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Persistent Organic Pollutants and Water Quality Evaluation in the Waste Water from Fish Farm Estate, Ikorodu and the Effect on Downstream Communities

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Abstract
Background: *The study evaluates the persistent organic pollutants and water quality characteristics in the bailed-out waste water from Fish Farm Estate Ikorodu, Lagos.*
Materials and Methods: *The evaluation was carried out for twelve (12) weeks. The study sites were divided into three phases (1, 2 and 3). The water samples were collected from each site into three amber glass bottles for POPs and three plastic bottles for physicochemical parameters respectively for laboratory analyses.*
Results: *The results obtained were subjected to ANOVA. pH, Dissolved Oxygen (DO), Electrical Conductivity (EC), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Dissolved Solids (TDS), Salinity in the bailed-out waste water are statistically significant at ($p<0.05$). However, Persistent Organic Pollutants (POPs) are not detected in the sampled water.*
Conclusion: *The result shows that the bailed-out waste water from fish farm estate is highly polluted though not with POPs and these pollutants are detrimental to aquatic life and lacustrine communities downstream. It is therefore recommended that relevant agencies on environmental protection should embark on project work on waste water treatment plant for fish farmers in the estate and also conduct an enlightenment campaign programme on the sources and impact of POPs to the aquatic life and human as well as preventive measures from future occurrences.*
Key words: *Persistent Organic Pollutants, Lacustrine, Waste water, Water quality*

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I. Introduction

Water quality characteristics are mostly frequently used by reference to a set of standards against which compliance can be assessed. Physicochemical characteristics of water are the common criterions used to evaluate water quality as it affects aquatic ecosystem and the health of human in contact with it [1]. According to [1, 3], water quality parameters assess the condition of water in terms of the requirements of aquatic animals and human purpose and water quality studies are necessary to continually assess and effectively management input of pollutants to aquatic environment that serve as sources of both domestic and industrial effluent and runoff.

Persistent organic pollutants (POPs) are group of non-biodegradable lethal substances that are remains in the environment for some years before breaking down[4]. Persistent organic pollutants are not natural products, but they are produced by humans. The occurrence of Persistent organic pollutants is a global phenomenon via a point source and dispersed globally through repeated process of evaporation and deposition. The process of transportation POPs by wind and water, most POPs produced in one region can affect human being and animals away from where they were generated and released. Persistent organic pollutants are toxic chemicals that can cause ill-health in human and environmental degradation around the world. The biological and chemical degradation of POPs are product of halogenations which is characterized by their source and application. POPs can be divided into 3 smaller groups; Industrial and Technical Chemicals, Pesticide and Residue of thermally processed chemicals such as; Aldrin, Chlordane, DDT, Dieldrin, Dioxins, Endrin, Furans, Heptachlor, Hexachlorobenzene (HCB), Mirex, Polychlorinated Biphenyls (PCBs), Toxaphene etc. [5]**.**

The fish farm estate at Odogunyan, Ikorodu, Lagos State of Nigeria which was established on 4.65km^2 area of land and the farm settlement covers 34 - hectare parcel of land. This farm estate is further divided into phase 1 and phase 2 for ease of community administration. The fish farm estate has 300 fish production plots which had been allocated to 250 prospective fish farmers making the estate fully subscribed with total production capacity of over 12,000 tons of fresh fish per annum [6]. Aside from fish farming, other areas of agriculture are also practiced such as arable farming, poultry, piggery, and cattle ranching which made the estate an integrated farm estate

The results of excess pollutants in the water have been identified as a major reason for impaired water quality in the water bodies, unbalanced aquatic ecology and pollution of lacustrine communities[7]. However, efforts have been geared towards considerations of downstream effects of water pollution by environmental protection regulatory bodies by developing a set of guidance criteria for pollution monitoring in the aquatic environment[8].

The assessments of waste water samples from fish farm estate need to be conducted for index classification of downstream-based water body management and bio-assessments purposes according to regulatory standard limit[3].

II. Materials And Methods

The study site is located in the fish farm estate at Odogunyan, Ikorodu, Lagos State of Nigeria which was established on 4.65km^2 area of land and the farm settlement covers 34 - hectare parcel of land.

Study Design: complete randomized design

Study Location: fish farm estate at Odogunyan, Ikorodu, Lagos State of Nigeria

Study Duration: twelve (12) weeks (July- September, 2017)

Sample size: 216 samples collected

Subjects & selection method: There are two major canals for discharging waste water from the fish farm estate which form locations of the study. The study site was divided into three parts; the first part is a canal coming from phase 1 of the fish farm estate and the second part from phase 2 while the third sampling station (phase 3) is where phase 1 and phase 2 canals met and flow downstream to adjacent lacustrine communities of Alaketu, Maya, and Ijede then flow into Lagos Lagoon. Phase 1, 2 and their meeting point (phase 3) represent three sampling stations.

Procedure methodology

The samples were collected into three plastic bottles in 3 replicates per sampling station for water chemistry analyses and three amber bottles in 3 replicates per sampling station for Persistent organic pollutants. Samplings are taken early in the morning by 7:00hrs on Monday and Wednesday during the collective discharging of pond water by fish farmers in the estate and done twice in a week for 12 weeks and weekly mean values are computed.

The samples for physicochemical parameters such as pH, Temperature, Dissolved Oxygen (DO), Electrical Conductivity (EC), Salinity were taken *in-situ* using hand-held digital water test kit (Ezodo Model PCT-407and Tracer Pocketer DO meter Model. Code 1761, USA).

The *ex-situ* of Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Dissolved Solids (TDS), Ammonia ($NH_{3)}$, Nitrate (NO_2), Nitrite (NO_3), Sulphate($SO_{4-2)}$,and Chloride (CL^-) were measured using standard laboratory procedure for physicochemical analyses of water. Persistent Organic Pollutants (POPs) such as Aldrin, Chlordane, DDT, Dieldrin, Dioxins, Endrin, Furans, Heptachlor, Hexachlorobenzene (HCB),Mirex, Polychlorinated Biphenyls (PCBs), Toxaphene were determined by extracting, evaporating and weighing of the samples using gas chromatography in the laboratory.

All the *ex-situ* analyses of the samples were carried out in the central laboratory of Nigerian Institute for Oceanography and Marine Research, Lagos.

Statistical analysis

All data were analyzed and calculated by the use of one-way analysis of variance. The level $P < 0.05$ was considered as the cutoff value or significance.

III. Results

The analytical data (*in-situ* and *ex-situ*) on water quality in the bailed-out waste water from Fish Farm Estate, Ikorodu, Lagos are presented in Table 1. The results are analyzed using one-way ANOVA.

Table no 1: Water quality characteristics in the wastewater from fish farm estate, Ikorodu, Lagos

Site	Month	Temp (oc)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	Salinity (‰)	E. Cond. (µS/cm)	pH	TDS (mg/l)	NH_3 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)	SO_{4-2} (mg/l)	Cl^- (mg/l)
1	July	21.46	3.86	1.90	4.23	1.95	3.85	6.32	4.85	0.31	0.09	0.32	20.52	2.75
	August	23.15	3.36	2.60	5.60	1.85	3.75	6.21	1.85	0.33	0.24	0.49	22.99	2.5
	Sept.	24.58	3.28	2.30	5.15	1.98	3.68	6.38	1.83	0.23	0.37	0.55	23.93	2.75
	Mean	23.06	3.50	2.27	4.99	1.99	3.74	6.30	2.84	0.30	0.23	0.45	22.48	2.58
	(±SD)	±1.56	±0.31	±0.35	±0.70	±0.06	±1.02	±0.09	±1.07	±0.87	±0.14	±0.12	±1.76	±0.14
2	July	22.31	3.80	1.28	4.48	1.45	2.86	6.15	2.54	0.17	0.06	0.27	24.46	1.75
	August	19.09	3.30	2.05	5.85	1.43	2.89	6.06	2.17	0.40	0.17	0.48	22.35	2.00
	Sept.	23.45	3.20	1.88	5.38	1.53	2.88	5.96	2.16	0.25	0.22	0.49	22.30	1.5
	Mean	21.62	3.43	1.73	5.24	1.49	2.88	6.06	2.29	0.27	0.15	0.41	23.04	1.75
	(±SD)	±2.26	±0.32	±0.41	±0.70	±0.05	±0.02	±0.10	±2.05	±0.82	±0.08	±0.12	±1.23	±0.25
3	July	23.00	3.82	1.75	4.68	1.48	2.94	6.29	1.95	0.38	0.07	0.32	25.51	3.00
	August	24.20	3.25	2.85	6.10	1.52	3.01	6.16	1.91	0.29	0.16	0.36	23.52	1.50
	Sept.	24.23	3.22	2.80	5.60	1.57	2.77	6.19	1.84	0.17	0.23	0.48	22.70	2.00
	Mean	23.80	3.44	2.47	5.46	1.52	2.91	6.21	1.90	0.28	0.15	0.39	23.91	2.17
	(±SD)	±0.70	±0.34	±0.62	±0.72	±0.05	±1.09	±0.07	±0.06	±0.84	±0.08	±0.08	±1.45	±0.76
WHO Standard(1996)		20-32	5-6	<10	< 50	0-1	1.0	6-8.5	5.0	0.2	10	0.1	250	1.0

Table 1 shows monthly and the mean standard deviation values of all the water quality parameters taken from the 3 sampling locations during the study periods. The highest temperature reading was recorded in September in all the 3 locations; the mean range of the temperature taken is 23.80±0.70°c - 21.62±2.26°c whereas Dissolved Oxygen concentration recorded in September in all the 3 phases with mean range of 3.50±0.31mg/L - 3.43±0.32mg/L. There is negative correlation between dissolved oxygen and temperature and both are significant ($P<0.05$). Biological Oxygen Demand mean range is 2.47±0.62mg/L - 1.73±0.41mg/L and Chemical Oxygen Demand mean range is 5.46±0.72mg/L - 4.99±0.70mg/L with highest concentration in location 2 in August and lowest in location 1 in July. There is positive correlation between Biological Oxygen Demand and Chemical Oxygen Demand at significant level of 5%.

Salinity, Electrical Conductivity and Total Dissolved Solids concentrations are positively correlated and all are significant at $P<0.05$. Salinity had the highest mean value of 1.99±0.06mg/L in phase 1 while Electrical Conductivity and Total Dissolved Solids had the highest mean concentration values of 3.74±1.02mg/L and 2.84±1.07mg/L respectively in the sampling station 1(phase 1).

Concentrations of Ammonia, Nitrite, pH and Chloride are also positively correlated in all the 3 phases as well as significant at $P<0.05$. They all have the highest mean concentrations in phase 1 which are 0.30±0.87mg/L, 0.45±0.12mg/L, 6.30±0.09mg/L and 2.58±0.14mg/L correspondingly with the exception of Nitrate (0.23±0.14mg/L). The concentrations of Sulphate in the samples were recorded and ranged between 23.91±1.45mg/L - 22.48±1.76mg/L in all the phases and significant at 5% level of probability.

Table no 2: Persistent organic pollutants in the waste water from fish farm estate

Site	Month	Aldrin (mg/l)	Chlordane (mg/l)	DDT (µg/l)	Dieldrin(mg/l)	Endrin (mg/l)	Heptachlor (mg/l)	Hexachlorobenzene (mg/l)	Mirex (mg/l)	Toxaphene (mg/l)	PCB (mg/l)	PCDD (mg/l)	PCDF (mg/l)
1	July	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	August	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Sept.	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Mean	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	(±SD)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	July	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	August	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Sept.	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Mean	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	(±SD)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	July	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	August	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Sept.	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Mean	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	(±SD)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Guideline values for chemicals that are of health significance in water													
UNEP Standard		**19**	**N/S**	**1.0**	**N/S**	**N/S**	**N/S**	**0.13**	**N/S**	**N/S**	**N/S**	**N/S**	**N/S**
WHO Standard		**0.01**	**0.01**	**1.0**	**0.01**	**0.6**	**< 0.1**	**0.5**	**1.0**	**1.0**	0.015	**1.0**	**0.03**

ND (Not Detected)** * N/S (Not Stated)**

Table 2 shows all the selected Persistent Organic Pollutants (POPs). However, these were not detected in the sampled waste water; hence no values were recorded against the months. The computed values from the data collected from the study area are compared with international regulatory agencies on environmental protection on aquatic environment for adequate evaluation and recommendations.

IV. Discussion

One of the global challenges in agricultural waste water management is the determination of relative point source discharges of loads of organic waste and persistent organic pollutants and their concentrations in the water for water quality assessment and effluent critical limits.

The exposure of aquatic life to persistent organic pollutants has been correlated with their population decline in the aquatic ecosystem[9] and may cause potential immune toxicity, dermal effects, impairment of reproductive performance and carcinogenicity in human as reported by[10].The investigated Persistent Organic Pollutants (POPs) are not detected in the sampled water. This shows that the companies that are into manufacturing of Industrial and Technical Chemicals, Pesticide, By-products of high-temperature process are not within the vicinity of the fish farm estate as proposed in the publication of [5] on the dangers of indiscriminate discharge of POPs to the environment by the manufacturing companies. Likewise, the farmers are not indulged in the use of any of these chemicals in their farms as a preservatives and or pest control. This also suggest that the adjunct arable, animal husbandry and horticultural farmers in the fish farm estate are not using synthetic fertilizers, herbicides and pesticides in their farms and also, the electric transformer in estate are constantly maintained to curtail leakages of electric transformer oil which contain PCB as one of the persistent organic pollutants as specified by[11]

The source of Ammonia concentrations in the bailed-out water from fish farm estate could be from fish urea, fecal materials and rotten uneaten food and dead fish in the pond. The effect of this in the natural body of water is fish “kill” and high concentration of it in waste water could cause ambient foul smells around farm estate and irritation of the eyes, nose and throat as well as burning the skin where there is direct contact to the waste water from fish farm estate and this could also be experienced by the downstream communities as reiterated by [12].

The effect of high concentration of nitrate in the downstream water body could cause alga bloom which can clog the gills of aquatic animals thereby leading to anoxia and low dissolved oxygen[13]. Navigation on such water body could pose a challenge because of water hyacinth proliferations on the surface of water body. This agreed with publication of [14] on eutrophication challenges and solutions.

In the same vein, high nitrate and nitrite concentrations in downstream water could in addition obstruct the effectiveness of red blood cell in transporting oxygen in human that depend on that water for drinking and can cause “blue baby syndrome” in the infant otherwise called methemoglobin where hemoglobin lacks oxygen-carrying capacity to the cells in the body. This was observed and reported by[15] as cited by[16].

The occurrence of Sulphate in the discharged waste water from fish pond could be as a result of oxidation and reduction potential (REDOX) action on organic matter present in the waste water as emphasized by[17]. Sulphate is important in the physiology of the aquatic animals[18] but at elevated concentrations, it could cause methylation of mercury and some metal species that can bio-accumulate in the tissues of fishes downstream and make it unsafe for consumption by riparian communities as reported by[19] on heavy metal pollution in Porto-Novo Lagoon ecosystem. Similarly, at higher concentrations sulphate are toxic to both land and aquatic animals and may also cause diarrhea and possible dehydration for the host communities that used it for domestic purposes[20].

The source of Chloride in the pond waste water could be from table salt and vitamin premix which form part of the ingredients in fish feed formulation. High chloride concentrations in freshwater aquatic habitat can harm aquatic organisms by interfering with osmoregulation and hinders their survival, growth, and reproduction as emphasized by[21] and reported [22]. Also, the effect of this long-term exposure of chlorinated water to the downstream communities that depends on it for their domestic use is that it could lead to the production of free radicals within the body which is carcinogenic and can cause serious damages to human cells with the risk factor of 93% in people who drink or exposed to chlorinated water as explained by[23] on the potential health hazard of chlorinated water to both children and adults.

The relatively low pH concentrations (pH< 7) during the sampling periods could perhaps due the diffusion of acid sulfate soil (acidic alum soil and acidic soil) into the water which could be from point source (bore hole) and non-point source (catchment area).This findings agreed with the publication of [24] on water chemistry. Naturally, Lagos State water table is known to be below pH of 7. The pH of natural water is greatly influenced by the concentration of carbon dioxide which is an acidic gas[25]. The harmful effect of low pH in the waste water to aquatic ecosystem downstream is that it could aid some metal pollutants transformations into lethal compounds and the bioaccumulation of such metal pollutants are detrimental to the health of both the aquatic organisms and the coaster community that consumes such aquatic organisms as reported by[26] on pollution effect on water quality characteristics.

The effect of salinity, electrical conductivity and total dissolved solids in the aquatic ecosystem are strongly correlated. The elevated value of salinity in the waste water may not be unconnected with the addition of salts in the fish feed formula and residual effect of administered medications in the water, from precipitations. (Lagos State being an industrial state) and the influence of Atlantic Ocean on the Lagos State water table could be responsible for the elevated salinity[27] while elevated concentrations of total dissolved solids is due primarily to ionic properties of saline water rather than osmotic effects[28] and electrical conductivity which is above standard limit of W.H.O could be from conductive ions that came from dissolved salts and inorganic materials such as alkalis, chlorides, sulfides and carbonate compounds in waste water [29]. The importance of Total Dissolved Solids to aquatic life is the effect on osmoregulation where cell density are kept balanced but the excess of Total Dissolved Solids in water can produce toxic effects on fish and fish eggs downstream as enumerated in the work of [30].

Similarly, the high concentrations of Salinity, Electrical Conductivity and Total Dissolved Solids in wastewater from fish farm estate could defeat the purpose of the freshness of the river and affect the aesthetic taste of the water to Alaketu, Maya, and Ijede host communities where the water are being used for their domestic household tasks. This could as well expose them to some food and water borne related diseases. Furthermore, the salinity concentration in water affects Dissolved Oxygen solubility (Henry's Law) [29] thus causing asphyxiation in aquatic organisms downstream[26].

Biological and Chemical Oxygen Demands in the bailed-out water from fish farm estate are above W.H.O standard of <10 and <50 respectively. The two parameters serve as pollution indicators in the aquatic environment[31]. BOD measures the putrescible and hygienic conditions of the water while the COD measures oxidative capacity of soluble and particulate organic matters in water[32]. The sources of these pollution indicators could be traced to high organic matters and bacteria loads from uneaten and decayed food, and fish metabolites in the waste water. The high concentrations of these might result to low Dissolved Oxygen concentration in the water and could cause asphyxiation and high toxicity levels of some metal pollutants downstream which could adversely affect the physiology of the aquatic organism and fish population dynamics[26]. This could lead to destruction of the means of livelihood of the three communities that engages in the fishing activities

Dissolved Oxygen concentration in the waste water from fish farm estate is expected to be below the W.H.O standard limit of 5-6mg/L, due to presence of microbes and organic matters load that use up the oxygen in water for oxidative processes. The level of concentration of dissolved oxygen in water is also a pollution indicator[33]. The observable low D.O in the waste water could affect the aquatic plants and animals downstream by distorting their metabolic activities. Moreover, this could as well alter the aesthetic value of water for the downstream communities by discourage the use of the water for commercial and domestic purposes especially for those that are using the water for local gin and beverage refinery.

Water temperature is the driving force behind water quality characteristics. It is either positively or negatively correlated with other water parameters. The mean value of temperature falls within the acceptable range of W.H.O standard of 20^{O}c -32^{O}c for aquatic environment. This will assist the aquatic organisms downstream in their metabolic rate and photosynthesis process in the case of aquatic plants provided if the temperature range is maintained. The effect of ambient temperature and the flow rate of the discharged water help in maintaining the temperature range [34]

V. Conclusion

It is obvious that discharged waste water from fish farm estate have a negative impact on downstream aquatic organisms and human life. Therefore, waste water treatment plant need to be constructed in the fish farm estate for adequate water treatment and re-use to conserve water and reduce the pollution downstream for healthy aquatic ecosystem and host communities. In addition, there should be adequate enlightenment campaigns on the danger associated with concentrations of persistent organic pollutants in the environment in order to prevent future occurrence of it.

References

[1]. Diersing and Nancy (2009)."Water Quality: Frequently AskedQuestions."Florida Keys NationalMarine Sanctuary, KeyWest, FL.

[2]. Johnson, D. L., Ambrose, S. H., Bassett, T. J., Bowen, M. L., Crummey, D. E., Isaacson, J. S., Johnson, D. N., Lamb, P., Saul, M., and Winter-Nelson, A. E. (1997).Meanings of Environmental Terms. J. Environ. Qual.26, 581-589.

[3]. Hart, M.H.; Quin, B.F. and Nguyen,M.L(2004) Phosphorus from agricultural land and direct fertilizer effects: a review. J. Environ. Qual., 33:1954-1972

[4]. UNEP (2008): Stockholme Convention: Protecting Human health and the environment from Persistent Organic Pollutants. Retrieved from http://chm.pops.int/TheConvention/2018

[5]. Safewater (2018) Frankwater,"Safe water Saves lives". Retrieved from **https://www.frankwater.com/** 08/07/2018

[6]. Babalola, O.A (2018): Pollution and Total Organic Carbon (TOC) in the discharged waste water from fish farm estate, Ikorodu, Lagos. 33rd Annual conference of Fisheries Society of Nigeria. Held on October 29th to 2nd November 2018 at Lagos State Polytechnic, Ikorodu, Lagos, Nigeria.

[7]. EPA (2000): Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape, Hatteras. EPA-822-F1-00-012

[8]. EPA (1986): Quality Criteria for Water. EPA-440/5-86-001

[9]. Harmon, S. (2015). The Toxicity of Persistent Organic Pollutants to Aquatic Organisms. Comprehensive Analytical Chemistry}, volume = {67}, pages = {587-613}

[10]. Ravindran Jayaraj, Pankajshan Megha, and Puthur Sreedev (2016). Organochlorine pesticides, their toxic effects on living organisms and their fate in the environment. Interdiscip Toxicol. 9(3-4): 90–100.

[11]. Pelitli V, Doğan O, Köroğlu HJ (2015) Transformer Oils Potential for PCBs Contamination. Int J Metall Mater Eng 1: 114. doi: http://dx.doi. org/10.15344/2455-2372/2015/114

[12]. Triplepointwater (2018).Triplepoint water technology.Retrieved from http://www.triplepointwater.com/ 08/07/2018UNEP/GPA, 2006a, The State of the Marine Environment: Trends and processes, The Hague

[13]. Leaffin (2018): How to Avoid and Treat Nitrite Poisoning in Your Aquaponics System Retrieved from https://www.leaffin.com/ 08/07/2018

[14]. Khan, M. Nasir and Mohammad, F. (2014) "Eutrophication of Lakes" in A. A. Ansari, S. S. Gill (eds.), Eutrophication: Challenges and Solutions; Volume II of Eutrophication: Causes, Consequences and Control, Springer

[15]. Manassaram, Deana M.; Backer, Lorraine C.; Moll, Deborah M. (2007)"A review of nitrates in drinking water: maternal exposure and adverse reproductive and developmental outcomes".Ciência&SaúdeColetiva. pp. 153–163. doi:10.1590/S1413-81232007000100018. Retrieved 08 July 2018.

[16]. EPA (2017): "Harmful Algal Blooms" Retrieved from https://www.epa.gov/ 08 July, 2018

[17]. Henner B. Andrea F. Young, C. M.. Alexander, O'D.Peter. H, Sujoy M. Larry R., and Nittler (2006): Interstellar Chemistry Recorded in Organic Matter from Primitive Meteorites. J. Science 05 May 2006:Vol. 312, Issue 5774, pp. 727-730. DOI: 10.1126/science.1123878

[18]. Esmail Gharedaashi, Hamed Nekoubin, Mohammad Reza Imanpoor, and Vahid Taghizadeh (2013). Effect of copper sulfate on the survival and growth performance of Caspian Sea kutum, Rutilus frisii kutum. Springerplus; 2: 498

[19]. Babalola, O.Aand Fiogbe D.E (2016): Seasonal Variation Assessment and Correlation Coefficient of Metal Pollutants in Sediments and Water from Porto-Novo Lagoon Ecosystem, Benin Republic. American Journal of Educational Research, 4(13) 976-982

[20]. Lenntech(2013):Retieved from http://www.lenntech.com/periodic/elements/08/07/2018

[21]. uri, (2012): Chlorides in freshwater. Retrieved from http://cels.uri.edu/ 08 July, 2018

[22]. Miguel Cañedo-Argüelles, Ben Kefford, and Ralf Schäfer (2019). Salt in freshwaters: causes, effects and prospects - introduction to the theme issue. Philos Trans R Soc Lond B Biol Sci. 374(1764)

[23]. bioray, (2013): Minimize chlorine in yourself and your child. Retrieved from http://www.bioray.com/08/07/2018

[24]. Ljung Björklund, Karin & Maley, Fiona & Cook, Angus & Weinstein, Philip. (2009). Acid sulfate soils and human health—A Millennium Ecosystem Assessment. Environment International. 35. 1234-1242. 10.1016/j.envint.2009.07.002.

[25]. Bogan, Robert & Ohde, Shigeru & Arakaki, Takeshi & Mori, Ikuko & Mcleod, Cameron. (2009). Changes in Rainwater pH associated with Increasing Atmospheric Carbon Dioxide after the Industrial Revolution. Water Air and Soil Pollution. 196. 263-271. 10.1007/s11270-008-9774-0.

[26]. Babalola, O.A and Fiogbe D.E (2017): Pollution and Effects of Hydrological Patterns onWater and Sediments Quality Characteristics from Porto-Novo Lagoon Bionetwork International Research Journal of Environmental Sciences,6 (8),1-8, 2319–1414

[27]. Santhosh, B. and Singh, N.P. (2007) Guidelines for Water Quality Management for Fish Culture in Tripura, ICAR Research Complex for NEH Region, Tripura Center, Publication No.29.

[28]. U.S .Environmental Protection Agency, Office of Water.(1986). Quality Criteria for Water(GoldBook). EPA 440/5-86-001.Washington D.C. Wetzel, R. G. 1983.Limnology.Second Edition.Saunders College Publishing, NY767 p.

[29]. Fondriest (2016): Fundamental of Environmental Measurements. Retrieved from https://www.fondriest.com/ 08 July, 2018

[30]. Phyllis K. Weber-Scannell and Lawrence K. Duffy (2007). Effects of Total Dissolved Solids on Aquatic Organisms: A Review of Literature and Recommendation for Salmonid Species. American Journal of Environmental Sciences 3 (1): 1-6, 2007

[31]. Tolulope E. Aniyikaiye, Temilola Oluseyi, John O. Odiyo, and Joshua N. Edokpayi (2019). Physico-Chemical Analysis of Wastewater Discharge from Selected Paint Industries in Lagos, Nigeria. Int J Environ Res Public Health v.16(7);

[32]. Xiang Wu, XijinXu, ChuanfeiGuo, and HaiboZeng (2014):Metal Oxide Heterostructures for Water Purification.Journal of Nanomaterials.Volume 2014, Article ID 603096, 2 pages.http://dx.doi.org/10.1155/2014/6

[33]. Babalola, O.Aand Agbebi F.O (2013): Physico-Chemical Characteristics and Water Quality Assessment from Kuramo Lagoon, Lagos**.** International Journal of Advanced Biological Research, 3 (1), 98-102

[34]. WHO(1996): Publications on water sanitation and health. Retrieved from http://www.who.int/water_sanitation_health/publications/en/

Babalola, O.A, et. al. "Persistent Organic Pollutants and Water Quality Evaluation in the Waste Water from Fish Farm Estate, Ikorodu and the Effect on Downstream Communities." *IOSR Journal of Environmental Science, Toxicology and Food Technology* (IOSR-JESTFT), 15(2), (2021): pp 07-12.