruminant animals in Akinyele and Bodija Abattoirs in Ibadan. A total of 157 blood samples were collected from cattle (82), sheep (9) and goat (66). 157 were screened by microscopy and 78 for *Trypanosoma* by Polymerase Chain Reaction (PCR). The result were analysed by Statistical Package for Social Science 10 (6.4%) were positive with *Trypanosoma* by Microscopy; 7(4.5%) in cattle, 3(1.9%) in goat. *Trypanosomal spp* screening by PCR gave overall prevalence 26 (33.3%). *Trypanosoma* infection was significatly higher ($P < 0.05$) in cattle 14 (17.9%) than goat 9 (11.5%) and sheep 3 (3.84%). This study suggest that trypanosomiasis in ruminant animals is prevalent in Ibadan, South West region of Nigeria The prevalence recorded in this study thus necessitates strategic control measures by government and all other disease control agencies to prevent further spread of toxoplasmosis and trypanosomiasis.

Keywords: Trypanosomiasis, *Trypanosoma*

INTRODUCTION

Animal Trypanosomiasis is a parasitic disease caused by haemoprotozoan parasites belonging to the genus *Trypanosoma*, family Trypanosomatidae. They are found in the blood and other tissues of vertebrates including ruminants and man. Most species of domestic animals are to some degree, susceptible to Trypanosomsiasis transmitted by various haematophagous insects, mainly *Glossina* species commonly known as tsetse flies. These are considered to be the true intermediate hosts of these parasites (Ugochukwu, 2014). The most important *Trypanosome* species affecting animals are *Trypanosoma congolense*, *Trypanosoma vivax* and *Trypanosoma brucei*, in cattle, sheep and goats while *Trypanosoma evansi* and *Trypanosoma equiperdium* affects camels and horses respectively (Getachew, 2016). *T. congolense* is considered to be the single most important cause of African AnimalTrypanosomiasis. This *Trypanosome* is also a major cause of the disease in cattle in West Africa. Sheep, goats, horses, and pigs may also be seriously affected. *T. vivax* though is considered to be less pathogenic for cattle than *T. congolense*, it is nevertheless a major cause of African Animal Trypanosomiasis in West African cattle perhaps, due to its persistence in areas

free of tsetse flies (for example, in Central and South America and in the Caribbean), where it is transmitted mechanically by biting flies or contaminated needles, syringes, and surgical instruments (Djiteye, 2016). *Trypanosoma brucei brucei* is an extremely polymorphic *Trypanosome* occurring as short, stumpy organisms without flagella, long slender organisms with distinct flagella, and intermediate forms that are usually flagellated. Horses, dogs, cats, camels and pigs are very susceptible to *T. b. brucei* infection. Infection of cattle, sheep, goats and sometimes pigs results in mild or chronic infection (WHO, 2018).

Trypanosomiasis affects domestic animals including cattle, swine, camels, goats, sheep and Wild animals. Wild animals known to be infected but which are trypanotolerant include greater kudu *Tragelaphus strepsiceros*, warthog *Phacochoerus africanus*, bushbuck *Tragelaphus scriptus*, bush pig *Potamochoerus porcus*, African buffalo *Syncerus caffer*, African elephant *Loxodonta africana*, black rhinoceros *Diceros bicornis*, lion *Panthero leo* and leopard *Panthera pardus*. Several species of wild animal appear not to be trypanotolerant, e.g.the southern white rhinoceros, *Ceratotherium simum simum* can* die from infection (Williams, 2015)

Most cases of Trypanosomiasis are chronic, but acute disease, which may be fatal within a week, can also occur. The first sign of Trypanosomiasis may be a localized swelling (chancre) at the site of the fly bite, but this usually remains unnoticed. The primary clinical signs are intermittent fever, signs of anemia, lymphadenopathy and weight loss and animals become progressively emaciated. Milk yield may be decreased in dairy animals. Neurological signs, cardiac lesions, diarrhea, keratitis, lacrimation, loss of appetite (Abenga *et al*., 2019)

The African Animal Trypanosomiasis is widely distributed in Africa, the fact that the disease is transmitted mechanically as well as cyclically has certainly expanded the disease distribution out of the tsetse belt area (WHO, 2008). The disease has a quite wide host range. Cattle, sheep, goats, pigs, horses, camels, dogs, cats, and monkeys are susceptible to African Animal Trypanosomiasis and may suffer syndromes ranging from subclinical mild or chronic infection to acute fatal disease. Rats, mice, guinea pigs, and rabbits are useful laboratory species (Simukoko *et al*., 2017)

The three African Animal *Trypanosomes* are considered to be non pathogenic to humans. *T. b. brucei*, although not causing human disease, is closely related to *T. b. gambiense* and *T. b. rhodesiense* (Osorio *et al.,* 2018). In east and southern Africa, *T. b. rhodesiense* is the cause of a much more acute form of human sleeping sickness. This *Trypanosome* also infects cattle, bushbuck (*Tragelaphus scriptus*), and probably many other wild animals that may serve as reservoirs of the parasite. The pathogenic *Trypanosomes* have been classified either as Stercoraria (posterior station *Trypanosomes*) *Trypanosoma theleria* which is mildly pathogenic to domestic and 20 wild ruminants and Salivaria (anterior station *Trypanosomes* which is pathogenic to both domestic and wild animals. These *Trypanosomes* mainly belong to three subgenera *Trypanozoon*, *Dutonella*, and *Nanomas* (Osorio *et al*., 2018).

The subgenus *Trypanozoon* contains *T.brucei*, two species of which *T.brucei gambiense* and *T. brucei rhodesiense* are responsible for sleeping sickness in man in Africa and one subspecies *T. brucei brucei* for infection in domesticated animals. *T.evansi* which is found in many parts of the world in a wide variety of animals and *T.equiperdium* also belong to the subgenus. *T.suis* in the subgenera Nanomas;

T.congolense and *T.simiae* are the important members. The most important African *Trypanosomes* species include: *T. vivax*, *T. congolense* and *T.brucei*. The important species causing diseases in cattle are *T.congolense*, *T. vivax* and *T.brucei* (Ugochukwu, 2014)

Table 1: Distribution of *Trypanosoma* Species among Vertebrate Host

Species	Host	Area
T. congolense	Goats	Nigeria
T. vivax	Cattle, Sheep, Goats,	Nigeria
	Horses	East Africa
T. simiae	Pigs, Monkeys	Nigeria
T. gambiense	Man	West Africa
T. rhodesiense	Man	East Africa
T. brucei	Dogs, Cats, Ruminants	West Africa
	Monkeys	East Africa

Source : Ugochukwu, (2014)

Epidemiology of Trypanosomiasis: The current threat of African Animal Trypanosomiasis ranked among the top 10 cattle disease on sustainable livestock production and mixed farming, coupled with failure of control as well as chemotherapy/chemoprophylaxis to control the resurgence of the disease, present a major constraint to inreased agricultural activities and the development of African continent. Currently, approximately 60 million people and 48million cattle are at risk contracting African Trypanosomiasis from the 23 species and 33 subspecies of tsetse flies infesting area of 10 million square kilometers of Africa strtching across 40 countries, and is responsible for 5,000 human and 3 million livestock death annually (WHO, 2018; Kristjanson *et al*., 2019; Abenga *et al*., 2019). The diseases transmitted by tsetse arguably represent the most debilitating on human development, agricultural production, food security and sustainable human livelihood on the continent, with an estimated loss in livestock production and mixed agriculture valued at 5 billion US dollars yearly in Africa (Winrock, 2017; Samdi *et al*., 2020). However, effective and sustainable control measures can result in up to 3 fold increase in the current estimated livestock population in Nigeria (Onyia, 2017). Most Tsetse transmission is cyclic and begins when blood from a Trypanosome-infected animal is ingested by the fly (Davila & Silva, 2019). The tsetse-fly-infested area of Africa extends from the southern edge of the Sahara desert (lat. 15°N.) to Angola, Zimbabwe, and Mozambique (lat. 20°S)

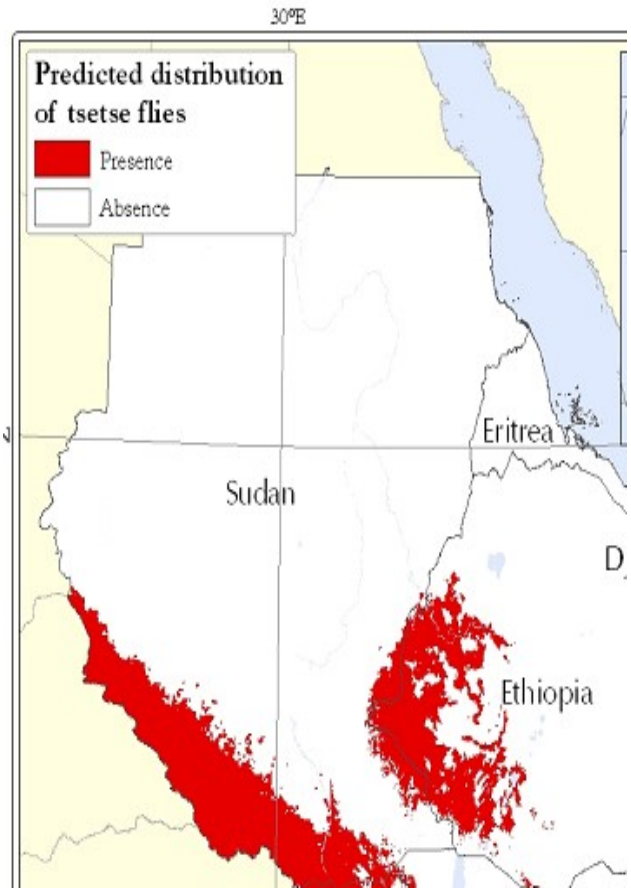

Figure 1: Tsetse Distribution in Africa. Source : Onyiah, (2017)

MATERIALS AND METHODS

This study was conducted at the Akinyele and Bodija abattoirs in Ibadan. A total of 157 animals comprising of cattle(82), sheep(9) and goat(66) were sampled. Five milliliters of jugular blood was collected randomly at the point of slaughter in bottles containing one milligram ethylene diamine tetra acetic acid (EDTA) per millimeter of blood. The blood samples were kept cool by placing them in cold boxes containing ice packs after collection. Parasitological examination (thin smear microscopy) and PCR was used to investigate *Trypanosomes*. *Trypanosome* were identified in a Giesma stained thin smear preparation when viewed under an oil immersion field while *Trypanosome* genes were amplified in the PCR analysis.

DETECTION OF *Trypanosomes* BY MICROSCOPY

A thin film from the whole blood sample was prepared on a clean grease free microscopic slide. The film was air dried, fixed in absolute methanol for 2 minutes and allowed to dry. The fixed dried thin smear was stained by Giesma for 25 minutes. At completion of 25 minutes, the stain was washed off with a clean water and allowed to dry. The slides were examined under a light microscope using immersion oil at x100 magnification to identify the *Trypanosome* parasite.

DNA EXTRACTION FROM BLOOD SAMPLES

DNA was extracted from blood samples using methanol extraction protocol. The whole blood samples collected from the animal were blotted on Whatmann filter paper and allowed to dry properly. Approximately 3x5 mm pieces of blood spot on the filter paper was cut off and transfered into 500 µl PCR microfuge tube. 100 µl of methanol was added to the tube while the content was allowed to submerge totally in the methanol. The tube was incubated for 15 minutes. At the completion of the incubation, the methanol was pipetted out using new tip for every sample. The lid of the tube was left opened to allow evaporation of remaining methanol in the tube at room temperature for about 15 – 60 minutes. At total dryness, 50 µl of sterile water was added into the tube and heated at 98^0C on a heating block for 15 minutes. Occassional vortexing during the heating process was done to get high yield of the DNA. The dislodged DNA was pipetted out from the tube and transfered into new sterile tube, ready for PCR.

DETECTION OF *Trypanosome spp* BY POLYMERASE CHAIN REACTION (PCR)

Among the target gene that have been developed for *Trypanosomes* detection, 237 base pair ESAG 6/7 gene was amplified from extracted DNA using reaction primers: forward (5'-ACA TTC CAG CAG GAG TTG GAG-3') and reverse (5'-CAC GTG AAT CCT CAA TTT TGT-3'). The PCR reaction was performed in a 25 µl reaction mixture containing 5 µl of master mix, 2 µl of each primers(forward and reverse), 10 µl of the extracted DNA and 6 µl sterile water. The prepared 25 µl reaction mixture was placed in a thermocycler where DNA amplification was performed using the following protocols: 4 minutes at 94^0C for initial denaturation in one cycle, followed by 35 cycles of 1 minute at 94^0C for denaturation, 1 minute at 55^0C for annealing and 1 minute at 72^0C for extension, followed by a final extension of 5 minutes at 72^0C. Each PCR product were electrophoresed on 1% agarose gel and visualized under Ultra Violet (UV) light.

DATA ANALYSIS

All data obtained were analysed by statistical package for social science, SPSS (version 21.0). Test for association among the animals was performed with chi square test.

RESULTS PREVALENCE OF TRYPANOSOMIASIS PREVALENCE IN CATTLE

Eighty two (82) cattle samples collected from the abattoirs were examined by microscopy. 39 of the samples were screened by PCR. 7 (4.5%) of the cattle samples examined microscopically were positive to *Trypanosome* as shown in figure 3. 14 (17.9%) of cattle samples screened by PCR were positive to *Trypanosome* while 25 (32.1%) were negative (figure 4). Prevalence is significantly higher ($p < 0.05$) in cattle than the rest of the animals in both diagnostic method i.e microsopy and PCR.

PREVALENCE IN SHEEP

None (0%) of the 9 sheep samples examined via light microscope were positive to *Trypanosome* as indicated in figure 3. 3 (3.84 to the parasite by PCR. while 6 (7.7%) were negative (figure 4). The prevalence is lower in sheep compare to the rest of the animals and the difference in the prevalence was not statistically significant ($p > 0.05$) with chi square value ($X^2 = 1.00$, P = 0.317, Cl = 95%).

PREVALENCE IN GOAT

Three (1.91%) of 66 goat samples screened via light microscope were positive to *Trypanosome* while 63 (40.1%) were negative (figure 3). 30 of the samples were screened by PCR. 9 (11.5%) were positive to *Trypanosome* by PCR while 21 (26.9%) were negative (figure 4). In this study, prevalence in goat is higher than sheep but lower than cattle in both microscopy and PCR diagnostic methods though the difference was statistically significantly ($p < 0.05$).

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1 2 3 4 5 6 7 8 9 10 11 12

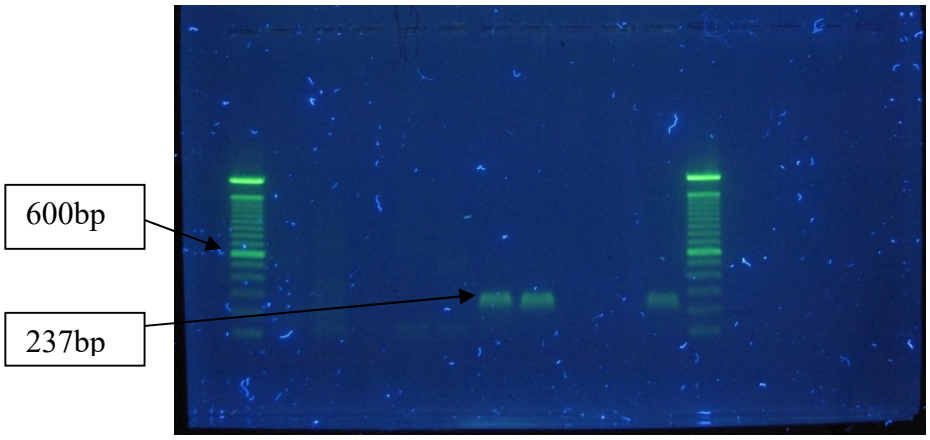

Figure 2: Agarose gel electrophoresis picture showing PCR amplification sensitive to 237 base pair gene of *Trypanosome* yielding three positive samples in lanes 7 , 8 and 11, seven negative samples in lanes 2,3,4,5,6,9 and 10 with DNA ladder 100 bp in lanes **1**

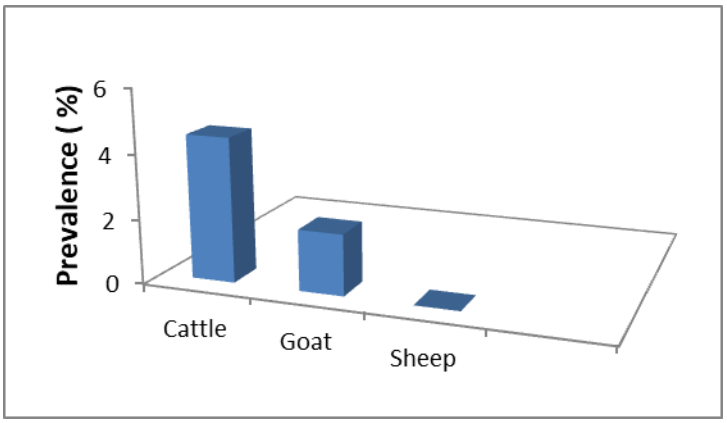

Figure 3: Prevalence of Trypanosome by microscopy in cattle, sheep and goat

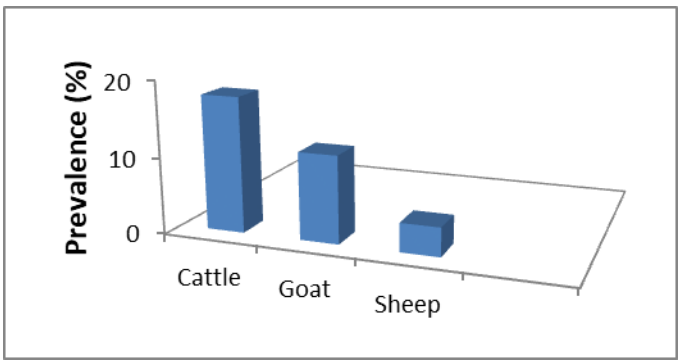

Figure 4: Prevalence of *Trypanosome* by PCR in cattle, sheep and goat.

DISCUSSION

The overall prevalence [26 (33.2%)] of trypanosomiasis in cattle , goat and sheep in Akinyele and Bodija Abattoirs 17.9%, 11.5% and 3.8% respectively using PCR investigation method shows that the infection is relatively high giving the economic importance of the livestock in generating income and contribution to food security. This result is considered more accurate and more reliable than the microscopic detection with the overall prevalence of 10 (6.4%), cattle having higher infection rate 7 (4.5%), goat 3 (1.9%) while 0 (0%) for sheep. These results agrees with the reports of Ugochukwu, (2014); Williams *et al.* (2015) that DNA based methodologies to determine prevalence of *Trypanosome* species in domestic livestock have been available for over 10 years and found more reliable. Despite this, they are rarely used to generate baseline data for control operations of the diseases in the field. Rather, such operations tend to rely on data which can be generated using low technology methods such as direct observation of parasites by light microscopy. Although Kalejaiye *et al*. (2015) reported 2.1% infection rates in goats at slaughter in Ibadan, South West Nigeria, these rates indicate a general resurgence in the menace

of trypanosomiasis in Nigeria with negative economic impact on meat quality of animals at slaughter (Abenga *et al*., 2020). These increase may be attributed to the problems of drug resistant *Trypanosome* strains, increased vector activities and insufficient policies for control of the disease in small ruminants. Also the ability of *T.vivax* (which has been identified in Nigeria) to be transmitted mechanically by other vectors other than *Glossina* has been identified as a factor responsible for spread of the parasite to many parts of the country (Abenga *et al*., 2019), and maintenance of *Trypanosome* infection transmission even in the presence of tsetse control. Higher infection rates was observed in cattle which may have risen from the husbandry practice in this part of Nigeria where cattle are usually taken out for grazing and in turn become more exposed to tsetse bites and other vectors, unlike goat and sheep that are rarely taken out for grazing or maintain a less free range grazing (Agu and Amadi, 2014). It has been revealed that *T. congolense* and *T. vivax* are the main constraint on livestock development in Nigeria. However, in Africa, *T. congolense* infection usually manifests asa chronic form of the disease and milder than that caused by *T. vivax*. Some of the factors that affect the prevalence of Trypanosomiasis in Nigeria include animal breed, type of management, season of the year and the type of vegetation. It is also known that nomadism tends to expose animals to high tsetse challenge and hence *Trypanosome* infection.

CONCLUSION AND RECOMMENDATION

Surveillance of trypanosomiasis in ruminants animals (cattle, sheep and goat) in major abbattoirs in Ibadan re-affirmed the incidence and resurgence of the disease following the surveillance of Kalejaiye *et. al*. (1995). In Nigeria, trypanosomiasis has been considered as a major threat to livestock production and declining status of quality meat. High mortality rate of livestock has been associated with the infection which no doubt underline the fact that trypanosomiasis is a menace to animal husbandry and high economic loss to the country and the continent at large.

Likewise, high infection rate has been found in cattle and sheep which indeed poses a risk to human to become infected though contamination of food and drinks and also through consumption of raw or undercooked meat. Indeed, all effort should be made towards combating these diseases so that our animals would not run into extinction as well as our economy would not be depressed. This can be achieved by proper information dissemination. Orientation Agencies either locally or internationally should be called into action and equally empowered by the government to conduct enlightenment programmes accros board for all and sundry, stressing the mode of transmission of the diseases ane the possible ways of preventing/controlling it.

Government should also include rural research and developmental projects in their yearly budget, provision of drugs and other structural amenities to checkmate the disease so as to ensure infection free life.

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LATTICE DYNAMICS OF SODIUM (Na): IFCs AND DFT APPROACH

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Abstract
The phonon dispersion curves of Sodium (Na) have been calculated from analytical (IFCs technique using Born – von Kármán model) with different numbers of interacting nearest-neighbours (NN) and computational approach (first principle using density functional theory) with the exchange correlation functional. The different branches of the phonon band structure follow from the Eigen values after diagonalizing the dynamical matrix. The phonon frequencies in the first Brillouin zone were calculated along the directions of high symmetry, $\Gamma \to H$ *,* $H \to P$ *,* $P \to \Gamma$ *and* $\Gamma \to N$ *. It is observed that the phonon dispersion curve of Na from IFCs calculation gave a fair agreement with experiment just like the first principles calculations*.

KEY WORDS: Brillouin Zone, Dispersion, Phonon, Ecutwfc, GGA, IFCs, MAE, MARE, PBE, PW, QE

INTRODUCTION

The behaviour of many physical properties of solidsfrom the method of orthogonalized plane-wave, centres on of their lattice-dynamics. Thus, in everythe method of Pseudopotential. This was in principal direction, if given a good fit to thedifferent forms improved upon by several authors dispersion curves with the force model foretell(Vosko, Taylorand Keech, 1965; Animalu, 1966; brilliantly all other properties of the latticeAnimalu and Heine, 1965; Abarebkov and Heine, dynamics of the material (Da Cunha Lima,1965; Harrison, 1969). In the calculation of the Brescansin and Shukla, 1974). The understanding ofproperties of lattice dynamics, this has proved an these properties in terms of phonons is thought-outeffective means for a lot of simple metals. The idea to be amongst the persuading piece validating theof quantum defect by Heine-Abarenkov correctness of the current quantum picture of solids(Abarebkov and Heine, 1965; Heine and (Baroni *et al*., 2001). Abrarenkov, 1964) was used to study certain

The importance in the connection associated with the properties of the lattice dynamics of a system and the electrons can never be overemphasized because, in the exploitation of these connection makes it feasible in computing the properties of the lattice dynamics of specific systems. The dynamics of lattice allows one to express the contributions of the internal strains in relation to the microscopic quantities like optoacoustical couplings and effective ionic charges (Michel, Cakir, Sevik and Peeters, 2017). As well as the models of elastic-force, (Phillips and Kleinman, 1959; Antonic, 1959) obtained Giannozzi, 2001) has often been used in resolving problems (Dal Corso and de Gironcoli, 2000; Heid electronic properties and the dispersion curve of several transition metals by Animalu (Animalu, 1974; Animalu, 1973), by formulating the transition metal model potential (TMMP). Animalu discovered that in FCC metals the results from the experiment agrees with theoretical results. This was different for BCC transition metals where the branch of transverse crosses over the longitudinal before the zone boundary. The first principle prediction of the dispersion curves of phonon of noble and transition metals has been a tough problem which has not been totally resolved. DFPT (Baroni, Gironcoli, Dal Corso and and Bohnen, 1999; Dal Corso, Pasquarello and Baldereschi,1997

Savrasov and Savrasov, 1996) but has succeeded to some extent in different metals. The prediction of the phonon curves of simple metals like aluminium is easy, and was amongst those studied first using first principle method (de Gironcoli, 1995). Also, in reasonable agreement with experimental results are Iridium, nickel and gold with exchange and correlation functional not below one, while several metals have not achieved this feat. Copper a noble metal is a typical example, whose theoretical phonon curves are with huge errors when compared to experiment (Grabowski, Hickel and Neugebauer, 2007; Favot and Dal Corso, 1999; Dal Corso, 2013, Dal Corso, Pasquarello and Baldereschi, 1997; Savrasov and Savrasov, 1996). Lately the investigation on the interaction of electron-phonon and the pairing mechanism in the superconducting Ca-intercalated bi-layer graphene (C_6CaC_6) using the first principle anisotropic Eliashberg theory with Coulomb interactions was carried out (Margine, Lambert and Giustino, 2016). The inelastic helium atom scattering (HAS) and high-resolution electron energy loss spectroscopy (HREELS) was employed to study the phonon dispersion of graphene grown on some single crystal metal surfaces (Al Taleb and Farias, 2016). The thermal properties of molecular crystals were computed by the using first principle quantum-mechanical theoretical framework which merge dispersion-corrected density-functional-theory (DFT-D), quasi-harmonic approximation, harmonic phonon dispersion, to the lattice dynamics for thermodynamic functions and thermal expansion, and quasi-static approximation for anisotropic thermos-elasticity (Alessandro, Jefferson and Bartolomeo, 2016). The challenge here is to determine and improve on existing techniques employed to determine the lattice dynamics of Sodium (Na) using analytical approach (Interatomic Force Constants – IFCs) and computational approach (first principle or ab-initio – QUANTUM ESPRESSO) and compare with experiment.

THEORETICAL FORMALISM

ANALYTICAL (IFCs) PROCEDURE

The Born-von Kármán theory was applied by assigning a force-constant matrix to each of the nearest neighbours of the atom considered, constructing the dynamical matrix from the individual force-constant matrices, and then solving the dynamical matrix for the phonon energies and the associated phonon polarizations.

INTERATOMIC FORCE CONSTANTS (IFCs)

The frequencies of the phonon of any material are typically somewhat a smooth function of the wave vector. Thus, for complete phonon dispersion an appropriate interpolation technique is needed. By Fourier analysis, the smoother the phonon dispersions considering the real space IFCs, the shorter the range of the real space:

$$\tilde{C}_{st}^{\alpha\beta}\left(\vec{R}\right)=\frac{1}{N_c}\sum e^{i\vec{q}.\vec{R}}\tilde{C}_{st}^{\alpha\beta}\left(\vec{q}\right) \quad (1)$$

Thus, real space IFCs, i.e., the force constants between atoms of a system in a real space is easy and achievable using a set of matrix force constants computed and presented in a table on an even grid of points within a reciprocal space. The *fast Fourier transform* (FFT) technique (Press, Teukolsky, Vetterling and Flannery, 1989) is the most effective way of computing numerically all these Fourier transforms. After obtaining the force constants between atoms of a system in real-space, then the dynamical matrices in reciprocal space (and, hence, vibrational) frequencies can be obtained at any wave vector (not necessarily contained in the original grid) by FFT. The shorter the range of real space force constants, the coarser will be the

reciprocal space grid needed for such Fourier interpolation.

ONSTRUCTION OF THE DYNAMICAL MATRIX

The phonon frequencies are given by the solution of the secular determinant

$$\left|D_{ij}(\vec{q}) - m\omega^2 I\right| = 0 \tag{2}$$

Where m is the mass of the ion, ω is the phonon frequency, $D_{ij}(\vec{q})$ is the dynamical matrix elements and I is a 3×3 unit matrix. The elements of the dynamical matrix are a matrix as shown below

$$D_{ij} = \begin{pmatrix} D_{xx}(\vec{q}) & D_{xy}(\vec{q}) & D_{xz}(\vec{q}) \\ D_{yx}(\vec{q}) & D_{yy}(\vec{q}) & D_{yz}(\vec{q}) \\ D_{zx}(\vec{q}) & D_{zy}(\vec{q}) & D_{zz}(\vec{q}) \end{pmatrix} \tag{3}$$

Once the force constant matrices have been determined the elements of te dynamical matrix are evaluated. This gives for the diagonal matrix elements of the first nearest to sixth nearest neighbours dynamical matrix as:

$$D_{xx}(\vec{q}) = \frac{1}{M}\begin{Bmatrix} 8\alpha_1 + 2\alpha_2 + 4\beta_2 + 8\alpha_3 + 4\beta_3 + 8\alpha_4 + 16\beta_4 + 8\alpha_5 + 2\alpha_6 + 4\beta_6 + 8\alpha_7 + 16\beta_7 \\ + 8\alpha_8 + 8\beta_8 + 8\gamma_8 + 8\alpha_9 + 16\beta_9 + 8\alpha_{10} - 8\alpha_1 \cos\left(\frac{aq_x}{2}\right)\cos\left(\frac{aq_y}{2}\right)\cos\left(\frac{aq_z}{2}\right) \\ - 2\alpha_2 \cos(aq_x) - 2\beta_2 \cos(aq_y) - 2\beta_2 \cos(aq_z) - 4\alpha_3 \cos(aq_x)\cos(aq_y) \\ - 4\alpha_3 \cos(aq_x)\cos(aq_z) - 4\beta_3 \cos(aq_x)\cos(aq_y) - 8\alpha_4 \cos\left(\frac{3aq_x}{2}\right)\cos\left(\frac{aq_y}{2}\right)\cos\left(\frac{aq_z}{2}\right) \\ - 8\beta_4 \cos\left(\frac{aq_x}{2}\right)\cos\left(\frac{3aq_y}{2}\right)\cos\left(\frac{aq_z}{2}\right) - 8\beta_4 \cos\left(\frac{aq_x}{2}\right)\cos\left(\frac{aq_y}{2}\right)\cos\left(\frac{3aq_z}{2}\right) \\ - 8\alpha_5 \cos(aq_x)\cos(aq_y)\cos(aq_z) - 2\alpha_6 \cos(2aq_x) - 2\beta_6 \cos(2aq_y) - 2\beta_6 \cos(2aq_z) \end{Bmatrix} \tag{4}$$

$$D_{yy}(\vec{q}) = \frac{1}{M}\begin{Bmatrix} 8\alpha_1 + 2\alpha_2 + 4\beta_2 + 8\alpha_3 + 4\beta_3 + 8\alpha_4 + 16\beta_4 + 8\alpha_5 + 2\alpha_6 + 4\beta_6 + 8\alpha_7 + 16\beta_7 \\ + 8\alpha_8 + 8\beta_8 + 8\gamma_8 + 8\alpha_9 + 16\beta_9 + 8\alpha_{10} - 8\alpha_1 \cos\left(\frac{aq_x}{2}\right)\cos\left(\frac{aq_y}{2}\right)\cos\left(\frac{aq_z}{2}\right) \\ - 2\alpha_2 \cos(aq_y) - 2\beta_2 \cos(aq_x) - 2\beta_2 \cos(aq_z) - 4\alpha_3 \cos(aq_x)\cos(aq_y) \\ - 4\alpha_3 \cos(aq_y)\cos(aq_z) - 4\beta_3 \cos(aq_x)\cos(aq_z) - 8\alpha_4 \cos\left(\frac{aq_x}{2}\right)\cos\left(\frac{3aq_y}{2}\right)\cos\left(\frac{aq_z}{2}\right) \\ - 8\beta_4 \cos\left(\frac{3aq_x}{2}\right)\cos\left(\frac{aq_y}{2}\right)\cos\left(\frac{aq_z}{2}\right) - 8\beta_4 \cos\left(\frac{aq_x}{2}\right)\cos\left(\frac{aq_y}{2}\right)\cos\left(\frac{3aq_z}{2}\right) \\ - 8\alpha_5 \cos(aq_x)\cos(aq_y)\cos(aq_z) - 2\alpha_6 \cos(2aq_x) - 2\beta_6 \cos(2aq_y) - 2\beta_6 \cos(2aq_z) \end{Bmatrix} \tag{5}$$

$$D_{zz}(\vec{q}) = \frac{1}{M}\begin{Bmatrix} 8\alpha_1 + 2\alpha_2 + 4\beta_2 + 8\alpha_3 + 4\beta_3 + 8\alpha_4 + 16\beta_4 + 8\alpha_5 + 2\alpha_6 + 4\beta_6 + 8\alpha_7 + 16\beta_7 \\ + 8\alpha_8 + 8\beta_8 + 8\gamma_8 + 8\alpha_9 + 16\beta_9 + 8\alpha_{10} - 8\alpha_1 \cos\left(\frac{aq_x}{2}\right)\cos\left(\frac{aq_y}{2}\right)\cos\left(\frac{aq_z}{2}\right) \\ - 2\alpha_2 \cos(aq_z) - 2\beta_2 \cos(aq_x) - 2\beta_2 \cos(aq_y) - 4\alpha_3 \cos(aq_x)\cos(aq_z) \\ - 4\alpha_3 \cos(aq_y)\cos(aq_z) - 4\beta_3 \cos(aq_x)\cos(aq_y) - 8\alpha_4 \cos\left(\frac{aq_x}{2}\right)\cos\left(\frac{aq_y}{2}\right)\cos\left(\frac{3aq_z}{2}\right) \\ - 8\beta_4 \cos\left(\frac{3aq_x}{2}\right)\cos\left(\frac{aq_y}{2}\right)\cos\left(\frac{aq_z}{2}\right) - 8\beta_4 \cos\left(\frac{aq_x}{2}\right)\cos\left(\frac{3aq_y}{2}\right)\cos\left(\frac{aq_z}{2}\right) \\ - 8\alpha_5 \cos(aq_x)\cos(aq_y)\cos(aq_z) - 2\alpha_6 \cos(2aq_z) - 2\beta_6 \cos(2aq_y) - 2\beta_6 \cos(2aq_x) \end{Bmatrix} \tag{6}$$

And the off - diagonal matrix elements of the first nearest to sixth nearest neighbour dynamical matrix as:

$$D_{xy}=\frac{1}{M}\left\{\begin{array}{l}8\beta_1\sin\left(\frac{aq_x}{2}\right)\sin\left(\frac{aq_y}{2}\right)\cos\left(\frac{aq_z}{2}\right)+4\gamma_3\sin(aq_x)\sin(aq_y)\\+8\gamma_4\sin\left(\frac{3aq_x}{2}\right)\sin\left(\frac{aq_y}{2}\right)\cos\left(\frac{aq_z}{2}\right)+8\gamma_4\sin\left(\frac{aq_x}{2}\right)\sin\left(\frac{3aq_y}{2}\right)\cos\left(\frac{aq_z}{2}\right)\\+8\delta_4\sin\left(\frac{aq_x}{2}\right)\sin\left(\frac{aq_y}{2}\right)\cos\left(\frac{3aq_z}{2}\right)+8\beta_5\sin(aq_x)\sin(aq_y)\cos(aq_z)\end{array}\right\} \quad (7)$$

$$D_{xz}=\frac{1}{M}\left\{\begin{array}{l}8\beta_1\sin\left(\frac{aq_x}{2}\right)\sin\left(\frac{aq_z}{2}\right)\cos\left(\frac{aq_y}{2}\right)+4\gamma_3\sin(aq_x)\sin(aq_z)\\+8\gamma_4\sin\left(\frac{3aq_x}{2}\right)\sin\left(\frac{aq_z}{2}\right)\cos\left(\frac{aq_y}{2}\right)+8\gamma_4\sin\left(\frac{aq_x}{2}\right)\sin\left(\frac{3aq_z}{2}\right)\cos\left(\frac{aq_y}{2}\right)\\+8\delta_4\sin\left(\frac{aq_x}{2}\right)\sin\left(\frac{aq_z}{2}\right)\cos\left(\frac{3aq_y}{2}\right)+8\beta_5\sin(aq_x)\sin(aq_z)\cos(aq_y)\end{array}\right\} \quad (8)$$

$$D_{yz}=\frac{1}{M}\left\{\begin{array}{l}8\beta_1\sin\left(\frac{aq_y}{2}\right)\sin\left(\frac{aq_z}{2}\right)\cos\left(\frac{aq_x}{2}\right)+4\gamma_3\sin(aq_y)\sin(aq_z)\\+8\gamma_4\sin\left(\frac{3aq_y}{2}\right)\sin\left(\frac{aq_z}{2}\right)\cos\left(\frac{aq_x}{2}\right)+8\gamma_4\sin\left(\frac{aq_y}{2}\right)\sin\left(\frac{3aq_z}{2}\right)\cos\left(\frac{aq_x}{2}\right)\\+8\delta_4\sin\left(\frac{aq_z}{2}\right)\sin\left(\frac{aq_y}{2}\right)\cos\left(\frac{3aq_x}{2}\right)+8\beta_5\sin(aq_y)\sin(aq_z)\cos(aq_z)\end{array}\right\} \quad (9)$$

Where M denotes the mass of the element, and $D_{xy}=D_{yx}$, $D_{xz}=D_{zx}$ and $D_{yz}=D_{zy}$. The elements $\alpha_1,\beta_1,\ldots$ are the nearest neighbour parameters in a least-squares fit to the data. The force constants were also of great value as a simple mathematical description of the phonon spectrum [27] used this property in their method of calculating the phonon distribution function.

COMPUTATIONAL PROCEDURE

In the density functional theory (DFT) carried out for Na, the electron was treated using scalar relativistic ultra-soft *ab - initio* Pseudopotential, within the applied self-consistent method. The computations are employed within DFT using QUANTUM ESPRESSO code (opEn Source Package for Research in Electronic Structure, Simulation, and Optimization) (Giannozzi *et al*., 2009; Giannozzi *et al*., 2017) for the exchange and correlation energy. The pseudo-wave functions expansion is carried out in plane waves with ecutwfc starting from 10Ry to 70Ry at an interval of 5Ry. The converged value of the ecutwfc was found to be 30Ryd for GGA (PBE) functional, 25Ry for LDA functional and 35Ry for GGA (PAW) functional. Also, the K-points values are integrated over the BZ in the reciprocal space with uniform K-point meshes of 7 X 7 X 7 points for GGA (PBE) and 5 X 5 X 5 points for both LDA and GGA (PAW) points. The self-consistency calculation was assumed to have converged when the difference in energy between subsequent iteration was 1.0×10^{-3} Ry.

DISCUSSION OF RESULTS

Figure 1, shows the phonon dispersion curve of sodium (Na) from IFCs calculated by sixth nearest neighbours force constant fit to Born – von Kármán model matched with data from experiment. The data from experiment (Woods *et al*., 1963) is shown as blue, green and red circles with the red solid line showing the calculations from IFCs. The force constants employed for the calculations and the force constant matrices are shown in Table 2 and 3 respectively. The first principle (*ab-initio*) calculation using QUANTUM ESPRESSO code compared with experimental inelastic neutron scattering data (Woods *et al*., 1963) is shown in Figure 2. The experimental data is shown as blue, green and red circles, the black solid curves the dispersion calculated using the generalized gradient approximation (GGA-PBE), the red solid curves the dispersion calculated using LDA and the blue solid curves the dispersion calculated using GGA (PAW) functional.

On assessing the different results obtained with IFCs, first principle (QUANTUM ESPRESSO) method and experiment, Tables 1a and 1b shows the frequencies in the principal symmetry points $H = \frac{2\pi}{a}(1,0,0)$, $P = \frac{2\pi}{a}\left(\frac{1}{2},\frac{1}{2},\frac{1}{2}\right)$, $N = \frac{2\pi}{a}\left(\frac{1}{2},\frac{1}{2},0\right)$ and '*a*' being the lattice constant. IFCs calculations of the phonon dispersions of sodium (Na) showed that the 1-6th nearest neighbours dispersions calculated with (MAE 0.0213THz), percentage error (MARE 0.74%) did not improve on the experimental results compared to 1-5th nearest neighbours with (MAE 0.0097THz), percentage error (MARE 0.34%) was lower, whereas, the density functional theory (DFT) using GGA (PBE), LDA and GGA (PAW) gave a larger MAE, percentage error (MARE) as (MAE 0.6812THz, MARE 23.55%), (MAE 0.9601THz, MARE 33.20%) and (MAE 0.4469THz, MARE 15.45%) respectively as shown in Tables 1a and b. In the first principle calculations using DFT, the GGA (PAW) functional gave a better result when compared to GGA (PBE) and LDA functional.

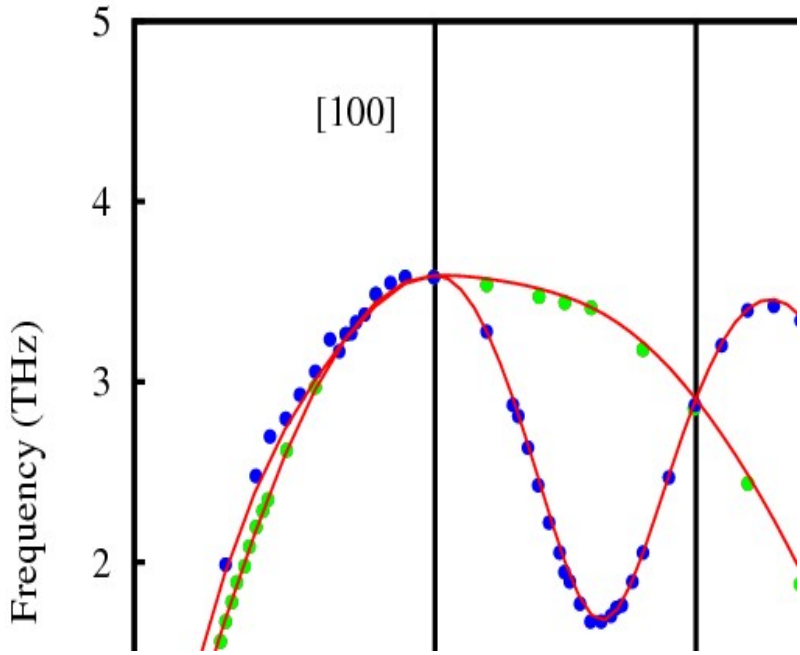

Figure 1: Sodium dispersion curves. The Red curves correspond to sixth nearest neighbours fit (IFCs). The experimental results from Woods *et al*. (1963) are shown by the symbols , and

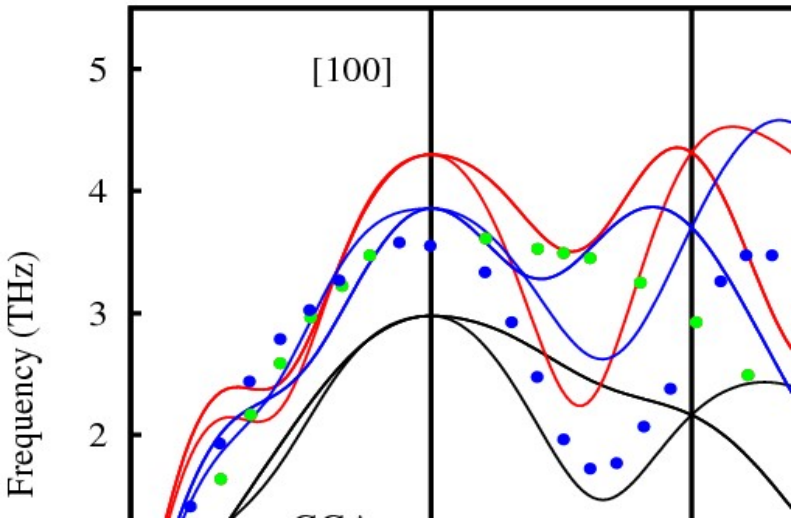

Figure 2: Sodium dispersion curves of GGA (PBE), LDA and GGA (PAW) results from QUANTUM ESPRESSO calculations. The experimental results from Woods *et al*. (1963) are shown by the symbols , and

Table 1: (a) The calculated frequencies and percentage errors at some high symmetry points for Sodium. (b) Calculated MAE and MARE for Sodium.

(a)

	a_T	FREQUENCY (THz)						
	$(a.u)$	H_L	H_T	P_L	P_T	N_L	N_{T_1}	N_{T_2}
GGA(PBE)	7.93	2.9771	2.9771	2.1651	2.1651	2.5617	0.7736	1.8576
LDA	7.69	4.2989	4.2989	4.3067	4.3067	4.1169	2.1059	3.5327
GGA(PAW)	7.93	3.8545	3.8545	3.7023	3.7023	3.7622	1.1782	3.3203
IFCs	-	3.5915	3.5915	2.9040	2.9040	3.8064	1.0288	2.5687
Expt. [a]	8.108	3.5809	3.5809	2.8713	2.8524	3.8458	0.9177	2.5970
			% Error					
GGA(PBE)	-2.24	16.86	16.86	24.60	24.10	33.39	15.70	28.47
LDA	-5.16	20.05	20.05	50.34	51.34	7.05	129.48	36.03
GGA(PAW)	-2.24	7.64	7.64	28.94	29.80	2.17	28.39	27.85
IFCs	-	0.30	0.30	1.14	1.81	1.02	12.11	1.09

(b)

	TOTAL	AVERAGE	$\pm(work - expt.)$(THz)	MAE (THz)	MARE (%)
GGA(PBE)	15.4773	2.2110	4.7687	0.6812	23.55

LDA	26.9667	3.8524	6.7207	0.9601	33.20
GGA(PAW)	23.3743	3.3392	3.1283	0.4469	15.45
IFCs	20.3949	2.9136	0.1489	0.0213	0.74
Expt. [a]	20.2460	2.8923	-	-	-

[a] (Woods *et al.,* 1963) (Experiment).

Table 2: First - sixth nearest neighbour general force models for Sodium.

Position of neighbour	**Force constant (dyn/cm)**	**Sixth nearest neighbour fit**	**Nearest neighbours**
$\frac{a}{2}(1,1,1)$	α_1	1162	First
$\frac{a}{2}(1,1,1)$	β_1	1338	First
$\frac{a}{2}(2,0,0)$	α_2	463	Second
$\frac{a}{2}(2,0,0)$	β_2	97	Second
$\frac{a}{2}(2,2,0)$	α_3	-46.7	Third
$\frac{a}{2}(2,2,0)$	β_3	-9.5	Third
$\frac{a}{2}(2,2,0)$	γ_3	-37.2	Third
$\frac{a}{2}(3,1,1)$	α_4	56.7	Fourth
$\frac{a}{2}(3,1,1)$	β_4	3.5	Fourth
$\frac{a}{2}(3,1,1)$	γ_4	19.9	Fourth
$\frac{a}{2}(3,1,1)$	δ_4	6.6	Fourth
$\frac{a}{2}(2,2,2)$	α_5	14.7	Fifth
$\frac{a}{2}(2,2,2)$	β_5	15.4	Fifth
$\frac{a}{2}(4,0,0)$	α_6	-40	Sixth

$\frac{a}{2}(4,0,0)$	β_6	20		Sixth

Table 3: Force-constant matrices $\phi(0,l)$ corresponding to the first nearest to sixth nearest neighbours of the atom at the origin

Atomic Pair	$\phi(0,l)$	Atomic Pair	$\phi(0,l)$	Atomic Pair	$\phi(0,l)$
$0-$ $1\ \frac{a}{2}(1,1,1)$ $\frac{a}{2}(-1,-1,-1)$	$-\begin{pmatrix}\alpha_1 & \beta_1 & \beta_1\\ \beta_1 & \alpha_1 & \beta_1\\ \beta_1 & \beta_1 & \alpha_1\end{pmatrix}$	$0-$ $2\ \frac{a}{2}(-1,1,1)$ $\frac{a}{2}(1,-1,-1)$	$-\begin{pmatrix}\alpha_1 & -\beta_1 & \beta_1\\ -\beta_1 & \alpha_1 & -\beta_1\\ \beta_1 & -\beta_1 & \alpha_1\end{pmatrix}$	$0-$ $3\ \frac{a}{2}(1,-1,1)$ $\frac{a}{2}(-1,1,-1)$	$-\begin{pmatrix}\alpha_1 & -\beta_1 & \beta_1\\ -\beta_1 & \alpha_1 & -\beta_1\\ \beta_1 & -\beta_1 & \alpha_1\end{pmatrix}$
$0-$ $4\ \frac{a}{2}(-1,-1,1)$ $\frac{a}{2}(1,1,-1)$	$-\begin{pmatrix}\alpha_1 & \beta_1 & -\beta_1\\ \beta_1 & \alpha_1 & -\beta_1\\ -\beta_1 & -\beta_1 & \alpha_1\end{pmatrix}$	$0-$ $5\ \frac{a}{2}(2,0,0)$ $\frac{a}{2}(-2,0,0)$	$-\begin{pmatrix}\alpha_2 & 0 & 0\\ 0 & \beta_2 & 0\\ 0 & 0 & \beta_2\end{pmatrix}$	$0-$ $6\ \frac{a}{2}(0,2,0)$ $\frac{a}{2}(0,-2,0)$	$-\begin{pmatrix}\beta_2 & 0 & 0\\ 0 & \alpha_2 & 0\\ 0 & 0 & \beta_2\end{pmatrix}$
$0-$ $7\ \frac{a}{2}(0,0,2)$ $\frac{a}{2}(0,0,-2)$	$-\begin{pmatrix}\beta_2 & 0 & 0\\ 0 & \beta_2 & 0\\ 0 & 0 & \alpha_2\end{pmatrix}$	$0-$ $8\ \frac{a}{2}(2,2,0)$ $\frac{a}{2}(-2,-2,0)$	$-\begin{pmatrix}\alpha_3 & \gamma_3 & 0\\ \gamma_3 & \alpha_3 & 0\\ 0 & 0 & \beta_3\end{pmatrix}$	$0-$ $9\ \frac{a}{2}(-2,2,0)$ $\frac{a}{2}(2,-2,0)$	$-\begin{pmatrix}\alpha_3 & -\gamma_3 & 0\\ -\gamma_3 & \alpha_3 & 0\\ 0 & 0 & \beta_3\end{pmatrix}$
$0-$ $10\ \frac{a}{2}(0,2,2)$ $\frac{a}{2}(0,-2,-2)$	$-\begin{pmatrix}\beta_3 & 0 & 0\\ 0 & \alpha_3 & \gamma_3\\ 0 & \gamma_3 & \alpha_3\end{pmatrix}$	$0-$ $11\ \frac{a}{2}(0,-2,2)$ $\frac{a}{2}(0,2,-2)$	$-\begin{pmatrix}\beta_3 & 0 & 0\\ 0 & \alpha_3 & -\gamma_3\\ 0 & -\gamma_3 & \alpha_3\end{pmatrix}$	$0-$ $12\ \frac{a}{2}(2,0,2)$ $\frac{a}{2}(-2,0,-2)$	$-\begin{pmatrix}\alpha_3 & 0 & \gamma_3\\ 0 & \beta_3 & 0\\ \gamma_3 & 0 & \alpha_3\end{pmatrix}$
$0-$ $13\ \frac{a}{2}(-2,0,2)$ $\frac{a}{2}(2,0,-2)$	$-\begin{pmatrix}\alpha_3 & 0 & -\gamma_3\\ 0 & \beta_3 & 0\\ -\gamma_3 & 0 & \alpha_3\end{pmatrix}$	$0-$ $14\ \frac{a}{2}(3,1,1)$ $\frac{a}{2}(-3,-1,-1)$	$-\begin{pmatrix}\alpha_4 & \gamma_4 & \gamma_4\\ \gamma_4 & \beta_4 & \delta_4\\ \gamma_4 & \delta_4 & \beta_4\end{pmatrix}$	$0-$ $15\ \frac{a}{2}(-3,1,1)$ $\frac{a}{2}(3,-1,-1)$	$-\begin{pmatrix}\alpha_4 & -\gamma_4 & -\gamma_4\\ -\gamma_4 & \beta_4 & \delta_4\\ -\gamma_4 & \delta_4 & \beta_4\end{pmatrix}$
$0-$ $16\ \frac{a}{2}(3,1,-1)$ $\frac{a}{2}(-3,-1,1)$	$-\begin{pmatrix}\alpha_4 & \gamma_4 & -\gamma_4\\ \gamma_4 & \beta_4 & -\delta_4\\ -\gamma_4 & -\delta_4 & \beta_4\end{pmatrix}$	$0-$ $17\ \frac{a}{2}(3,-1,1)$ $\frac{a}{2}(-3,1,-1)$	$-\begin{pmatrix}\alpha_4 & -\gamma_4 & \gamma_4\\ -\gamma_4 & \beta_4 & -\delta_4\\ \gamma_4 & -\delta_4 & \beta_4\end{pmatrix}$	$0-$ $18\ \frac{a}{2}(1,3,1)$ $\frac{a}{2}(-1,-3,-1)$	$-\begin{pmatrix}\beta_4 & \gamma_4 & \delta_4\\ \gamma_4 & \alpha_4 & \gamma_4\\ \delta_4 & \gamma_4 & \beta_4\end{pmatrix}$
$0-$ $19\ \frac{a}{2}(1,-3,-1)$ $\frac{a}{2}(-1,3,1)$	$-\begin{pmatrix}\beta_4 & -\gamma_4 & -\delta_4\\ -\gamma_4 & \alpha_4 & \gamma_4\\ -\delta_4 & \gamma_4 & \beta_4\end{pmatrix}$	$0-$ $20\ \frac{a}{2}(1,3,-1)$ $\frac{a}{2}(-1,-3,1)$	$-\begin{pmatrix}\beta_4 & \gamma_4 & -\delta_4\\ \gamma_4 & \alpha_4 & -\gamma_4\\ -\delta_4 & -\gamma_4 & \beta_4\end{pmatrix}$	$0-$ $21\ \frac{a}{2}(1,-3,1)$ $\frac{a}{2}(-1,3,-1)$	$-\begin{pmatrix}\beta_4 & -\gamma_4 & \delta_4\\ -\gamma_4 & \alpha_4 & -\gamma_4\\ \delta_4 & -\gamma_4 & \beta_4\end{pmatrix}$
$0-22$ $\frac{a}{2}(1,1,3)$ $\frac{a}{2}(-1,-1,-3)$	$-\begin{pmatrix}\beta_4 & \delta_4 & \gamma_4\\ \delta_4 & \beta_4 & \gamma_4\\ \gamma_4 & \gamma_4 & \alpha_4\end{pmatrix}$	$0-23$ $\frac{a}{2}(1,1,-3)$ $\frac{a}{2}(-1,-1,3)$	$-\begin{pmatrix}\beta_4 & \delta_4 & -\gamma_4\\ \delta_4 & \beta_4 & -\gamma_4\\ -\gamma_4 & -\gamma_4 & \alpha_4\end{pmatrix}$	$0-24$ $\frac{a}{2}(-1,1,3)$ $\frac{a}{2}(1,-1,-3)$	$-\begin{pmatrix}\beta_4 & -\delta_4 & -\gamma_4\\ -\delta_4 & \beta_4 & \gamma_4\\ -\gamma_4 & \gamma_4 & \alpha_4\end{pmatrix}$

$0-25$ $\frac{a}{2}(1,-1,3)$ $\frac{a}{2}(-1,1,-3)$	$-\begin{pmatrix} \beta_4 & -\delta_4 & \gamma_4 \\ -\delta_4 & \beta_4 & -\gamma_4 \\ \gamma_4 & -\gamma_4 & \alpha_4 \end{pmatrix}$	$0-26$ $\frac{a}{2}(2,2,2)$ $\frac{a}{2}(-2,-2,-2)$	$-\begin{pmatrix} \alpha_5 & \beta_5 & \beta_5 \\ \beta_5 & \alpha_5 & \beta_5 \\ \beta_5 & \beta_5 & \alpha_5 \end{pmatrix}$	$0-27$ $\frac{a}{2}(-2,2,2)$ $\frac{a}{2}(2,-2,-2)$	$-\begin{pmatrix} \alpha_5 & -\beta_5 & -\beta_5 \\ -\beta_5 & \alpha_5 & \beta_5 \\ -\beta_5 & \beta_5 & \alpha_5 \end{pmatrix}$
$0-28$ $\frac{a}{2}(2,-2,2)$ $\frac{a}{2}(-2,2,-2)$	$-\begin{pmatrix} \alpha_5 & -\beta_5 & \beta_5 \\ -\beta_5 & \alpha_5 & -\beta_5 \\ \beta_5 & -\beta_5 & \alpha_5 \end{pmatrix}$	$0-29$ $\frac{a}{2}(2,2,-2)$ $\frac{a}{2}(-2,-2,2)$	$-\begin{pmatrix} \alpha_5 & \beta_5 & -\beta_5 \\ \beta_5 & \alpha_5 & -\beta_5 \\ -\beta_5 & -\beta_5 & \alpha_5 \end{pmatrix}$	$0-30$ $\frac{a}{2}(4,0,0)$ $\frac{a}{2}(-4,0,0)$	$-\begin{pmatrix} \alpha_6 & 0 & 0 \\ 0 & \beta_6 & 0 \\ 0 & 0 & \beta_6 \end{pmatrix}$
$0-31$ $\frac{a}{2}(0,4,0)$ $\frac{a}{2}(0,-4,0)$	$-\begin{pmatrix} \beta_6 & 0 & 0 \\ 0 & \alpha_6 & 0 \\ 0 & 0 & \beta_6 \end{pmatrix}$	$0-32$ $\frac{a}{2}(0,0,4)$ $\frac{a}{2}(0,0,-4)$	$-\begin{pmatrix} \beta_6 & 0 & 0 \\ 0 & \beta_6 & 0 \\ 0 & 0 & \alpha_6 \end{pmatrix}$		

CONCLUSION

The dispersion curves of Sodium (Na) were calculated successfully in the ambit of the interatomic force constants (IFCs) technique employing the Born – von Kármán model and the first principle technique based on DFT implemented by QUANTUM ESPRESSO. The phonon dispersions were computed along the principal symmetry directions of the Brilouin (BZ). The results obtained from both techniques were matched with data from experiment. We conclude that the phonon dispersion curve of Na from IFCs calculation shows a close agreement with experiment just like that from the first principle calculations. In the first principle calculations using DFT, the GGA (PAW) functional gave a better results compared to GGA (PBE) with the LDA worst of the functional. Also, the GGA (PBE) (2.24%), GGA (PAW) (2.24%) and LDA (5.16%) all substantially underestimated the lattice constant.

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PHYTOCHEMICAL AND ANTIOXIDANT PROPERTIES FROM METHANOLIC EXTRACT OF *Azadirachta indica BARK*

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ABSTRACT

Several researches have shown that Azadirachta indica (neem, family: Meliaceae) is one of those candidate plants which their different parts have protective effect and strong antioxidant potentials used in traditional medicine. This study evaluated the flavoiniod content, polyphenol contents and ferric reducing antioxidant power (FRAP) in bark of methanolic extracts of neem. The dry powder of the bark of neem tree was extracted using methanolic by cold maceration (1:10, m/v) method, followed by concentration of filtrate using rotary evaporator. The extracts were tested for antioxidant activity using ferric reducing antioxidant power; flavonoid and total phenol contents by Folin Ciocalteu's reagent method. The experimental results revealed that the extracts exhibited antioxidant activities and possess polyphenols in a concentration dependent order significant at 250µg/ml (P< 0.05). Thus, the polyphenol concentrations of bark extracts revealed a positive correlation with its antioxidant capacity. Neem plant and its bark may be exploited for clinical medicine as potent factor because of its antioxidant property.

Key words: ***Azadirachta indica bark, methanolic' polyphenol content and antioxidant***

INTRODUCTION

Plants have been a source of medicine in the past centuries and today scientists and the general public recognize their value as a source of new or complimentary medicinal products (Premanath and Lakshmidevi, 2017). The medicinal value of these plants lies in some chemical active substances that produce definite physiological action on the human body (Aiyelaagbe and Osamudiamen, 2015). Medicinal plants are used by 80% of the world population as the only available medicines especially in developing countries (EL-Kamali and EL-amir, 2015). Nigeria has a great variety of natural vegetation, which is used in trado-medicine to cure various ailments; some plants are also useful for ornamental purposes, while many due to their odoriferous nature are used in flavoring or as food additives and preservatives (Egwaikhinde and Gimba, 2018). Practically, every part of the *A. indica* (leaves, bark, fruit, flowers, oil and gum) has been reported to be associated with various remedial properties such as the treatment of general body pain after child delivery, pyorrhea, intestinal worms, antimicrobial effects, storage behavior, *in vitro* antiviral activity and antibacterial agent (Biu *et al.,* 2015; Taha *et al*., 2015). Acalypha species are popularly used for the treatment of malaria, dermatological and gastro-intestinal disorders.

The good understanding of some important plants and herbs around us is not only essential for maintaining a healthy body. It is fundamental to understand why it's important to be acquitted with nature as well as noting those important medicinal plants and herbs around us for our benefit. This

will save the stress, time cost of searching for expensive method of treatment when we are surrounded by free gift of nature. Even though this is your first time of hearing of *Azadirachta indica* or not, you should know what this leaf is, what it does and how it should be used.

The aim of this project work is to determine the polyphenol content and antioxidant property from methanolic extract of Azadirachta *indica* bark.

MATERIALS AND METHODS

MATERIALS

Apparatus and Equipments

Beaker, Test tubes, rack, foil paper, masking tape, weighing balance, Grounding engine, handkerchief, Spatula, Mortar and pestle, micro-pipette (500µl and 200µl), Empeldulf tubes, funnel, Gallon (10 litres), rotary evaporator (RE300DB), water bath and spectrophotometer (GENESYS 10S, UV-Vis).

CHEMICALS AND REAGENTS

2,4,6-tris-2-pyridyl-S-triazine (TPTZ), sodium trioxocarbonate (iv) (Na_2CO_3), Folin reagent, methanol, distilled water, aluminum chloride ($AlCl_3$), acetate buffer (0.2M, pH of 3.6), ferric chloride ($FeCl_3$), and hydrochloric acid (HCl) were obtained from Sigma- Aldrich (St. Louis, MO USA). All other chemicals and solvents used were of analytical grade.

PLANT COLLECTION AND EXTRACTION

The bark of Azadirachta *indica* (Neem) was gotten from a tree located at Akpekpe Secondary School, Auchi, Edo State, and was authenticated by a botanist at the federal polytechnic Auchi. The sample was shred into smaller piece and was air dried for two weeks, and then weighed after it is fully dry. Then it was pounded to break into the shaft before grinding it into coarse form.

1000 g of the sample was weighed and then poured into 10litre of solvent (1:10 m/v) using cold maceration method.The sample was then kept in the lab for 72 hours, and then filtered using white handkerchief, after which the sample was concentrated using the rotary evaporator to get a dry extract. The process of extraction took 72 hours and then the extract residue and methanol was recovered back from the sample.

METHODS

PHYTOCHEMICAL ANALYSIS

Tannins

1ml of sample was mixed with 2ml of distilled water in a test tube after which few drops of 0.1% ferric chloride was added and observed for brownish green coloration (Lawal *et al*., 2019; Solanki *et al*., 2019; Dubale *et al*., 2023).

Amino Acids

2ml of sample was mixed with two drops of Ninhydrine solution. But there was no purple color (Solanki *et al*., 2019).

Flavonoids

5ml of 10% ammonia was added to 1ml of sample of the plant extract, followed by addition of concentrated 1ml of H_2SO_4. A pale yellow coloration was observed in the extract which indicates there is little presence of flavonoid (Lawal *et al*., 2019).

Glycosides

1ml of the sample, 2ml of glacial acetic acid containing one drop of ferric chloride solution was added. This was then layered with 1ml of concentrated H_2SO_4, a brown ring obtained at the interface indicates the presence of deoxysugar characteristics of cardenolides (Lawal *et al*., 2019; Solanki *et al*., 2019).

Saponin

1ml of extract was mixed with 3 drops of olive oil, and then shaken vigorously and was observed for the formation of emulsion (Solanki *et al*., 2019).

Fixed Oil

A small quantity of extract is pressed between two filter papers. Oil stain on the paper indicates the presence of fixed oil (Lawal *et al*., 2019; Dubale *et al*., 2023).

DETERMINATION OF TOTAL PHENOL

The total phenol content was determined according to the method of Singleton *et al.,* (1999). Briefly, appropriate dilutions of the extracts were oxidized with 2.5 ml 10% Folin-Ciocalteau's reagent (v/v) and neutralized by 2.0 ml of 7.5% sodium carbonate. The reaction mixture was incubated for 40 minutes at 45^0 C and the absorbance was measured at 765 nm in the spectrophotometer. The total phenol content was subsequently calculated as gallic acid equivalent.

DETERMINATION OF TOTAL FLAVONOID

The total flavonoid content of the extracts was determined using a slightly modified method reported by. About 0.5ml of appropriately diluted sample extract were mixed with 0.5ml methanol, 50µl 10% $AlCl_3$, 50µl 1M potassium acetate and 1.4ml water and allowed to incubate at room temperature for 30 min. The absorbance of the reaction mixture was subsequently measured at 420nm and the total flavonoid content calculated as quercetin equivalent (Meda *et al*., 2005).

FERRIC REDUCING ANTIOXIDANT POWER

The reducing property of the extracts was determined by assessing the ability of the extracts to reduce $FeCl_3$ solution. A 2.5 ml aliquot was mixed with 2.5 ml of 200 mM sodium phosphate buffer (pH 6.6) and 2.5 ml of 1% potassium ferricyanide. The mixture was incubated at 50^oC for 20 min and then 2.5 ml of 10% trichloroacetic acid was added. This mixture was centrifuged at 801 × g for 10 min. 5 ml of the supernatant was mixed with an equal volume of water and 1 ml of 0.1% ferric chloride. The

absorbance was measured at 700 nm and ferric reducing power was subsequently calculated using ascorbic acid equivalent (Oyaizu, 1986).

STATISTICAL ANALYSIS

All values obtained were expressed as mean ± SEM of three independent experiments carried out in different days using Duncan's New Multiple Range Tests where appropriate. * Represent significant difference from control at $p < 0.05$.

RESULTS AND DISCUSSION

RESULTS

PHYTOCHEMICALS OF *AZADIRACHTA INDICA*

The results of the phytochemical screening of Azadirachta *Indica* bark extract are presented in Table 1. The extracts contained tannins, amino acids, flavonoid, glycosides, saponin and fixed oil.

Table 1: Phytochemical Screening of methanolic extract of *Azadirachta indica*

	TEST	INFERENCE
1	Tannins	++
2	Amino Acids	-
3	Flavonoid	+
4	Glycosides	+++
5	Saponin	++
6	Fixed Oil	-

Key: + (trace), ++ (moderate), +++ (abundant), - (absent)

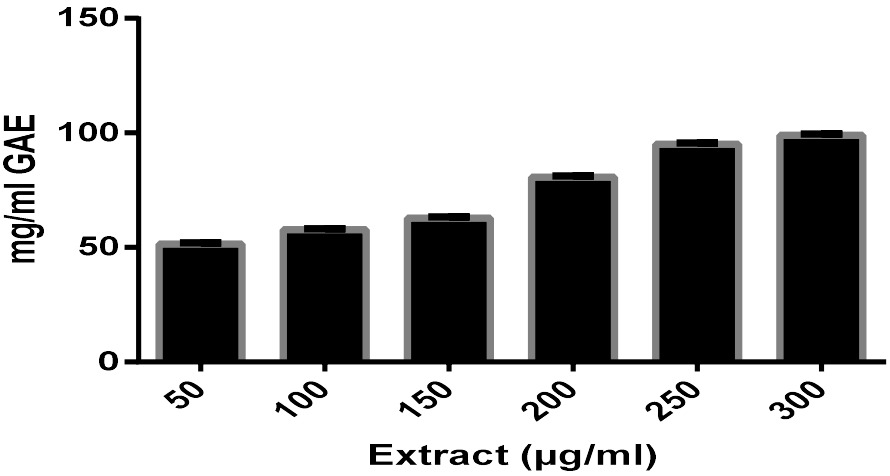

Figure 1: The Total phenol content of the methanolic extract of *Azadirachta indica* bark. Data are presented as mean ± SEM values from three independent experiments done in duplicate in different days with significant difference from control at $p < 0.05$.

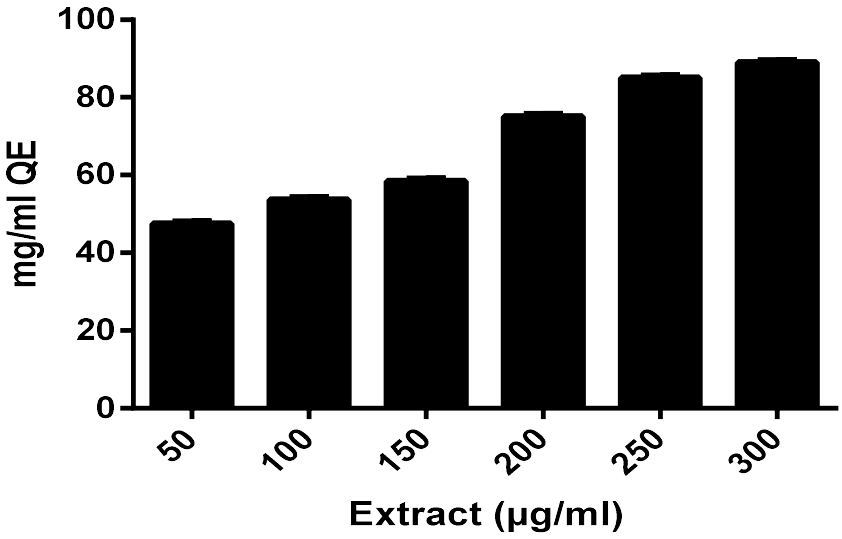

Figure 2: The flavonoid content of the methanolic extract of *Azadirachta indica* bark. Data are presented as mean ± SEM values from three independent experiments done in duplicate in different days with significant difference from control at $p < 0.05$.

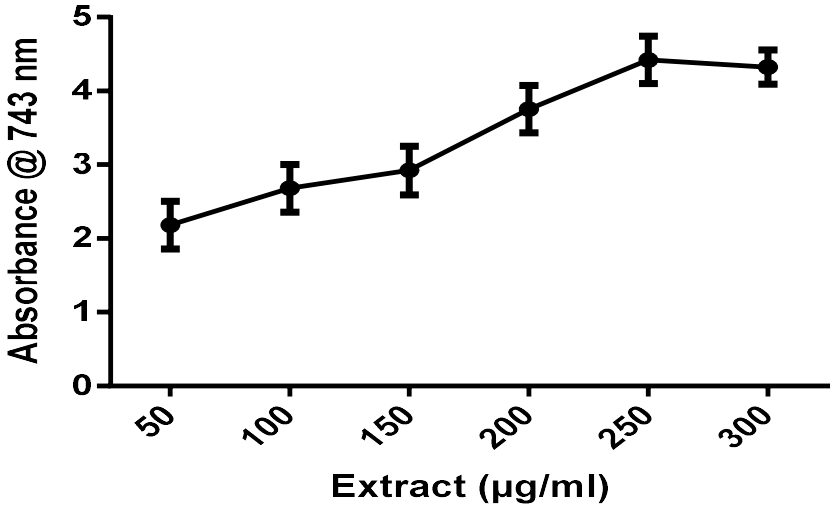

Figure 3: The ferric reducing activity of the methanolic extract of *Azadirachta indica* bark. Data are presented as mean ± SEM values from three independent experiments done in duplicate in different days with significant difference from control at $p < 0.05$.

DISCUSSION

Azadirachta indica is one of those candidate plants which has polyphenols such as phenol and flavonoid with strong antioxidant potential (Sittisarn *et al*., 2018). Flavonoids are broadly spread and form major colouring components of plants. They are a large group of phenolic compounds and are responsible for a variety of pharmacological activities (Mondal and Mondal, 2022). Researchers have shown that there are active compounds in neem plant, like nimbin, azadirachtin, nimbidiol, quercetin, and nimbidin (Sharma *et al*., 2022). Table 1 shows the presence of glycosides, tannins and fixed oil with traces of flavonoids. However, amino acid was not detected. Figures 1 and 2 explain the phenolic and flavonoid contents of methanolic extracts of bark of *Azadirachta indica*. The bark extracts reveal the presence of phenol and flavonoids in concentration dependent manner for phenolic and flavonoid contents. Moreover, the ferric reducing antioxidant power (FRAP) of the plant extract in the reduction of ferric ion to a ferrous state, it was equally observed that the plant extract exhibited ferric reducing antioxidant ability in a concentration dependent manner, as shown in Figure 3. The principles of the FRAP assay is based on the antioxidant strength in reducing ferric tripyridyltriazine

complex to its ferrous form. The intensity of the blue colour formation is proportional to the concentration of the ferrous form and the antioxidant capacity of the extract. Antioxidant compounds that exhibit antioxidant capacity in FRAP assay are usually election donors as they reduce the oxidized intermediate to the stable form in order to eliminate the oxidation chain reaction (Prakash *et al*., 2007).This goes a long way to show that this plant extract demonstrated antioxidant properties. This is in accordance with research findings that used different parts of leaf stem bark and seed of neem extracted with methanol and their efficacy were tested against pathogens and stress mediated diseases (Verkerk and Wright 2020).

CONCLUSION AND RECOMMENDATION

CONCLUSION

This work may have vindicated some conventional uses of *Azadirachta Indica* in the management of stress linked diseases. The exploitation of this plant may offer solutions to some prevailing clinical and nutritional conditions, since it is becoming obvious that the natural vegetation around us is enriched with solutions of most of our health challenges.

RECOMMENDATION

It therefore recommended that more *in vitro* studies (biological and enzyme), isolation and characterization of the active principles; and *in vivo* studies could be done in further research work on the methanolic extract of the bark of *Azadirachta indica.*

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PHYSIOCHEMICAL AND ANTIMICROBIAL EVALUATION OF NEEM (*Azadirachta indica*) BASED TOOTHPASTE

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ABSTRACT

This study examines the physiochemical and antimicrobial properties of formulated Azadirachta indica based tooth paste. The formulated toothpaste using items such as powdered Neem leaves and bark (0.1 %), sodium lauryl, sodium benzoate, sodium CMC, methyl perabo, calcium carbonate (41 %) , alovera gel, honey, peppermint, clove oil and glycerine (44 %), *was compared with a control toothpaste (Oral B Toothpaste).* The physiochemical analysis: *cleaning ability, foaming ability, moisture content, spreadability, stability, pH, abrasiveness and homogeneity were carried out. The physiochemical results revealed that the neem formulated toothpaste is relatively good compared to Oral B tooth paste. Furthermore, the antimicrobial activity of the formulated toothpaste was tested against Treponema denticola (isolated and characterized) and the zone of inhibition was determined. 50 µl of the formulated toothpaste had a zone of inhibition of 25 mm, 100 µl of same had 28 mm while 50 µl of Oral B toothpaste had a zone of inhibition of 30 mm, 100 µl had 33 mm. However, the distilled water had no zone of inhibition and this indicates the distilled water was void of microorganisms.* The formulated toothpaste may be safe for oral consumption against oral pathogen like *Treponema denticola*.

KEY WORDS: Physiochemical, antimicrobia, *Azadirachta indica*, toothpaste

INTRODUCTION

Oral hygiene is the practice of keeping the mouth and teeth clean to prevent dental problems, most commonly, dental cavities, gingivitis, and bad breath. There are also oral pathologic conditions in which good oral hygiene is required for healing and regeneration of the oral tissues (Divya *et al*., 2019). These conditions included gingivitis, periodontitis, and dental trauma, such as subluxation, oral cysts, and following wisdom tooth extraction ood oral hygiene helps to prevent cavities and stained or yellowed teeth, as well as bad breath. Bacteria in the mouth build up over time and mix with food particles and white blood cells to form a transparent, sticky film called plaque (Chen *et al*., 2020). The acids in the plaque break down your tooth enamel, weakening it, and allowing cavities to form. If you do not brush and floss regularly, this plaque hardens and forms tartar, a hard, yellow substance that cannot be removed easily. Tartar is not only unsightly; it also increases your chances of developing periodontal disease. Aside from benefiting your dental health and making your teeth look and feel better, good oral hygiene is essential to your overall health as well. Poor oral health has been linked to a variety of general health problems, such as heart disease and strokes. Medical researchers discover more links between oral and general health each year (Zingue *et al*., 2019).

The Neem tree, is primarily cultivated in the southern regions of Asia and Africa, where it has been seen used through many ages, in medical folklore. The plant and its various parts, including the leaves, bark, fruit, flowers, oil, and gum are used in medical

folklore in the treatment of certain medical conditions such as cancer, hypertension, heart diseases, and diabetes (Zingue *et al*., 2019). The potential effects that are seen when using the plant can certainly be attributed cellular and molecular mechanisms, these mechanisms include free radical scavenging, detoxification, DNA repair, cell cycle alteration, programmed cell death mitigation and autophagy, immune surveillance, anti-inflammatory, anti-angiogenic, and anti-metastatic activities and the ability to modulate of various signaling pathways (Arumugam *et al*., 2014, Patel *et al*., 2016).

It has been extensively used in homoeopathic medicine and has become a wonder tree of modern medicine. Traditionally, it is used the treatment of inflammation, infections, fever, skin diseases and dental problems. It is effective in several epidermal dysfunctions such as acne, psoriasis, eczema. *Neem* leaves have been reported to also possess antihyperglycemic, immunomodulatory, anti-inflammatory, antimalarial, antioxidant, antiviral, antimutagenic and anticarcinogenic properties (Lakshmi *et al*., 2015). Neem also exhibits antibacterial, antifungal, hepatoprotective, anti-ulcer, anti-fertility and anti-nociceptive activity. *Neem* twigs are used as oral deodorant, toothache reliever and for cleaning of teeth. *Neem* bark possesses antibacterial and deodorant activity (Yang *et al*., 2020). The phytochemical constituents present in *neem* are nimbidin, nimbin, nimbolide, Azadirachtin, gallic acid, epicatechin, catechin, and margolone. All these exhibit potent antibacterial activity. The chief active constituent of *neem* is azadirachtin, which is an effective antimicrobial agent. *Neem* has *Streptococcus.*
methanolic extracts of Neem has antibacterial activity against *Vibrio cholera* and chloroform extracts against *E. coli, Bacillus subtilis, Enterococcus faecalis and* also been traditionally used as a skin moisturizer (Doh *et al*., 2020).

People in both India and Africa have used neem twigs as tooth brushes for centuries. Neem twigs contain antiseptic ingredients necessary for dental hygiene. Neem powder is also used to brush teeth and massage gums. In Germany many researchers have shown that neem extracts prevent tooth decay and periodontal disease. Infections, tooth decay, bleeding and sore gums have all been treated successfully with daily use of neem mouth rinse or neem leaf extract added to the water. Some people have reported a total reversal of gum degeneration after using neem for only a few months (Din *et al*., 2020).

It has great antimicrobial activity it contains 35 biological active compounds. Neem leaf juice and twigs are used to clean teeth and used as a tonic and people of India used to place Neem leaves in their beds, books and cupboards to prevent bugs. A number of potent pharmaceutical compounds limnoods and triterpenoids have been isolated from the fruits and bark of neem tree. Neem extracts and its different constituents play essential role in the inhibition of several microbes which includes viruses, fungi and bacteria. The extracts of methanol and hexane chloroform of *Azadirachta indica* were selected against antibacterial activity on *Escherichia coli*, *Proteus vulgaris*, *Klebsiella pneumonia*, *Bacillus subtilis, Micrococcus luteus*, *Streptococcus faecalis* and *Enterococcus faecalis*. Neem usually used in medicine and pharmaceutics. The stem and bark of Neem has great antibacterial activity against *Klebsiella, Serratia* species and

The *Streptococcus faecalis* (Waikar *et al*., 2020). This study was to carry out physiochemical analysis and antimicrobial tests of (*Azadirachta indica*) formulated toothpaste.

2.0 MATERIALS AND METHODS

Technology, Area I, Federal Polytechnic, Auchi, Nigeria. The leaves and barks were air dried and pulverized into coarse powder for use.

MATERIALS

Plant Collection and Sample Preparation

Apparatus/Instruments

pH meter (pH 25 PEC Medical, USA), analytical weighing balance/sensitive, normal weighing balance (digital scale – 6k), grain, oven (Thermostat oven – DHG-9109-ISA), autoclave, incubator machine (Uniscope SM9052), stirring rod, brush, glass tie, measuring cylinder, gavage, crucible, blender, adaptor, mortal/pestle, measuring cylinder, desiccator and glass plate.

The fresh leaves and barks of *Azadirachta indica* were collected behind the former building of Applied Sciences and

Chemicals

Sodium lauryl, sodium benzoate, methyl powder, calcium carbonate, glycerin and carboxyl methyl cellulose. All other chemicals and solvents used were of analytical grade.

METHODS

FORMULATION OF TOOTHPASTE

Items / Reagents	Quantity weighed
Neem bark	0.05g
Neem leaves	0.05g
Sodium lauryl	2.50g
Sodium benzoate	0.10g
Sodium CMC	1.80g
Sodium fluoride	0.90g
Methyl perabo	0.20g
Calcium carbonate	41.00g
Liquid Solvents	**Quantity Measured**
Aloe-vera gel	7.60 ml
Honey	0.25ml
Peppermint oil	0.25ml
Clove oil	0.02ml
Glycerin	44.00ml

PHYSIOCHEMICAL ANALYSES OF TOOTHPASTE

The physicochemical analysis; such as cleaning ability, foaming ability, moisture content, spread ability, abrasiveness, homogeneity and pH of formulated and Oral B toothpastes were carried out by method of Mangilal and Ravikumar, (2016).

Cleaning ability

One eggshell was used for each toothpaste tested. 200 mL of water was heated to boiling in a beaker. 15 mL of vinegar and 20 drops of red food colouring were added respectively. A hard-boiled egg was immersed in the food colouring solution for 5 minutes until it is stained with red colour. Using a permanent marker, a line was drawn along the length of the eggshell dividing it in half. A toothbrush moistens with distilled water and the water shaken off was used to brush one side of the egg for 10 strokes (each stroke was a complete back and forth motion). The egg was inspected for any colour removal. The toothbrush was rinsed with water and the water shaken off, a pea-sized amount of formulated toothpaste was placed on the toothbrush and the brush was used to brush one side of the egg for 10 strokes. The egg was rinsed and inspected for colour removal. The procedure was repeated for each toothpaste that was tested (Mangilal and Ravikumar, 2016).

Foaming ability

5 g of toothpaste sample was dispersed in 10 mL of water in a glass beaker. The beaker was covered and allowed to stand for 30 min. The mixture was stirred with a glass rod to break up lumps and transferred into a 250 ml graduated measuring cylinder while ensuring that no foams >2 ml were formed. The beaker was rinsed with 5-6 ml of water into the measuring cylinder. The cylinder was filled with up to 50 mL of water, covered with a stopper, maintained at 30^0C, and shaken for about 20 seconds. The cylinder was then allowed to stand for 5 min. The volume of foam with water (V_1) and water only (V_2) was recorded (Mangilal and Ravikumar, 2016).

$$\text{Foaming ability} = V_2 - V_1$$

1).

Abrasiveness

A known weight of formulated toothpaste was placed on a clean plastic microscope slide and a drop of distilled water added. A clean cotton swab was rubbed on the toothpaste sample in a back and forth

V_1 = Volume in ml of water only

V_2 = Volume in ml of foam with water

Moisture content

5g of toothpaste was heated in an oven at 105^0C for 4 hours. It was allowed to cool and reweighed. The heating and reweighing process continued until a constant weight was recorded in consecutive checks. The weight loss was used to calculate the moisture content using the formula (Mangilal and Ravikumar, 2016).

$$\% \text{ Moisture} = \frac{\text{Weight of moisture}}{\text{Weight of sample used}} \times \frac{100}{1}$$

Spread ability

One gram of toothpaste was placed in the centre of a glass plate and a second glass plate placed over it. A 1 kg weigh was carefully placed on top of the set up and allowed for 10 minutes. The weight was removed and the diameter of the spread was measured in cm (Mangilal and Ravikumar, 2016).

Stability

Five grams of the toothpastes were transferred into each of 3 glass test tubes and stopped. The test tubes were heated at 45°C for 3 days, allowed to cool and content examine visually for homogeneity, signs of fermentation and other deterioration results were reported as pass or fail (Mangilal and Ravikumar, 2016).

pH

10 g of toothpaste was dissolved in 10 ml of deionised water, stirred well to make a suspension in a 100 ml beaker. The pH was measured with pH meter (Ali and Abdul-Rasool,2011

motion 30 times using short strokes. The slide was carefully rinsed and dried with soft tissue. The slide was examined under a dissecting microscope illuminated from above. The number of scratches on the surface of the slide were determined and rated on a scale of 0 (no scratch) to 5 (high degree of scratches) (Mangilal and Ravikumar, 2016).

Homogeneity

At room temperature normal force was applied on the tube containing the toothpaste at room temperature and observed if the paste extrude homogeneously from the tube (Mangilal and Ravikumar, 2016).

ANTIMICROBIAL ANALYSIS

Soya casein digest agar was prepared for the antimicrobial analysis. Pour plate method was used for isolation. A sample of mouth wash (saliva) was taken in a petri dish and incubate for 24 – 72 hours with the use of an incubator (UNISCOPE SM9052). After 3 days, it was observed that there was growth (a cloudy substance in the dish) of micro organism.

Soya casein digest agar was poured in a petri-dish and put in an oven (Selecta Oven) to sterilize at 105^0C to avoid contamination. After which it was timed for 1 hour. 5ml of water was weighed in a urinalysis container by measuring cylinder and also sterilized in the same oven at the same time. The water and dish containing agar was placed in a biological safe laminar to for 10 minutes. Water, dish containing agar, micro-pipette was also sterilized in the laminar (Mangilal and Ravikumar, 2016).

Well Agar Method

5 –10g of the samples toothpaste were weighed with an analytical weigh balance (Golden-Mettler USA Electronic Balance, max 200g). After solidification, 100 microliter (i.e. 0.1ml) of the sample was taken and placed on the little filter paper on another dish. Micro organism was spread on the surface of the agar. A well was created and the agar was put in the well to cover the surface at the dish. The samples were placed in the well (Oral B and formulated) and were labeled. Label 1 and 2 are formulated samples while Label 3 and 4 are oral B samples (Mangilal and Ravikumar, 2016).

Agar Diffusion Method

Micro organism (broot) was cleaned on the surface of the agar and few of the samples were placed on the same agar. Part labeled 3 and 4 is oral B and part labeled 1 and 2 is formulated paste and were placed in an incubator for 18 to 24 hours (Mangilal and Ravikumar, 2016).

STATISTICAL ANALYSIS

The Statistical analysis was done using SPSS windows by applying mean value T-test, analysis of variance (ANOVA) with Post-hoc least significant differences (LSD) method ($P< 0.05$).

RESULTS AND DISCUSSION

RESULTS

Table 4.1: Physiochemical Analysis of samples

Parameters	Formulated Paste	Oral B
pH	8.51	9.73
Foaming Ability (ml)	86.67	34.00
Spread ability (x 10^2)	24.00	23.00
Moisture content (%)	13.20	24.77
Abrassiveness	Good	Good
Homogeneity	Good	Good
Stability	Stable	Stable

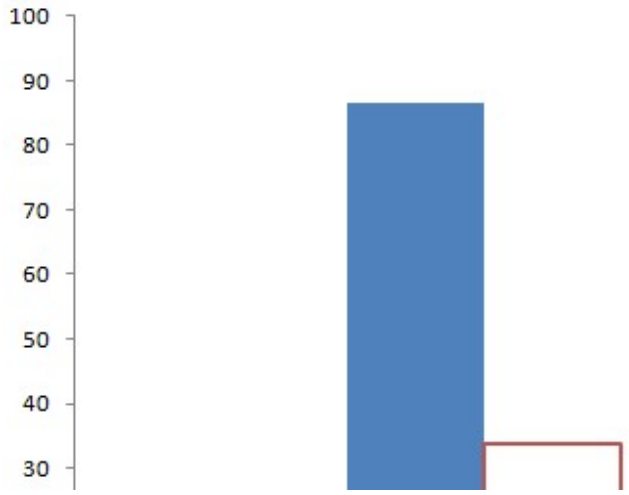

Figure 1: The result of the physiochemical analysis of formulated toothpaste and Oral B toothpaste.

Table 3.2: Antimicrobial activities of formulated toothpaste and Oral B toothpaste

Toothpaste	**Concentration**				
	Formulated 50µL	Formulated 100µL	Oral B 50 µL	Oral B 100 µL	Sterile distilled water
Zone of Inhibition (mm)	25	28	30	33	0

Table 3.3: Organoleptic parameters of formulated toothpaste and Oral B

Parameters	**Formulated toothpaste**	**Oral B toothpaste**
Colour	Green	Blue
Texture	Slightly smooth	Smooth
Taste	Task taste (sweet)	Task taste (sweet)
Odour	Pleasant and pepper mite	Pleasant and pepper mite

DISCUSSION

This study investigates the physiochemical and antimicrobial properties of the neem based toothpaste and were compared with Oral B Toothpaste.

Physicochemical properties are the intrinsic physical and chemical characteristics of a substance. These include colour, taste, odour, spreadability, texture, abrasiveness, foaming ability, moisture content, pH, stability, homogeneity etc. Physicochemical properties are essential indicators used in hazard, exposure and risk assessments. The physiochemical properties of the formulated neem based toothpaste were investigated and result recorded in table 4.1 and 4.3 accordingly. Furthermore, table 4.2 discusses the antimicrobial properties of the toothpaste.

The pH of the toothpastes was analyzed in Figure 1. The pH of the formulated toothpaste was discovered to be 8.51 while that of Oral B was 9.73. This indicate that both toothpaste samples are basic, hence, considered safe for usage.

Foaming ability of the samples was also determined. The foaming ability of the formulated toothpaste was determined to be 34.00ml while that of oral B was discovered to be 86.67ml. This indicates a significant

difference between the two samples and it can be detected that the foaming ability of the produced paste is significantly higher than that of Oral B.

Of the control paste (Oral B) was
found to be 0.23ml. This shows a slight difference between the spread ability of both samples and this indicates that the toothpaste produced has good spread ability.

Cleaning ability of the samples was investigated and the findings revealed that the cleaning ability of the formulated toothpaste and Oral B was discovered okay.

Moisture content determination is an important factor that is critical in toothpaste quality, preservation, and resistance to deterioration. As recorded in table 4.1, the moisture content of the formulated toothpaste was discovered to be 13.20% while that of Oral B was discovered to be 24.77%.

The stability test of the samples were detected using Oven at 45^0C for 3 days and the result showed that both samples possess good stability quality. The abrasiveness of the samples was detected and was discovered to be okay. Also, homogeneity of the samples was determined and a uniform mixture was detected.

The antimicrobial activities of the formulated toothpaste were investigated as the zone of inhibition was determined. At 50 µL and 100 µL, Oral B showed higher zone of inhibition when compared to the formulated toothpaste. However, both Oral B and formulated toothpaste showed antimicrobial activities. The Neem plant used in this study, contribute tremendously to antimicrobial activity of the formulated tooth paste due to its phytochemicals such as saponin, alkaloids, tannins, phenols and flavonoids, is being utilized frequently in various cooked food preparations and therapeutic purposes (Sinaga *et al*., 2016.; Oluwasina *et al*., 2023). Consequently, the

The spread ability of the toothpaste was determined and was discovered to be 0.24ml while that

produced toothpaste can be in use in oral hygiene as a substitute for synthetic kinds of toothpaste, which have been ascribed with various harmful effects such as white or brown speckled teeth (Beulah et al., 2018; Lin *et al*., 2019; Oluwasina *et al*., 2023).

CONCLUSION

The formulated toothpaste exhibited antimicrobial activity against the tested oral pathogen (*Treponema denticola*) and may be safe for oral consumption.

RECOMMENDATIONS

This study recommends that further studies should be carried out on the toxicity of neem based toothpaste. Furthermore, other isolates other than *Treponema denticola* should be used to test the antimicrobial properties of the formulated toothpaste.

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PHYSICO-CHEMICAL AND MICROBIAL ANALYSIS OF AUCHI POLYTECHNIC HOSTEL PIPE-BORNE WATER

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Abstract

Water is one of the most important natural resources needed for the survival of all organisms. Poor quality of drinking and potable water as a result of waterborne diseases, chemical contaminants and heavy metals poisoning has been a major public health concern. The quality of water is important as consumption of contaminated water may cause serious health challenges. The availability of potable and clean drinking water has been of great concern especially in developing countries like Nigeria. Hence, the need for the treatment and purification of drinking water from different sources. In Auchi Polytechnic Hostel Complex, students usually complaints of not being able to drink the pipeborne water, while others complaint of having water borne diseases through the intake of this water. This study was aimed at investigating the physico-chemical and microbial parameters of Auchi Polytechnic hostel pipe-borne water to ascertain its suitability for drinking / human consumption. Results obtained from the study / analysis were compared with W.H.O. and NAFDAC standards for drinking water and the results clearly shows that all the water samples failed at least one or two of the tested parameters and this pose serious health risk on consumption. The study recommends the need for W.H.O. and NAFDAC in conjunction with other relevant authorities to focus on promoting the safety of drinking water in Nigeria and other developing countries most especially in students hostels.

Keywords: Physico-Chemical, Microbial, parameter, Analysis, Pipe-Borne Water, standards

INTRODUCTION

Water is essential to life; however, more than one million people worldwide do not have access to safe drinking water. Waterborne diseases have been estimated to cause more than two million deaths and four billion cases of diarrhea annually (WHO, 2000). Lack of adequate supply of potable water is a critical challenge in developing countries such as Nigeria. Potable water, also called drinking water in reference to its intended use, is defined as water which is fit for consumption by humans and other animals. One of the targets of the Millennium Development Goals (MGDs) in terms of healthy living for the masses can be achieved through the supply of safe and convenient water (Orewole *et al.,* 2007). The quality of water influences the health status of any populace, hence analysis of water for physic-chemical and microbial properties including trace element contents are very important health studies. Water, a substance composed of the chemical elements; hydrogen and oxygen and exist in gaseous, liquid, and solid states. It is one of the most plentiful and essential compounds. A tasteless and odourless liquid at room temperature, it has the important ability to dissolve many other substances. Bitton (2005). defined water as a liquid substance that is clear, colourless and odourless, capable of existing in a liquid, solid and gaseous (that is, vapour) phase. It is a basic necessity of life, second to air, because it

serves as a source of nourishment to man, animal, microorganisms and even plants. There are two major sources of water which are surface water and groundwater. Surface water is found in lakes, rivers, and reservoirs. Groundwater lies under the surface of the land, where it travels through and fills openings in the rocks.

The different types of water include; tap water, Mineral water, Spring or Glacier water, Sparkling water, Distilled water, Purified water, Flavored or Infused water, Alkaline water, Well water, hard water, soft water, de-ionized water, fresh water, blackish water, sea water (salt water), potable water, waste water, rain water, e.t.c.

All plants and animals need water to survive. There can be no life on earth without water. Our bodies use water in all the cells, organs, and tissues, to help regulate body temperature and maintain other bodily functions. Because our bodies lose water through breathing, sweating, and digestion, it's crucial to rehydrate and replace water by drinking fluids and eating foods that contain water. Some of the importance of water are; water helps to create saliva, it regulates body temperature, water aids cognitive functions, water protects the tissues, spinal cord, and joints, It helps excrete the waste in our bodies through perspiration, urination, and defecation, water maximizes our physical performance, it helps to boost our energy levels, Water prevents overall dehydration.

Water can be used for direct and indirect purposes. Direct purposes include bathing, drinking, and cooking, while examples of indirect purposes are the use of water in processing wood to make paper and in producing steel for automobiles. The most common uses of water include agriculture, industry, recreation and electricity.

Purified water is usually produced by the purification of drinking water or ground water. The impurities that may need to be removed are;

i. inorganic ions (typically monitored as electrical conductivity or resistivity or specific tests).
ii. Organic compounds (typically monitored as TOC or by specific tests).
iii. Bacteria (monitored by total viable counts or epifluorescence).
iv. Endotoxins and nucleases (monitored by LAL or specific enzyme tests).
v. Particulates (typically controlled by filtration).
vi. Gases (typically managed by degassing when required).

Clean, safe and sufficient water is vital for the survival of all living organisms and smooth functioning of ecosystems, communities and economies. Water quality refers to the basic physical, chemical and biological characteristics of water that determine its suitability for life or for human uses (Husain *et al*., 2010). The acceptable quality of water varies with its intended use. The characteristics of water can be classified into three broad categories:

i. **Physical Properties:** Temperature, color, taste and odor, turbidity and suspended and total dissolved solids et.c.
ii. **Chemical Properties:** pH, conductivity, salinity, hardness, BOD, COD, inorganic Nutrient (manganese, fluoride ammonia and chlorides), Alkalinity e.t.c
iii. **Biological or Microbial (microbiological) parameters:** Microorganism such as bacterials, viruses, parasites, fungi e.g E. coli, Salmonella e.t.c.

According to Edema (2005), water is considered to be an essential ingredient for human survival and development throughout history. For example, more than two and

half millennia ago, the Greek philosopher, Thales of Miletus concluded that “best of everything is water”, while, the world has changed dramatically since the time of Thales, the fact still remains that human survival continues to depend on water.

Water-related disease is defined as any significant or widespread adverse effects on human health, such as death, disability, illness or disorders, caused directly or indirectly by the condition, or changes in the quantity or quality of any water. The causes of water related disease include micro-organisms, parasites, toxins and chemical contamination of water. Most waterborne diseases are characterized by diarrhoea, which involves excessive stooling, often resulting to dehydration and possibly death (Nwabor *et al.,* 2016).

Pipe-borne water distribution system is used to provide adequate quantity of safe water to various end users. Pipes used for distributing water under pressure include ductile iron, plastic, concrete and steel types. Pipe materials used in water distribution are expected to have a smooth, non-corrosive interior surface in order to be resistant to corrosion. Corrosion is one of the most important problems in the water utility industry. It can affect public health, public acceptance of a water supply and the cost of providing safe water. WHO, (2004) defines corrosion as the partial dissolution of the materials constituting the treatment and supply systems, tanks, pipes valves and pumps. It may lead to structural failure, leaks, loss of capacity and deterioration of chemical and microbial water quality. Again, USEPA (1993) defines it as a dissolving and wearing away of a metal caused by a chemical (in this case water) reacting with the metal pipes or a reaction between two different metals.

The corrosiveness of water can be attributed to low pH (high acidity), high temperature, low total dissolved solids, a high flow rate, and the presence of dissimilar metals and dissolved gases (as oxygen and carbondioxide). When these factors are combined, the corrosion is accelerated (ACC, 2004). For internal corrosion, the "environment" of concern is water. All waters are corrosive to some degree. Water’s corrosive tendency will depend on its physical and chemical characteristics including the nature of the material with which the water comes in contact. (Shock, 1990).

Infectious diseases caused by pathogenic viruses are the most common and widespread health risk associated with drinking water. The pathogens that may be transmitted through contaminated drinking water are diverse. While many of the pathogens are known, it is unlikely that all waterborne pathogens have yet been recognized. For pathogens transmitted by the faecal-oral route, drinking water is only one vehicle of transmission. Contamination of food, hands, utensils and clothing can also play a role, particularly when domestic sanitation and hygiene is poor. Due to this multiplicity of transmission routes, improvements in the quality and availability of water, in excreta disposal and in general hygiene education are all important factors in achieving reductions in morbidity and mortality rates of faecal origin (Egwari & Aboaba, 2002).

Microbial analysis of drinking water for coliform identification can be evaluated using; the most probable number (MPN) method, the solid medium plating method and the Membrane filtration technique.

Some standards for potable water in Nigeria includes NIS, NAFDAC, SON, NSDWQ standards. e.t.c. International standards includes W.H.O., EPA. FEPA, USEPA, EU standards e.t.c.

The aim of this study was to determine the physico-chemical and biological (microbial) parameters of Auchi

Polytechnic Hostel pipe-borne water in comparison to the World Health Organization (WHO) and National Agency for Food and Drugs Administration Control (NAFDAC) standards for drinking water with a view to ascertain its quality and suitability for drinking/human consumption .

Experimental procedure

Materials

Water Sample

The water samples used for the analysis were collected from the various pipe-borne water tanks (reservoirs) in Auchi polytechnic hotel complex with the use of water containers, pre cleaned by washing with non-ionic detergents and rinsed with water.

Apparatus/ Reagent

All apparatus and reagents used were of analytical grades.

Method

Sample collection

The water samples were collected from the reservoirs (tanks) in Auchi polytechnic, hostel complex with different screwed/capped plastic bottles/containers and labeled as shown in table I below:

TABLE 1: Water samples from the different tanks

SAMPLE A	Water from hostel H tank
SAMPLE B	Water from hostel C tank
SAMPLE C	Water from hostel D tank
SAMPLE D	Water from hostel F tank
SAMPLE E	Water from hostel B tank
SAMPLE F	Homogenous mixture of sample A,B,C,D, and E.

Sample Preparation, preservation and storage

The samples were stored/ preserved in a refrigerator at $4^{o}C$ before analysis. All analysis were done within 24 hours of sample collection.

Analysis of Physico-chemical Parameter

The physico-chemical test was carried out to determine the physical impurities and chemical contamination of the samples.

Determination of Colour

Platinum-cobalt method and Visual comparison test were used. In the visual colour comparison method, 20ml of the sample and 20ml of distilled water were taken into two separate wide mouthed test tubes and visually assessed. The results were tabulated by comparing the colour of the sample with that of distilled water. In the platinum-cobalt method, Colour was measured by visual comparison of the water sample with the standard coloured water prepared by dissolving platinum-cobalt in distilled water. The intensity of colour in water was expressed on the platinum-cobalt scale as the number of colour units. On the scale, one unit of colour is the colour produced by 1mg of platinum-cobalt dissolved in 1 litre of distilled water.

Determination of Taste: The taste was measured by threshold test. In this method, the sample was diluted with water free from any taste (distilled water) to an extend that the mixture of the water sample and the added water just becomes taste free. The volume of the water sample and that of the tatse free water added for dilution was measured and the taste of the water sample was expressed in terms of flavor threshold number (FTN) which represents the dilution ratio at which the water sample loses its taste. Also, the water samples were poured

into a glass cup were tested for any unusual taste using the tongue.

Determination of Odour

The flavor threshold test was used. Hydrochloric acid was used to rinse a wide mouth glass stopper bottle until it was odourless before it was finally rinsed with distilled water. The bottle was half filled with the water samples, the stopper was inserted and shook vigorously for 3-5 seconds. Thereafter, the stopper was removed and the odour was quickly observed by putting the nostril over the mouth of the bottle.

Determination of Temperature

Temperature measurement was made by taking a portion of the water sample (about 100ml) at the point of collection and immersing the thermometer into it for a sufficient period of time (till the reading stabilizes) and the reading was taken, expressed as ^{O}C.

Determination of Turbidity

The nephelometer (turbidity meter) used for the determination of turbidity was calibrated using distilled water (Zero NTU) and a standard turbidity suspension of 40NTU. The thoroughly shook sample was put in the nephelometric tube and the value was recorded as follows:

Turbidity (NTU) = (Nephelometer readings) (Dilution factor*).

When the turbidity of a sample was more than 40NTU, then the sample was diluted and the dilution factor was accounted for in the final calculations.

Determination of pH

The pH meter was standardized with a buffer solution of pH value 6.8. 100ml of water samples were put into a beaker and continuously stirred. The pH meter was dipped into the beaker containing the samples. The pH value was recorded as displayed on the pH meter screen.

Determination of conductivity

The conductivity meter was carefully adjusted to 0.00. 100m1 of the water sample was measured into a beaker with continuous stirring of the water samples in the beaker. The conductivity meter was dipped into the water samples and a stable reading was recorded from the display.

Determination of total Solids

A known volume of the well-mixed sample (50ml) was measured into a pre-weighed dish and evaporated to dryness at $103^{0}C$ on a steam bath. The evaporated sample was dried in an oven for about an hour at $103\text{-}105^{0}C$ and cooled in a desiccator and recorded for constant weight.

Determination of total dissolved Solids

The water sample (100ml) was measured into a beaker and the total dissolved solid meter was placed inside the beaker.The total solid meter was turned on and the value on the TDS meter was recorded.

The diffence in the weights of total solids (W_1) and total suspended solids (W_2) expressed in the same units was also used to determine the total dissolved solids (TDS).

Determination of Total Hardness

Exactly 50ml of the well mixed sample was weighed into a 250ml conical flask, to which 1ml of ammonium buffer and 2-3 drops of Eriochrome black- T indicator was added. The mixture was titrated against standard 0.01M EDTA until the wine red colour of the solution turns pale blue at the end point.

Determination of Calcium Hardness

A known volume (50ml) of the sample was pipetted into a clean conical flask, to which 1ml of sodium hydroxide and 1ml of iso-propy1 alcohol was added. A pinch of murexide indicator was added to this mixture and titrated against EDTA until the pink color turns purple.

Microbial Analysis

Multiple tube/most probable number (MPN) technique/method as described by Monica cheesboigh (2000) was used for the

detection of E. Coli and total coliform count. Samples were diluted into broth media, with the counting of tubes that ferment lactose.

Results and Discussion

Result

TABLE II: Results of Physical Chemical and Microbial Analysis as Against W.H.O and NAFDAC Standards.

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	WHO standard	NAFDAC standard
Temperatur ^{o}C	$27^{o}C$	$26^{o}C$	$28^{o}C$	$27^{o}C$	$27^{o}C$	$28^{o}C$	$30^{o}C$ / Ambient	$30^{o}c$ / Ambient
pH	7.6	7.8	7.7	7.9	7.4	7.8	6.5-8.5	6.5-8.5
Total hardness [Mg/L]	490	560	540	650	530	570	1000	1000
Calcium hardness [Mg/L]	46	60	65	43	45	55	150	75
Hardness as ($CaCO_{3)}$	60	69	58	57	63	60	500	500
Chloride [Mg/L]	220	210	198	240	233	220	250	250
Chlorine (mg/L)	1.8	2.1	2.0	2.1	2.2	1.9	5mg/L	5mg/L
Odour	Nil	Nil	Nil	Nil	Nil	Nil	UN. O	UN. O
Colour TCU	Nil (1)	Nil (1)	Nil (1.5)	Nil (2)	Nil (1)	Nil (1.5)	UN. O	3.0 TCU
Taste	Nil	Nil	Rusty taste	Nil	Rusty taste	Nil	UN. O	UN. O
Turbidity [NTU]	4.5	5.3	6.0	6.2	5.6	4.2	5	5
Conductivity (uS/cm)	750	670	930	890	760	970	1000	1000
Magnesium hardness	0.20	0.07	0.30	0.33	0.40	0.3	150	20

Total dissolved solid (mg/l)	320	347	456	520	480	500	1000	500
Total Solids (	620	590	685	700	720	780	1000	500
Magnesium hardness (mg/ml)	13	12	12	15	18	17	50	30
Alkalinity (ppm)	25	28	28	32	35	30	100	100
Total suspended Solid[Mg/L	400	250	340	190	340	305	1000	500
E.Coli (MPN/100Ml) or (CFU /100ml)	0	0	0	0	0	0	0	0
Total coliform (CFU)	0	0	1	0	0	2	0-10	0-10

UN. O = Unobjectionable

Note that all standard values are maximum permisable limits rather than the desirable limits.

Discussion

This study assessed some physico-chemical and biological (microbial) parameters in Auchi Polytechnic hostel pipe-borne water and compared them with W.H.O and NAFDAC standards. Some of the parameters analysed include properties such as temperature, color, taste, odor, turbidity, total solids, suspended solids, total dissolved solids, pH, conductivity, hardness, salinity (calcium, magnesium, $CaCO_3$) inorganic Nutrient (chlorides), Alkalinity, coliform count, e.t.c.

Potable drinking water is expected to be colourless (devoid of any colour). The colour must be unobjectionable to the sensory organ (visual sight). Colour may be imparted to water by the presence of natural

metallic ions (iron and manganese), peat (decayed vegetable matter), weeds, humus, plankton, and industrial wastes. An undesirable appearance is produced by colour in water and people may not like to drink coloured water. Coloured water may spoil the clothes washed in it and it may affect various industrial processes. As such colour should be removed from water to make it suitable for general and industrial purposes.

The taste of water may be bitter, salty, sour and sweet. Similarly water may possess odour such as unpleasant, earthy, fishy, grassy, mouldy, peaty and sweetish. Taste and odour are closely related and these may be imparted to water by the presence of dissolved gases such as H_2S, CH_4, CO_2, O_2, etc., combined with organic matter, mineral substances like NaCl, iron compounds, carbonates and sulphates of other elements, and phenol and other tarry or oily matter. It is evident that the water to be supplied from a public water supply scheme should not have any undesirable or objectionable taste and odour. In otherwords, potable drinking water should be tasteless and odourless with unobjectionable appeal to the sensory organs.

Water temperature measures how hot or cold water is. It affects most water quality parameters and plays a major role in water consumption by humans, aquatic life and habitats. The temperature of water may affect its digestive properties and other physiological processes. The temperature of potable drinking water should be ambient (within room temperature) i.e. about 28-30^0C as it varies from one environment to the other.

Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble coloured organic compounds, and plankton and other microscopic organism. Therefore, turbidity is a function of the total dissolved and suspended solid and other components in water.

Suspended solids in water may consist of inorganic particles or of immiscible liquids (oils or greases). Inorganic solids such as clay, silt and other, soil constituent are common in surface water. Organic materials such as plant fibres and biological solids (bacteria, alga cells etc) are also common constituents of surface waters.

pH is a measure of the concentration of hydrogen ions in a solution. The more of these hydrogen ions there are in a solution, the more acidic that water is. Acidity affects the taste of water, but it can also affect how healthy water is to consume. Drinking water that's not neutral enough or that is acidic can make people sick. Potable drinking water should have a pH range of 6.5-8.5.

The total amount of dissolved salts present in water can be easily estimated by measuring the specific conductivity of water. Salt such as magnesium, calcium and chloride salts dissolved in water contributes to the conductivity of that water. Potable drinking water should have some considerable amount of dissolved salts as they play crucial roles in metabolical and physiological processes. The use of chlorine in drinking water as a disinfectant has played a critical role in the prevention of water borne disease. According to W.H.O, the adoption of drinking water chlorination has been one of the most significant advances in public health protection. However, when the concentration of the chlorine content is above the guideline value of 5mg/L, it could result in irritation of the esophagus, a burning sensation in the mouth and throat.

The alkalinity of water is its capacity to neutralize a standard solution of acid. It is due to the presence of bicarbonate (HCO_3–), carbonate (CO_3–and hydroxide (OH^-). Water may also contain appreciable amount of carbonate and hydroxide alkalinities

particularly surface waters blooming with algae. The algae take up CO_2 for its photosynthesis activities and raise the pH.

In water testing. E. coli is usually used as an indicator organism to determine the presence of faecal contamination. Its presence indicates that other harmful bacterial, viruses, parasites, may also be present. The main sources of E. coli in water include sewage, animal waste and runoff from agriculture. Water quality standards basically requires that E.Coli levels in drinking water be below certain threshold, usually 0 colony forming units (CFU) per 100 milli liters (Ml) of water. Treatment option for water containing E.coli may include boiling, disinfection, filtration or the use of ultraviolet light to kill the bacteria. Total coliform count give a general indication of the sanitary condition of a water supply. Total coliforms include bacteria that are found in soil, water that has been influenced by surface and in human and animal waste.

Results obtained from the study/analysis were compared with W.H.O. and NAFDAC standards for drinking water and the results clearly shows that all the water samples failed at least one or two of the tested parameters and this may pose serious health risk on consumption.

The presence of contaminants at levels above or below guideline values in potable water poses serious health risk to the population. This underscores the need for water managers to promote water treatment techniques and good water hygiene.

Conclusion

This study evaluated the physico-chemical and microbial analysis of Auchi polytechnic hostel pipe-borne water. It can be concluded that although the water samples failed one or two of the tested parameters which may pose health risk, it is not completely unsafe for consumption. The purification process of the water has to be improved on for better quality. The treatment methods of this water may affects its quality. The water should be boiled adequately before drinking and consumption.

The study recommends the need for W.H.O. and NAFDAC in conjunction with other relevant authorities to focus on promoting the safety of drinking water in Nigeria and other developing countries most especially in student's hostels.

Periodic unannounced inspection should be conducted on facilities used in dispensing water to different hostels such as the pipe and tanks across to ensure that the standards are highly maintained.

Efficient management of water resources in Nigeria institutions should be an increasing necessity if health and well-being of student is of utmost priority.

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ISOLATION AND COMPARATIVE QUALITATIVE ANALYSIS OF THE ACTIVE INGREDIENTS IN SOME ANALGESIC DRUGS AND HERBS USED FOR PAIN RELIEF

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Abstract

Pain is a symptom of many human diseases and different analgesics are routinely used to relieve it. Substances that relieve pain (algesia) can be described as analgesics (painkillers). The purpose of this research was to compare the active ingredient(s) in some standard analgesic drugs (Ibuprofen, Aspirin, paracetamol, piroxicam, anacin and diclofenac) with those of some plant materials [Tumeric (*Curcuma longa*), Ginger (*Zingiber officinale*), Aloe vera (*Aloe barbadensis miller*), neem plants (*Azadirachta indica*), Awolowo leaves (*Chromolaena odorata*), and cloves (*Syzygium aromaticum*)] used traditionally for the treatment of pains and pain related conditions.The analysis involved three basic processes of extraction, melting point determination and TLC analysis of the analytes. The extraction process of the active ingredients involved dissolution (percolation) of the text materials, centrifugation and filtration using a column packed with alumina. The purity of the extracts were tested using melting point determination, afterwhich TLC and iodine analysis were used to determine the composition of the various drugs and plant extracts. The result of the analysis shows that the plant analytes have similar active ingredients as those of the standard analgesics. From the result of the TLC analysis, it was cleared that similar active ingredient(s) present in the standard reference analgesics were comparatively present in the analysed plant samples. While five out of the six plant samples have one active ingredient each, Neem gave three spots indicating that it may combines different analgesic properties with acetylsalicylic acid, acetaminophen and caffeine as the active ingredients. The iodine analysis made the spots clearer and more visible and gave a brown colour to those spots that were colourless and not initially visible.

Keywords: Analgesics, Analgesia, Drugs, Herbs, TLC analysis, Iodine analysis.

Introduction

Pain is a general term that describes any kind of inpleasant or uncomfortable sensation in the body. It can be defined as a somantic sensation of acute discomfort, a system of physical hurt or disorder, or even emotional distress (Angela, 2020).

Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage (IASP, 1986). It affects approximately 70% of world population and is associated with deficit in quality of life (W.H.O. 2002).

Pain is a physical suffering associated with a bodily disorder (such as a disease or injury) and accompanied by mental or emotional distress Pain in its simplest form is a warning mechanism that helps protect an organism by influencing it to withdraw

from harmful stimuli (such as pinprick). In its more more complex form, such as in the case of a chronic condition accompanied by depression or anxiety, it can be difficult to isolate and treat.

Pain can be classified into two types; acute and chronic pains. Acute pain is generally intense and short-lived. It is how the body alerts a person to an injury or localized tissue damage. Treating the underlying injury usually resolve acute pain. It triggers the body's fright mechanism, often resulting in faster heart beats and breathing rates. The different types of acute pain include; somatic pain, visceral pain and referred pain. Chronic pain lasts longer than acute pain, and there is often no easy cure. Chronic pain can be mild or severe. It can also be either continuous, such as in arthritis, or intermittent, as with migraines, intermittent pain occurs on repeated occassions but stops in between flares (Manish, 2010). Other specialized ways of describing pain which is influenced by the type of organ damage involved such as tissue (Nociceptic pain) or nerve damage (Neuropathic pain) includes; Neuropathic pain which occurs following injury to the peripheral nerves that connects the brain and spinal cord to the rest of the body; Phantom pain which occurs after the amputation of limb; Central pain which occurs due to infraction, abscesses, tumors, degeneration, or bleeding in the brain and spinal cord; Nociceptic pain which is a result of tissue damage; psychogenic pain which is caused by psychological factors like fear, depression, stress or anxiety (Warnsanne, 2011).

Pain is also classified by the type of tissue that's involved or by the part of the body that's affected. For example pain may be reffered to as muscle pain or joint pain or a chest pain or back pain e.t.c.

Causes of pain include headache, toothache, sore throat, stomach ache or vramps, muscle cramps or strains, cuts, burns, bruises, bone fractions, shooting, stabbing e.t.c.

The chemistry of pain involves the transmission of pain messages by the body's chemicals and hormones by stimulating neurotransmitter receptors found on the surface of cells. Pain receptors, found in the skin and other tissues, are nerve fibres that react to mechanical, thermal, and chemical stimuli. Pain impulses enter into the spinal cord and are transmitted to the brain stem and thalamus. The perception of pain is highly variable among individuals; it is influenced by previous experiences, cultural attitudes (including gender stereotypes), and genetic makeup. Inflamed tissue can induce macrophages, monocytes and lymphocytes to release endogenous opioids that mediate pain. Glutamate is the predominant primary afferent neurotransmitter, eliciting fast excitatory responses in postsynaptic neurons in the dorsal horn of the spinal cord.

The symptoms of pain includes a dull ache, throbbing, burning, shooting, squeezing, stinging, soreness and stiffness e.t.c.

Pain management refers to techniques used to reduce and control the amount of pain a person experiences over the long term. Pain management include interdisciplinary (multiple) approach for ameliorating the suffering and improving the quality of life of a persons living with chronic pain. It aims to provide relief and improve the quality of life for patients with chronic pain conditions. Pain management and pain medicine are the two ways by which a pain can be managed. Pain medicine can be used as part of pain management plans. However, pain management plans can incorporate non-pharmaceutical methods to help patients feel better. Pain medicine

focuses on providing immediate relief. Pain medicine centers on treating the symptoms of pain using various pain relievers such as over the counter (OTC) medication and prescription medication. OTC medication does not require a prescription from a physician. Common forms include acetaminophen, ibuprofen, aspirin, naproxen, and cough suppressants. Pain relievers can be in form of tablets, caplets, gelcaps, liquids, or creams. Prescription medication is much stronger than OTC medicine. As such, they are only available for purchase with a prescription.

Although pain medicine can be used in pain management treatments, it incorporates non-pharmaceutical methods to relieve pain. This non-pharmaceutical methods can come in variety of forms which include physical therapies (such as exercises, massage, hydrotherapy); psychological tharapies (such as cognitive behavioural therapy, relaxation techniques and meditation); mind and body techniques such as Acupuncture. Other types of pain management are cold and heat therapy, transcutaneous electrical nerve stimulation (TENS), YOGA, medication and surgery.

Analgesics are drugs that eliminate or alleviate pain that accompanies many pathogenic conditions. Analgesic is any medicine that reduces pain without inducing unconsciousness. Analgesics are a group of drugs that include aspirin, acetaminophen (commercial name Tylenol), and ibuprofen (commercial name; motrin, Advil, and Medipren) and are used as painkillers. Aspirin and ibuprofen are also known as nonsteroidal anti-inflammatory drugs (NSAID). Analgesic or painkiller is any drug that relieves pain selectively without blocking the conduction of nerves impulses, markedly altering sensory perception nor affecting consciousness. This selectivity is an important distinction an analgesic and an anesthetic which temporary affect, and in some cases, eliminate sensation. Analgesic (pain-relieving) drugs generally fall into one of four categories. These drugs may contain acetylsalicylic acid, acetaminophen, or ibuprofen as the active ingredient, or some combination of these compounds may be used in a single preparation (Angela 2020).

Analgesics generally falls into two groups (classes of analgesics) which are the opioids, which predominantly act on the brain i.e the central nervous system (CNS). The opioid analgesics were once called narcotic drugs because they can induce sleep and nonopioids, which predominantly act on the peripheral nervous system. Generally, pain killers can be classified into four as; opioids e.g codeine, tramadol, morphine; non-opioids such as paracetamol; non-steroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen and as compound pain killer that contain the combination of two different type of drugs as one e.g co-codamol, which combines paracetamol with codeine.

Analgesic drugs act in various ways on the peripheral and central nervous system (Manish and Zafar, 2010). Analgesic drugs can be categorized into four according to the type of active ingredients it contains. They may contain acetylsalicylic acid, acetylminophen, or ibuprofen as the active ingredient or a combination of two or more of these active ingredients may be used in a single preparation of some analgesic drugs. All analgesics in tablet form, regardless of type, contain a large amount of starch or other inert substances. This material act as a binder to keep the tablet from falling apart and to make it large enough to handle. Some analgesic drugs also contain caffeine or buffering agents. In addition, many tablets are coated to make them easier to swallow and to prevent users from experiencing the unpleasant taste of the drugs.

Four physiological mechanism have been proposed to explain referred pain; activity in sympathetic nerves, peripheral branching different receptors, convergence projection and convergence facilitations.

Common side effects of pain killers and relievers are; Nausea, drowsiness, itching, dizzeness, depression, weakened immune system e.t.c.

The active ingredients in analgesics with their melting points and common brand names are as follows

Drug	**Melting point**	**Brand Name**
Aceltalsalicylic acid	135-136 ^{o}C	Aspirin, Empirin e.t.c
Acetylminophen	169-170.5 ^{0}C	panadol, paracetamol, Tylenol
Ibuprofen	75-77^{0}C	Iboprofen, Advil, Motrin, Nutrin

Despite significant efforts from research, researchers and pharmaceutical industries, very few alternative therapies for pain treatment have been introduced to clinical practice (Hruby *et al*., 2006). As a result, pain management continues to depend on therapeutic modalities that present limited efficacy and/or important adverse effects, such as respiratory depression, constipation, tolerance, dependence, gastritis and ulcers (Brunton *et. al.,* 2011).

Alternative therapy for the treatment and management of pain include the traditional use of natural plants and plant extracts by herbal practitionals in what is known as folk or ethonomedicine (Ahmed, 2021). These plants which contain Flavonoids, terpenoids, tannins, alkaloids, e.t.c as active ingredients has long history of use and has flourished significantly. In Nigeria, many people use alternative medicine to remedy various diseases (Nidal, 2005). The world health organization recognizes the use of herbal medicine for the treatment of diseases provided they are efficacious and safe (W.H.O. 1985). These traditional herbal remedies have been used and passed on from one generation to the other based on personal experience rather than scientific experiments (Ahmed, 2021).

Numerous medicinal plants and their derived phytochemicals have been evaluated for their analgesic and anti-inflammatory effects. Some plants used traditionally for the treatment of pains and pain related conditions are cloves (*Syzygium aromaticum*), capsaicin present in chili peppers, willow bark, fever few, Tumeric, Ginger, devils claw, Aloe vera, Awolowo leaves (*Chromolaena odaranta*), neem plant (*Azadirachta indica*), (Lana, 2019).

Drug analysis and testing involves the study of composition, physical and chemical properties, purity and the determination of the content of the active pharmaceutical ingredients and their preparations to ensure that the medications are safe, rational and effective. Some most commonly used drug analysis methods are; gravimetric analysis, acid –base titration, pH measurement, spectroscopic analysis, chemiluminescence technology, chromatography, electrophoresis, DNA amplification method e.t.c

Chromatography is a common and extremely useful method used to separate and analyze complex mixtures. Using this technique, the course of a reaction can be followed, and the products separated and isolated. In this method, the components within the mixture are distributed between

two phases: a stationary phase and a mobile phase (which moves through the stationary phase) Chromatography works on the principle that different compounds will have different solubilities and adsorption to the two phases bwtween which they are to be partitioned. Thin layer chromatography (TLC) offers a simple method of analysis for analgesic drugs. TLC is an extremely valuable analytical technique in the organic laboratory. It provides a rapid separation of compounds, and thereby gives an indication of the number and nature of the components of a mixture. TLC can also be used to identify compounds by comparison with known samples, to check the purity of a compound, or to monitor the progress of a reaction, an extraction, or a purification procedure (Pavial *et. al*., 2010); (Miller, 2005)

Natural products from medicinal plants, either as pure compounds or as standardized extracts provide unlimited opportunities for the development of new drugs because of the unmarched availability of chemical diversity (Unesco, 1996). As a result of increasing demand for analgesics, the demand for therapeutic drugs from natural products, particularly in edible plants suitable for pain relief, has grown tremendiously throughout the world. The significant of this study is that it will serve as a good support for the use of herbs as analgesics and also help in the development of more friendly, safer, and less toxic analgesic drugs.

This research work is therefore aimed at providing scientific and empirical (experimental) basis for the use of some plants for the treatment of pains, by extracting and isolating the active ingredients and qualitatively comparing them with standard analgesic drugs to see if they contain similar active ingredients or otherwise.

The objective of the study was

i. To extract and isolate the active ingredients in different analgesics and some plants used to relief pain.
ii. To test the purity of the drug and plant extracts by doing a melting point determination.
iii. To analyze the active ingredients in both the analgesics and plants extracts
iv. To carry out qualitative comparison of the different plant extracts to that of the standards analgesics.

Materials and method

Materials

a. **Drug materials:** Ibuprofen, Aspirin, paracetamol, piroxicam, anacin and diclofenac.
b. **Plant materials:** Tumeric (*Curcuma longa*), Ginger (*Zingiber officinale*), Aloe vera (*Aloe barbadensis miller*), neem plants (*Azadirachta indica*), Awolowo leaves (*Chromolaena odorata*), and cloves (*Syzygium aromaticum*).

Method: All analysis were carried out according to the modified method of Pavial *et al*., 2010.

Preparation and extraction of active ingredients in drugs and plants materials

Each of the analgesic tablets and plants materials were crushed into fine powder using mortal and pistle, and blender (Kinelco-G) respectively. 5g of each of the blended tablets and plants were

transferred into a centrifuge tube with a tight-fitting cap and labeled with their corresponding names respectively. About 5ml of methanol was added to each of the centrifuge tube, capped and mixed thoroughly by shaking. The cap was loosened at least once during the shaking process in order to release any pressure that may buid up in the tube. The undissolved portion of the powder with cloudy suspension was allowed to settled in the centrifuge tube for about five minutes until it was obvious that the larger particles have settled completely. Using the Pasteur pipette, the liquid phase (supernatant) was transferred into another centrifuge tube and a second 5ml portion of ethanol was added to the original centrifuge tube and mixed thoroughly by shaking. After the solid had settled, the liquid phase was transferred to the centrifuge containing the first extract. The centrifuge tube containing the combined extracts was place in a centrifuge along with other centrifuge tube of equal weight on the opposite side. Being carefull not to disturb the solid at the bottom of the tube, the supernatant iquid was transferred with a Pasteur pipette to a test tube or small beaker. The same process was repeated for all the drugs and plants materials.

Extraction of the active ingredients using column chromatography

An alumina column was prepared using a chromatographic column by inserting a small ball of cotton into the top of the column. The cotton was pushed down with a glass stirring rod into the column so that it fits into the column where the constriction begins. About 1g of alumina was added to the column and the column was tapped with finger to pack the alumina. The column was thereafter clamped in a vertical position and a small beaker was placed under the column so that the liquid can drain from the column into the beaker. With a patsteur pipette, 2ml of ethanol was added to the column and the liquid was allowed to drain until the level of the methanol just reaches the top of the alumina in the column. Immediately the methanol was added to the alumina, the top of the alumina in the column was not allowed to run dry before more methanol was added when necessary. When the level of the methanol reaches the surface of the alumina, the solution containing the drug or plant materials from the beaker was transferred to the column using Pasteur pipette. The liquid that passes through the column was collected into a test tube. After al the liquid from the beaker was added to the column and had penetrated the alumina, additional 1ml methanol was added to the column and was allowed to drain to ensure thatb all the analgesic drug was eluted from the column. The same process was repeated for each of the drug and plant materials.

Evaporation of the solvent and determination of the melting point of the extracts

The methanol in the extracts was evaporated in the test tube using a water bath at about 50^{o}C. A spatula was used to transfer the material in the test tube to -the hirch funnel to allow the vaccum draw any remaining solvent from the crystals. The dried crystals were allowed to dry for 5-10 minutes while air was drawn through the crystals in the hirch funnel. The dried crystals were carefully scrapped from the filter paper onto a previously weighed watch glass. Thereafter, the weight of the exracts were determined. The weight of the active

ingredients specified on the label of each drug was used t ccalculate the weight percentage recoveryn and were compared to that of the plant extracts. A small portion of the sample crystals (of each of the extracts) was used to determine the meting point. The extracts were placed in a small vial and labeled accordingly.

TLC Analysis of the drugs and plants materials:

A 10cm × 66cm TLC plates (EM science silica gel 60 F-254, No. 5554-7) were obtained for the TLC analysis. On THE First plate marked as the reference plate, the reference drugs, starting from left to right were spotted alphabetically. The standard reference mixture marked as (ref-1) was also spotted on the last position of the reference plate. The plant sample extracts were spotted on the second TLC plate alphabetically with the standard reference mixture also spotted on the last position. A wide-mouthed screw jar was used as the development tank with 0.5% glacial acetic acid in ethyl acetate as the development solvent. After the development and the TLC plates were dried, they were observed under a short-wavelength UV- lamp in a darkened hood (room) and all the observed spots were highlited with a pencil. Thereafter, the distance travelled by each spot relative to the solvent front was measured and recorded and the RF values for each of the spot was calculated.

Iodine Analysis:

After the UV comparison of the plates, they were placed in a jarn containing a few iodine crystals, the jar was capped and warmed gently on a steam bath (warmed hot plate) until the spots began t appear. The visibility and relative colours of the spots were noted and the colours of the referernce spots to those of the plants sample (unknown) plate were directly compared.

Results and Discussion

Results: The result of the analysis of the standard reference analgesics compared to the plant extracts are as follows

Table 1: The composition of the standard reference analgesic drugs and sample TLC plates used for the analysis

S/N	Reference Plate	Sample plate
1.	Anacin	Aloe vera
2.	Asprin	Awolowo leave
3.	Diclofenac	Cloves
4.	Extra paracetamol	Ginger
5.	Ibuprofen	Neem leaves

6.	Paracetamol	Turmeric
7.	Piroxicam	Sample mixture
8.	Reference mixture	

Table 2: Results of the TLC analysis and the computed Rf values of the spots

S/N	Analgesic Drug	Number of spot(s)	Distance moved by the spot (cm)	Rf value
1.	Anacin	2	1.0, 4.0	0.08, 0.33
2	Aspirin	1	3.0	0.25
3	Diclofenac	1	3.0	0.25
4	Extra paracetamol	2	4.8, 1.7	0.40, 0.14
5	Ibuprofen	1	5.0	0.42
6	Paracetamol	1	5.0	0.42
7	Piroxicam	1	5.0	0.40
8	Aloe vera	1	3.0	0.25
9	Awolowo leaf	1	3.0	0.25
10	Cloves	1	3.9	0.33
11	Ginger	1	4.0	0.33
12	Neem plant	3	4.2, 1.3, 3.0	0.35, 0.11, 0.25
13	Turmeric	1	5.0	0.42

Distance travelled by the solvent (solvent front) = 12 cm

Discussion

The objective of this research work was to compare the active ingredients in standard analgesic drugs with those of some medicinal plants used for the treatment of pains and pain related conditions. The analysis involved three basic processes of extraction, melting point d etermination and TLC analysis of the different analytes. The

active ingredients were extracted by mixing the powdered (blended) analytes (drugs and plants) with the solvent methanol. Centrifugation was used to romove most of the fine particles of binders and other components of the analytes which were suspended in the solvent. And thereafter, filtration was done the resulting extracts using a column packed with alumina. The solvent was then evaporated to yield the solid analgesics and plant extracts which were collected by filtration. The purity of the extracts was then tested using a melting point determination. Thereafter, TLC and iodine analysis were used to determine the composition of the various drugs and plant extracts to know the active ingredient(s) present in the unknown plant samples. For proper identification of each spot, the references and samples were numbered alphabetically and the numbering were used to identify each spot on both the reference and sample plates respectively. The results of the analysis shows that two (2) out of the seven (7) analgesic drugs had two (2) spots while one out of the six(6) plant samples had three (3) spots which indicates the presence of two or more active ingredients or impurities in the analytes. The different analgesic drugs and plant that were observed to have two (2) or more spots were anacin, extra paracetamol and neem plant.

Rf values were also computed by the distance (cm) travelled by the solvent. The spots were also measured and for those samples that had two (2) or more spots, each spots were measured individually.

The equation used for solving the Rf value is

$$\text{Rf} = \frac{\textit{distance travelled by the substance}}{\textit{distance travelled by the solvent}}$$

Rf values were used to compare the analytes and identify the analgesic ingredient(s) present in the unknown samples.

From the results of the TLC analysis, as shown in table 4.2, it is clear that similar active ingredient(s) present in the standard reference analgesics are also comparatively present in the analysed plants samples. Based on the results, the standard reference drugs; aspirin and diclofenac gave the same Rf values of 0.25 respectively which was also the same with the Rf values for the three of the plant samples; Aloe vera, Awolowo leave and neem leave samples with Rf values of 0.25 respectively. This shows that these drugs and plant samples contain similar active ingredients responsible for their activities as analgesics. Since the active ingredient in aspirin and diclofenac is acetylsalicylic acid, the active ingredient responsible for the activities of Aloe vera and Awolowo leave as anti pain agents may also be acetylsalicylic acid.

Furthermore, the standard reference drug; anacin, gave two Rf values of 0.08 and 0.33 respectively, confirming that anacin contains two active substances (aspirin and caffeine) which help it function as an analgesic drug. When compared to the results of the plant samples, cloves and ginger also produced Rf values of 0.33 respectively, indicating that they contain similar active ingredient responsible for pain relief. Looking at the other components of anacin, which gave an Rf value of 0.08, it was observed that the standard reference drug; paracetamol and the plant sample; neem, gave similar Rf values of 0.14 and 0.11 respectively. This is an indication that the active ingredient responsible for these Rf values is similar and common to the three of them. It may then be concluded that the spots with Rf values of 0.33 produced by anacin, cloves and ginger respectively are as a result of the active ingredient; acetylsalicylic acid since it is one of the active ingredient in anacin, as the Rf value is approximately the same with that of aspirin, Aloe vera e.t.c. with Rf value of of 0.25. The

slight difference in the Rf values may be due to other particles or substances used as binders or as a result of biological or chemical modifications of the drugs and plant samples. The other spot produced by anacin with Rf value of 0.08 is approximately the same with one of the spot produced by extra paracetamol with Rf value value of 0.14. This has confirmed the presence of caffeine in both drugs since caffeine is one of the active substance in both of them. One of the three spots produced by neem gave an Rf value of 0.11 showing that neem may also contain caffeine which helps in it's action as a pain reliever.

One of the spots produced by extra paracetamol gave an Rf value of 0.40 which was the same with that of piroxicam (0.40) and approximately the same with that of paracetamol (0.42). This confirmed that these three, have acetaminophen as their active ingredient. In omparison, Neem, with Rf value of 0.35 and turmeric (0.42) may also have acetaminophen as active ingredient.

Furthermore, ibuprofen gave an Rf value of 0.42 which was comparatively similar to the Rf value of the plant samples of turmeric, these shows that turmeric may either contain acetaminophen or ibuprofen or both as active ingredients in its molecule.

From the results of this analysis, it is clear that all the plant samples have one or more active ingredients comparatively similar to those of the standard analgesics that make them useful agents in the treatment of pains and pain related conditions.

Conclusively, while five out of the six plant samples have one active ingredient each, Neem, gave three spots, indicating that it may combines different analgesic properties. Neem plant may contain acetylsalicylic acid, acetaminophen and caffeine which makes it a good candidate for the treatment of pain. The iodine analysis made the spots clearer and more visible and gave a brown colour to those spots that were colourless and not initially visible.

In comparing the compounds (analytes), it was observed that compounds with higher Rf values are less polar because they interacts less strongly with the polar adsorbent (silica gel) on the TLC plate (Ault, 1998).

It is recommended that further work be done on these plants using other methods of drug test and analysis both *in-vitro* and *in-vivo* to ascertain this findings and to establish their mechanism of actions. These plants are therefore recommended as good candidates for the management of pain.

This research work will no doubt enhance the management and treatment of pain while creating opportunities for cheaper, less toxic and alternative means for treating pain, thereby, reducing dependency on synthetic drugs and their side effects (Ahmed, 2021).

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IMPACT OF MATERIAL WASTE IN BUILDING CONSTRUCTION SITES IN EGOR LOCAL GOVERNMENT AREA, EDO STATE

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ABSTRACT

This paper focused on Impact of Material Waste in Building Construction Sites in Egor local government area, Edo State. The aim of this research is to X-ray the impact of material waste in Building construction site, in Egor local government area in Edo State, Nigeria. Three objectives guilded this study, these are : to identify the causes of material waste in Egor local government area and to also identify measures in reducing material wastes in the studied area. To achieve this objectives, the two types of wastes in built environment are discussed: They are physical waste, which are waste generated from bricks, ceramic and tiles, wood, plastic and glass, waste from ferrous metal, hazardous waste among others. The non-physical wastes , which normally occur during the construction process, these include- time and cost overrun for a construction projects (Time overrun and Cost Overrun). Purposive sampling techique was adopted in collecting the data using a structed questionnaire. 70 copies of the questionnaires were administered by the researcher to stakeholders in built environment in the study area and 66 copies were retrieved. The data collected were analysed using statistical tools such as mean item score and standard deviation. The study revealed that concrete and bricks constitute the major construction waste generated with a weighted mean score (WMS) of 4.53; ranked 1st in the causes of waste in construction sites; It was observed that rework due to worker's mistakes is the major cause of material waste in construction site in Egor with a mean score of 4.65 which ranked 1st. Furthermore, proper methods of waste disposal and how to convert these waste materials in Egor Community were suggusted. Finally recommendations on proper handling of these materials were made.

Keywords: Environment, Management, Waste , Building, Construction Site.

INTRODUCTION

Environmental Management deals with the regulation process and protection of the health of our planet, by promoting human behaviours that make a positive impact on the natural environment.(Babatunde,2012) Environmental Management addresses issues such as global warming, pollution, deforestation, soil erosion, landfills, or depletion of Earth's natural resources. It is a systematic approach to finding practical ways for saving water, energy, and materials, and reducing negative environmental impacts. It further helps to identify degradation factors and implement strategies to mitigate their future impacts.

Environmental damage is the result of either shortsighted policies or lack of knowledge, as well as insecure land tenure, system. *A*rtificially low farm prices, and illiteracy keep farmers from practicing soil conservation (Putrantomo, Soesilo, and Hamzah, 2021). Forests are burned to make room for food crops, the soil is depleted when cow dung must be used for cooking fuel instead of fertilizer - and both the environment and prospects for economic betterment suffer. This could lead to environmental degradation such as pollution, overpopulation, improper waste disposal, climate change, global warming,

and the greenhouse effect, which will further threaten the productivity of agricultural and forest resources and the health and safety of human lives. Every country normally puts up an environmental management system to prevent pollution, meet compliance obligations and enhance conditions of the environment.

Environmental problems may arise from the following: Population expansion, overconsumption, over exploitation, pollution, and deforestation which are some of the human activities that harm the environment on a global scale. The rate of urbanization in developing countries such as Nigeria has witnessed tremendous increase in the last two decades.

Census in the early fifties showed that there were about 56 cities in the country and about 10.6% of the population lived in these cities but today, the national population is now estimated to be about 228.1 million according to Worldometer elaboration of the latest United Nations data(2024) The recent World Bank estimate shows that 53% of these people lived in urban (Google, 2024). The astonishing rise in population, number and size of cities over the past few years have manifested in the acute shortage of dwelling units which resulted to generation of large waste (both solid, liquid and gasous). The result of block drains, water flow arises, various degrees of polluted water mixed with (valuable) drinking-water get into the sewer (Adewuyi, and Otali, 2013). The purification of this relatively complex waste water flow is difficult. So the organisms and substances that are risky for public health and were originally concentrated in a small volume of waste (faeces) are drained in a large (waste) water volume often over long transport distances in very much diluted form and spread over the environment Adewuyi and Otali further noted. Waste can present a major problem for the environment *because* of air pollution and leaching of toxic chemicals like manganese, mercury, lead, hydrocarbon compounds, costruction waste among others which are dumped in landfill, ocean and river (Doron, 2018). There are different views held by researchers as to what constitute construction waste. Cheung (2012) defined construction wastes as the bye- product generated and removed from construction, renovation and demolition work places or sites of building and civil engineering structures.

There is need to handle waste properly in built environment in Nigeria and particulaly in Egor community. The community is a business community where alot of waste such as: papers, glass, metals and plastics. Household waste which include toxic materials, such as paints, batteries, plastic diaper(nappies) motor oil, and old pesticides and cleaning product containers among others. These wastes find their way to the major Benin –Auchi road and also to the building sites when it rained. This sometimes blocked the drains resulting to frequent accidents.

Therefore, to avoid accident and environment pollution, these unused or damaged materials can be recycled while some cannot because they are hazardous in nature. The dumping of waste may cause an uncontrolled emission of greenhouse gases, possible soil pollution and the leakage of dangerous substances into the groundwater which could result to environmental breakdown. Putrantomo, *el al* (2021) identified five main potential barriers to effective waste management , these include: lack of commitment from the management of the stakeholders; lack of financial resources; lack of expertise on Environmental Management System (EMS) organization; lack of engagement from students, staff, and faculty. They enumerated

ways of handling waste in most European countries. According to them, there are three processing options for the mixed, or "grey", solid waste flow. First, there are the waste treatment plants, where the flow is divided into subflows each of which are processed in a different way: a high-energetic (or caloric) fraction, a low-energetic fraction and a fraction with paper/plastics/ steel and other metals. The high-energetic fraction is sent to the incineration, the low-energetic fraction goes to a washing plant, after which the metals are separated for reuse. Finally, the third fraction (the mix of paper and plastics) is processed further by the paper and plastics industry. The second option is the incineration plant. This is considered the most expensive method of solid waste management. In order to prevent any air pollution, the waste treatment requires expensive after-care. Reducing construction site wastes can reduce environmental problems and some of the human activities that harm the environment on a global scale. The aim of this research is to X-ray the impact of material waste in Building construction site, in Egor local government area in Edo State, Nigeria. Hence the study fucused on ways to reduce material waste in building construction sites in Egor local govrnment area in Edo State as a case study.

RESEARCH METHODOLOGY

Descriptive research design was used for the study, data were collected from clients: Quantity Surveyors, Architects, Builders, and Coctractors. A total of 70 questionnaires were administered out of which 66 were collected and filled. The questionnaire required the respondents to rank their answers on a likert scale with the rating: strongly agree (SA)=5, agreed (A)= 4, Neutral =3, disagree, (D)=2, strongly disagree (SD)= 1.

Pilot Studies: This was carried out to establish the clarity and relevance of the questionnaire to the respondents. A copy of the questionnaires was given to two expects in the field and their corrections were effected. For items in section B of the questionnaire, boundary limit of numbers where used to take decision on the items. Any item with a mean scale above 2.50 is adequate or agree while below 2.50 is inadequate or strongly disagree.

RESULTS AND DISCUSSION

Table 1 Field of Discipline of Respondents

Field of Discipline	No of Respondents	Percentage (%)
Land Surveyors	8	12
Architects	12	18
Builders	18	27
Quantity Surveyors	8	12
Engineers	20	31
Total	**66**	**100**

Source: Field Survey 2022

Table 1 shows the fields of disciplie of Respondents**:** 8(12%) were land surveyors, 12(18%) were Architects, 18(27%) were builders, 8(12%) were quantity surveyors while 20(31)% were engineers.

Table 2: Type of Construction Waste Generated

Types of Construction Waste Generated	*SA*	*A*	*D*	*SD*	*Total*	*WMS*	*Rank*
Concrete and bricks	42	19	3	2	66	4.53	1st
Mortal from rendering and plastering waste	18	30	13	5	66	4.30	2nd
Cement and sand	33	23	7	3	66	4.29	3rd
Tiles and ceramic	7	20	33	6	66	4.17	4th
Dry wall and paint cans waste	11	34	13	8	66	3.92	5th
Wood, glass and plastic	6	11	41	8	66	3.85	6th
Ceiling board and formwork waste	24	31	9	2	66	3.73	7th
Metallic waste	11	39	11	5	66	3.42	8th
Dredging waste	32	25	5	4	66	3.23	9th

Source: Field Survey 2022

Table 2 above shows the types of construction waste generated, it was discovered that concrete and bricks is the major construction waste generated with a weighted mean score (WMS) of 4.53 ranked 1st, followed by mortal from rendering and plastering waste with a mean score of 4.30 ranked 2nd and Cement and sand with a weighted mean score of 4.29 ranked 3rd respectively. This is in agreement with (Ameh and Itodo, 2013) who observed that mortar from plastering/rendering is most wasteful building material during construction operations on site. And the further observed that mortar from timber formwork, sandcrete blocks and concrete were the most wasteful construction materials out of 14 most commonly used building materials on site.

Table 3: Major Causes of Material Waste in the Construction Site

Causes of Material Waste	*SD*	*A*	*D*	*S*	*Total*	*WMS*	*Rank*
Rework due to workers mistake	41	17	8	0	66	4.65	1st
Frequent designs and client changes	37	29	0	0	66	4.62	2nd
Lack of onsite materials control (measurement)	5	13	36	12	66	4.56	3rd
Damage of materials during transportation	15	47	4	0	66	4.52	4th
Poor material handling	43	23	0	0	66	4.55	5th
Failure in formwork (columns, beans and lintel)	26	37	3	0	66	4.50	6th
Imperfect planning of construction work	39	24	3	0	66	4.48	7th

Source: Field Survey 2022

The table 3 above shows the causes of material waste in the construction site in Egor. It was revealed that rework due to worker's mistakes are the major causes of material waste in construction site in Egor with a mean score of 4.65 ranked 1st followed by frequent design and client changes with a mean score of 4.62 ranked

2rd, poor material handling with a mean score of 4.52 ranked 3rd respectively. This is in line with the study of (Adewuyi and Otali, 2013),who reviewed that rework contrary to drawing and specification, design changes and revision and waste from uneconomical shapes, were the most important factors which contributed to construction material waste.

Table 4: Effect of Materials Waste on Construction Site

Effect of Material Waste	SA	A	D	SD	Total	WMS	Rank
Human damage	30	36	0	0	66	4.30	1st
Air contamination	21	37	8	0	66	4.17	2nd
Material waste increase the cost of construction project	23	43	0	0	66	3.92	3rd
Material waste reduce contractor's profit	28	38	0	0	66	3.85	4th
Soil contamination	13	47	6	0	66	3.73	5rd
Water contamination	7	49	0	0	66	3.42	6th
Extreme weather caused by climate change	11	48	7	0	66	3.23	7th

Source: Field Survey 2022

Table 4 above shows the various effects of material waste on construction sites, human damage 4.30 ranked 1st, air contamination 4.17 ranked 2nd, material waste increase the cost of construction project 3.92 ranked 3rd While water contamination and extreme weather caused by climate change ranked 6th and 7th with 3.42 and 3.23 respectively. The results showed that human damage is the major effect of material waste on construction site with a mean score of 4.30 ranked 1st

Table 5: Ways of Effective Waste Management

Effective Waste Management	*SA*	*A*	*D*	*SD*	*Total*	*WMS*	*Rank*
Minimize waste at the project level	24	42	0	0	66	4.56	1st
Reuse and return scraps	29	37	0	0	66	4.50	2nd
Work with a construction waste disposal partner	22	44	0	0	66	4.44	3rd
Deconstruct materials for reuse	37	29	0	0	66	4.41	4th
Identity recyclable materials	27	39	0	0	66	4.32	5th
Place recycling and waste receptacles on-site	11	55	0	0	66	4.29	6th

Source: Field Survey 2022

Table 5 above shows that the respondents strongly agree that workers should learn to minimize waste at the project level this ranked 1st with a mean score of 4.56 , reuse and return scraps 4.50 ranked 2nd, work with a construction waste disposal partner 4.44 ranked 3rd while place recycling and waste receptacles on-site ranked the least with mean scores of 4.29.

Table 6: Methods of Waste Disposal

METHOD OF WASTE DISPOSAL	SA	A	D	SD	TOTAL	MIS	RANK
WASTE RECYCLING	25	41	0	0	66	4.61	1st
LANDFILLS	28	38	0	0	66	4.42	2nd
WASTE REUSE	19	44	3	0	66	4.24	3th
WASTE MINIMIZATION	20	39	7	0	66	4.20	4rd
INCINERATION	20	37	9	0	66	4.18	5th
USE OF INCLINATION	18	42	6	0	66	4.17	6th
CHEMICAL-PHYSICAL AND BIOLOGICAL TREATMENT	9	37	13	6	66	3.75	7rd

Source: Field Survey 2022

Table 6 above shows the various method of waste disposal which includes: The respondents strongly agreed that waste recycling of waste materials should be the best method of waste disposal in Egor with a mean score of 4.61 ranking 1st ; followed , landfills 4.42 ranked 2nd, waste reuse 4.24 ranked 3th respectively. The study revealed that waste recycling should be the major method of waste disposal in Egor community.

CONCLUSION

The study reveiwed that concrete and bricks from the major construction waste generated with a weighted mean score (WMS) of 4.53 ranked 1st; It was also observed that rework due to worker's mistakes are the major causes of material waste in construction sites in Egor with a mean score of 4.65 which ranked 1st. Furthermore, human damage is the highest effect of material waste on construction site with a mean score of 4.30 ranked 1st followed by air contamination with a mean score of 4.17 ranked 2nd respectivel

RECOMMENDATIONS

The folloing recommended were made:

i. There should be improved and better storage and handling of materials delivered in Nigeria construction site particularly in Ehor Community
ii. There should be proper site supervision, materials control and security on site.
iii. Site operatives and craft men should be aware of material waste generation and be carried along in management decision regarding waste management.
iv. Waste should be sorted out at the point of disposal for easy rec

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APPENDIX 1

Fig 1 Bricks Waste

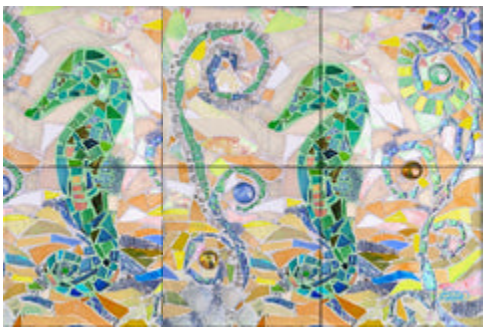
Source: Shutterstock.com

Fig 3 **Waste from ceramics tiles**

Fig 2 Bricks from construction waste

Fig 4 **Recycled ceramics products**

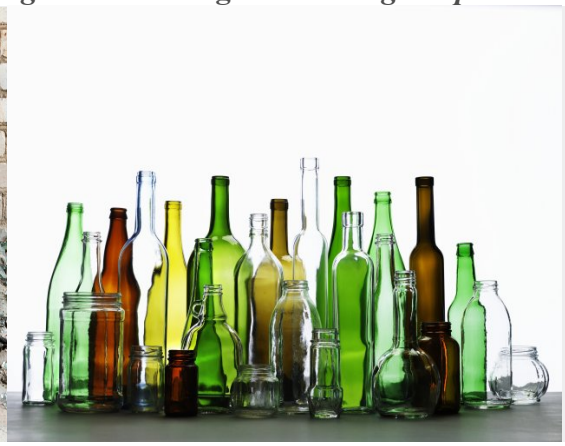
Source: Google, 2023



Recycling Tiles

Fig 5. ***Waste from broken glasses***

fig 6. ***Reused glass products***



Source: Dreamstimes.com

EFFECT OF MATERIAL WASTES IN BUILDING CONSTRUCTION SITE

Fig: 7. Pile of concrete debris at a building demolition site

Source:Alamy.com - RF**R0JHD5**

Fig 8. Refuse dump

Fig 9. Water Contamination

Source: Google 2023

CHALLENGES AND BENEFITS OF APPLYING RISK MANAGEMENT TO CONSTRUCTION PROJECTS IN EKITI STATE

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Abstract
Construction projects are inherently complex and involved significant risks. The aim of this study is to assess the challenges and benefits of application of risk management to construction projects with a view to minimize the occurrence of any failure in achieving the project goals. The study adopted a quantitative survey design with a questionnaire used to solicit information from construction professionals and some selected contractors within Ekiti State. One hundred and sixty five (165) questionnaires were distributed using random sampling technique; one hundred and sixteen (116) were returned and considered suitable for analysis. Data analysis was done using percentage and mean item score. Findings revealed that difficulty linking management to achieve project objectives in terms of saving time or cost to the employer; and much time need to conduct effective risks management practice were the most serious challenges of risk management to construction projects. The result also revealed that risk management helps to increase and improve communication efficiency between project stakeholders, avoid project delays and its impact to project objective were most important benefits of applying risk management to construction projects. The study recommended that construction organizations should practice effective risk management and every construction industry expert should know the risks and the challenges can be overcome through education, training or workshop on risk management.

Keywords*: Application, Benefits, Challenges, Construction Projects, Risk Management*

Introduction

The construction industry globally serves as the bed rock for nation's sustained infrastructure development, economic growth and survival (Eze, Sofolahan, Ugulu & Nwankwo, 2021).Construction is a high risk industry that operates a very complex and dynamic environment which significantly contributes to the existence of high uncertainty and risk in construction projects (Siraj & Fayek, 2019). According to Smith, Merna and Jobling (2014) Construction projects are inherently complex and involved significant risks. Risk is defined as an uncertain event or condition, the effect of which manifests as either benefit or loss to project objectives that is scope, quality, cost and schedule and to specific individual, group or organizational objectives (Loosemore, Raftery & Reilly, 2006; PMI, 2017). In construction, risks are important factors to be considered through the different project development stages starting from initiating and planning and ending with construction and commissioning (Gharaibeh, 2019).

If risks are not considered in projects this could lead to adverse effect on project objectives mainly time, cost and quality of work completed. Therefore, it becomes necessary to address risks at the very early stages of the project and be able to plan for the consequences of risks happening on the project. Risk in construction has been the object of attention because of time and cost overruns associated

with construction projects (Jaffari, 2001). Risk management is defined as the process of identifying and assessing risk and to apply methods to reduce it to an acceptable extent (Serpella, Ferrada, Howard & Rubio, 2014). The Project Management Institute (2013). Stated that risk management include the processes of conducting risk management planning, identification, analysis, response planning and controlling of risk on a project. Cagliano, Grimaldi and Rafele (2015) opined that in recent times, sound risk management is a crucial determinate of the success of a project based on project performance measurement, due to growing time and cost pressure. Tang, Qiang, Duffield, Young and Lu (2007) established that risk management was widely accepted as a vital tool to manage projects. Hence risk management forms a critical element in project management.According to Iqba *etal.* (2015) the importance of risk analysis and management as part of the decision making process in the construction industry.The main goal is to minimize or totally avoid the possibilities of any failure in achieving the project goals. Lyons and Skitmore (2004) advocated the criticality of project risk management and stated that unmanaged or unmitigated risks are one of the primary causes of project failure. The risk management process is comprised of six key steps; risk management planning, risk identification, risk analysis, risk response planning and risk monitoring and control. Hwang, Zhao and Toh (2014) identified some of challenges to effective risk management as lack of time, lack of knowledge, lack of potential benefits, lack of funds, lack of expertise and lack of resources.

Furthermore, some of the benefits are it reduces the likehood of problems and conflicts between project stakeholders, reduce the number of risks that can occur during project execution, reduce the impact of problems if they occur during project execution and avoid project delays and its impact to project objectives. This study concerns itself with the matter of challenges and benefits of applying risk management to construction projects in Ekiti State with a view to minimize the possibilities of any failure in achieving the project goals.

Materials and Methods

This study aims to assess the challenges and benefits of application of risk management to construction projects in Ekiti State. This choice of Ekiti State is premised on the report of Ade-Ojo, Akinola, Arijeloye and Gabriel (2017) that there are incessant construction project failures and poor construction project performance in the study area.The study employed survey research design approach in the collection of the required data. The data was collected through the use of well-structured questionnaire. The population under study for this research was construction professionals who have the requisite knowledge and experience in risk management of construction projects within the study area. These include registered Architects, Quantity Surveyors, Builders, Engineers and Selected Contractors within Ekiti State with the total population of 280. The sample size was 165, and this was determined or computed using Yamane (1967) formula.

$$n = \frac{N}{1 + N(e)^2}$$

Where N= Total Population Size, e= Margin of Error, n= Sample Size

Random sampling technique was used for the study since it gives all the respondents an equal chance of contributing to the subject matter. The questionnaire was divided into two sections; the preliminary section of the questionnaire dwelt on the background information of the respondents while the other section focused on matters relating to the research objectives. Questions inherent in the structured questionnaire were multiple-choice type with different checkboxes and tables posed on a 5-point likert-type scale for ease and uniformity of response. Its application implies that most part of the data analysis was based on a scoring system. Out of 165 questionnaires administered, only one hundred and sixteen (116) were considered suitable for analysis which represented a healthy return rate of seventy percent (70%). The analysis of the collected data was carried out using percentile and mean item score. The background information of the respondents was analysed using percentiles while mean Item Score (MIS) was used to analyze identified challenges and benefits of

applying risk management to construction projects.

Mean Item Score (MIS)

Mean score was used to rank the challenges and benefits of applying risk management to construction projects. The premise of decision for the ranking is that the factor with the highest mean item score is ranked 1st and others in such subsequent descending order.

The formula for mean score is = $\frac{\sum (FX)}{N}$

Where X is the rating used per column, F is the sample size for each rating andN is the total sample size.

Since a Likert of 5-point scale was employed for the collection of data, the formula can thus be written as

Mean Score = $\frac{5F5 + 4F4 + 3F3 + 2F2 + F1}{N}$

The basis of determination of challenges and benefits of applying risk management to construction projects using mean item score was on this premise:

$1.00 < MIS \leq 1.99$: Not Important

$2.00 < MIS \leq 2.99$: Fairly Important

$3.00 < MIS \leq 3.99$: Somehow Important

$4.00 < MIS \leq 4.89$: Important

$4.90 < MIS \leq 5.00$: Very Important

Cronbach's reliability test was used to test the reliability of the questionnaires. Creswell (2013) noted that for all the items of an instrument to be internally consistent and reliable, the result of the reliability test should produce a minimum Cronbach's Alpha of 0.7. In this study, all the items of the two variables were subjected to the reliability test. The results according to Creswell (2013) suggested that all the items are good and consistent internally because the Cronbach's Alpha coefficient for the items were 0.7 and above. The results are presented in Table 1 below.

Table 1: Test of Reliability for Measuring Scale

Scale of Measure	Cronbach α – Value
Identified Challenges of Risk Management	0.774
Identified Benefits of Risk Management	0.854

Research Questions

i. What are the challenges of applying risk management to construction projects in Ekiti State?

ii. What are the benefits of applying risk management to construction projects in Ekiti State?

Results and Discussion

Table 2: Summary of General Information of the Respondents

Category	Classification	Frequency	Percen

			t
Profession of Respondent	Quantity surveyor	25	22
	Architect	20	17
	Builder	30	26
	Engineer	38	32
	Others specify	3	3
	Total	**116**	**100**
Professional Body of Affiliation	NIA	18	16
	NIQS	22	19
	NIOB	27	23
	NSE/COREN	35	30
	Others	14	12
	Total	**116**	**100**
Professional Membership Type	Graduate/Probationer	10	9
	Corporate	98	84
	Fellow	8	7
Total		**116**	**100**
		Frequency	**Percent**
Highest Academic Qualification of Respondent	HND	20	17
	B.sc/B.Tech	30	26
	PGD	25	22
	M.sc/M.Tech/M.Eng	38	32
	Phd	3	3
	Total	**116**	**100**
Years of working Experience	1-5 years	22	19
	6-10 years	35	30
	11-15 years	34	29
	16-20 years	15	13
	Over 20 years	10	9
	Total	**116**	**100**
	Average	**11**	

Result from Table 2 shows that 38 (32%) of the repondents were Engineers, 30 (26%) were Builders, 25 (22%) were Quantity Surveyors, 20 (17%) were Architects while 3 (3%) were others. Table 2 shows that all the respondents were affiliated to relevant professional bodies in their respective professions. Out of which 91% of them have attained corporate membership grade while 9 % of the respondents were graduate/probationer members of their respective professional bodies. It shows that they are capable of providing vital information on the objectives of this research.

Table 2 also reveals that 38 (32%) 30 (26%) and 25 (22%) of the respondents had M.Sc/M.Tech, B.Sc/ B. Tech and PGD degrees respectively. About 17% (20) were HND holders, while 3% (3) have PhD. The years of working experienced posessed by respondents was on the average of 11 years. Any respondent with 11 years of experience is considered to be knowledgeable in his/her

discipline, therefore the data obtained from these respondents can be deemed to be reliable.

Table 3: The Challenges of Applying Risk Management to Construction Projects.

Identified Challenges	MIS	S.D	Rank
Difficulty linking risk management to achieve project objectives in terms of saving time or cost to the employer	4.75	0.66	1
Much time needed to conduct effective risks management practice	4.62	1.01	2
The difficulty of identifying mechanisms and methods of treatment of risks in projects	4.48	0.82	3
Difficulty collecting the necessary information about project risks	4.26	1.02	4
Subjective nature and lack of consistency in assessing risks	4.26	1.09	5
Lack of practical experience in construction projects necessary to conduct risk management	4.05	0.88	6
The complexity of analytical tools	3.88	1.15	7
Lack of expertise and qualifications required to implement risk management in projects	3.80	1.46	8
Low profit margin	3.77	1.05	9
Not recognising team member's responsibility for certain specific risks	3.74	0.92	10
It dependents on external entities	3.66	1.22	11
Confusing risks response planning with mitigation	3.52	1.03	12
Unmanaged losses result from poor scheduling of risks	3.43	0.98	13
The additional cost of implementing risk management and unwillingness of any party to bear it	3.39	1.32	14
Lack of faith in risk management on both contractor and client's side	3.31	1.06	15
Lack of government legislation	3.27	1.25	16
Lack of clear definition of causes, events and impact	2.95	0.97	17
Underestimation of risks impact	2.83	1.24	18
Lack of consideration of opportunities	2.65	0.92	19

Table 3 shows the results of the analysis of the data gathered on the challenges of risk management. It can be observed that the top five most challenges of risk management according to the respondents are; difficulty linking risk management to better achieve project objectives in terms of saving time or cost to the employer, much time needed to conduct effective risks management practice, the difficulty of identifying mechanisms and methods of treatment of risks in projects, difficulty collecting the necessary information about projects and subjective nature and lack of consistency in assessing risks. While the least challenges are; lack of government legislation, lack of clear definition of causes, events, and impact, underestimation of risks impact and lack of consideration of opportunities. The findings in this study support what has been reported in the construction management literature (Lukas & Clare, 2011; Reddy, 2016; Ezebasili *etal*., 2021). In order to apply risk management you need resources and dedicated team and you need to invest time in planning for the risk management process right from the beginning of the project.

Table 4: The Benefits of Applying Risk Management to Construction Projects

Identified Benefits	Mean Score	Rank
Risk management helps to increase and improve communication efficiency between project stakeholders	4.88	1
Avoid project delays and its impact to project objectives	4.76	2
More precise estimate (through reduced uncertainty)	4.65	3
Risk management at the time of project planning helps to decide on the feasibility of the project	4.58	4
Maximisation of the objectives of the projects	4.44	5
Maximisation of opportunities in the business environment	4.28	6
Reduce the incremental cost risks that may occur in the project	4.17	7
Healthier bottom lines with regards to quality, time, cost and scope	4.16	8
Minimisation of surprises	4.13	9
Improves the reputation of an organisation	4.12	10
More customers satisfaction	4.06	11
Provide alternatives and solutions to address risks if they occur during project implementation	3.97	12
Encourages pro-active responses to uncertainties	3.85	13
Improves project performance which helps organisations to reposition in competition	3.71	14
Reduced the number of risks that can occur during project execution	3.60	15
Better operational consistency and efficiency	3.42	16
Improves safety consciousness of the project	3.26	17
Decision making is more objective and systematic	3.05	18
Improves the economic fortune and profitability	2.97	19
Reduce duplication of effort through team awareness of risk control action	2.76	20
Identification of formidable alternative courses of action	2.61	21

Table 4 shows the results of the analysis of the data gathered on the benefits of risk management. The top five benefits of risk management according to the respondents are; risk management helps to increase and improve communication efficiency between project stakeholders, avoid project delays and its impact to project objectives, more precise estimate through reduced uncertainty, risk management at the time of project planning helps to decide on the feasibility of the project and maximisation of the objectives of the projects. While the least benefits are; improves safety consciousness of the project, decision making is more objective and systematic, improves the economic fortune and profitability, reduce duplication of effort through team awareness of risk control action and identification of formidable alternative courses of action. This outcome substantiates the findings of Renaults and Agumba (2016), which ranked the aforementioned factors as one of the most influencing benefits of risk management. Ezeabasili *etal* (2021) reported that the most important benefits of risk management are timely completion of projects within the planned budget. The role of risk management in meeting project objectives, reducing wastes and losses and opportunities maximisation and pro-activeness in responding to risk events are very important.

Conclusion and Recommendations

The study aimed to assess the challenges and benefits of applying risk management to construction projects in Ekiti State. The **survey questionnaire was administered to construction professionals in consulting and contracting organisations using random sampling techniques to aid data collection. The study has found that there is an acceptable level of knowledge of the risk management concept among contractors and consultants. However, the lack of application of this concept in construction projects is due to the inability to link the application of risk management with key project objectives and the difficulty in justifying the value added by adopting risk management practices in construction. Conclusions were drawn based on the findings of this study.

The top challenges of risk management in construction are; difficulty linking risk management to better achieve project objectives in terms of saving time or cost to the employer, much time needed to conduct effective risks management practice, the difficulty collecting the necessary information about project risks, subjective nature and lack of consistency in assessing risks. The study also found that the top benefits of risk management are; risk management helps to increase and improve communication efficiency between project stakeholders, avoid project delays and its impact to project objectives, more precise estimate, risk management at the time of project planning helps to decide on the feasibility of the project. It recommends that construction organisations should practice effective risk management and every construction industry expert should know the risks. The challenges should be overcome through education, training or workshop on risk management. This should be organised by the various professional bodies to ensure that their members, regardless of status, gain adequate knowledge of the various tools and techniques for effective risk analysis and assessment. Also, in order to improve the application of risk management in construction, clients should encourage the application of risk management by dedicating sufficient resources and funds to be used in this process as well as raising awareness among project stakeholders about the value of risk management to construction contractors and consultants.

Implication to Research and Practice

This study has helped the construction industry in Ekiti State to understand in details, the various challenges that prevent project stakeholders from applying risk management to their projects despite the fact that most of them realise the significance of it in improving project performance. The study also helped to define a set of enablers that if adopted by project managers in construction projects can very much help to increase the level of application of risk management and will assist project stakeholder to better manage their projects and avoid or minimise the impact on project cost and schedule.

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THE INFLUENCE OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) ON ACCESSIBLE TOURISM IN NIGERIA (A REVIEW)

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Abstract

The paper highlights the untapped potential of the tourism industry in Nigeria and the pivotal role that Information and Communication Technology (ICT) can play in fostering accessible tourism. Despite being rich in cultural, historical, and natural attractions, Nigeria's tourism sector has faced challenges, including insufficient infrastructure, security concerns, and limited marketing efforts. The study emphasizes the concept of accessible tourism, aiming to make tourism products and services available to all individuals, regardless of age or physical condition, and underscores the integral role of ICT in achieving this goal. The study employed an empirical review of several literature to understand the role of ICT in accessible tourism in Nigeria. The findings reveal that Nigeria's tech hub status, coupled with the developmental strides in ICT, provides a unique opportunity to leverage technology for economic growth through accessible tourism. The study recommends a multifaceted approach, including investment in ICT infrastructure, integration of ICT in tourism promotion, focused ICT training, public-private partnerships, enhanced data management, security measures, financial support for tourism businesses, collaboration with technology companies, and inclusive policy implementation.

Keywords: *Accessible Tourism, ICT, Nigeria, Tourism*

INTRODUCTION

In recent times, the economic downturn of Nigeria has affected the economic growth of the country, and this has led the country to an economic recession(Bassey, et al., 2024). Today, Nigeria stands as one of the countries that has so much potential yet is hampered by poor decision-making by the government(United States Institute of Peace, 2021). This is especially so when there are other areas of diversification and interest, that could boost the economic growth of the country, but the focus has always remained on petroleum exportation(Hairsine, 2021). Hence, there has been a neglect of important areas like tourism, which holds more potential and has been said to be a major source of income generation in many countries of the world(Dele, 2021).

Tourism is arguably one of the leading sources of income generation today and many countries have tapped into the potential for their economic development(Richardson, 2021). However, the case of Nigeria is still a far cry from what is expected, since the country is blessed with abundant tourism facilities, yet there is not much that has been achieved so far. According to Esuola (2009), Nigeria has 275 tourism prospects that are evenly distributed throughout the six geopolitical zones; the majority of these have not yet reached a point where they can draw tourists and generate income for the nation.These

tourism potentials are grouped into three different types of tourism: *ecotourism*, also known as ecological tourism, which represents natural sites like beaches, waterfalls, caves, and other natural features that have not been altered by human activity and are primarily in their original states; *cultural tourism*, which emphasises the people's customs, traditions, and culture; and *religious tourism*, which represents houses of worship and ritual offerings (Dele, 2021).In all of this, Nigeria still lags, especially in the area of accessible tourism, while most countries in the world have leveraged the use of Information Communication Technology (ICT) for tourism and economic development(Reuters, 2021).

Accessible tourism in its simple definition is the ongoing endeavour to ensure that tourism-related products, services, and attractions are available to all individuals, irrespective of their age, physical condition, or other constraints (United Nations, 2023). Nigeria today is seen as the tech hub of Africa(Michael, 2023). This has been fueled by the development of ICT showing the potential for economic development(Adeniyi & Ezekiel, 2023). Undoubtedly, information is the foundation of accessible tourism, which makes ICTs indispensable tools in this domain(Oyetunji, 2023). In the subject of accessible tourism, which is growing more and more important for the social and economic sectors, ICTs can be vital instruments for removing barriers to accessibility (United Nations World Tourism Organisation (UNWTO), 2020).ICTs are responsible for more than just disseminating information but help to connect everything in real-time, up to the point of making everything available to persons with disabilities (Teixeira, Teixeira, & Eusébio, 2023). Hence, the study aims to understand the influence of ICT on accessible tourism in Nigeria and to suggest strategies for its utilization in the economic growth of the nation.

Literature Review

Concept of ICT and Accessible Tourism

The goal of accessible tourism is to make travel and tourism inclusive for all people, including the elderly and those with temporary or permanent disabilities, irrespective of their disability or other impairments (Coffey & Tea, 2021). Based on the spatial model of disability, accessible tourism does not focus just on characteristics connected to disabilities; rather, it adapts the environment to various social demands (Fig 1) (Kołodziejczak, 2019).

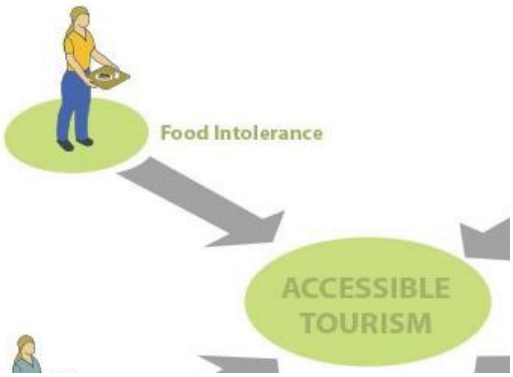

Figure 1: Concept of Accessible Tourism.
Source: Coffey and Tea (2021)

By offering a variety of electronic devices for communication and information sharing, ICT is essential to attaining accessible tourism (Khan & Hossain, 2018). Key accessibility features about location, information, social interactions, and activity goals are identified by Zajadacz (2014). Skalska (2010) proposes a model that takes institutional, social, economic, and environmental resources into account when determining how accessible tourist information should be. Essential requirements for trustworthy travel information, such as availability, clarity, currency, comprehensiveness, honesty, and communicability should be made available (Kruczek and Walas 2004). It is vital to

ensure that information is legitimate and reliable, especially for people

, especially for people with disabilities, since outdated or wrong information might create obstacles to accessible travel (Kołodziejczak, 2019). Adopting this concept is to see that more tourism information is made known through ICT to help promote the growth of tourism in Nigeria.

Methodology

The approach used for the study entails a thorough analysis of the body of research on the subject of the relationship between ICT and accessible tourism in Nigeria. Scholarly articles, research papers, and pertinent publications from reliable databases like PubMed, Scopus, and Google Scholar were used in the review. Combinations of "Information and Communication Technology," "ICT," "accessible tourism," and "Nigeria" were included in the search phrases. This study aims to examine and amalgamate the existing body of knowledge, significant discoveries, and patterns concerning how ICT has impacted the creation and execution of accessible tourism projects in Nigeria. The evaluation will also look at the potential problems that come with integrating ICT to improve accessibility for visitors—especially those with disabilities—and offer insightful information for future studies and useful applications in the travel and tourism sector.

Discussion of Findings

Nature of Tourism in Nigeria

Nigerian tourism is distinguished by a wide range of sites that showcase the nation's abundant natural, historical, and cultural legacy. Nigeria, the most populous nation in Africa, has a plethora of historical sites, ethnic groups, and cultural variety that enhance the country's tourism offerings. The nation offers tourists a distinctive cultural experience with its many festivals, customary rites, and colourful arts and crafts (Eja, 2017). Nigeria's tourist industry benefits greatly from its natural features, which draw visitors who are interested in wildlife. Some of these attractions include the Erin Ijesha Waterfall, Aso Rock, and the Ogbunike Caves (Oladokun et al., 2018). Nigeria's natural beauty is further enhanced by its fauna, which includes the drill monkeys found in Yankari and Cross River National Parks(Iwuoha & Nwosu, 2017).

The historical significance of Nigeria, including places like the ancient city of Benin and the Sukur Cultural Landscape, further boosts its tourism appeal (Nwosu & Iwuoha, 2016). However, despite these advantages, the tourist business in Nigeria has obstacles such as inadequate infrastructure, security concerns, and limited marketing efforts (Ihugba & Okoroafor, 2016). The Nigerian government has taken steps to develop infrastructure and support the tourism industry after realising the potential of the industry (Oladokun et al., 2018).

Nigerian ecotourism and sustainable tourism practices have received more attention in recent years, with an emphasis on the need to protect the nation's natural and cultural resources for coming generations (Adesanmi, 2019). The role of community empowerment and involvement is also growing in Nigeria's tourism industry, with programmes designed to make sure that tourism-related activities are beneficial to the local community (Nwosu & Iwuoha, 2016).

Challenges Facing the Accessible Tourism in Nigeria

Because Nigeria has so many diverse natural and cultural landscapes, tourism has a great potential to boost the country's economy and create jobs. Nonetheless, several obstacles prevent the industry's growth especially as it relates to accessible tourism. The lack of infrastructure to facilitate accessible tourism is one major

issue. Nigeria does not have many facilities that are universally designed, which makes it difficult for people with disabilities to travel around and enjoy tourist attractions (Oyetunji, 2023). The challenges experienced by travelers with disabilities are exacerbated by poorly maintained roads, a lack of accessible transit alternatives, and a shortage of lodgings with adequate amenities (Nwosu & Iwuoha, 2016). Overall accessibility of tourist destinations is limited by inadequate infrastructure, which also includes a shortage of elevators, wheelchair ramps, and accessible restrooms (Kruczek & Walas, 2004).In the era of globalization, the sector's development is further hindered by inadequate information and communication infrastructure (Cogburn & Adeya, 2000).

Another significant obstacle to accessible tourism in Nigeria is security worries. The nation has seen several security problems, such as violent assaults and the kidnapping of people connected to the petroleum industry, affecting travelers from within and beyond the country. In its travel advisories, the U.S. Department of State highlights the risks associated with visiting Nigeria (U.S. Department of State, 2023). It cites crimes perpetrated by people using military and police uniforms as well as the frequent occurrence of kidnapping, especially in the Niger Delta region (Charles, 2024). For travelers, particularly those with impairments who could be more susceptible to such threats, such security concerns pose a barrier according to Kołodziejczak (2019). Initiatives and regulations to promote inclusivity could not get the attention and support they need if the value of accessible tourism is not widely recognised.

The negative comments on social media and some online blogs further compound the problem. Negative comments about the country and the media further aggravate the problem, putting fear in the minds of those who would have loved to visit the country for tourism activities (Oladipo, 2022).

One major obstacle to the growth of accessible tourism in Nigeria is insufficient finance. The development and expansion of tourist enterprises in Nigeria are hampered by a lack of funding (NACCIMA, 2012; Okpara, 2005). Making tourism locations more inclusive is hampered by a lack of funding for the installation of accessible infrastructure and amenities(Olatunji & Falabi, 2014). Investments in technologies that could improve accessibility, such as mobile applications and digital information systems designed for people with impairments, are hampered by a lack of funding (Ihugba & Okoroafor, 2016).Few business owners in the tourism industry obtain the required financial support, despite current rules on the matter, making it challenging for them to compete worldwide. The rising exchange rate has further heightened this problem and has put so many businesses out of operation(Abina, 2023).

Planning and executing programmes for accessible tourism are further complicated by the lack of thorough and current data on issues linked to tourism in Nigeria(Oyetunji, 2023). Without comprehensive knowledge of the particular requirements Developing tailored methods for travelers with disabilities becomes challenging due to their preferences, length of stay, and travel history (Skalska, 2010). Effective decision-making in promoting accessible tourism and meeting the various demands of potential tourists is hampered by the lack of trustworthy data (Oyetunji, 2023).

In addition, neither the general public nor the stakeholders in Nigeria's tourism business are aware of or comprehend the notion of accessible tourism. Inadequate accessibility provisions

stem from a lack of knowledge of the requirements and preferences of travelers with impairments (Badiora, 2020). The situation is made worse by the fact that tourism service personnel are not trained in handicap awareness(Olatunji & Falabi, 2014).

A further crucial concern is the insufficient information on issues about tourism, which makes it difficult to plan strategically for the industry's growth(Olatunji & Falabi, 2014). For well-informed decision-making and efficient planning, comprehensive data on the demographics of tourists, their tastes, and the required infrastructure are crucial (NACCIMA, 2012).

When it comes to how policies are implemented, one important element impeding the efficacy of tourism-related policies is corruption. Numerous tourism development attempts have failed as a result of corruption, which has also damaged the reputation of the nation in the international arena (Soyombo, 2006; NACCIMA, 2012).

Need for ICT in Accessible Tourism in Nigeria

To meet the complex requirements of accessible tourism, information and communication technology (ICT) use is essential, especially in Nigeria. Kołodziejczak (2019) highlights the role of ICT in delivering accessible information to people with disabilities. He emphasizes the relevance of the internet and different devices in disseminating information about resources, facilities, routes, and tourist destinations. Travel businesses should manage databases and central information systems that incorporate comprehensive tourist information, which should be distributed through a variety of media platforms including the Internet, specialized publications, TV, radio, and social media. This is consistent with the finding that the Internet is crucial for marketing destinations and that, as a networked technology, it integrates with other ICTs (WTO, 2011).

The use of ICT in accessible tourism goes beyond the sharing of information to incorporate the fusion of different companies and service providers. According to Buhalis and Licata (2002), e-tourism organizations are increasingly integrating through the use of technology such as Computer Reservation Systems (CRS) and Global Distribution Systems (GDS). The proliferation of ICT applications is further demonstrated by the introduction of new 'eMediaries' that facilitate e-commerce, including mobile devices, interactive digital TV, the internet, and mobile commerce ('eCommerce') (Khan & Hossain, 2018).

As a subset of ICT, social media has grown in importance in contemporary e-tourism, facilitating communication amongst industry participants. Social media platforms offer a democratic forum for the exchange of thoughts and experiences, shaping the views of potential customers. However as noted above, companies need to carefully weigh the advantages and disadvantages of integrating websites and ICT systems with social networks(Kuttainen & Lexhagen, 2012). Tourism companies in Nigeria can leverage this to promote tourism centers to the world, through adverts, and jingles among others, thereby attracting more visitors to the country in the process. This can improve networking, and economic transactions, and give consumers around the world access to information. By assisting with site management and monitoring, geospatial information technologies also improve the accessibility of tourism destinations (Shanker, 2008).

According to Bethapudi (2013), traditional tourism enterprises are not adopting ICT as much as they should be. Government initiatives, technology improvements, and the business case for inclusive tourism are driving the growing use of ICT in accessible

tourism (Minnaert & Girginov, 2016). The Nigerian government should seek more companies to make investments in technological solutions to meet the needs of the ever-

expanding clientele and get a competitive edge in the market and turn using this for the promotion of tourism which can help to improve the economic Gross Domestic Product of the country.

Conclusion

In conclusion, Nigeria is at a turning point in its history where the unrealized potential of its tourism industry can be used to drive economic expansion; but, to overcome current obstacles, a strategic integration of information and communication technology (ICT) is needed. Due to its many natural, cultural, and historical features, the nation is well-known around the world as a top travel destination. However, the tourism industry's growth has been hampered by the underutilization of this potential, which has been made worse by economic downturns and an excessive focus on petroleum exports. .Accessible tourism in Nigeria faces significant hurdles due to a lack of information, limited infrastructure, security concerns, and budgetary limits, among other issues. However, a thorough approach that places a high priority on funding ICT infrastructure, encourages inclusive policies, cultivates public-private partnerships, and makes use of technology for accessibility and promotion can open the door to a journey of transformation. All things considered, ICT integration into accessible tourism can help Nigeria move towards a future in which its tourism sector not only contributes significantly to economic success and international recognition but also serves as a source of pride for the country as it continues to establish itself as a tech hub.

Recommendations

The following suggestions are put forth in light of the difficulties and the obvious need for information and communication technology (ICT) in accessible tourism in Nigeria:

i. **Investment in ICT Infrastructure:** The establishment of a strong ICT infrastructure ought to be a top priority for the Nigerian government. This entails boosting digital technology use, increasing network coverage, and improving internet access. Better ICT infrastructure will help the nation's economy as a whole in addition to facilitating accessible travel.

ii. **Integration of ICT in Tourism** Promotion: To effectively promote tourism, Nigerian tourism boards and pertinent authorities should make use of ICT tools. By using official websites, mobile applications, social media platforms, and other digital means, tourism destinations may be more widely visible, accurate information can be shared, and a worldwide audience can be drawn. By using this tactic, Nigeria may be shown as a desirable travel destination and unfavourable perceptions can be refuted.

iii. **ICT training with an accessibility focus:** Training programmes that are specifically designed for tourism service staff should be implemented to overcome the lack of awareness and expertise regarding accessible tourism. ICT usage should be covered in training, with a focus on how these tools may help people with disabilities access information and services. The goal of this programme is to develop an informed and diverse workforce in the tourism industry.

iv. **Public-Private Partnerships:** It is critical to promote partnerships between the public and private sectors. Public-private partnerships have the potential to facilitate the advancement of ICT solutions, accessible infrastructure, and tourism amenities. Together, the public and private sectors can overcome funding limitations

and encourage sustainable growth in accessible tourism.

v. **Data Management and Research:** It is necessary to enhance the processes of gathering and organizing data about tourism in Nigeria. Planning and decision-making are critical processes that require accurate and current information. The government should carry out studies in conjunction with academic institutions to compile detailed information on the preferences, demography, and accessibility needs of tourists.

vi. **Security Measures and Communication:** The expansion of accessible tourism depends critically on addressing security concerns. Putting in place strong physical and cyber security measures can reduce dangers and boost trust among travelers, including people with disabilities. Additionally, worries can be allayed and a favorable perception of Nigeria as a safe travel destination can be fostered through clear and regular communication on safety measures through ICT channels.

vii. **Financial Assistance for Tourism Businesses**: To help tourism businesses overcome financial obstacles businesses engaged in tourism, the government must look into ways to give financial assistance. Grants, low-interest loans, or other incentives could be offered to companies that invest in ICT solutions and accessible infrastructure. In the tourism industry, financial support can foster innovation and competitiveness.

viii. **Cooperation with Technology Companies:** Working with startups and technology companies can help find creative answers to the problems facing accessible travel. The government should work closely with these organizations to design and carry out technology-driven programmes that increase accessibility, enhance tourist experiences, and support the expansion of the travel and tourism sector.

Collaborative Networks and Social Media Promotion: There should be cooperation

ix. amongst travel industry participants, such as hotels, tour operators, airlines, and accessibility groups. The use of social media to promote travel destinations in a focused and efficient manner should be done. A worldwide audience can be drawn in by implementing skillfully designed social media ads, which highlight the diversity of Nigeria's tourism offerings and promote favorable opinions.

x. **Inclusive Policy Implementation:** Accessible tourism should be specifically included in government policies. This entails putting laws into effect that require ICT integration, accessible infrastructure, and training for companies that provide tourism services. Through coordinating policies with inclusive values, Nigeria can foster an atmosphere that is favorable to the long-term growth of accessible tourism.

xi. **Campaigns for Public Awareness and Political Support:** There should be an extensive public awareness initiative to inform stakeholders and the general public about the advantages and concepts of accessible tourism. The government should learn to support the growth of the tourism sector through the use of its resources and policies. Make use of ICT resources like social media, online forums, and informational websites to spread information, clear up misunderstandings, and promote a favorable image of accessible travel in Nigeria.

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AN OVERVIEW OF MATERIALS MANAGEMENT CONTROL IN EFFECTIVE PROJECT DELIVERY

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Abstract

Rural and urban developments in an emerging economy is a theme of interest in recent time that requires an urgent and important attention if an economy is to survive. There is no way a country like Nigeria grow without rural and urban developments. The development is an all-encompassing phenomenon of the construction industry in part and parcel. It is against this background this paper is aimed at An Overview of materials management control in effective project delivery. In order to attain this aim, the following objectives were carried out: identifying the concept of materials management and its related components, highlight in different materials management challenges, its impact to the project delivery and suggested possible ways of reducing it. Relevant literature review was discussed on how materials management is done on construction site to ensure effective project delivery. The methodology involved was a survey design where questionnaire was administered. Findings were made, useful recommendations were made and reasonable conclusions were drawn.

Key words: Project delivery, Management, Cost, Material, Time

INTRODUCTION

The Wikipedia dictionary defined Materials management as the function responsible for the coordination of planning, sourcing, purchasing, transporting, storing and controlling materials in an optimum manner in order to provide a pre decided service to the customer at a minimum cost. In construction project, the availability of materials in the right place at the right time coupled with having a right person with right skills and equipment that is able to deliver on time and on budget is very crucial. Previous studies in building sector have indicated that building materials account for between 50 to 60% of the total construction input (Adedeji, 2012) and (Ogunsemi, 2010), yet adequate attention has not be given to materials management in general. Materials is generally measured by accomplishing on time delivery to the customer, on time delivery from the supply base, attaining a freight, budget, inventory shrink management, and inventory accuracy. It has to be obtained at a reasonable cost and much available at all time. Effective and efficient management on site can enhance proper and overall construction project outcomes. Specifically, it can cut down on time, and material wastages: both of which have negative implications for construction cost if it is not properly managed. Management is an act of planning, implementation and controlling of construction resources in terms of supply, storage, processing and handling (Regassa, 2015). Based on previous studies similar definitions of materials management have been obtained from the works of(Dey 2001); (Ngwu, et. al 2015);(Donyavi and Flanagan, 2001), Frank and Ronald. The result of improper, handling and managing materials on site during a construction process will influence the total project cost, time and the quality (Che Wan Putra et al. 1999). Proper planning becomes the basic and essential guide to construction teams and other management devices of controlling materials which have to start from design stage in order to optimize profit, reduce cost and quality. Besides, the cost of materials in a project represents a huge proportion of the cost of construction. Therefore, there is a need for efficiency and effectiveness of materials management in order to control productivity and cost in construction projects. A well-managed material in construction project will be of benefit to the industry because its encompasses different dimensions, loopholes such as pilfering, deterioration during storage, delays and extra expenses may be incurred if materials required for activities are not available. Based on the scenario above, the paper provides a better understanding on the concept of materials management and its related components in Nigeria using Enugu as scope of the study.

Secondly, the paper highlighted on different materials management challenges, its impact to the project delivery and suggested possible ways of reducing it.

Materials management plays an important function in the project delivery and helps to improve productivity in construction projects. Bell and Stukhart (1986) defined materials management as functions which include "planning and material take off, vendor evaluation and selection, purchasing, expenditure, shipping, material receiving, warehousing and inventory, and material distribution". The result of improper handling and managing materials on site during a construction process will influence the total project cost, time and the quality (Che Wan Putra et al. 1999).(Dey, 2001) indicates that almost 60% of the total working capital of

any industrial organization consists of materials costs. However, in (Donyavi and Flanagan, 2011), it is observed that a good proper material management in the project delivery that will bring reduction in construction costs, improvement in productivity, quality and timely on project delivery. Material management effectiveness must be a major concern on project delivery. Therefore, there is a need for efficient materials management and a good supply chain in order to control productivity and cost in construction projects. There are many issues which contribute to poor materials management in construction projects. (Zakeri et al. 1996) suggested that waste, transport difficulties, improper handling on site, misuse of the specification, lack of a proper work plan, inappropriate materials delivery and excessive paperwork all adversely affect materials management. (Donyavi and Flanagan, 2009) divide material management into five categories namely, measurement and specification, procurement and purchasing process where the order is transmitted to the supplier, delivery to site and logistics of checking the order, off loading, and storing on site, administrative and financial process of payment and using the materials in production on the job site and removing the waste. Furthermore, (Dey, 2001) noted that there are different challenges affecting materials management and other factors gotten from various researchers as follows:

i) Receiving materials before they are required which may increase inventory cost and may increase the chance of deterioration in quality

ii) Not receiving materials at the time of requirement causing to decrease motivation as well as productivity

iii) Incorrect materials takeoff from drawing and design documents.

iv) Subsequent design changes.

v) Damage/loss of items due negligence

vi) Selection of type of contract for specific materials procurement;

vii) Vendor evaluation criteria.

viii) Lack of supervision.

ix) Piling up of inventory and controlling of the same.

x) Management of surplus materials.

xi) Shortage of materials

xii) Inaccurate measurement and specification;

xiii) The procurement and purchasing process where the order is transmitted to the Supplier.

xiv) Delivery to site and logistics of checking the order, off-loading, and storing on Sitc

In another study conducted by (Donyavi, 2009) states the common problems in material management as follows:

i) Inefficient communication on site.

ii) The administrative and financial process of payment.

ii) Using the materials in production on the job site and removing the waste.

iii) Failure to order on time which delays the projects.

iv) Delivery at the wrong time which interrupts the work schedule.

v) Over ordering.

vi) Wrong materials or error in direction of \\

vii) materials requiring re-work.

viii) Theft of materials from delivery into production.

ix)

xii) Lack of adequate room for the effective handling of materials The use of materials on construction site Bailey and Farmer (2002) define materials “as the goods purchased from sources out of the organization that are used to produce finished products". (Chandler, 2001) informed that the construction materials can be classified into different categories depending on their fabrication and in the way that they can be handled on site and these include:

Bulk materials: These are materials that are delivered in mass and are deposited in a container. **Bagged materials:** These are materials delivered in bags for ease handling and controlled use. **Palleted material:** These are bagged materials that are placed in pallets for delivery.
Packaged material: These are materials that are packaged together to prevent damage during transportation and deterioration when they are stored

Loose materials: These are materials that are partially fabricated and that should be handled individually. Building materials have an important role to play in this modern age of technology, although their most important use is in construction activities, no field of engineering is conceivable without their use and also, the building materials industry is an important contributor in our national economy as its output governs both the rate and the quality of construction work. Building materials are bought in standard length or lot quantities. Examples of such materials include pipes, wiring, and cables. They are more difficult to plan

because of uncertainty in quantities needed. Engineering materials are specifically fabricated for a particular project or are manufactured to an industry specification in a shop away from the site. This includes materials that require detailed engineering data while fabricated materials are materials that are assembled together to form a finished part or a more complicated part. Examples of such materials include steel beams with holes and beam seats. Other material includes cement, blocks/bricks, reinforcement bars and glass products.

x) Double handling of materials because of inadequate material.

xi) Lack of adequate storage space.

MATERIALS MANAGEMENT AND ITS PROCESSES

Materials management is a process that co-ordinates planning, assessing the requirement, sourcing, purchasing, transportation, storing and controlling of materials, minimizing the wastages and optimizing the profitability by reducing cost of materials (Chetna, 2011). The essence of this coordination is to optimize cost, ensure quality and availability of sufficient quantities of material for project needs. A construction project that has a good and effective materials management tends to maintain these processes in order to be successful.

INNOVATIVE TRENDS ON MATERIALS MANAGEMENT

These are some measures introduced as a means of managing materials management in general and they include:

i) Effective requirement planning: it is important for projects to spent time on planning with enough detils before involvement in the main project.

ii) Effective materials handling: Tompkins and White (1984) defined effective material handling as "using the right method, amount, material, place, time, sequence, position. Condition, and cost which involves handling, storing, and controlling of the construction materials". Handling of materials is the flow of materials which provides for their movement and placement. The importance of appropriate handling of materials is highlighted by the fact that materials are expensive and require critical decisions.

iii) Adequate preparation of materials documents: appropriate preparation of materials schedules, material specifications and network analysis from the inception of project will reduce improper control of material wastages. A good material schedules provide benefit to the teams operation and provide coding and classification of materials.

Use of IT: Use of IT has the capability for changing a cultural structure with an objective by reducing barriers between different functionality. IT also is a great opportunity for communication

parties and different activities. Electronic data interchange (EDI) and Electronic funds transfer (EFT) are some other technologies in IT that enable a retailer to electronically do some functionality such as purchasing orders, paying invoices and processing credit checks. SMEs want to use affordable, reliable, and available technologies to improve performance that are straightforward to use. One of such technology is Bluetooth, which is an open wireless. Such basic technology like mobile telephone or laptop is the most common available at the moment. Some other technologies such as internet, RFID (radio frequency

identification), GIS (geographic information system), GPS (global positioning system), tracking technologies are also available which have the capability of tracking materials.

Material Planning

The most essential guide for project planning is Bill of Quantities prepared by the client, it will enhance good planning and control toward meeting the required date, at optimum cost with desired quality. (Khyomesh,2011) informed that the most commonly used basis for planning things out for the project is the Bill of Quantity prepared by the client. Material planning helps in providing co-ordination within the project team and engineers in the project delivery in terms of uses of firm's resources.

Assessing of Materials

This process is able to identify the materials needed, including its specifications and calculate the required quantity of project materials. Obviously, the uses of drawing and specification in deriving out quotation help the builder's estimate in controlling, managing and directing the work. This is done in order to achieve the total actual required quantity of materials needed at a particular time. This will evaluate and enable them to classify the materials according to their operational stages and costs for consistency based on their specification and schedules.

Procurement

Procurement is not only about appointing massive modules. Knowledge of requirements, source and availability of this equipment may be critical to successful execution of the work,

between different
contractors and preparing contract, but is also very much a starting point in the process of delivery (Mead and Grunebcrg, 2013). Therefore to successfully deliver a project, it is not about adopting a procurement system with best practice and tactic to fix all problems, but to embrace an approach that has the best-fit tactic that gets the job done most efficiently (Keith, et al., 2016).Procurement is a wide term which covers all the firms purchasing and related activities. Activities included in the procurement process ranges from purchasing of equipment, materials, labour and services required for construction and implementation of a project (Kasim, et al., 2005).

Purchasing

Purchasing has the responsibility and authority to commit projects or materials through an appropriate vendor (Obiegbu 1999). Purchasing involves obtaining all materials, tools and supplies necessary for operation and maintenance of the organization's facilities; it includes the responsibility of obtaining the right quality at the right prices, from the right source and at the right time to ensure the availability of material in the construction sites. Purchasing function is primary necessity to materials management.

Transportation of materials

The movement of materials, equipment, and personnel to the job site thereby encompasses planning and controlling flow in order to represents a unique and specialization clement of materials management. Experienced traffic personnel can have a positive impact on the execution of the project while minimizing

transportation cost (Ahuja and Dozzi 1994). Good logistics involved the use of minimum of materials waste on site, having a good cash flow; this makes it easier to keep the site clean and tidy for an effective logistics team. Transportation will also pay attention to the maintenance of plant and equipment. Transportation aids the materials management team in handling numerous types of special loads from delicate electronics t

transport permitting requirements also must be considered early in the project (Bailcy and Farmer,2002). For smooth handling of the materials, space need to be carefully allocated for

material handling equipment, access roads, warehouses, workshop, and lay down materials in the construction site (Pellicer, et al., 2013). ECI (1994) states that "material delivery to site is a critical productivity-related aspect which demands the introduction of a carefully-developed system of monitoring and control as early as possible and transportation in terms of loading and unloading of materials should not be done in rainy season to avoid damages and wastes"

Materials Storage and Control

Effective material handling involves handling, storing and controlling of construction material (Kasim, et al. 2005).Material storage on site requires close attention in order to desist from waste,loss and any damage of materials which would affect the operation of the construction project.Problems always arise during materials supply because of improper storage and protection facilities (Canter, 1993). Material storing on site can sometime have some negative impact on project outcomes if it is not properly attended to because material can be damaged by weather moving equipment's or people (Fei, 2014). When proper protection during storage is ignored, this can result to poor material quality or material deterioration. Stock control can include raw materials, processed materials, and components for assembly, consumable stores, general stores, maintenance materials and spares, work in progress and finished products (Prabu, 1986). Materials control is of a great importance to the project delivery on construction management. This function is important to avoid any potential materials shortage or surplus occurring at the construction sites. The efficiency of this measure is to optimize the construction productivity and minimize the construction costs. It is also noted that the storage area needs to be clean, enclosed and dry with good circulation and for some materials need to be stacked on pallets, not more than a certain safe height to prevent dampness and so on (Low and Ong, 2014). By adopting this effective measures for material storage and control will help to keep the material intact and in good quality. And also will reduce loss of profit due to theft, damage and wastage as well as running out of stock (Kasim,ct al., 2005).

IMPACT OF MATERIALS MANAGEMENT IN PROJECT DELIVERY

A construction project depends upon having the right people with right skills and equipment that are able to deliver the project on time and on budget. From the related literature studied above, material management can help in proper project delivery. Effective use of for men in the construction site will harmonize a great impact to the material management. They are as follows.

i) Systematic operations

ii) Reduction in cost of material handling

iii) Reduction in overall cost of the project

iv) Increase in productivity of the labors

v) Time management

vi) Quality control

vii) Better relations with suppliers

viii) Better relations with customers.

METHODOLOGY OF THE STUDY

A survey of expert opinion on material management in construction sites was conducted in Enugu town comprising of six major construction companies and professionals in the building industry.

A total of one hundred (100) questionnaires were constructed and distributed out of which eighty seven (87) representing 87.0% were properly completed and returned. The major issues on the challenges of materials management were discussed and expert opinions were gotten. Relevant secondary data were obtained from related text books, journals and book of proceedings used in this research work.

DATA ANALYSIS PROCEDURE

Most of the questions in the questionnaire relied on the review of related literature assessing some indices on materials management in Effective project delivery on five (5) poin likert's scale. The data analysis thereby employs the following:

a. Computation of the mean using the weighted average formula

$$X = \frac{\sum fx}{\sum f}$$

Where X = mean

X = points on the likert's scale (5,4,3,2, and 1) F = Frequency of respondents.

DATA PRESENTATION

Data obtained from expert opinion survey are presented in tables 1

Table l: Identified challenges of materials management in construction sites VLE = Very little effect

LE = Little Effect L = Fairly

SE = Severe effect

VES = Very Severe effect

TABLE 1: RESPONSE ON CHALLENGES RESPONSIBLE FOR POOR MATERIAL MANAGEMENT

S/N	FACTORS	RANK SCORE					TOTAL	MEAN SCORE	MEAN RANK
		VLE	LE	F	SE	VSE			
1	Lack of established quantities of materials needed before orders are made.	11	9	16	27	24	87	3.54	1
3	Lack of consideration in detailed period over which deliveries can be spread without affecting the contract.	10	11	22	17	27	87	3.54	1
3	Delay in receiving materials on sites.	13	12	15	16	3124	8787	3.483.45	3
4	Poor control of materials wastage on site	13	8	18	24				4
5	Lack of consideration of making deliveries of materials at scheduled dates and time.	10	15	17	21	24	87	3.40	5
6	Lack of keeping adequate buffer stock in case of delay in receiving materials.	16	12	16	19/	24	87	3.26	6
7	Non consideration of stocking materials at various points where work is going	17	14	20	20	16	87	3.06	7

9	Lack of planning of sites to indicate main storage area and stockpiles	18	16	16	19	17	87	3.03	9
10	Lack of procedures for checking inspecting and documentation of materials.	17	18	15	20	17	87	3.01	10
11	Lack of co-ordination for movement of plant handling materials.	20	18	17	15	17	87	2.93	11
12.	Lack of co-ordinate system of withdrawing materials from the stores.	20	18	17	15	1	87	2.90	12
13	Double handling of materials (which can cause problems of workmanship and finish	20	17	19	16	15	87	2.87	13
14	Lack of proper design (which do not allow effective handling and fixing of materials.	23	18	15	15	16	87	2.80	14
15	Lack of pre information toward the arrival of the goods.	21	19	16	15	16	87	2.71	15

Source: Field Survey, 2018

RESULT AND DISCUSSION

From Table 1, lack of established approximate quantities of materials before orders are made and lack of consideration in detailed period over which deliveries can be spread without affecting the contract was observed to be the most important challenges affecting materials management in the project delivery having a mean score of 3.5 respectively, they are called materials schedule. From the study, preparation of material schedule is given high priority despise, it is estimators who produces schedules and figures of materials to the buyer. Consequently, the presentation and clarity of the schedule does not always receive consideration
as a material control document. For the benefit of materials management, material schedule should be most important document associated with project programme in order to manage materials effectively. Proper schedule of ordering of materials has to be confirmed by the site manager based on dates and time of arrival in order not to have adverse effect on contract. Nevertheless, other challenges such as overestimating the quantity required, faulty workmanship, misinterpretation of drawings, careless handling of materials, and design requirements such as excessive cutting of components to achieve non-standard solutions can be controlled once material schedule has been put in place

Conclusion and Recommendations

Materials management control is as old as the construction industry. It is a practice which contributes mostly on time, quality and cost. This study addresses the issues and challenges of materials management in construction sites. Professionals should put more interest on the identified measures by contacting the quantity surveyors and cost engineers in the project delivery in order to upgrade their standard in those affected areas. The preparation of schedules could be classify into groups, operations or stages and should start from pre-contract stage-contract stage post-contract stage in order to ascertain a clear

flow and supply of materials accordingly.

Based on the research analysis and findings, the following recommendations are stated:-

i There should be a centralized material management team and proper co-ordination between the site and the organization.

ii there should be a Proper control, tracking and monitoring of the system.

iii adequate awareness and accountability should be created within the organization

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Recommendation

iv There is a need of an efficient MIS integrating all aspects of material management.

Use of software like MSP, PRIMAVERA,ERP,SAP, etc, should be done to avoid manual errors in material management.
>To avoid delay due to rejection of materials by quality control department or seasonal problems, the construction firms should store extra materials like steel, cement,etc.for emergency purpose

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DISTRIBUTION OF GOODS AND SERVICES LAND TRANSPORTATION APPRAISAL

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ABSTRACT

The study is a conceptual review of literature and adopts descriptive investigation. The methodology adopted is secondary source of information. The desire for efficient and effective transport system remains inadequate both qualitatively and quantitatively considering the population growth. In view of the above, users/people have developed different methods of moving themselves from a point to a destination (origin to destination) and their goods from a point of production to a point of consumption (production to consumption). Land transport is a major activity for the attainment of economic growth and development of every nation, despite series of debates between transport and economic development. The paper aimed at appraising land transportation in distribution. The objective is to know the best way amongst other alternatives of moving equipment, people, and delivery of goods. It also examined the problems faced which include inefficiency in service delivery and non-availability of sufficient infrastructure facility, like road networks. It was discovered that land transport remains the most common transportation method to reach every nook and cranny of the society. Also, it was discovered that inefficiencies has affected peoples output. It is therefore, recommended that maintenance should be carried out in all land transport systems and policy should be made to ensure efficient land transportation.

Introduction

Transportation is the bedrock to the growth and development of any environment. Land transportation has been overwhelming dynamic factor for development, growth and change in all human capacity and has brought about changes in social, economic, political, recreational, religious and cultural exchange in different environment. Transportation awaken factors of production, trade, commerce and other related social economic development. Thus, it remains the movement of people, goods, ideas and information from one place to another. The inability to make suitable policies to influence the efficiency, growth and development of the environment could result to low functionality of the sector. Jean-Paul R, Claude G, and Brains (2006) Both scholars agree that policies that disrupt the growth and smooth running of the transport system will definitely affect the efficiency, growth and development of the society and its well-being.

Among the transportation system are Land, Sea, Air among other. Land transportation is the most common means of transportation. Land transportation system provides an efficient means of moving people within towns and cities. Transportation is a necessity for the growth and development of a community. According to Sumaila, A. P. (2013) he said whether in a developing or developed country, transportation serves as the driving force for the movement of the people and the flow of information, raw materials and semi finished and finished products for the building and maintenance of the society.

Transport determines the quality of life in the society because all aspect of development involves transportation. Thus Oyesiku, (2002) agree that there is always need to collect, assemble, transfer and distribute people, goods and services. Land transport helps productivity, it has grown nations and economy (Lyndron and Toda, 2006): Land transportation is used in moving people and goods from one place to the other. No nation is self reliant without a good transport system.

Ogundara, (2002) Oyesiku, (2002). Both agreed transportation assists in the movement of factors of production, such as production, trade, commerce and other socioeconomic activities within and through the world. (Badejo, 2003; Rabi and Cord, 2006), transportation is the propelling force for growth and development, whether developed or developing nations, it is the encouraging force for the movement of the people and the flow of information, raw materials, semi finished and finished products for the building and maintenance of the society. The primary aim of transportation is safe arrival of the people, goods, material and equipment in the right place, right time and in good condition.

Transportation

Transportation is the backbone of economic development, enabling movement of goods, services and people Dr Jean-Paul Rodrigue (2020) according to David Levinson (2019) transportation is a critical component of urban systems providing access to employment, education, healthcare and other essential services. Michael Browne (2018) said transportation is a vital part of the supply

chain, connectivity produces and consumers through various network. These definitions rightful the vitality of transportation in facilitating enhance development, urban mobility and access to essential services while emphasizing its role in connecting producers and consumer through various modes and network.

Land transportation is a vital factor for logistics management. It determines the growth and success of any economy, as well as trade and commence of a country. The success of any country today is attributed to the good networking of the transportation system that allows people to move from one place to the other and move goods from point of no need to a point of need at the right time and freely. A good transport network assists organizations to allocate its resources efficiently (Christopher Cadlive, 2017).

Importance of Transportation

- It makes goods and services available to customers.
- It ensures that there is time and place utility for goods and services.
- It enables large and bulky commodities to be easily moved and distributed.
- Transportation shortens the length of the distribution channel.
- Transportation is a major force that is transforming the world into a global village, because it helps to create a world of interdependence (Robert Cervero, 2017).
  i. The contr mibution of road transportation assists in the development of many countries, thereby bridging the gap between the cities and rural areas and between people and businesses.
  ii. Transportation helps businesses to widen its market areas by moving both raw materials and equipment from one market to another.
  iii. It reduces the rate of damage to perishable goods, since food arrive on time.
  iv. It affords the consumer a greater choice of items and opportunity to choose goods.
  v. Transportation helps in job creation.

Factors Affecting the Choice of Transportation

There are several ways goods and services can be moved for use by businesses or organizations. They are classified into two, the single mode transport consisting of road and rail transport (land), others include shipping (water) and airlines (air) and intermodal or multimodal transport consisting of piggy backing, fish backing, roll-on-roll-off, sea-air

combination and pipelines combination (Mohammed, 2009). The main discussion is the single mode transport which forms 85% of the transport activities of our country. Land transport includes the use of human, animal, cars, tricycles and motorcycles (Okada). Many distribution networks consist of a combination of these means of transportation and all of these transportation choices have advantages and disadvantages.

Below are some of the factors that affect the choice of transportation;

1. **Cost:** the cost of transportation is vital in choosing a particular mode. Cost is the amount paid for the shipment of goods between two geographical locations. It is associated to the degree of urgency, distance and volume of goods. Transport companies will charge based on distance, if close or goods are in small quantity viz and viz if the distance is far apart and goods are in large quantity. Some modes of transport are more expensive than others. These guide the decisions of transport managers (Christopher Caplive, 2017).
2. **Distance:** Air transportation is preferable for long distance journeies especially in international trade, where goods cover greater distance. Where goods are to be transported to a long distance, whether domestic or international air transport will be required.
3. **Flexibility:** Road transport is more flexible. This is vital where the route is convenient and where minimum facilities are required. This also involves the movement of goods at anytime.
4. **Availability:** This is the mode of transport that is unavailable in the area where the goods are being moved.
5. **Business:** This is when goods are large or bulky and to be carried over long distances. Some firms specialize in shipping large volume of goods while others specializes in moving only goods in small size.
6. **Safety and Security:** This is delivery of goods without loss or damage. Where the goods to be transported are fragile, perishable and expensive, transportation will be by air or motor vehicles.
7. **Traffic condition:** Traffic situation in an area and at a particular time could

8. encourage or discourage the use of a particular mode of transportation. This includes government regulations and rules on the conduct of transporters and other legislation on the movement of goods. The law dictates that certain modes are to be used in transporting certain goods, then owners have no option than to abide by such regulations.
9. **Urgency/time:** The urgency of the goods will determine the transportation mode to be chosen. The speed of transportation is the time that is taken to complete the movement of goods from point of origin to destination. Speed is the transportation mode that can facilitate the delivery of goods at the required data and time.
10. **Weather condition:** The weather condition in a particular area and at a particular time will influence the choice of transportation Lonelon (2020).

Challenges of Land Transportation

According to Vincent et al, (2013) opined that the challenges faced by land transportation cannot be overemphasized. These challenges are;

1. Lack of resources to make improvement and repair of roads.
2. Topography and differences in environment are different from one another.
3. Lack of funds to link bridges together.
4. Climate/weather condition: This involves poor drainage which has made culverts to be eroded by rains during the raining season.
5. High rate of accidents due to bad roads, potholes and limited signs on the roads.
6. Insecurity on the roads leading to banditry and kidnapping Vincent et al, (2013).

Distribution

Distribution begins with interactive sessions between the producer and the customers. It allows the customer to negotiate bills, quantity, quality and time for delivery. Production is not complete until goods are moved to the customers. Distribution is one of the marketing mix variables. Distribution are basically of two types, namely; (Christopher Caplive, 2017).

Channels of direct (zero) channel and indirect channel. Organizations use either of the two or both depending on his product or market. Direct distribution is dealing with the workers without the use intermediaries, while indirect distribution engages the use of channels of distribution to reach the customers. Tangible goods are usually distributed directly such as house furniture and agricultural products. While intangible are distributed indirectly such as health, education, insurance, electricity etc (Robert W. Grubbstrom 2018).

Channel Member

Transportation plays a major role in distribution. It is an activity that concludes factors of production.

Types of Distribution Strategy

Three (3) types of distribution strategies can be used to move products available to customers.

1. Intensive Distribution Strategy
2. Selective Distribution strategy
3. Exclusive Distribution strategy

1. **Intensive Distribution Strategy:** This is placing of goods and services by a producer in all the outlets available. It is used mainly for consumer of goods that is featured with frequent purchase with minimum efforts. Intensive distribution, the product is sold to retailers by the wholesales. Example of such products include chewing gum, bread and pure water where the primary factors influencing the purchase decision is convenience.
2. **Selective Distribution Strategy:** this is the use of few intermediaries who are willing to carry a particular product. It involves using limited outlets (few intermediaries) in a given zone. It is common with shipping goods, where the numbers of goods are limited. By carefully selecting wholesales or retailers, the producer can concentrate on potentially profitable outlets and develop solid working relationships to ensure that the product is properly merchandised. The producer may also restrict the number of retailer outlets if the product requires specialized serving or sales support. Examples of such products include appliances, televisions, stereo equipment and sport equipment. Intensive distribution is more likely to involve indirect channel with two or more intermediaries.
3. **Exclusive Distribution Strategy:** This is using only one intermediary in a geographical location to be solely responsible for selling the company's products. It is connected with special products. It is exclusive distribution because a single outlet is given to an exclusive franchise to sell the product in a geographical location, products such as special automobiles, some major

appliances, certain brands of furniture and lines of clothing that enjoy a high degree of brand loyalty fall into this system of distribution. It involves aggressive selling approach, it involves the willingness of wholesales or retailers or consumers to overcome the inconvenience of travelling some distance to obtain the products. Exclusive distribution occurs more frequently at the wholesale level than at the retail level Douglas .M. Lambert (2016).

Channels of Distribution

This is the way through which goods move from producer to the consumers. It is the method through which the ownership of products is transferred as it moves from the producer to customers. Some channels include;

Middlemen: This middleman includes the wholesalers and retailer who specialize in performing activities relating to the purchase and sale of goods in the process of their flows from producer to final buyers. They are middlemen situated in the marketing channel at points between the producers and final consumers Fowill G. (2015).

Different Channel of Distribution

Production → Consumer

Production → Agent → Retailer → Consumer

Production → Agent → Wholesalers → Retails Consumer

Production → Wholesalers → Retailer → Consumer

Production → Wholesalers → Agent → Retailer → Consumer

Production → Wholesalers → Agent → Retailer → Agent → Consumer

Production → Agent → Consumer

Production → Retailer → Consumer

Fig 2.1: Supply Chain Management Towill, G. (2015),

Findings

i. The review finds that land transportation forms 85% of moving goods from one place to the other.
ii. That the inefficiency of land transportation is caused by poor maintenance of the roads.
iii. It also revealed that land transportation is the lowest transport cost to reach urban and rural areas.

Conclusion

This review concludes that land transportation is very vital in the movement of people, goods, information, etc. It also concludes that there is adequate road network, but rail transportation is lacking in most locations with the country.

Recommendations

The review recommends that there should sufficient and effective road networks, and such roads should be maintained to ensure efficient and speedy movement. Insecurities as a bane of land transport should be addressed in a holistic manner to make our roads safe. Police and soldiers should be well paid and motivated to actually help to secure roads, and not them constituting nuisance to travelers.

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