MAN, WATER AND ENVIRONMENT: MAKING LIFE COMFORTABLE FOR THE FISH

By

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College of Environmental Resources Management
Federal University of Agriculture, Abeokuta, Nigeria

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Series No. 100

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This 100th Inaugural Lecture was delivered Under the Chairmanship

of

The Vice-Chancellor

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PROTOCOLS

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Distinguished Academic and Professional Colleagues in FUNAAB and from other Institutions,

Members of my family,

Gentlemen of the Press,

Distinguished Ladies and Gentlemen,

Great FUNAABites!

PREAMBLE

Mr Vice Chancellor Sir, with reverence, humility, due respect and appreciation to the most high God, the giver of life with whom there is no variableness of life, comes this auspicious time in my voyage as a University scholar to deliver the 100th Inaugural Lecture of this prestigious citadel of learning, this day, Wednesday, April 2, 2025. This period almost coincides with my Diamond jubilee, to the utmost glory of the almighty God.

Inaugural lecture is an academic obligation for all professors in the course of their academic career to showcase their achievements/contributions to knowledge in order to solve the myriads of problems facing the society or humanity at large. It is indeed, an academic exercise to specifically mark the appointment of a University Professor. This exercise therefore, gives me the rare privilege to share my close to 25 years of experience in the world of academics as I stand before you today.

I came into this University as a student in 1987, under the erstwhile College Science and Technology (COSTAB), University of Lagos Abeokuta Campus. But in 1988 with the establishment of University of Agriculture Abeokuta, I was among the first set of students in the erstwhile Department of Forestry, Fisheries and Wildlife Management. Thereafter, I became the first Master of Aquaculture and Fisheries (Fish Pathology) and Ph.D (Fish Pathology) student, respectively.

The number 100 is spectacular, in that, the prime factors are 1 and 10. The first in the Inaugural Lecture Series of this great University titled: Once Upon A Forest, came from the College of Environmental Resources Management, COLERM, by the revered Emeritus Professor Julius Amioba Okojie, the former

Vice Chancellors of UNAAB and The Bells University, Ota; and the former Executive Secretary, National University Commission. Today, the 100th is being presented by Professor Adeolu Akanji Akinyemi also from COLERM, the college of the maiden presenter. I am therefore through unmerited favour of God, the centenary Inaugural Lecturer of FUNAAB. This is a milestone in the series of inaugural lectures of this great University.

Furthermore, the first inaugural lecture from the Department of Aquaculture and Fisheries Management was delivered by Professor Samuel Olu Otubusin, followed by my amiable major supervisor, Professor Godfrey Nnamdi Onyenoro Ezeri (the first Professor of Fish Pathology), the third was by Professor 'Yemi Akegbejo – Samsons and the fourth is being delivered today. It happens to be the second by a Professor of Pathology in the Department of Aquaculture and Fishereis Management, the very first by an alumnus of the Department of Aquaculture and Fisheries Management.

1.0 INTRODUCTION

Genesis Chapter 1, beginning from verse one to twenty dwelt extensively on creation of the universe. No wonder, the world today comprises 75% waters. We have surface waters covering the Oceans of the world, seas, rivers, streams, lakes, ponds, beels, etc. and underground waters (some of these are accessed through boreholes, wash bores, wells, etc).

These different water bodies have diverse creatures in them, such that the highest level of species diversity of the world is found in the aquatic ecosystems. The resources in the aquatic environment include aquatic plants and animals in their different array, which are either macro or micro in nature. The

management of the aquatic ecosystem is now evolving as the blue economy.

1.1 Diseases and health of fishes

Mr Vice Chancellor Sir, I have developed interest and passion in fish pathology, devoted time to knowing what happens at different levels of interplay among the unique features of the aquatic ecosystem. These interactions and imbalances in the aquatic ecosystem result into factors predisposing occurrences of diseases in fish culture systems. Fin and shell fishes are susceptible to diseases caused by pathogens, under favorable environmental conditions. Thus, their health and survival depends greatly on this interplay.

The Host includes all living things in the aquatic environment (plants and animals of our water bodies), but my presentation here focuses on fin and shell fishes. The Environment has to do with marine, brackish and fresh water bodies. These water bodies are distinguished based on their marked variations in their physical and chemical characteristics which are greatly influenced by the dynamics of the global ecosystem of which climate change is a strong phenomenon and of growing concern.

The Pathogens include parasites, bacteria, fungi and viruses capable of inflicting injuries and health hazards to the host above. This presentation is broadly on fish bacteria among others. The interplay of these factors shows that the host will be relatively healthy until there is intersection of the three factors (host, pathogen, and environment).

2.0 MY CONTRIBUTIONS TO KNOWLEDGE

Mr Vice Chancellor, Sir, principally, all my studies and research works have been on the Sustainable Development Goal of the United Nations, SDG 14: Life below water (the blue economy) either directly, tangentially or indirectly. Nonetheless, the import of the whole exercise has to do with SDG 15: Life on Land which has to do with humanity. Listed below are the subject areas of my research focus:

a. Fish health
b. Fish pathology
c. Ecotoxicology
d. Fisheries management
e. Fish nutrition
f. Fish processing and preservation
g. Fish breeding

2.1 Fish health

The success of any fish husbandry depends on early detection of problems, which is very crucial for effective treatment and prevention of fish diseases by ensuring adequate cultural practices. My efforts in studying fish microorganism is to provide data base for effective monitoring and evaluation of the health status of fish.

2.1.1 Microbiology of Fin Fishes

Micro-organisms are naturally present in fin and shell fishes. Some of these microorganisms are capable of causing diseases, which are of economic importance to fish husbandry. A host of studies were done by me in this area.

Akinyemi and Ajisafe (2011) studied the occurrence of bacteria in the buccal cavity, gill and skin of *Chrysichthys nigrodigitatus,*

Sardinella maderensis, and *Mugil cephalus* from Lagos Lagoon. The viable bacteria count in the three fish samples (cfu/ml). *C. nigrodigitatus* had a range of 2.0×10^3 to 2.90×10^4 in the skin, 1.64×10^4 to 2.99×10^4 in the buccal cavity and $1.1\times10^3$to 2.56×10^4 in the gill. For *Sardinella maderensis* the range in the skin was 1.6×10^{3t} to 2.78×10^4, 1.5×10^3 to 2.95×10^4 in the buccal cavity and 5.7×10^3 to.58×10^4 in the gills while for *Mugil cephalus*, the skin had a range of 5.7×10^3 to 2.58×10^4; 6.3×10^3 to 2.83×10^4 in the buccal cavity and 2.1×10^3 to 2.78×10^4 in the gills. The occurrence of bacteria flora from gills, buccal cavity and skin of the three fish samples. It indicated that *Escherichia coli* had 11%, 8% and 8% occurrence in the skin, buccal cavity and gills of *Chrysichthys nigrodigitatus* respectively. *Pseudomanas aeruginosa* had the highest percentage occurrence in the buccal cavity and gills of *Sardinella maderensi* and *Mugil cephalus* also respectively. *Enterobacter aeruginosa, Staphylococcus epidermis* recorded the least percentage occurrence in the buccal cavity of *Mugil cephalus* recording 6%. *Enterobacter aeruginosa* recorded in *Chrysicthys nigrodigitatus* the gills, none in the skin and buccal cavity of and in other fish species used, while Staphylococcus epidermis had 6% in the gills of Mugilcephalusand none in the buccal cavity and skin, and in other species used.

This work provided information on the bacterial flora from the gills, buccal cavity and skin of three commercially important brackish water fish species such as *Chrysichthys nigrodigitatus, Mugil cephalus,* and *Sardinella maderensis* which support huge artisanal and culture fisheries in Nigeria. Hence, this study confirmed the existence of pathogenic bacterial organisms which are of public health importance. Revealing that fish can be infected with a variety of microbial species especially those bacteria in the brackish environment. The isolates from the gills,

buccal cavity and skin can be accounted for mainly by the filter effect of the gills, the feeding habit or the slime layer of the skin, also partly as a result of the active bacteria multiplication and adaptation. The isolates have the potentials to cause serious infections to fish, to the animals that feed on them and finally to man.

2.1.2 Microbiology of Processed Shellfishes

Food-borne illnesses are caused by bacteria, fungi and viruses capable of inhabiting processed shell fishes. These could include Salmonella, Listeria, *Escherichia coli* to mention but a few.

Our research team (Olaoye *et al.* 2014) isolated and characterized micro-organisms of *Macrobranchium* spp. gotten from markets in Abeokuta Metropolis. Samples of whole smoked prawns (*Macrobranchium* spp.) were collected from two different locations each in six major markets (Itoku, Omida, Iberekodo, Lafenwa, Panseke and Olomore) within the Abeokuta metropolis in Ogun State. Their microbial load was analyzed using Mac-Conkey agar (MA), Deoxycholate citrate agar (DCA), Nutrient agar (NA), and Mannitol salt agar (MSA) for bacteria isolation while Potato Dextrose agar (PDA) used to isolate the fungi in the microbiology laboratory of the Department of Microbiology, Federal University of Agriculture, Abeokuta. *Staphylococcus aureus* and *Citrobacter s*pp (22.22% each) dominated the samples while the fungal species that occurred most frequently in the samples was *Aspergillus niger* (31.03%). The total bacterial counts for all the samples ranged from $9x10^2$ to $1.0x10^3$ cfu/g and fungal count were between 21%-90% in terms of frequency of occurrence. These microorganisms cause food spoilage and poisoning. The occurrence of such microorganisms may be as a result of unhygienic handling of prawns during processing as some of the

microorganisms may be post-harvest contaminants. Adequate cooking could help in reducing microorganism of smoked prawn. The total counts were generally high and it ranged from $1.1x10^3$ to $9x10^2$cfu/g. Samples from locations 1 and 3 (Kuto and Lafenwa) possessed the highest bacteria load (22.04% and 22.95%) respectively; locations 2 and 5 (Iberekodo and Olomore) had the least bacteria load of 10.63% and 9.56% respectively. Though, location 3 had a higher bacterial load as compared with location 1 but there was no significant difference between the bacterial loads of the samples from the two locations. Similarly, location 3 (Lafenwa) had the highest load of fungi (32.89%), followed by samples from location 2 (Iberekodo 22.09%), samples from 4 had the least fungi load.

2.1.3 Sensitivity of Microorganisms to Synthetic Antibiotics

Antibiotics are deployed in the chemotherapy of micro-organisms. However, each microorganism exhibits different susceptibility level to the antibiotics, while others are wholly resistant in the presence of same antibiotics.

2.1.3.1 Sensitivity of micro–organisms associated with smoked cured fresh water prawn in open markets in Abeokuta

Akinyemi (2013) studied the sensitivities of microorganisms of smoked cured fresh water (Microbranchium) in four (4) different markets in Abeokuta (Itoku, Lafenwa, Kuto and Omida). The following antibiotics were examined for the susceptibility of the bacteria species to them. Amoxilin, Augumentin, Cloxacilin, Erythromycin, Cotrimozazole, Nalaxidic Acid, Nitrofurantin, Oflaxacin, Gentamycin and Tetracycline. However, Gentamycin and Tetracycline were found to be more effective as the bacteria species were more resistant to the other antibiotics.

In another study, Akinyemi *et al*. (2012) investigated the occurrence and sensitivity of bacteria found in gills, skin, buccal cavity of *Mormyrus Rume, Labeo ogunensis,* and *Oreochromis niloticus* in Ogun River to synthetic antibiotics. Specimens collected from Ogun River were examined for bacterial flora from the gills, skin, and buccal cavity of these species. The different bacteria isolated were tested for their sensitivities to different antibiotics. Nine (9) bacteria were identified (*Staphylococcus aureaus, Proteus mirabilis, Klebsellia pneumonia, Pseudomonas aerogenosa, Escherichia coli, Proteus vulgaris, Enterobacter aerogenes, Serretia marcescens* and *Salmonella* spp). The incidence of the bacteria count of *Mormyrus rume* was highest in the skin (5.00±0.60, f<0.05) than gills (3.60±0.98, f<0.05) and buccal cavity (1.22±0.76, f<0.05), in *Labeo ogunensis,* bacteria count was highest in skin (5.30±0.70, f<0.05) than gills (4.80±0.80, f<0.05) and buccal cavity (3.70±1.07, f<0.05), in *Oreochromis niloticus,* bacteria count was also highest in skin (6.20±0.83, f<0.05) than gills (5.95±0.79, f<0.05) and buccal cavity (4.54±0.78, f<0.05).

Antibiotics used were selected based on their different effects on the bacteria. Gentamicin and Ceforoxime were found most active because all the bacteria isolated was either sensitive or intermediately sensitive to them and while Ofloxacin and Caftazidime were found least active in bacteria like *Proteus vulgaris,* Sparfloxacin and Caftazidime were found least active in *Proteus mirabilis* and Caftazidime was most active for *Staphylococcus aureaus*. Ceforoxime and Caftazidime are cephalosporin and act on the cell wall of the bacteria, Ofloxacin, Sparfloxacin and Ciprofloxacin have Quinoline while Gentamicin acts on the protein. In the results Gentamicin and Ceforoxime were found most active possibly because of the

presence of the factor that helped disable the bacteria and allowing it to be sensitive to the antibiotics.

2.1.4 Application of Biotechnology in Fish Health Studies

Biotechnology is a tool capable of enhancing sustainable aquaculture, in that it helps to improve fish health, due to its rapidity in pathogen identification among others benefits.

Akinyemi and Oyelakin (2014) carried out molecular characterization of bacteria isolates from farm-raised catfish *Clarias gariepinus* using selected bacterial isolates from skin, gut and gills of *Clarias gariepinus* collected from five fish farms at Ijebu Ode. The isolates were assessed using 16S rRNA gene sequencing method to identify them and to construct the phylogenetic relationship. Ten isolates were selected, their colonial morphology determined, and their DNA were prepared using CTAB method. PCR amplification of 16S ribosomal RNA gene of isolates was carried out using universal primer for bacteria, purification of the PCR product using ethanol precipitation. Thereafter sequenced using an automated DNA sequencer. These sequence data were compared with other gene sequences in GenBank database (NCBI) using a BLAST search to find closely related sequences. Eighty percent (80%) of the isolates belonged to different species of Pseudomonas, sharing 92% to 96% 16 S ribosomal RNA identity with the respective type-strain, whereas the remaining 2 isolates belonged to *Pediococcus acidilactici* and *Lysinibacillus fusiformis* with 96% 16S ribosomal RNA homology.

The size of the amplified band with 16S universal primer was 1.6Kb for the 10 samples (Plate 1). The blasting of the sequence for the isolates showed that there were three types of bacteria species present. The bacteria are eight Pseudomonas species,

one Lysinibacillus fusiformis and one *Pediococcus acidilactici*. The eight isolates had 96% homology identity with Pseudomonas, Lysinibacillus (96% homology) whereas Pediococcus had 91% homology. (Fig. 1) showed the clustering analysis for the ten strains, Pseudomonas flluorescens, lysinibacillus fusiformis, Pseudomonas plecoglossicid and, Pseudomonas nitroreducensare very closely related forming one sub-group. The isolates in the second sub-group are Pseudomonas flluorescens, Pseudomonas nitroreducens and Pediococcus acidilactici while Pseudomonas putida and two Pseudomonas flluorescens species stand alone.

Isolates related to Pseudomonas were represented by P. fluorescens (isolates code: ES1A, CT3A, CG3A, AS1D), P. nitroreducens (isolates code: AS1B, BG1A), P. plecoglossicida (isolate code: AS3B), P. putida (isolate code: AS3A) while Lysinibacillus fusiformis (isolate code: BT1A) and Pediococcusacidilactici (isolates code: AS1A).

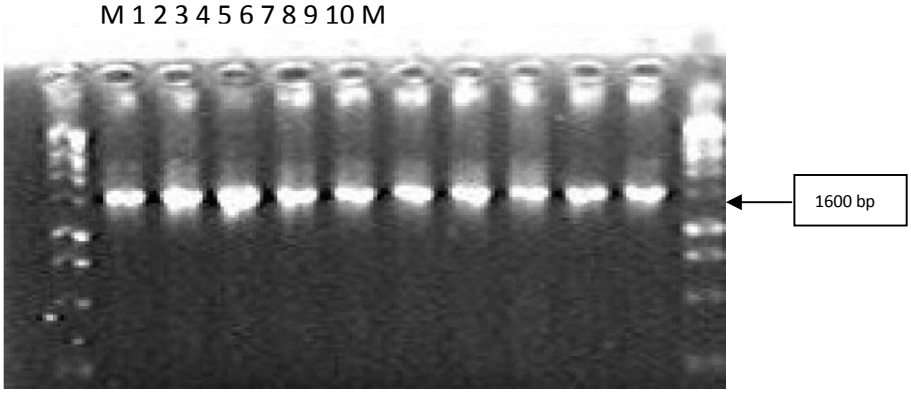


Plate 1: Electrophoresis gel for the isolates using 16S universal primer

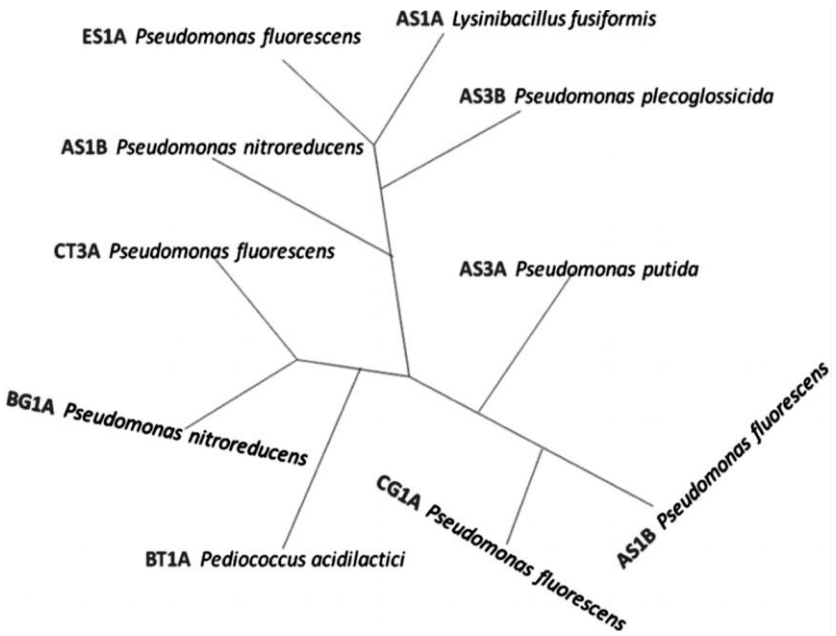


Fig. 1: Clustering Analysis for the Bacteria isolates

The DNA target for amplification using PCR technique was 16S ribosomal RNA in accordance to view of [9] that 16S rRNA has its presence in almost all bacteria, often existing as a multigene family, or operons and the function of the 16S rRNA gene over time has not changed, suggesting that random sequence changes are a more accurate measure of time (evolution); and the 16S rRNA gene (1,500bp) is large enough for informatics purposes. Fragment of 16S rDNA gene was amplified by PCR using 16S rDNA specific universal forward and reverse primers, 8F [5'AGAGTTTGATCCTGGCTCAG3'] and 1492R [5'ACGGCTACCTTGTTACGACTT3'] respectively against

forward primer (9F; 5'GAGTTTGATCCTGGCTCAG-3' and reverse primer (1510R; 5'GGCTACCTTGTTACGA-3 '). The size of the amplified band in this study was 1,600bp for the 10 bacteria isolates. The BLAST search shows that most selected isolates belong to the Gram negative group. As the major gram negative bacteria strain found, the dominance of *Pseudomonas* species in the ponds suggested that ponds should be allowed to dry out completely to eliminate or reduce *Pseudomonas* species bacterial pathogens.

2.1.5 Antimicrobial Resistance (AMR) to Synthetic Antibiotics

The ability of microorganisms to produce mechanisms in their body system to withstand effect of anitibiotics on them is becoming an issue of global concern, because such drugs becomes ineffective and the challenge posed by the illness is protracted.

Molecular detection of tetracycline types (A) and (B) resistant genes in bacteria associated with C*hrysichtys nigrodigitatus* was carried out by Oyelakin *et al.* (2023). Bacteria found in the gills intestine and skin were characterized using Tetracycline types A and B resistant markers. We had 135 isolates in total, there were five bacteria found in the gills, intestine and skin of the *Chrysichtys nigrodigitatus.* The five bacteria isolates included *Escherichia coli, Staphylococcus aureus, Bacillus spp, Salmonella spp and Pseudomonas auregenosa.* It was revealed that the isolates were sensitive to Ciprofloxacin, Pelfloxacin, and Tarivid. It was also indicated that all the bacterial isolates were susceptible to Ciprofloxacin and Sparfloxacin. The result on *Escherichia coli* showed susceptibility to Pefloxacin, Ciprofloxacin and Tarivid while it equally showed resistance to Streptomycin, Augmentin and Amoxacillin, Gentamycin, Septrin and Chloranphenicol. The molecular detection showed

that *Escherichia coli* and *Salmonella spp* were susceptible to Tetracycline Type A while others were resistant to it, so therefore tetracycline type A can only be used to treat infection with *Escherichia coli* and *Salmonella* spp.

2.1.6 Alternative to Synthetic Antibiotics

This study was carried out by Awe *et al* (2013). The result of Phytochemical analysis obtained from ethanolic leaf extract of *A. wilkesiana* indicated that cardiac glycoside and alkaloids were slightly present; saponin, flavonoids, Phylobatanins and glycosides (reducing sugar) are moderately present while tannin and glycoside (from glycosides) are highly present. Phylobatanins, alkaloids and cardiac glycosides are slightly present in Leucaena, saponin and flavonoids are moderately present while tannins and glycosides (reducing sugar and glycoside) are highly present. Alkaloids was absent in Sena and Saponin was slightly present. Tannins, flavonoids, phylobatanins, glycosides (reducing sugar and cardiac glycosides are moderately present while glycoside from glycosides was highly present. Phylobatanins and glycosides from glycosides was absent; saponin, alkaloids are slightly present while tannins, flavonoids, glycosides (reducing sugar)and cardiac glycosides were highly present. The results of this study showed that *Acalypha wilkesiana, Leucaena leucocephala, Peperomia pellucida* and *Senaa alata* contains pharmacologically active principles which are extensively used in chemotheraphy useful in the treatment of bacterial infections and related diseases in fish and enhancing immune responses which are of great immense medicinal value.

2.1.7 My Research Voyage and Adventure (Escapade) into Yewa Land and on Yewa River

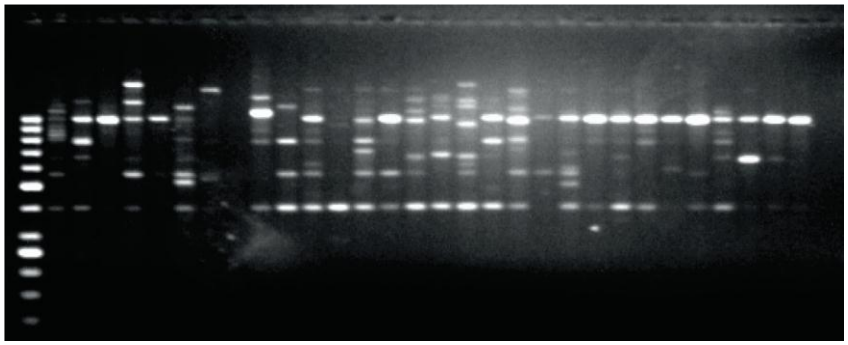
Mr Vice Chancellor, Sir, during the course of my research voyage, I was not unmindful of the place of my birth and the sepulcher of my fathers. In this regard, I made a modest intervention by studying fish health in the major river of Yewa Land, Yewa River thus contributing in a way to the public health of my cherished people. In doing this, I constituted a 25 man research team to unravel the microbial composition of fishes along the river course right from the point of entry into Nigeria untill it drains or empties into the Atlantic Ocean. The locations of our sample collections were Egua, Ebuta Gbooro, Yewa Mata, Idogo, Ijaka Oke and Ajilete. Our microbiological studies of Yewa River were published in 12 off shore (international) journals.

2.1.7.1 Genetic Diversity Studies of Bacteria Isolated from Clarias Gariepinus at Ajilete along Yewa River in Nigeria Using Random Amplified Polymorphic DNA (RAPD) Techniques and their Antibiotic Resistance Profile

Oyelakin *et al* (2016) studied the genetic diversity of bacteria isolated from *Clarias gariepinus* at Ajilete along Yewa River in Nigeria using Random Amplified Polymorphic DNA (RAPD) techniques and their antibiotic resistance profile. Pathogenic bacteria are responsible for heavy mortality in both wild and cultured fish. Molecular characterization was carried out using Random Amplified Polymorphic DNAPolymerase Chain Reaction technique (RAPD-PCR), sensitivity to antibiotics of bacteria in *Clarias gariepinus* post juveniles sampled. Bacteria were isolated from the gut, gills and skin of the fish. Identification was done using the conventional culture-based method. Bacteria isolates were selected and the DNAs were extracted using CTAB method, PCR amplification of the

isolates was carried out using RAPD primer and five primers were used. Data collected were subjected to descriptive (mean and standard deviation) statistics.

There were 63 polymorphic and 14 monomorphic markers generated from the five RAPD markers. The primers generated 77 alleles altogether (Figure 2). Out of the 10 antibiotics used, Cephalexin recorded the highest inhibition zone (33 mm) on one sample, Gentamicin on second sample had (30 mm). The least inhibition zone was recorded in Cotrimoxazole on the second sample with (8 mm), 70.5% bacteria strains were susceptible to Gentamicin while two samples displayed 100 % resistance to all the antibiotics. These were pathogenic and opportunistic bacteria species in *C. gariepinus* which could be zoonotic (Plate 2).



M 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Plate 2: Electrophoresis gel for RAPD primer (OPH-08)

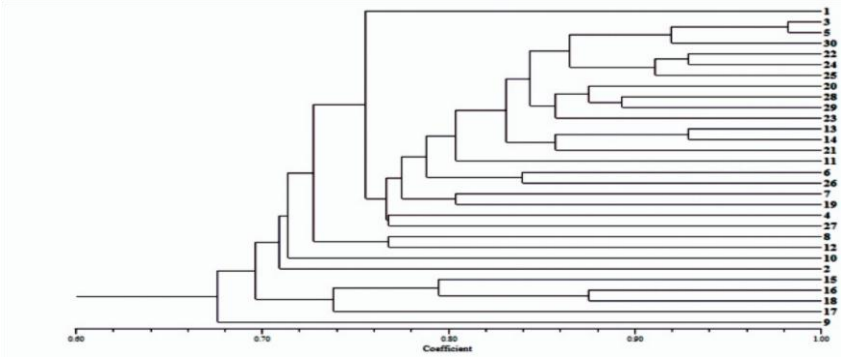


Figure 2: Cluster analysis of the 30 selected

2.1.7.2 *Molecular Characterization and Antibiotic Resistance Profile of Bacteria Associated with Brycinus Longipinnis from Egua Station on Yewa River*

Morphometric characteristics of *Brycinus longipinnis* from Eggua station on Yewa River has indicated that fish samples were as follows: mean value in weight, standard length, total length and head length of 245±0.2 g 8.8±0.2 cm, 9.6±0.2 cm and 3.4±0.1 cm respectively. The size of the amplified band using 16S universal primer was 1.6 Kb for the 14 samples. The blasting of the sequence for the isolates showed that there were different types of bacteria species present. There were eight different bacteria strains that were identified; there were three *Pseudomonas* spp*, one Pseudoalteromonas* spp*, two Enterobacter cloacae, two Escherichia coli, one Serratia marcescens, two Proteus* spp*, one Alcaligenes faecalis, two Comamonas* spp. The most occurrencing bacteria were *Pseudomonas spp* and *Enterobacter* spp. The highest bacterial isolates were found in the gut, followed by skin and then the gill. The gut and skin had *Escherichia coli* in common. Cluster analysis showed *Proteus* spp*, Escherichia coli, Alcaligenes*

faecalis, Serratia marcescens were grouped together in the first group and others were grouped together as well. The level of resistance and sensitivity of these bacteria to clinically relevant antibiotics differs. Among the isolates, 70% bacteria strains were sensitivity to Ofloxacin while 95% showed high resistance rate to Cefuroxime and 60% to Augmentin. The study has clearly showed variation in bacterial species in different parts of *B. longipinnis* collected from Eggua station on Yewa River. The results also revealed that *Pseudomonas spp.* is the predominant bacteria found in *B. longipinnis*, with a few strains of *Comamonas* spp, *Pseusdoalteromona* spp, *Proteus* spp, *Escherichia coli, Serratia marcescens and Enterobacter* spp. with high level antibiotic resistance. It was also observed that most of the bacterial isolates from *B. longipinnis* showed high rate of resistant pattern.

2.1.7.3 Genetic Diversity Study of Bacteria Associated with Clarias Gariepinus from Ebute-Igbooro on Yewa River Using Random Amplified Polymorphic DNA

Genetic study of bacterial isolates found in the guts, gills and skin samples of catfish obtained from Ebute Igbooro landing site of Yewa River was carried out using Random Amplified Polymorphic DNA Chain Reaction Techniques.Bacterial isolates were obtained from samples grown in culture medium using Nutrient agar. Subculturing was done in order to obtain the pure isolates. Five RAPD primers were used, a total of number of 62 markers were generated with 54 being polymorphic and 8 being monomorphic. Two main groups were observed from the dendrogram derived from the RAPD results. Group 1 consists of one organism while Group 2 consists of 19 organisms. Group 2 was further divided into sub groups with each sub group having its own constituent of organisms.

Haemolysis test carried out on this bacteria isolates to determine their pathogenicity and this showed that 12.5% of the organisms indicated complete haemolysis, 37.5% indicated incomplete haemolysis while the remaining 50% indicated no haemolysis. The results show that RAPD fingerprinting is one of the best molecular tools for identification. The presence of these organisms were known to be a major cause of infections in human and animals as it signified a potential threat to farmers who tend to source for their seeds in the wild, fishermen and also consumers through potential transfer of resistance to human and animal pathogens. RAPD marker could be used to study the genetic diversity of bacteria associated with fishes in the wild pointed towards the amplicons generated by OPH-08. The species specificity can be confirmed only by checking these primers with isolates of other similar bacteria.

2.1.8 Nanotechnology Approach in Fish Health

Application of nanotechnology in fish health has a lot of prospects, in that it is capable of developing and managing antibacterial activities through the synthesis of nanoparticle drug in chemotherapy.

Comparative studies on antibacterial potentials of cerium oxide and zinc oxide nanoparticles against fish pathogens was studied by Olugbojo *et al.* 2024. Plant-mediated synthesis of nanoparticles has gained significant attention due to its eco-friendliness, non-toxic nature, ease of preparation, and biocompatibility. This study compared the antibacterial potentials of biosynthesized cerium oxide and zinc oxide nanoparticles (CeO_2NPs and ZnONPs) against selected fish pathogens, *Aeromonas hydrophila*, *Aeromonas schubertii*, *Bacillus subtilis*, *Bacillus cereus*, and *Klebsiella pneumoniae*. Qualitative analysis of *Carica papaya* leaf extract was

conducted to examine the biomolecules present, followed by the biosynthesis of the nanoparticles. The obtained CeO_2NPs and ZnONPs were characterized through UV-visible spectrophotometry, scanning electron microscopy, energy-dispersive X-ray spectroscopy, X-ray diffraction, and Fourier-transform infrared spectroscopy to confirm the formation of the nanoparticles. The results showed that CeO_2NPs had a spherical shape with an average size of 46.34nm, while ZnONPs exhibited a cylindrical shape with an average size of 46.34nm, while ZnONPs exhibited a cylindrical shape with an average size of 43.77nm. Antibacterial sensitivity tests (AST) indicated that ZnONPs had greater antibacterial potential than CeO_2NPs against *A. hydrophila* (0.00 and 13.00 ± 1.15mm), *A. schubertii* (16.50 ± 1.73 and 15.50 ± 0.58mm), *B. cereus* (0.00 and 17.00 ± 1.15mm), and *K. pneumoniae* (13.00 ± 1.15 and 16.50 ± 0.58mm). However, CeO_2NPs were more effective against *B. subtilis* than ZnONPs (12.00 ± 1.15 and 13.00 ± 1.15mm). Both nanoparticles showed significant differences in their AST values against *A. hydrophila*, *B. cereus*, and *K. pneumoniae* ($P< 0.05$), while no significant difference was observed against *A. schubertii* and *B. subtilis*. Based on these findings, ZnONPs were more effective than CeO_2NPs against *A. hydrophila*, *B. cereus*, and *K. pneumoniae*, and therefore may be useful in treating fish diseases caused by these pathogens.

2.2 Fish Pathology

Fish pathology has to do with studying the causes, diagnosis and treatment of fish disease, abnormalities and injuries in aquaculture system.

2.2.1 *Pathological study of Clarias gariepinus (Burchell, 1822) sub-adult artificially infected with Pseudomonas aeruginosa*

Amrevuawho *et al.* (2014) carried out pathological study of *Clarias gariepinus* (Burchell, 1822) sub-adult artificially infected with *Pseudomonas aeruginosa*. Hematology and histopathological variations in *Clarias gariepinus* sub-adults subjected to oral challenge with Pseudomonas aeruginosa ATCC27853 were studied for a period of 21 days, with a view to assess the pathogenesis of the bacteria and compared with a control. The symptoms of the infected fish included tail and fin rot, internal hemorrhages and skin patches of superficial ulcers. Tissue sections revealed marked loss and sloughing off of the gill lamellar epithelium, liver showed that hepatocytes appear finely reticulated and foamy; however there were a few foci of large cytoplasmic vacuolations of the hepatocytes and the sinusoids were moderately congested while the intestine showed shortened rugae; the submucosa glands were reduced in numbers; however the surface epithelial cells appeared to be proliferating rapidly and immature (hyperplastic).

There was a significant reduction in the mean values of packed cell volume from 34.67±5.2% to 22.33±0.3%, hemoglobin from 9.77±0.2g/dL to 6.97±0.2g/dL, red blood cell from $2.23\pm0.3x10^{12}$/L to $1.27\pm0.1\ x10^{12}$/L and lymphocyte count from 69.00±2.3% to 52.33±0.9% of C. gariepinus after three weeks of exposure to P. aeruginosa. However, the reverse was the case in the mean values obtained for white blood cell and neutrophil for infected fish which were reasonably higher when compared to that of uninfected fish (17.13 ± 0.5 to10.80 ± $0.3x10^{9}$/L) and (47.33 ± 1.2% to 30.33 ± 2.9%) respectively. It could therefore be concluded that changes in organs and blood parameters of fish occur proportionately to pathogen invasion.

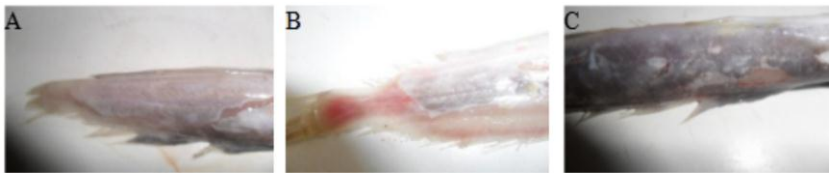


Plate 3. External signs and symptoms of infection in Clarias gariepinus sub-adults infected with Pseudomonas seruginosa: (a) tail and fin

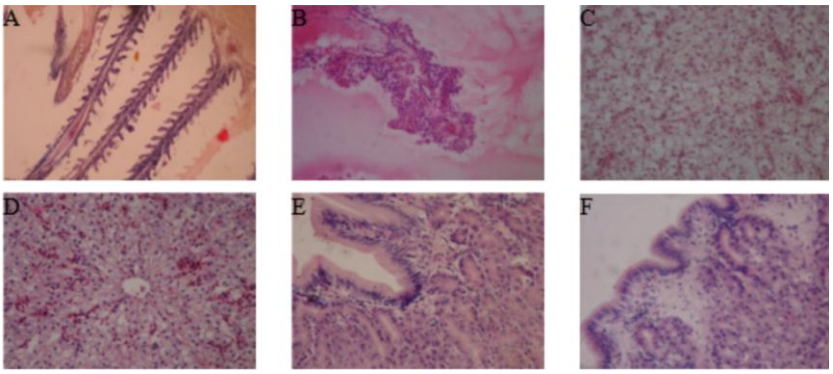


Plate 4. Histopathological changes in the organ of Clarias gariepinus sub-adults infected with Pseudomonas seruginosa: (a) tail and fin

Three weeks (21 days) after exposure, experimental fish exposed to *P. aeruginosa* began exhibiting some signs and symptoms of infection such as discoloration of the skin due to the development of different patches of hemorrhagic and ulcerative skin; the tail and fins started rotting although skin lesions were superficial.

Tissue examination revealed an invasive action of the bacteria pathogen on the organs and tissue of the diseased fish whereas no observable (a) effect rot (b) internal hemorrhage (c) skin patches of superficial ulcers exhibited by *P. aeruginosa* infected fish. (a) Photomicrograph of the gills showed no visible lesion in the gills of uninfected C. gariepinus (100x magnification). (b) Photomicrograph of the gills showed marked loss and sloughing off of the gill lamellae and epithelium of infected fish. (c) Photomicrograph of the liver of uninfected fish showed that the liver had a few foci of hepatocytes containing variably-sized cytoplasmic vacuoles. (d) Photomicrograph of the liver showed that the hepatocytes appear finely reticulated and foamy; there are however a few foci of large cytoplasmic vacuolations of the hepatocytes; the sinusoids are moderately congested. (e) Photomicrograph of the stomach of uninfected fish showed no visible lesions, the rugae are of sufficient height and have a mature tall columnar surface epithelium. (f) Photomicrograph of the stomach of infected fish showed that the ruggae are shortened; the submucosal glands are reduced in numbers; however the surface epithelial cells appear to be proliferating rapidly and immature (hyperplastic) (400x magnification).

The photomicrograph of the stomach of experimental fish exposed to the bacteria pathogen showed that the rugae are shortened; the submucosa glands are reduced in numbers; however the surface epithelial cells appear to be proliferating rapidly and immature (hyperplastic) but this was not the case with uninfected fish which exhibited no visible lesions, the rugae are of sufficient height and have a mature tall columnar surface epithelium at a 400x magnification as shown in the photomicrograph of the organs in Plates 3 and 4.

There was a significant reduction in the mean values of packed cell volume (PCV) from 34.67±5.2% to 22.33±0.3%,

hemoglobin from 9.77±0.2g/dL to 6.97±0.2g/dL, red blood cell (RBC) from 2.23±0.3x10^{12}/L to 1.27±0.1 x10^{12}/L and lymphocyte count from 69.00±2.3% to 52.33±0.9% of C. gariepinus after three weeks of exposure to P. aeruginosa however, the reverse was the case in the mean values obtained for white blood cell (WBC) and neutrophil for infected fish which were reasonably higher when compared to that of uninfected fish (17.13±0.5 to10.80±0.3x10^{9}/L) and (47.33±1.2% to30.33±2.9%) respectively.

Results obtained from this research showed the invasive nature of *P. aeruginosa* not only on the external features of the fish but also on the internal organs and blood parameters. The state of both the internal organs and blood parameters of an organisms are the major indicators of the health of that organism thus the significant difference observed between the infected and uninfected fish is a major indicator of the virulent nature of *P. aeruginosa*. Stressors including overcrowding, high temperature, a sudden change of temperature, rough handling, transfer of fish, poor nutritional status contribute to physiological changes and exacerbate susceptibility to bacterial infection. Thus, there is need for farmers to adhere to good management practices and adequate feeding so as to reduce disease outbreak to the barest minimum.

2.3 Ecotoxicology

Environmental pollution is a growing concern, especially in the aquatic ecosystem due to indiscriminate discharge of toxic effluents into our water-bodies and other anthropogenic activities. The knowledge and continual studies of the constituents of the water-bodies is capable ameliorating ecotoxicity.

2.3.1 Assessment of Heavy Metals in Different Body Parts of Sarotherodon Galillaeus from Ilo-Idimu River, Ota Ogun State, Nigeria

Olugbojo and Akinyemi (2016) assessed heavy metals in different body parts of *Sarotherodon galillaeus* from Ilo-Idimu River, Ota, Ogun State, Nigeria. Ilo-Idimu River is a tropical zone lying between 60.47ºN of the equator and 20.33ºE, and 30.18ºE of the Greenwich meridian. The aim of this research was to determine the concentration of heavy metals in *Sarotherodon galilaeus*; a predominant fish species in Ilo-Idimu River, and its public health significance. The levels of heavy metals concentrations ranged between 0.00 and 3.14, 0.00 and 2.18, 0.52 and 3.08, 0.000.68 and 0.00 and 1.48 mg/kg in the gill, flesh, gut, skin and scale respectively. The highest level of heavy metals was recorded in the gill while the lowest was recorded in the skin. The concentration of each of the heavy metals was significantly different across body parts (P□0.05) except lead. Concentration of most of these heavy metals exceeded the maximum permissible limit. Our results indicated that there is inherent danger in consuming fishes from Ilo-Idimu river.

This study showed that fish take up and bioaccumulates heavy metals in various quantities depending on their concentrations in the water and the route they pass in to the body such as the gill and gastro intestinal tract. Since the concentration of most of these heavy metals in the studied fish and water were more than the recommended limit most especially Cu, Fe and Pb, the people in this area should be discouraged from consuming this fish species until its safety is ascertained.

2.3.2 Assessment of the Pollution Status of Eleyele Lake, Ibadan, Oyo State, Nigeria

A similar study by Olayinka *et al* (2017) assessed the pollution status of Eleyele Lake, Ibadan, Oyo State, Nigeria. The availability of safe and reliable sources of water is an essential prerequisite for development. However, rapid urbanization, population and industrial growth, and other anthropogenic activities have resulted in the mass generation of domestic, municipal and .industrial wastes which are often discharged into surrounding water bodies; making the water unfit for human use as well as threatening aquatic biodiversity Contamination of fresh water sources such as urban lakes with a wide range of pollutants was a matter of concern due to the impact on the ecological balance of the recipient environment and its diversity of aquatic organisms. Eleyele Lake, located in Ibadan, Nigeria, was constructed for the purpose of providing pipe-borne water to the population. It is also used for artisanal fishing.

Water p^H ranged from 6.00 to 7.50, while electrical conductivity ranged from 205.00 to 221.00 µs/cm^3. Dissolved oxygen ranged from 0.30 to 6.00 mg/L and total dissolved solids ranged from 105.00 to 113.00 mg/L. Phosphate levels ranged from 13 to 0.99 mg/L. Nitrate and sulphate in the dry season ranged from (3.10 to 3.80 and 35.81 to 40.97 mg/L) and (0.12 to 0.37 and 6.10 to 10.30 mg/L) in the wet season. Heavy metal concentrations were in the order cadmium (Cd) > zinc (Zn) > copper (Cu) > chromium (Cr) > lead (Pb) for the dry season and Cd > Zn > Cr > Pb > Cu for the wet season. Total PCBs ranged from 493.90 to732.55 µg/L and 52.00 to 390.03 µg/L for the dry and wet seasons, respectively. All determined physical and chemical parameters were within permissible levels, while heavy metals and PCB concentrations were higher than permissible levels. The hazard quotients and carcinogenic risk values were greater

than acceptable limits, indicating that PCBs in Eleyele lake water pose adverse health effects to the local population. It was observed in the study that lower chlorinated PCBs were more prevalent than higher chlorinated PCBs. This may be attributed to the fact that the lower chlorinated PCBs are influenced by atmospheric deposition as a result of their volatility, and they are more susceptible to atmospheric transport than highly chlorinated PCBs. PCBs possess serious health risks to the population that depends on the lake as a source of domestic water and its aquatic organisms.

2.3.3 Assessment of Saxitoxin in Water and Shellfishes within Lagos Lagoon, South Western Nigeria

Oluwafemi *et al*. (2019) assessed saxitoxin in water and shell fishes within Lagos Lagoon, South Western Nigeria. Some micro algae are known to produce phycotoxins that cause various poisoning in humans include Amnesic Shellfish Poisoning (ASP), Diarrrhetic Shellfish Poisoning (DSP) and Paralytic Shellfish Poisoning (PSP). Phycotoxins can enter the food chain when they contaminate and accumulate in various marine species such as fish, crabs or filter feeding bivalves (shellfish) such as mussels, oysters, scallops and clams. These toxins can be toxic for the marine fauna or for consumers via shellfish or fish. Usually these toxins are classified by their clinical signs observed during intoxication. Saxitoxin is a potent neurotoxin produced by microalgae responsible for paralytic shellfish poisoning. The study ascertained the safety of shellfishes obtained from Lagos lagoon. Microalgae identified were Melosirasphaerica, Asterionellopsis glacialis, Corethroncriophilum, Guinardiastriata, Oscillatoria, Microcystis, Coscinodiscus, Rhizosolenia and Scenedesmus. Saxitoxin concentrations in water samples for both wet and dry seasons were 2.1-2.4 and 3.0-3.04 mg/ml respectively. Saxitoxin

concentrations in shellfishes in µg/g for both wet and dry seasons were: carapace of Callinectessapidus69.93 ± 0.90 and 114.71 ± 0.02, pancreas of Callinectessapidus8.18 ± 0.02 and 9.01 ± 0.03, flesh of Pomadasysjubelini12.46 ± 0.09 and 17.86 ± 0.02, head of Pomadasysubelini 52.21 ± 0.06 and 62.11 ± 0.04, shell of Parapeneopsisatlantica 97.83 ± 0.45 and 151.33 ± 0.15, flesh of Parapeneopsisatlantica8.27 ± 0.00 and 9.95 ± 0.00, Mytilusedulis flesh 13.69 ± 0.02 and 17.13 ± 0.02, flesh of Littorinalittorea 6.29 ± 0.01 and 11.39 ± 0.04 and Crassostreagigas flesh 8.04 ± 0.08 and 12.38 ± 0.03 respectively. Consumption of some of these shellfishes may pose a potential health risk to humans depending on the frequency, season and species of sea foods consumed. Microalgae identified were Coscinodiscus species (Plate 5), Melosirasphaerica (Plate 6), Microcystis species (Plate 7), Rhizosolenia species (Plate 8), Asterionellopsis glacialis (Plate 9), Corethroncriophilum (Plate 10), Oscillatoria species (Plate 11), Guinardiastriata (Plate 12) and Scenedesmus species (Plate 13).

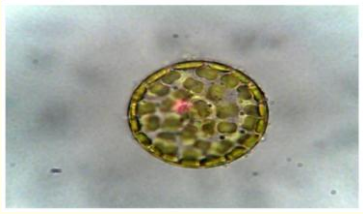


Plate 5: Coscinidiscus

Plate 6: Melosirasphaerica

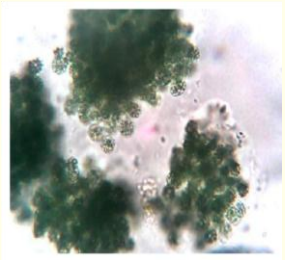


Plate 7: Microcystis

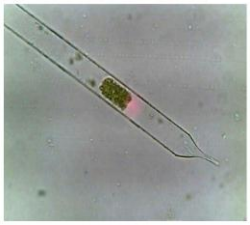


Plate 8: Rhizosolenia

Plate 9: Asterionellopsis glacialis

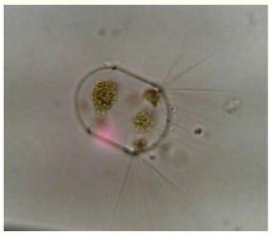


Plate 10: Corethroncriophilum

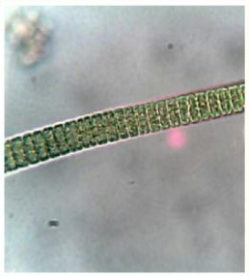


Plate 11: Oscillatoria species

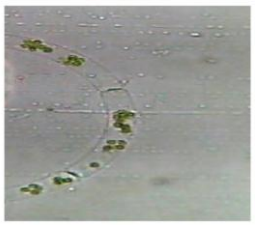


Plate 12: Guinardiastriata

Plate 13: Scenedesmus species

This study revealed the presence of saxitoxin in Lagos lagoon, Nigeria and in shellfishes, therefore showing the importance of establishing a water quality monitoring of the studied areas. The results also showed that some values of saxitoxin concentration in shellfishes were above the limit of 80 µg/100g proposed by WHO. The accumulation of saxitoxin in humans that consume such fishes can lead to chronic exposures that may pose health hazard. We recommend monitoring programmes to identify human exposures and to protect human health.

2.4 Fisheries management

The sustainability of our fishery demands regulating fishing activities on our water-bodies, devoid of obnoxious practices capable of endangering and depleting the fish stock and the aquatic environment. Thus, the Government prescribe fish gears type and sizes among other practices to ensure productivity in perpetuity.

2.4.1 Water Quality and Fish Diversity of Federal University of Agriculture Abeokuta's Reservoir

Our team of researchers (Adeosun *et al.* 2012) studied the University Reservoir on this campus for the water quality, fish diversity and catch assessment. The fish specimens caught were identified and classified into 5 species belonging to 3 families. The percentage species composition of the harvest by numbers and weight for all fish species that contributed more than 1% in all the stations combined, were computed. Study of the physical and chemical parameter such as dissolved oxygen ranged from 5.03 to 7.19mg/l; 26 to 28^0C temperature; 64.8 to 148ppm alkaline; p^H 6.67-6.90; 32.5 to 53.5m transparent; 8.86 to 13.72mg/l nitrate; 0.58 to 0.64mg/l phosphate; 0.024 to 0.069% saline; 103-270cm deep. p^H and water temperature served as variables since the fluctuation of one affects the values of others. The water quality parameters were favourable for fish production. The gillnet fisheries indicated that different mesh sizes of experimental gillnets were sensitive to different fish species. The 67.2mm, 78.4mm and 112mm, mesh sizes were efficient in catching *Clarias gariepinus*, *Barbus occidentalis* and the Cichlids respectively. The study provided baseline information on the abiotic parameters and the fish species diversity.

2.4.2 *Management Indicators and Growth Performance Index of Tilapia Zillii in a Tropical Coastal Estuary*

An investigative study was carried-out by our team of researchers (Abdul *et al.* 2016) on management indicators and growth performance index of *T. zillii* in a tropical coastal estuary for twenty-four consecutive months using length-weight data. Ogun estuary is situated between longitude $4^{0}15^{1}$E–$4^{0}30^{1}$E and latitude $6^{0}20^{1}$N–$6^{0}45^{1}$N and bounded in the east by Lekki lagoon and south by Bight of Benin. It empties into the Atlantic Ocean via Lagos Harbour, falling into the western littoral area. The climate is tropical with rain (April-November) and dry season (December-March). The vegetation of Ogun water side and Ijebu–East Local Government forms a coastal belt of mangrove swamp forests. The water does not have direct access to the marine condition but it is linked to the Lekki and Lagos lagoons. The lack of direct access to the Atlantic Ocean coupled with the discharge of Rivers Osun, Mosafejo and Oni into the water makes it essentially freshwater. Sustainable fishery will require close monitoring between February and April, and exploitation of larger size fish to prevent recruitment overfishing. The study revealed that *T. zillii* in tropical coastal water, Ogun estuary, matures at small size, and attains maximum sustainable yield at a greater size. The longevity of the fish is low as it might be dependent on the growth curvature. Growth performance index is typical of tropical estuarine fishes. As such, fisheries managers should assess their fish stocks regularly and provide data on management indicators and growth performance index to guide in appropriate decision making to aid sustainable fish production to support their teeming populations.

2.5 Fish Processing and Preservation

Fish is highly perishable at ambient temperature due to its high moisture level. Therefore, it is very important to extend the shelf life through the utilization of medium capable of maintaining the fish quality to avoid spoilage for a wholesome consumption.

2.5.1 Traditional and Solar Fish Drying Systems Towards Enhancing Fish Storage and Preservation

Akinola *et al*. (2006) studied traditional and solar fish drying systems towards enhancing fish storage and preservation in Nigeria using the case study of Abeokuta Local Government Areas. The results revealed that traditional methods still remain the predominant fish processing and drying methods employed in the country. Advantages of using direct application of solar thermal energy employing some means of collecting solar radiation with the result that elevated temperatures and, in turn, lower relative humidity is achieved for drying fish in developing countries, like Nigeria. The average age of the people engaging in fish smoking activities in the Local Governments being considered was 32½ years. The highest education level of most of this people is primary education As such, the preservation technique employed is influenced by socioeconomic status of the people. The major source of fish supply is through cold store, followed by landing centers and then fishermen. The fish preservation in the cold store is through refrigeration and freezing, which is powered by electricity and as far as Nigeria is concerned today, the grid-connected electricity is unreliable and the cost of running diesel generator is high and not economical. This is one of the factors affecting the supply of fish in Nigeria. African mud catfish (Abori), Tilapia (Epiya) and Osan are the common fish species smoked in Abeokuta North Local Government while Herring, Mackerel, Hake and Sardine were the most common in Abeokuta South Local Government. Solar

dryers collects solar radiation resulting in elevated temperatures and thereby lower relative humidity.

2.5.2 Effect of Spices on the Chemical Properties of Hot-Smoked Catfish Clarias Gariepinus (Burchell, 1822) Using Completely Randomized Design (CRD)

In a study by Ayeloja *et al* (2015) on the proximate and mineral composition of spiced, smoked catfish *Clarias gariepinus* (Burchell, 1822) freshly harvested catfish were spiced with garlic, ginger, garlic-ginger homogenate- spiced and the control without spices before smoking. Proximate and mineral content analysis were carried out using standard experimental procedures. There were significant differences ($p<0.05$) in the proximate composition of the spiced smoked fish. The smoked catfish with no spice had the highest moisture content with a mean value of 6.18 $\pm$ 0.13% which reduced significantly ($p<0.05$) with the application of different garlic and ginger . Smoked catfish spiced with garlic-ginger homogenate had the lowest moisture content of 5.73 $\pm$ 0.14%. The differences in moisture content could be due to variation in the moisture absorbing properties of the spices applied prior to smoking. The resultant reduction in the moisture content of the smoked fish products will prolong the shelf life of the products.

This study indicated that the crude protein composition formed the largest quantity of the dry matter in all the fish products. Also, there was significant difference ($p<0.05$) in the percentage crude protein contents of the differently spiced hot-smoked catfish. The control (smoked catfish without spices) recorded the highest protein content with a mean value of 79.44 $\pm$ 0.13% . The garlic ginger spiced smoked catfish had the lowest percentage crude protein content (75.69 $\pm$ 0.13). The reduction in the percentage crude protein of the spiced fish could be as a

result of the increase in the fibre content from the spices applied to the fish. However, the result of the crude fibre content indicated that the control had the lowest value with a mean value of 0.16 $\pm$ 0.13% which was significantly different ($p<0.05$) from other spiced fish products while garlic spiced hot-smoked catfish had the highest percentage crude fibre content with a mean value of 10.54 $\pm$ 0.13. The result of the mineral composition indicated that there was no significant difference ($p>0.05$) in magnesium content of the various fish products. However, there were significant differences ($p<0.05$) in other mineral contents. The spiced smoked fish were rich in calcium with garlic-ginger homogenate-spiced product having the highest value of calcium (0.980±0.02%), while the control had the lowest calcium value (0.539±0.04%). Generally, the minerals occurred at levels within international limits, thereby making this fish product safe for consumption.

This study indicated significant differences ($p<0.05$) in the proximate composition and mineral contents of variously spiced smoked fish products. The moisture content on account of the addition of spices suggested the possibility of prolonging the shelf-life of fish by reducing water activity. The addition of spices also enriched the mineral contents of the products. Generally, the use of spices (garlic and ginger) in the present study added quality value to smoked fish products.

2.5.3 Micro-organisms Associated with Cold-Smoked Fish in Two Local Govemment. Areas, Ogun State

This work was conceived as a result of poisoning after consumption of smoked dried fish by a lady in Abeokuta prior to using it to cook soup. This work may serve to warn consumers on the danger of consuming smoked fish without further processing or using it to cook under low heat. Four markets in two Local Government Areas (Abeokuta North and South LGA's) of Ogun State were sampled for micro-organisms associated with cold-smoked fish by Ezeri *et al.* (2001). Hake, Herring, Mackerel and Sardine were purchased from the four different markets in Abcokuta North and South L G.A's. The total viable bacterial count revealed 2.2xc10'cfug-93x10 cfu/g from the intestines, 3.4x10'cfu/g-9 1 10cfu/g from the skin and 1.9-10' cfu/g-6.5x10/g from the gills of cold-smoked fish. A range of total viable of bacteria from the different markets revealed a range of 2.1 x 104.cfu/g-9.1x 10'cfu/g in Elega market, 1.9x10'. Four Gram-positive bacteria namely; *Bacillus sp. Micrococcus* ***sp,*** *Staphylococcus aurous* and *Staphylococcus epidermidis* and four Gram-negative bacteria namely: *Escharichia coli, Klebsiella sp, Proteus morgani and Psoudomonas sp Penicillium sp* and two yeasts strains; *Candida sp, and Rhodotorula* from the intestines. The microbial Isolates and bacterial counts are of food poisoning and food spollage significance.

2.6 Fish Nutrition

The growth, health and reproductive activities of fish largely depend on ingestion of balanced diet comprising good nutrients like protein, carbohydrate, fat, minerals and vitamins. Fish feeding is known to cover 80% of cost of production, because man is competing with the same ingredients for survival. Effort

is being geared towards sourcing for unconventional feed stuff to salvage the situation.

2.6.1 Replacement of Maize Meal by Toasted African Breadfruit (Treculia Africana) Seed Meal in the Diet of Clarias Gariepinus (Burchell 1822) Fingerlings

Our research team (Obasa *et al.* 2013) carried out feeding trials to investigate the effect of toasted African breadfruit (TAB), *Trecullia africana* on growth performance, nutrient utilization, survival and blood parameters of *Clariasgariepinus* fingerlings. Weight gain (WG) and feed conversion ratio (FCR) were not different from 22.0g and 1.71 respectively in fish fed diet TAB50. Also, protein efficiency ratio (PER) was not different from fish fed diets TAB0 (1.51) and TAB50 (1.53) respectively. Then, PER decreased as TAB increased in the diet. Packed cell volume was highest in fish fed TAB75 (33.0%) and was higher than 28.0% of fish fed TAB100. From the above results, yellow maize could therefore be replaced by toasted African breadfruit seed meal at 50% level without affecting growth and nutrient utilisation and 75% without affecting the blood profile in the diet of African mud catfish, *C. gariepinus* fingerlings.

Water temperature in the experimental systems ranged from 25.6-27.2^{0}C, dissolved oxygen ranged from 6.3-8.2 mg/l while p^H ranged from 6.17 and 7.16. Moisture content increased as TTA increased in diets while crude protein was highest in diet TAB75 with a value of 40.40% and lowest in diet TAB0 with a value of 39.30%. Lipid content was lowest in diet TAB25 and then increased as TAB increased in diet. Growth response, nutrient utilisation and survival of C gariepinus fed varying levels of TAB are presented in (Table 1). There were no differences in growth response and nutrient utilisation indices in fish fed diets from TAB0 to TAB50. Then, these indices

decreased as TAB increased in diet. There was no difference in survival of fish fed control diet and those fed diet TAB75.

Table 1: Growth response, nutrient utilization and haematocrit of *C. gariepinus* fingerlings fed various level of African breadfruit based diets

Parameters	**TAB0**	**TAB25**	**TAB50**	**TAB75**	**TAB100**	**SEM**	**P-value**
Initial mean weight (g)	6.27	5.93	5.97	6.03	6.13	0.12	0.063
Final mean weight (g)	28.3^{ab}	31.0^{a}	27.7^{b}	18.9^{c}	16.43^{c}	5.72	0.015
Mean weight gain (g)	22.1^{ab}	26.3^{a}	21.7^{b}	12.9^{c}	10.3^{c}	6.49	0.014
Mean feed intake (g)	36.6^{a}	39.3^{a}	37.1^{a}	25.3^{b}	24.0^{b}	6.49	0.036
Mean protein intake (g)	14.6^{a}	15.7^{a}	12.9^{a}	9.71^{b}	9.58^{b}	2.51	0.012
Feed conversion ratio (g)	1.66^{bc}	1.50^{c}	1.71^{bc}	1.96^{a}	2.33^{a}	0.29	0.000
Protein efficiency ratio	1.51^{ab}	1.67^{a}	1.53^{ab}	0.71^{c}	0.66^{c}	0.44	0.008
Specific growth rate (%)/day	2.82^{a}	2.90^{a}	2.48^{ab}	1.85^{b}	1.63^{c}	0.51	0.001
*App. NPU (%)	59.9^{a}	53.2^{ab}	40.6^{ab}	23.4^{c}	20.5^{c}	15.7^{d}	0.006
Survival (%)	83.3^{a}	83.3^{a}	76.7^{ab}	76.7^{ab}	73.3^{b}	4.00	0.026

Note: Values without common superscripts in horizontal rows are significantly different ($P<0.005$) *Apparent net protein utilisation.

Moisture did not maintain any order. Ash content increased as TAB increased in diet while crude protein decreased as TAB content of diet increased from fish fed diet TAB50. Lipid was highest in fish fed diet TAB25, then decreased as TAB increased in diets.

There were no differences in the values of Packed cell volume and the red blood cells between fish fed the control diet (TAB0) and fish fed diet TAB75, while white blood cells and mean corpuscular volume were higher in fish fed diet TAB100 than in fish fed diets with lower inclusion levels of toasted African breadfruit seed meal. Maize can therefore be replaced at 50% level by toasted African breadfruit seed meal without affecting growth and nutrient utilisation, while replacement can also be achieved at 75% level without any adverse effect on the blood profile in the practical diet of African catfish *C. gariepinus* fingerlings.

2.6.2 Effects of Replacing Dietary Fish Oil with Vegetable Oils on Heamatological Properties of African Catfish (Clarias Gariepinus)

George *et al*. (2012) evaluated dietary fish oil replaced with vegetable oils as an ingredient in practical diet for *C. gariepinus* reared in net fish hapas (1m x 1m x 1m) suspended by bamboo poles in an earthen pond. The blood valves of Cat fish, namely the Haemoglobin (Hb), packed cell volume, (PCV) White Blood Cell (WBC), Mean Corpuscular Volume, Mean Corpuscular Haemoglobin (MHC) and Mean Corpuscular Haemoglobin Concentration (MCHC) levels, increased, whereas Hb level content varied between 10.7gldl (Diet 2) and 12.8gldl and was significantly different (P< O.05). PVC (38%) was recorded and the lowest PVC (32%) for diet 2. Reduction in packed volume cell and Haemoglobin concentration of fish may be as a result of essential fatty acid, mineral and vitamin differences or imbalance and heat treatment, have been known to cause such deficiencies in legumes. In the light of the present study, the mean value of PVC was 35 in the control group (T,) which was decrease significantly from other treatments (32, 38, 34, 33) in groups 2, 3, 4 and 5, respectively with groups 2, 4 and 5 having

significantly (P = 0.83, 0.84, 0.80 respectively) lower PCV compare to the control.

2.7 Fish Breeding

The quality and quantity of fish spermatozoa will determine the success level in fish breeding. Therefore, effort is ongoing to unravel the best means of preserving it for effective artificial insemination.

Akinyemi *et al.* (2014) examined the effect of cold storage of *Clarias gariepinus* sperm on hatchability and survival. Broodstocks were used for this experiment, testes were collected from the male and stored at 4^{o}C for the treatment of 12hrs, 36hrs and 48hrs respectively, while fresh sperms were also obtained for the controls. The stored testes were activated to room temperature with stored clean water before being used for the fertilization of all the fertilized eggs from the four trials were observed to hatch as well as the control. Percentage hatchability was observed to be very low for all the treatment. The percentage hatchability was (10% (12hrs), 20% (36hrs) and 10% (48hrs) respectively. Hatched eggs were under observation for seven days to estimate percentage survival, which was observed to be normal for all treatment, but having a significant differences (P<0.05), with the control having 5168 + 1014^{b}, and the treatment 71.7 + 2.9^{a}, 104 + 3.5^{a} and 110.3 + 20.5^{a} respectively.

The treatment as compared with their control was observed to be relatively low in the percentage hatchability of eggs which may be attributed to sperm motility, milt quality and temperature of the activating medium. Therefore, because of this result, it may be concluded that cold storage of sperm of *Clarias gariepinus* is possible but in very low capacity and except other methods of cold storage such as liquid nitrogen is adopted, it was, therefore

recommended based on the poor hatchability in this work, that sperm storage may not be economical for commercial purpose except for experimental programs such as genetic studies, thus fresh sperm for fertilization should be considered the best, and should be encouraged.

3.0 CONTRIBUTION TO HUMAN CAPACITY DEVELOPMENT

This University has a tripodal mandate of teaching, research and extension/community service. Mr Vice Chancellor Sir, please permit me to showcase some of my teaching efforts along with my extension and community service.

3.1 Teaching/Supervision

My teaching career in this University started in 2001, since then I have trained over 1000 Bachelor of Aquaculture and Fisheries, over 50 Master of Aquaculture and Fisheries (MAF) and seven at Ph.D level.

Some of my students pulling their weights in their career are the following:

i. Dr. Awe Folalu, Senior Lecturer, Department of Fisheries, Lagos State University

ii. Dr. Olugbojo Joseph Abiodun, Lecturer, Department of Agriculture and Agricultural Technology, Bells University of Technology, Ota.

iii. Dr Ayeloja Ayodeji Ahmed, Senior Lecturer, Department of Fisheries Aquaculture and Wildlife, Faculty of Agriculture, University of Abuja.

iii. Dr. Lanre Badmus, Pioneer Regional Director, World Aquaculture Society, African Chapter, West Africa Region.

iv. Steve Okeleji, Executive Director, Aquatic Hub Afrique Network Limited. Currently a Scholar in Netherland Business School. He was recognized by World Bank in 2017 and International Food Policy Research Institute (IFPRI), Washington DC featured him as a case study for aquaculture development for Africa. He also won African Champion for Agriculture Development.

v. Dr Mavis Oghenebrorhie Ruben, Senior Lecturer, Landmark University, Offa.

vi. Mrs Bidemi Green-Ojo, Ph.D, Researcher, University of Portsmouth, United Kingdom.

vii. Dr. Biola Akintayo, Assistant Director, Nigerian Institute for Oceanography and Marine Research (NIOMR), Lagos.

viii. Mr Bamidele Opeifa, Chief Operating Officer (COO) of SIFT Group AS, Tromsø, Norway.

3.2 Extension/Community Service

I was a regular guest on Paramount FM 94.5, Abeokuta, Radio Broadcast (Fisheries Programme) on the bill of Lafenwa Community Bank, Lafenwa, Abeokuta, between July-December, 2006. I played the same role simultaneously on Gateway AM, Abeokuta, Radio Broadcast (Fisheries Programme) on the bill of Lafenwa Community Bank, Lafenwa, Abeokuta. July-December, 2006.

I participated in Voyage of Discovery 2010 by National Universities Commission (NUC), Abuja, which was presented on National Television Authority (NTA) and African Independent Television (AIT).

I served in the Executive Council of Fisheries Society of Nigeria (FISON) both as National Financial Secretary (2014-2018) and

National Treasurer (2018 – 2022). I was also the Assistant Secretary of the Council of Fellows of same FISON (2017-2022). I am presently the State Chapter Chairman of Ogun State Chapter of FISON. This gave me the opportunity to be involved in the yearly Aquaculture and Fisheries Trade Fair organized by Ogun State Chamber of Commerce, Industry, Mining and Agriculture (OGUNCCIMA), working hand in hand with notable personalities, such as Iyalode Alaba Lawson (a former President) of blessed memory. The organizers have given me opportunities as Guest Lecturer on several occasions.

3.3 Leadership

During my tenure as Head, the Department of Aquaculture and Fisheries Management, the Department produced the Overall Best Graduating Student of the University, the first in the history of the Department. I also domiciled the NUC-BMAS Curriculum for the Departmental Programme, as well as facilitating the process for a successful accreditation exercise.

I was involved in the coordination of the First Biennial International Summit on Forestry, Wildlife and Fisheries Management held in FUNAAB in January 2019 for FUNAAB, University of Missouri, USA, Forestry Research Institute of Nigeria and Universite National D'Agriculture de Benin, Republic du Benin to develop Memorandum of Understanding (MOU) among the Institutions for the conservation of our natural resources

I was the Rapporteur of the Joint Fisheries Society of Nigeria (FISON)/PESCAO ECOWAS high profile Conference of Stakeholders held at the Conference Room of the National Institute of Oceanography and Marine Research, Nigeria between September 9 and 10, 2019 to inaugurate umbrella body for West Africa Non-State Actors in Fisheries and Aquaculture

(WANSAFA) to coordinate the unification of the Non - State Actors and the stakeholders. It was to properly harness the existing informal cross border trade of processed fish products in West Africa through the ECOWAS trade liberalization scheme ETLS.

During my tenure as Director, Students' Industrial Experience Scheme (SIWES), 2022-2025, I anchored orientation programmes for all students in their penultimate years, during which Area Manager of Industrial Training Funds (ITF) and her team officially mobilised students for out of classroom experience, to equip them with experience regarding work life after graduation, among other roles in the Directorate. In 2024 ITF Abeokuta instituted Lecture Series as part of Directors of SIWES in Ogun State Tertiary institutions Zonal Meetings. I was nominated to present the maiden edition, which was adjudged fit for Award for Outstanding Presentation of Students' Industrial Work Experience Scheme (SIWES) Lecture Series (September 25, 2024.

4.0 CONCLUSION

In conclusion, my pathway have dotted the shorelines of ponds, lakes, dams, streams, reservoirs, rivers, the lagoons, beaches and cliffs of oceans. These efforts are in a bid to unravel underlining factors, capable of undermining sustainable development and growth of our well-endowed aquatic environment and God-given aquatic resources for abundant productivity in perpetuity.

All available tools ranging from bacteriological, hematological, pathological, biotechnological, Molecular Techniques, using DNA Extraction, PCR, Gene Sequencing, Gel Electrophoresis were deployed in the various studies conducted. My research works also examined bacterial sensitivities to synthetic

antibiotics, detected antibacterial resistance, as well as multi-drug resistance to antibiotics, along with drug residues in fish tissues.

Amelioration of the challenges posed by drug resistance in fish chemotherapy led the way into studying phyto-medicine and eventually into nanotechnology as an alternative, which paved way for chitin from over grown maggot utilization as chitosan (waste to wealth), a precursor for nanoparticles.

Indeed, my aspiration, mission and vision for the marine and blue economy of the Federal Republic of Nigeria is as presented in the third Epistle of John the beloved, *"Beloved, I wish above all things that thou mayest prosper and be in health, even as thy soul prospereth"* (3 John 2).

5.0 RECOMMENDATIONS

There must be a high level of commitment in promulgation of regulations and enforcement to achieve a near no disease situation. Such regulations must include:

i. Strict control and quarantine of fish and fish products across Nigerian boarders, to avoid cross boundary transmission of pathogens.

ii. Adequate mapping of facilities all over the country and proper certification of fish practitioners to remove quacks and unwholesome practices.

iii. Standardization of grading systems in the fish industry to achieve uniformity in cultural practices.

iv. Regular monitoring and evaluation of all existing fishing and cultural facilities.

v. Professionalism in fish health handling and administration should be improved. Nonprofessionals should be not be allowed to carry out drug administration. Auxiliary fish health workers can be trained to bridge the gap, while standard structure must be put in place to ameliorate these challenges.

vi. The Federal Government should provide standard world class laboratories in geopolitical zones, with mandate strictly on fisheries to carry out routine diagnoses on mode of transmission and spread of disease agents on regular basis.

vii. Global best practice in aquaculture demands enforcement of standard bio security measures in every functional fish farm and value addition facilities. Strict adherence to this practice will forestall occurrence of disease outbreak.

viii. In order to avoid spoilage occurring at ambient temperature and to enhance shelf life prolongation in fish and fish products; provision of cold rooms and cold storage vans for fish transportation throughout the nation is very essential.

ix. A clarion call for all the establishment of Faculty/College of Marine and Blue economy in all Institutions offering agricultural courses. FUNAAB is hereby implored to take the lead, as the 'pacesetter' that we are as 'trailblazers'. All State Governments should emulate Mr President, Bola Ahmed Tinubu in ensuring domestication of Ministry of Marine and Blue Economy in their respective States.

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I had my elementary school in International Primary School, Cotonou, Republique Du Benin (1971-1975) and I wish to thank Mr Joseph Hounmenou, the Headmaster and the Proprietor and family; Mr Remi Hunye and family, Leopold Bonou and family, Jean Owolawi and family; Frere Jean Fayomi and family, Corniel Kwuaponu; Souer Jeanne Bailey; Souer Moloto Bailey, The De Souzas. I completed the elementary school in Saint James' Primary School, Oke Odan and I wish to thank Hon. Chief David O. Bankole, the Headmaster in 1978/1979 and Messrs Akindele from Ado-Odo and O. A. Akinola from Ajilete.

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I bless the Almighty God for the gift of a virtuous woman, in person of my darling wife, Helen Folakemi Akinyemi. *"Who can find a virtuous woman? for her price is far above rubies" says* Proverbs 31: 10. May we live to enjoy the fruits of our labour in Jesus mighty name. Amen

Join me in thanking God with this hymn:

He Looked Beyond My Faults and Saw My Need

Verse 1
Amazing grace shall always be my song of praise,
for it was grace that bought my liberty,
I do not know just why he came to love me so,
he looked beyond my faults and saw my need.

Chorus:
I shall forever lift mine eyes to Calvary
to view the cross where Jesus died for me,
how marvelous the grace that caught my falling soul,
he looked beyond my faults and saw my need.

Verse 2
Redeeming blood my Savior shed for me one day,
to restore me back to where I used to be,
he became my sin so I could be his righteousness,
when he looked beyond my fault and saw my need.

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