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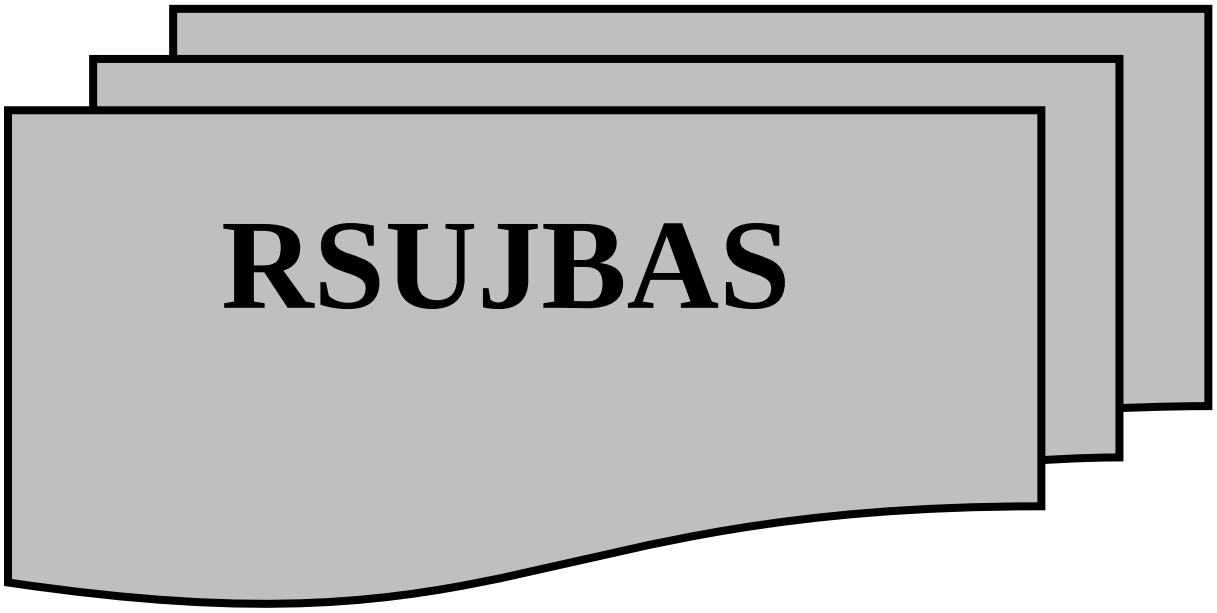

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# INNOVATIVE RESEARCH APPLICATION IN DISASTER MANAGENENT IN NIGER DELTA

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## ABSTRACT
*The increasing rate of natural and man-made disasters in all parts of the world has become so worrisome to stakeholders and world leaders. The situation in Nigeria is what mentioning as the recent incidence of flood disaster which occurred in some parts of the country has caused serious damages and economic losses to the people especially those living in the riverine areas. As the consequences of the disaster begin to take its tore, it becomes necessary to find a way to minimize the impact of this disaster. For this reason, this paper takes an insight into the role of research in disaster management with a view of analyzing the key issues, challenges, implications and way forward. The system theory which was propounded by Ludwig Von Bertarlanffy in 1938 was used as the theoretical framework of analysis. The paper resolved that research provides information needed by individuals, industries and communities to address disaster issues. Poor research and disaster management have negative implications. It was established that an individual, corporate entity or community that fails to conduct a proper research and develop a well-articulated disaster management plan will experience great damages, property and financial losses as a result of the disasters victims of such situation will not be able to recover from the situation on time. The study further recommended that local and national authorities should developed an emergency development plan for effective disaster management, which must include disaster management policy to address disaster issues in Niger Delta and Nigeria.*
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**Keywords:** Research, Disaster, Management, Over view, Globally**.**

## Introduction
Research is the systematic process of finding solution to a problem. It involves identifying the nature of a problem, discovering the root cause (s) of the problem, and proffering solution to the problem (Rotanz, 2007). Within the context of disaster phenomenon, research involves the process of investigating the incidence and nature of a disaster, identifying the root causes of the disaster, determining the extent of damages done by the disasters and proffering solution to the situation (Philips, 2011). Research is very important in addressing disaster phenomenon; it provides information on disaster event and facilitates effective management of the situation by

anticipating the occurrence of a disaster, exposing the nature and reasons for the possible reoccurrence of the disaster and streamlining the management process to reduce its negative impact. In a nut shell, research brings about effective disaster management.

Disaster management is a sum total of all the activities, programmes and measures which can be taken up before, during and after a disaster with the purpose of avoiding, reducing the impact or recovering from the losses (Khan, et al, 2016). The various aspects of disaster management include disaster prevention, disaster preparedness, disaster response, disaster mitigation, rehabilitation and reconstruction (Karan, 2019). The aim of disaster management is to reduce the potential losses from the disaster, provide appropriate assistances to victims, and achieve quick recovery (Levy, et al, 2005). Considering the increasing rate of natural and man-made disasters experienced in all parts of the world. Issues that boarder on fire blow out, oil spillage, explosions, drowning, toxic release, nuclear reactor accidents and natural calamities like earthquakes, cyclones and unprecedented rainfall (flood) had been on the increase. Available statistics showed that the number of natural and man-made disasters has increased tremendously by 60% per year between the period of 1999-2001 (Khan, et al, 2016). The highest increase was in the countries of low human capital development which recorded an increase of 142% (Khan, et al. 2016). The average annual cost of damages from natural and man-made disasters have risen from $14 billion between 1976-1985 to over $140 billion between 2005-2014 (World Bank Facility for Disaster Reduction and Recovery Reports, 2016). The economic losses arising from natural disasters in 2015 stood at $92 billion with an average annual loss estimated at about $300 billion per year (World & GFDRR, 2016). This dramatic increase in natural and man-man disasters across the world and their antecedent impact on the people have attracted national and international concern. Strategies on how to minimize the negative impacts of these disasters have been the major area of emphasis. A good disaster management would help individuals, corporate entities and communities to minimize losses that may occur as a result of the disaster. Disaster can happen any time; it is an unexpected incidence which is capable of bringing losses to people, organizations and the community at large. Such incidence cannot be avoided in the case of natural disaster and even in man-made disaster, the situation cannot be completely prevented but their impacts can be minimized by adopting a strategy for dealing with the situation (Rodhi, 2018).

**Concept of Disaster Management**

Disaster management can be defined as a range of activities designed to maintain control over a disaster and emergency situations and to provide a framework for helping those who are at risk to avoid or recover from the impact of the disaster (Kelly, and Karan, 2019). Levy, et al, (2005) defined disaster management as the way in which individual, corporate entity and community deal with human, material, economic or environmental impact of said disaster. It is the way in which companies and community prepare for a disaster, respond to it and recover from the impacts of such disaster (Levy,et al, 2005). Khan, et al, (2016) described disaster management as a sum total of all the activities, programmes and measures which can be taken up before, during and after a disaster with the purpose of avoiding, reducing the impact or recovering from the losses. The aim of disaster management is to restore order to a disastrous

situation by minimizing the impacts of disaster and providing assistance to victims (Abdalla & Esmail, 2018).

Disaster management has a number of phases which are popularly known as the disaster management circle. These phases include the event itself, response phase, recovering phase, mitigation phase and preparedness phase (Bavej, 2016). Organizing these phases logically make it easier to understand what must be done in each of the disaster management phases.

Once an event (a natural or man-made disaster) occurs, it follows with a response and when the response has been taken, the recovering phase starts and may actually begin even when the response phase is still ongoing. The recovery phase is the longest phases, and could last for weeks, months or even years depending on the nature and impacts of the disaster. Following the recovery phase is the mitigation phase where feedback from the response is used to figure out how to prevent the consequences that occurred in case the same event reoccurs in future. Having figured out the mitigation phase, the next phase is the preparedness phase which involves getting ready for the next event. The preparedness phase requires buying and stocking disaster supplies for whatever aspect of the event, outlining the responsibility of each agency and personnel, writing out the disaster plans, training the various personnel and testing the effectiveness of the disaster plans.

A good implementation of disaster management plans can be seen in this example. For instance, if there is a major hurricane in Nigeria, there will be a period of time for preparation before the storm arrives. Once the storm occurs, it follows with a response which begun by positioning medical personnel close to the area of event. The response to the event begins by doing a quick assessment to see the extent of damages caused by the storm, and to determine the resources that are still functional. This will guide the responder on what to do. Will the people or victims require shelter? Will hospitals or health centre still be standing and able to function? Do people or victims need to be rescued? Is power available or is the grid out? Do the victims need rehabilitation? By providing answers to these questions, the disaster manager can be able effective analyze the situation and bring to bear what is needed. A crucial aspect of the response phase is setting up or establishment of centralized Command and Control System which takes place by using the Incidence Command System. This will be staffed by the disaster manager and invite experts related to the type of disaster (Rodhi, et al, 2018).

Many countries including Nigeria have experienced different forms of disasters; some of which are caused by failures of the operational system of companies or uncontrolled situations within their plants and beyond, while others are caused by natural phenomenon of which nothing can be done to avoid their occurrence. Natural disasters such as earthquakes, cyclones and unprecedented rainfalls occur naturally and nothing can be done by man to avoid their occurrence. The recent flood disaster which occurs in some parts of Nigeria in 2018 is a good example of natural disaster that cannot be avoid but its impacts can be minimized by early preparation and effective management of the situation. States like Bayelsa and Rivers suffer massive flood which destroy some people's home and render them homeless. Many farmlands were erased by the flood resulting in massive damages and economic/financial losses to the people. In any subsequent reoccurrence of this event, individuals and the local authorities must be prepared to handle the situation to minimize its impacts and recover quickly.

It is believed that continuous research and effective disaster management can help to minimize the impacts of natural and man-made disasters in Nigeria. Karan (2019) argued that individuals and local authorities that engage in research and develop a well-articulated and documented disaster management plan will surely reduce the negative impacts of natural and man-made disasters and recover quickly from any loss suffered as a result of the incidence. It is against this backdrop that this paper examines research and disaster management in Nigeria with a view of addressing the key issues, challenges, implications and way forward. To achieve this, paper discusses the concept of disaster, types of disasters, concept of research, concept of disaster management, issues and challenges in disaster management, the implications of poor research and disaster management, and the way forward.

## STATEMENT OF PROBLEM

Disaster is a catastrophic situation in which the normal patterns of life (or ecosystem) have been disrupted and extraordinary, emergency interventions are required to save and preserve human lives and/or the environment (National Institute of Disaster Management (NIDM), 2017). The United Nations in Kaushik (2013) defines disaster as a serious disruption of the functioning of a society, causing widespread human, material or environmental losses which exceed the ability of the affected society to cope using its own resources. Khan, Vasilescu & Khan (2016) described disaster as a sudden adverse or unfortunate event which causes great damage to human beings as well as plants and animals. A disaster is not just the occurrence of earthquake, flood, conflict, health epidemic or an industrial accident, a disaster occurs if the event negatively impacts on human population (Karan, 2019).

## AIM AND OBJECTIVES OF THE STUDY

The study is aimed at providing a based line data information for the management of disasters in oil reached Niger Delta region of Nigeria. The study also examines various sources of disaster at various ecosystem, such as mangrove zone, transition zones, lower delta zone, where various onshore and offshore activities are frequently carried out. It is also aimed in providing a lasting safety oriented approaches in arresting disaster, so as to minimize loss and severe occurrences.

### Categories of Disaster

Disasters are broadly categorized into two types namely, natural and man-made disasters. This categorization is based on the causes and impact of the disaster. The two types of disaster are discussed below:

### Natural Disaster

Natural disaster is a type of disaster that occurs naturally. Such disaster arises as a result of the actions of nature which are accepted as being unfortunate (Al-rousan, et al, 2014). Natural disasters are inevitable as they cannot be prevented by man. Examples of natural disasters are earthquakes, flood, cyclones, famines, snow storm, volcanoes, hurricanes, tornadoes, and droughts (Karan, 2019). Masozera, et al, (2007) stated that natural disasters are inevitable and when they occur, companies, community and the government work together to minimize the

impact on human beings and the environment. Abdalla & Esmail (2018) stated that natural disasters cause a lot of damage to the people and sometimes lead to loss of lives and properties.

**Man-Made Disaster**

Man-made disasters are those disasters that are caused by man and not nature. This type of disaster arises as a result of failure in operational system or uncontrolled plants and installations (Karan, 2019). Bavej (2016) stated that man-made disasters are caused by the economic activities embarked upon by man to satisfy needs and maximize profit. According to him, such disasters arise as a result of breakdown in operational plants or malfunctioning of the operational system. Examples of man-made disaster are explosions, fire break out, release of toxic chemical, dam failure and nuclear reactor accidents (Karan, 2019).

**Concept of Research**

Research can be defined as a systematic process of investigating a problem, identifying its causes and effects and making recommendations on how the identified problem can be resolved (McEntire, 2015). Philips (2011) described research as the process of investigating and providing information about a problem with a view of finding a lasting solution to it. Disaster is considered as a problem which causes damages and losses to people and their community. Such problem can be researched to find out why the event occurs, nature of the event, the extent of damages done to the people and the community and other information related to it. The process of investigating a disaster phenomenon with a view of providing possible ways to reduce their impact on people and community is known as disaster research (Rotanz, 2007). Kaur & Sood (2019) defined disaster research as the process of finding out the nature of a disaster, identifying its root causes and impacts, and suggesting ways to address the situation.

Disaster managers rely on research information in addressing disaster issues. According to McEntire (2015), research provides adequate information which disaster managers need to effectively and efficiently manage and handle disaster event. Rotanz (2007) argued that the information and recommendations provided at the end of any disaster research aid community and the local authorities to identify ways of preparing and dealing with disaster event. Research helps to supply information on the various types of disaster events, the reasons why they occur, their impacts and the possible ways to deal with the situation. The information provided by research assist community, disaster managers and the local authorizes to effectively prepare and address disaster issues. Kaur & Sood (2019) noted that disaster managers rely on researchers to observe, evaluate and manage disaster issues. They further stated that research enables disaster managers or local authorities to better understand the magnitude of issues related to disaster event and formulate disaster policy that will help to ensure effective disaster management.

**THE STUDY AREA**

The study area was Niger Delta Region of Southern Nigeria. The geographical area known as the Niger Delta is located between latitude $4^{o}$ and $6^{o}$ north of the equator and longitudes $5^{o}$ and $9^{o}$ east of the Greenwich Meridian. According to Tamuno (2008), the Niger Delta sub-section of Africa is “fan-shaped and it is the third largest in the world after the Missippi and Pantanal

(South – West Brazil)". The South-North extent of (4-6)$^{o}$ North of the equator is expressly defined by the Great Atlantic Ocean in the South to Aboh (Delta State) in the North where River Niger forks into Rivers Nun and Rivers to River Sapele, in Delta State. The East-West extent of approximately 440km is twice that of the North-where River Niger forks into River Nun and River Forcados at a village called Obotor. The East-West extension is from the boundary of the Bonny River of River Sapele, in Delta State.

The East-West extent of approximately 440km is twice that of the North-South extent of approximately 220km. The states state covers the actual geographical area of Niger Delta. Are Bayalsa, Delta and Rivers. However, for political reasons, all the oil producing states of southern Nigeria are now part of the Niger Delta. This implies that the Niger Delta region consists of nine (9) states, Abia AkwaIbom, Bayelsa, Cross River, Delta, Edo, Ondo and Rivers Fig 1 shows, the states and their major cities (capitals). The Niger Delta is a geographical sub-region of Nigeria and Nigeria itself is located at the eastern end of West Africa, north of the Gulf of Guinea and nearly equidistant from many far away African capital cities (Iloeje, 2012). The Niger Delta region covers a total land area of about 112, 110km$^2$ which represents about 12% of Nigeria's total surface area and by 2005, the region controls over 31 million inhabitants or 22.30% of Nigeria's population (Igwe, 2009). Table 1 shows the nine Niger Delta state, their land area, major cities (capital city) and their population.

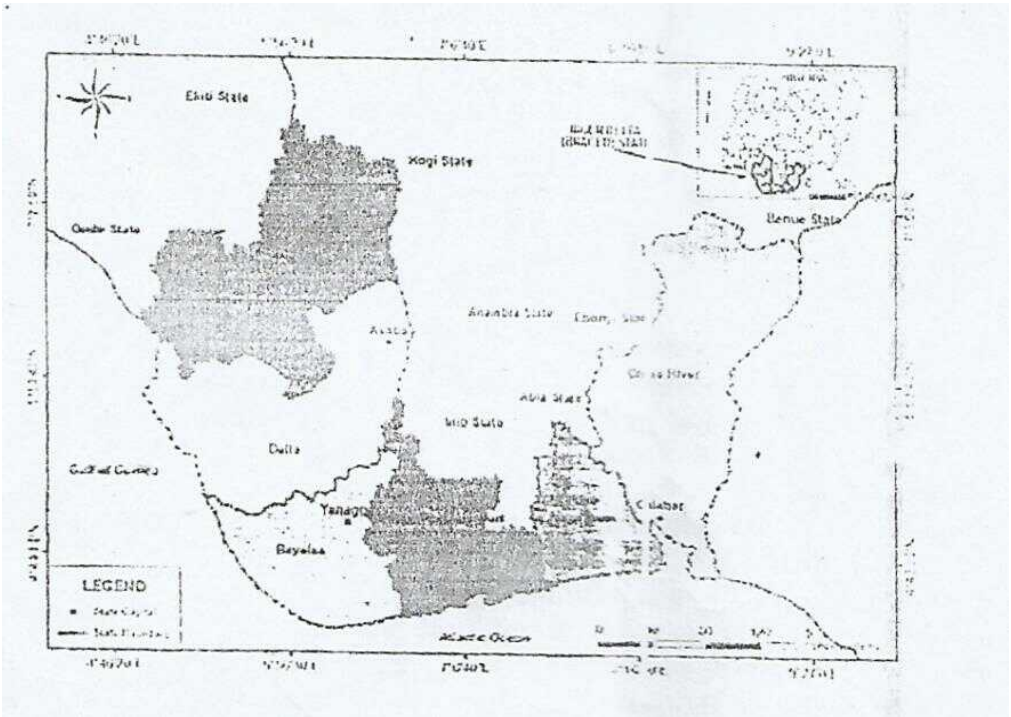

*Fig: Map of Niger Delta States*

**Table 1: Study Area showing Niger Delta States and their major cities (Capitals)**

| S/No | State | Land Area (K $^2$) | State Population | Capital City |
|---|---|---|---|---|
| 1 | Abia | 4,877 | 2,833,999 | Umuahia |
| 2 | AkwaIbom | 6,806 | 3,920,208 | Uyo |
| 3 | Bayelsa | 11,007 | 1,703,358 | Yenagoa |
| 4 | Cross River | 21,930 | 2,888,966 | Calabar |
| 5 | Delta | 17,163 | 4,098,391 | Asaba |
| 6 | Edo | 19698 | 3,218,332 | Benin |
| 7 | Imo | 5,165 | 3,934,899 | Owerri |
| 8 | Ondo | 10378 | 3,441,014 | Akure |
| 9 | Rivers | 10378 | 5,18,420 | Port Harcourt |
| 10 | **Total Region** | 112,110 | 31,224,582 | South south region |
| 11 | **Nigeria** | 923,773 | 140,020,952 | Abuja |

**Source: Nigeria, National Population Commission Abuja, 2006.**

**Issues and Challenges in Disaster Management in Nigeria**

In any disaster management, the real issues and challenges faced when the community or company is structure with an unexpected disaster makes people to be stranded, imaging what to do to reduce the impact of the catastrophe. At this point, the questions that come to the mind are: What can we do to minimize the impact of this situation? How can we do it? Are resources available for rescue operation? What are the rehabilitation resources available? These are the rapid questions and issues that come to the mind at the very first glance to a disaster situation.

The main issue in disaster management is how to reduce the impact of the disaster. Abdalla & Esmail (2018) noted that each time a disaster occurs, the major issue that arises is how to respond to the situation and recover quickly from it. This issue relates to the various phases of the disaster management plans such as the event itself, response phase, recovering phase, mitigation phase and preparedness plan. The recent experience in Nigeria last year, is the unprecedented rainfalls which cause flood disaster in some parts of the country. In States like Bayelsa and Rivers, there are cases of flood disaster which drove people away from their homes and offices. Many farmlands were erased by flood resulting in the loss of food crops waiting to be harvested. This resulted in scarcity of some food items, leading to hike in price of the available food items in the market. In view of this situation, the major issue arising from this circumstance is how to deal with this situation to reduce its impacts and ensure quick recovery and rehabilitation of the victims. Many people living in the riverine areas in Nigeria have been victims of flood disaster from year to year and the reason for this is the lack of preparedness to combat or mitigate the situation. Bavej (2016) observed that many people and communities do not have a well-documented "Emergency and Disaster Management Preparedness Plan" and this is why they continue to suffer from the same disaster year to year. They often fail to prepare for the next event and ignore the purchase and stocking of disaster equipment. McNally & Minyard (2015) noted that many persons, industries, community leaders and government agency do not anticipate the possible occurrence of a disaster, make plans for it by purchasing

equipment and providing intensive training for key personnel on disaster operations. Even those that have a disaster preparedness plan often fail to put their plan to test to confirm its effectiveness in combating the anticipated situation. There are no long-term, inclusive and coherent institutional arrangements to address disaster issues with a long-term vision (Khan, et al, 2016). Disaster issues in Nigeria are viewed in isolation specifically as a process of poverty alleviation planning and mainstream development. For instance, disaster management, environmental management and development planning institutions operate in isolation and integrated planning between these sectors is almost lacking (Khan, et al, 2016). Besides, absence of a centralized authority for integrated management of disaster and lack of effective coordination within and between disaster institutions is responsible for the ineffective and inefficient disaster management in developing countries (Kaur & Sood, 2019). Preparedness and mitigation measures at the State-level of disaster management are heavily tilted towards structural perspectives and undermine non-structural factors such as knowledge and capacities of the local people as well as the livelihood protection issues (Al-rousan, et al, 2014). The time has come when all industries and local authorities need to look at disaster management preparedness plan from a wider perspective.

Baveja (2016) stated that a good and comprehensive disaster preparedness plan can help to educate all stakeholders and concerned persons to minimize the casualties and damages by well-conceived evacuation, rehabilitation and clean-up programmes. With a greater capacity of the individual, community and environment to face the disasters, the impact of a hazard would be drastically reduced (Khan, et al, 2016).

**Implications of Poor Research and Disaster Management**

The implications of poor research and disaster management in any country can be severe. According to Karan (2019), an individual, industry or community that fails to conduct a proper research and develop a well-articulated disaster management plan will experience great losses as a result of disasters and the victims of such situation will not be able to recover from the situation for a long time. Poor research can lead to ineffective disaster management. When a community or company does not carry out a proper research to identify the root cause of a disaster, they will fail to prepare for it in the next event (Rotanz, 2007). Philips (2011) stated that research is the key to effective disaster management; it brings to limelight the nature of a disaster, causes of the event and the solution to the problem. The information generated through research can assist disaster managers to understand why the event occurs and prepare for it reoccurrence in future. However, when research on disaster issue is poorly conducted, the information generated from the exercise will misguide disaster managers and result to failure of his efforts to minimize the impact of the catastrophe (McEntire, 2015).

Poor research and disaster management can cause a great deal of suffering and property loss to the people of a country (Balikuddembe, et al, 2014). In Nigeria, people who fall within the lower income group live in homes that are more vulnerable to disaster impact than those who belong to the higher income group that live in home that are less vulnerable to disaster impact. If the disaster is not properly planned for and managed effectively, the lower income earners will experience massive financial loss, material loss, property loss and perhaps greater destruction of their home. Fothergill et al, (2003) noted that poor research and disaster

management in many cases have made many low income earners homeless. According to them, earthquake which occurred in California in 1989 caused homelessness for the lower income earners. Philips in Benson & Clay (2003) recalled that Hurricane Hugo which took place in 1989 led to homelessness for about 60,000 people of which many belong to the lower income group (Philips, et al, 2003). Poor disaster management cannot only lead to property loss but also increase the level of poverty and hunger among victims of a disaster. According to Levy, et al, (2005), poor disaster management can increase the level of poverty and hunger among victims of the disaster. In Nigeria, flood disaster which occurred in 2018 was not adequately planned for and when the disaster occurred, the situation was poorly managed and this led to massive hunger and poverty among victims of the incidence. In States like Bayelsa and Rivers where the flood disaster was severe, the rate of poverty among the people living in the flooded areas was higher than those living in dry tracts. One of every four flooded areas had a poverty rate of 40% or higher. Poor people were living in the flooded areas while the rich people are living in dry lands. A 2006 study conducted by Logan as reported in Substance Abuse and Mental Health Services Administration (SAMHSA) (2017) revealed that nearly 30% of people in areas with moderate or more severe levels of damages were living in poverty, while only about 25% of people in areas with limited damages or no damages were poor. The higher poverty rate among those living in areas with moderate or more severe levels of damages is caused by poor disaster management.

A disaster that is poorly managed can bring about serious injuries and physical disabilities among the people living in the areas where the disaster occurs. This is because when a company or local authority fails to prepare for a natural or man-made disaster, the event will take them unaware and instead of responding quickly to the situation to minimize its impact, more physical injuries will be sustained by people living in the area where the disaster occurred (Khan, et al, 2016). Kaur & Sood (2019) confirmed that lack of research and poor management of disaster situation has caused a lot of injuries to people in areas where disaster took place. Many people have been victims of poor disaster management in many countries of the world. Most of them have lost huge sum of money because of the inefficiency of the disaster managers. Moser et al, (2017) noted that poor people around the world save their money and livestock in their homes which are most likely to be damaged or lost during disaster. This is why natural disasters push $26 million more people around into poverty each year (World Bank, SAMHSA, 2017). Poor research and disaster management can bring about difficulty in obtaining and receiving aid. Fothergill et al, (2017) noted that most victims of disaster find it difficult to interact with bureaucratic systems to receive housing and other types of aid. The barriers to obtaining aids include lack of knowledge of the systems through which disaster survivors receive aid; discomfort with the systems; an issue in getting to and from disaster assistance centers, such s transportation, child care and work schedule (Rovai, et al, 2017). In Nigeria, victims of disaster may depend on non-disaster aid program particularly medical as a way of coping with the disaster damages and losses.

**Theoretical Framework**

This paper is anchored on the system theory which was developed by Ludwig von Bertarlanffy et al, (1938). This theory views systems as a set of interrelated parts that must function together as a whole to achieve a common purpose. In other words, a system is a group of individual

parts that work together to form a unified whole. The system theory is a way of studying a system as one unit, instead of individual parts. The basic idea in a system is that the parts of anything are so related and dependent that the interaction of any parts affects the whole. This is why Nwankwo, et al, (2011) defines a system as a unit with series of interrelated and inter-dependent parts, such that the interplay of any part affects the whole. The systems theory helps to focus on the primary mission or purpose of a system.

The system theory is applied to disaster management system, such as the way a disaster is handled to minimize its impact on people and community. By examining a system as a whole, it is easier to understand how each disaster management institution contributes to the overall mission of reducing the impact of disaster. The system theory tends to explain that long-term institutional arrangements and all institutions established to address disaster issues must work together to achieve a common goal of minimizing the impact of a disaster. The theory emphasized that disaster management institutions, environmental management institutions and development planning institutions must work together to address disaster issues with a common vision. As a system, a central authority must be established in the integrated disaster management system and proper coordination within and between disaster related institutions must be made to ensure that the goal of disaster management is achieved. In addition, the systems theory makes it easier to pinpoint flaws in the system. This implies that if the various institutional arrangements do not work together as a system, it will be difficult to achieve the common goal of reducing the impact of a disaster.

**Review of Related Empirical Studies**

Some related empirical studies have been conducted on research and disaster management. For instance, a national survey conducted by the National Center for Disaster Preparedness at Columbia University as reported by Sury et al, (2017) revealed that most Americans which fall within the low income group are not well prepared for disasters. According to the survey, about two-third of low income earners (65%) have no disaster plans while others have plans that are not adequate. In another study conducted by the Federal Emergency Management Agency (FEMA (2017) as reported in SAMHSA (2017), it was revealed that less than half of the American populations are familiar with local disaster or hazards but only 40% or less have developed a household emergency plan and discussed it with household members. The report also has it that only 52% have disaster supplies at their home (FEMA, 2017).

A study conducted by Turner, Nigg et al, Fothergill & Peek (2004) revealed that poor people with less education in India are less prepared for disasters. The study also confirmed that poorest people with less education are not adequately prepared for disasters due to the fact that some disaster preparedness actions are very costly and too much for them (poor people) to afford. The study cited the example of purchasing earthquake or flood insurance and strengthening the home for greater earthquake and flood resilience. In a study conducted among Louisiana residents, it was reported that districts of Louisiana City with large number of persons in poverty had few numbers of persons with flood insurance (Masazera, et al, 2007).A recent study conducted by World Bank and the Global Facility for Disaster Reduction and Recovery (GFDRR) as reported in Hallegate, Vogt-Schilb, Bangalore & Rozenberg (2017)

revealed that countries with large number of poor people with limited resources tend to invest less in preventing and mitigating the adverse effects of natural disaster. In another study conducted among 1,304 adults aged 50 years and above on disaster preparedness, it was reported that those who falls within the lower income group were less prepared for natural and man-made disasters (Al-rousan, et al,2014).

In a study conducted on disaster warnings and evacuation in the United States, it was reported that Americans who belong to the lower income class are less likely to respond to official warnings of disaster (Gladwin & Peacock, 2004). The study also revealed that Americans who were homeless and unemployed lacked money and resources needed to evacuate and respond to disaster even when they received disaster warnings.

**Findings**

This paper examined research and disaster management. It took an insight into the concept of research and disaster management and discussed the key issues and challenges in disaster management. A qualitative research approach was used to analyze the real issues and challenges in disaster management. The real issue and challenge in any disaster management is faced when the individual, company or community is stuck with an unexpected disaster and at this point everyone looks at each other, prescribing what to do to reduce the impact of the catastrophe. Each time a disaster occurs, the major issue that arises is how to respond to the situation and recover quickly from it. Poor research and disaster management have serious implications. It was established that an individual, corporate entity or community that fails to conduct a proper research and develop a well-articulated disaster management plan will experience great damages, property and financial losses as a result of the disasters and victims of such situation will not be able to recover from the situation on time. Some related empirical studies were reviewed to prepare the ground for the findings. From the empirical review, it was discovered that poor people are not well prepared for disasters. Many people who belong to the lower income class do not have a disaster plan while others have plans that are not adequate. Although many people are familiar with disaster phenomenon, only few of them have created an emergency disaster management plan.

**Conclusion**

From the foregoing discussion, it was established that research plays a key role in effective disaster management. It was reported that research provides information needed by individuals and communities to address disaster issues. A sound disaster policy can aid effective disaster management and encourage continuous research in disaster phenomenon. Research and disaster management can help to reduce or minimize the negative effects of disasters on people and communities. Early preparation for disaster is considered to be key in dealing with disaster issues. However, it was revealed from our empirical literature that most people who fall within the low income group are not well prepared for disasters. A large number of poor people have no disaster plans while others have plans that are not adequate. Although research has made people to be familiar with disaster phenomenon such as fire blow out, oil spill in land and water, explosions, drowning, toxic release, nuclear reactor accidents and natural calamities like earthquakes, cyclones and unprecedented rainfall (flood); only few people and communities

have developed an emergency disaster management plan and discussed it with the relevant institutions.

**Recommendations**

Based on the discussion above, the following recommendations are provided to improve disaster management in Nigeria.

i. Local authorities to conduct proper research and formulate effective disaster management policy to address disaster issues.

ii. The local authorities should ensure that there are long-term institutional arrangements and all institutions established including the disaster management institutions, environmental management institutions and development planning must work together to address disaster issues with a long-term vision.

iii. A central authority should be established in the integrated disaster management system and ensure proper coordination within and between disaster related institutions to facilitate effective disaster management.

iv. At the State level, disaster preparedness and mitigation measures should be taken to minimize the impact of disaster.

v. Here, the knowledge and capacity of the people at the local level and other related livelihood protection issues should be taken into consideration when developing a disaster management plan.

vi. Equipment and rescue operation devices should be acquiring ahead of a disaster and intensive training should be given to key personnel on disaster operations.

vii. The local community should set-up a disaster management agency and provides adequate disaster rescuing equipment's and training program for the staff of the agency.

viii. With intensive training and a greater capacity of the individuals and community to face the disasters, the impact of a disaster would be drastically reduced.

ix. Individuals should make adequate preparation ahead of possible disasters by acquiring disaster equipment's to enable them rescue themselves in case of disaster before the arrival of government disaster management agency to implement rescue operation

x. All internally displaced persons should be kept in a hygienic IDP camp, while adequate care be given to them

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# CARBOHYDRATE AND AMINO ACIDS COMPOSITION IN BREAST MILK OF LACTATING MOTHERS FROM RUMUOLUMENI HEALTH CENTER, RIVERS STATE.

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## ABSTRACT

*Breastmilk is a complex fluid, rich in nutrients and in non-nutritional bioactive components. This study investigated the amino acid and carbohydrate compositions in breast milk of mothers of different age groups from Rumuolumeni health center. Eighteen breast milk samples were collected from lactating mothers aged 16-45 years old. Amino acid content was analyzed with amino acid analyzer, while the carbohydrate content was analyzed with HPLC and data generated was analyzed using one-way ANOVA and presented as mean and standard deviation. Results showed that rabinose, maltose, and HMF levels for mothers of age 16-25 were significantly higher when compared with values for mothers of age 26-35 years. Raminose and glucose levels for mothers of age 36-45 were significantly higher ($P \leq 0.05$) when compared with values for mothers of other age groups. Young mothers had galactose value of 1.29 ppm while the values for middle and older aged mothers were 1.43 ppm and 1.39 ppm respectively. Values for the young mothers showed a significant decrease when compared with the other age groups. Results of amino acid composition showed that alanine, serine, proline, valine, threonine, lysine, glutamate, phenylalanine, histidine, arginine and tyrosine values for mothers of age 26-35 were higher than those of mothers of 16-25 and 36-45 years. Value for threonine (3.54 mg/100g), isoleucine (4.50 mg/100g), and lysine (4.54 mg/100g) for mothers of 36-45 years were significantly higher when compared with the values for mothers of age 16-25. The amino acid compositions of some were below the standard recommended by WHO/FAO in all age grades. While methionine and isoleucine values for age 36-45 years, cysteine, histidine and methionine values for mothers of 26-35 years and cysteine values for age 16-25 years were above the recommended standard.*

**Key Words:** Breast milk, amino acid, carbohydrates

## INTRODUCTION

Breastmilk is a complex fluid, rich in nutrients and in non-nutritional bioactive components. Knowledge of the composition of human milk and the factors that influence it has increased considerably over the past two decades (Raj *et al.*, 2020). Breast milk has long been recognized as the optimal food for infants and young children (Girerd-Barclay, 2013; Raj *et al.*, 2020). The practice of breastfeeding babies from birth until about six months of age without additional supplements, also known as exclusive breastfeeding (EB), and of continued breastfeeding for two years or more, combined with appropriate, nutritious complementary food, has been acknowledged globally as optimal feeding for all young children, regardless of their origin (Girerd-Barclay, 2013).

Human milk is the first and the best feeding option for growth and healthy development of the newborns and infants (Brodribb, 2015). Human milk contains numerous components (proteins, carbohydrates, and inorganic elements) which provide basic nutrients for infants during the first period of their lives. The qualitative composition of milk components from healthy mothers maybe similar, but their levels change during lactation stages (Rasmussen & McGuire, 1996). Colostrum which is the fluid secreted during the first days postpartum by mammary epithelial cells is replaced by transitional milk during 5–15 days postpartum and from 15 days postpartum, mature milk is produced (Ballard & Morrow, 2013). Human milk, apart from the nutritional components, is a source of biologically active molecules such as immunoglobulins, growth factors, hormones, antiviral, and antibacterial proteins. These bioactive molecules present in the milk support the immature immune system of the new born and also protect against the development of infection (Ballard & Morrow, 2013).

Human milk composition varies considerably within and between mothers and even within a single milk expression. This multidimensional variation in composition is believed to be an adaptation to the infants' changing needs, geographical region and food supply (Hinde & German, 2012). The variations in human milk composition between individual woman and populations have been reported to be in response to cultural differences such as diet and other lifestyle factors, environmental factors, such as mineral content of the soil that is then reflected in the mineral density of the foods grown there and human genetic differences (Zachara and Pilecki, 2000). However, human milk composition data has not been collected from all world regions, populations and among different age groups. Therefore, studies of human milk composition in other regions and populations are important, particularly with regard to specific carbohydrates and amino acids, where a large variability has been noted from existing studies (Yang *et al*., 2018). This work examines the compositions of carbohydrates and amino acids in breast milk of lactating mothers and possible variations among different age groups.

## MATERIALS AND METHODS

### Inclusion Criteria

The criteria for defining lactating women were if they were apparently healthy and reported breast feeding at least 3 times a day and are within 16-45 years old. The purpose of the study was explained to the lactating mothers and their consent was obtained prior to commencement of sample collection. This study was approved by the ethics committee of the Rivers State Hospital Management Board, Port Harcourt.

**Collection of samples**

Breast milk samples (10ml) were collected from eighteen (18) breast feeding mothers from Rumuolumeni Health Center, Rivers State, Nigeria. The subjects were categorized into young mothers (16-25), middle aged mothers (26-35), and older mothers (36-45) years old. The milk was expressed with a manual pump into sterile containers. The samples were placed in ice-packed container and transported to the laboratory.

**ANALYSIS OF CARBOHYDRATE WITH HPLC (**APHA, 1998)

**Hydrolysis of the sample:** ten milligrams (10mg) of breast milk was dissolved in 1ml of 3M trifluroacetic acid (TFA) in a 5ml ampole. The breast milk was incubated at $130^0$C for 2hours, further centrifuged at 200 rpm for 5 minutes and evaporated to dryness under reduced pressure to remove TFA.the hydrolysed and dried samples were dissolved in 1ml of distilled water.

**Derivatization of hydrolysed sample:** Thirty microliters (30) µL of NaOH (0.3M) was added to the breast milk. Fructose was added as an internal standard to each sample, the breast milk was incubated at 70 $^0$C for 60 minutes cooled to room temperature and neutralised with 30 µl of HCl. One milliliter (1 ml) of trichloromethane was added to the breast milk and vigorously shaken. The breast milk sample passed through 0.45µm syringe and filtered before HPLC analysis.

**AMINO ACID ANALYSIS [**Modified method of Elkin and Griffith (1985)].

**Preparation of sample and standards:**

Zero point one gram (0.1g) of breast milk was weighed into a 16 X 125mml screw cap pyrex. Fifteen micromole (15mml) of 6N hydrochloric acid was added to the breast milk, and the tube was thoroughly flushed with $N_2$. The breast milk was placed in an oven at $110^o$C for 24hrs. After hydrolysis, the breast milk was filtered to remove solid and a standard solution containing 125 µm/mL of each amino acid in 0.1N hydrochloric acid was created.

**Derivatization procedure:** The procedure used was a modified method of Elkin and Griffith (1985) in which 5,10,15, 20 and 50ul of breast milk was pipetted into a 10 X 5mm tube and dried at 65$^o$C. 30 µL of methanol water-phenylisothiocianate (2:2:1 (v/v)) was added to each tube containing the breast milk and then removed in vacuo at 65$^o$C. Then 30 µL of methanol water-Phenylisothiocianate (7:1:1:1 (w/v)) was added, and the tube was agitated and left to stand at room temperature for 20min.Finally, the solvent where removed under a nitrogen stream, and the tube was sealed and stored at $4^O$C, pending analysis. Prior to injection, 150 µL of diluent consisting of 5Mm sodium phosphate with 5% acetonitrile was added to each tube.

## RESULTS AND DISCUSSION

| S/N | CHO | 16-25 (yrs) (ppm) | 26-35 (yrs) (ppm) | 36-45 (yrs) (ppm) |
|---|---|---|---|---|
| 1 | HMF | 0.72±0.21[bd] | 0.28±0.09*[ac] | 0.28±0.9*[ac] |
| 2 | Xylose | 3.86±1.77[d] | 2.45±1.62 | 0.00±0.00*[c] |
| 3 | Arabinose | 3.71±0.00[b] | 0.00±0.00*[a] | 2.35±1.29[b] |
| 4 | Raminose | 0.55±a0.00[ad] | 0.57±0.09[ad] | 0.82±0.00*[bc] |
| 5 | Fructose | 3.16±0.12 | 2.82±0.57 | 3.14±0.02 |
| 6 | Rabinose | 1.26±0.05[bd] | 0.01±0.01*[ac] | 0.01±0.01*[ac] |
| 7 | Maltose | 12.47±0.01b[d] | 4.43±0.01*[ac] | 4.58±0.27*[ac] |
| 8 | Galactose | 1.29±0.00[bd] | 1.43±0.07*[ac] | 1.39±0.00*[ac] |
| 9 | Glucose | 19.77±0.89[ad] | 24.5±0.10[ad] | 32.0±4.25*[bc] |

Table 1: Carbohydrate content in breast milk of mothers of different age groups.

**Table 2: Amino acid content of breast milk of mothers of different age groups.**

| S/N | Amino acid | 16-25 (yrs) mg/100g) | 26-35 (yrs) (mg/100g) | 36-45 (yrs) (mg/100g) | WHO/FAO Standard |
|---|---|---|---|---|---|
| 1 | Lysine | 2.91±1.62[b] | 6.83±2.72[a] | 4.54±0.12*[a] | 11.1 |
| 2 | Methionine | 1.35±0.24 | 3.78±4.07 | 4.44±0.06 | 1.3 |
| 3 | Tryptophan | 0.92±0.84 | 1.27±0.34 | 1.55±0.79 | - |
| 4 | Phenylalanine | 2.54±1.61[ac] | 3.55±1.87[ad] | 0.55±0.16[bc] | 3.2 |
| 5 | Valine | 1.92±0.72 | 2.46±1.83 | 0.76±0.12 | 9.4 |
| 6 | Threonine | 1.70±0.14[bd] | 3.94±0.29*[ac] | 3.54±0.14*[ac] | 8.6 |
| 7 | Iso leucine | 2.60±0.24[d] | 3.70±1.00 | 4.50±0.38*[c] | 4.0 |
| 8 | Leucine | 6.59±0.09[ad] | 6.17±1.34[ad] | 1.63±0.30*[bc] | 8.9 |
| 9 | Histidine | 2.26±0.96[ad] | 3.13±0.44[ad] | 0.61±0.33*[bc] | 2.6 |
| 10 | Glycine | 3.01±0.64 | 2.44±0.28 | 1.67±0.15 | - |
| 11 | Alanine | 2.37±0.64 | 3.14±2.20 | 2.69±0.36 | 4.2 |
| 12 | Serine | 1.88±0.07 | 3.11±1.29 | 1.52±0.17 | 3.2 |
| 13 | Glutamate | 11.30±0.44 | 16.43±4.34 | 15.63±1.11 | - |

| | | | | | |
|---|---|---|---|---|---|
| 14 | Proline | 2.49±0.71 | 3.32±2.00 | 1.36±0.10 | 10.2 |
| 15 | Arginine | 2.44±0.92$^{bc}$ | 5.12±1.36$^{ad}$ | 2.01±0.69*$^{bc}$ | 3.9 |
| 16 | Tyrosine | 2.29±1.19$^{ac}$ | 3.16±0.71$^{ad}$ | 0.92±0.58b$^{c}$ | 2.6 |
| 17 | Aspartate | 4.27±4.85 | 2.27±1.11 | 1.66±0.02 | 6.8 |
| 18 | Cysteine | 2.13±0.94 | 1.41±0.10 | 0.91±0.78 | 1.2 |

Values for both tables are expressed as mean ± standard error of mean (SEM) for n=6 at 95% confidence level. Values with super script * differ significantly when comparing age range 16-25years with others. Values with different superscript ab differ significantly when comparing age rang 26-35 years with other ages. Values with superscript cd differ significantly when comparing age range 36-45 years with other ages.

**Discussion**

Carbohydrates are poly hydroxyl aldehydes or ketones and could be classified into monosaccharide, oligosaccharide and polysaccharide. The result in table 1, showed that HMF, xylose, arabinose, fructose, rabinose and maltose values for mothers of age 16-25 years old were higher than that for mothers of 26-35 and 36-45 years old. Raminose and glucose levels for mothers of age 36-45 years old were significantly high ($p<0.05$) when compared with the values from mothers of age 26-35 years old. HMF, xylose, fructose, rabinose, and maltose values for mothers of age 16-25 years were significantly higher when compared with values for mothers of age 36-45 years old. Young mothers had galactose value lower than the values for middle and older mothers. The values for the young mothers showed a statistical decrease when compared with the other age groups. Carbohydrates generally constitute the major source of energy in human diet. The basic raw materials for energy production are these simple sugars. This research showed high glucose level in breast milk especially in mothers of age 26-35 and 36-45 years old.

The result in table 2, showed that alanine, serine, proline, valine, threonine, lysine, glutamate, phenylalanine, histidine, arginine and tyrosine values for mothers of age 26-35 were higher than that for mothers of age 16-25 and 36-45. Phenylalanine is a primary amino acid that is abundant in dietary protein. Its main metabolic pathway yields the amino acid tyrosine, which is involved in the production of melanin pigments (Sterkel and Oliveira, 2017). Tyrosine contains hydroxyl and aromatic group, it is an essential component for the production of several important brain chemicals called neurotransmitters, including epinephrine, norepinephrine, and dopamine and contributes to the absorptivity of protein molecules (Sterkel and Oliveira, 2017).

Histidine is required for synthesis of proteins. It plays important roles in the active site of enzymes, such as serine proteases (trypsin) where it is a member of the catalytic triad. Excess histidine may be converted to trans-urocanate by histidine ammonia lyase (histidase) in liver and skin (Brosnan and Brosnan, 2020). Middle aged mothers had the highest histidine value and were significantly higher when compared with the value for older mothers, also the

histidine value for middle aged mothers was higher than the WHO/FAO/UNU (1985) recommended value.

Threonine, isoleucine and lysine levels for mothers of 36-45 years were significantly higher when compared with the values for mothers of age 16-25. Also, Leucine, phenylalanine and arginine values for mothers of age 26-35 were significantly higher when compared with the values for mothers of age 36-45. Arginine plays an important role in cell division, wound healing, immune function, and the release of hormones. It is a precursor for the synthesis of nitric oxide (NO), making it important in the regulation of blood pressure (Scibior and Czeczot, 2004).

Glycine, aspartate and cysteine values for mothers of age 16-25 were the highest when compared with the values for mothers of age 26-35 and 36-45 though not statistically significant.

From the results of this study, it was observed that most of the amino acids in the breast milk of mothers of age 16-25 were lower than standard except for methionine and cysteine which were higher than the reported standard by WHO/FAO/UNU (1985). Methionine and cysteine are sulphur containing compounds that plays unique role in epigenetic regulation by affecting DNA methylation (Colovic *et al.*, 2018). Linbald and Rahimtoola (1974) reported that poorly nourished mothers in Pakistan secreted milk low in methionine and cysteine and attributed it to poor protein quality in the diet of the mothers studied. Methionine values for mothers of age 26-35 and 36-45 in this study agrees with that reported by Ukegbu and Ijeh (2013), they reported methionine value in their study to be higher than WHO/FAO/UNU 1985 recommended value. The limiting amino acids (lysine, threonine and valine) may be explained by low consumption of animal protein and soy which are good sources of the essential amino acid lysine. Erdman Jr and Fordycee (1989) Reported that soy is inexpensive and contains adequate quantities of essential amino acids. Inadequate protein intake of the mothers could have also contributed to the limiting amino acids observed.

## Conclusion

The study revealed the carbohydrates and amino acids composition in the breast milk of mothers of different age group. Mothers of age 16-26 years old have the highest carbohydrate composition than the other age groups. The amino acids composition in the breast milk of the three age groups were below the recommended standard except for the values of methionine for mothers of 16-45 years old, cysteine value for mothers of 16-25 and 26-35 years old, phenylalanine, histidine and arginine for age 26-25 years old and isoleucine for age 36-45 years old which were higher than the recommended standard. The amino acid composition was higher in mothers of age 36-45 years old.

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# OCCURRENCE OF SALMONELLA SPECIES IN SOME WATER SUPPLIES OF PORT HARCOURT METROPOLIS, RIVERS STATE, NIGERIA.

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## ABSTRACT
*This study investigated the occurrence of Salmonella organisms and other enteric pathogens in some water sources from Port Harcourt metropolis, Rivers State, Nigeria. Six different water samples, two from each of the three selected water sources (Borehole, River and Well water) were collected from Timber water-side River and Choba River; two different wells located in Rumuolumeni, and two different boreholes located in Port Harcourt from and evaluated for percentage occurrence of Salmonella species and other enteric pathogens. The water samples were analysed using standard microbiological methods. The total heterotrophic count was very high, ranging from 2.9xl0$^{9}$cfu/ml in River water to 1.5 x 10$^{11}$ cfu/ml in borehole water, while the Salmonella count from the River water was 3.0 x 10$^{9}$cfu/ml. A total of eight different organisms were identified colonial morphological and biochemical tests. Five out of the fifteen (15) isolates (WS01, 06, 07, 08 and 14) were identified as Shigella; Salmonella were two isolates (WS05 and 10); Vibrio (WS09), Proteus (WS13), Escherichia (WSQ2), Enterobacter (WS04), Klebsiella (WS13) all occurred once. The result showed that all the water samples evaluated had more than the recommended level of bacteria for drinking water. The presence of these organisms in the water samples reveals that the water sources were fiscally contaminated and not suitable for public use.*

**Key words:** Salmonella spp, Enteric pathogens, Water sources, Port Harcourt

## INTRODUCTION
The genus, *Salmonella,* represents one of the most common pathogens frequently isolated from water. It is also commonly associated with food handlers who are responsible for human-to-

human transmission of the organism. Thus, *Salmonella* infections are of major concern to public health. The species, *Salmonella enterica* is the most pathogenic species in the genus and there are about 2,600 serovars so far characterized (Jajere, 2019).

According to 2015 and 2016 figures from the World Health Organization (WHO), some 663 million people, i.e. 9 percent of the world's population do not have access to safe drinking water; while 2.4 billion, representing 40 percent of the world's population lack proper sanitation (hygienic toilet facilities). Although, there have been significant improvements in securing access to clean water, relatively little progress has been made on improving global sanitation in the last decade. Sewage disposal affects people's immediate environments and leads to water-related illnesses such as diarrhea that kills 525,000 children under five each year. Back in 2002, the World Health Organization estimated that water-related diseases could kill as many as 135 million people by 2020. In developed countries, most people have flush toilets that take sewage waste quickly and hygienically away from their homes, while in the developing countries the reverse remains the case. Some of the bacteria that are often reported polluting our various water bodies include species of *Shigella, Salmonella, Pseudomanas, Escherichia, Vibrio, Proteus, Enterobacter, Klebsiella, Staphylococcus, Bacillus, Streptococcus* and *Listeria* (Chitimbar *et al.*, 2012). The other organisms that are found associated with water pollution include *Burkholderia pseudomallel, Cryptosporidium parvum, Giardia lambda*, Norovirus and other viruses and parasitic worms including *Schistosoma* species (Alamance *et al*., 2012).

The predominant dependence on water supplied or sourced from bore-holes, rivers and wells for domestic activities including food preparation and drinking and the alarming poor hygiene and or poor waste management across Rivers State, Nigeria, and indeed all developing countries of the world have been blamed for the alarming millions of cases of various bacterial, fungal and protozoan infections and the consequential millions of deaths that are recorded globally each year with some of such bacterial infections being caused by many species of *Salmonella*. Chukwukere (2008) admits that in most developing countries of the world, the average source of drinking water is surface water, which is commonly untreated before use.

People who have access to treated or good drinking water cannot boast of its regularity. Some even drink untreated water from rivers, oceans, rainfall, stream, etc, which have been contaminated. The World Health Organization estimates that 80% of illnesses in developing countries are caused by inadequate sanitation, polluted water or unavailability of water. Similarly, Chukwukere (2008), in her analysis of the microbial contamination of locally packaged sachet water in Port-Harcourt Metropolis, reported contamination of the various water samples by the heavy presence of species of *Klebsiella, Streptococcus, Proteus, Pseudomonas, and Escherichia*, most of which he associated with fecal contamination of sources of the raw water supply.

Egwari and Aboada (2002) studied the environmental impact on the bacteriological quality of domestic water supplies in Lagos, Nigeria. The result of the study showed the presence of enteric pathogen such as *E. coli,* and various species of *Salmonella, Shigella, Vibrio,*

*Campylobacter*, etc. The result further indicated that shallow wells were more contaminated than deep wells and boreholes. The contamination was higher during periods of heavy rainfall.

As cited by Kayambo *et al*. (2006) and Lucas and Gilles (2008), the World Health Organisation estimated that over 1.1 billion people worldwide lack access to adequate supply of clean water. Water sources in Nigeria are not free of bacterial and other microbial contamination. This further emphasizes the urgent need for continued research and the adoption of preventive measures to forestall or control microbial water pollution.

## 2. Materials and Methods

### 2.1 Sample Collection

A total of six water samples were collected from different locations within Port Harcourt metropolis. Different sterile plastic water-bottles were used for each of the water supplies (borehole water, well water and river water). The samples were collected as indicated below.

(a) River water: This was collected from two different rivers; (i) Timber water-side River, located along Diobu, Eagle Island Road, Port Harcourt. ii), Choba River (segment of the New Calabar River).

(b)Borehole water: This was collected from the following areas; (i) 11, Elder Harry Wike Close, Rumuepirikom by Oro-Ekpo, Port Harcourt. (ii) 360, Ikwerre road, Port Harcourt.

(c)Well water: This was collected from the following areas: (i) A well opposite Ignatius Ajuru University of Education main gate, Rumuolumeni, Port Harcourt. (ii) A well close to Rumuolumeni Town Hall, Rumuolumeni, Port Harcourt.

All the water samples were taken to the Biology Laboratory, Ignatius Ajuru University of Education for analysis.

### 2.2 Bacteriological Examination of the Water Samples

#### 2.2.1 Isolation and culture

i) Total Heterotrophic Bacterial Count (THBC): Nutrient agar was used to enumerate the total heterotrophic bacteria in all water samples. The nutrient agar medium was prepared according to the manufacturer's instruction. 0.1 ml of each set of the diluted water sample was pipetted onto the surface of nutrient agar in agar plates using a 1-ml pipette. A bent glass rod, sterilized over flame was used to spread out the water sample on the agar. The plates were incubated at room temperature (37$^{o}$C) for 24 hours for growth. Discrete bacterial colonies were counted and converted to colony –forming units per ml. This represented the total heterotrophic bacterial count.

ii) **Total *Salmonella* count (TSC):** *Salmonella- Shigella* Agar (SSA) medium was used to culture and isolate *Salmonella* species while Desoxycholate Citrate Agar (DCA) medium was used for other enteric bacteria. The media were prepared according to the manufacturer's instruction. After plating out and incubating at 37$^{o}$C for 24 hours, discrete colonies showing different cultural characteristics were picked using a sterile wire loop and sub-cultured onto fresh Nutrient Agar (*Salmonella* species) and Desoxycholate Citrate Agar (DCA) plates (other enteric bacteria) to obtain pure cultures. Pure colonies from the sub-cultures were stored in Nutrient Agar slants, in screw-capped McCartney bottles and incubated at 37$^{0C}$ for 24 hours.

iii) **Morphological and Biochemical Characterisation of Isolates:** The bacterial isolates were characterized and identified by cultural morphology and biochemical tests as described by Holt *et al* (1994) and Cheeseborough (2004).

## 3. Result

The total heterotrophic bacteria count (THBC) is shown in table 1: Tables 2 and 3 show the biochemical characteristics and percentage occurrence of the isolates, respectively. Figures 1 and 2 show the occurrence of the Salmonella species and the enteric bacteria associated with the water samples, respectively.

**Table 1:** Total heterotrophic and Salmonella count of the water samples

| Water Sample | Average no. of colonies for THBC | Average number of colonies for Total Salmonella Count (TSC) |
|---|---|---|
| River Water A | 2.9 X l0$^9$cfu/ml | 2.9 x l0$^3$cfu/ml |
| River Water B | 2.8 x l0$^9$cfu/ml | 2.7 x l0$^3$cfu/ml |
| Borehole Water A | 1.8 X 10$^9$cfu/ml | 1.3x l0$^3$cfu/ml |
| Borehole Water B | 1.7 x l0$^9$cfu/ml1. | 1.7 X l0$^3$cfu/ml |
| Well Water A | 2.9 x 10$^9$cfu/ml | 2.7 x 10$^3$cfu/ml |
| Well Water B | 2.8 x l0$^9$cfu/ml | 2.5 X l0$^3$cfu/ml |

**Key**

River water (A) -Timber River, along Diobu-Eagle Island Road, Port Harcourt

River water (B) -Choba segment of New Calabar River., Port Harcourt

Borehole water (A) -No. 11 Eld. Harry Wike Close, by Oro Ekpo, offAda George/ Port Harcourt

Borehole water (B) -No. 360 Ikwerre road, Port Harcourt

Well water (A) Opposite IAUE main gate, Rumuolumeni, Port Harcourt

Well water (B) . Rumuolumeni Community Town Hall, Port Harcourt

**Figure 1:** The occurrence of Salmonella species in the selected water samples.

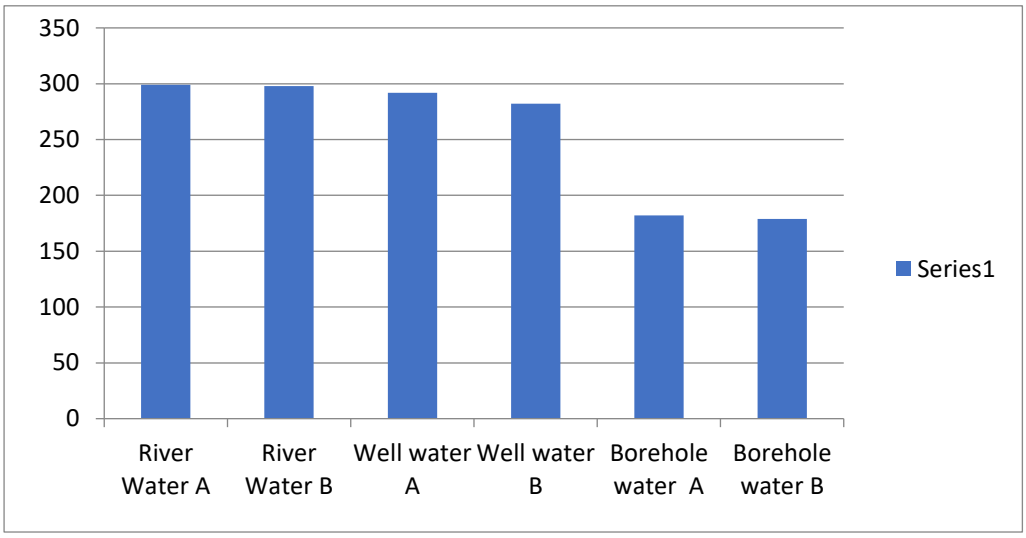


**Figure 2: The** occurrence of enteric bacteria associated with *Salmonella* species in the selected water samples.

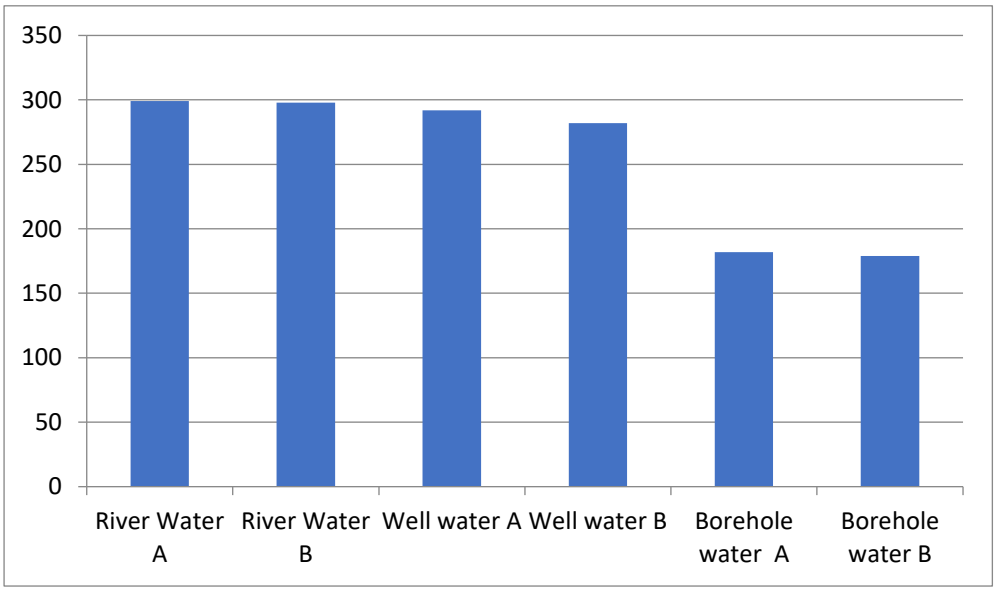

**Table 2:** Identification of isolates by biochemical reactions

| S/N | ISOLATES | GRAM REACTION | UREASE | CITRATE | INDOLE | COAGULAS | OXIDASE | CATALASE | LACTOSE | GLUCOSE | $H_2S$ | MOTILITY | ORGANISM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | WSO1 | - | - | - | - | - | - | - | - | A | - | - | *Shigellasp* |
| 2. | WSO2 | - | - | - | + | - | - | - | + | A/G | - | + | *Escherichia sp* |
| 3. | WSO3 | - | - | + | - | - | - | - | - | A/G | + | + | *Salmonella sp* |
| 4. | WSO4 | - | - | + | - | - | - | - | + | A/G | - | + | *Enterobactersp* |
| 5. | WSO5 | - | - | + | - | - | + | + | - | A/G | - | + | *Pseudomonas sp* |
| 6. | WSO6 | - | - | - | - | - | - | - | - | A | - | - | *Shigella sp* |
| 7. | WSO7 | - | - | - | - | - | - | - | - | A | - | - | *Shigella sp* |
| 8. | WSO8 | - | - | - | + | - | - | - | - | A | - | - | *Shigella sp* |
| 9. | WSO9 | - | - | - | + | - | + | - | - | A | - | + | *Vibrio sp* |
| 10. | WS10 | - | - | + | - | - | + | + | - | A/G | - | + | *Pseudomonas sp* |
| 11. | WS11 | - | - | + | - | - | - | - | - | A/G | + | + | *Salmonella sp* |
| 12. | WS12 | - | - | + | - | - | - | - | - | A/G | + | + | *Salmonella sp* |
| 13. | WS13 | - | + | + | - | - | - | - | - | A/G | + | + | *Proteus sp* |
| 14. | WS14 | - | - | - | - | - | - | - | - | A | - | - | *Shigella sp* |
| 15. | WS15 | - | + | + | - | - | - | - | + | A/G | - | - | *Klebsiella sp* |

Keys:
- = Negative
+ = Positive
A = Acid production
G = Gas production
$H_2S$ = Hydrogen sulphide
WS = Water sample

**Table 3:** Percentage occurrence of the different enteric bacterial species in the water samples

| Bacteria | Percentage occurrence (%) |
|---|---|
| Sh*igella sp.* | 3.33 |
| *Escherichia sp.* | 6.7 |
| *Salmonella sp.* | 20.0 |
| *Enterobacter sp.* | 6.7 |
| *Pseudomonas sp.* | 13.3 |
| *Vibrio sp.* | 6.7 |
| *Proteus sp.* | 6.7 |
| *Klebsiella sp.* | 6.7 |

## DISCUSSION

The ugly experiences of contamination of natural water sources used by both animals and humans by different species of microorganisms have continued to remain a major global threat to the quest for the provision of potable and good quality water. According to Rachna and Disha (2016), the ever increasing population, urbanization and modernization pose problems of sewage disposal and contamination of natural water sources.

From the findings of this study, the Timber water-side river and Choba river recorded the highest total heterotrophic bacterial count which ranged from 2.96 109 cfu/ml to 3.0 x $10^9$ cfu/ml, followed by the well water (2.8 x $10^9$ cfu/ml to 2.9 x $10^9$ cfu/ml). The borehole water samples had the least bacterial count ranging from 1.75 x $10^9$cfu/ml to 1.77 x $10^9$cfu/ml. Similarly, the total *Salmonella* species count was highest in the river water with a range of 2.7 x $10^3$ to 3.0 x $10^3$ cfu/ml. The borehole had the least total *Salmonella* species count of 1.3 x$10^3$ to 1.7 x $10^3$ cfu/ml. The total bacterial counts exceeded the maximum permissible microbial limit of the International Commission on Microbiological Specifications for Food and the United States Food and Drug Administration standards.

Using the cultural and morphological characterisation and biochemical tests, a total of eight different organisms were identified including *Shigella, Salmonella, Pseudomanas, Escherichia, Vibrio, Proteus, Enterobacter* and *Klebsiella* species. Among the eight organisms isolated in this research work, *Shigella* had the highest percentage occurrence (33.0%), followed by *Salmonella* (20.0%) and *Pseudomonas* (13.3%)*; Escherichia, proteus, Klebsiella, Vibrio* and *Enterobacter species* had low counts of 6.7% each.

All the organisms isolated have health implications for man. They include: severe infantile diarrhea caused by enteropathogenic *Escherichia coli* (EEC); typhoid fever due to *Salmonella* species; Shigellosis by *Shigella* species; Cholera by *Vibrio* species; septicemia and neonatal

meningitis, wounds and burn infections, nosocomial infections and other opportunistic illnesses resulting from contamination with *Pseudomonas, Proteus, Klebsiella* and *Enterobacter*. (Cheeseborough, 2004, Brooks *et al*., 2007; Ochei *et al*., 2007, and Talaro, 2008;).The contamination of water sources by similar organisms have been reported by many researchers (Kumar *et al.,* 2009; Adedeji and Ibrahim, 2011; and Wandili et *al.,* 2011 Esomonu *et al.,* 2012; ).Although this research identified mainly gram-negative bacteria, Bukola*et al., (*2006); Adedeji and Ibrahim, (2011); and Egwari and Aboaba, 2002 in their different analysis of water samples noted the presence of some gram positive organisms such as *Staphylococcus, Bacillus, Streptococcus* and *Listeria* species.

Direct defecation, dumping of refuse and the discharge of other untreated wastes into the Timber water-side river and the Choba river were responsible for the high occurrence of heterotrophic bacteria and *Salmonella* species in the water samples. The well water samples from two separate wells within the Port Harcourt metropolis had high bacterial contamination because of their closeness to septic tanks, which is against the 50 feet distance recommended by the World Health Organization. The insensitivity of man with regards to his environment, especially in waste disposal and management, ranging from open defecation, indiscriminate dumping of refuse, discharge of untreated sewage into surface water bodies, to the release of untreated chemicals or industrial wastes into the environment have brought upon man different environmental and health challenges.

Amakolonwa (2007) worked on analysis of the microbial quality of commercial bottled water brands in Port-Harcourt metropolis and found the presence of *E. coli* in virtually all bottled water brands. In addition, the *Vibrio* and species of fungi were also detected in some of the sampled brands. The total heterotrophic bacteria count ranged from I.lxl0$^{3}$to 2.6xl0$^{6}$cfu/ml. In the analysis of the microbial quality of borehole water from land and swamp locations in parts of Rivers State, Amesi (2007) reported a total heterotrophic count range of 1.08xl0$^{6}$ cfu/ml to 8.0xl0$^{6}$ cfu/ml for swamp location and 2.5xl0$^{6}$ cfu/ml to 9.3xl0$^{6}$ cfu/ml for land location respectively. The bacteria contaminants confirmed were *Bacillus, Flavobacterium, Citrobacter, Pseudomonas, Staphylococcus, Arthrobacter, Escherichia, Micrococcus, Enterobacter* and *Corynebacterium.*

Esonomi *et al.* (2002) studied enteric pathogens and diarrhea disease potentials of underground tank and stream-water sources in Ahiazu Mbaise, Imo State, Nigeria and found that total heterotrophic bacteria and coliform count ranged from 2.0xl0$^{1-}$ to 4.8 x l0$^{3}$ respectively. They identified *E, coli* (50% occurrence), *Salmonella* spp. (100% occurrence), *Shigella* spp. (100%), *Vibrio* spp. (20%), *Proteus spp.* (30%), *Klebsiella* spp. (80%), *Enterobacter spp.* (50%) and *Streptococcus* spp. (50%) as the contaminating bacteria.

Sewage disposal affects people's immediate environment, and leads to water related illnesses that kill many children under five years old annually. In addition, bacterial contamination of water bodies especially rivers and seas, renders the aquatic animals especially filter feeders, and scavengers unfit for consumption; their bacterial had increases beyond the acceptable standards.

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# PROFILES OF MICROORGANISMS AND DISEASES ASSOCIATED WITH BIOAEROSOLS AND WAYS OF IDENTIFYING THEM.

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## ABSTRACT
*A review of published works related to the profiles of microorganisms in bioarosols was done. It also gives a description of some specific diseases caused by these organisms. Identification methods used for these organisms was also considered. Some key groups of associated microorganisms are bacteria, fungi, viruses, and protozoa. Examples of bacterial organisms and diseases caused by them (in parenthesis) are Mycobacterium tuberculosis (tuberculosis), Streptococcus pneumoniae (Pneumonia); Haemophilus influenzae (meningitis); and Bordetella pertussis (whooping cough). Some fungi related diseases are Microsporum racemosus (Dermatosis - superficial mycosis); Aspergillus fumigatus (Aspergillosis); and Cryptococcus neoformans (Cryptococcosis). Some Viruses associated with bioaerosols and their related diseases are Corona virus (Corona virus infection (COVID-19); Orthomyxoviruses (Influenza); Paramyxovirus (Influenza, measles, mumps, and pneumoniae in neonates); Rhinoviruses and Corona virus (Cold, Rhinitis) and Pox virus (Cowpox). Pneumocystis carrinii, a protozoa is also associated with bioaerosols. Methods of identification of microorgnisms in bioaerosols are both conventional/classical, and advanced. Some methods are manually operated using miniaturized devices while others are automated, and depends on phenotypically expressed traits for their identification. PCR-based methods are now in vogue. The cost implications, using advanced methods is high and poses a challenge to individuals who may be interested to research in related fields. It is therefore recommended that government agencies should make grants available to researchers in need. Most importantly, some microorganisms associated with bioaerosols are pathogenic and poses a serious health challenge, and are epidemic prone. Thus, affordable and rapid means of detection, identification and prevention of diseases implicating these microorganisms is paramount.*

**Key words***:* Profile, bioaerosol, diseases, bacteria, fungi, identification.

## INTRODUCTION
Biological aerosols also known as Bioaerosols or organic dust, consists of microorganisms (bacterial cells, fungal spores, detritus, cellular fragments, pollen, viruses, protozoa, microalgae and cyanobacter***ia***), microbial products (such as Lipopolysaccharides) and toxins in the air and other volatile organic compounds. In brief, a bioaerosol is an airborne collection of biological materials which may be solid or liquid. Exposure to these agents may cause

different health conditions such as infection, respiratory diseases, allergies, acute toxic effects, nervous system disorders, and possibly cancer (Lighthart, 1997; Crook and Swan, 2001; Douwes and Thorne, 2008). Some sources of bioaerosols are water, soil, waste dump sites, and sewage. These collections of biological materials form a profile of microorganisms responsible for several debilitating and life-threatening human infections and diseases (Obire *et al*., 2002; Londahl, 2014; National Academies Press, 2017). The distribution of bioaerosols vary in different geopositions due changing environmental and anthropogenic activities with respect to the procedures of operation, ranging from residential, industrial or agricultural activities (Ekaterina & Agranovski, 2018). There is also the concept of sampling efficiency namely physical efficiency, which is the comparison of the amount of the collected particles to the amount of particles in the sampling location or environment, and biological efficiency, which is an estimation of the fraction of microorganisms that remain viable after collection, since some bioaerosol organisms are non-viable (Hogan *et al*., 2005; Kulkarni *et al.*, 2011).

**Microbial Groups of Bioaerosols**

Microorganisms associated with bioaerosols are bacteria, fungi, viruses, protozoa and microalgae, and with their microbial products and volatile organic compounds (Srikanth *et al*., 2008; Londahl, 2014).

In these groups, bacterial species and their diseases caused by them are *Mycobacterium tuberculosis* (Tuberculosis); *Legionella sp.* (Legionnaires disease, Pontiac fever)*; Streptococcus pneumonia* (Pneumonia); *Streptococcus sp.* (Scarlet fever, Angina, laryngitis); *Haemophilus influenzae* (Inflammation of upper and lower respiratory system, Menigitis); *Bordetella pertussis* (Whooping cough); *Legionnella pneumophillia* (Pulmonary infections > Legionnaire disease); Norcardia sp. (Norcardiosis); and Corynebacterium diphtheria (Diphtheria) (Burge1990; Nrior, 2020).

Fungal profiles found in bioaerosols with their respective diseases are *Alternaria sp*. (Asthma, rhinitis); *Cladosporium* (Asthma, rhinitis); *Microsporum racemosus* (Superficial mycosis); *Aspergillus fumigatus* (Aspergillosis); *Cryptococcus neoformans* (Criptococcosis) (Nrior & Chioma, 2017).

In the profile of viruses, the following types are prominent in bioaerosols with their diseases in parenthesis: Influenza A and B (Influenza); Rubella virus (Measles); Corona virus (Corona virus infection – COVID 19); Orthomyxoviruses (Influenza); Paramyxovirus (Influenza, measles, mumps and, pneumoniae among new borns); Rhinoviruses and Corona virus (Colds); Pox virus (Cowpox); Adenoviruses (Sorethroat, Pneumonia); Enteroviruses (Meningitis, Pleurdynia); Rhinoviruses, Hantavirus from rodent faeces, and Coronaviruses (chicken pox) (Diglisic *et al*., 1999; Nrior, 2020). Prozoal organisms found in bioaerosols is *Pneumocystis carrinii* which causes Pneumoniae in humans. Protozoa and algae are also found in bioaerosols and they are implicated in Hypersensitivity pneumonitis (Burges, 1990; Londahl, 2014).

**Disease Categories Associated with Bioaerosols.**

Diseases associated with bioaerosols are due to exposure to bioaerosols. The incidences are due to a combination of allergens, toxins and microorganisms. Three distinguishing diseases associated with bioaerosols are infectious diseases, respiratory diseases and cancer (Turjanmaa, 1987; Charous *et al.*, 1994).

**Infectious diseases**

Infectious diseases arise from viruses, bacteria, fungi, protozoa and helminthes, and involve the transmission of an infectious agent from a reservoir to a susceptible host through direct contact, a common vehicle, airborne transmission or vector-borne transmission. Diseases caused by microorganisms associated with bioaerosols may be attributable to occupation-specific exposures, such as in health workers (tuberculosis, winter stomach flu, measles). For farmers, abattoir workers, veterinarians diseases of common occurrence are Q-fever, swine influenza and anthrax) and forestry workers (tularaemia). Gathering or clustering of people in the workplace such as in the case of market places, office, military or schools may experience influenza, winter stomach flu, Tuberculosis and Corona infection) (Driver *et al.*, 1994; Van den Ende *et al.*, 1998; Srikanth *et al*., 2008; NCDC, 2020). Other bioaerosol transmitted infections are (particularly *Legionella pneumophila*) caused by exposure to Legionellae. They become airborne often as a result of active aerosolizing processes (Pastoris *et al.*, 1997; Brown *et al.*, 1999). Aloso, inhalation of fungal spores in the course of handling decaying matters, faeces, composts or soils can result in several mycoses. They include adiaspiromycosis, aspergillosis, blastomycosis, coccidioidomycosis and histoplasmosis. (MMWR, 1993 ; NIOSH, 1997). Thus, high-risk occupations for occupational infectious diseases due to bioaerosol exposure include farmers, veterinarians, health care workers and biomedical workers studying infectious agents.

**Respiratory diseases**

Bernstein *et al.* (1999) explains that respiratory, dust-aerosol associated diseases range from acute mild conditions to severe chronic respiratory diseases that require specialist medical attention. Respiratory diseases due to bioaerosls result specifically from exposures to toxins, pro-inflammatory agents or allergens.

**Cancer**

Cancer can be caused by a variety of factors including oncogenic viruses and other biological agents. Notably the only clearly established non-viral biological occupational carcinogens are the mycotoxins. Hayes *et al.,* (1984) reported that aflatoxin from *Aspergillus flavus* was capable of causing liver cancer. These occur in industries in which mould-contaminated materials are handled (Anonymous, 1998).

Viruses are considered as the most common cause of infectious diseases acquired within indoor environments (Brankston *et al*., 2007), and many nosocomial infections are due to respiratory and enteric infections of viruses (Belliot *et al.*, 2014; Bruijning *et al*., 2012, Kambhampati *et al*., 2015, Rhinehart *et al*., 2012). Recent examples of particular concern are emerging infectious diseases such as Severe Acute Respiratory Syndrome (*SARS*) coronavirus (*SARS*-

CoV)– *virus* identified with outbreak in 2003, the outbreak of Ebola Virus Dissease (EVD) in West Africa in 2014-15, and the on-going Middle East Respiratory Syndrome Coronavirus (MERS CoV) outbreaks in the Middle East since 2012, where many health care workers (HCWs) were infected and acted as the amplifiers for the spread of the disease to the community, and the Corona Virus infection (COVID 19) which became a pandemic and affected virtually all countries in the world from March, 2019 to June, 2020, with implied extension towards the second half of 2020. (Ansumana *et al*., 2017; Ho e*t al*., 2003; Ki, 2015; Shears and O'Dempsey, 2015; Nrior & Dumbor, 2019; WHO, 2020).

**Bioaerosol organism detected by qPCR analysis of aerosol samples.**

Quantitative Polymerace Chain Reaction (qPCR) approach has discovered various kinds of fungal and bacterial species. These include both culturable and unculturable species of bacteria, fungi and viruses. According to (Kaarakainen *et al.,* 2011), fungal organisms associated with bioaerosols include *Aspergillus fumigatus/ Neosartorya fischeri, Aspergillus niger/awamori/foetidus/phoenicis, Aureobasidium pullulans, Cladosporium cladosporioides, Cladosporium herbarum, Cladosporium sphaerospermum, Eurotium amstelodami/ chevalieri/herbariorum /rubrum/repens, Epicoccum nigrum Penicillium brevicompactum/stoloniferum, Penicillium chrysogenum*, *Penicillium variabile*, *Wallemia sebi, Cladosporium spp*. *Streptomyces spp*., and Gram-positive and –,Gram-negative. Several of which are implicated in diverse infectious diseases, posing serious health hazards to humans (Kaarakainen *et al.,* 2011). Some of the microbial bioaerosols are culturable while others were unculturable, so could only be detected using metagenomic approache. Some bacterial and fungal species detected through metagenomic studies include *Micrococcus*. *Nocardiopsis, Paracoccus, Streptomyces*, *Scopulariopsis*, *Pseudonocardia*, *Staphylococcus, Enhydrobacter, Methylobacterium, Corynebacterium, Sphingomonas, Acinetobacter, Bacillus, Kocuria, Massila* and *Nocardioides*. Some fungi in indoor and outdoor air identified at the phylum and class levels discovered through metagenomic insight are given on Table 1 (Shin *et al*., 2015).

Table 1: Fungi in indoor and outdoor air identified at non-specific levels

| | | |
|---|---|---|
| Dothideomycetes | Eurotiomycetes | Sordariomycetes |
| Leotiomycetes | Pezizomycetes | Saccharomycetes |
| Orbiliomycetes | Lecanoromycetes | Arthoniomycetes |
| LIchinomycetes | Unclassified Ascomycota | Agaricomycetes |
| Tremellomycetes | Exobasidiomycetes | Waalemiomycetes |
| Ustilaginomycetes | Agaricomycotina | Agaricostilbomycetes |
| Dacrymycetes | Atractiellomycetes | Tritirachiomycetes |
| | Chytridiomycetes | Unclassified Glomeromycota. |
| | Unclassified Eukarya | |

Source: Shin *et al*, (2015).

Bioaerosols are generated due to anthropogenic activities. Such activities include residential, industrial, agricultural and laboratory experimentation, Bioaerosols can be generated in the laboratory by a number of different methods utilizing either dry or wet procedures. Dry dispersion methods are predominantly utilized for fungal aerosol generation. Fungal spores can be detached and dispersed directly from their culture medium by vibration (Scheermeyer and Agranovski, 2009), brushing or establishment of airflow across the surface of the agar plate (Jung *et al.*, 2009; Zhen *et al*., 2014).

Bioaerosols are also generated in anthropogenic environments by bursting bubbles: When bubbles from sea waves burst whitecaps becomes efficient producers of marine bioaerosol particles. In residential and industrial environment transfer of microorganism from water to air by bursting bubbles occur frequently during aeration or agitation of liquids (Aziz *et al*., 2008; Chen *et al*., 2013; Mannina *et al*., 2016). Other methods of bioaerosol generation are liquid dispensing and splashing with high probability of bacteria surviving more than one hour after generation process (Joung *et al*., 2017); High pressure cleaning using high pressure mechanical spray guns and machines applied in various industrial and residential areas for cleaning contaminated surfaces (Seidl *et al*., 2016).

**Transmission of Bioaerosol associated microorganisms/diseases**

In nosocomial instances, airborne transmission usually occurs only when an infected subject is coughing, sneezing, or otherwise actively shedding fresh organisms into air close to susceptible individuals. Bio-aerosols can be transmitted either at long distances beyond the patient room environment, or within short distances. Small particle are transmitted to persons in the immediate area near the patient. Viruses like Corona virus (COVID 19), Severe Acute Respiratory Syndrome (SARS), influenza and norovirus are transmitted from patients usually by contact and/or droplet routes, while airborne transmission occurs over a limited distance (Bollin *et al.*, 1985). Centre for Diseace Control (2020) recommends at least 6 feet (2 arms) length physical/social distance from person to person (Legionella may be derived from the environment (Bollin *et al*., 1985) and others include contaminated food, water, medications (e.g., intravenous fluids) or through vectors (Anaissie *et al*.,2003).

Transmission routes of infections is not always easily determined in an environment with undefined parameters. Infection by direct contact can occur when infected hosts are in close proximity with a susceptible population. On the other hand, infected hosts can transmit the disease without direct contact. Moreover, many microorganisms, including viruses (Dinsdale *et al.*, 2008), can remain infectious outside their hosts for prolonged periods of time, and this can lead to infections by indirect contact. For example, a surface can become contaminated by deposited infectious droplets and eventually cause the infection of susceptible hosts coming into contact with it. The probability of airborne transmission of an infectious disease can be determined by conducting epidemiological studies (Pirtle and Beran, 1991) and/or by analyzing the microbiological content of air samples.

**Methods of Identification of Microorganisms in Bioaerosols**

Sampling and Cultivation of airborne bacteria and fungi follows mostly a passive approach. The passive sampling based on settle plate (sedimentation sampling) method which is preferred mostly in the collection of air borne particles containing microorganisms (Sivagnanasundaram *et al*., 2019)

**Bacteria**: Identification of microorganisms from bioaerosols according to conventional methods. In this proposal bioaerosol samples are collected in a specified environment and their cultivation on agar nutrient media. Representative colonies are picked and inoculated unto nutrient agar to obtain pure cultures. The bacterial isolates are identified either gram positive or gram negative based on their reaction with gram stain. The pure cultures are stored as frozen 10%(v/v) glycerol suspensions at -35$^{o}$C in a refrigerator. This glycerol stock serves as a means for fresh working cultures. Further inoculation of pure cultures unto appropriate media is done to check for consistency. Identification of the isolates are carried out using appropriate identification schemes, which supposes that traditional schemes for identifying a pure culture phenotype characteristics chosen for an identification scheme should be easily determinable by most microbiology laboratories (Krieg, 2001; Duquenn, (2018; Sivagnanasundaram *et al*., 2019).

**Fungi**: Isolation and identification of fungi is based on their macroscopic morphology, such as best growth temperature *(e.g.* Growth at 37$^{O}$C, 40$^{O}$C, 45$^{O}$C), growth rate (e.g. colony diameter 5 cm in 15 days), colour or pigmentation on SDA (e.g. white, cream, yellow, brown, pink, grey, black *etc*.), colour/pigmentation on reverse side of plate (e.g. none, yellow, brown, red, black, *etc*.) , texture and special features (e.g. glabrous, suede-like, powdery, granular, fluffy, downy, cottony), Surface topography (*e.g.* flat, raised, heaped, folded, domed, radial grooved), septation of hyphae (septate, non-septate), while the microscopic morphologies and identities of the different species of fungal isolates are based on characteristic features of conidiophore, phialides, vesicle, sclerotia, hulle cells, sporangiophore, apophysis, columella, sporangium and rhizoids according to scheme of Cheesbrough, 2002; Kidd *et al*., 2016; Lindsley, *et al*., 2017; Nrior, 2020).

**Some Settled Dust Collection Devices used for Bioaerosol sampling.**

Instead of passive sedimentation method, bioaerosol is also sampled using settled dust collection devices. These include Vacuums, Swabs, wipes, adhesive tapes and contact plates. Their respective methodologies are giving by HUD (2008); Bolanos-Rosero *et al.* (2013); Morey, (2007) and Poletti *et al.,* (1999).

**Enumeration of viruses**

Prior to molecular PCR-based detection methodologies, cell cultures and serological methods were used as detection methods of viral pathogens. By the use of commercially available immortal cell lines, researchers can screen collected bioaerosols by inoculating cells and observing for modal cytopathic effects (CPEs) such as fusion and lysis of cells (Leland and Ginocchio, 2007).

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**Sampling and Characterization of Viruses in Bioaerosols**

Several methods are available, but only few are mentioned below.

**Viral Plaque assay (VPA)**

A common method for detecting and quantifying viral pathogens and titres respectively is the viral plaque assay (VPA) (Condit, 2007).

**Tissue Culture infectious dose Assay (TCID)**

Tissue Culture Infectious Dose assay (TCID) also known as endpoint dilution assay, is also a culture based method of assaying viruses in bioaerosols (Condit, 2007). The procedure selecting cells which are plated at a predetermined concentration in a 96-well format and inoculated with serial dilutions of the collected sample. Predetermined incubation period is set, and then cytopatic effects (CPEs) are closely observed. The TCID50 is defined as the dilution of virus required to infect 50% of the cell culture wells (Reed & Muench, 1938). Based on the number of cells that are infected at the designated virus dilution, viral titers are mathematically calculated. However, this method has its limitation (Reed & Muench, 1938).

**Immuofluorescence Antibody (IFA) Assay**

Detection and quantification of viral loads is also achieved via direct or indirect immunofluorescence antibody (IFA) assays and are frequently used in combination with cell culture-based methods (Flint *et al*., 2009; Tortora *et al*., 2013). Infected cells are by this method combined with a fluorescently-labeled, antigen-specific antibody. Optimization is possible by varying the parameters (Flint *et al*., 2009; Tortora *et al*., 2013).

**Molecular Genetic Methods**

Molecular identification of bioaerosol samples follows a predetermined procedure. Samples are collected in a specified environment and subsequently, cultivation on agar nutrient media (except for viruses). The morphologically different colonies are then selected, and individually transferred into a DNA-free reaction tubes. *PCR Amplification of Purified Bacterial DNA using* 16S rRNA gene region of bacterial genomic DNA is amplified using universal bacterial primers. An amplicon-mixture of each bioaerosol sample is prepared by mixing equimolar DNA amounts of PCR product from each selected colony. Then, the amplicon-mixture is used to generate clone libraries that are sequenced; the gene sequences are finally aligned against the NCBI database for bacterial identification (Schäfer *et al.*, 2017; Disegha & Akani, 2919; Sivagnanasundaram *et al*., 2019).

**PCR-based method of identifying Viruses from Bioaerosol.**

Generally, viruses consist of more genetic material, DNA or RNA than other microorganisms. More general studies have also been conducted ( Sigari *et al*., 2006) based on PCR detection of a number of viruses, especially enteroviruses and reoviruses, from aerosols around a sewage treatment facility. The most generalized detection of viruses, however, lies in the metagenomics studies mentioned above, particularly the study of Dinsdale *et al*. (2008). In this study, viral DNA only, not RNA, was isolated from the smallest-size fraction of a serially filtered environmental sample, and included a wide variety of viruses, phages and prophages.

More effective and rapid detection of viruses in collection media, preferably in real-time, is well-preferred in aerovirology. Some good technologies include loop-mediated isothermal amplification, which has the potential to detect and offer a presumptive identification of a virus under one hour, as demonstrated for influenza virus (Mori and Notomi, 2009), and real-time PCR.

**Analytical Formula for Direct Sedimentation Methods**

**Culturable Microbial Sample Analysis.**

In culturable microorganisms, the number of both bacterial and fungal colonies is enumerated on each agar plate after incubation and the counts are obtained as colony forming units per $m^2$ area (cfu/m2) (Sivagnanasundaram *et al*., 2019. A good background information on enumeration of bioaerosol microorganisms can be found in Nrior & Chioma (2017). Analytic method is used to calculate the estimated number of colony forming units from a bioaerosol sample. The standard time for bioaerosol sampling is ten minutes (10 mins) (Nrior, 2020).

**For Direct Sedimentation Method:**

$$CFU(min - m^2 = \frac{Number\ of Colonies}{Time\ of\ Exposure\ (Min)\ \text{x}\ \pi r^2}$$

Where $r$= radius of media plate (Petri dish) used (in meters).

The above method uses settled plates using prepared Petri dishes with preferred medium for microbial growth.

**For Indirect Sedimentation Method:**

$$CFU(min - m^2 = \frac{Number\ of Colonies\ x\ VD}{Time\ of\ Exposure\ (Min)\ \text{x}\ \pi r^2 \text{x}\ VP}$$

Where: $r$ = radius of beaker used in (in meters); VD = Volume of diluent (normal saline 100 ml in 250ml beaker) and VP = Volume plated (usually 0.1 ml aliquot /inoculum) ( Nrior and Dumbor, 2019).The indirect method uses beaker with diluents placed for at least 24 hours.

**Other Devices used for bioaerosol sampling**

This review considers only settle plate (gravitational sedimentation) method for bioaerosol sampling. Settle plates are culture plates containing culture media exposed at sampling locations of interest for passive inoculation of microorganisms. Airborne particles are allowed to settle onto the plates for a specified time. Usually 10 minutes (Nrior, 2020), and the plates are then closed, incubated and inspected for growth (Dyer *et al.* 2004). For purposes of simplicity and efficiency in cost, settle (gravitational sedimentation) plates are more frequently used by researchers in conducting bioaerosol sampling. However, there are other devices or techniques used for bioaerosol sampling. Some of them are given below:

(i)**Filters:** These are useful for personal bioaerosol sampling because filter-based collectors are small and lightweight and work well with personal sampling pumps (Raynor *et al*., 2011).

(ii) **Impactors**: These are described by Hering (2001) and Marple and Olson (2011) as instruments consisting of a series of nozzles (circular- or slot-shaped) and a surface for

impaction (Marple and Willeke, 1976). Air is drawn into the impactor using a vacuum pump, and the air stream flows through the nozzles and toward the impaction surface, where particles are separated from the air stream by their inertia. Larger particles collect on the impaction surface, while small particles that do not impact follow the air stream. The impaction surface typically consists of a greased plate or tape, filter material, or growth media (agar) contained in Petri dishes. In some applications, impactors are not used as collection devices themselves, but rather to remove particles above a certain size before collection or characterization of the downstream aerosol (Figure 1). The most commonly used impactor for sampling airborne culturable bacteria and fungi is the Andersen impactor illustrated below (Andersen ,1958).

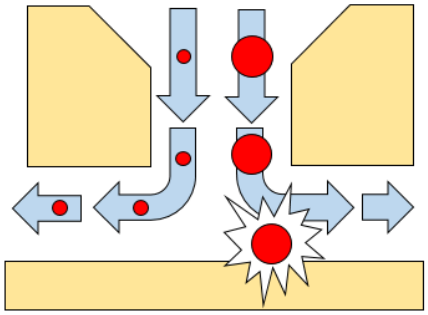

Figure 1: Example of impaction mechanism. Existing air stream in the impactor nozzle, quickly changes direction following the arrows. On the left, smaller/ligher particles flow with the air stream and are not collected. Larger particles cannot change direction as quickly due to their higher inertia and collide with the collection surface and are accumulated. (Source: Lindsley *et al*., 2017)

**(iii) Cyclones:** A cyclone sampler consists of a circular chamber with the aerosol stream entering through one or more tangential nozzles (Hering, 2001). Clone is similar to an impactor; a cyclone sampler depends upon the inertia of the particle to cause it to deposit on the sampler wall as the air stream curves around inside. See Figure 2

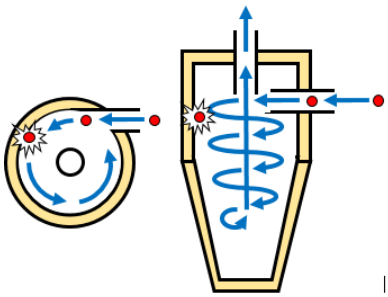

Figure 2: Cyclone aerosol collection. From the inlet, aerosol stream enters the body of the cyclone, the air flow is according to curved interior wall and moves in a spiral pattern. Collision of larger aerosol particles with the inner wall occur due to the inertia of the particles and accumulate. After spiraling downward, the air flow exits through the vortex finder via the center of the cyclone. Source: Lindsley *et al*. (2017).

**(iv) Liquid Impingers:** Many microorganisms can lose their viability if they are collected onto dry solid surfaces. Impingers often have curved inlets to remove larger particles from the air

stream before collection. Because impingers are essentially another type of inertial collection device, they have a collection efficiency curve and a cut-off diameter like impactors and cyclones. Additives to the collection medium such as proteins, antifoam, or antifreeze aid in resuscitation of bacterial cells, prevent foaming and loss of the collection fluid, and minimize injury to the cells (Chang and Chou, 2011; Cown *et al*. 1957; Dungan and Leytem, 2015).

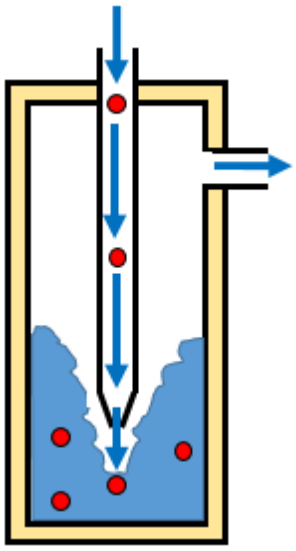

Figure 3: Impingement. Bioaerosol particles exit the nozzle of the impinger at high velocity and impact the liquid or the bottom surface of the collection vessel. Some types of impingers produce air bubbles in the collection media, which can enhance particle collection, but can damage some types of microorganisms. Source: Lindsley *et al*. (2017).

**(v). Wetted-surface bioaerosol samplers (WSBS)**

Wetted-surface bioaerosol sampler generates streams of air, which impacts onto a wetted surface with collection media (Kesavan and Sagripanti, 2015; Kesavan *et al.,* 2011). WSBS produce bubbling and agitation, which may not be favourable to some microorganisms (Lin *et al.,* 2000).

**CONCLUSION:**

This study has made some exposition on the profile of microorganisms associated with bioaerosols. It was noted that the predominant microbial groups of bioaerosol are fungi, bacteria and viruses, while protozoa and microalgae were present in low numbers. Some disease categories caused by specific organisms or combination of them are infectious diseases, and respiratory diseases expressed on humans in varying degrees, depending on the measure of exposure. Sources of micro-bioaerosols and transmission routes are critical for contact of microorganisms and their consequent infection on susceptible hosts. Some sampling devices are also mentioned which are used in bioaerosol researches. Detection and identification of bioaerosol microorganisms used to be carried out using cultural and biochemical methods. But recently, the trend has changed to molecular approaches using different advanced method, including the real time PCR and other analytical techniques. The use of advanced techniques enhances the detection of microoganisms including non-culturable species via metagenomic

approaches, is a great achievement. However, cost of advanced techniques is high and not easily affordable by research students, and even some Research Institutes.

It is therefore recommended that government agencies such as TETFUND, World Bank and non-governmental establishments should make grants available to researchers in need of such equipment and devices. Most importantly, some microorganisms associated with bioaerosols are pathogenic and are of significant health challenge, and are epidemic prone. Thus, affordable and rapid means of detection, identification and prevention of diseases and epidemics from bioaerosols associated microorganisms is paramount.

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# A RAIN- STIMULATED FLOOD PREDICTION FOR RIVERS STATE USING NEURAL NETWORKS.

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**ABSTRACT:**
*This project is to study the ability of neural networks to perform short-term prediction of the amount of rainfall of Rumudara River flooding for a specified area given previous rainfall data for a specified period of time. Short-term, in this case, means predicting the total rainfall for the next 24-hr period. The literature provides examples of neural networks being able to generate future averages of weather data if provided with data over a reasonably long range prior to the period being predicted. The dataset used in this study for training and consequently testing the Neural Network was sourced from Weather Underground official web site https://www.wunderground.com. An iterative Methodology was used and implemented in MATLAB. We adopted multi-layer Feedforward Neural Networks. Thus, for this project, the ability of a neural network to predict next day rainfall given a short range of precious days' data is investigating.*

**KEY WORDS:** Weather Prediction, Feedforward Multilayer, Neural Networks Rivers State, Rain-Stimuted Flood.

## INTRODUCTION

River flooding is one of the direct effects of climate change and its impact on the environment is usually devastating and worrisome.

In recent time flooding has become a frequent occurrence in the Niger Delta sub region and Nigeria in general. According to Global Facility for Disaster Reduction and Recovery (GFDRR), floods regularly affect Nigeria. In 2012 alone there was a widespread flooding that affected almost the entire country and caused a damage computed by the post-disaster needs assessment (PDNA) (of GFDRR) and valued at 17 billion US Dollar plus various losses. And majority of the occurrence of the flooding in Nigeria are caused and started by rain. GFDRR PDNA also discovered that "Low-income households are the most vulnerable to weather-related natural disasters. Agriculture, which is heavily impacted by flooding and drought, serves as the main source of income for 80 percent of the rural poor. Furthermore, the rapid rise of urban poverty increases potential flood risk."

Flooding has also caused and justify some agencies of government receiving more funding, resources and capacity build up with inputs coming from both within the country and foreign donor government. A good example is National Emergency Management Agency (NEMA) and Federal Ministry of Environment (setup during the President Olusegun Obasanjo administration) which agrees that "in Nigeria, the basic causes of floods are heavy and intense rainfall associated with high run-off". Bulk of the funding of these government agencies are targeted at mitigating the after effect of the flood on the society. In some instances, flood caused the premature death of some businesses and lives. The actual value of the loss incurs during and after flooding can only be estimated in billions of naira. More worrisome is the fact that flooding now appears to be a recurring experience with little done to provide a precautionary measure that can help to reduce or eliminate the damage associated with flooding especially that which occurs during rainfall.

Since 2009 till date, several budgetary efforts have been exacted towards providing reliable flood forecasting mechanism for the entire country. While government effort in this direction is yet to be felt on large scale, this project is seeking to produce a solution that can be adapted and used by individual and software developers to produce solutions that are portable and easy to apply by all. More so, data set targeted are immediate past weather conditions and not the long historical weather data set.

Rain-induced flooding simply refers to floods caused by rainfall. According to Hofmann and Schüttrumpf (2019), rain-induced flooding may also be referring to as pluvial flooding or pluvial flash flood. Pluvial flooding occurs when the duration of the rainfall in a particular geographical area is lengthy or in continuous fashion thus generating high volume of water. While pluvial flash flooding occurs when the duration of the rainfall is very brief yet the volume of the sudden rain is also high.

Pluvial floods are dangerous. Hofmann and Schüttrumpf (2019) maintained that Pluvial "flash flood are natural hazards that are defined as fast surface flows with high peak discharge values, often limited in their spatial extent. The most frequent cause of this type of flood is heavy rainfall events, hence the expression pluvial flash flood is used. Pluvial flooding occurs when rainfall with a high intensity (high amount of precipitation during a very short period) exceeds the infiltration capacity of soil, or the discharge capacity of sewage and drainage systems, and water flows uncontrolled through urban areas. The rainfall-induced runoff and flow processes are highly complex and vary in space and time with respect to terrain and climate conditions". Floods are natural occurrences that have fatal potentiality. According to the World Meteorological Organization (WMO), flash floods are among the natural hazards with the highest mortality rate (deaths/people affected) and because devastating property damage every year. Due to the physical characteristics of convective heavy rainfall cells, the forecasting time of pluvial flash floods is, unlike river (fluvial) floods, very short.

Consequently, as we continue to experience frequent extremes weather variables, couple with expanding vulnerable settlements and business locations, a significant risk to civilian security is posed by heavy rainfall induced floods. In contrast to river floods, pluvial flooding can occur

anytime, anywhere and vary enormously due to both terrain and climate factors. Thus, it is vital to continually "…strengthening flood forecasting and national early warning capacity".

**WEATHER PREDICTION**

Weather forecasting is considered in many circles as the description or computation of what the weather pattern will be in future.

Existing flood forecasting systems (FFS) rely largely on long-range weather data representing measurements of rainfall occurrence, intensity or monitoring water levels collected over a long period of time. Whereas, using short-range weather forecasting is to provide information on the expected weather with forecast projection times ranging from a few hours to two or three days for both particular locations and areas covering a few million square kilometers. Almost all currently used short-range forecasting techniques involve dynamic prediction models based on an application of compressible fluid mechanics equations to the atmosphere.

Weather prediction is as old as humanity. Many of human activities are controlled by weather situations. Activities greatly impacted by weather conditions and which requires high degree of reliability in predictions are not limited to agriculture, civil constructions, transportations, games and entertainment, aviation and many others. Hence there have evolved a lot of different methods of forecasting, interpreting and reporting the weather behaviours.

All weather forecasting can be classifying under the following categories:

**NOW CASTING:**

Now Casting in which the details about the current weather and forecasts up to a few hours ahead are given.

**SHORT RANGE FORECASTS (1 TO 3 DAYS):**

Short range forecasts in which the weather (mainly rainfall) in each successive 24 hrs. Intervals may be predicted up to 3 days.

**MEDIUM RANGE FORECASTS (4 TO 10 DAYS):**

Medium range forecasts Average weather conditions and the weather on each day may be prescribed with progressively lesser details and accuracy than that for short range forecasts.

**LONG RANGE /EXTENDED RANGE FORECASTS (MORE THAN 10 DAYS TO A SEASON):**

There is no rigid definition for Long Range Forecasting, which may range from a monthly to a seasonal forecast.

**RAINFALL PREDICTION MODELS:**

A wide range of rainfall forecast methods are employed in weather forecasting at regional and national levels. There are two approaches to predict rainfall. They are Empirical method and dynamical methods.

**GENERAL FORECASTING MODEL**

Making a weather forecast involves five steps:

1. observation,
2. collection and transformation of data,
3. plotting of weather data,
4. analysis of data and extrapolation to find the future state of the atmosphere, and
5. Prediction of particular variables.

**DYNAMICAL MODEL**

In dynamical approach, predictions are generated by physical models based on systems of equations that predict the evolution of the global climate system in response to initial atmospheric conditions. The Dynamical approaches are implemented using numerical rainfall forecasting method.

**USE OF FLUID MECHANICS IN WEATHER PREDICTION**

The purpose of short-range weather forecasting to-day is to provide various users with information on the anticipated weather over forthcoming two or three days for the sites in the areas of a few million square kilometers to take necessary precautions beforehand and thus to reduce the damage of adverse weather conditions, as well as to gain maximum advantage from those favourable for various kinds of the human activity.

Attempts to predict weather on the basis of simple qualitative rules and subjective judgments have a multi-century history. From the ancient times on, human civilizations have tried to find relationships between various weather and celestial events and to use them in weather forecasting, mainly for sailing and crop production purposes. However, the quantitative and fully objective approach to weather forecasting has proved to be feasible only by describing the atmospheric weather-producing mechanisms using the basic laws of the fluid dynamics. Advances in the application of fluid dynamics to the investigation of various processes and motions in fluids and gases have attracted the scientists' attention to the dynamical weather prediction already in the 19th century. In this context, the earth's atmosphere should be considered as a viscous and compressible baroclinic fluid, which is exposed to the thermal and dynamical effect of the underlying surface, to the absorption and emission of the radiation in various spectral domains and to the heating and cooling due to phase transformations of atmospheric moisture. The equations describing evolution of this fluid are constructed on the basis of three fundamental physical laws: the laws of the conservation of momentum, mass, and energy. The first of these laws leads to three equations of motion for a fluid exerting action of the gravity force and the Coriolis force that results from the earth's rotation, the second one leads to the equations of continuity for air and water vapour, and the third one leads to the thermodynamic energy transfer equation (or the first law of the thermodynamics) which describes the air temperature, pressure, and density variations in both the presence and absence of external sources and sinks of heat (radiation emission and absorption, water phase transformations, and turbulent heat exchange). The principal problem arising when these equations are applied to the dynamical weather forecasting lies in the necessity to define and separate the atmospheric weather-producing processes among the variety of other processes occurring in the atmosphere and described by these equations (e.g., propagation of acoustic waves). This necessity has been understood only after a number of unsuccessful attempts to use the equations for straightforward prediction of the weather elements.

Predicting is making claims about something that will happen, often based on information from past and from current state.

Everyone solves the problem of prediction every day with various degrees of success. For example, weather, harvest, energy consumption, movements of forex (foreign exchange) currency pairs or of shares of stocks, earthquakes, and a lot of other stuff needs to be predicted.

In technical domain predictable parameters of a system can be often expressed and evaluated using equations - prediction is then simply evaluation or solution of such equations. However, practically we face problems where such a description would be too complicated or not possible at all. In addition, the solution by this method could be very complicated computationally, and sometimes we would get the solution after the event to be predicted happened.

It is possible to use various approximations, for example regression of the dependency of the predicted variable on other events that is then extrapolated to the future. Finding such approximation can be also difficult. This approach generally means creating the model of the predicted event.

Neural networks can be used for prediction with various levels of success. The advantage of then includes automatic learning of dependencies only from measured data without any need to add further information (such as type of dependency like with the regression).

The neural network is trained from the historical data with the hope that it will discover hidden dependencies and that it will be able to use them for predicting into future. In other words, neural network is not represented by an explicitly given model. It is more a black box that is able to learn something.

Hence the object of this project centre around the need to determining the amount of rainfall in a location if we are given some previous rainfall data.

## 1.2 STATEMENT OF THE PROBLEM

Rainfall of River flooding is a natural hazard that must be avoided. Applying various weather forecasting models and applications help to reduce the post-flood impact on environment, people and businesses. Consequently, early warning systems (EWS) that are designed to provide efficient alarm protocols must constantly be reviewed and improved upon to reduce error or failure rate of the EWS. This is critical to ensuring that reaction time to alarm time is enough for optimal preparation that will contribute to dropping the degree of damages resulting from flood and most importantly save lives in the event of flood.

Therefore, in view of the forgoing, the problem the project seek to address is: How can we determine the volume of rainfall for the next 24-hours for a particular location.

## 1.3 AIM AND OBJECTIVES

The aims to evaluate the ability of neural networking to be used to predict the amount of future rainfall of River flooding over a defined period (less than or equal to one month) based on previous rainfall data. The program will be designed, built and tested in Matlab which is a software capable of implementing the concept of neural network.

## 1.4 SIGNIFICANCE OF THE STUDY

Weather forecasting is constantly providing avenue of averting dangers and helping to reduce the devastating impact of floods and associated hazards upon the people and businesses. The significance of this research is to provide solutions that are suitable, beneficial and useful for theoretical understanding and practical applications.

In this research, one of the core technologies of Neural network is back propagation which is evaluated and applied in designing the flood forecasting system. Back propagation is the technique used by computers to find out the error between a guess and the correct solution, provided the correct solution over this data. Theoretically this project will demonstrate the effectiveness of using Backpropagation method of neural network in carrying out prediction.

Physically, the findings of this study shall provide model and solutions which can be applied to solving flood prediction. The type of people and organizations that shall benefit from adapting the solutions are not limited to: Travelers, Tourists, Businesses, Ministry of environment, National Emergency Management Agency, Risk Management experts, Trip planners and logistics officers and many others.

Software developers and designers can also adapt the algorithm and source codes to developing mobile applications that can be of great benefit to mobile phone users.

## 1.5 SCOPE OF THE STUDY

This research covers the Rumudara Area of Port Harcourt sub region of Rivers State in the Niger Delta.

The data utility of the analysis and development of this system is mostly about Port Harcourt and its environs.

Port Harcourt is notorious for rainfall and therefore, the high frequency of the rainfall in port Harcourt also form a suitable data collection spot by which the efficiency of back propagation tool of neural network can be properly tested to see how it handles and uses previous locational data to predict the amount of rainfall in short range of time.

## 2.0 LITERATURE REVIEW

### 2.1 NEURAL NETWORK

Kumar Abhishek et al (2012) describe neural network as a computational structure inspired by the study of biological neural processing. We currently have many different types of neural networks, from relatively simple to very complex, just as there are many theories on how biological neural processing takes place. In some text it is refer to as artificial neural network (ANN) and just neural Network (NN). In this work, the word ANN and NN refers to the same neural network.

The advantage of the usage of neural networks for prediction is that they are able to learn from examples only and that after their learning is finished, they are able to catch hidden and strongly non-linear dependencies, even when there is a significant noise in the training set.

When relating to the biological process that gives rise to neural network some other experts describe Neural networks as relatively crude electronic networks of neurons model after the neural structure of the brain. They treat, examine, analyses and process records one at a time, and learn the features, characteristics, relationships and other attributes of that one record by comparing their assessment, assumption and prediction of the record (largely arbitrary) with the known actual record. The errors from the initial prediction of the first record is then fed back to the network and used to modify the network's algorithm for the second iteration. These steps are repeated multiple times.

**TRAINING AN ARTIFICIAL NEURAL NETWORK**

In the training phase, the correct class for each record is known (i.e., supervised training), and the output nodes can be assigned correct values -- 1 for the node corresponding to the correct class, and 0 for the others. Results have been found using values of 0.9 and 0.1, respectively. As a result, it is possible to compare the network's calculated values for the output nodes to these correct values, and calculate an error term for each node. These error terms are then used to adjust the weights in the hidden layers so that the next time around the output values will be closer to the correct values.

**THE ITERATIVE LEARNING PROCESS**

A key feature of neural networks is an iterative learning process in which records (rows) are presented to the network one at a time, and the weights associated with the input values are adjusted each time. After all cases are presented, the process often starts over again. During this learning phase, the network trains by adjusting the weights to predict the correct class label of input samples. Advantages of neural networks include their high tolerance to noisy data, as well as their ability to classify patterns on which they have not been trained. The most popular neural network algorithm is the back-propagation algorithm proposed in the 1980s.

Once a network has been structured for a particular application, that network is ready to be trained. To start this process, the initial weights are chosen randomly. Next, the training begins.

The network processes the records in the training data one at a time -- using the weights and functions in the hidden layers -- then compares the resulting outputs against the desired outputs. Errors are then propagated back through the system, causing the system to adjust the weights for the next record. This process occurs again as the weights are continually tweaked. During the training of a network, the same set of data is processed many times as the connection weights are continually refined.

Note that some networks never learn. This could be because the input data does not contain the specific information from which the desired output is derived. Networks also will not converge if there is not enough data to enable complete learning. Ideally, there should be enough data available to create a Validation Set.

**FEEDFORWARD, BACK-PROPAGATION**

The feedforward, back-propagation architecture was developed in the early 1970s by several independent sources (Werbor, Parker, Rumelhart, Hinton, and Williams). This independent co-development was the result of a proliferation of articles and talks at various conferences that

stimulated the entire industry. Currently, this synergistically developed back-propagation architecture is the most popular and effective model for complex, multi-layered networks. Its greatest strength is in non-linear solutions to ill-defined problems. The typical back-propagation network has an input layer, an output layer, and at least one hidden layer. Theoretically, there is no limit on the number of hidden layers, but typically there are just one or two. Some studies have shown that the total number of layers needed to solve problems of any complexity is five (one input layer, three hidden layers, and an output layer). Each layer is fully connected to the succeeding layer.

The training process normally uses some variant of the Delta Rule, which starts with the calculated difference between the actual outputs and the desired outputs. Using this error, connection weights are increased in proportion to the error times, which are a scaling factor for global accuracy. This means that the inputs, the output, and the desired output all must be present at the same processing element. The most complex part of this algorithm is determining which input contributed the most to an incorrect output and how to modify the input to correct the error. (An inactive node would not contribute to the error and would have no need to change its weights.) To solve this problem, training inputs are applied to the input layer of the network, and desired outputs are compared at the output layer. During the learning process, a forward sweep is made through the network, and the output of each element is computed layer by layer. The difference between the output of the final layer and the desired output is back-propagated to the previous layer(s), usually modified by the derivative of the transfer function. The connection weights are normally adjusted using the Delta Rule. This process proceeds for the previous layer(s) until the input layer is reached.

## 2.2 BACKPROPAGATION IN NEURAL NETWORK

Based on review of several neural paradigms and their strengths, it has been determined that the multilayer feedforward fully connected neural network structure will be utilized employing the backpropagation (BPN) algorithm. This algorithm has continuously displayed superior ability to perform prediction and adjust to non-linear relationships among various input parameters.

Backpropagation may be regarded as supervised learning procedure, which Multi-Layer Perceptron's in an neural network must learn or be trained upon.

The training and learning angle are one of the core features of any neural network and so cannot be abandoned. Backpropagation is an algorithm that justifies the training of the NN.

Backpropagation was introducing in neural network because when designing a Neural Network, we initialize weights in the beginning, with some random values or any variable for that fact.

Since we are often prone to errors it's not necessary that whatever weight values, we have selected will be correct, or it fits our model the best.

Thus, we have to choose some weight values in the beginning, but our model output is way different than our actual output i.e. the error value is huge. Therefore, we must find a way to

reduce the error. In order to eliminate and or reduce the error, we simply need to somehow explain the model to change the parameters (weights), such that error becomes minimum. Or in another words we say we are training our model and one way to train our model is Backpropagation.

The Backpropagation steps can be summarizing as follows:

- **Calculate the error** – How far is your model output from the actual output.
- **Minimum Error** – Check whether the error is minimized or not.
- **Update the parameters** – If the error is huge then, update the parameters (weights and biases). After that again check the error. Repeat the process until the error becomes minimum.
- **Model is ready to make a prediction** – Once the error becomes minimum, you can feed some inputs to your model and it will produce the output.

## 2.3 USE OF NEURAL NETWORK IN PREDICTING WEATHER

Weather forecasting is a complex operation performed by meteorological services all over the world. It includes numerous specialized fields of knowledge how. The task is complicated because in the field of meteorology all decisions are to be taken in the visage of uncertainty. Different scientists over the globe have developed stochastic weather models which are based on random number of generators whose output resembles the weather data to which they have been fit.

This project however demonstrates, the ability of neural network to utilized short-range weather data to forecast pluvial flooding in order to reduce the scale of damage to the environment, loss of lives, crippling effects on investment and businesses which demands that preventive approach is critical to curtail and reduced the level of loss and to protect lives in the event of eventualities resulting from rain-induced flooding.

The reason is that NN (Neural Network) model is based on 'prediction' by smartly 'analyzing' the trend from an already existing voluminous historical set of data. Apart from NN, the other models are either mathematical or statistical.

These models have been found to be very accurate in calculation, but not in prediction as they cannot adapt to the irregularly varying patterns of data which can neither be written in form of a function, or deduced from a formula.

These real-life situations have been found to be better interpreted by 'artificial neurons' which can learn from experience, i.e by back-propagation of errors in next guess and so on. This may lead to a compromise in accuracy, but give us a better advantage in 'understanding the problem', duplicating it or deriving conclusions from it.

Amongst all weather happenings, rainfall plays the most imperative part in human life. Human civilization to a great extent depends upon its frequency and amount to various scales. Several stochastic models have been attempted to forecast the occurrence of rainfall, to investigate its seasonal variability, to forecast yearly/monthly rainfall over some geographical area.

The project endeavors to develop a system solely driven by an NN model to forecast the volume of rainfall in the next 24 hours and up to 2 or 3 days in Port Harcourt.

Port Harcourt is the capital city of Rivers State, dubbed the Treasure base of Nigeria's. It plays host to major economic drivers of the nation and with its known irregular and frequent rainfall pattern the issue of prediction of rainfall is a challenging topic to

Atmospheric experts in Nigeria.

## 2.4 SOME HISTORICAL REVIEW OF VARIOUS WEATHER PREDICTION MODEL IN RELATION TO NEURAL NETWORK

Kumar Abhishek et al (2012) provide some historical perspective of neural network and its initial application when they said that Hu (1964) initiated the implementation of NN, an important soft computing methodology in weather forecasting. Since the last few decades, NN a voluminous development in the application field of NN has opened up new avenues to the forecasting task involving environment related phenomenon (Gardener and Dorling, 1998; Hsiesh and Tang, 1998). Michaelides et al (1995) compared the performance of NN with multiple linear regressions in estimating missing rainfall data over Cyprus. Kalogirou et al (1997) implemented NN to reconstruct the rainfall over the time series over Cyprus. Lee et al (1998) applied NN in rainfall prediction by splitting the available data into homogenous subpopulations. Wong et al (1999) constructed fuzzy rules bases with the aid of SOM and back-propagation neural networks and then with the help of the rule base developed predictive model for rainfall over Switzerland using spatial interpolation. Toth et al. (2000) compared short-time rainfall prediction models for real-time flood forecasting. Different structures of auto-regressive moving average (ARMA) models, NN and nearest-neighbor's approaches were applied for forecasting storm rainfall occurring in the Sieve River basin, Italy, in the period 1992-1996 with lead times varying from 1 to 6 h. The NN adaptive calibration application proved to be stable for lead times longer than 3 hours, but inadequate for reproducing low rainfall events. Koizumi (1999) employed an NN model using radar, satellite and weather-station data together with numerical products generated by the Japan Meteorological Agency (JMA) Asian Spectral Model and the model was trained using 1-year data. It was found that the NN skills were better than the persistence forecast (after 3 h), the linear regression forecasts, and the numerical model precipitation prediction. As the NN model was trained with only 1-year data, the results were limited. The author believed that the performance of the neural network would be improved when more training data became available. It is still unclear to what extent each predictor contributed to the forecast and to what extent recent observations might improve the forecast.

Abraham et al. (2001) used an NN with scaled conjugate gradient algorithm (ANN-SCGA) and evolving fuzzy neural network (EfuNN) for predicting the rainfall time series. In the study, monthly rainfall was used as input data for training model. The authors analyzed 87 years of rainfall data in Kerala, a state in the southern part of the Indian Peninsula. The empirical results showed that neuro-fuzzy systems were efficient in terms of having better performance time and lower error rates 5 compared to the pure neural network approach. Nevertheless, rainfall is one of the 20 most complex and

difficult elements of the hydrology cycle to understand and to model due to the tremendous range of variation over a wide range of scales both in space and time (French et al., 1992).

## 3.0 METHODOLOGY

At this stage of the Research, we shall discuss the procedure that is adopted in carrying out this project. The discussion shall focus on the research design, area of the study, procedures followed and resources used to develop the system

The area of research is Port Harcourt. On 25 July 2017, GardaWorld reported that as a result of flooding in Port Harcourt, Rivers State, Nigeria three people had lost their lives and severe damage to infrastructure had occurred (GardaWorld). These results are indicative of what can occur when extreme rains coupled with inadequate contingency planning coincide. As Port Harcourt is subject to this type of weather, especially during the annual rainy season from March.

Port Harcourt, which is an important trading center for Nigeria, lies in the Niger Delta at a low elevation. Waterways, such as the Bonny River and creeks, are subject to flooding during periods of "high intensity" rains. According to (K. C. Chiadikobi), high intensity rains are categorized as high volume events where the rate of downfall is greater than 0.13mm/min. And during the decade from 1998-2007, the following high intensity rainfall occurred (see figure 3.1).

At least two conclusions can be drawn from this. First, the area is at a reasonable risk of flooding even when the number or percentage of rainfall days during the rainy season is moderate to low. Second, there are other factors contributing to the flood events themselves.

The second conclusion stated above is the focus of research performed by Akukwe in *Determinants of Flooding in Port Harcourt Metropolis, Nigeria*. By gathering data from a number of sources; including persons living in the affected areas, the author analyzed and ranked nine factors according to their documented or presumed causality for flooding. The results obtained ranked rainfall as the second most important factor behind inadequate drainage facilities. **Source and reliability of historical weather data_** the historical data is critical to this kind of project. The historical weather data for the area under study was source from Weather Underground official web site (https://www.wunderground.com). Weather Underground is powered by IBM and it is one of the respected weather data centre that captures, archive and report weather data on minute by minute basis. Weather Underground also have over 250,000 on ground personal weather stations including more than 8000 additional international weather stations and more than 5000 automated weather networks operated at different airports and other government facilities.

The network of Weather Underground generates weather data also from Meteorological Assimilation Data Ingest System (MADIS) which is managed by the National Oceanic and Atmospheric Administration (NOAA) and other satellite observatory agencies like NASA and their observations are reported on hourly basis.

Weather underground weather data is suitable for research and weather forecasting applications and they have been providing this public service on weather information since 1993.

consequently, the backpropagation (BPN) algorithm has continuously displayed superior ability to perform prediction and adjust to non-linear relationships among various input parameters.

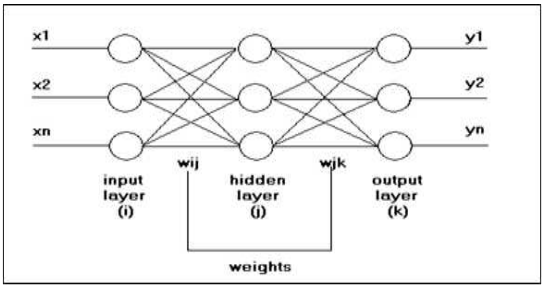


Figure1: Neural network architecture

### 3.1 Determination of neural structure and parameters

A general view of the BPN network is shown in Figure, above. The network consists of three layers and several parameters that need to be determined. In order to determine a suitable network architecture for the neural network FPS or Neural Network Flood Prediction System (NFPS), the process defined in *"An Optimal Design Method for Multilayer Feedforward Networks"* (Cooke) is relied upon. In this work, the author presents a systematic method for arriving at an optimal neural network architecture based on the problem to be solved. Here a portion of that strategy is implemented to determine the boundaries for the Neural Network Flood Prediction System.

Let's define the target date for prediction to be x, then we want to know if the Neural Network Flood Prediction System can accurately determine the risk of flooding or the level of rainfall for days x-1, x-2, …, x-7 or up to one week before the target. Thus, our network needs to be able to accept the actual rainfall for the seven days before the target and provide a single output of the predicted rainfall for the target day. This indicates that the Neural Network Flood Prediction System should have seven neurons in the input layer and one output layer neuron. According to Cooke in *"An Optimal Design Method for Multilayer Feedforward Networks",* the maximum number of hidden layer neurons would be seven. Thus, this will be the network architecture for this initial investigation of the Neural Network Flood Prediction System.

### 3.2 Result and Discussion

This research used the following hardware and software tools:

- Hardware: Desktop Computer
- Software: Matlab *(Matlab is an industry leader in mathematical and scientific modeling and analyses distributed by* ***The MathWorks, Inc.****)*

The neural network was implemented using Mathlab. The program created with Mathlab is saved as npfs.m as the filename. By building the NFPS using this platform, extensions, enhancements or modifications can be performed and tested easily. Moreover, the program can be converted to executables for other operating systems; such as Windows and Linux.

### 3.3 Training and Testing Data

***Experimentation:***

In order to evaluate the ability of neural networks to perform short-term rainfall prediction, a BPN network will be modelled in Matlab and tested for various short-term input periods. These results will be compared, and the best model will be determined. Successful prediction will be measured as the network's ability to match the actual next day rainfall within a present tolerance, which is yet to be determined.

Table1: Training Data Sample

| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0.04 | 0 | 0.83 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 1.38 | 0 | 0.04 |
| 0.04 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0.12 | 0 | 0 | 0 | 0 |
| 0 | 1.46 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0.75 | 0.94 | 0.08 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0.04 | 0 | 0 | 0 | 0 |
| 0.04 | 0.43 | 0 | 0 | 0 | 0 | 0.24 |
| 0 | 0 | 0.63 | 0 | 0.08 | 0 | 0 |
| 0.04 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1.73 | 0 | 3.39 | 0 | 0 | 0 |

Table2: Testing Data Sample

| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0.04 | 0 | 0.83 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 1.38 | 0 | 0.04 |
| 0.04 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0.12 | 0 | 0 | 0 | 0 |
| 0 | 1.46 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 0 | 0.75 | 0.94 | 0.08 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0.04 | 0 | 0 | 0 | 0 |
| 0.04 | 0.43 | 0 | 0 | 0 | 0 | 0.24 |
| 0 | 0 | 0.63 | 0 | 0.08 | 0 | 0 |
| 0.04 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1.73 | 0 | 3.39 | 0 | 0 | 0 |
| 0 | 0 | 0.28 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0.39 | 0 | 0.12 | 0 | 0 |
| 0 | 0.91 | 0 | 0 | 0 | 1.26 | 0 |
| 0 | 0 | 0.16 | 1.14 | 0 | 0 | 0 |
| 0 | 0 | 0.08 | 0.24 | 0 | 0 | 0 |
| 0 | 0.51 | 1.77 | 0 | 0 | 0.75 | 0 |
| 0 | 1.1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0.43 | 0 | 0 | 0.35 | 0 | 0 |
| 0.12 | 0 | 0 | 2.2 | 0.71 | 0 | 0 |
| 0 | 0.04 | 0.12 | 0 | 0 | 0 | 0.01 |
| 1.3 | 4.57 | 0 | 0 | 1.42 | 0.04 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0.01 | 0.02 |
| 0.31 | 0.39 | 0.12 | 0.31 | 0 | 0.08 | 0.16 |
| 0 | 0 | 0.35 | 0.12 | 0.12 | 0.67 | 0.2 |
| 0.47 | 0.16 | 0.79 | 0.12 | 0 | 0 | 0 |
| 0.43 | 2.36 | 0.24 | 0.35 | 1.34 | 0.01 | 0.31 |
| 0 | 0.01 | 2.2 | 1.57 | 0.08 | 0 | 0 |
| 0 | 0.12 | 3.15 | 0 | 0.01 | 0 | 0 |
| 0.02 | 0 | 0 | 2.52 | 0.35 | 0 | 0.24 |
| 1.97 | 0.31 | 0 | 0.28 | 0 | 0 | 0 |
| 0.2 | 0.08 | 0.87 | 1.3 | 0 | 0.39 | 0 |
| 0.04 | 0.47 | 0 | 0.04 | 0 | 0 | 0.08 |
| 1.73 | 0 | 1.02 | 0 | 0.04 | 0 | 0 |
| 0.28 | 0 | 0 | 0 | 0 | 0.87 | 0 |
| 0.28 | 0 | 0.03 | 0.51 | 1.1 | 0 | 0 |
| 0.04 | 0.01 | 0 | 0 | 0 | 0 | 0 |
| 0.28 | 0 | 0 | 0 | 0 | 0.35 | 0 |
| 1.65 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Year | Pct. of High Intensity Rainfall Days |
|---|---|
| 1998 | 24.2 |
| 1999 | 52.7 |
| 2000 | 20.4 |
| 2001 | 20.4 |
| 2002 | 40 |
| 2003 | 35.8 |
| 2004 | 25.5 |
| 2005 | 53.8 |
| 2006 | 44.6 |

Flooding actually occurred for seven of the ten-years illustrated in chart below, Fig. 3.1: 1998, 2000, 2002-2004, 2006 and 2007.

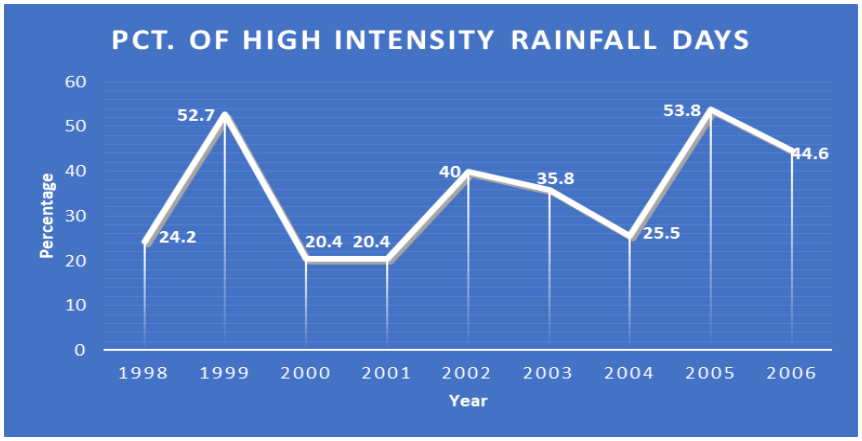


Figure 2: Review of Port Harcourt Rainfall Intensity, 1998-2007

Port Harcourt, which is an important trading centre for Nigeria, lies in the Niger Delta at a low elevation.

## 4.0 SOURCE CODE LISTING

**This source is purely a Math lab source code:**

%This program implements the ANN rainfall prediction module of the NFPS. This %module implements a multilayer feedforward architecture running the BPN

%paradigm. It accepts as input data files for:

% Option 1: Training a Network

% Option 2: Testing a Network

%and generates files consisting of learning/training and testing results.

%The ANN structure is also saved, if desired by the user, for further

%training/testing. The user is able to select both input files and output

%file names.

```
%%
```

**DEFINE VARIABLES**

```
%net current network being built/trained/tested.
%option indicates training (1) or testing (2) mode.

%% INITIALIZE
Clear all;
Fprintf ('\n\n Starting module NFPS:');
%% GET USER INPUT
Option=9;
While option ~= 0
 Option=input ('\n\n Select one: \n 1) Train Network\n 2) Test Network\n 0) Exit\n  >>');
   if option == 0
      break;
   elseif option ~= 1 && option ~= 2
      fprintf('\n INVALID OPTION! PLEASE REENTER!');
   else
%% GET INPUT DATA
      if option == 1
         fprintf('\n Running Training Mode:');
         trainin=input('\n Enter train data file name>> ','s');
         load (trainin);
         x=x';
%           A=size(x)
         y=y';
%           C=size(y)
%% BUILD/EDIT ANN
         usropt=input('\n Select one:\n  1) Existing network\n  2) New network\n  >>');
         if usropt == 1
            netin=input('\n Enter ANN input file name>> ','s');
            net=load(netin);
         elseifusropt == 2
%%             Network Default Parameters. These can be edited.
            net = newff(x,y,7);
            net.trainParam.show = 1;
            net.trainParam.lr = 0.5;
            net.trainParam.epochs = 1000;
            net.trainParam.goal = 1e-3;
            net.trainParam.mc = 0.9;
         else
            break;
         end
%% TRAIN ANN
         usropt=1;
         while usropt ~= 0
            if usropt == 1
               [net,tr,out,err] = train(net,x,y);
               g=tr
            elseifusropt == 2
               netout=input('\n Enter ANN output structure file name>> ','s');
```

```
            save(netout,'net','tr')
         elseifusropt ~= 0
            fprintf('\n INVALID OPTION! PLEASE REENTER!');
         end
         usropt=input('\n Select one:\n  1) Continue\n  2) Save\n  0) Done\n >>');
      end
      fprintf('\n Exiting Training Mode:');
      clear 'x"y"net';
%% TEST ANN
   elseif option == 2
      fprintf('\n Running Testing Mode:');
      testin=input('\n Enter test data file name>> ','s');
      load(testin);
      x=x';
      y=y';
      netin=input('\n Enter ANN input file name>> ','s');
      load(netin,'net');
      [net,tr,out,err] = train(net,x,y);
      figure
      plot(err);
      title('Error/Input');
      net = revert(net);
      usropt=input('\n Save results?\n  1) Yes\n  2) No\n >>');
      if usropt == 1
         result=input('\n Enter ANN output results file name>> ','s');
         save(result,'net','out','err');
      end
      fprintf('\n Exiting Testing Mode:');
      clear 'x"y"net';
   end
end
%% EXIT
end

fprintf('\n\n Exiting module NFPS:\n');
```

**4.1 ANALYSIS OF RESULTS**

A neural network structure defined with 7 inputs, 1 output and a seven pe hidden layer was built, trained and tested. The network structure is given in Attachment 7. The network was trained and tested on data presented via Attachment 8. The target mean-squared error (MSE) rate for training was .001. The network was able to exceed this threshold and training was halted once an error/pe of 7.69775e-005 was obtained. An excerpt of the training session is shown below.

**TRAINLM, PERFORMANCE GOAL MET.**

After training, the network was tested on the weather data and the following results were obtained.

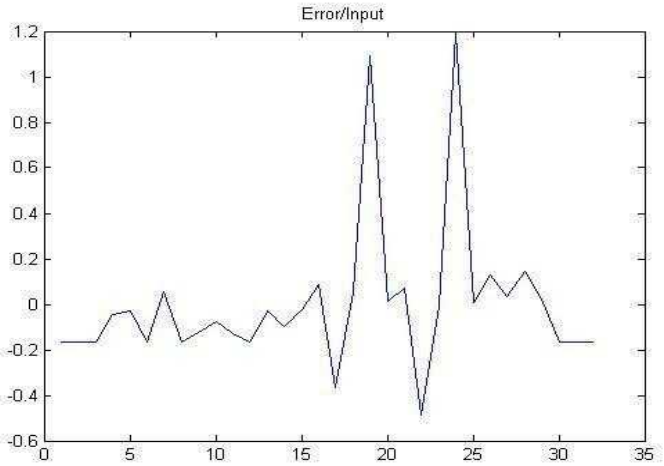


Figure 3: NFPS Testing Results

As shown above, the testing results hover around 0 and peak at 1.2 MSE (mean-squared error). Although, these is not as impressive at the training results, it is still significant. Based upon these extremely low values for daily input rainfall data presented weekly it is reasonable to assume that smaller intervals, which translates to more precise data would yield even better results. As BPN networks have been shown to benefit from increased data set size, as well as pre-processing schemes (none were applied here due to the values of the data), it is likely that these results can be improved.

## 5.0 CONCLUSION AND RECOMMENDATION

In this research, the justification for and implementation of a neural network structure to perform short-term rainfall prediction is presented. The goal here was to take the first step in validating this approach for what may blossom into a sophisticated early warning system to minimize the destruction and fatalities that have been suffered by people in the Port Harcourt, Rivers State region of Nigeria.

The results clearly validate the underlying artificial neural network foundation and should be used as motivation for continued research and development.

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# ASSESSMENT OF GASTRO-INTESTINAL HELMINTHS AMONG FREE-RANGE CHICKEN (GALLUS GALLUS DOMESTICUS) IN OGBA/EGBEMA/NDONI LOCAL GOVERNMENT AREA OF RIVERS STATE, NIGERIA

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**Abstract**

*The prevalence of gastrointestinal helminthes among free-range chicken (Gallus gallus domesticus) in Ogba / Egbema / Ndoni Local Government Area, Rivers State Nigeria, was studied. Twenty-eight birds selected from 4 communities (Erema, Akabta, Obuburu and Akabuka) were euthanized for the study. The formol ether sedimentation and the Zinc sulphate floatation methods were employed. Of the total birds examined, 25(89.3%) tested positive for 6 genera of gastrointestinal parasites (3 nematodes and 3 cestodes). Nematodes were Ascaridia galli 7(28.00%), Heterakis gallinarum 6(24.00%) and Syngamus trachea 1(4.00%) while Cestodes were Raillientina tetragona 4(16.00%), Raillientina cesticillus 2(8.00%) and Choanotaenia infundibulum 2(8.00%). Mixed infection accounted for 3(12.00%). The infection rates according to the sexes sampled were males 94.4% (17/18) while females had 80% (8/10) indicating that the males were more parasitized than the females. Chi square statistics shows that the relationship with respect to sex was statistically non-significant with p=0.236. Parasites were seen in the following preferred sites: Large intestine – Ascaridia galli 6(40.0%), Heterakis gallinarum 2 (13.33%), Syngamus trachea 1(6.67%), Raillientina tetragona 2(13.33%), Raillientina cesticillus 1(6.67%) and Choanotaenia infundibulum 1(6.67%). Small intestine – Ascaridia galli 1(12.50%), Heterakis gallinarum 2(25.00%), Raillientina tetragona 2(25.00%), Raillientina cesticillus 1(12.50%) and Choanotaenia infundibulum 1(12.50%), Caecum –Heterakis gallinarum 2 (100%). The site prevalent distribution was statistically non-significant (p>0.05). Birds from the communities sampled showed the following prevalence rates: Erema - 80% (8/10), Oboburu - 85.7% (6/7), Akabuka – 100% (7/7) and Akabta – 100% (4/4). The community related prevalence is statistically non-significant (p=0.510). This study has revealed the parasite infection status of free-range chicken (Gallus gallus domesticus) in the study area.*

**Key words: cestodes,** chicken, free-range, helminthes, Ogba/Egbema/Ndoni.

## 1.0 INTRODUCTION

Poultry is one of the most important sources of protein and farm manure, for man and is the main stream income for many homes today (Frantovo, 2002). In the last few years, with increase in poultry production, a lot of losses have been incurred due to disease causing agents such as viruses, bacteria and parasites (Sayyed *et al.,* 2000).

The term "Free range chicken" is used to describe chickens which are reared by allowing the birds to roam around in search of food with little or no attention by the farmers. In this system, low levels of management skills are employed and the birds roost in coops in low sanitary conditions with little control measures against parasitic diseases (Onyirioha, 2011). Free-range system is easy and less expensive method and it is also a good source of meat, eggs, income and other importance as necessary to the farmers, and generally play a vital role in the national economy as a revenue provider to developing countries and improves the nutritional status and income (Onyirioha, 2011). The domestic chicken feed on a wide range of food substances ranging from grains, fruits to insects which may harbor infective stages of parasites thereby predisposing them to parasitic infection, particularly gastrointestinal parasites (Oniye *et al.,* 2000; Frantovo, 2002).

In aviculture, parasitic diseases such as *Eimeria* spp. (protozoa) and *Ascaridia spp., Capillaria spp. and Heterakis spp.* (Helminths) are detrimental to the health of the birds especially the free-range ones, resulting in poor yields both in eggs and meats. (Ensuncho *et al*., 2015; Afolabi *et al*., 2016; Berhe *et al*., 2019)

Helminth parasites have more complex biological cycles including intermediate hosts such as snails, earthworms and insects and this has a unique economic influence in free-range systems (McDougald, 2008; Lozano *et al*., 2019).

## 2.0 MATERIALS AND METHOD

### 2.1 Sample Area

The study was carried out in selected communities in Ogba/Egbema/Ndoni Local Government Area of Rivers State, Nigeria. The communities are; Erema (5.2220°N and 6.7070°E; Akabuka (5.2100°N and 6.6398°E); Akabta (5.2388°N and 6.6982°E) and Oboburu (5.2266°N and 6.6025°E). The people are predominantly farmers and traders. The major sources of animal proteins are free-range chicken, fishes and bush meat. The area is characterized with tropical rainforest, high humidity and rainfall. Two rivers run through the area: - Orashi through the Western end and Sombreiro through the Eastern end. The Local Government is host to major oil companies such as Total E & P limited and Nigeria Agip Oil Company and several other industries (Ellah, 1995).

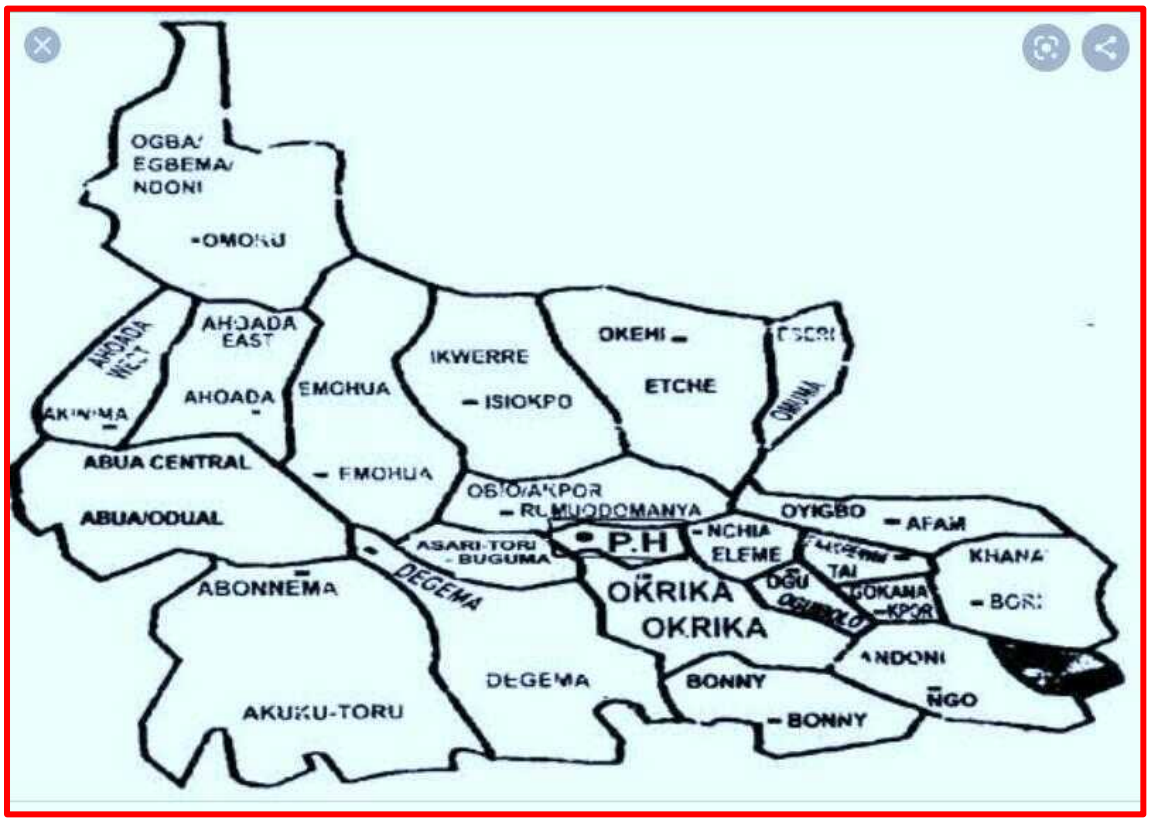


**Fig. 1: Map of Rivers State showing the study Local Government Area: (Ogba/Egbema/Ndoni)**

## 2.2 Sample Collection

A total of 28 free-range chickens (18 males and 10 females) were sourced from the communities; 10 from Erema; 7 each from Oboburu and Akabuka while in Akabta 4 chicken were bought. The birds were bought at varied prices from farmers in the communities at giveaway prices ranging from one thousand and two hundred to one thousand and five hundred naira only. The birds were transported alive to Research Laboratory, Ignatius Ajuru University of Education, Rumuolumeni, Port Harcourt for parasitological assay.

## 2.3 Ethical consideration

Verbal consents were sought from poultry farmers in the respective communities in Egni, Ogba/Egba/Ndoni Local Government Area, Rivers State, Nigeria.

## 2.4 Collection of Specimen

The study was conducted over a period of 8 weeks from October to December 2020. After collecting each of the birds, they were examined for clinical signs of infection and labeled properly, before proceeding to the laboratory for parasitological examination. Each of the birds was euthanized through manual cervical dislocation and the gastrointestinal tract carefully removed for onward examination. The gastrointestinal tracts were separated into different regions: the gizzard, crop, small intestine, large intestine and caecum, each region was cut open using dissecting sets and the contents examined according to standard parasitology methods, after Cheesbrough (2005).

## 2.5 Parasitological Examination

The formol either concentration technique for sedimentation, and zinc sulphate floatation technique for floatation, as described by Cheesbrough (2005) was employed for this study.

### 2.5.1 Sedimentation Method

For this method, the formal ether concentration technique, after Cheesbrough (2005) was used: Using electrical weighing balance, a measured 2g of faecal sample was collected with a spatula and introduced into an empty sample bottle, after thorough stirring of the faecal sample with the use of a pipette, 10mls of normal saline was added into the sample bottle and stirred with a glass rod to obtain a faecal suspension. The solution was filtered into a clean and empty sample bottle with a sieve. Another 10ml of normal saline was added to the filtered sample and stirred till a suspension was obtained. The suspension was filtered for the second time into an empty test tube. 3ml of normal saline was added to the already filtered sample and allowed to stand for about 15 seconds. 3ml of ether was added to the solution and mixed gently. The solution was then centrifuged at 3000rpm for 5 minutes. At the end of the centrifugation, the following layers were observed in the test tube: ether at the top (colourless clear liquid); a plug of debris (dark coloured thick substance); formal solution (a colourless liquid with suspended debris) and sediment (solid at the bottom of the tube). The supernatant (top layers of the centrifuged specimen) was carefully decanted after stirring with a glass rod, and the sediment was left.
Another 3ml of normal saline only was added to the sediments, stirred with a glass rod, centrifuged again for the second time at 2000rpm for 3 minutes. The supernatant was carefully decanted again. 1ml of normal saline was added to the sample sediment and introduced into a preservation bottle.

The final phase involved examination of the prepared specimen, with a pipette. The specimen was collected and put on a microscope slide. A drop of Lugol's iodine was added, covered with a cover slip then viewed under the microscope using the 4x, 10x and 40x objective lenses.

### 2.5.2 Floatation Method

For this method, the zinc sulphate floatation technique, after Cheesbrough (2005) was also used. Before the laboratory experiment commenced, the zinc sulphate solution was first prepared thus: using the electric weighing scale, 165 grams of zinc sulphate salt was measured after which 500ml of distilled water was added to the salt and mixed thoroughly until homogeneity was achieved. The test tube was filled to one quarter with zinc sulphate solution. 2 grams of faecal specimen was introduced into the test tube using a spatula and emulsified until a solution is obtained. The test tube was filled with the zinc sulphate solution and mixed well. The faecal suspension was strained to remove large faecal particles. The suspension was returned to the tube and kept in a completely vertical position in a rack. With the use of a pipette more zinc sulphate solution was carefully added until the test tube was filled to the brim. A clean (grease- free) cover slip was placed on top of the test tube and care was taken not to trap air bubbles. The experiment was left to stand for between 30-35 minutes in order to give time for the eggs and cysts to float. After the expected time, the cover slip was carefully lifted from the test tube by a straight pull upwards, placed downward on a microscope slide and viewed using the 4x, 10x and 40x, objectives lenses.

### 2.6 Data analysis

Data generated from the work were subjected to chi-square statistics. Values below probability level of 0.05 were termed significant. Also, the raw data were transformed using simple percentages.

## 3.0 RESULTS

### 3.1 Overall Prevalence

The results obtained from this parasitological investigation revealed that of the 28 birds examined, 25(89.3%) were positive for various gastrointestinal parasites. The gastrointestinal parasites isolated and identified include 3 genera each in nematodes and cestodes. The Nematode prevalence were *Ascaridia galli:* 7 (28.0%), *Heterakis gallinarum*: 6 (24.0%), *Syngamus trachea* has the least prevalence of 1 (4.0%) and cestodes were *Railietina tetragona*: 4(16.0%), *Railietina cesticillus:* 2 (8.0%) and *Choanotenia infundibulum* with an overall prevalence of 2 (8.00%). Mixed infections were observed in three birds with prevalence of 12.0% (Fig. 1).

### 3.2 Sex Related Prevalence

Sex related prevalence revealed that of the 18 males and 10 female's birds studied, - 17 males tested positive for the various gastrointestinal parasites which represent 94.4% prevalence while 8 females tested positive for various gastrointestinal parasites representing 80%prevalence. Data analysis showed that there was no difference in relation to sex at ($p>0.05$) (Table 1).

### 3.3 Site specific prevalence

Among all the sites of the gastrointestinal tract investigated in this study, helminth parasites were seen in only 3 sites as follows: Large intestine: Nematode - *Ascaridia galli* 6 (40.00%), *Heterakis gallinarum* 2 (13.33%), and *Syngamus trachea* 1 (6.67%). Cestodes: - *Raillientina tetragona* 2 (13.33%), *Raillientina cesticillus* 1(6.67%) and *Choanotaenia infundibulum* 1 (6.67%). Mixed infection occurred in 2 (13.33%). Small intestine: - *Ascaridia galli* 1 (12.50%), *Heterakis gallinarum* 2 (25.00%), *Syngamus trachea* 0 (0%). Cestodes:- *Raillientina tetragona* 2 (25.00%), *Raillientina cesticillus* 1(12.50%) and *Choanotaenia infundibulum* 1 (12.50%). Mixed infection occurred in 1 (12.50%). Caecum: - Only the nematode *Heterakis gallinarum* 2(100%) was seen. The distribution of gastrointestinal parasites in the preferred sites was however statistically non-significant as ($p>0.05$) (Table 2.)

### 3.4 Station/Community Related Prevalence

In each of the 4 communities, gastrointestinal helminthes were found in the birds sampled as follows: In Erema community, 10 free-range chickens were sampled out of which 8 were positive for gastrointestinal helminthes, thereby giving us a percentage prevalence rate of 80%. In Oboburu community, 7 free-range chickens were sampled out of which 6(85.7%) were positive for gastrointestinal helminthes. In Akabuka community, 7 free-raange chikckens were sampled out of which 7(100%) were positive for gastrointestinal helminthes. Finally, in Akabta community, 4 free-range chickens were sampled out of which 4(1000 were positive for gastrointestinal helminthes. Statistically, the distribution of gastrointestinal helminthes in relation to station/community was non- significant ($p=0.510$) (Table 3.)

## 4.0 DISCUSSION

The findings from this study revealed an overall prevalence rate of 89.3% which represents 25/28 of the birds examined. This prevalence is significantly higher than that of Dawet *et al*., (2012); Luka and Ndams, (2007); Imam *et al*., (2017) & Asumang *et al*., (2019) who reported 37.9%, 62.0%, 72.0%; and 65.5% prevalence's respectively except Idika *et al*., (2014); who reported 96.8% and Mwale and Masika (2011) who recorded a prevalence rate of 99.0% in their studies. This result is however in slight agreement with the result of Eshetu *et al.,* (2001) who reported a percentage prevalence of 91.0%, in their study of gastro-intestinal helminths of scavenging chickens in four rural districts of Amhara region, Ethiopia; Matur *et al.,* (2010) who reported an overall percentage prevalence of 90.2%, in their study on gastrointestinal helminth parasites of local and exotic chickens slaughtered in Gwagwalada, Abuja (FCT), Nigeria; Eslami *et al.,* (2009) who also reported an overall prevalence of 90.0%, in their study of parasitic infections of free-range chickens from Golestan province, Iran, and Yoriyo *et al.,* (2005; 2008a) who reported a prevalence of 87.0% & 87.8% respectively in Bauchi State, Nigeria.

However this result is slightly higher than those of the following researchers; Ashenafi and Eshetu (2004) who reported a prevalence of 86.3 and 75.8%, in their study on gastrointestinal helminths of local chickens in Central Ethiopia; Yoriyo *et al.,* (2008b) who reported a prevalence of 77.0%, in their research on the prevalence of gastro-intestinal helminths in free-ranging chickens and guinea fowls in Bauchi and its environs; Matur (2002) who recorded a percentage prevalence of 71.0%, in FCT Abuja. This could be attributed to variations in sample sizes and sanitary conditions of the stations and helminth extraction method.

The high incidence of gastro-intestinal parasites in the present study could be attributed to poor sanitary condition of the area. The continuous exposure of chickens to the free-range conditions which facilitate infections as local chickens satisfy their nutrient requirements by moving from place to place, seeking their food in the superficial layers of the soil which is often contaminated with living organisms of all kinds, including various insects or worms, human and animal wastes which serve as intermediate hosts for parasites that infest poultry and other animals (Gadzama, 2001). The difference in prevalence could also be due to the number of birds sampled by the researchers, and the geographical location where these birds are found.

This study further reveals that higher infection rate was found among males which were more in the number of birds examined. This result is in conformity with the report of Yoriyo *et al.,* (2008b) who found higher infection among male chicken than females. The results also correlate with that of Adang *et al.,* (2014), who found helminths infection among male chicken higher than that of the female chickens. This result is however contrary to the findings of Berhe *et al.,* (2019), who found higher prevalence rate of parasitic infection among female chickens than male chickens. The lower prevalence rate of gastro-intestinal parasite in female chickens may be attributed to the reduction of their feeding habits and feeding niche during breeding season and incubation period. In addition to that, the chicken owners tend to give special treatment to the females during such period which reduces their chance of picking infection. But the male chickens increase their niche by moving freely in search of food and mate which increases the chances of picking infection.

The following component parts of the gastrointestinal tracts studied harbored the following helminthes as follows; Large intestine: Nematodes: - *Ascaridia galli*, *Heterakis gallinarum*, and *Syngamus trachea*, Cestodes: - *Raillientina tetragona* and *Railientina cesticillus*. This result agrees with Luka and Ndams, (2007), who reported the presence of three nematodes in the large intestine and four cestodes in the large intestine, in their research carried out in Samaru, Zaria, Nigeria. In the small intestine, the following gastrointestinal parasites were seen: Nematodes: - *Ascaridia galli*, *Heterakis gallinarum*. Cestodes: - *Railientina tetragona*, *Railientina cesticillus*, and *Choanotaenia infundibulum*. This is also in-line with the result of Luka & Ndams, (2007), who reported 4 nematodes and 6 cestodes in the small intestine. In the Caecum only the nematode *H. gallinarum* was seen. This result further agrees with Luka and Ndams, (2007), who also found *H. gallinarum* in the caecum of the chicken sampled.

Community related prevalence showed that Erema, Oboburu, Akabuka and Akabta had prevalences of 80%, 85.7%, 100% and 100% respectively. This showed that there was no significant difference in infection at $p < 0.05$. This high level of prevalence's could be attributed to small size of sample. However, sample size could be increased to further evaluate infection rate. Furthermore, the sanitary level of the communities also needs to be revisited.

The sedimentation method yielded more results, revealing more parasite eggs than the floatation method. This may be because of the length of time it takes for the parasites to float to the cover slip of the set up and also the overall time consumed in viewing one slide from the floatation method, whereas several slides can be viewed from the sedimentation method once the process has been completed.

## 5.0 CONCLUSION

From the results obtained in this study, it is concluded that; both nematodes and cestodes are equally common helminths which affect chicken *(Gallus gallus domesticus)* in free-range condition.

## 6.0 RECOMMENDATIONS

Farmers under the free-range and intensive systems of poultry keeping should be educated by veterinary extension officers on the various kinds of gastrointestinal parasites in association with chickens and poultry as a whole and the dangers they pose. The prevalence level shown by the birds in the study area is a clue to the susceptibility of the domestic fowl to many infectious diseases that may be detrimental to human consumption. It is therefore recommended that handlers and managers of poultry farms should improve their management skills and issues concerning hygiene.

Veterinary extension officers are also requested to pay particular attention to the managerial practices of farmers in the area and provide the necessary assistance in protecting the health and wellbeing of poultry as well as contributing to public health protection. It is also recommended that further studies should be carried on the subject matter, covering different methods and parameters to enhance better results (Asumang *et al.,* 2019).

## Conflict of Interest

The authors declared that there is no conflict of interest.

**Acknowledgements**

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**Table 1: Sex related prevalence of the gastrointestinal helminths (n=28)**

| Sex | Total No. Sampled | No. Positive (%) | No. Negative (%) |
|---|---|---|---|
| Males | 18 | 17 (94.4) | 1 (5.6) |
| Females | 10 | 8 (80) | 2 (20) |
| Total | 28 | 25 (89.3) | 3 (10.7) |

Chi Square ($X^2$) = 1.40, df = 1, p=0.236

**Table 2: Distribution of type of parasites among the infected sites (n=28)**

| Site | Parasite type seen | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | Nematodes | | | Cestodes | | | Mixed infection (%) | |
| | *A. galli* (%) | *H. gallinarum* (%) | *S. trachea* (%) | *R. tetragonal* (%) | *R. cesticillus* (%) | *C. infundibulum* (%) | | |
| Large intestine | 6(40.00) | 2(13.33) | 1(6.67) | 2(13.33) | 1(6.67) | 1(6.67) | 2 (13.33) | 15 |
| Small intestine | 1(12.50) | 2(25.00) | 0 (0) | 2(25.00) | 1(12.50) | 1(12.50) | 1 (12.50) | 8 |
| Caecum | 0 (0) | 2 (100) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 2 |
| | 7(28.00) | 6(24.00) | 1(4.00) | 4(16.00) | 2(8.00) | 2(8.00) | 3(12.00) | 25 |

$X^2$ = 10.1, df = 12, p=0.611

**Table 3: Station/Community Related Prevalence (n=28)**

| Community | No. Sourced | No. Positive (%) prevalence | No. Negative (%) Prevalence |
|---|---|---|---|
| Erema | 10 | 8 (80) | 2 (20) |
| Oboburu | 7 | 6 (85.7) | 1 (14.3) |
| Akabuka | 7 | 7 (100) | 0 (0) |
| Akabta | 4 | 4 (100) | 0 (0) |
| Total | 28 | 35 (89.3) | 3 (10.7) |

Chi square ($X^2$) = 2.31, d.f = 3, p = 0.510

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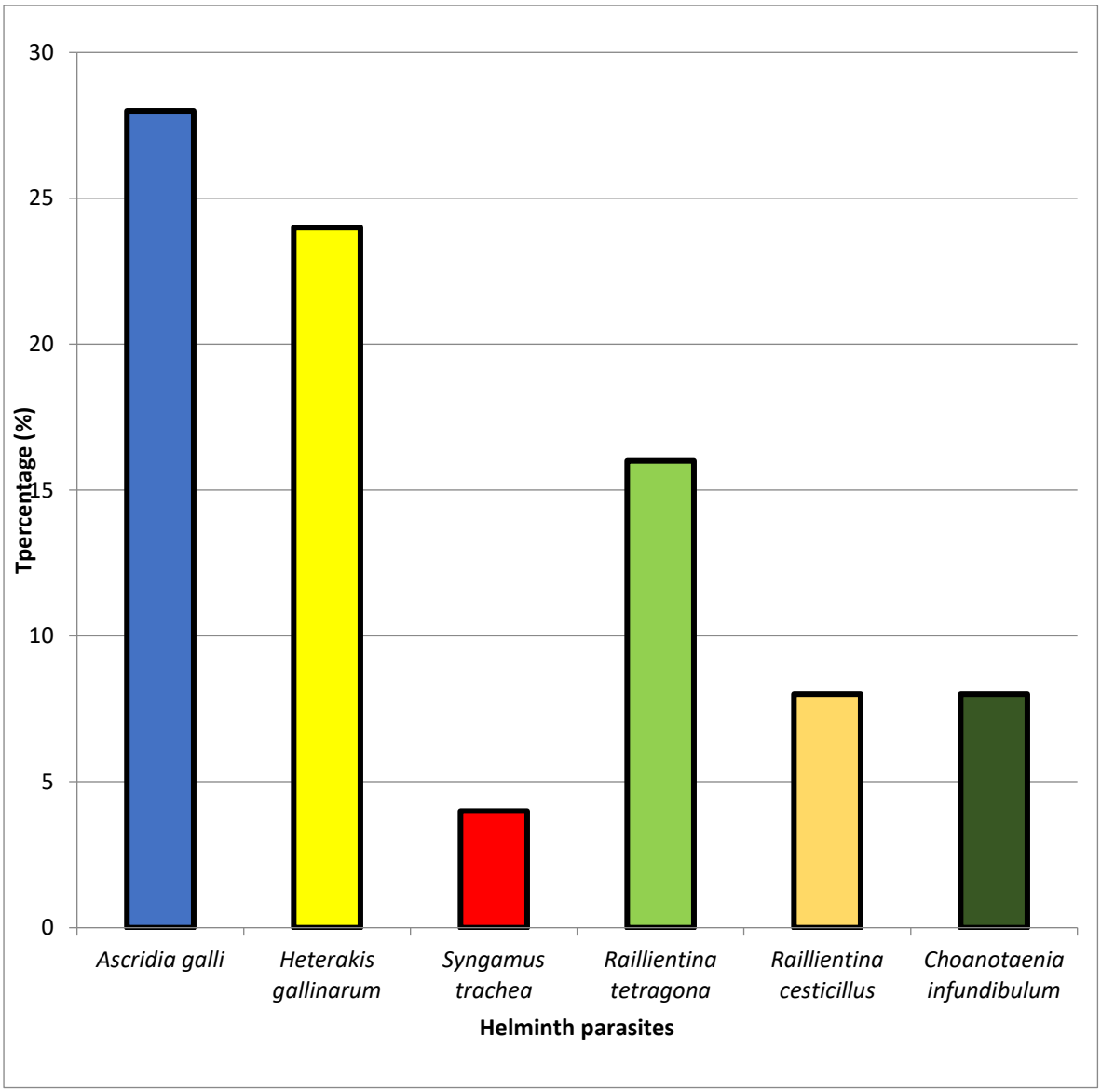


**Fig. 1: Graphical representation of overall prevalence of gastrointestinal parasites**

# EXAMINATION OF EFFECTIVE MATERIAL MANAGEMENT IN BUILDING WORKS FOR ENVIRONMENTAL DEVELOPMENT FOR NATIONAL ECONOMY

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**Abstract**
*The problem associated with the materials management is one of the main issues/acing the building and construction industry in Nigeria. The activities identified ranging from ordering of materials to supply and materials usage we considered key to materials management because they basically affect the economy, effectiveness of material movement, productivity optimization of profit and reduction of materials cost thereby contributing to the economy of the country. Result shows that factor eight (8) with a mean score of 3.25 and mean ranking of which falls under material control is mostly responsible for ineffective materials management and lack of consideration in detailing the period over which deliveries can he spread without affecting the contract which falls under material storage has the least mean ranking.*

**Keywords**: materials management materials control, materials schedule, materials storage.

## INTRODUCTION

The effective construction materials management process is the secret to success of any construction project. Materials management can be viewed as a management system that is needed in proper planning and controlling of quality and quantity of the material, timely equipment placement, good price and the correct quantity as needed.

In the other hand, material management is a management system that combines purchasing, shipping and material control from suppliers. Based on this definition, generally speaking, material can be defined as a process of planning, executing and controlling the correct source of materials with the specified quality, at the right time and location suitable for minimum cost construction process.

The ability to efficiently coordinate and integrate purchasing, shipping and material control from suppliers is needed for cost control and regulation.

There are three important areas that hold the secret to a successful material management, and they include, materials purchasing, materials usage and material storage. It is a tool to cost reduction, which enhances profit-making and directs the production.

The Nigerian building and construction industry continues to occupy an important position in the nation's economy even though it contributes less than the manufacturing or other service industries Albinu and Jagboro, 2002).

Then contribution of the building and construction industry to national economic growth calls for improved efficiency in the industry by means of cost effectiveness and timeliness and would in no" little measure contribute to cost saving for the country at large. It is also known that the implementation of the construction project in the industry is usually accompanied with poor quality delivery time delay and cost increase as well as owner dissatisfaction (Hafez, 2001). Thus, the efficient use and management of material have an important influence on a company's profit and can delay project construction (Abdul Rabmanand Alidrisyi, 1993). In this research I will examine the effects (impacts) of material management on project delivery in Nigeria.

Waste of construction materials on site refers to the difference between materials delivered to construction sites and those that are actually used for the construction work (Onabule, 1991). It can be deduced from Onabule's point that construction wastes are those materials supplied to site for construction and are not being used in the actual construction constituents.
Therefore, there is a need for efficient materials management in order to control productivity and cost in construction projects.

## 1.1 OBJECTIVES OFTHE STUDY

- To examine the impact of materials management in Nigeria economy
- To examine the effects of material management on project delivery time in Nigeria
- To examine the causes of material wastage in the construction industry
- To examine the economy, benefit of effective material management strategy in the construction industry.

## 1.2 LIMITATION OF THE STUDY

This research work is limited to building/construction works only as regards impact of effective materials management practical by some construction industries in Nigeria.

## 2.0 LITERATURE REWEW

Construction materials constitute a major cost component in any construction project. The total cost of installed materials (or value of materials) may be 50% or more of the total cost (Stukhart 1995, Benold and Tresler 1991). The efficient procurement and handling of materials represent a key role in success of the work. It is important for the contractor to consider that there may be significant difference in the date that the material was requested or date when the purchase order was made, and the time at which the material will be delivered.

The need for an effective material planning system becomes mandatory. Some companies have increased the efficiency of their activities in order to remain competitive and secure future work. Many other forms have reduced overheads and undertaken productivity improvement strategies. Considerable improvement and cost savings would seem possible through enhanced material management. Better materials management practices could increase efficiency in operations and reduce overall cost. There is a growing awareness in the construction industry that material management needs to be addressed as a comprehensive integrated management activity.

The typical tasks associated with a material management system according to (Tersine and Campbell (l977), Ammer (I980), Stukhart (1995) are:

- Procurement and purchasing
- Expediting
- Materials planning
- Materials handling
- Distribution
- Cost control
- Inventory management/Receiving/Warehousing
- Transportation

## 2.1 CLASSIFICATION OF MATERIALS

Stukhart (1995) states that the main categories of materials encountered in a construction project are engineered materials and fabricated materials.

- **Bulk materials:** Bulk materials- these are materials manufactured to standards and are purchased in quantity. They are bought in standard length or lot quantities. Examples of such materials include pipes, wiring, and ethics. They are more difficult to plan because of uncertainty in quantities needed.
- **Engineered materials-** these materials are specifically fabricated for a particular project or are manufactured to an industry specification in a shop away from the site. These materials are used for a particular purpose. This includes materials that require detailed engineering data.
- **Fabricated materials**- these 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.

## 2.2 EFFECTS OF MATERIAL MANAGEMENT

- Poor planning and control of materials, lack of materials when needed, poor identification of materials, re-handling and inadequate storage cause losses in labor productivity and overall delays that can indirectly increase total project costs.
- Effective management of materials can reduce these costs and contribute significantly to the success of the project.

- Based on the studies presented, it is clear that effective management of materials can minimize the impact that lack of materials or improper management of materials could have on the overall schedule and cost of the project.

## 2.3 BENEFITS OF MATERIAL MANAGEMENT

An effective material management system can bring many benefits for a company. Previous studies by the Construction Industry institute (CII) concluded that labor productivity could be improved by six percent and can produce 4-6% additional savings (Bernold and Treseler, 1991). Among these benefits are:

- Reducing the overall costs of materials
- Better handling of materials
- Reduction in duplicated orders
- Materials will be on site when needed and in the quantities required
- Improvements in labor productivity
- Improvements in project schedule
- Quality control
- Better field material control and good relationship with suppliers
- Reduce storage of materials on site
- Labor savings and stock reduction
- Purchase savings and better cash flow management

## 2.4 CHALLENGES OF MATERIALS MANAGEMENT

The following are some of the challenges encountered in materials management;

- Process of purchasing and supply of materials, the challenges often occurs when the materials are not equivalent as the ordering purchase, the skipped list out ordering materials, timing of materials arriving, quantities of materials, lack of training and adequate management, lack of communication and relation between contractor and supply chain arc the main impediments.
- The executive and monetary process of payment
- The specification and measurement of the materials in construction site the challenges are obvious which are specifically as:
- The quantity ordered more than the needed quantity
- Mistaken time delivery which interrupts the work schedule
- Wrong material or fault in track of materials which will eventually lead to double work

## 3.0 METHODOLOGY

The data for the research was obtained through a well structured questionnaire designed to assess the views of respondents on material management on building construction sites. Respondents were asked to rate their perception regarding the level of importance of these strategies on a four (4) point likert ordinal scale where 4totally agree, 3agree, 2=disagree, and I —totally disagree.

The study was carried out in Port Harcourt, Rivets state capital. The questionnaires were given to contractors in their main offices and their representatives on construction sites. A total of

forty (40) questionnaires were being distributed. 1-linkel Et al (1998), however believes that the minimum sample size that allows normal distribution assumptions to be used rather than using at-distribution is 30. Hence, the Sample size of 40 is inline.

Data obtained from the survey were analyzed using mean score index to rank the severity of the factors using the formula;

$X = \sum (W \times R)/N$

Where, W=the weight assigned to each strategy by the respondents,

R = number of respondents,

N = total number of the respondents. Eleven variables related to factors that hinder productivity as a result of poor material management were obtained from the interviews conducted. This form is the background of the questionnaires that divided into 5 groups, namely; material schedule, material scheduling, material control, material handling and material storage.

The study also made use of related literature to address the problems identified in the study.

| S/N | FACTORS | RANK SCORE | | | |
|---|---|---|---|---|---|
| | | 1 = TOTALLY AGREE | 2 = DISAGREE | 3 = AGREE | 4 = TOTALLY AGREE |
| | **Material Schedule** | | | | |
| 1. | Lack of establishment of total approximate quantities of materials before orders are made | | | | |
| 2. | Lack of consideration in detailing the period over which deliveries can be spread without affecting the contract. | | | | |
| 3. | Delay in receiving materials on sites | | | | |
| | Material Scheduling | | | | |
| 4. | Lack of consideration of making deliveries of materials at scheduled dates and times. | | | | |
| 5. | Lack of keeping adequate buffer stock in case of delay in receiving materials. | | | | |
| 6. | Non consideration of stacking materials at | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | various points where work is going on. | | | | |
| | Material Control | | | | |
| 7. | Lack of planning of sites to indicate main storage area and stockpiles. | | | | |
| 8. | Lack of co-ordination of movement of plant handling materials. | | | | |
| | Material storage | | | | |
| 9. | Inadequate protection of materials (which can cause problems of workmanship and general finish) | | | | |
| 10. | Lack of procedures for checking, inspecting and documentation of materials. | | | | |
| 11. | Lack of coordinated system of withdrawing materials from the stores. | | | | |

Finally, forty questionnaires were properly completed and returned as shown in table 2. In order rank the severity of the factors, a mean score was employed.

**Table 2: Response on factors responsible for poor material management.**

| S/N | FACTORS | RANK SCORE | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 = TOTALLY DISAGREE | 2 = TOTALLY DISAGREE | 3 = AGREE | 4 = TOTALLY AGREE | TOTAL | MEAN SCORE | MEAN BANKING |
| | **Material Schedule** | | | | | | | |
| 1. | Lack of establishment of total approximate quantities of materials before orders are made. | 5 | 8 | 12 | 15 | 40 | | |
| 2. | Lack of consideration in detailing the period over which deliveries can be spread without | 6 | 7 | 13 | 14 | 40 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | affecting the contract. | | | | | | | |
| 3. | Delay in receiving materials on sites. | 4 | 6 | 12 | 18 | 40 | | |
| | Material scheduling | | | | | | | |
| 4. | Lack of keeping adequate buffer stock in case of delay in receiving materials. | 2 | 8 | 13 | 17 | 40 | | |
| 5. | Lack of keeping adequate buffer stock in case of delay in receiving materials. | 3 | 7 | 10 | 20 | 40 | | |
| 6. | Non consideration of stacking materials at various points where work is going on. | 1 | 9 | 12 | 18 | 40 | | |
| | Material Control | | | | | | | |
| 7. | Lack of planning of sites to indicate main storage area and stockpiles. | 4 | 7 | 10 | 19 | 40 | | |
| 8. | Lack of co-ordination of movement of plant handling materials. | 2 | 6 | 12 | 20 | 40 | | |
| | Materials storage | | | | | | | |
| 9. | Inadequate protection of materials (which can cause problems of workmanship | 3 | 6 | 11 | 20 | 40 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | and general finish). | | | | | | | |
| 10. | Lack of procedures for checking, inspecting and documentation of materials. | 5 | 5 | 11 | 19 | 40 | | |
| 11. | Lack of coordinated system of withdrawing materials from the stores | 2 | 8 | 12 | 18 | 40 | | |

## 4.0 RESULTS AND ANALYSIS

Table 3: The mean ranking of the factors;

| S/N | FACTORS | RANK SCORE | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 = TOTALLY DISAGREE | 2 = TOTALLY DISAGREE | 3 = AGREE | 4 = TOTALLY AGREE | TOTAL | MEAN SCORE | MEAN BANKING |
| 1. | Lack of co-ordination of movement of plant handling materials. | 2 | 6 | 12 | 20 | 40 | 3.25 | 1 |
| 2. | Inadequate protection of materials (which can cause problems of workmanship and general finish). | 3 | 6 | 11 | 20 | 40 | 3.20 | 2 |
| 3. | Lack of keeping adequate buffer stock in case of delay in receiving materials | 3 | 7 | 10 | 20 | 40 | 3.18 | 3 |
| 4. | Non consideration of stacking materials at various points where work is going on. | 1 | 9 | 12 | 18 | 40 | 3.18 | 3 |
| 5. | Lack of coordinated system of withdrawing materials at | 2 | 8 | 12 | 18 | 40 | 3.15 | 5 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | scheduled dates and times. | | | | | | | |
| 6. | Lack of consideration of making deliveries of materials at scheduled dates and times. | 2 | 8 | 13 | 17 | 40 | 3.13 | 6 |
| 7. | Delay in receiving materials on sites. | 4 | 6 | 12 | 18 | 40 | 3.10 | 7 |
| 8. | Lack of planning of sites to indicate main storage area and stockpiles. | 4 | 7 | 10 | 19 | 40 | 3.10 | 7 |
| 9. | Lack of procedures for checking, inspecting and documentation of materials | 5 | 5 | 11 | 19 | 40 | 3.10 | 7 |

Table 3 above shows the responses to the factors affecting materials management in building/construction sites and the mean ranking. Result shows that factor eight(8) with a mean score of 3.25 and mean ranking of 1 which falls under material control is mostly responsible for ineffective materials management and Lack of Consideration in detailing the period over which deliveries can be spread without affecting the contract which falls under material storage has the least mean ranking.

## 5.0 CONCLUSION AND RECOMMENDATION

This study has reviewed the problem areas in materials management which need to be addressed. The most significant among them are non-preparation of material schedule and material scheduling. Now that the problem areas have been identified, measures should be taken by contracting organizations P upgrade their performance. This could be achieved by engaging full time estimators or quantity surveyor and material controllers. The estimators would provide figures on materials to be delivered in bulk. These will go a long way to reduce cost thereby contributing to the profit of the contractor.

In preparing schedules, the building sequence could be broken down into operational groups such as;

- Substructures
- Superstructures
- Finishes
- Painting and decoration
- Plumbing and electrical installation
- External work

Other construction works can also be divided into stages for easy planning and supply of materials to avoid wastages or stockpiling the site with materials, which may lead to wastage or theft as the case may be.

The value of materials stored on sites together with the controls needed for distributing material availability of adequate supplies; as well as ensuring that correct materials are supplied in the first ph suggests that the only way to solve the problem satisfactorily is by assigning responsibilities to material controllers (builders or quantity surveyors).

The above suggestion if put in place, will help solve such problem as; Inadequate stockpile of materials at work locations.

- Time wastages
- Material wastages
- Delay in supply of materials on site
- Inadequate materials on site, and
- Contract period extension.

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