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Assessing the Quality of Surface Water for Direct Rural Water Supply: A Case Study of Osun River, Nigeria

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Abstract

Water is one of the most essential resources for life and living. Yet, many of our surface water bodies in Nigeria are under constant unabated attack of anthropogenic pollution. This study assessed the level of pollution of Osun River to determine the suitability of the river for domestic water supply. Samples from eight (8) different tributaries to Osun River were taken and analysed using standard procedures. The physical, chemical and biological parameters (TDS, Turbidity, Colour, Temperature, Chloride, Conductivity, Lead, Iron, Hardness, Nitrate, pH, Total Coliform , E. Coliform and Biological Oxygen Demand) were compared with the Federal Environmental Protection Agency Standards and also subjected to statistical analysis (two way ANOVA and Correlation analysis). The Duncan Multiple Range Test (DMRT) was further used to explain the differences between the means. TDS, Turbidity, Colour, Temperature, Chloride, Conductivity, Lead, Iron, Hardness, Nitrate, pH were within permissible limits while the biological parameters indicate very high organic pollution. The highest Biological Oxygen Demand of 390mg/l, Total Coliforn Count of 330mg/l and Escherichia coli form count of 175mg/l were recorded for the IjebuJesha tributary. Statistical analysis showed significant difference between the physical and chemical parameters considered, but no difference between the parameters for each of the sampling points. The biological parameters showed significant difference for both the parameters and the sampling points since $F>3.74$ and $P<<0.05$ for the parameters $F>2.76$ and $P<<0.05$ for the sampling points. The correlation between the parameters for all the sampling points gave high correlation values which ranges between 0.5343 and 0.9972 as expected since the sampling points are all distant tributaries to a common source. Osun river has high level of organic pollution load and cannot be used directly without appropriate biological treatment.

Évaluation de la qualité des eaux de surface pour l'alimentation en eau directe en milieu rural: étude de cas de la rivière Osun au Nigéria

Abstrait

L'eau est l'une des ressources les plus essentielles à la vie et à la vie. Pourtant, un grand nombre de nos masses d'eau de surface au Nigéria font l'objet d'une attaque constante de la pollution anthropique. Cette

étude visait à évaluer le niveau de pollution de la rivière Osun afin de déterminer si celle-ci était adaptée à l'approvisionnement pour l'usage domestique. Des échantillons de huit (8) affluents différents de la rivière Osun ont été prélevés et analysés à l'aide de procédures standard. Les paramètres physiques, chimiques et biologiques (TDS, Turbidité, Couleur, Température, Chlorure, Conductivité, Plomb, Fer, Dureté, Nitrate, pH, Coliformes totaux, E. Coliformes et Demande biologique en oxygène) ont été comparés aux normes de 'Federal Environmental Protection Agency'. et également soumis à une analyse statistique (ANOVA à deux voies et analyse de corrélation). Le test DMRT (Duncan Multiple Range Test) a ensuite été utilisé pour expliquer les différences entre les moyennes. Les TDS, la turbidité, la couleur, la température, le chlorure, la conductivité, le plomb, le fer, la dureté, le nitrate et le pH se situaient dans les limites admissibles, tandis que les paramètres biologiques indiquaient une très grande pollution organique. La plus forte demande en oxygène biologique de 390 mg / l, le nombre total de coliformes de 330 mg / l et le nombre de formes d'Escherichia coli de 175 mg / l ont été enregistrés pour l'affluent Ijebu Jesha. L'analyse statistique a montré une différence significative entre les paramètres physiques et chimiques pris en compte, mais aucune différence entre les paramètres de chacun des points d'échantillonnage. Les paramètres biologiques ont montré une différence significative pour les paramètres et les points d'échantillonnage depuis F> 3,74 et P << 0,05 pour les paramètres F> 2,76 et P << 0,05 pour les points d'échantillonnage. La corrélation entre les paramètres de tous les points d'échantillonnage a donné des valeurs de corrélation élevées, comprises entre 0,5343 et 0,9972, comme prévu, car les points d'échantillonnage sont tous des affluents distants constituant une source commune. La rivière Osun a une forte charge de pollution organique et ne peut être utilisée directement sans traitement biologique approprié.

Introduction

Water remains one of the most important natural resource, (Adesogan, 2014) and Nigeria as a developing country is blessed with several water bodies which include lakes, rivers, estuaries, pond, stream and the likes. Water from some of these fresh water sources can be harnessed for use in agriculture, aquaculture, irrigation, electricity generations, navigation and sometimes waste disposal (Andem *et al*, 2012).

These water bodies should ordinarily be self sufficient in catering for industrial, domestic, agricultural and recreational needs of the populace. Unfortunately, surface water bodies especially rivers are basically used as dumping sites for solid wastes, refuse and rubbish. Industries do not also hesitate to discharge their untreated wastes directly into water bodies prior to treatment and this makes this precious natural resource continually subjected to severe attack from pollution (Adesogan, 2014). In many parts of Nigeria, human sewage, animal wastes from large farms, effluents from residences, abattoirs and industries are always disposed off into flowing rivers, (Fagade *et al.*, 1993). These acts; especially in developing countries to very large extent limit the use of surface water in industries, households and institutions. Water bodies are undoubtedly the major recipients of anthropogenic wastes of various forms (Osibanjo*et al,* 2011). This menace makes surface water bodies unsafe especially for those who depend on it at the downstream side of the flow. Osibanjo *et al* (2011) further submitted that dumping of solid wastes in surface waters can lead to outbreak of diseases, insect proliferations, poor aesthetic, fire outbreak and flooding, as well as polluted ambient air resulting from pungent odour emitted from dumped refuse. Polluted surface

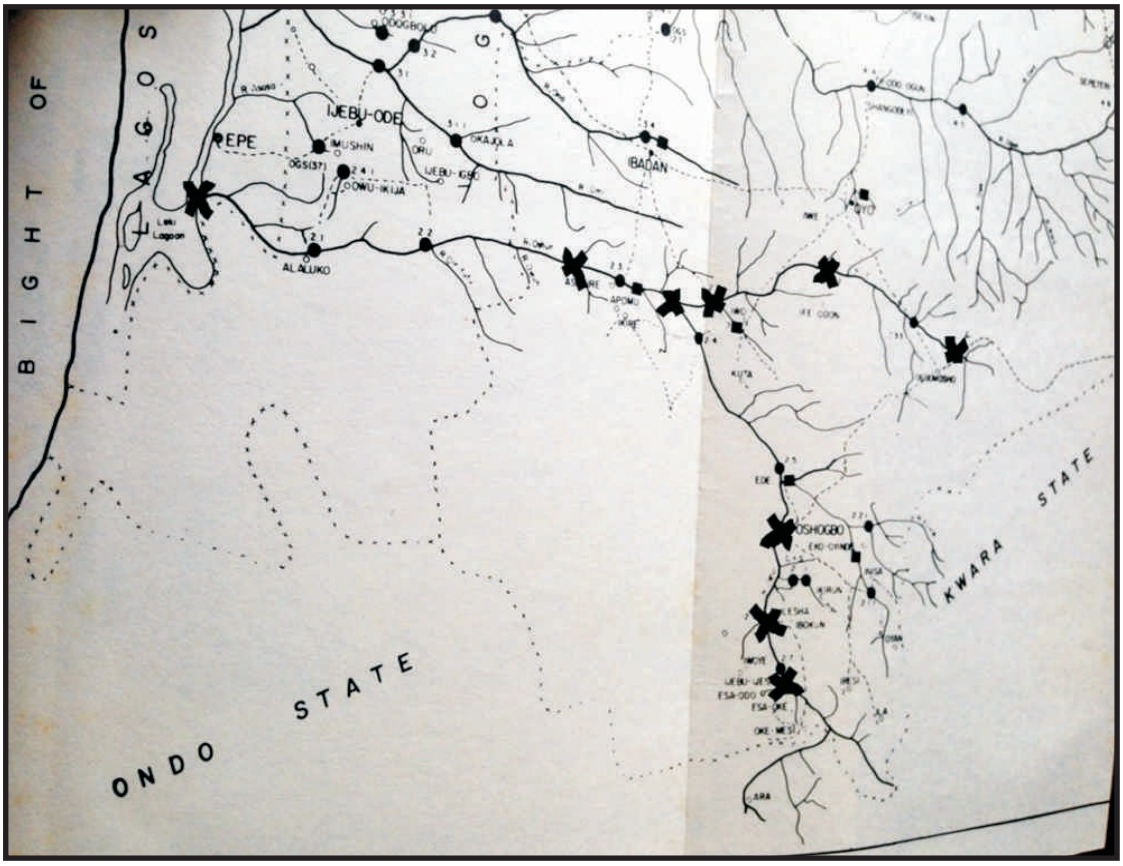
water bodies sometimes pollute surrounding groundwater, thus leaving the inhabitants of the environment exposed to diseases and infections caused by water-borne pathogens. The exposure of surface or ground water to excessive pollution according to Awomeso *et al,* (2012) are however dependent on factors such as geology, topography, soil type, climate, atmospheric condition as well as land use and land management practices. (Fawole *et al.,* 2008) attributed excessive surface water pollution to world population growth which informs rapid urbanization technological, agricultural and industrial development. Omole and Longe (2008) was also able to point out the fact that runoff from agricultural lands which are laden with pesticides, fertilizers, salts, animal faecal and abattoir wastes also contribute majorly to the pollution of surface and ground water.

Investigation and monitoring of water qualities of water bodies in different parts of the country is receiving great attention by researchers in recent times, (Akpan *et al.*, 2002). The water quality of river from various sampling points was investigated by (Osibanjo *et al.*, 2012, Awomeso *et al,* 2012 and Andem *et al,* 2012). The quality of river Alaro was also investigated Osibanjo *et al*, (2012). The research of Osibanjo *et al*, (2012) considered some physical chemical parameters such as pH, temperature, total solids, suspended solids, dissolved solids, alkalinity, hardness, sulphate, total phosphorus, chlorides, Nitrate, dissolved oxygen, COD and also oil and grease were considered by taking the samples at the upstream, industrial and the downstream zones of the rivers. Awomeso *et al,* (2012) sampled River Ona from five different locations and some physical and metallic parameters were investigated to confirm the degree of pollution of the water as a result of urbanization. Olajire and Imeokpara (2001) attributed high level of pollutants in Osun River to agricultural, industrial and domestic activities around the river. Olajire and Imeokpara (2001) further recommended the proper treatment of industrial discharges, avoidance of domestic sewage stagnation and provision of sewage treatment plant to reduce the possible health risk associated with the use of this water source. On the contrary, (Farombi *et al.,* 2014) reported moderate pollution in the river because analysis of water from the river sample showed acceptable limit of total alkalinity and pH, but high value of BOD_5 during the rainy and dry seasons.

This study was carried out on Osun River during the dry season of the year 2016 basically to determine the increase in the level of pollution as compared to earlier researches on this water body.

Materials and Methods

Ground water samples were taken fortnightly for six months from eight different tributaries of Osun River in year 2016. Twenty samples each were taken for each of the physical, chemical and biological analyses. The tributaries are at Ogbomosho, Ife Odan, Iwo, Odo Oba, IjebuJesha, Ilesha, Oshogbo and Asejire as shown on Figure 1. The sampling points were shown in the map. The clean samples were collected into sampling bottles which had been rinsed with distilled water and thereafter, water from the sample source. The samples were collected from the direction of stream and immediately transported to the laboratory at temperature less than 4^0C for physico-chemical 'Standard Methods for the Examination of Water and Wastewater' (Standard Methods), 19th Edition, APHA, AWWA, WEF, 1995 and bacteriological analysis using coliform MPN test. The results were compared with the Federal Environmental Protection Agency standards and subjected to statistical analysis.



X = *Sampling Points*

Figure 1: Map of Osun River Tributaries and Sampling Points
Source: Ogun Osun River Basin Authourity(OSRBA)

Results and Discussions

Table 1: Physio - Chemical Parameters of Osun River

Parameters	Sampling Points								
	Ogbomosho	Ife Odan	Iwo	Odo Oba	Ijebu-Jesha	Ilesha	Oshogbo	Permissible Limits (mg/l)	Desirable Limits (mg/l)
TDS (mg/l)	5.26	5.20	5.87	5.51	5.29	5.58	5.17	500	<200
Turbidity(NTU)	0.00	0.00	0.08	0.06	0.00	0.07	0.11	25	-
Colour (Hz)	3.00	3.00	3.40	3.30	3.20	3.50	3.80	75	<1.0
Temperature (°C)	28.80	28.80	28.8	28.80	28.70	28.80	28.80	Ambient	Ambient
Chloride	3.99	19.99	5.99	5.99	3.99	7.99	7.99	2.5	<2.5
Conductivity	8.73	8.42	9.78	9.18	8.81	9.32	8.60	-	-
Lead	0.005	0.007	0.008	0.009	0.006	0.005	0.007	<0.05	None
Iron	0.003	0.004	0.005	0.007	0.004	0.002	0.003	<0.3	None
Hardness	64.00	60.00	60.00	52.00	68.00	88.00	100.00	30-500	30-500
Nitrate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<1.0	None
pH	5.44	4.84	5.62	5.01	5.77	6.27	6.16	6.0-8.5	6.0-8.5

Table 2: Microbiological Parameters of Osun River

Parameters (mg/l)	Sampling Points									
	Ogbomosho	Ife Odan	Iwo	Odo Oba	Ijebu Jesha	Ilesha	Oshogbo	Asejire	Permissible Limits (mg/l) NESRA	Desirable Limits (mg/l) NESRA
Total Coliform (MPN/100ml	140	70	60	90	330	140	40	40	10	0
E. Coliform (MPN/100ml)	140	70	60	90	175	140	40	40	0	0
BOD (mg/l)	155	180	295	175	390	300	50	50	0	0

Table 3: Analysis of Variance of Physical Parameters

Source of Variation	SS	Df	MS	F	P-value	F crit
Physical Parameters	4122.8033	3	1374.268	42605.09	6.94E-40	3.072467
Sampling Points	0.46285	7	0.066121	2.049899	0.096054	2.4875777
Error	0.677375	21	0.032256			
Total	4123.9436	31				

Table 4: Analysis of Variance of Chemical Parameters

Source of Variation	SS	Df	MS	F	P-value	F crit
Chemical Parameters	30392.2407	6	5065.373	122.7247	5.38E-25	2.323994
Sampling Points	290.146808	7	41.44954	1.004247	0.441991	2.23707
Error	1733.51901	42	41.27426			
Total	32415.9065	55				

Table 5: Analysis of Variance of Bacteriological Parameters

Source of Variation	SS	Df	MS	F	P-value	F crit
Rows	49952.083	2	24976.04	8.38231	0.004041	3.738892
Columns	144216.67	7	20602.38	6.914448	0.001123	2.764199
Error	41714.583	14	2979.613			
Total	235883.33	23				

Table 6: Correlation Coefficients of Physical, Chemical and Biological Parameters for the Various Tributaries

Sampling Points	Ogbomosho	Ife Odan	Iwo	Odo Oba	IjebuJesha	Ilesha	Oshogbo	Asejire
Ogbomosho	1							
Ife Odan	0.8879	1						
Iwo	0.7662	0.9678	1					
Odo Oba	0.9479	0.9848	0.9302	1				
IjebuJesha	0.9454	0.9124	0.8431	0.9537	1			
Ilesha	0.9321	0.9893	0.9458	0.9972	0.9481	1		
Oshogbo	0.6664	0.6617	0.5343	0.6459	0.5392	0.6389	1	
Asejire	0.8246	0.7953	0.6665	0.8030	0.7137	0.7874	0.9622	1

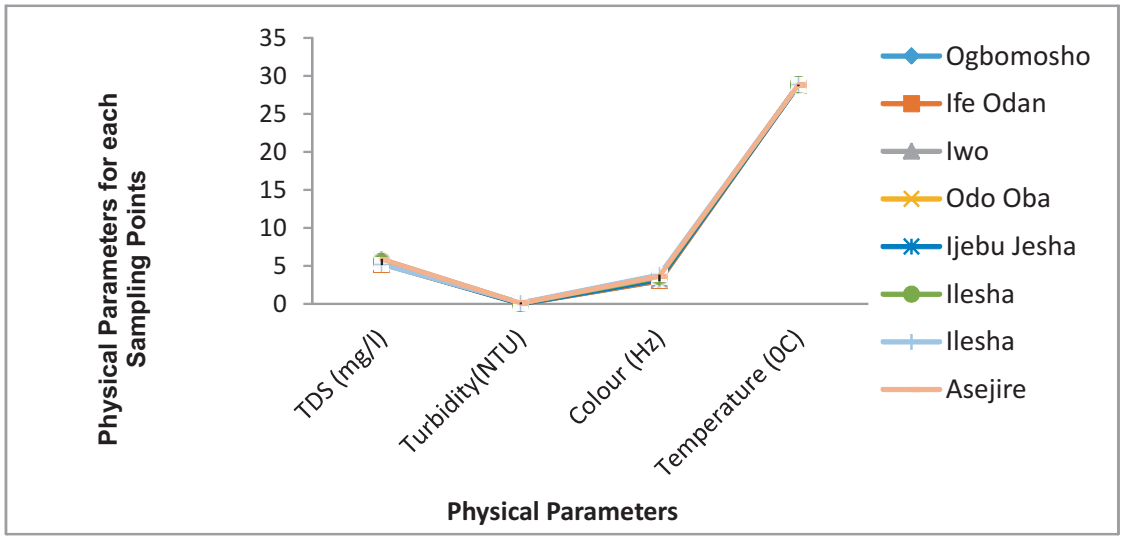


Figure 2: Comparison of Physical Parameters at Sampling Points

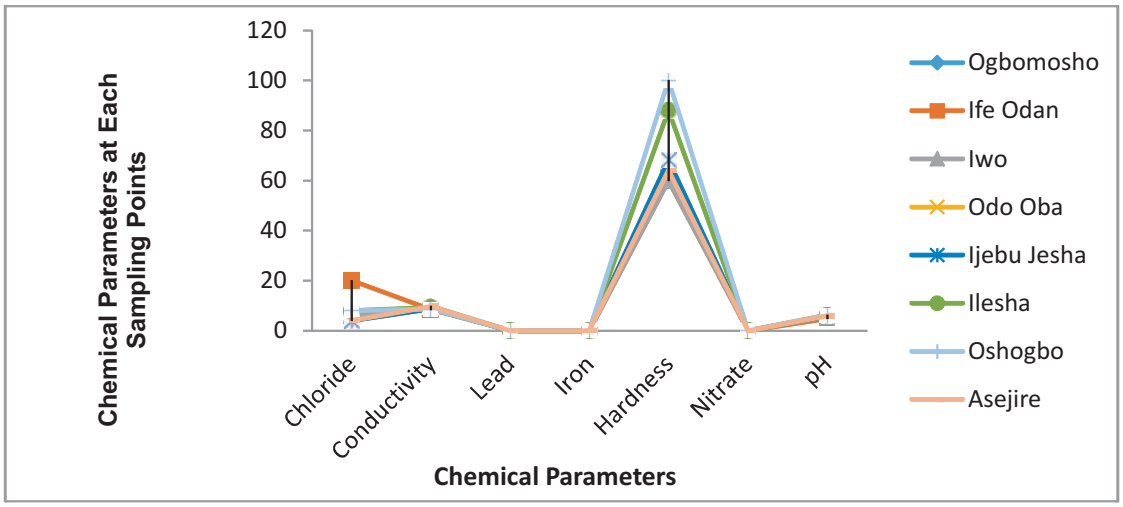


Figure 3: Comparison of Chemical Parameters at Sampling Points

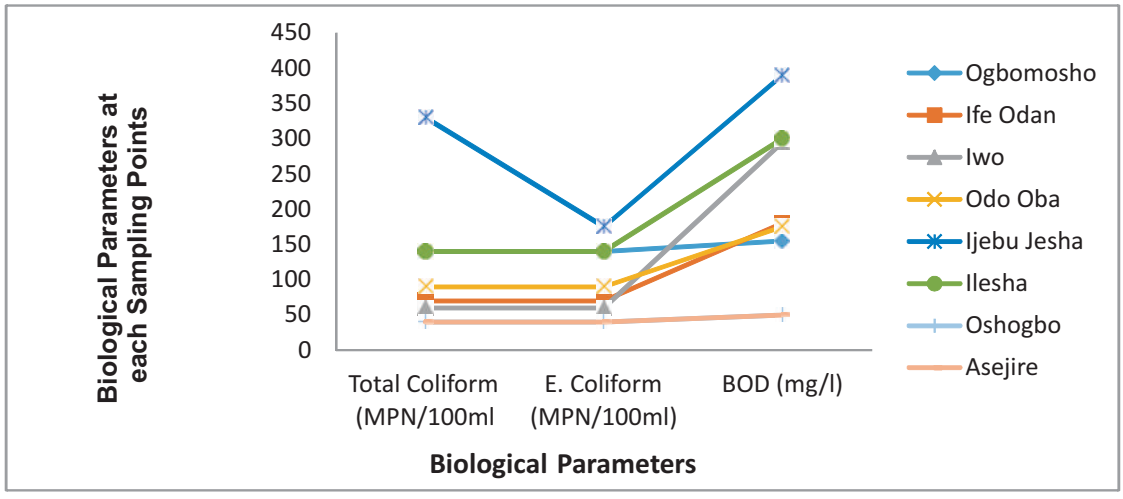


Figure 4: Comparison of Biological Parameters at each Sampling Points

Tables 1 and 2 show the results of the tested physical, chemical and biological parameters of Osun River from eight sampling points at eight different tributaries to the river. Figures 2 through 4 compares respectively the physical, chemical and biological parameters from each of the sampling points. The physical and biological parameters tested which included total dissolved solids (TDS), Turbidity, Colour, Temperature, Chloride, Conductivity, Lead, Iron, Hardness, Nitrate and pH were within permissible limits according to the Federal Environmental Protection Agency standards on Table 4. The microbiological parameters tested were however; higher than standards. The total coli form count (TCC) ranged between 40 and 330 MPN/100ml. The total coliform count at the Osogbo and Asejire sampling points were low.

This might be due to the fact that the water at these sampling points (especially Asejire) is being harnessed as a source for municipal water supply, so the pollution load from refuse dumped into rivers were avoided. The sampling point at Ijebujesha however recorded very high TCC of 330mg/l. This indicates very high pollution load at this sampling point in the water course. The same trend was noticed from the Escherichia coliform count (ECC) and the Biological Oxygen Demand (BOD).The highest ECC and BOD of 175MPN/100ml and 390mg/l were respectively recorded at Ijebujesha sampling point. The lowest ECC and BOD of 40MPN/100ml and 50mg/l respectively resulted at the Osogbo and Asejire sampling points as expected. These values are high as compared with the standards provided by FEPA on Table 4.

Olajire and Imeokpara (2001) as well as Farombi *et al* (2012) did not delve into the microbiological aspect of water quality parameters for Osun River. However, some of the physico-chemical parameters compared are different from those of the authors. Despite these, the fact remains that there are lots of pollution loads in the surface water body and this limits the potential use of the river at certain tributaries for domestic water supply, until further treatment methods are put in place.

Table 3 compares the variation between the physical parameters and the sampling points using the two way analysis of variance. There was significant difference between the values of the parameters because $F>3.07$ and $P<0.05$. There was no significant difference between the values of the physical parameters at each of the sampling points since $F<2.49$ and $P>0.05$. The Duncan Multiple Range Test (DMRT) showed significant difference between the physical parameters at Asejire and Ife Odan, Ogbomosho, IjebuJesha, Odo Oba, Osogbo, Ilesha as well as Iwo. Significant difference was also recorded between the physical parameters at Iwo and Ife odan, Ogbomosho, IjebuJesha, Odo Oba, Osogbo and also Ilesha. This same trend was noticed for Ilesha and Odo Oba, IjebuJesha, Ogbomosho and Ife Odan. There are however no significant differences between Ilesha and Osogbo, IjebuJesha and Ogbomosho as well as Ogbomosho and Ife Odan. There was a significant difference between the values of each of the chemical parameters considered because $F>2.26$ and $P<0.05$, while there was no significant difference between the values of the chemical parameters at each sampling points. This resulted from the fact that $F<2.18$ and $P>0.05$ (Table 6).

The DMRT showed no significant difference between any of the sampling point for the analysed chemical parameters. Table 5 gives detailed statistical comparison of the biological parameters between each of the sampling tributaries and the biological pollution parameters indicated in this study. Significant difference existed between the different biological parameters tested ($F>3.74$ and $P<<0.05$) and the biological parameters at the sampling points ($F>2.76$ and $P<<0.05$). The DMRT indicated difference between the biological parameters at IjebuJesha and Asejire, Osogbo, Ife Odan, Odo Oba, Iwo, Ogbomosho and also Ilesha. Significant difference existed as well between the biological parameters at Ilesha and Osogbo, There were no significant differences between Asejire and Osogbo, Ife Odan and Osogbo, Odooba and Ife Odan, Owo and Odo Oba, Ogbomosho and Iwo, as well as Ilesha and Ogbomosho.

Table 6 shows the various correlation coefficients which compares the parameters obtained for each of the sampling points. The coefficient between Ilesha and Odo Oba had the value 0.9972. This was closely followed by

Osogbo and Asejire; OdoOba and IjebuJesha with respective coefficients of 0.9622 and 0.9537. The lowest correlation coefficients were found between Iwo and Osogbo; Osogbo and IjebuJesha with respective values of 0.5343 and 0.5392. In general, the correlation coefficients were high for all the sampling points. These results are expected since all the sampling points are distant tributaries to the same source.

Conclusion

This comprehensive study confirmed the high pollution of Osun River at different sampling points based on the high values of biological parameters obtained from the tested samples. The pollution load of Osun River needs to be reduced by employing suitable and affordable biological treatment methods which can effectively remove the organic load of the water source. Ijebujesha and Ilesha sampling points which indicated the highest level of organic pollution depict the types of practices such as dumping of refuse, defecation, laundry at these sites. The statistical analysis of the means showed no significant difference for physico-chemical parameters at the different sampling points, but the biological parameters contradicted this. As expected, high correlation exists between the physical, chemical and biological parameters obtained for each of the samples' sampling points.

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