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AMELIORATIVE EFFECTS OF *BLIGHIA SAPIDA* (K.D. KOENIG) EXTRACT ON WATER QUALITY PARAMETERS, LIVER AND GILL OF AFRICAN CATFISH, *CLARIAS GARIEPINUS* EXPOSED TO KEROSENE-INDUCED TOXICITY

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ABSTRACT

This study investigated the ameliorative properties of *Blighia sapida* extracts on the water quality parameters, liver, and gills of sub-adults of African catfish, *Clarias gariepinus* (185±2.87g) exposed to kerosene-induced toxicity. The fish species were acclimatized for 14 days and the water was partially replaced every 48 hours. The test organisms were fed with commercial pelletized fish feed (42% CP) at 3% body weight twice per day throughout the acclimatization period. 189 pieces of the test animal were randomly divided into nine groups (G) of seven fish each in plastic tanks containing 20L of borehole water to which treatments were set up in triplicates: G1: control, G2: 100 ml kerosene, G3: 200 ml kerosene, G4: 100 ml kerosene + 50 mg/kg body weight (bwt) ethanol extract (EE), G5: 100ml kerosene + 100 mg/kg bwt. EE, G6: 100 ml kerosene + 150 mg/kg bwt. EE, G7: 200 ml kerosene + 50 mg/kg bwt. EE, G8: 200 ml kerosene + 100 mg/kg bwt EE, G9: 200 ml kerosene + 150 mg/kg bwt EE. The study was carried out for 28 days and the obtained water quality parameters data were analysed using descriptive and inferential statistical tools. The results showed significant ($p<0.05$) effect on the water quality parameters of total dissolved solids, hydrogen ion concentration, electrical conductivity, dissolved oxygen, and temperature with increase in the volume of kerosene. The histological examination revealed mild/severe vacuolar degeneration on the liver and gills of fish exposed to varying volumes of the kerosene. However, *B. sapida*, ameliorated the toxic effects of the kerosene in dose-dependent manner. Severe portal and central venous congestions were observed in the organs, however, the severity of these congestions decreased with increase in the extract concentration. The result indicated that *B. sapida* displayed ameliorative effects on sub-adults African catfish, as such could be used to treat the fish species in the case of oil spillage.

Key words: *Blighia sapida*; Catfish; Kerosene; Vacuolar degeneration; Venous congestions; Water quality parameters.

INTRODUCTION

African catfish *Clarias gariepinus)* is regarded as a resilient fish species, due to the accessory breathing organs that enable it to endure poor water quality conditions (Fawole *et al*., 2020). However, this fish species could suffer the toxic effect of pollutants leading to a compromise in the growth, survival and overall health in the aquatic habitats. Pollutants from crude oil and its other by-products could lead to an alteration in the physical and chemical water quality parameters which is crucial for the health and survival of fish species. African catfish inhabit a variety of freshwater habitats, lakes, rivers, confined culture systems, and other natural bodies of water; this diversity renders them susceptible to the adverse effects of persistent crude oil pollution (Orowe and Ikponmwen, 2022). Moreover, incessant oil spillage, oil exploration and other related anthropogenic activities carried out around natural water bodies is a significant contributor to water contamination (Häder *et al*., 2020; Madhav *et al*., 2020). The crude oil products which include gasoline, kerosene, propane, fuel oil, lubricating oil, wax, and bitumen, are complex mixture of hydrocarbons (Ivon *et al*., 2021) which could pose detrimental effect on the health of the aquatic flora and fauna.

Crude oil is an intricate amalgamation comprising numerous organic constituents, with trace elements and hydrocarbons comprising the majority (Kennedy 2015; Ylitalo *et al*., 2017). The toxicity of crude oil and its effects on fish tolerance, survival, and physiology have been documented in the literature (Abdel-Tawwab 2012; Umar *et al*. 2017; Khursigara *et al*., 2019). The toxicity of crude oil can be attributed to polycyclic aromatic hydrocarbons (PAHs), which are constituent compounds (Lee *et al*., 2017; Armstrong *et al*., 2019). Diverse species of fish exhibit heightened vulnerability to these compounds within the aquatic context. Moreover, the health, reproduction, and behaviour of fish are all negatively impacted by oil exposure (Khursigara *et al*., 2019). Instances of oil spills and contamination of intertidal mangrove wetlands in Nigeria led to significant losses of crabs, fish, and their intertidal eggs, with the repercussions lasting for multiple months (Akpofure *et al*., 2000; Aguigwo, 2002). Additional impacts on aquatic environments encompass direct lethal toxicity, habitat modification that disrupts biological processes, significant mortality rates of fish embryos, and sub-lethal disturbances that disrupt physiological and behavioural activities, ultimately resulting in mortality due to interference with feeding and reproduction (Sumonu and Oloyede, 2006; Abdel-Tawwab, 2012; Umar *et al*., 2017; Armstrong *et al*., 2019; Khursigara *et al.,* 2019 and Ivon *et al*., 2021). Consequently, measures must be taken to mitigate the impact of crude oil and its byproducts on aquatic organisms.

Several researches have examined the mechanism by which antioxidants or plant extracts can mitigate the harmful effects of free radicals. Moreover, plants hold significant societal value owing to the secondary metabolites they produce, which are utilized as sources of sustenance and medicine (Tapsell *et al*., 2006; Oloyede *et al*., 2019; Onanuga and Oloyede, 2021). *B. sapida*, a deciduous perennial plant that is indigenous to the Guinean forests of West Africa (Orwa *et al*., 2009). The plant is utilized as an insecticidal agent and has been reported to be effective against cold, pain, and has emulsion properties (Elizabeth *et al*., 2012). In certain African nations, the leaves of *B. sapida* (Ackee) are incorporated into culinary preparations as vegetables. Other parts of Ackee plants have been used for anti-malarial, sedative, and analgesic properties (Burkill, 2000; Hyde *et al.*, 2002). Moreover, the results of phytochemical analysis indicated the existence of flavonoids, polyphenols, and polyterpenes (Osuala, 2020). Additionally, Dorcas *et al.* (2017) reported the essential oil compositions of the plant, which suggested the existence of terpenes, while the pulverized bark is applied topically for stimulating effects. Fruits and root bark of *B. sapida* were discovered to contain alkaloids, saponins, cardiac glycosides, reducing sugar, carbohydrates, flavonoids, phenol, and tannin (Oyeleke *et al.*, 2013; Dossou *et al.*, 2014). These bioactive components of *B. sapida* pose therapeutic potentials that could ameliorate the effect of crude oil spills on aquatic fish species that have not yet been documented. Thus, this study was carried out to determine the ameliorative effect of *B. sapida* on Afrcican catfish exposed to kerosene induced toxicity under laboratory conditions.

MATERIALS AND METHODS

Chemicals and reagents

Ethanol and anhydrous sodium sulphate were purchased from BDH Chemical Laboratory and Sigma Chemical Company, London, England. All reagents used in this study were of analytical grade. The crude petroleum oil (kerosene) was obtained from the Nigerian Independent Petroleum Company (NIPCO) fuelling station in Nigeria.

Collection and Preparation of Plant Extracts

Blighia sapida (K.D. Koenig) stem-bark was obtained from Sekona-Ede Road, Osun State, South-Western Nigeria. The identification and authentication with specimen number 17623 was done at the IFE Herbarium, Department of Botany, Obafemi Awolowo University, Ile-Ife, Nigeria. Prepared *B. sapida* stem-bark was air-dried to constant weight for two weeks and ground into fine particles using an electrical blender. Powdered plant material (1500g) was extracted with 70%v/v ethanol. The extraction process was allowed to stand for 72 h and thereafter sieved and strained with a muslin cloth, followed by filter paper. The filtrate was concentrated using a rotary evaporator attached to a vacuum pump. The extract was kept in the refrigerator at − 4 °C for further analysis.

Collection of African Catfish

A total of 270 sub-adult African Catfish (*Clarias gariepinus)* with weight range of 185±2.87g were purchased from a reputable local fish farm in Ijebu Ode, Ogun State, Nigeria. The catfish were carefully transported in a 25L plastic container half-filled with water around 0800h to the hatchery Unit, University Fish Farm, Federal University of Agriculture Abeokuta, Nigeria, where the experiment was carried out. The fish species were acclimatized for 14 days and the water was partially replaced every 48 hours. The test organisms were fed with commercial pelletized fish feed (42% CP) at 3% body weight twice (0900 and 1700h) per day throughout the period of acclimatization.

Experimental procedure

The experimental procedures and protocols used in this study conformed to the National Institute of Health's (NIH) recommendations guide for the care and use of laboratory animals. The ethical approval for the study (reference number FUNAAB/COLVET/CREC/2023/05/02) was obtained from the Research Ethics Committee, College of Veterinary Medicine, Federal University of Agriculture Abeokuta, Nigeria. A total number of 189 pieces of the test animal were randomly divided into nine (9) groups (7 fish in a group) in plastic tanks containing 100 and 200mL each of kerosene dissolved in 20L of borehole water to which treatments were set up in triplicates.

The groups were numbered as follows:

- G1 - (Positive Control) - No kerosene.
- G2 - (Negative Control 1) - 100ml kerosene.
- G3 - (Negative Control 2) - 200ml kerosene.
- G4 - 100ml kerosene + 50mg/kg bwt. EE.
- G5 - 100ml kerosene + 100mg/kg bwt. EE.
- G6 - 100ml kerosene + 150mg/kg bwt. EE.
- G7 - 200ml kerosene + 50mg/kg bwt. EE.
- G8 - 200ml kerosene + 100mg/kg bwt EE.
- G9 - 200ml kerosene + 150mg/kg bwt. EE.

The African Catfish (*Clarias gariepinus*) were exposed to a toxicant (kerosene) for 28 days after the acclimatization. During the period of the experiment, African Catfish were treated with *B. sapida* ethanol extract (EE) and fed at 3% body weight. At the end of the experiment, the animals were sacrificed, livers and gills were excised and kept in formalin (10%) for histological observation.

Liver and Gill histology Examination

The histology of liver and gill was performed according to the methods of Zhang *et al.* (2017) and Okpoghono *et al.* (2018). Smaller portions (5 mm) of the excised liver and gill of the experimental fish was cut and fixed in 10% formalin, dehydrated in graded ethanol, cleared in xylene, embedded in paraffin wax. From the sectioned tissues on a rotary microtome, slides were prepared and stained with haematoxylin and eosin for observation under light microscopy.

Water Quality Analysis

The physical and chemical water quality parameters monitored during the experimental period include electrical conductivity (EC), hydrogen ion concentration (pH) total dissolved solids (TDS) temperature and dissolved oxygen DO. These were monitored and recorded twice per day in S/m, mg/l, degrees Celsius and mg/dl respectively using a multi-parameter hand-held HANNA water probe (HI-98199).

Data analysis

Data were subjected to statistical analysis. The groups' mean ± standard error was calculated for each data and significant differences were evaluated using one-way analysis of variance (ANOVA). Posthoc test analyses were done using the Tukey multiple comparison test at 5% significance level, using the GraphPad Prism 9 software.

RESULTS

Water Quality Parameters

The electrical conductivity was significantly different between the treatments. EC ranged from 0.17± 0.04S/m in G9 to 0.29± 0.10S/m in G6 (Table 1). The highest (11.0± 0.09) pH value was recorded in G6 while the lowest (6.8± 0.10) was found in G3. Similar pH values were recorded in G1 and G4. In a similar vein, G9 had the lowest total dissolved solids (TDS) value of 105.7± 0.33mg/l while G8 had the highest (169.7± 0.37mg/l) TDS value, TDS values were significantly different between the treatments. The temperature value ranged from 30.7± 0.21^{0}C in G2 to 33.9± 2.17^{0}C in G6, with similar temperature values in G4 and G5. The dissolved oxygen levels varied notably across the experimental groups, with values ranging from 5.01± 0.54 mg/dl to

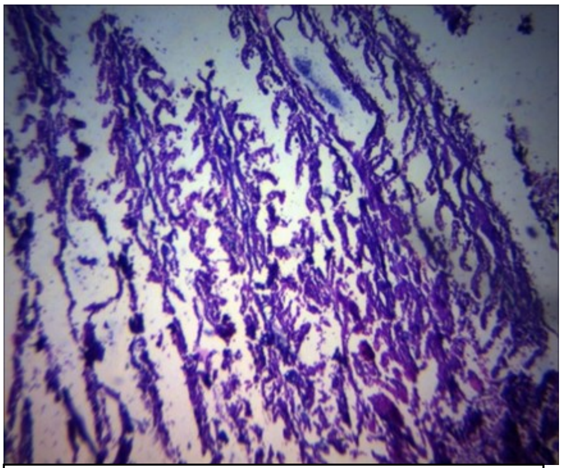
8.51±0.21mg/dl in G7 and G3 respectively. There were no significant values in the dissolved oxygen found in G1 and G5 (Table 1).

Histopathology of Liver and Gill

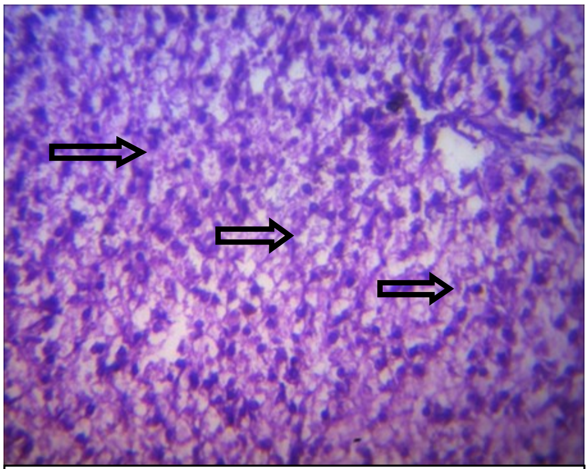
The photographs of the livers and gills of *C. gariepinus* in the control group displayed normal architecture with no visible lesions (Plate 1a G1 and Plate 2a G1). However, photographs of the livers and gills of *C. gariepinus* in the groups exposed to kerosene result revealed mild to severe vacuolar degeneration on the liver and gills of *C. gariepinus* based on the volumes of kerosene (Plate 1a, G2 and G3; Plate 2a, G2 and G3). Extract of *B. sapida*, ameliorated the toxic effects of the kerosene in dose-dependent manner. Severe portal and central venous congestions were observed in the organs, the severity of these congestions decreased with increase in the extract concentration. The result indicated that *B. sapida* displayed ameliorative effects on sub-adults African catfish, as such could be used to treat the fish species in the case of oil spillage.

Table 1: Water Quality Parameters during 28 Days Exposure of sub-adults *C. gariepinus* to kerosene and the treatment with *B. sapida* Stem-Bark extract

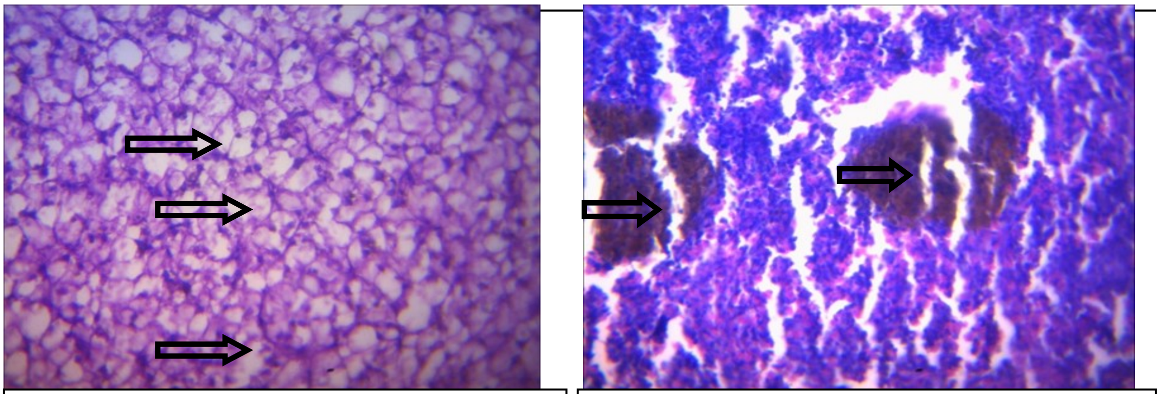
PARAMETERS	EC(S/m)	pH	TDS (mg/L)	TEMP(°C)	(DO) (mg/dl)
G1- (Positive Control) - No kerosene	0.19±0.00^{d}	7.0±0.06^{e}	150.2±0.73^{c}	31.7±0.03^{b}	7.6±0.04^{bc}
G2 (Negative Control 1) -100ml kerosene.	0.24±0.01^{b}	7.8±0.03^{d}	118.1±1.58^{d}	30.7±0.21^{c}	5.7±0.33^{e}
G3 (Negative Control 2) - 200ml kerosene	0.23±0.00^{bc}	6.8±0.10^{f}	149.7±19.03^{c}	31.5±0.03^{b}	8.51±0.21^{a}
G4 - 100ml kerosene + 50mg/kg bwt. EE	0.22±0.01^{c}	7.2±0.00^{de}	162.5±0.5^{a}	32.1±0.25^{ab}	7.45±0.13^{c}
G5 - 100ml kerosene + 100mg/kg bwt. EE	0.18±0.04^{d}	10.8±0.10^{b}	162.7±0.33^{a}	32.0±0.06^{ab}	7.56±0.12^{bc}
G6 - 100ml kerosene + 150mg/kg bwt. EE	0.29±0.10^{a}	11.0±0.09^{a}	116.3±2.67^{d}	33.9±2.17^{a}	8.01±0.01^{b}
G7 - 200ml kerosene + 50mg/kg bwt. EE	0.21±0.02^{c}	10.8±0.03^{b}	169.5±0.29^{a}	31.6±0.15^{b}	5.01±0.54^{e}
G8 - 200ml kerosene + 100mg/kg bwt EE	0.20±0.03^{c}	10.7±0.03^{bc}	169.7±0.37^{a}	31.97±0.18^{b}	5.5±0.91^{e}
G9 - 200ml kerosene + 150mg/kg bwt. EE	0.17±0.04^{d}	10.6±0.13^{c}	105.7±0.33^{e}	31.96±0.09^{b}	6.11±0.11^{d}



G1: No visible lesions seen



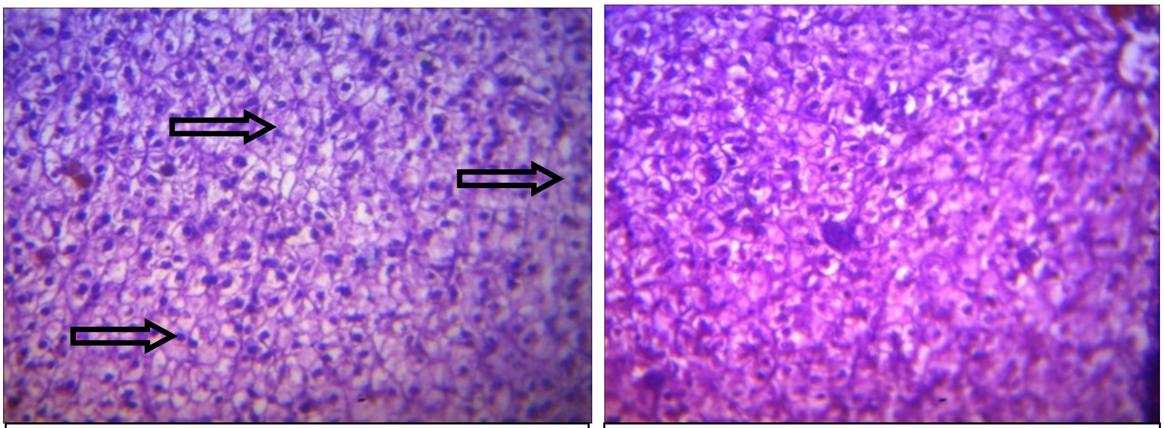
G2: There is a mild diffuse vacuolation of hepatocytes (arrows)



G3: There is a severe diffuse vacuolar degeneration of hepatocytes (arrows).

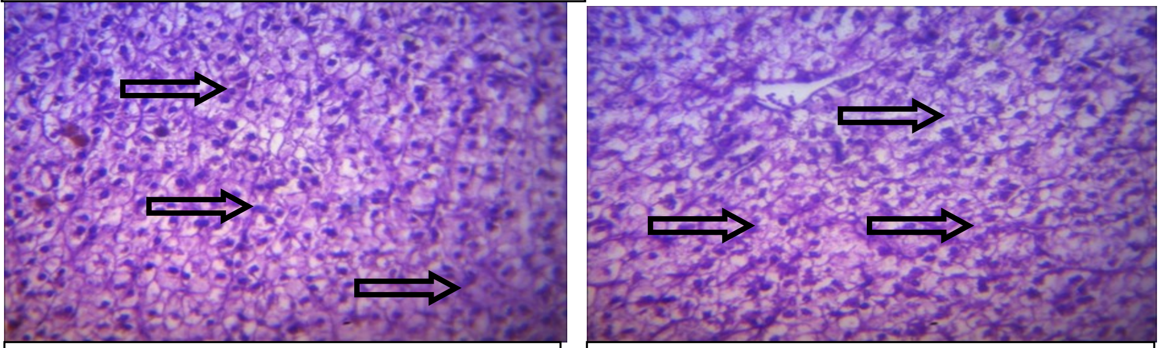
G4: There is a severe portal and central venous congestion (arrows).

Plate 1a: Photomicrograph of catfish liver section before and after exposure to kerosene and treatment with ethanol extract of *Blighia sapida*



G5: There is a severe vacuolar degeneration of hepatocytes (arrows).

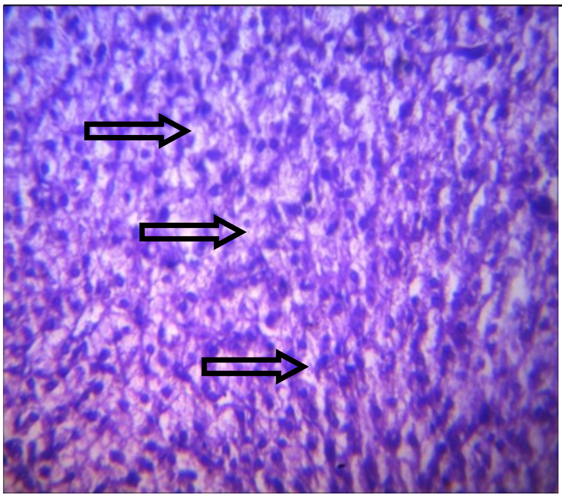
G6: No visible lesions seen hepatocytes



G7: Very mild diffuse vacuolation of hepatocytes (arrows). hepatocytes (arrows)

G8: There is a mild diffuse vacuolation of the hepatocytes (arrows). hepatocytes (arrows)

Plate 1b: Photomicrograph of catfish liver section before and after exposure to kerosene and treatment with ethanol extract of *Blighia sapida*

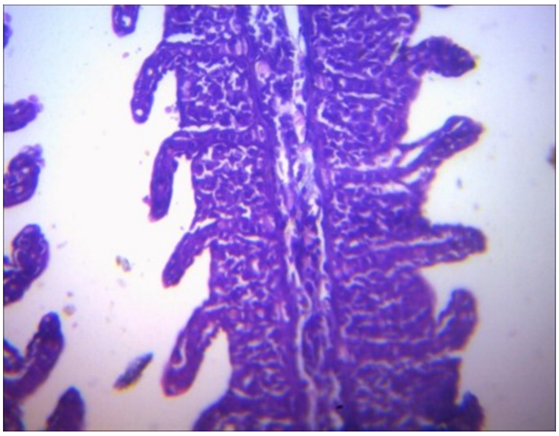


G9: There is a mild diffuse vacuolation of the hepatocytes (arrows).

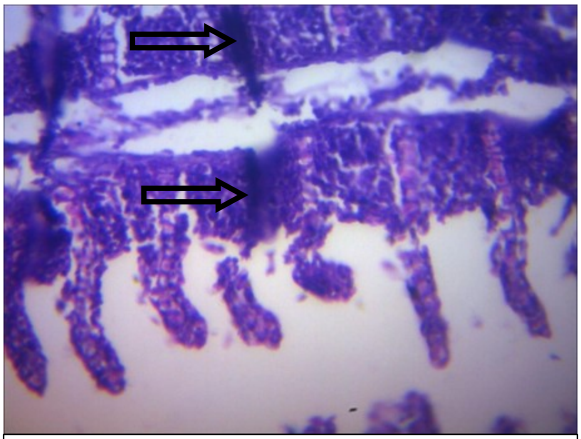
Plate 1c: Photomicrograph of catfish liver section before and after exposure to kerosene and treatment with ethanol extract of *Blighia sapida*

KEYS

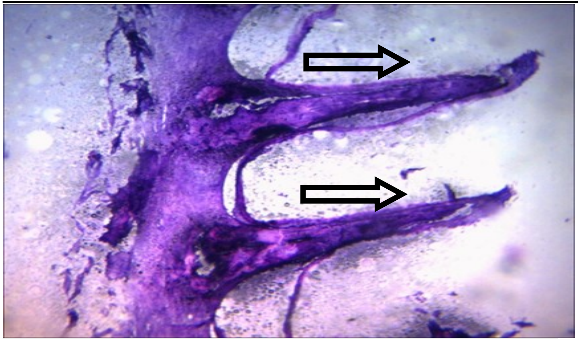
G1 - (Positive Control) - No kerosene.
G2 - (Negative Control 1) - 100ml kerosene.
G3 - (Negative Control 2) - 200ml kerosene.
G4 - 100ml kerosene + 50mg/kg bwt. EE.
G5 - 100ml kerosene + 100mg/kg bwt. EE.
G6 - 100ml kerosene + 150mg/kg bwt. EE.
G7 - 200ml kerosene + 50mg/kg bwt. EE.
G8 - 200ml kerosene + 100mg/kg bwt EE.
G9 - 200ml kerosene + 150mg/kg bwt. EE.



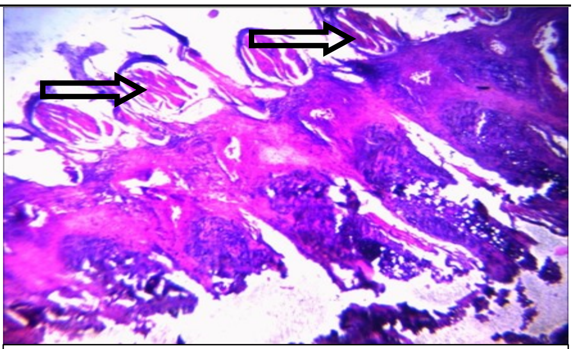
G1: No visible lesions seen



G2: There is a mild submucosal congestion (arrows)

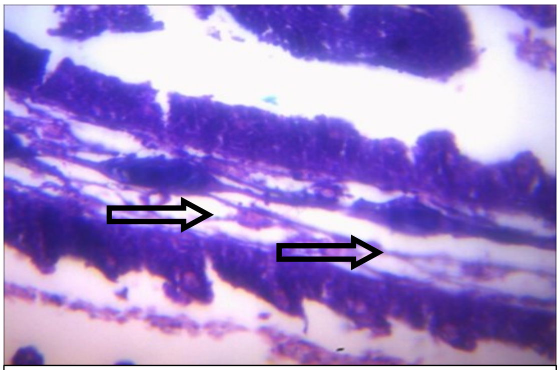


G3: There is a severe erosion of the secondary lamellae (arrows)

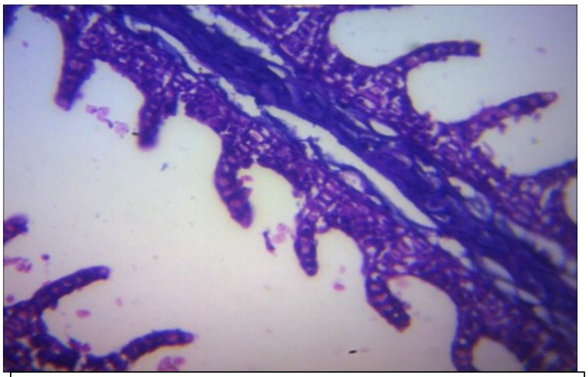


G4: The secondary lamellae is severely stunted (arrows)

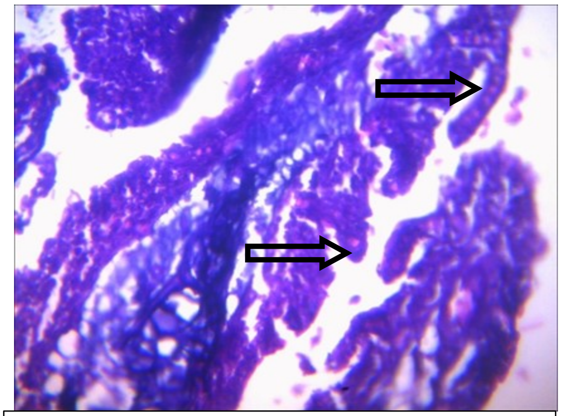
Plate 2a: Photomicrograph of catfish gill section before and after exposure to kerosene and treatment with ethanol extract of *Blighia sapida*



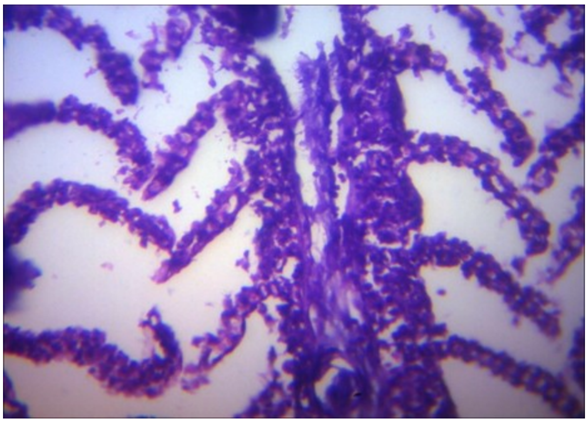
G5: There is a mild submucosal congestion (arrows)



G6: No visible lesions seen

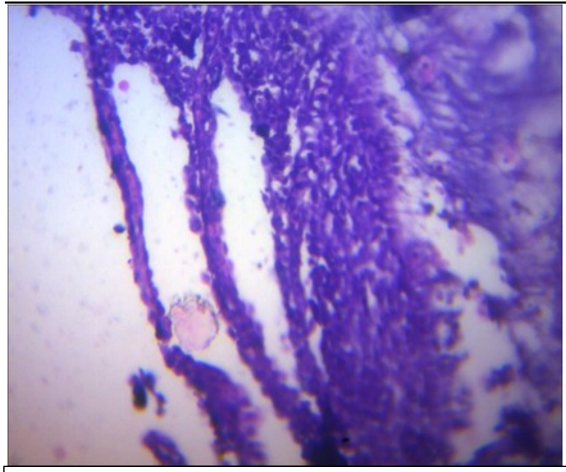


G7: The secondary lamellae appear stunted (arrows)



G8: No visible lesions seen.

Plate 2b: Photomicrograph of catfish gill section before and after exposure to kerosene and treatment with ethanol extract of *Blighia sapida*



G9: There is a mild submucosal congestion

Plate 2c: Photomicrograph of catfish gill section before and after exposure to kerosene and treatment with ethanol extract of *Blighia sapida*

KEYS

G1 - (Positive Control) - No kerosene.
G2 - (Negative Control 1) - 100ml kerosene.
G3 - (Negative Control 2) - 200ml kerosene.
G4 - 100ml kerosene + 50mg/kg bwt. EE.
G5 - 100ml kerosene + 100mg/kg bwt. EE.
G6 - 100ml kerosene + 150mg/kg bwt. EE.
G7 - 200ml kerosene + 50mg/kg bwt. EE.
G8 - 200ml kerosene + 100mg/kg bwt EE.
G9 - 200ml kerosene + 150mg/kg bwt. EE.

DISCUSSION

Water quality maintenance is crucial for ensuring the healthy and survival of aquatic flora and fauna. Moreover, any alteration in the water quality parameters poses a significant threat to the existence of fish and other aquatic organisms (Idowu *et al.*, 2019; Olajuyigbe *et al.,* 2020). An evaluation of the physical and chemical qualities of the water in the kerosene-induced experimental tanks is very crucial, as they provide vital information regarding the variations and effects of the toxicant (kerosene) and *B. sapida* ethanol extract at different concentrations on experimental fish. Electrical conductivity (EC) provides insights into the ion concentration in water, which can be influenced by contaminants like kerosene. In this study, the electrical conductivity values were significantly different between treatments. In addition, the EC values in G2 and G3 (negative controls) were significantly different from the EC values obtained in the positive control (G1), indicating potential disturbance from kerosene exposure. G4 to G9 treatments, with varying concentrations of *B. sapida* exhibited EC levels that suggest potential mitigation effects. For instance, highest EC value was recorded in 100 ml kerosene + 150mg/kg bwt. ethanol extract (G6) probably as a result of the higher concentration of kerosene toxicity in combination with *B. sqpida* extract in this treatment compared to the lower EC value recorded in positive control group (G1) with no concentration of kerosene (Garg *et al.,* 2019; Meng *et al.,* 2020). However, the improved EC values in treatments with *B. sapida* suggests a promising ameliorative effect of Ackee plant on the ion concentrations of kerosene-induced toxicity in aquatic ecosystems. The pH is a crucial parameter indicating the acidity or alkalinity of water. The fluctuations of pH can impact aquatic ecosystems and biological processes (Sultana *et al*., 2019). The pH value in 100 ml kerosene + 50mg/kg bwt. ethanol extract (G4) was not significantly different from the pH value in G1 which was the positive control. The observed pH values in 100 ml kerosene + 50mg/kg bwt. ethanol extract (G4) to 200 ml kerosene + 150mg/kg bwt. ethanol extract (G9) indicated a potential stabilizing effect shortly after the toxicity exposure. The recorded pH levels could potentially be attributed to the synthesis of alkaline metabolites in the treated water with plant extracts. This is in contrast to the findings of Effiong *et al.* (2020), who reported a decrease in pH upon utilizing stem bark extracts of Ackee. The observed variation in this study might be attributed to the different experimental fish species or rearing environmental conditions. According to Noga *et al.* (1996), the optimal pH range for freshwater fish is between 6.5 and 8.5. However, the pH values obtained from this study ranged from 6.8 to 11, suggesting *B. sapida*'s potential to buffer pH changes induced by kerosene toxicity. In contrast to the control groups (Negative and Positive), the pH of the other treatments (kerosene + *B. sapida* ethanol extract) differed significantly from the control group. The concentrations of the extracts exhibited a tendency toward potential alkalinity. This phenomenon may be ascribed to the synergistic influence of kerosene and the ethanol extract of *B. sapida.* A comparable pattern was documented by Orowe and Ikponmwen (2022), who hypothesized that this could be a result of carbonic acid or its metabolites being deposited into the medium by the catfish, in conjunction with the catfish secreting mucus into the aqueous environment as a means of survival. The quantity of total dissolved solids or salts, including anions, potassium, sodium, and magnesium, is correlated with conductivity (Nadeem and Saeed, 2014). Total dissolved solids (TDS) represent the cumulative concentration of dissolved substances in water, reflecting pollution levels and water quality status. In the same way, the substantial rise in conductivity observed in the bio-`augmentation group as opposed to the control group may have been influenced by byproducts of kerosene biodegradation in the containers. TDS values were significantly different between the treatments. However, groups of fish in 100 ml kerosene + 50mg/kg bwt. ethanol extract (G4) to 200 ml kerosene + 150mg/kg bwt. ethanol extract (G9) displayed improved TDS values which suggest the phytoremediative potentials of *B. sapida* to mitigate the pollutant-induced TDS accumulation in the rearing water (Wu *et al* 2021). It is well known that temperature significantly affects biochemical processes such as enzyme reaction, and immune response in fish which can influence pollutant toxicity (Islam *et al.,* 2022). There was no observed disparity in temperatures between the negative controls and the positive control in the conducted study. This is in contrast to the findings of Orowe and Ikponmwen (2022), who observed a rise in temperature in treatments that were subjected to different concentrations of crude oil. The temperature measurements revealed that the concentration of the toxicant (kerosene) has a negligible impact on the quality of the water within a relatively small range, suggesting that the water remains stable despite the presence of kerosene. Nevertheless, the introduction of *B. sapida* ethanol extract resulted in a marginal rise in temperature with limited influence of *B. sapida* on the thermal changes induced by kerosene. Although, similar temperature values were observed in 100 ml kerosene + 50mg/kg bwt. ethanol extract (G4) and 100 ml kerosene + 100mg/kg bwt. ethanol extract (G5) with significant differences between treatments. Potential causes for these variations include metabolic alterations induced by kerosene and *B. sapida* ethanol extract exposure. The dissolved oxygen is an important determinant of the respiration and survival rate of aquatic animals including fish species in their rearing systems. Dissolved Oxygen (DO) is very sensitive to pollutants, including kerosene. The DO values recorded in this study were significant between treatments with similar DO values in Positive Control (G1) and 100 ml kerosene + 100mg/kg bwt. ethanol extract (G5) which suggest the ameliorative effect of the *B. sapida.* The recorded higher DO values in the groups exposed to *B. sapida* extracts revealed the phytoremediation potentials of Ackee plants to enhance the oxygen level in contaminated water (Wang *et al.,* 2021).

The histological analysis of gill and liver tissues that had been exposed to a range of toxins, including industrial contaminants, pesticides, crude oil, and nanoparticles, unveiled significant to moderate damage to the anatomical structures of these organs. The amelioration of these altered or damaged structures by *B. sapida* extracts may be ascribed to the antioxidant properties of the extract, as reported by Adekola *et al.* (2022). In contrast to the negative control (100 and 200 mL/l kerosene), which exhibits severe diffuse vacuolar degeneration of hepatocytes, the histological examinations of fish livers exposed to kerosene and treated with ethanol extract of *B. sapida* revealed only mild diffuse vacuolation of hepatocyte structure. Olajuyigbe *et al.* (2020) observed comparable outcomes in their research examining the impact of bioremediation on water quality for Nile tilapia (*Oreochromis niloticus*) in the presence of petroleum oil contamination. It has also been documented that oil palm fronds possess a protective effect against crude oil damage in rats (Achuba, 2018). The potential protective effects of these plant extracts may be attributed to their ability to eliminate free radicals. This is due to the fact that the induction of oxidative stress is the primary mechanism underlying petroleum toxicity, a process that has been documented to be inhibited by a range of substances possessing antioxidant properties (Hamzah *et al.,* 2013; Dossou *et al.,* 2014; and Oloyede *et al.,* 2023). Adekola *et al.* (2020) identified bioactive components in the ethanol stem-bark extract of *B. sapida* that possess antioxidant properties. These components potentially serve to mitigate the detrimental effects of petroleum contamination on cells. In contrast to the negative controls, the histology of the gill structure of fish in the treated groups revealed only mild sub-mucosal congestion and no visible lesions in some groups, whereas the gill structure of fish in the kerosene group exhibited mild submucosal congestion and a severe erosion of the secondary lamellae. Olajuyigbe *et al.*

(2020) and Ogunsuyi *et al.* (2019) documented comparable outcomes in their investigations, which involved the exposure of Nile tilapia and *Clarias gariepinus*, respectively, to crude oil and nanoparticles. According to Abdel-Moneim *et al.* (2016), there is a significant correlation between the presence of lesions in fish tissues and oxidative stress, free radical production, enzymatic inhibition, and cell membrane integrity impairment.

CONCLUSION

The findings of this study provided additional support for the toxic impact of kerosene exposure on fish through the abnormal histology of the liver and gills of the pollution groups. Conversely, the treated groups, which received an ethanol extract of *Blighia sapida*, exhibited minimal or no lesions. This provides a more comprehensive understanding of the protective effect of the plant extract in mitigating the toxicity of crude oil on fish, the effect which has been attributed to the antioxidant properties of the extract.

Conflict of Interest

The authors declare that they have no conflict of interest.

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