Assessment of Proximate Profile of Selected Fin and Shell Fish and Physicochemical Assessment of Water from Named Rivers in Ogoniland

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Authors' contributions

This work was carried out in collaboration among all authors. Author AAJ designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript, managed the analyses of the study and managed the literature searches. Authors MOW, DCB and BMO supervised the entire research and read and approved the final manuscript.

Original Research Article

ABSTRACT

Aims: This study investigated the physicochemical assessment of Rivers Kaa and Bodo in Ogoniland, as well as the proximate profile of selected fin and shell fish from these Rivers.
Study Design: Random sampling.
Place and Duration of Study: Kaa and Bodo communities of Ogoniland, between August and November 2014.
Methodology: The physicochemical analysis; pH, temperature (T), biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), total suspended solids (TSS), total dissolved solids (TDS), conductivity (C), salinity (S) and total hydrocarbon content (THC), were done. The results were compared to FEPA and APHA permissible limits. Proximate composition was determined using Association of Official Analytical Chemist standard analytical methods.
Results: Physicochemical analysis results showed that T ($26.5\pm.010$), ($26.8\pm.006$) and TSS ($8.68\pm.006$), ($12.5\pm.006$) for Kaa were lower than Bodo (sp≤0.05), S ($7.20\pm.021$), ($8.40\pm.010$) and

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THC (0.25±.015), (3.00±.040) were both lower for Kaa than Bodo, at (p≤0.05), BOD was higher for samples collected from Bodo than samples collected from Kaa (188±.234), (259±.690). The TDS and Conductivity were both higher for samples from Bodo than those from Kaa, while pH and DO were higher for samples collected from Kaa than samples collected from Bodo. The moisture content for all samples collected from Kaa (63.7±.289), (72.5±.488), (75.1±.973), (67.4±.455), were significantly lower at p≤0.05 than the moisture content for samples from Bodo (68.7±.514), (80.6±.476), (86.2±.790), (74.5±.514) indicating that the samples from Kaa are better sources of protein, lipid, and energy than samples from Bodo. The protein, lipid, crude fibre, ash and dry matter content of all samples from Kaa were significantly higher (p≤0.05) than those for samples from Bodo.

Conclusion: These findings suggest a contamination of the study sites particularly Bodo with petroleum products. Furthermore, it shows that the protein contents in all samples from Bodo were below the recommended standards, suggesting that the consumption of fishes from the study area particularly Bodo, is unhealthy.

1. INTRODUCTION

Though petroleum has played an important role in the economy of the country, over the past three decades, the Niger Delta ecosystem has been subjected to destruction by petroleum product spillage and other effluents resulting from oil exploration /operational activities [1]. The contents of the effluents (oil spill) have serious toxicological effects on aquatic environments and humans [2]. According to Sala *et. al.*, [3] the loss of biodiversity and its effects are predicted to be greater for aquatic, ecosystems than for terrestrial ecosystems. The healthy aquatic ecosystem is dependent on its physicochemical and biological characteristics [4]. Pollution of a river first affects its chemical qualities, and then systematically destroys the community, disrupting the delicate food web, and impairing the use of the river [5]. Nevertheless, it is noteworthy to know that the water quality of rivers and lakes change with seasons and geographical areas, even when there is no pollution present. Important physical and chemical parameters influencing the aquatic environment are temperature, rainfall, pH, salinity, dissolved oxygen, carbon dioxide, etc. Others are total dissolved and suspended solids, total alkalinity and acidity. These parameters are the limiting factors for the survival of aquatic organisms (flora and fauna). Poor water quality may also be caused by low water flow, municipal effluent and industrial discharges [6,7]. Also, industrial activities increase concentration of metals and toxic chemicals, suspended sediments, temperature, and lower oxygen concentration in water. Each of these effects can have a negative impact on the aquatic ecosystem, and /or make water unsuitable for established or potential uses [7]. Therefore, the physicochemical parameter study is very important [8].

Fish is widely consumed in many parts of the world because it has high protein content, low saturated fat and also contains calcium, phosphorus, iron, trace elements like copper and a fair proportion of the B-vitamins known to support good health [9]. Proximate composition is used as an indicator of fish quality; it varies with diet, feed rate, genetic strain and age [10]. Knowledge of the proximate composition of fishes is essential to estimate their energy value and to plan the most appropriate industrial and commercial processing [11]. But more importantly, information on the proximate and heavy metal composition of fishes is of particular importance for the determination of their nutritive values as well as for investigating the level of pollution or contamination [12]. Generally, composition of live-weight, whole fish is 70 to 80% water, 20 to 30% protein, and 2 to 12% lipid [11]. However, in different environmental conditions, the composition of the fish may differ in relation to the differences in water quality, feeding conditions, sex, and state of maturity [11]. The protein content of fish is very important when considering quality and texture of the fish meat [13,11]. Ogoniland, the site of this research, has a tragic history of pollution from oil spills and oil well fires and according to UNEP, [14], field observations and scientific investigations found that oil contamination in Ogoniland is widespread and severely impacting many components of the environment. Although a few studies have been carried out in Ogoniland, the state of Bodo River,

the test site has not been investigated. This study was aimed at investigating the physicochemical parameters of the waters of Rivers Bodo and Kaa, and studying the proximate analysis of selected fish samples from these Rivers.

2. MATERIALS AND METHODS

2.1 Study Sites

The study sites Bodo (test) and Kaa (control) are located in Ogoniland of Rivers State, with a population of close to 832000, and land area covering 1000 km^2 [15,14].

2.2 Collection of Test Samples

Water samples were collected using glass amber bottles, kept at temperature between 0 and 4°C and taken straight to the laboratory. Fresh samples of selected fin and shell fish were collected from Bodo and Kaa Rivers of Gokana and Khana local government areas of Rivers State, Nigeria. At each site, 10 individual fishes of similar size for each species were collected. Collected samples were cleaned and wrapped in aluminium foil plates, and cooled in an ice chest, before transportation to the laboratory. The identification of fish samples was done in the of the Department of Fisheries, Faculty of Agricultural Science, University of Port Harcourt.

2.3 Reagents

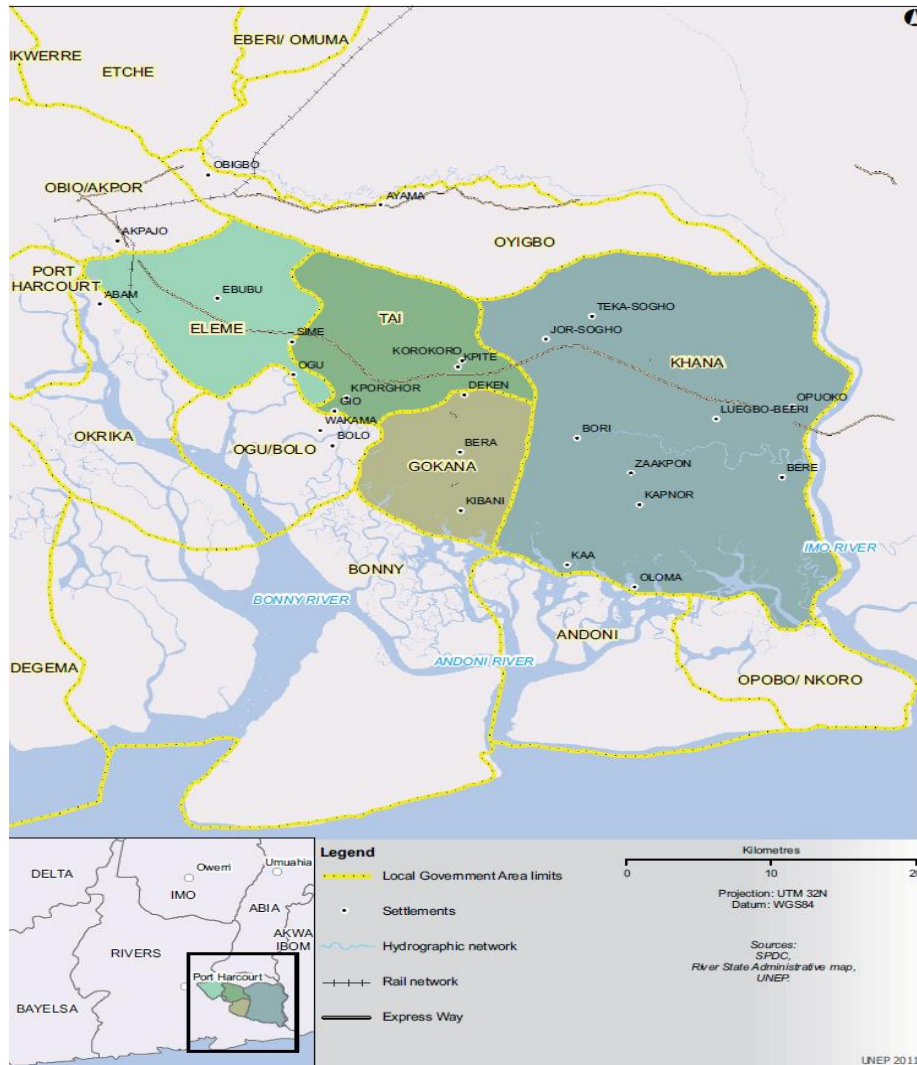All reagents used were of analytical standard.

Fig. 1. Map of Ogoniland showing the study sites; Kaa (Khana L.G.A) and Bodo (Gokana L.G.A) [14]

2.4 Physicochemical Analysis

2.4.1 Determination of temperature

The temperature measurements were made in-situ at the site of sampling with the aid of a Wagtech digital field thermometer. The probe of the instrument was dipped in the water, and the temperature reading taken when a steady temperature was attained.

2.4.2 Determination of pH

Hannah digital field pH metre was used to take the pH of the water at the site of sampling. The pH meter was standardized with pH 4 and pH 9. The electrode of the meter was thoroughly rinsed with the river water before dipping in the river to record the pH. A steady pH value was recorded as the pH of the water sample.

2.4.3 Conductivity

Electrical conductivity of the water samples were measured with the Hannah conductivity meter. The probe of the meter was inserted in the water sample and a steady reading recorded as the conductivity of the sample in μScm^{-1}.

2.4.4 Salinity

The conductivity meter has a salinity position, so that as the probe was dipped into the water sample, the switch was turned to the salinity position and a steady reading was obtained as the salinity of the sample.

2.4.5 Dissolved oxygen

The probe of the DO meter was dipped into the water body, and a steady read out was recorded as the dissolved oxygen in the sample.

2.4.6 Total dissolved solids

Procedure: An evaporating dish was washed, oven dried at 108^0C until a constant weight was obtained. 100ml of the sample was poured into the dish and placed on a steam bath with holes. The water was evaporated to dryness, placed in the desiccator to cool to room temperature. The dried evaporating dish and solids were then weighed and the weight difference recorded as the total dissolved solid, expressed in mg/l.

2.4.7 Chemical oxygen demand

Procedure: A 0.4g of mercury II sulphate ($HgSO_4$) was weighed into a refluxing flask and 20ml of sample was added. A 10ml of $Kr_2Cr_2O_7$ were added by means of a pipette slowly, and with gentle swirling. $AgSO_4$ in H_2SO_4 solution, 20ml was added. The refluxing condenser was then connected. The mixture was then refluxed for 2hrs. The system was cooled and condensed, washed into a conical flask, and the content was allowed to attain room temperature. With the aid of a 0.05M ferrous ammonium sulphate (FAS) solution, the excess dichromate solution was titrated using ferroin as the indicator. A blank titration was also done. The Chemical oxygen demand was then calculated using the formula

$$\text{Chemical oxygen demand COD (mg)} = \frac{(Vb - Va) \times M \times 16000}{\text{vol of sample used}}$$

Where

V_b = ml of ferrous ammonium sulphate (FAS) for blank titration
V_a = ml of ferrous ammonium sulphate (FAS) for sample titration
M = molarity of ferrous ammonium sulphate solution (FAS)

2.4.8 Biological oxygen demand

Procedure: Preparation of dilution water.

i. Phosphate buffer solution; consisting of 8.5 g of potassium dihydrogen phosphate KH_2PO_4, 21.75 g of dipotassium hydrogen phosphate K_2HPO_4, 33.4 g sodium hydrogen phosphate $Na_2HPO_4.7H_2O$ and 1.7 g Ammonium chloride NH_4Cl in a litre of solution. This was preserved in stock bottles. At pH of 6.8.
ii. Magnesium sulphate solution ($MgSO_4$); consisting of 22.5 g magnesium sulphate $(MgSO_4).7H_2O$ was dissolved in 1L flask and made up to the mark with distilled water.
iii. Calcium chloride solution; consisting of 27.5g of calcium chloride ($CaCl_2$) was dissolved in 1L of solution.
iv. Ferric chloride solution; consisting of 0.25 g $FeCl_3.6H_2O$ was dissolved in 1L of solution with distilled water.

Item (i) to (v) constitute the dilution water. The water samples were diluted by 2% into the 150 ml BOD bottles, 100 ml of the 2% diluted samples were placed with the aid of a 50 ml long

tipped pipette. Extra 50 ml of the diluted sample was added to the bottle, bringing it to the brim. The stoppers were inserted living no air bubbles in the bottles. An initial determination of DO was taken before the dilution from one of the duplicate bottles. The samples were then incubated including a blank for 5 days in the dark at 20°C in an air-cooled incubator. On the 5th day, the DO was measured in the incubated samples and the blank. The 5 days BOD was computed from the DO values DO$_o$ (initial DO before dilution) and DO$_d$ (DO after 5 days). Biological oxygen demand was then calculated using the formula

$$\text{Biological oxygen demand BOD (mg/ L)} = \frac{\text{DOo} - \text{DOd}}{\text{\% dilution}}$$

where

DO$_o$ =   initial dissolved oxygen before dilution
DO$_d$ =   dissolved oxygen after 5 days

2.4.9 Total hydrocarbon content

Procedure: Into a 500 ml separating funnel, 250 ml of water sample was added. The water was acidified with 9.5 M H$_2$SO$_4$ by the addition of 5ml of acid solution. 25 ml n-Hexane was added into the funnel, and shaken vigorously for 3mins. The organic layer was allowed to separate. The aqueous layer was withdrawn, and the organic layer was transferred into a tarred distillation flask of 250 ml capacity. The process was repeated for about 3 times with the aqueous layer and the organic layer added to the 250 ml distillation flask. A condenser was fixed to the flask and was refluxed on a heating mantle. When about 10ml of the organic fraction remained, the condenser was disconnected and the solvent boiled off. The flask was then dried on a steam bath. Total hydrocarbon content was then calculated using the formula

$$\text{Total hydrocarbon content THC} \left(\frac{\text{mg}}{\text{L}}\right) = \frac{\text{A} - \text{B x 1000}}{\text{ml of sample}}$$

where

A = weight of tarred distillation flask and hydrocarbon
B = weight of tarred distillation flask alone

2.4.10 Total suspended solids

Procedure: A pre-weighed filter paper was used to filter 100 ml of water. The filter paper was then dried in an oven at 105°C. When the filter paper had attained a constant weight, the weight was measured. The weight of the filter paper before filtration was subtracted from the weight of the filter paper after filtration and drying. The total suspended solids was then calculated using the formula

$$\text{Total suspended solids TSS} = \frac{\text{mg SS x 1000}}{\text{vol of sample}}$$

where

SS = suspended solids

2.4.11 Grease and oil

Procedure: Into a 1 L separating funnel, 250 ml water sample was placed, 5 ml of 9.5 M H$_2$SO$_4$ was added to acidify the water sample to bring the pH to 2.0. The mixture was then shaken for 2 minutes by inversion. 25 ml of the organic solvent (petroleum spirit) was added to the separating funnel and then shaken vigorously for 2 minutes. The funnel was allowed to stand for the organic solvent to separate. The aqueous layer was then withdrawn into a clean container, while the solvent layer was placed in a tarred distillation flask of at least 250 – 500 ml capacity. The aqueous layer was further extracted with 25 ml aliquots twice and the extracts placed in the distillation flask. The solvent was distilled off until 10 ml of extract was left. The solvent was finally evaporated over a water bath completely. The flask was left on the water bath for further drying until all traces of the solvent were completely evaporated. It was then allowed to cool in a desiccator, after which the distillation flask and content was reweighed. The oil and grease was then calculated.

$$\text{Oil and grease (mg/L)} = \frac{\text{A} - \text{B x 1000}}{\text{vol of sample}}$$

where

A = weight of tarred disk flask + oil or grease
B = weight of tarred disk flask alone

2.5 Proximate Profile

Proximate profile of all samples was carried out according to the Association of Official Analytical Chemist method [16].

2.5.1 Crude moisture

Procedure: Evaporating dishes were dried to constant weight at 105°C in a moisture extraction

oven. 5 g of dried and ground fish powder was weighed into evaporating dishes and placed in a hot air-drying oven and set at 105°C. This was kept for 24hours, cooled and then weighed on an analytical balance. The weight loss was determined by calculation.

2.5.2 Crude ash

Procedure: Two grams of dried fish samples were placed in preheated crucibles and placed in a muffle furnace and the temperature set at 550°C and heated for 16 hours. At the end of heating, the muffle furnace was allowed to cool down and the ash weighed. The percentage ash was then calculated.

2.5.3 Crude protein

Procedure: A 0.5 g of samples were weighed into a 100 ml Kjehdal flask containing 1.5 g Na_2SO_4 and 1.5 g $CuSO_4$. Some anti-bumps were also added. 5mls of conc. sulphuric acid / Nitric acid was also added. The digestion flask was then placed on the hot plate and heated for 1hour slowly, then vigorously, until the content formed a clear solution after frothing for up to about 8 to 10 hours. After digestion, the digest was cooled and quantitatively transferred into a 50ml standing flask and made up to the mark. 10ml of this solution was transferred into a micro Kjehdal flask containing 10ml of 40% NaOH solution and then heated. The gas evolved was ammonia gas. It was distilled into an Erlenmeyer flask containing 10 ml of 5% Boric acid, into which 2 drops of mixed indicator (methyl red and methyl blue) was added. The distillate was titrated with 0.1 M HCl until the green colour turned to a pink end. The % protein was calculated using the %N.

2.5.4 Crude lipid or ether extract

Procedure: Five grams of sample was weighed into a weight extraction thimble and placed in a 100 ml soxhlet extractor. 200 ml of petroleum ether was placed in the flask and heated in a heating mantle, after several siphoning processes with anti-bumps in the flask. The glass was cooled and connected to the rotary evaporator to recover the solvent. The flask was further dried and weighed. The difference in weight of the empty flask and the flask with the extract was obtained. The % lipid was then calculated.

2.5.5 Crude fibre

Procedure: Two grams of the fat free sample from above was weighed and quantitatively transferred into a 250 ml beaker which was marked at the 150 ml mark. 50ml of the 1.25% H_2SO_4 was added, and then brought to boiling after the addition of distilled water up to the 150 ml mark. The content was boiled for 30mins. It was then filtered through a Buchner funnel with the aid of a pump. The residue was washed with hot water until it was acid free. The residue was quantitatively transferred into another 250 ml beaker and was diluted with 50ml of 1.25% NaOH and made up to the 150 ml mark. The mixture was then boiled for 30 mins with constant stirring. It was then filtered and washed with hot distilled water until it was base free. The residue was further washed with 95% ethanol/methanol. This was then transferred into a pre-weighed porcelain crucible and dried in an oven at 105°C. The crude fibre was then weighed, and the % fibre calculated.

2.5.6 Dry matter

Five grams of sample was placed in a porcelain crucible and dried in a hot air-drying oven at 105°C until a constant weight was achieved. The % dried matter of the sample was then calculated.

2.6 Statistical Analysis

Student's t-test was used for paired comparison. The results were expressed as mean ±standard error of the mean (S.E.M.). The confidence level was set at 95% ($p ≤ 0.05$).

3. RESULTS

The results are as shown in Tables 1 and 2.

4. DISCUSSION

The physicochemical parameters study is very important, because it gives an exact idea about the quality of the water, as the values obtained are compared to standard values [8]. These characteristics can identify certain conditions of the ecosystem of aquatic organisms, and suggest appropriate conservation and management strategies [17,18,19]. The quality of the water in this study was determined by comparing all results of physicochemical analysis with FEPA and APHA permissible limits, as stated by FEPA, 1991 and APHA, 2005. "Table

1" above shows the results. The mean pH for water from Kaa (7.21) was significantly higher than that from Bodo (6.88). Even though both values were within the FEPA permissible limits of 6 – 9 [20]. There was an observed significant decrease in pH for water from Bodo compared to pH of water from Kaa. This suggests the presence of pollutants which include acidic gases which in solution slightly decreases the pH of both surface and ground water. This may be attributed to the reduced rate of photosynthetic activity, and /or the assimilation of carbon dioxide and bicarbonates [8], which may all be attributed to oil spill of petroleum product in the vicinity of the water [21], The mean temperature for water samples collected from Kaa (26.5^{o}C) were significantly lower at p≤0.05 than the mean temperature of water samples from Bodo (26.8^{o}C). However, they were both within the permissible temperature range for shell fish as reported by APHA, who stated that "the temperature of fish depends on the species, tropical fish are most healthy in the range of 75-80°F (24-27°C)" [22]. However, the observed significant decrease for temperature of water samples from Kaa compared to water samples from Bodo suggests a reduced rate of photosynthetic activity, which ultimately leads to increase in pH, decrease in dissolved oxygen, and increase in temperature [8], which are all consistent with water contaminated with petroleum products. The mean dissolved oxygen (DO) measured were 7.38 mg/l and 5.68 mg/l for water samples from Kaa and Bodo respectively, which were both below APHA permissible standards of >7 mg/l for fishes [22]. The dissolved oxygen is directly influenced by temperature, pH and biological oxygen demand; high temperature, biological oxygen demand and acidity all reduce dissolved oxygen [23,7,8]. The findings from this research are consistent with this, and they suggest a contamination of the study sites with petroleum and heavy metals. Total suspended solids (TSS) are solid materials, including organic and inorganic, that are suspended in the water. These include silt, plankton and industrial wastes. Sources of total suspended solids include erosion from urban runoff and agricultural land, industrial wastes, or wastewater discharges. High concentrations of suspended solids can lower water quality by absorbing light. Waters then become warmer, which lessens the ability of the water to hold oxygen necessary for aquatic life. Because aquatic plants also receive less light, photosynthesis decreases and less oxygen is produced [7]. The TSS observed in the study

sites were 8.68 mg/l for water samples collected from Kaa, which was within the FEPA and APHA permissible limits of >10 mg/l and < 25 mg/l respectively, and 12.5 mg/l, for water samples collected from Bodo which was within the FEPA and APHA permissible limits. It is important to note that TSS concentration of more than 50 mg/l will affect the proper functioning of shellfish, as a result, Total Suspended Solid standards of 50 mg/l and 25 mg/l have been adopted for fisheries and water supply use respectively. APHA has also stated that "Generally, measured TSS should be less than 25 mg/l to prevent any harmful effect to the aquatic environments." [22]. It can therefore be concluded that the total suspended solids in the study sites were within the permissible limits. Total dissolved solids directly influence the water conductivity; the higher the total dissolved solids, the higher the conductivity and total suspended solids [7]. This was observed in this study. The total dissolved solids measured were 7270 mg/l and 8230 mg/l for Kaa and Bodo respectively, which were both far above the FEPA permissible limit of 500 mg/l. The high TDS in this study could be an indication for hard water, and the presence of toxic substances [7], which may suggest petroleum contamination. The conductivity which may be used to obtain an estimate of dissolved solids [24], were 14500 and 16500 µScm^{-1} for samples collected from Kaa and Bodo respectively. Like the values of total dissolved solids in this study, the conductivity was above the FEPA permissible limit of 200 mg/l. This suggests the presence of a large number of conductive solutes in the study sites. The salinity measured for the study sites were 7.2 mg/l for water samples collected from Kaa and 8.4 mg/l for water samples collected from Bodo. The higher salinity was measured for Bodo. The mean salinity for the two study sites (Kaa and Bodo) were below FEPA permissible limit of 2000 mg/l. Biological oxygen demand (BOD) is the dissolved oxygen needed by aerobic organisms in water to breakdown organic materials present in the water. A high BOD means that there is plenty of organic matter, and a great number of micro-organisms present. This is seen when there is an influence of sewage (waste water) or other industrial contamination. A high BOD implies a low DO, because the dissolved oxygen is depleted by the microorganisms as they feed on the organic matter. There was a significant increase at p≤0.05 for the BOD (188 and 259 mg/L) in water samples collected from Kaa when compared to BOD in water samples collected from Bodo. The BOD for the study sites were far above the APHA

and FEPA permissible limits of 2-3 mg/l and 10mg/l respectively. The high BOD levels indicate high microbial activity and high levels of contamination which is further increased by oil

Table 1. Physicochemical analysis (mean ≤ S.E.M) of water samples collected from study sites [Bodo (test site) and Kaa (control site)]

S/No	Parameters	Control (KAA)		Test (BODO)		FEPA	APHA
1	Temperature (^{o}C)	26.5±	.010 [a]	26.8±	.006 [b]		24-27
2	pH	7.21±	.006 [a]	6.88±	.010 [b]	6-9	
3	Salinity (mg/L)	7.20±	.021 [a]	8.40±	.010 [b]	2000	
4	Conductivity (µS/cm)	14500±	25.2 [a]	6500±	36.1 [b]		
5	TSS (mg/L)	8.68±	.006 [a]	12.5±	.006 [b]	>10	<25
6	TDS (mg/L)	7270±	17.0 [a]	8230±	38.8 [b]	500	
7	DO (mg/L)	7.38±	.006 [a]	5.68±	.044 [b]		>7
8	BOD (mg/L)	188±	.234 [a]	259±	.690 [b]	10	2-3
9	COD (mg/L)	399±	.761 [a]	486±	.509 [b]		
10	Oil And Grease (mg/L)	0.34±	.021 [a]	2.48±	.045 [b]		
11	THC (mg/L)	0.25±	.015 [a]	3.00±	.040 [b]		

Values are expressed as mean ± standard error of mean (S.E.M) of three replicates, (n=3). Values with different superscript (a,b) in the same row are significantly different at the 0.05 levels (P≤0.05)

contamination in Bodo. The chemical oxygen demand is the amount of dissolved oxygen required to cause chemical oxidation of organic matter [8], it is often used as a rough approximation of BOD, even though the COD test measures some additional organic matter (such as cellulose) which is not normally oxidized by biological action [21]. The results of this study indicate that the COD like the BOD shows some level of contamination in the study sites. Oil and grease cause depletion of oxygen as well as suffocation of aquatic species, and as such, high levels are detrimental to aquatic life [24]. The mean oil and grease for Kaa and Bodo were 0.34 mg/l and 2.48 mg/l respectively. The values obtained though lower than the FEPA recommended standard of 20 mg/ l, were significantly higher at p≤0.05 for water from Bodo than water from Kaa. This suggests a contamination of the surface water in Bodo by petroleum products. The total hydrocarbon contents (THC) obtained in this study were 0.25 mg/l and 3.00 mg/l for Kaa and Bodo respectively, and were both below the FEPA permissible limits of 10mg/l. There was a significant statistical decrease at p≤0.05 for THC in water from Kaa, when compared to water from Bodo. This suggests some level of petroleum contamination in Bodo.

Body composition is a good indicator for the physiological condition of fish. The percentage of water is a good indicator of its relative content of energy, proteins and lipids. The lower the percentage of water, the greater the lipid and protein contents, and the higher the energy density of the fish [25,26]. This pattern was observed in this study and was consistent for all samples tested. Proteins and fats are the major nutrients in fish, and their levels help to define the nutritional status of a particular organism [27,28]. It has been reported that the chemical composition of fish varies from one individual to another depending on age, sex, environment and season with protein level ranging from 16 to 21%, lipid from 0.1 to 25%, ash 0.4 to 1.5%, moisture content of 60 to 80% with extreme of 96% having been reported [29]. Moisture content range of 65.88 to 78.62 [30], 77.93 to 82.7% [31] and 68.6 to 77.1% [27] have also been reported for fishes. All the results obtained from this study fall in line with the above reported ranges, except for the crude protein composition obtained for samples collected from Bodo, which were lower than the above reported standards. The results obtained for percentage crude protein in the species tested indicate that the samples collected from Kaa are very good sources of protein, but those from Bodo are not. "Table 2" shows the mean proximate profile for Tilapia, Mullet, Sompat grunt and shrimps collected from Kaa and Bodo. The mean crude protein content, crude fibre, lipid, ash and dry matter contents were significantly higher at p≤0.05 for all samples collected from Kaa than samples collected from Bodo. The mean moisture content for all the samples from Kaa were all significantly lower at p≤0.05 than the mean moisture contents from the samples collected from Bodo. However, the mean moisture contents for samples from both study sites were all within standard which range from 60-80% with extremes at 96% as reported by [29]. This indicates that the samples from Kaa are richer in protein, lipid and energy, according

to Dempson, [25] and Ali, [26], who stated that the lower the percentage moisture, the greater the lipid and protein content, and the higher the energy density of the fish. The mean ash content

Table 2. Proximate profile (mean ± S.E.M, % composition) for fin and shell fishes from study sites [Bodo (test site) and Kaa (control site)]

%	Tilapia		Mullet		Shrimp		Sompat grunt	
	KAA	BODO	KAA	BODO	KAA	BODO	KAA	BODO
Moisture	63.7±.289[a]	68.7±.514[b]	72.5±.488[a]	80.6±.476[b]	75.1±.973[a]	86.2±.790[b]	67.4±.455[a]	74.5±.514[b]
Ash	1.20±.067[a]	0.86±.036[b]	2.40±.200[a]	1.38±.021[b]	1.60±.010[a]	0.96±.006[b]	4.00±.168[a]	2.85±.031[b]
protein	27.6±.329[a]	10.5±.055[b]	21.9±.057[a]	17.1±.136[b]	28.0±.077[a]	10.7±.012[b]	28.9±.598[a]	11.2±.049[b]
crude fibre	0.70±.012[a]	0.48±.012[b]	0.90±.015[a]	0.62±.015[b]	1.05±.012[a]	0.72±.006[b]	0.88±.012[a]	0.60±.006[b]
Lipid	1.60±.012[a]	0.98±.006[b]	1.90±.153[a]	1.16±.006[b]	0.60±.012[a]	0.37±.116[b]	2.20±.006[a]	1.35±.015[b]
dry matter	36.3±.169[a]	31.3±.027[b]	27.5±.057[a]	19.4±.022[b]	25.6±.682[a]	13.8±.012[b]	32.6±.046[a]	25.5±.050[b]

Values are expressed as mean ± standard error of mean (S.E.M) of three replicates, (n=3). Values with different superscript (a,b) in the same row are significantly different at the 0.05 levels (P≤0.05)

obtained for all the fish species were within the standard as reported by Muraleedharan [29], except for the mean ash content for Mullet collected from Kaa, and Sompat grunt collected from both sites (Bodo and Kaa), which were much higher than the standard as reported by Muraleedharan [29]. All mean protein content for fish species from Bodo (test site) were lower than the standard 16-21% reported by Muraleedharan [29], except for mullet collected from Bodo, which was 17.1±.136 while the mean protein content for all species from Kaa were above the standard except the mean protein for mullet samples which were within the records reported by Muraleedharan [29]. The mean lipid content obtained for the species from both Kaa and Bodo were within the standard, except for shrimp from Bodo, which was lower at 0.37±.116. However, the mean lipid content for the samples from Kaa were all significantly higher than the mean lipid content for samples from Bodo. These results indicate that the samples collected from Kaa are very good sources of protein, while the samples collected from Bodo are not.

5. CONCLUSION

It can be deduced from the findings of this research that there is significant pollution of the study sites (test site Bodo and control site Kaa) with the presence of high levels of hydrocarbon, though, in much higher levels in the test site than the control site. It can also be deduced that sea foods from Bodo are poor sources of protein and energy. The people of Ogoniland are exposed to significant health risks if they continue to consume the fish from these sites. Drastic measures should be employed to clean up the polluted land and waters of Ogoniland. However, due to the wide extent of contamination in Ogoniland, and nearby areas, and the varying degrees of degradation, several clean-up techniques appropriate for the entire area may need to be employed, including a combination of approaches ranging from active intervention for cleaning the top soil and replanting mangrove to passive monitoring of natural regeneration [14]. Also, the community should take a stand against individuals or groups who engage in illegal activities such as bunkering since these activities result in great environmental damages that seriously impact public health in their community.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Adeniyi A. Afolabi J. Determination of total petroleum hydrocarbons and heavy metals in soils within the vicinity of facilities handling refined petroleum. Environ. Int. 2002;28:79–82.

2. Uzoekwe SA, Oghosanin FA. The Effect of Refinery and Petrochemical Effluent on Water Quality of Ubeji Creek Warri, Southern Nigeria. Ethiopian Journal of Environmental Studies and Management 2011;4(2).
Available:http://dx.doi.org/10.4314/ejesm.v4i2.12

3. Sala OE, Chapin III FS, Armesto JJ, Berlow E, Bloomfield J, Dirzo R, Huber-Sanwald E, Huenneke LF, Jackson RB, Kinzig A, Leemans R, Lodge DM, Mooney HA, Oesterheld M, Poff N, Sykes MT, Walker BH, Walker M, all DH. Global biodiversity scenarios for the year 2100, Science. 2000; 287:1770–1774.

4. Venkatesharaju K, Ravikumar P, Somashekar RK, Prakash KL. Physico-chemical and bacteriological investigation on the river cauvery of kollegal stretch in karnataka. Journal of Science Engineering and Technology. 2010;6(1):50-59.

5. Mohan Joshi D, Kumar A, Agrawal N. Studies on physicochemical parameters to assess the water quality of river Ganga For Drinking Purpose In Haridwar District. Rasayan Journal of Chemistry. 2009;2(1): 195-203

6. Chitmanat C, Traichaiyaporn S. Spatial and temporal variations of physical-chemical water quality and some heavy metals in water, sediments and fish of the Mae Kuang River, Northern Thailand. International Journal of Agriculture and Biology. 2010;12(6) 816-820.

7. Lawson EO. Physico-chemical parameters and heavy metal contents of water from the mangrove swamps of Lagos Lagoon, Lagos, Nigeria. Journal of Advances in Biological Research. 2011;5(1):08-21.

8. Patil PN, Sawant DV, Deshmukh RN. Physico-chemical parameters for testing of

water – A review. International Journal of Environmental Sciences. 2012;3(3): 12-22.

9. Tucker BW. Overview of current seafood nutritional issues: Formation of potentially toxic products, in Shahidi F, Jones Y, Kitts DD (Eds.), Seafood safety, processing and biotechnology. Technomic Publishing Co. Inc., Lancaster, PA(USA); 2007.

10. Ayeloja AA, George FOA, Dauda TO, Jimo WA, Popoola MA. Nutritional comparison of captured *Clarias gariepinus* and *Oreochromis niloticus.* International Research Journal of Natural Sciences. 2013;1(1):9-13.

11. Palani KM, Ruba AA, Jeya SR, Shanmugam SA. Proximate and major mineral composition of 23 medium sized marine fin fishes landed in the Thoothukudi Coast of India. Journal of Nutrition and Food Science. 2014;4(1):7-14

12. Fawole OO, Yekeen TA, Adewoye SO, Ogundiran MA, Ajayi OE, Nwaiya MN. Nutritional qualities and trace metals concentration of six fish species from Oba reservoir, Ogbomoso, Nigeria. African Journal of Food Science. 2013;7(8):246-252

13. Majid A, Mokhlesi A, Bastami KD, Khoshnood R, Eshaghi N. Survey of some chemical compositions and fatty acids in cultured common carp (*Cyprinus carpio*) and Grass Carp (*Ctenopharyngodon idella*), Noshahr, Iran. World Journal of Fish Marine Science. 2011;3:533-538.

14. United Nations Environmental Programme (UNEP). Environmental Assessment of Ogoniland. Published by United Nations Environmental Programme, Nairobi, Kenya. 2011;7-49,198- 225.
    [ISBN: 978-92-807-3130-9]

15. Jumbo AA, Wegwu MO, Belonwu DC, Okerenta BM. Assessment of heavy metal concentrations of selected fin and shell fish from Ogoniland. Journal of Environment and Earth Science. 2015;5(18).
    [ISSN 2224-3216 (Paper)]
    [ISSN 2225-0948 (Online)]
    Available:www.iiste.org

16. Association of Official Analytical Chemists (AOAC). Official Methods of Analysis of the Association of Official Analytical Chemists, Vols. I & II, Association of Analytical Chemists, Arlington. 2000. 17th Edition; 2000.

17. Srivastava N, Harit G, Srivastava R. study of Physico-chemical characteristics of lakes around Jaipur, Inida. Journal of Environmental Biology. 2009;30(5):889-894.

18. Damotharan P, Perumal NV, Arumugam M, Vijayalakshmi S, Balasubramaniyan T. Seasonal variation of physico-chemical characteristics of Point Calimere coastal waters (South East coast of India). Middle-East Journal of Scientific Research. 2010;6 (4):333-339.

19. Prasanna M, Ranjan PC. Physico-chemical properties of water collected from Dhamra Estuary. International Journal of Environmental Science. 2010;1(3):334-342.

20. Federal Environment Protection Agency (FEPA). Guidelines and standard for environmental pollution control in Nigeria. Federal Environment Protection Agency, Lagos; 1991.

21. Nkpaa KW, Wegwu MO, Essien EB. Assessment of Polycyclic Aromatic hydrocarbons (PAHs) Levels in Two Commercially Important Fish. Species from crude oil polluted Waters of Ogoniland and Their Carcinogenic Health Risks. Journal of Environment and Earth Science. 2013;3(8): 128-137

22. American Public Health Association (APHA). Standard methods for the examination of water and waste water. 19th ed. American Water Works Association and Water Pollution Control Federation, New York, USA; 2005.

23. Oloruntegbe KO, Akinsete MA, Odutuyi MO. Fifty Years of Oil Exploration In Nigeria: Physico-chemical impacts and implication for enviromental accounting and development. Journal of Applied Sciences Research. 2009;5(12):2131-2137 .

24. Ewa EE, Iwara AI, Adeyemi JA, Eja EI, Ajake AO, Out CA. Impact of industrial activities on water quality of Omoku creek. Journal of Environmental Studies. 2011;1 (2):8-16.

25. Dempson IB, Schwarz CJ, Shears M, Furey G. Comparative proximate body composition of Atlantic salmon with emphasis on Parr from fluvial and lacustrie habitats. Journal of Fish Biology. 2004;64: 1257-1271.

26. Ali M, Iqbal F, Salam A, Iram S, Athar M. Comparative study of body composition of different fish species from brackish water

pond. International Journal of Environmental Science and Technology. 2005;2(3):229-232.

27. Aberoumad A, Pourshafi K. Chemical and proximate composition properties of different fish species obtained from Iran. World Journal of Fish and Marine Sciences. 2010;2(3):237-239.

28. Fawole OO, Yekeen TA, Adewoye SO, Ogundiran MA, Ajayi OE, Nwaiya MN. Nutritional qualities and trace metals concentration of six fish species from Oba reservoir, Ogbomoso, Nigeria. African Journal of Food Science. 2013;7(8):246-252

29. Muraleedharan V, Antony KP, Perigreen PA, Gopakumar K. Utilization of unconventional fish resources for surimi preparation. Proceedings of the second workshop on scientific results of FORV SAGAR. Sampada. Dept. of Ocean development. New Delhi, (India). 1996;539-543.

30. Mazumder MSA, Rahman MM, Ahme ATA. Begum M, Hossain MA. Proximate composition of some small indigenous fish species in Bangladesh. International Journal of Sustainable Crop Production. 2008;3(4):18-23.

31. Ravichandran S, Kumaravel K, Pamela FE. Nutritive composition of some edible fin fishes. International Journal of Zoology and Research. 2011;7(3):241-251.