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Proximate Assessment of Shrimp (*Macrobrachium felicinum*) Sourced from Crude Oil Polluted Sites in Rivers State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study investigated the nutrient value and the level of hydrocarbon contamination in shrimps sourced from crude oil contaminated sited such as Bodo, Borokiri, Bomu in Rivers state and Oron in Akwa Ibom as control. A total of eight samples of shrimps and water were sourced from four different locations and analyzed to determine the level of hydrocarbon contamination in shrimps sourced from crude oil polluted environment and proximate composition (ash, moisture, crude fiber,

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protein, carbohydrate and fat and oil) using standard procedures. The results obtained from the hydrocarbon analysis of the water samples indicated that TPH of the water samples ranged from 4.6616 mg/l to 28.3599 mg/l and PAH ranged from 4.00 to 208.86 mg/l. The result of the shrimps' samples shows that TPH and PAH contained in the shrimps' samples ranged from 4.0862 ppm to 18.7339 ppm, and 2.38 ppm to 236.05 ppm respectively. In the proximate composition, ash content ranged from 3.21% to 4.93%, moisture content ranged from 70.42% to 71.40%, fat and oil content ranged from 0.79% to 1.89%, Crude fiber ranged from 0.15 to 1.27%, protein content ranged from 13.87% to 20.87%, and carbohydrate ranged from 1.36% to 8.57%. The proximate composition of the samples from the four different locations show variation in the composition of shrimps in relation to the different locations. The proximate composition indicated that pollutions have reduced the nutrient levels and altered the mineral composition of the shrimps when compared with samples from unpolluted water body. There were significant differences between data obtained from the different study areas.

Keywords: Proximate; shrimp; Macrobrachium felicinum; crude oil; Rivers State.

1. INTRODUCTION

Any type of marine organism that can be eaten is referred to as seafood in general. Fish and shellfish are the two main categories of sea animals that make up seafood [1]. The term "seafood" frequently refers to a wide variety of aquatic species from both freshwater and marine settings, including mollusks, crustaceans, and all sorts of finfish, according to Lund (2013) and Reuthers et al. [2]. Shellfish and fish are the most common types of marine life that are considered to be "seafood" by humans. When a crab or mollusk has an exoskeleton resembling a shell on its body, it is referred to as a "shellfish.". Found in freshwater, saltwater, and terrestrial environments, they are a diverse collection of invertebrates [1].

Crustaceans are marine organisms that often live in marine environments and have diversified into sea oceans, inhabit land, chiefly as hoppers and Oniscus asellus, also known as slaters. They even exist in freshwater environments. Worldwide, there are between 50,000 and 67,000 known members of these species. Scientists believe that there may be 10–100 times more crustaceans in the world than is currently believed. The larger species of decapod crustaceans are more significant. Around the world, prawns, spiny lobsters, King crab (Paralithodes), and centolla are frequently caught by fishermen [1].

Bivalve mollusks, finfish, and crustaceans are among the quick booming food diet on earth which are important sources of revenue for both developed and developing nations. Odeyemi et al. [3] describes bivalve molluscs, which include mussels, oysters, clams, and scallops, as marine animals that are sedentary in habit, feed on phytoplankton, filter feed, come into touch with sediment, have a low metabolism, are highly resistant to chemical exposure, and are widely distributed in marine environments. The nutritional advantages of seafood are essential for promoting good and wellbeing and averting health impediments. While no one food can supply every nutrient needed for good health, ocean fish represent a significant and well-balanced source of a number of elements that are otherwise hard to come by Liu and Ralston, [4].

Members of the class Crustacea, order Decapoda, shrimps are a popular sea meal that may be found all over the world. Approximately 300 of the 8,500 species of decapods—which include 2,000 species of shrimp—are important to the global economy. They serve a variety of economic functions, such as supplying food, foreign exchange, revenue, and jobs [5]. Rich in protein, shrimps is a highly sought-after delicacy worldwide, often topping meat and poultry in popularity. Its superior body composition comprises high-quality proteins, fats, and amino acids, all of which serve as markers of optimal physiological and biochemical conditions. Prawns are a major economic resource and are considered crucial in terms of biomass overall. Because of the extremely important omega-3 and omega-6 fatty acids they contain, they are very nutritious [6].

In a wider sense, the terms "shrimp" and "prawn" could refer to stalk-eyed, swimming crabs having short legs, strong, muscular tails (antennae), and tail that are narrow and long. Generally speaking, any little crustacean that resembles a prawn is referred to as one. They use swimmerets on the underside of their abdomens to paddle ahead while swimming, but their usual escape manoeuvre involves repeatedly flicking their tails rapidly backward. Crabs and lobsters have strong walking appendages, while prawns have slender, delicate legs that they mostly employ for perching. Numerous prawn species have adapted to survive in an extensive variety of habitats; they can be found along the bottom of rivers, lakes, and most beaches and estuaries. In order to avoid being eaten, several prawn species flip off the seafloor and plunge into the silt. The majority of prawn species are little, as their name implies, with a maximum length of 2 cm (0.79 in), while others can reach up to 25 cm (9.8 in) in length. They abound, everywhere you look. Many animals have adapted to live well in a range of conditions. They are typically found eating along the bottom in rivers, lakes, and estuaries. To escape predators, some animals dive into the silt and flip off the seafloor. Despite the fact that many species of shrimp are as small as their name suggests, with a maximum length of 2 cm (0.79 in), certain shrimp can reach up to 25 cm (9.8 in). Prawns, or larger prawns, are more frequently targeted for commercial purposes [5].

Shrimps are among the many kinds of crustaceans ranging in length from over 35 cm to a few millimeters. They are highly prized food organisms that are extensively traded as a vital export good in West Africa. The enormously expanding Nigerian population's reliance on wild catches to supply shrimps is linked to a number of issues. Among them are the wild stock's rapid decrease due to increased catching efforts. Due to the production of shrimps in several regions of the world, shrimp farming has become a significant global aquaculture industry. Among the species raised in aquaculture, shrimps make up a sizable fraction [7].

Nigeria is one of the tropical nations having abundant resources of prawns. Shrimps, primarily belonging to the family Penaeidea, are abundant in Nigeria's coastal waters and have an annual capability for production of 12,000 metric tonnes. Currently, capture fisheries provide the majority of Nigeria's shrimp supply, which is processed and exported to developed nations [8]. According to Okayi et al. [7] there are two types of shrimp fisheries: the commercial or extensive shrimp fisheries, which are extremely well-organized and a significant supplier of shrimp for export; and the small-scale shrimp fisheries, in which a large number of rural residents use both motorised and non-motorized boats to harvest shrimp from the creeks and rivers that surround coastal communities. Numerous kinds of shrimps and prawns can be found in Nigeria's waterways. According to Konan et al. [8] freshwater prawns of the *Macrobrachim* species are the most prevalent shrimp species in Nigerian rivers.

As per Siva-Reddy et al. [9] the physiological condition of an organism can be accurately determined by examining the proximate body composition of Macrobrachium species, which includes protein, moisture, fat, and ash. Aquatic crustaceans are used as protein sources by a sizeable portion of the global population, especially in developing nations where animal protein is costly and out of the reach of the underprivileged [10]. This is due in part to their chemical makeup and nutritional characteristics. Season, animal size and age, maturity stages, food availability, feeding behaviour, and environmental factors—specifically, temperature, habitat salinity, and rainfall patterns—have all been found to affect the proximate composition of crustaceans [10]. The study conducted by Ukpatu and Udoh [11] revealed that size, temporal, and seasonal variations had a significant impact on the shrimp's proximate compositions. Meanwhile, Siva-Reddy et al. [9] reported a significant difference in proteins, moisture, fat, and ash between male and female *Macrobrachium rosenbergii* subjects. According to a 2013 study by Jimoh et al. on *Macrobrachium* sp, moisture did not significantly vary seasonally for prawns, However, crude protein, crude fibre, crude lipid, ash, and crude carbohydrate did.

Shrimps and other crustaceans are a key source of protein for people all around the world. It is also low in fat and calories and gives the body minerals, calcium, and other absorbable nutrients. The bulk of shrimps' lipid is composed of polyunsaturated fatty acids, also known as essential fats. Shrimp-sourced essential fatty acid is beneficial to human health in terms of brain and ocular development and function. Deficiencies in their diet might lead to ailments since they require specific micronutrients. When present in prawns at suitable concentrations, some elements with beneficial biological functions, such as copper, zinc, manganese, iron, and chromium, are particularly beneficial to human health [12].

Crude oil, according to Koshalf and Ball [13] is essentially a complex mixture of organic molecules made up mostly of hydrogen and carbon atoms, with trace amounts of metallic elements, nitrogen, and oxygen also present. Crude oil is arguably the most complex naturally occurring mixture of organic components, with over 17,000 unique chemical compounds found [14]. Petroleumgenic hydrocarbons consist of four fractions, according to Yasin et al. [14] and Koshalf and Ball [13] the aliphatic fraction (saturates), the aromatic fraction, the asphaltene fraction (phenols, fatty acids, ketones, esters, and porphyrins), and the resins (sulfoxides, carbazoles, quinolines, pyridines, and amides).

The environment is instantly altered when petroleum hydrocarbon is released into an uncontaminated hydrocarbon environment. Many microbial species are killed or inhibited by the hydrocarbons, which changes how the microbial community and ecosystem function [15]. The direct toxicity, obstruction of light, and incapacity of oil-restricted nutrients and water uptake through the soil matrix all severely reduce plant output in hydrocarbon-exposed plants [16]. There is little chance that the contaminated habitat can sustain higher-order life forms in the absence of primary producers and functional microbial biogeochemical networks [17].

The process of weathering occurs when hydrocarbons from petroleum find their way into the biosphere. For example, photo-oxidation, auto-oxidation, sorption, and plant and microbial hydrocarbon catabolism are some of the physical, physicochemical, chemical, and biological processes that cause petroleum hydrocarbons to weather in the environment [17]. Microorganisms are necessary for maintaining the equilibrium of an environment. They are in charge of controlling a number of activities that take place in the soil ecosystem, such as the nutrient recycling, the breakdown of organic matter and the formation of plant-based symbiotic relationships [17].

This study was aimed at assessing the proximate composition of shrimps sourced from crude oil contaminated environment.

2. MATERIALS AND METHODS

2.1 Sampling Site/ Collection

The samples, which included shrimp and water, came from four distinct places: Bodo, Bomu, Borokiri all in Rivers State and Oron in Akwa Ibom state. Bodo and Bomu are in Ogoniland of Rivers state. Nigerian subsidiary of shell Petroleum Development Company is in charge of five flow stations and 96 oil wells in Ogoni and two flow stations are in Bomu and Bodo. The region is extremely vulnerable to oil spills due to the existence of these facilities, which include multiple Trans-Niger pipelines that crisscross the Gokana land and seascape. Bodo Creek is a network of brackish water creeks that flank the Bodo settlement on the upper levels of the Andoni-Bonny estuary system in Rivers State [18]. Bodo Creek has four primary channels via which seawater enters and departs. Numerous feeder rivers, some of which end aimlessly in mangrove swamps, connect these main waterways [19,20]. In addition, the coordinates of 7.036° E and 4.748° N place the city of Borokiri in Port Harcourt, River State, Nigeria. The capital of Nigeria's Rivers state, Port Harcourt, is located twelve metres above sea level. Situated in the Nigerian Niger Delta, it is situated beside the Bonny River. 2015 saw Ebong and Ekong. Oron Beach, Oron in Akwa Ibom State receives massive inflow of water from Atlantic Ocean which stretches from Ikot Abasi to Oron. A sprawling volume of water seemingly meeting the skyline from flank to flank.

2.2 Sample Collection

Eight (8) samples of shrimps and water were taken, one from an uncontaminated site in Oron, Akwa Ibom state (control), and the others from crude oil-polluted rivers (Borokiri, Bodo, and Bomu) in Rivers state. The shrimps were aseptically put in an iced-packed container and the water sample in bottled water container to the laboratory for examination. The samples were divided into two portions for hydrocarbon and proximate analyses.

2.3 Determination of Total Petroleum Hydrocarbon Content of Samples

Total Petroleum Hydrocarbon (TPH) analyses were carried out on the samples using Gas Chromatography (GC) for Day 1, 56 Total Petroleum Hydrocarbon (TPH) in each of the set-ups was determined by a modified Environmental Protection Agency 8015 technique. The samples were extracted using a gas chromatograph, equipped with a flame ionization detector (FID). The residual Total Petroleum Hydrocarbon (TPH) in the different samples was extracted with 40 µl of n-pentane (HPLC grade) by sonicating the sample 5min at each extraction for 3 times. The pentane extract was centrifuged at 3000 g for 5 min, the three organic phases were oven-dried over sodium sulphate (Na_2SO_4), pooled and adjusted to 150 ml after which 32 µl of cumene (isopropyl benzene) was added as internal standard analyses were carried out using a Varian 1440 GC-FID (Califoni, USA). The extractable TPH was identified and quantified by comparison using a sample chromatogram with standard calibration.

2.4 Estimated value Assessment (Proximate Analysis)

- **Composition of protein**

Method used for the evaluation of the composition of protein was the Kjedahl method and this was done in three stages: First Digestion Stage: In a sterile 250 ml conical flask, the zero-point One gramme (0.1 g) of the shrimp sample was broken down into three grammes of catalyst for digestion. The sample was also heated to facilitate the digestion process and 20 ml of concentrated sulfuric acid added.

Stage 2 Distillation: After measuring out twenty (20) millilitres of the diluted digest, the flask was placed on top of a heated plate or electrothermal heater. A syringe linked to the mono-arm steelhead was used to inject 40 millilitres of 40% sodium hydroxide into the digest until it was extremely alkaline. A Liebig condenser that was attached to a container holding ten millilitres of a two percent boric acid indicator was linked to the distillation flask. The colour of the boric acid turned from purple to a greenish-green after the mixture was heated to a boiling point and the ammonia gas was forced into the receiver beaker by the condenser.

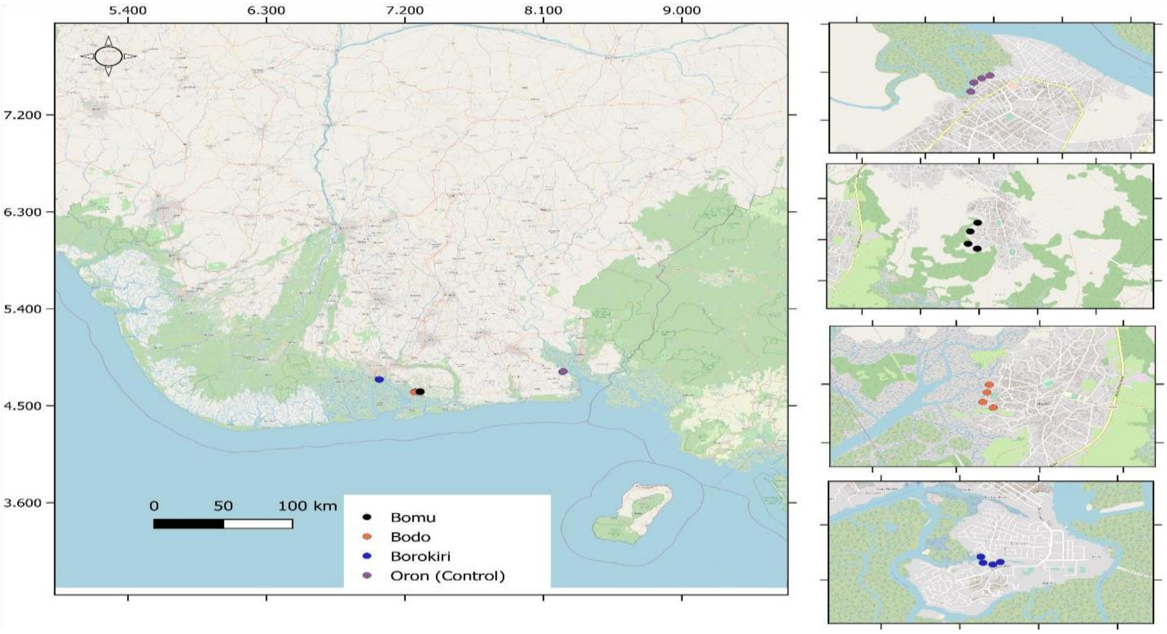

Fig. 1. Map of the Study Areas, Rivers State and the control, Oron in Akwa Ibom State

Fig. 2. Freshly harvested Shrimp sample

Phase Three Distillation: The titer value was calculated as the amount of hydrochloric acid added to induce this transformation. After that, a standard 0.1N hydrochloric acid solution was used to titrate the distillate in order to turn it back from greenish to purple.

- **Carbohydrate content**

The shrimp samples were weighed to determine its carbohydrate content using the Clegg Anthrone method. A 25 ml volumetric flask was filled with sample containing 0.1g, one ml of distilled H_2O, 1.3 ml of 62% pentatonic acid. The mixture was shaken for 20 minutes to ensure thorough homogenization. The flask was filled with distilled water and a cork to the 25 ml mark. After the mixture was allowed to settle and be decanted, glass filter paper was used to filter it. One millilitre of the filtrate was put into a ten millilitre test tube, where it was diluted to the required volume with distilled water. A single millilitre (1 millilitre) of the solution was pipetted inside a sterile test tube, additional of five millilitres reagent of Antrone, one millilitre of distilled water was then combined with 5 millilitres of Antrone reagent and prepared as a blank solution, the entire mixture was read at a wavelength of 630 nm. Additionally, 0.1 millilitre of glucose was treated; the absorbance of the standard glucose and carbohydrate were measure and calculated.

- **The amount of Moisture**

The instrument used for analyzing moisture content in samples is air oven method. A single gramme shrimps was weighed out and put into a dry, clean porcelain evaporating dish. The dish was then baked for six hours at 105oC and allowed to cool in room temperature in a desiccator, then weigh again and recorded.

- **Lipid content**

Lipid contents were analyses by using Soxhlet extraction method. A sample of two gram of shrimps was put into a soxhlet extractor along with some filter paper. The extractor was set within a dry distilled flask that had been previously weighed. The solvent, acetone, was connected to the soxhlet extractor and delivered into the distillation flask through the condenser. Retort stand clamps held the setup in place while the condenser allowed cooled water jet in, which causes the solvent that was heated to reflux. They were detached; the extractor and the condenser, while the solvent evaporated to concentrated to lipid, and lipid solvent chamber was extracted through a continuous refluxing process until the lipid was clearly removed entirely from the test sample. To determine the weight of lipid, the flask was weighed again after being dried in an air oven.

- **Ash content**

The ash content was examined using the igniting method and the law. A porcelain crucible that had been prepared and weighed was filled with one (1) gramme of the prawn sample. The crucible was then placed inside a muffle furnace and heated to 630°C for three hours. After that, once it had cooled to normal temperature, the weight was measured once more.

3. RESULTS

3.1 Hydrocarbon Analysis of the Water Samples

The Baseline of hydrocarbon parameters of the water samples from the different locations are presented in Table 1 and Fig. 3. The TPH of the water samples included a ranged of 4.6616 mg/l to 28.3599 mg/l with the sample, AKW having the least concentration while the highest TPH was in the sample, BORW. The PAH ranged from 4.00 to 208.86 mg/l with the sample, AKW had the smallest amount of PAH and the sample, BODW having the highest value of PAH.

3.2 Hydrocarbon Analysis of the Shrimp Samples

The Baseline of hydrocarbon parameters of the water samples from the different locations are presented in Table 2 and Fig. 4. The TPH ranged from 4.0862 ppm to 18.7339 ppm, BORS sample having the highest concentration while AKS sample was the least. The shrimp samples had varying concentrations of PAH from 236.05 ppm to 2.38 ppm, BODS was observed to have the highest value while AKS having the lowest value.

3.3 Proximate Composition of the Shrimp Samples

The proximate composition (crude fiber, protein, carbohydrates, moisture content, fat and oil, and ash) among the samples of shrimp from the different locations of study as appeared in Table

3. Ash content valued between 3.21% to 4.93% with the sample AKS having the least value while the highest amount was observed in BODS sample. The amount of moisture (in percentage) in the shrimp samples analyzed ranged from 70.42% to 71.40% with the sample AKS having the highest moisture content and the least amount was obtained in the sample, BORS. The concentration of fat and oil in the samples ranged from 0.79% to 1.89%, the sample, AKS obtained the highest value of fat and oil while the sample, BORS contained the least value of the fat and oil. Crude fiber present in the shrimp samples ranged from 0.15 to 1.27% with the sample, AKS having the highest crude fiber and the sample with the least amount of crude fiber was BODS. Protein content in the shrimp samples ranged from 13.87% to 20.87%, the greatest amount was obtained in the sample AKS and the least was observed in sample BODS. The carbohydrate composition of the shrimp samples ranged from 1.36% to 8.57%, the sample, BORS obtained the highest percentage of carbohydrate while the least amount was observed in the sample, AKS.

Table 1. Hydrocarbon Analysis of the water samples

Parameters	BORW	BODW	BOMW	AKW	DPR Permissible limit in surface water
TPH (ppm)	28.3599	19.6773	14.3015	4.6616	10
PAHs (ppm)	197.75	208.86	44.0	4.00	0.007

Key
BORW (Borokiri water sample) BODW (Bodo water sample)
BOMW (Bomu water sample) AKW (Akwa Ibom water Sample)

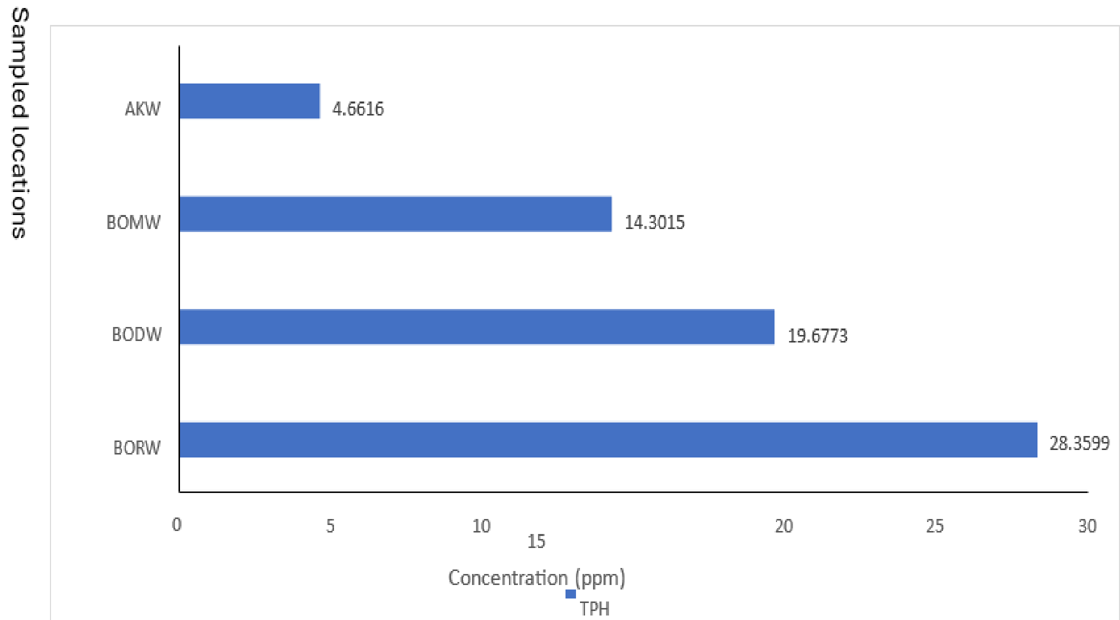

Fig. 3. The TPH of the water samples obtained from crude oil contaminated sites

Table 2. Hydrocarbon Analysis of the shrimp samples

Parameters	BORW	BODW	BOMW	AKW	WHO Permissible limit in food
TPH (ppm)	18.7339	10.9422	14.1266	4.0862	10
PAHs (ppm)	96.22	236.05	26.17	2.38	0.002

Key
BORW (Borokiri shrimp sample) BODW (Bodo shrimp sample)
BOMW (Bomu shrimp sample) AKW (Akwa Ibom shrimp Sample)

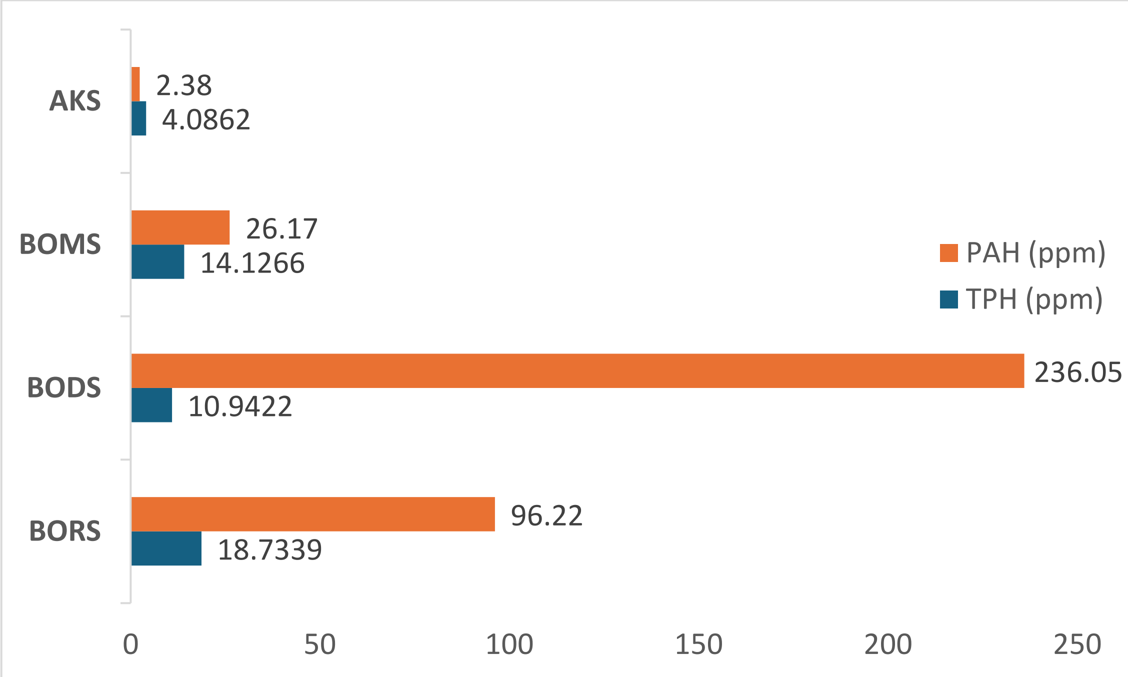

Fig. 4. The shrimp samples obtained from crude contaminated site

Table 3. Proximate composition of shrimp samples obtained from crude oil contaminated sites

Parameters	BORS	BODS	BOMS	AKS
Ash (%)	4.78	4.93	4.33	3.21
Moisture (%)	70.42	72.1	71.24	71.40
Fat and Oil (%)	0.79	0.87	1.10	1.89
Crude fiber (%)	0.21	0.15	0.72	1.27
Protein (%)	15.23	13.87	16.01	20.87
Carbohydrate (%)	8.57	8.08	6.60	1.36

4. DISCUSSION

The combined terms PAHs and TPH concentration can be potentially toxic and dangerous when they cross the food chain into the biological system. The hydrophobic, mutagenic, and carcinogenic properties of PAHs are what make them environmentally dangerous pollutants [21]. The amount of total petroleum hydrocarbon (TPH) of the water samples from Rivers (BORW, BODW, BOMW) were observed to be above the Directorate of Petroleum Resource (DPR, 2011) acceptable limit of 10 mg/l, however, the control sample (AKW) was within the standard. The range of results in the current investigation is greater than that of a study conducted by Edori et al. [22] on the surface water and sediment of the Edagberi Rivers in Niger, Nigeria.

In every sample of water, the amount of polycyclic aromatic hydrocarbons was found to be higher than the DPR-established tolerable limits for surface water. The results of this study's PAH analysis differ from those of Benibo et al.'s [23] investigation, which found that the surface water's DPR content was below allowable limits. Petroleum hydrocarbons will inevitably poison and pollute the environment wherever oil exploration and production occur [24]. According to Edori et al. [22] petroleum hydrocarbons have the capacity to impede aquatic organism lifeforms by blocking olfactory cells and causing bioaccumulation in surface water or sediments. The environment, particularly the rivers, becomes uninhabitable for people because of petroleum hydrocarbon contamination brought on by illicit oil activities, the unintentional release of petroleum products by illicit operators, and faulty treatment by transporters and others in the oil business. The findings of this research rivers' aquatic systems are seriously endangered by the presence of total petroleum hydrocarbon components [22].

In the physicochemical parameter of the shrimp samples, the total petroleum hydrocarbon concentration of the shrimp sample from non-polluted river was observed to be within the permissible limit compared to the other samples that recorded concentration above WHO permissible limit of 10mg/kg. All the shrimp samples were observed to have polycyclic aromatic hydrocarbon (PAH) concentration above the acceptable range of 0.002 mg/kg in food however, the control sample (AKS) had lower concentration. The United States Environmental Protection Agency (EPA) lists polycyclic aromatic hydrocarbons (PAHs) as priority hazardous components due to their persistence in the environment and fish toxicity; The most hazardous contaminants present in crude oil are PAHs. PAHs are therefore especially significant in environmental control and after oil spills. They originate from both natural and artificial sources. Pyrolysis and the partial combustion of organic molecules are related to natural sources. Air deposition, wastewater, and oil spills are a few of the primary sources of PAHs.

The proximate composition of the samples from different locations showed variations in the composition of shrimps in relation to the different locations. Protein, fat and oil, and crude fiber had been shown to be higher in Akwa Ibom shrimp samples (the control sample) compared to samples from other locations however, the same observations was not observed in the other parameters which the components varied. Composition of seafood varied greatly between and within species and especially between the different groups Oehlenschlager, [25] and the organism populations are interdependent on one another and their surroundings [26]. The higher amount of the component (protein, crude fiber and fat and oil) in Akw Ibom samples (i.e. the control samples) in relation to other samples can attributed to consequence of contamination of petroleum in the reduction of certain nutritional composition of shrimp as shown in this study. The discovery that protein constituted the majority of the ingredient suggests that prawn muscle can serve as a valuable fount for molecules that combines to form proteins (amino acids). Puga-lopez et al. [27] examined the proximate composition of Pacific white leg prawns collected in the wild and on farms and discovered that the protein content varied between 19.930.69 and 20.100.52. This study's protein content, which ranged from 15.23% to 20.87%, is similar to that study's findings. The proximate composition of prawns gathered from Kasimedu Fish Landing Centre in Chennai was analysed by Ali et al. [28] who found that the shrimp's crude protein content was 17.90.05%. The samples' fat and oil concentrations, which varied from 0.79% to 1.89%, are in line with a related study by Puga-lopez et al. [27] which assessed the range of fat content to be 1.270.36 to 1.340.18. The percentage of moisture in the shrimp samples that were analysed ranged from 70.42% to 71.40% [29]. This is less than what was reported in the study by Tawade et al. [12] where the moisture content of the shrimp samples was observed to be between 73.2% and 77.9% with no significant difference. However, it was consistent with the study by Puga-lopez [27] which found that the moisture content of the shrimp samples ranged from 73.14 to 73.91%. The concentration of carbohydrate of shrimps recorded in this study ranged from 1.36% to 8.57% and corresponds with the findings of another research conducted by Tawade et al., [12] Ali et al., [28].

5. CONCLUSION

This research demonstrated that hydrocarbons pollution in the water bodies alter some proximate compositions such as protein, fat and oil, crude fiber in the Shrimp samples. Seafood could be altered or reduced due to pollution by hydrocarbon as recorded in this study. Accumulation of hydrocarbon in Shrimp tissues might lead to biomagnification, affecting the shrimp quality, shrimp nutritional values, shrimp food safety, change shrimp texture and flavor, and can equally impose high health risks to humans consuming hydrocarbon contaminated seafood.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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