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The Caryophylladace cestodes, *Wenyonia spp* Woodland, 1923 Harbours High Quantities of A Specific PCBs Congener in the Fish Host, *Synodontis clarias* (Linnaeus, 1758), with Histopathological Alterations as Biomarker Response

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**ABSTRACT**

One hundred and fifty samples of *Synodontis clarias* were collected, and subjected to parasitologic examination. They were analyzed from three stations of the sampling site (Epe axis of Lekki Lagoon). Out of the total number of specimens examined from the three stations, 56 (37.33%) were infected. The total infected individuals from the three stations had 30 (20.0%) males and 26 (17.33%) females while the non-infected individuals for all the stations had 64 (42.67%) males and females. Also, in this study, *Synodontis clarias* were infected with two (2) species of parasites the Cestodes (*Wenyonia spp*) and Nematode (*Raphidascaroides spp*) which is common among family Mockokidae. The concentration of Polychlorinated biphenyl in the fish tissue, parasite, sediment and water collected from the sampling site were also analyzed. The PCB congeners 8, 18, 28, 44, 77, 81, 123, 153, 156 detected in the water and sediment sample of all the 209 PCB congeners were also reported. The findings presented in the study showed more of the lower chlorinated PCB congeners in the water sample than in the sediment, *Synodontis clarias* and parasite sample from the three stations in the Epe axis of Lekki Lagoon. The concentration of PCB congeners in the parasite was high in Oribo and Ikosi (549.53 ppb and 569.95 ppb) sampling station while it is low in Imode (57.77 ppb) station. There was high quantity of PCB 81 found in the parasite but not found in the fish host. The fish samples collected from Oribo had the high concentration of congeners 28, 18, 44, and 52 among other detected, while fish samples collected from station Imode had the high concentration of 44, 18, 8 and 28 and the fish samples collected from station Ikosi also had the high concentration of PCB 44, 18, 8 and 123 respectively. However, the concentration of PCBs level found in the fish tissue was above W.H.O limits of 200 part per billion (ppb) in Oribo and Ikosi (607.42 ppb and 325.43 ppb) sampling station while the concentration was below in Imode (188.61 ppb) sampling station and hence the *Synodontis clarias* in Oribo and Ikosi is not safe and edible for consumption. Laws enacted to protect our Aquatic environment should be enforced. However, the study showed a need for continuous pollution assessment study of aquatic organisms and its environment.

**INTRODUCTION**

Persistent organic pollutants (POPs) are organic compounds that are resistant to environmental degradation through chemical, biological and photolytic processes (El-Shahawi et al., 2010). An example of these compounds is polychlorinated biphenyls (PCBs). PCBs are a group of synthetic organic chemicals that contain 209 possible individual chlorinated biphenyl compounds.
These chemically related compounds are called congeners and vary in their physiochemical properties and toxicity (Beyer et al., 2002). Due to the affinity of PCBs to adsorb to suspended particulate material like sediment and biota and their hydrophobic behaviour, they can be found in nearly all water bodies and in all biota (Walker et al., 1997). Previously, these compounds were used in hundreds of commercial and industrial applications due to their chemical stability, high heat capacity, low flammability, and insulating properties (Erickson et al., 1997). There is a widespread use of PCBs in dielectric fluids in transformers and capacitors, printing ink, paints, de-dusting agents, pesticides, hydraulic fluids, plasticizers, adhesives, fire retardants, and lubricants. Due to human health concerns, the manufacture of PCBs was banned in the United States in 1976 (ASTDR, 2001). Humans and wildlife can be exposed to PCBs either directly from contact with contaminated air, sediments, or water or indirectly through the diet. When considering exposure pathways, it is imperative to assess the biologically available fraction of PCBs. In sediments, PCBs can be buried below the biologically active zone and, therefore, are less available for uptake by aquatic organisms. The biologically active zone is the top layer of sediments, typically 5–10 cm deep. This layer is continuously reworked by sediment-dwelling organisms and remains in contact with the overlying water. PCBs that are strongly adsorbed to organic sediment particles in the biologically active zone tend to have reduced bioavailability to organisms that ingest or are exposed to these sediments (EPA 1994). Consumption of PCB-contaminated foods is the most significant route of exposure to PCBs for the general human population (Fitzgerald et al., 1996). This exposure occurs as a result of bioaccumulation of PCBs through the food chain.

Numerous studies have indicated adverse health effects from exposure to PCBs including cancer and effects on the cardiovascular, hepatic, immune, musculoskel et al., endocrine, gastrointestinal, reproductive and dermal systems (ASTDR 2001). Though PCBs were banned in the U.S. three decades ago, these health concerns and issues about persistence in the environment have made PCBs a notorious class of anthropogenic compounds that are still garnering much research attention. In addition, ingestion of PCBs that have accumulated in fish is a major route of introduction of the chemicals in the human environment (EPA 2005).

PCBs continue to enter the environment from landfills containing PCB waste materials and products, incineration of municipal refuse, sewage sludge, and though both legal and illegal use and disposal of PCB-containing materials (EPA 2005). Given that PCBs do not readily degrade in the environment after disposal and they are lipophilic (fat soluble), they are environmentally persistent and tend to bio-accumulate in biota (Erickson 1997). Furthermore, PCBs may bio-magnify through food chains. This process results in higher trophic level organisms having significantly more contaminant within their bodies than their prey items of lower trophic position (Danuta et al., 1997). Through urban run-off, dumping and/or air transport, PCBs may enter water bodies and once there, tend to accumulate in the sediments (Ashley and Baker 1999). Additionally, PCBs accumulate in the fatty tissues of fish and other aquatic organisms. If humans ingest these items, this may represent a major pathway of PCB exposure (Birmingham et al., 1989). Most of the data on human health effects from exposures to PCBs are based on occupational exposures or
The Caryophyllaceae cestodes, *Wenyonia* harbours high quantities of a specific PCBs in consumption of contaminated fish. These studies have correlated relatively high levels of exposure to PCBs with potential subclinical health effects (WHO 1992).

The roles of parasites in ecosystems are multiple although too often neglected by scientists (Lafferty et al., 2008). For example, the sporadic attempts at understanding the synergistic or antagonistic interactions between parasites and pollutants have in general been ignored by the scientific community for decades. One of the first applications to utilize fish parasites as biological indicators using standard parasitological methodologies was related to fisheries, including the separation of fish stocks (McKenzie 2002). In short, pollution has typically been viewed as an added stress to hosts leading to an increased vulnerability to parasitic diseases (Arkoosh et al., 1998), or as affecting parasites’ impact proper has been ignored in evaluating the effects of environmental pollutants on organisms. The complexity of the relationship between parasitism and pollution has begun to unravel, showing the necessity to consider parasitism in evaluating environmental stressors (Sures, 2006) since parasites may in turn influence the hosts’ response to pollutants by affecting their hosts’ response to pollutants by affecting their hosts physiology and tolerance of stressed conditions (Sures and Radszuweit 2007). Recently, another aspect of the role of parasites in evaluating environmental pollution has emerged via the recognition of their ability to concentrate contaminants like organic and inorganic elements at much higher levels than free-living organisms (Taraschewski, 2000). Ecological exposure to PCBs is primarily an issue of bioaccumulation resulting in chronic effects rather than direct toxicity. PCBs bio-accumulate in biota by both bio-concentrating (being absorbed from water and accumulated in tissue to concentrations greater than those found in surrounding water) and biomagnifying (increasing in tissue concentrations as they go up the food chain through two or more trophic levels).

The concentration of poorly metabolized chemicals accumulated in fish might reflect the degree of aquatic system pollution (Fang et al., 2009). Certain parasitic organisms may provide information about the chemical state of the environment (Gelnar et al., 1997), and some are able to concentrate pollutants inside their tissues (Sures et al., 1999). Some parasites in the fish intestine may also accumulate PCBs in their tissues, and thus may reduce the PCB load of the fish host. Laboratory and field studies with wildlife have demonstrated a causal link between adverse health effects and PCB exposure (Bowerman et al., 1995). Chronic toxicity has been observed in fish, birds, and mammals; impacts include developmental effects, reproductive failure, liver damage, cancer, wasting syndrome, and death (Metcalf and Haffner 1995). Fish are specific indicators of different levels of contaminants bioaccumulation depending on habitat or food chain position (Scaps, 2002). Some parasites are sensitive to environmental change, others are more resistant than their hosts and tend to increase in number in pollutant conditions (Sures, 2004). The parasitic infection rate in fish is often concern as indication of the degree of immunity of organism, or community or system subjected to exogenous, potentially recurring stimulus (Szefer et al., 1998). Parasites have a variety of impacts on their hosts: they impose energetic demands, alter behaviours, affect morphology and appearance, reduce fecundity and growth, and cause mortality (Marcogliese, 2004).

There has been several published report on fish parasites as the potential indicators of environmental quality because of the variety of ways they
respond to anthropogenic pollution (Sures et al, 1999). There are few published reports on the parasites of *Synodontis clarias*, as potential indicators of environmental pollution. Therefore, investigation of parasites and accumulation of polychlorinated biphenyls in *Synodontis clarias* is needed. Biological monitoring is the use of biological responses to assess changes in the environment, generally changed due to anthropogenic causes. Biomonitoring programs may be qualitative, semi-quantitative, or quantitative. Biomonitoring is a valuable assessment tool that is receiving increased use in water quality monitoring programs of all types. Biomonitoring is a vital and rapidly growing field that uses several biological groups such as phytoplankton, macrophytes, invertebrates and fish as bioindicators (Rosenberg and Resh, 1993). This research therefore emphasises biological monitoring in lekki lagoon due to anthropogenic activities.

**MATERIALS AND METHODS**

Epe axis of lekki Lagoon is situated between latitudes 30°50’-40°10’N and longitudes 5°030’-50°40’E. It has a surface area of more than 243km² and is sandwiched between two other lagoons, the Lekki lagoon (freshwater) in the east and Lagos lagoon (brackish water) in the west. (Fig. 1). The lagoon is connected to the sea through the Lagos Harbour. The lagoon lies within the rainforest belt of southern Nigeria which experiences two major seasons, the rainy season concentrated between May and November, and dry season occurring between December and April.

Annual rainfall ranged from 6 to 330 mm during the study period. Riparian vegetation at the bank of the lagoon consists mainly of grasses and secondary rainforest. Land use in the study area includes Agriculture; human activities in the study stretch include sand mining, artisanal fisheries and...
transportation of people and goods using Motorized Boats. A major feature of the lagoon is the overwhelming preponderance of floating vegetation of water hyacinth, a phenomenon that has been linked to pollution (Nwankwo and Onitiri, 1992). The study area is a rural setting with most of the population concentrated along the bank of the lagoon. Wastes of various types are dumped into the lagoon. Also, most inhabitants of the shore communities do not have toilet facilities hence defecation and release of other human wastes into the lagoon are common features in the study stretch. This is actually from the southern Benin border to the Niger Delta which is about 200km. Both rivers Oni and Osun discharge to the north-eastern and into the north western parts of the lagoon respectively. Both dry and rainy seasons are experienced in the lagoon typical of the southern part of Nigeria. The flora around the lagoon is characterised by Raphia palms (Raphia sudanica), and oil palms (Elaeis guineensis). Grasses are found on the periphery of the lagoon while coconut palms (Cocos nucifera) are widespread in the surrounding villages. The fishes in the lagoon include *Heterotis niloticus*, *Gymnarchus niloticus*, *Clarias gariepinus*, *Malapterurus electricus*, *Synodontis clarias*, *Synodontis filamentous*, *Chrysichthys nigrodigitatus*, *Parachanna obscura*, *Mormyrus rume*, *Calabaricus calamoichtys*, *Tilapia zilli*, *Tilapia galilae*, *Hermichromis fasciatus* and *Sarotherodon melanothero*.

Three stations were randomly selected with their geographical locations shown in Table 1.

| S/N | Latitude   | Longitude  | Station |
|-----|------------|------------|---------|
| 1   | 60°34'50.11" | 30°59'34.11" | ORIBO   |
| 2   | 60°34'56.17" | 30°59'26.92" | IKOSI   |
| 3   | 60°34'52.34" | 30°59'14.32" | IMODE   |

**Collection of Samples:**
Specimens of *Synodontis clarias* were randomly collected at the sample locations. These were purchased at Oluwo Market from local fishmongers who are based at the Epe jetty, Lagos, Nigeria. A total of 150 (length ranged from 20 - 36 cm and weight ranged from 88.8 - 220 g) *Synodontis clarias* specimens were collected on six trips over a period of 3 months from July, 2016 to September, 2016. Most of the specimens were purchased while still alive. The sex and maturity of the collected specimens were determined by gross examination of the gonad. The weights of the fish were recorded using a weighing balance (Camry, EK5055), standard lengths and total lengths of the fishes also were recorded using a measuring board.

**Collection of water samples:**
From the three stations, water samples were collected on one of the field trips. Water samples were collected using a five liters container which was firstly cleaned with the surface water at each site. The collected samples were then stored in the refrigerator prior to further analysis. Samples were collected for analysis of physiochemical parameters.

Water collected from Epe lagoon was used to analyse the following physico-chemical parameters: hydrogen ion concentration (pH), temperature, conductivity, salinity, dissolved oxygen, total suspended solids and total dissolved solids using standard methods.

**Hydrogen Ion Concentration (pH):**
This is a measure of the hydrogen ion activity in the water sample. The pH of the water sample was determined in situ with the aid of a pH meter.
**Temperature:**

The temperature was measured using a thermometer. It was done by lowering the thermometer so the tip is a few inches below the water surface. The thermometer time came to equilibrium and the values were read off and recorded.

**Conductivity:**

This is a measure of how well a solution conducts electricity. Water with absolutely no impurities (which is rare) is a poor conductor of electricity. In the real sense, the impurities in water increase its conductivity. The conductivity of the water samples was measured using the Horiba water quality checker, model U-10. The water sample was put in the sample cup and coupled with the probe, and readings were recorded from the meter.

**Salinity:**

The salinity of the water was determined in-situ using a hand held refractometer. A drop of the water sample was placed on the prime of the meter of the refractometer and the meter was adjusted to 0% marks and viewed through the eye piece. The daylight plate was closed and the salinity of the water sample was read on the scale.

**Dissolved Oxygen:**

The dissolved oxygen level was measured in-situ using a DO meter. The probe was placed in the water sample and the reading was recorded from the meter. The trimetric method was used for the determination of dissolved oxygen demand. The BOD bottle was submerged with the cap in the sample water. The cap was employed and the BOD bottle was filled with water. The BOD bottle was covered while it was still under water. The BOD bottle was removed and it was checked for air bubbles. Immediately 8 drops of alkaline Potassium Iodide azide solution was added. The solution in the bottle was mixed by inverting it several times. The precipitate was then allowed to settle. 1 gram spoon was used to add one level measure of H₂SO₄ powder. The mixture was gently inverted to mix the contents until the reagents totally dissolved.

The titration bottle was filled to 20ml line with the sample and 8 drops of starch indicator solution were added. The sample turned blue, this was then titrated against a standard solution of sodium thiosulphate until the blue coloration disappeared.

\[ \text{DO (mg/l)} = \frac{16,000 \times M \times V}{V_1 - V_2} \]

M = Molarity of Thiosulphate
V = Volume of Thiosulphate used for titration
V₁ = Volume of bottle with stopper in place
V₂ = Volume of aliquot taken for titration

**Total Suspended Solids:**

A portion of the water sample was measured and filtered using pre-weighed what-man filter paper. The filter paper with the residue was dried for 1 hour at 105°C in an oven. The filter paper with then residue was then cooled and weighed. The amount of suspended solids was calculated using the formula:

\[ \text{SS} = \text{R} - \text{F} \]

SS = Suspended Solids
R = Weight of filter paper and residue
F = Weight of the filter paper.
Total Dissolved Solids:
One hundred cubic centimeters (100cm$^3$) of the filtered sample was measured. This was transferred into a weighed evaporating dish. This was

Total dissolved solids (TDS) were calculated using:

$$\text{Total dissolved solids (mg/l)} = \frac{R-D \times 1000}{\text{Volume of filtered sample}}$$

where:
- $R$ = weight of evaporating dish & residue
- $D$ = weight of the evaporating dish.

Laboratory Procedures:

Determination of Phosphate:
The surface water Phosphate-phosphorus was determined using the ascorbic acid method. A mixture was prepared by mixing 1% ammonium molybdate in 2M H$_2$SO$_4$ and Hydrazine sulphate 0.1% (orSnCl$_2$ and Ascorbic acid immediately before use). The resulting solution PO$_4$/mg/ml of 4.39 KH$_2$PO$_4$ (dried at 110ºC) was dissolved in distilled water. 1ml CHCl$_3$ was added and further diluted to one liter of distilled water. 10 to 25ml of the sample was acidified with nitric acid and 25ml of the reagent was added. The absorbance was read off using 780nm.

Determination of Nitrates:
Surface water Nitrate-nitrogen was determined gravimetrically, 20.0ml of the water sample was added to 1ml of fresh prepared 0.3% Sodium salicylate. The mixture was then evaporated in a bath and thereafter left to cool. On cooling, 2ml sulphuric acid was added for 10min, the solution was then washed with 25ml of distilled water into a calorimetric cylinder. 7ml of alkaline reagent (30% NaOH and 60% Rochelle salt) was added. Next, the solution was made up to 50ml by adding distilled water. The yellow colour developed was matched with prepared standards using a calorimeter at 420nm. The nitrate content was recorded in mg/l.

Biochemical Oxygen Demand (BOD):
This is a measure of the amount of oxygen that is removed from water sample due to natural biological assimilation or degradation of organic compounds by the organisms present, especially bacteria. The Biochemical Oxygen Demand for the water samples from the study area was determined to take the difference between the DO content of the samples on the day of sample collection and then 5 days after the samples were collected. The water samples were incubated at 20ºC for five days. Measurement of the 5-day DO was carried out using the same Horiba water checker (Model U-10) used to measure the DO during the sampling period.

Sediment Collection and Analysis:
Sediments were collected with the aid of Van Veen grab and stored immediately in the polythene bag. Sediments collected were stored at 4ºC in an ice-box and transported to the laboratory. The entire samples were separately air dried in a laboratory. When dried, it was homogenized and sieved to remove big particulates of sediments samples which were then digested as follows: 5g of the powdered sediment samples were weighed into a 100 ml beaker. 15ml of the freshly prepared mixture of HNO$_3$/ H$_2$O$_2$ ratio 1:1 were added to each sample and covered with washed glass. It was allowed to stand for 30 minutes during which the initial reaction subsided. Digestion was carried out on a hot plate whose temperature was allowed to rise gradually until it reached a maximum temperature of 160ºC in a fume cupboard. Heating was continued for about 2 hours, reducing the volume in the beaker to about 2-5 ml. The beaker and its contents were allowed to cool and the content was transferred with what
man filtration into a 50ml volumetric flask and made up to mark with distilled water (FAO/SIDA, 2003).

Examination and Method of Analysis of Fish Samples:
Collection of Internal Organs of the fish samples:
A total of one hundred and fifty specimens of freshly obtained *Synodontis clarias* from Epe axis of Lekki Lagoon were randomly collected bimonthly during the wet season (July - September) at three different locations along the Epe axis of Lekki Lagoon, Epe Lagos, Nigeria. The fish were immediately preserved in an ice-chest with ice-blocks prior to laboratory analysis. The collected fish samples were arranged on a table. Each fish was slit open using scissors through the urogenital opening. Specific internal organs (Gills, liver, and gastrointestinal tract) were then carefully extracted and placed in Petri dishes filled with 0.09% saline.

Examination of the Gastrointestinal Tract:
Examination of parasites presents within the intestinal tract was carried out using the techniques of Akinsanya et al. (2007). The Petri dishes containing the internal organ were examined using a hand lens. Afterward, the intestines were carefully teased open from the anterior to the posterior end (from the rectum through to the esophagus region) to aid parasite emergence. The emergence of the parasite was carefully observed through its movement in the saline solution. The recovered parasites were fixed in 70% alcohol, counted and recorded.

Preservation of Organs and Parasites:
The organs were stored in labelled universal bottles with 0.09% saline, then transported to the laboratory for further analysis. Recovered parasites were fixed in 70% alcohol in differently labeled specimen bottles.

Histological Assessment of Fish Samples:
The selected target organ, the intestines from both infected and uninfected intestines were dissected for histological preparation after dissection. The intestines were stored in bouins solution in separate universal bottles. After 6 hours, the bouins fluid in each bottle was decanted. Then 10% phosphate buffer formalin was added to preserve the tissue. Random selection was made from the preserved tissue based on single or multiple infections and light, heavy or no infection. The dehydration of the tissues took place in increasing concentrations of alcohol and twice in absolute alcohol at 30 minutes interval. Tissues were impregnated in molten paraffin three times and later embedded in molten paraffin wax and allowed to solidify. The blocked tissues were sectioned at 4-5 microns floated into pre-coated slides and dried. The sections were stained using haematoxylin and eosins stains. The stained tissues were washed off in tap water and the over stained ones destained in 1% acid alcohol. The tissues were mounted using DPX mountant dried and examined under the microscope. The photomicrographs were taken at the pathology laboratory, Veterinary Pathology, University of Ibadan, Nigeria.

Analysis of PCBS:
All chemicals and reagents were of analytical grade and of highest purity possible. LC grade dichloromethane and n-hexane used for the extraction and clean up were obtained from Fisher Scientific. The silica gel used in clean up was supplied by BDH Laboratories. The acetone and anhydrous sodium sulphate used in this study were also obtained from BDH Laboratories. A mixture of 8 PCB congeners (namely PCBs 28, 52, 107, 105, 118, 153, 156 and 180) was obtained from Sigma Aldrich.
Extraction:
Prior to extraction, the fish specimens were dissected and the muscle tissue removed. 10 g of muscle tissue was ground with anhydrous sodium sulphate until completely dry homogenate was obtained (Anyakora et al., 2005). Extraction was carried out with dichloromethane in a cold extraction mode (Anyakora et al., 2004). After the extraction, the extracting solvent was evaporated using a rotary evaporator and the mass of the extractable fat determined by gravimetry.

Sample Clean Up:
The isolation of PCBs from the lipid matrix was done by solid phase extraction in a normal phase mode. Activated silica gel was loaded into a glass chromatographic column (20mm, height 400mm) and conditioned with dichloromethane. The extractable fats from the samples were dissolved in 5 ml n-hexane and loaded on to the column and eluted with about 60 ml n-hexane. The effluents were then concentrated using a rotary evaporator and under a gentle stream of pure nitrogen. The samples were thereafter dissolved in 1 ml acetone and ready for GC analysis.

Gas Chromatography:
Analyses were performed with Perkin model 5890 gas chromatograph equipped with Ni 63 electron capture detector. A low polar HP–5 column of 30 m length, 0.32 mm and 0.25 mm film thickness was used. Nitrogen was used as a carrier gas at a flow rate of flow rate 40 ml/s. Data were processed using an HP 3396 integrator. The operating parameters were as follows: injector temperature set at 250 and 300°C for the detector, the oven temperature was programmed at 150°C initially (5 min hold) and increased to 300 at 4°C/min to give the analysis period of 34 min.

Identification and Quantification:
PCB congeners in the fish were identified by retention time match with those of the standards. The standard mixture contains PCBs 28, 52, 107, 105,118, 153, 156 and 180. Hence only these congeners were identified and determined in the fish samples during this study, quantification was done based on area count match with those of known concentration of the standards. Parasitic prevalence and mean intensity were calculated using the formulae according to Ezewanji, et al., (2005) as thus:

\[
\text{Prevalence} \% = \frac{\text{Number of fish infected}}{\text{Number of fish examined}} \times 100
\]
\[
\text{Mean intensity} = \frac{\text{Total number of parasite}}{\text{Number of fish infected}}
\]
\[
\text{Bio-load} = \frac{\text{Number of collected parasites}}{\text{Number of infected fish}}
\]
\[
\text{Abundance} = \frac{\text{Number of collected parasites}}{\text{Number of fish examined}}
\]

Calculation of Bioaccumulation Factor (BAF):
Bioaccumulation is the increase in concentration of the test substance in or on an organism (specified tissues thereof) relative to the concentration of test substance in the surrounding medium, the biota to soil accumulation factor (BSAF) and bio-concentration factor (BCF) were determined as ratio of PCBs in the fish to that in the soil and water samples as follows:

\[
\text{BSAF} = \frac{\text{Concentration of PCBs in animal tissue}}{\text{Concentration of PCBs in soil sample}}
\]
\[
\text{BCF} = \frac{\text{Concentration of PCBs in animal tissue}}{\text{Concentration of PCBs in water sample}}
\]
Statistical Analysis:
Data generated from the investigations was entered into Microsoft excel spreadsheet (2013) and later subjected to two-way analysis of variance (ANOVA) (SPSS Version 20 software).

RESULTS
Physiochemical Parameters in three stations at Epe Lagoon, Lagos, Nigeria

Table 2 presents the physiochemical parameters of the water sample obtained from the three different stations at the study location. A slight variance in the parameters recorded is observed within the stations. The mean value recorded for the parameters include: pH of 6.6±0.1, 6.4±0.3, 6.5±0.1, dissolved oxygen; 4.5±0.4, 3.50±0.3, 3.2±0.2 mg/l, total suspended solids; 11±5.5, 7.1±2.6, 9±1.5 g/l, total dissolved solids; 106.3±8.4, 113.9±6.3, 110.1±5.6 g/l, conductivity; 152.7±0.5, 172.3±2.6, 193.3±3, µS/cm, salinity; 4±0.5, 5±0.3, 4.5±0.5 ppt, turbidity; 10.3±3.5, 7.7±3.2, and 7.7±2.5 NTU, for the three stations (ORIBO, IMODE, IKOSI) respectively.

| Parameters                  | Orib (mean) | Imode (mean) | Ikosi (mean) | Fepa Limit |
|-----------------------------|-------------|--------------|--------------|------------|
| Temperature (°C)            | 26.5±0.5    | 25.8±0.3     | 25.2±0.7     | < 40       |
| pH                          | 6.6±0.1     | 6.4±0.3      | 6.5±0.1      | 6-9        |
| Dissolved Oxygen (mg/L)     | 4.5±0.4     | 3.5±0.2      | 3.2±0.3      | > 5.0      |
| Total Suspended Solids (g/L)| 11±5.5      | 7.1±2.6      | 9±1.5        | NA         |
| Total Dissolved Solids (g/L)| 106.3±8.4   | 113.9±6.3    | 110.1±5.6    | 2000       |
| Conductivity (µS/cm)        | 152.7±0.5   | 172.3±2.6    | 193.3±3      | NA         |
| Salinity (ppt)              | 4±0.5       | 5±0.3        | 4.5±0.5      | NA         |
| Turbidity (NTU)             | 10.3±3.5    | 7.7±3.2      | 7.7±2.5      | 10         |

Prevalence of Intestinal Helminth Parasite of Synodontis Clarias in Lekki Lagoon, Lagos:

Table 3: Shows the prevalence of intestinal helminth parasite of Synodontis clarias in Lekki Lagoon, Lagos. Out of the 120 fishes collected, 45 were females and 75 were males; 45 fishes were infected (37.5%) and 75 fishes were not infected (62.5%). The Chi-square (χ²) for the distribution is 14.79** p<0.001. Among the sexes, 21 females were infected (46.67%) and 24 were not infected (53.33%), 24 males were infected (32%) and 51 males were not infected (68%). The parasites found in the intestine of the infected fish were cestodes (Wenyonia spp) and nematoda (Raphidiaroides spp) and are shown in plate 1a to 2b. Plates 1a and 1b show the cephalic and caudal regions of the Wenyonia spp found in the infected intestine while plates 2a and 2b show the cephalic and caudal regions of the Raphidiaroides spp.

| Sex/Infection | Number examined | Infected | Non-Infected |
|---------------|-----------------|---------|--------------|
| Female        | 56 (37.5%)      | 26 (17.33%) | 30 (20.00%)  |
| Male          | 94 (62.5%)      | 30 (20.00%) | 64 (42.67%)  |
| Combined      | 150 (100%)      | 56 (37.33%) | 94 (62.67%)  |

Morphometrics and Condition Factor of Synodontis Clarias in Lekki Lagoon, Lagos:

Table 4: Shows the morphometrics and condition factor of Synodontis clarias in Epe axis of Lekki Lagoon, Lagos. Standard length of mean is
The Caryophyllaceae cestodes, *Wenyonia* harbours high quantities of a specific PCBs, 14.34±1.19, p<0.01, with minimum and maximum value of 11.00-20.00 (cm). Total length with mean, 20.35±1.81, p<0.01 with minimum and maximum value of 15.00-26.00 (cm). Weight with mean±SD, 64.72±11.47, p<0.01 with minimum and maximum value of 28.50-105.50 (g). Liver weight with mean±SD, 1.10±0.48, p<0.01 with minimum and maximum value of 0.30-3.00 (g). Gonad weight with mean±SD, 2.02±3.49, p<0.01 with minimum and maximum value of 0.00-20.00 (g). Condition factor with mean±SD, 2.21±0.36, p<0.01 with minimum and maximum value of 1.00-3.60.

Table 4: Morphometrics and condition factor of *Synodontis clarias* in Lekki Lagoon, Lagos, Nigeria.

| Parameters               | N   | Mean   | SD    | Min-Max       |
|--------------------------|-----|--------|-------|---------------|
| Standard length (cm)     | 150 | 14.34**| 1.19  | 11.00-20.00   |
| Total length (cm)        | 150 | 20.35**| 1.81  | 15.00-26.00   |
| Weight (g)               | 150 | 64.72**| 11.47 | 28.50-105.50  |
| Liver weight (g)         | 150 | 1.10** | 0.48  | 0.30-3.00     |
| Gonad weight (g)         | 150 | 2.02** | 3.49  | 0.00-14.00    |
| No of parasite           | 150 | 2.12** | 4.48  | 0.00-20.00    |
| Condition factor         | 150 | 2.21** | 0.36  | 1.00-3.60     |

** Mean significant at level 0.01
*Mean significant at level 0.05

Length-Weight Relationship in *Synodontis Clarias* in Lekki Lagoon, Lagos using Nine Regression Models:

Table 5 shows the correlation coefficients of the linear model (R² = 0.453, p<0.001, β = 0.675), and the logarithm coefficient (R² = 0.470, p<0.001, β = 0.688), the quadratic coefficient as (R² = 0.465, p<0.001, β = 1.620), Cubic coefficient as (R² = 0.465, p<0.001, β = 1.620), compound coefficient as (R² = 0.492, p<0.001, β = 2.022), the power model coefficient as (R² = 0.517, p<0.001, β = 0.721), growth model coefficient as (R² = 0.492, p<0.001, β = 0.704), the exponential model coefficient as (R² = 0.492, p<0.001, β = 0.704), and the logistic model coefficient as (R² = 0.492, p<0.001, β = 0.495). The logistic, exponential and growth models have the same correlation coefficient (R = 0.704, p<0.001); and also the quadratic and cubic models correlation coefficient being the same (R = 0.688, p<0.001); with the highest being the power model (R = 0.721,p<0.001); and the linear model being the least (R = 0.675,p<0.001).

Table 5: Length-Weight relationship in *Synodontis clarias* using nine regression models

| Models       | R        | R²       | B       |
|--------------|----------|----------|---------|
| Linear       | 0.695**  | 0.479**  | 0.695   |
| Logarithm    | 0.711**  | 0.502**  | 0.711   |
| Quadratic    | 0.731**  | 0.526**  | 3.374   |
| Cubic        | 0.731**  | 0.526**  | 3.374   |
| Compound     | 0.691**  | 0.473**  | 1.996   |
| Power        | 0.714**  | 0.506**  | 0.714   |
| Growth       | 0.691**  | 0.473**  | 0.691   |
| Exponential  | 0.691**  | 0.473**  | 0.691   |
| Logistic     | 0.691**  | 0.473**  | 0.501   |
Histopathological Alterations Showing A Degree of Changes in The Intestines and Gills of Synodontis clarias in Epe Lagoon, Lagos:
The microscopic study of the infected intestine and gill recovered from the fish host revealed different pathological effects. These effects are shown in plate 1.

The infected intestine showed severe congestion of the submucosa. The villi structure and the surface epithelial were moderately preserved while the gill showed vasodilation with blood congestion of primary filament, loss of filaments, curling of filaments and hyperplasia.

PLATES: 1 (A): The villi structure and the surface epithelial were moderately preserved. (B) Photomicrographs of intestinal tissue show severe congestion of the submucosa (black arrow). (C) Gill showing vasodilation with blood congestion of primary filament (black arrow). (D) Loss of filaments (blue arrow). (E) Curling of filaments and hyperplasia.
Mean Concentration of PCBS Congeners in the Tissue of Synodontis clarias across Stations (PPB):

The analysis of polychlorinated biphenyls in the tissue of Synodontis clarias from Epe axis of Lekki Lagoon showed that between the three stations there was a significant difference (Anova, P>0.05) in the congeners identified, possibly indicating that PCBS availability and concentrations were significantly impacting the aquatic ecosystem. (Table 6). There was no significant difference between congeners in Oribo and Ikosi but revealed that there was a significant difference between congeners in Imode. The trend of mean concentration ranged from 5.02 (PCB 77) to 265.73 (PCB 44) in Oribo, 5.08 (PCB 123) to 71.12 (PCB 44) in Imode and 0.00 (PCB 52) to 32.37 (PCB 18) in Ikosi sampling station.

| CONGENER | ORIBO    | IMODE    | IKOSI    |
|----------|----------|----------|----------|
|          | MEAN (PPB) | SD      | MAX  | MEAN (PPB) | SD      | MAX  | MEAN (PPB) | SD      | MAX  |
| PCB 8    | 7.96     | 11.25    | 15.91 | 35.44     | 49.023  | 70.00 | 12.44     | 8.59    | 19.00 |
| PCB 18   | 202.00   | 264.37   | 389.30 | 46.58     | 56.32   | 86.00 | 28.41     | 32.37   | 51.00 |
| PCB 28   | 44.77    | 63.32    | 89.55 | 21.36     | 22.96   | 38.00 | ND        | 0.00    | 0.00  |
| PCB 44   | 265.73   | 20.956   | 280.56 | 71.12     | 100.58  | 142.00 | 36.54     | 20.45   | 51.00 |
| PCB 52   | 68.22    | 5.76     | 72.29 | 3.36      | 4.75    | 7.00  | 0.00      | 0.00    | 0.00  |
| PCB 60   | ND       | 0.00     | 0.00  | ND        | 0.00    | 0.00  | ND        | 0.00    | 0.00  |
| PCB 77   | 5.02     | 7.09     | 10.03 | 5.68      | 8.03    | 11.00 | 8.38      | 11.85   | 17.00 |
| PCB 101  | 7.99     | 11.31    | 15.99 | ND        | 0.00    | 0.00  | ND        | 0.00    | 0.00  |
| PCB 123  | 5.37     | 7.59     | 10.73 | 5.08      | 7.189   | 10.00 | 10.22     | 0.86    | 11.00 |
| TOTAL PCBS | 343.33  | 223.42   | 95.99 |

*TOTAL PCB REFERS TO THE TOTAL PCB OBSERVED IN THE FISH AT THAT STATION
*CONCENTRATIONS ARE REPORTED IN WET WEIGHT*(p>0.05)
*ND (NOT DETECTED)*

Mean Concentration of PCB Congeners in Parasites of Synodontis clarias across Stations (PPB):

Parasites from the fish samples at the three different stations were taken for PCBs analysis and their mean concentration was calculated although the PCBs congeners identified were higher than those in the fish, their values ranged from 0.00-483.20 in Oribo, 7.40 to 20.70 in Imode and 0.00 to 546.30 in Ikosi. (Table 7). However, the concentration of PCBs congener PCB 81 was high at Oribo and Ikosi and is above W.H.O residual limit of 200ppb.

| CONGENERS | ORIBO    | IMODE    | IKOSI    |
|-----------|----------|----------|----------|
| PCB 18    | 50.70    | 20.70    | 21.70    |
| PCB 28    | 0        | 7.40     | 0        |
| PCB 52    | 15.70    | 9.30     | 0        |
| PCB 77    | 0        | 8.20     | 0        |
| PCB 81    | 483.20   | 12.20    | 546.30   |
| TOTAL     | 549.60   | 57.80    | 368.00   |

*TOTAL PCBs REFERS TO THE TOTAL PCBs OBSERVED IN THE FISH AT THAT STATION
*CONCERNTRATIONS ARE REPORTED IN WET WEIGHT*(p>0.05)
*ND (NOT DETECTED)
Mean Concentration of PCB congeners in Sediment Media Across Stations (PPB):

Sediment samples were taken from the three different sampling stations at Epe axis of Lekki lagoon and were taken for analysis, ORIBO means concentration ranges from 0.00 to 371.40, while that of IMODE range from 0.00 to 821.70 and IKOSI from 0.00 to 358.10. This is shown in table 8.

Table 8: Mean concentration of PCB congeners in sediment across stations

| CONGENERS | ORIBO (PPB) | IMODE (PPB) | IKOSI (PPB) |
|-----------|-------------|-------------|-------------|
| PCB 8     | 6.10        | 0           | 3.2         |
| PCB 18    | 11.90       | 8.10        | 0           |
| PCB 77    | 14.20       | 14.70       | 14.20       |
| PCB 81    | 371.40      | 821.70      | 358.10      |
| PCB 101   | 0           | 0           | 20.10       |
| PCB 123   | 11.20       | 10.20       | 9.80        |
| PCB 153   | 0           | 6.00        | 0           |
| TOTAL     | 414.90      | 860.70      | 405.40      |

Mean Concentration of PCB Congeners in Water across three Stations (PPB):

Water samples were taken for analysis and across the three stations, Imode had the highest PCBs content with a total of 5.9608, while Oribo and Ikosi had 3.1556 and 3.3071, the reason for Imode high content may be due to the fact that it is just close to fresh water source when contaminants from anthropogenic activities enters the lagoon. (Table 9).

Table 9: Mean concentration of PCB congeners in water three sampling across stations

| CONGENERS | ORIBO (PPB) | IMODE (PPB) | IKOSI (PPB) |
|-----------|-------------|-------------|-------------|
| PCB 8     | 0           | 2.0606      | 0           |
| PCB 28    | 0           | 0.0978      | 0           |
| PCB 44    | 1.6656      | 2.0556      | 0           |
| PCB 77    | 1.1008      | 0.8207      | 2.0463      |
| PCB 81    | 0           | 0           | 0.0905      |
| PCB 123   | 0           | 0           | 0.6878      |
| PCB 153   | 0.3892      | 0           | 0.4825      |
| PCB 156   | 0           | 0.9261      | 0           |
| TOTAL     | 3.1556      | 5.9608      | 3.3071      |

Summary Concentration of PCBs:

The summary of total PCBs concentration in fish, parasite, water and sediment are shown in Table 10. In all the three stations, the sediment has the highest PCBs concentration, while the water has the lowest PCBs concentration, indicating that these contaminants sediment at the bottom of water while.

Table 10: Total PCBs concentrations in fish, parasite, water and sediment collected in three sampling stations

| SITES | FISH (PPB) | PARASITE (PPB) | WATER (PPB) | SEDIMENT (PPB) |
|-------|------------|----------------|-------------|----------------|
| ORIBO | 607.42     | 549.53         | 3.20        | 414.90         |
| IMODE | 188.61     | 57.77          | 6.00        | 860.70         |
| IKOSI | 325.43     | 569.95         | 3.30        | 405.50         |
| TOTAL | 1121.46    | 1177.25        | 12.50       | 1681.10        |
The Caryophyllaceae cestodes, *Wenyonia* harbours high quanities of a specific PCBs 41

**Bioconcentration Factor (BCF):**

Table 11 shows the bio-concentration factor in the fish and parasite across stations. The Parasite had the highest concentration factor (319.88) while *Synodontis clarias* had a low bio-concentration of 319.88 compared to the parasite. Across the stations, Oribo (361.55) had the highest concentration followed by Ikosi (271.33) while Imode (41.07) had the least concentration.

| SITES | BCF   |
|-------|-------|
|       | FISH  | PARASITE |
| ORIBO | 189.82| 171.73    |
| IMODE | 31.44 | 9.63      |
| IKOSI | 98.62 | 172.71    |
| Total | 319.88| 354.07    |

**Biota-Soil Accumulation Factor (BASF):**

Table 12 shows the biota-soil accumulation factor in fish and parasite at the Epe axis of Lekki lagoon. The parasite had the highest accumulation factor of 2.80 while the fish had 2.42 which were slightly low compared to that of the parasite. Across the stations, Oribo (2.72) had the highest accumulation followed Ikosi (2.21) and the lest was IMODE (0.29)

| SITES | BSF   |
|-------|-------|
|       | FISH  | PARASITE |
| ORIBO | 1.40  | 1.32      |
| IMODE | 0.22  | 0.07      |
| IKOSI | 0.80  | 1.41      |
| TOTAL | 2.42  | 2.80      |

**DISCUSSION**

Adverse stress predisposing factors allows parasites to attack their hosts and parasitic diseases can be transmitted from one host to another with grave consequences. The presence of parasitic infections in fishes is an indication of environmental stress (Schludermann et al., 2003). There are host-related reactions against the parasites which could lead to inflammatory lesions (Don-Pedro et al., 2004; Falcao et al., 2008). Helminthes parasites infections were higher in males 30 (20.00%) than females 26(17.33%). Similar results that a higher rate of intestinal parasite infection was obtained in male fishes have been reported by (Allumma and Idowu, 2011; Akinsanya et al., 2008). Higher prevalence in both genders of the fish hosts may be naturally enhanced but there is no scientific reason to link parasitic infections to a particular sex in the fish hosts. The overall prevalence of the parasites (37.5%) recorded in this study in *Synodontis clarias* was lower than that of 85.2% reported in Zaria (Ashraf, 2005). The differences in the prevalences may be due to different conditions in the affected water bodies. Condition factor is also needed to assess the degree of the wellbeing of a fish population (Ighwela, et al., 2011). In this study, randomly selected specimens were measured to obtain their length and weight parameters (Sarkar et al., 2013). Similar findings were made by Abowei and Davies (Abowei and Davies, 2009) (Deekae et al., 2010) where a negative allometric growth was obtained (b=0.88
and \( b=2.88 \) for the studies of *Clarotes laticeps*. The relationship between length and weight of fish is anchored on factors such as season, habitat, gonad maturity, sex, diet and annual fluctuations in environmental condition (Falcao et al., 2008). The differences in reports could be attributed to or combined factors of the differences in the number of species, geographical location and season (Akinsanya, 2007). The general wellbeing of fishes is an estimation of its condition factor (Marcogliese, 2005). It is anchored on the fact that fishes with high weight in a given length are in better condition than fishes with less (Falcao et al., 2008). The determination of the general wellbeing of a fish is an index of its growth and feeding intensity. Marcogliese (2005) reported that the wellbeing of fishes in different populations who are of the same species is a confirmation of the availability of food supply and regular timing and duration of breeding. Dykova and Lom (2007) reported that the extent of the wellbeing of a fish can be influenced by factors such as sex, age, season, maturity and food preference of the organism. The condition factor as reported in this study is to determine the wellbeing of the fish hosts as a result of the stress based on the uptake of the contaminants in the aquatic ecosystem as reported for mature fresh water fish body weight (Mir, et al., 2012). This suggested that the water body might be favourable for *Synodontis clarias* species.

Histopathological observations in the intestinal mucosa of the fish hosts show different pathological effects which agrees to the report of (Akinsanya, 2007). In this study, several pathological conditions of the intestinal mucosa were also reported. According, to Winkaler, *et al.*, (2001) and Tkatcheva, *et al.*, (2004), some morphological changes in gills and intestine may represent adaptive strategies to maintaining physiological functions, but the histopathological lesions as described in this study indicated that fishes were affected by exposure to pollutants present in water and sediment. In this study the fish gill showed hyperplasia, epithelial lifting, fusion and loss of filaments which can result in difficulty of oxygen, carbon dioxide, acids and ammonia exchanges. The effects can also lead to hindrance in the transfer of ions and water. The presence of surfactants, phenols, PAHs (Polycyclic Aromatic Hydrocarbons), metals and other urban pollutants certainly were the reason to those damages, as also described by Tkatcheva, *et al.*, (2004) The reduction of oxygen may also be the source of physiological disturbances that can sometimes reflect in morphological damages (Alberto *et al.*, 2003). The exposure of gills to different contaminants may be marked by the occurrence of lamellar fusion, tissue hyperplasia as neoplastic events, cellular hypertrophy and aneurysms (Tkatcheva, *et al.*, 2004 and Ribeiro *et al.*, 2000 and 2005). Hyperplasia and fusion of the gill filament found in this study are considered as moderate severity according to the classification of Bernet *et al.*, (1999). These types of lesion may occur as a tissue response to the presence of pollutants diluted in water, increasing the distance between the blood capillary and lamellae surface. However, this cell proliferation also leads to respiratory dysfunction, affecting gas exchange due to the decreasing of gill surface and also leading to disturbances in the fish

In this study *Synodontis clarias* were infected with two species of parasites the cestodes (*Wenyonia spp*) and Nematode (*Raphidascaroides spp*) which is common among the family Mockokidae and is in conformity with the report of Ahmed *et al.*, (2012). *Raphidascaroides* is a small ovoviparous nematode that is prevalent in most African freshwater fishes, notably Siluroids.
osmoregulation. The intestine of *Synodontis clarias* showed congestion of the submucosa, degeneration of epithelia layer and debris in the lumen. These effects can hinder the digestion and absorption of food materials in the fish which might lead to loss of appetite of the fish leading to decrease in the size of fish or reduction in rate of reproduction or even mortality of the fish thereby leading to species extinction and reduction in economic value of the fish.

Parasitism coupled with pollution could either increase or decrease the prevalence, intensity and load of the parasites and upset host/parasite equilibrium which could lead to diseased condition and mortality of the host.

The PCB congeners 8, 18, 28, 44, 77, 81, 123, 153, 156 detected in the water and sediment sample of all the 209 PCB congener is in line with reports from (Wania and Mackay, 1996) who stated that the concentration of volatile compound is low in tropical areas and higher in temperate or polar regions. Also, it is well known that lower chlorinated PCB can volatilize and are thus more susceptible to atmospheric removal process (Mackay *et al.*, 1992, Fiedler 1998). The findings presented in the study, showed more of the lower chlorinated PCB congeners in the water sample than in the sediment, fish (*Synodontis clarias*) and parasite sample from the three stations in the Epe axis of Lekki Lagoon. Anyasi and Atagana (2013) showed that lower chlorinated PCB congeners tend to be more volatile and soluble in water, while adsorption to organic materials, sediments, and soils tends to increase with chlorination of PCB and organic content of the substrate because of their hydrophobic nature (Passatore *et al.*, 2014). High chlorinated PCBs were also detected in *Synodontis clarias* and parasite samples from Epe axis of Lekki Lagoon, having relatively high amount of congeners is an indication that the water body is less contaminated as it contains the high concentration of poly chlorinated biphenyl, which is a toxic form of PCB.

The fish samples collected from Oribo had the high concentration of congeners 28, 18, 44, and 52 among other detected, while fish samples collected from Imode had high concentration of 44,18,8 and 28 and the fish samples collected from Ikosi also had high concentration of PCB 44, 18, 8 and 123 respectively. However, the concentration of PCBs level found in the fish tissue was above W. H. O limits of 200 part per billion (ppb) in Oribo and Ikosi (607.42ppb and 325.43ppb) sampling station while the concentration was below in Imode (188.61ppb) sampling station and hence the *Synodontis clarias* in Oribo and Ikosi is not safe and edible for consumption. The parasite samples collected from the organs of *Synodontis clarias* in ORIBO was analysed and found to be high in PCB 81, 77 and 52 while parasite collected fish samples from IMODE was found to be high in PCB 18, 81 and 77 and parasite collected from fish samples in IKOSI was also analysed and found to be high in PCB 81 and 18 respectively.

The concentration of PCB congeners in the sediment from each of the three stations were also analysed and found to contain high amount of PCB 81, 77 and 8 in samples collected from Oribo, PCB 81, 77 and 123 in Imode and PCB 81, 101 and 77 in Ikosi respectively. Although the major sources of PCB contamination in the Epe axis of Lekki Lagoon is not known, the presence of PCB congeners can be linked to run-off from industrial sites around the environ.

The accumulation pattern of PCBs in the fish species does not seem to implicate fish diet as the only pathway for bioaccumulation, which could either be as a result of either presence of PCBs in the water column or food chain (Kasozzi *et al.*, 2005), a conclusion should be attempt to draw in further studies by
investigating the concentration of PCBs in the entire food web.

The results from this study demonstrates a persistent problem with polychlorinated biphenyls, leading to high risk in fish species in aquatic ecosystems, and for the human populations living near these regions, concentration of PCBs in Synodontis clarias at Epe axis of Lekki lagoon in Oribo and Ikosi is already far above the WHO limits for PCBs in fish, while is at warning limits in Imode sampling station. In view of the importance of fish to diet of man, it is necessary that biological monitoring of the water and fish meant for consumption should be done regularly to ensure continuous safety of the fisher. Safe disposal of domestic sewage and effluents should be practiced and where possible, recycled to avoid these PCBs and other contaminants from going into the environment. Laws enacted to protect our Aquatic environment should be enforced. The activities at the three sampling stations (Oribo, Imode and Ikosi) should be kept under strict surveillance as they are capable of increasing PCBs discharge into the Lagoon, especially as population is bound to increase. However, the study showed a need for continuous pollution assessment study of aquatic organisms and its environment.

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