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Effects of Land Use Land Cover Run Off on Surface Water Quality in Enugu Urban Area, Enugu State, Nigeria

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Abstract
The physico-chemical characteristic of runoff on land use land cover along the river basin as well as geographical dispositions, combined with anthropogenic factors are strong causative factors of of pollution in surface water quality in the study area. The purpose of this research determines the effect of land use land cover along the river basin on surface water quality in Enugu urban area. The landsat 8 of 2017 of Enugu urban was downloaded from United State Geological Survey (USGS) web site and was used to assess the land use land cover of the study area through remotely sensing pixel based image classification. The measurements were conducted on the on six major rivers in the study area (Ekulu, Asata, Aria, Idaw, Ayo and Ogbete river). Two samples were collected from each river but Ekulu river being the longest of all, three samples were collected with aid of handheld Geographical Position System (GPS). The laboratory test was conducted on the sample water to assess the physico-chemical characteristic of surface water in the study area. All the generated data was imported into ArcGIS software where the Geostatistical analysis was run. The physico-chemical parametes were analysed using Inverse Distance Weighting (IDW) interpolation. Inverse distance weighted (IDW) interpolation explicitly implements the assumption that things that are close to one another are more alike than those that are farther apart. GIS proximity analysis was used to determine the river basin by creating a buffer of 500 m along the main river line and 250m along the tributary. The result shown that the total percentage covered by residential land use (urban land) area is 35.19%, followed by woodland (32.09%) and then tropical rain forest(12.16%) the agricultural area accounted for 2.22%. above that the urban area is mostly caused the degradation of urban waterways. The runoff water with high concentration of physico-properties was recorded in urban area. The major pollutants found in runoff from urban areas include Ph, Total Dissolved Solid, Temperature, Conductivity and turbidity. It also revealed that urban area and vegetation area were the most highly pollutants land use in the study area because of its high concentration of chemical-properties. the nature of the quality of surface water from runoff in various land use in the study area using remote sensing image classification shows that the land use land cover of the area has been drastically affected by physico-chemical properties of surface water runoff and this is evidently clear from land use land cover Maps of Enugu urban Subcatchment area. Additional studies should be conducted to cover the rural areas of Enugu state for land use and cover analysis, for extraction runoff /land degradation prone area in order to educate and evacuate inhabitants of the environs before runoff lead land failure occurs.
Keywords: Land Use, Land Cover, Runoff, Water Quality, Surface Water.

1 .0 Introduction

The degree of pollution of a given water basin is a function of its water quality characteristics which include physical, chemical and microbiological composition (Aina and Adedipe, 1996). These factors interact with one another to influence the quality of surface water and the aquatic life. The geographical location, land characteristics, multiplicity of rivers and the climate cause reactions to areas near these rivers highly vulnerable to runoff. In most rivers, during dry season, runoff flow is made up primarily of water which seeps from the ground. However, most of the runoff flow is contributed during the high runoff. During the period of high runoff, most rivers exhibit their most favorable chemical water characteristics. There are some instances where high run off cause deterioration in water quality. For instance, if rain falls selectively on the watershed of a tributary which contributes poor-quality water to a comparatively good-quality river system, the water contributed may cause a transitory deterioration of the water quality in the system. The pollution of water bodies from pollutant transport through surface runoff and uncontrolled discharge of untreated (non-point source) and partially treated sewage (point source) has been reported severally Davis, (2010), and Wetzel, (2003). Some of the identified

effects of runoff on surface water bodies include nutrient enrichment, deterioration of the water qualities, and destruction of spawning grounds for aquatic life. In Enugu urban area, Ekulu River, Aria, Ayo, Asata, Ogbete and Idaw River are the major catchment rivers also various land use activities like commercial, agricultural, residential are prevalence in the area. It is important to know that rivers in Enugu urban area are somehow linked to one another across some neighborhoods for instance Ekulu river is the major river and has some tributaries as it moves from one place to another, it moves from New market flyover to Abakpa and then Emene. A review of urban surface runoff shows that most sites are located on surfaces identified by their different land use, such as typical residential areas, commercial areas and agricultural area. Enugu has various land use activities that are commonly noticed in the area. These land use activities seemly generate different kinds of debris and deposits (Davis, 2010). This could result to having different effects in the quality of rivers that these deposits from different land use activities drain their waste. A review of urban surface runoff shows that most sites are located on surfaces identified by their different land use, such as typical residential areas, commercial areas and agricultural area. Enugu has various land use activities that are commonly noticed in the area. These land use activities seemly generate different kinds of debris and deposits (Davis, 2010). This could result to having different effects in the quality of rivers that these deposits from different land use activities drain their waste. The aim of this research is to assess the effect of runoff on land use land cover on surface water quality in Enugu urban area, Enugu State Nigeria. Enugu, the political and administrative headquarters of Enugu State is located on latitude 06° 21' N and 06° 30' N and between longitude 07° 26'E and 07° 37'E (figure 1.1

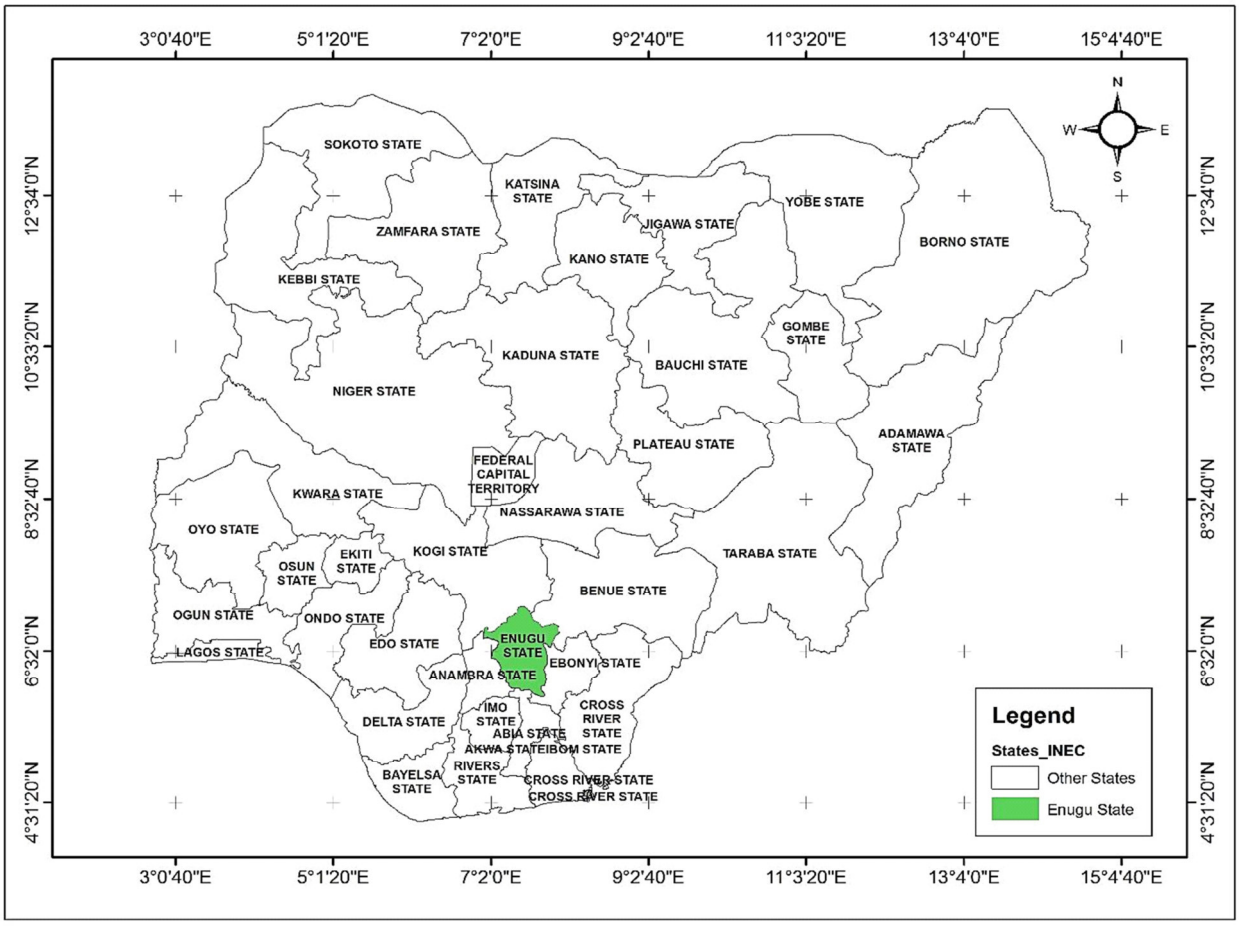


Figure 1.1: Map of Nigeria showing Geographic Location of Enugu State.

The study area occupies a land area of 8000sqkm covering the spatial entity under Enugu Town Planning Authority Area. The Enugu Urban area is bounded to the West by Ngwo settlement in Udi Local Government Area, in the East by Nkanu East Local Government Area, in the North by Enugu East Local Government Area and in the South by Nkanu West Local Government Area (Figure 1.2).

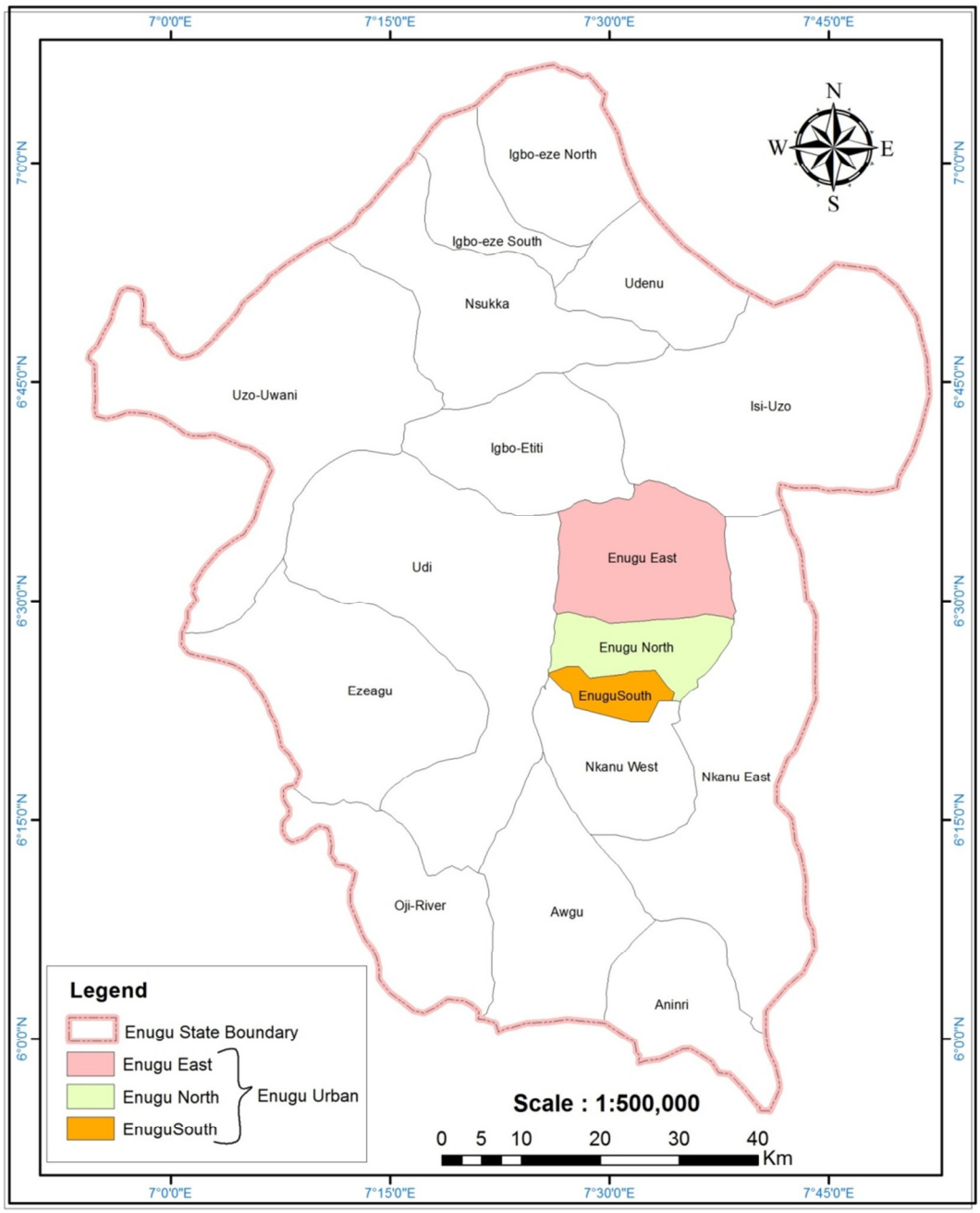


Figure 1.2: Map of Enugu showing Enugu Urban.

2.0 Research Methodology

The basic data required in this study include observation of activities in the area sampled, laboratory data (physical, chemical and microbiological parameters) and satellite imagery of the study area sampled. The data involved only those relevant parameters that give insight on the observed changes and consequences of effects of runoff on the quality of surface water in the study area. The measurements were conducted on the sample water collected from six major rivers in the study area. Two samples were collected from each river but Ekulu river being the longest of all, three samples were collected with aid of handheld Geographical Position System (GPS). Some measurement / test of samples were done in-situ (temperature, conductivity, pH and total dissolved solid) while others were done within 24 - 48 hours. The population comprised of 6 different rivers (Ekulu, Asata, Aria, Idaw, Ayo and Ogbete river) with 13 stations for runoff measurement in Enugu urban area. The distribution is as shown on Table 2.1.

Table 2.1: Description of the sample location

S/N	Sample Code	Sample Location	Latitude	Longitude
1	A	Ekulu River at New market fly over	6°28'2.97"N	7°28'23.477"E
2	B	Ekulu River at ujodo Development Centre	6°28'9.368"N	7°29'7.311"E
3	C	Ekulu River at Abakpa 1st Bus stop	6°28'36.045"N	7°31'8.772"E
4	D	Asata River at Enugu Port-Harcourt Express way, New Artisan	6°27'17.934"N	7°32'24.803"E
5	E	Asata River at Amigbo Lane CIC.	6°27'20.15"N	7°30'44.56"E
6	F	Aria River at Works Road	6°26'53.509"N	7°28'55.007"E
7	G	Aria River at Access Bank , Garden Avenue	6°27'11.184"N	7°29'38.807"E
8	H	Idaw River at Maryland, Timber Shed	6°24'52.165"N	7°30'11.164"E
9	I	Idaw River at Abalukwu Street	6°24'57.079"N	7°29'37.323"E
10	J	Ayo river at Enugu Port Harcourt Express way, Ugwuaji Bridge	6°24'42.435"N	7°31'53.299"E
11	K	Ogbete River at Old UNTH	6°26'2.095"N	7°28'45.137"E
12	L	Ogbete River at Holy Ghost Cathedral	6°26'0.321"N	7°29'20.849"E
13	M	Ayo River at Amechi Road	6°23'58.858"N	7°29'56.286"E

Source: Field work (20/6/2016)

The landsat8 satellite image of 2017 was downloaded through United State Geological Survey (USGS) and was processed using Geographical Information System (GIS) and Remote Sensing Technique. The maximum likelihood image classification in Arcgis 10.1 and land use land cover of the study area was extracted through Landsat 8 satellite imagery of 2017.The Arc GIS proximity analysis was used to determine the river basin by creating a buffer of 500 m along the main river line and 250m along the tributary. Nine coverage area of the land use land cover classes were identified such as Mangrove, Tropical Rain Forest, Agricultural Land, Wetland, Bare land, Water Area, Grass Land, Woodland and Urban Area. The nine classes were distinctly produced for the study but with more emphasis on residential land use (urban area) as it is a combination of anthropogenic activities and pollutant waste that make up this class and indeed, it is one that affects the other classes. The sample data was imported into ArcGis 10.1 to run the Geostatistical analysis. The physico-chemical parameters were analysed using Inverse Distance Weighting (IDW) interpolation. Inverse distance weighted (IDW) interpolation explicitly implements the assumption that things that are close to one another are more alike than those that farther apart. The measured values closest to the prediction location have more influence on the predicted value than those farther away. IDW assumes that each measured point has a local influence that diminishes with distance. It gives greater weights to points closest to the prediction location, and the weights diminish as a function of distance, hence the name inverse distance weighted**.** The closest points are rank as High , closer are rank as medium, the farther are rank as low.

3.0 Result

3.1 Land use Land cover analysis

The result revealed nine classes such as Mangrove, Tropical Rain Forest, Agricultural Land, Wetland, Bare land, Water Area, Grass Land, Woodland and Urban Area (figure 3.1) and the coverage area of the land use land cover classes were quantified in table 3.1. The total percentage covered by residential land use (urban land) area is 35.19%, followed by woodland (32.09%) and then tropical rain forest(12.16%) and the agricultural area accounted for 2.22%.

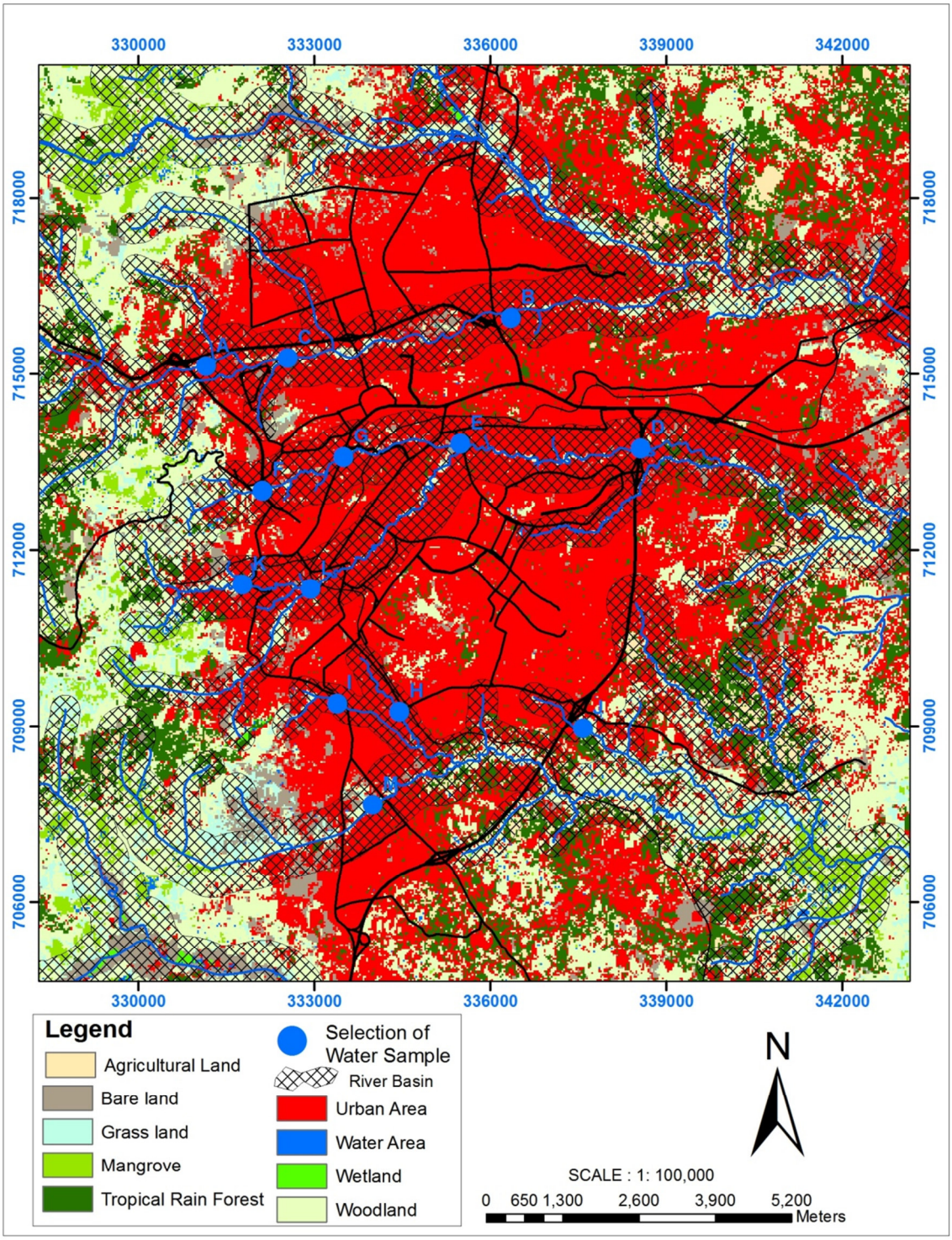


Figure 3.1: Landuse/land cover of River Basin (Landsat imagery 2017)

Table 3.1 : Evaluation of Land use Land cover Classes of River Basin.

VALUE	Class Name	Area (m^2)	percentage (%)
1	Mangrove	9182700	5.55
2	Tropical Rain Forest	20115900	12.16
3	Woodland	56402100	32.09
4	Grass land	5979600	3.61
5	Agricultural Land	3664800	2.22
6	Wetland	354600	0.21
7	Bare land	13432500	8.12
8	Water Area	1402200	0.85
9	Urban Area	54909900	35.19
Total		**165444300**	**100.00**

3.2 Effect of Land use land cover runoff on Physico- characteristics of surface water along the River Basin .

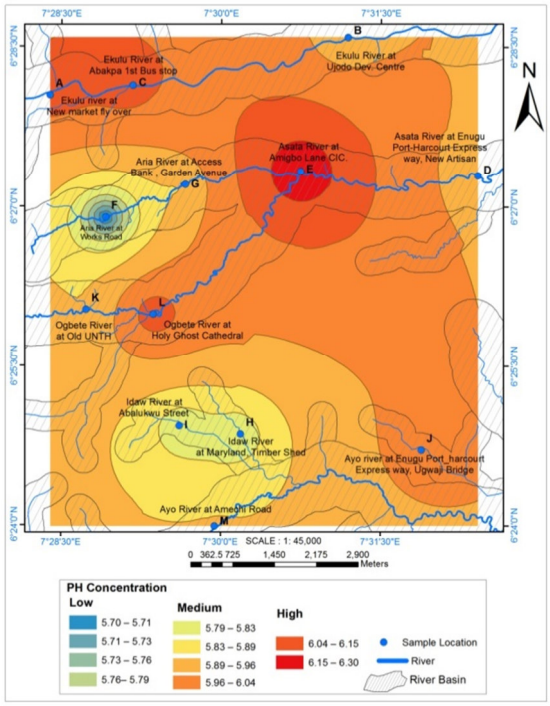
The water analysis was carried out at the water laboratory, Federal Ministry of Water Resources (Department of water quality control) Enugu. The table 3.2 shows the laboratory result of physical parameter properties of runoff surface water in the Enugu urban area.

Table 3.2 : Physical-parameter of runoff surface water in Enugu urban.

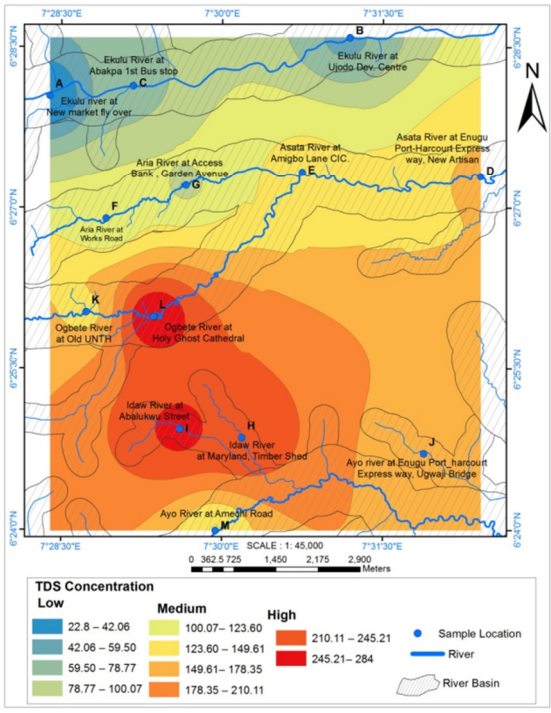
River	Temperature (^oC)	Turbidity (NTU)	pH value	Conductivity (µs/cm)	Total Dissolved Solid (mg/l)
Ekulu River	28.1	58	5.9	45.4	22.8
Asata River	30.3	14	6.3	263	132
Aria River	27.9	14.6	5.7	203	101
Idaw River	30.8	10.6	5.8	518	449
Ayo River	28.8	18.9	6	318	160
Ogbete River	31.6	20.4	6.1	568	284
Mean	**29.58**	**22.75**	**5.97**	**319.23**	**191.47**

Source: Author's Field Work, 2016

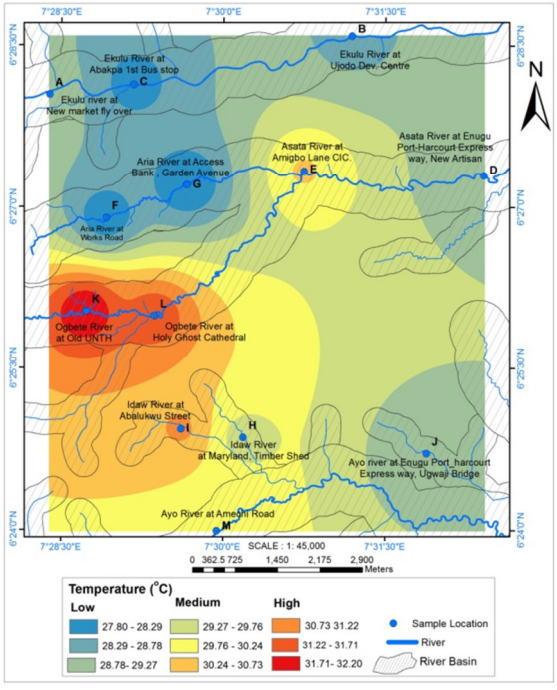
The table 3.2 shows that the temperature of surface water range from 27.9^{o}C to 31.6 ^{o}C, while turbidity range from 10.6 NTU to 58 NTU, the pH concentration varies from 5.7 to 6.3, conductivity between 45.4 µs/cm to 568 µs/cm and the Total Dissolved Solid comprises of value range from 22.8 mg/l to 449 mg/l. The interpolation of those physical-properties in the study area has shown highly concentration of runoff pollution in land use land cover of the river basin. Figure 3.2 shows the spatial mapping of runoff pollution in the study area. The study revealed that the Enugu river contained more acid as it range from 5.7 to 6.3. Urbanization can affect pH in rivers by point source pollution, when industrial pollutants are dumped directly into the surface water.



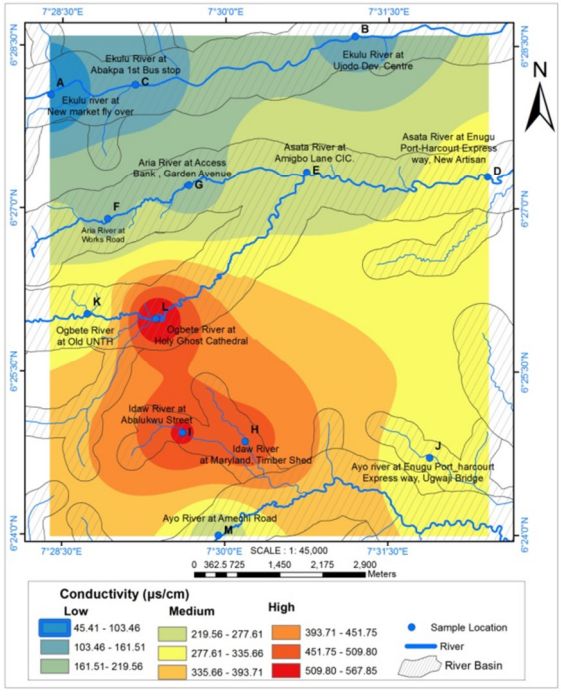
pH concentration of the river basin



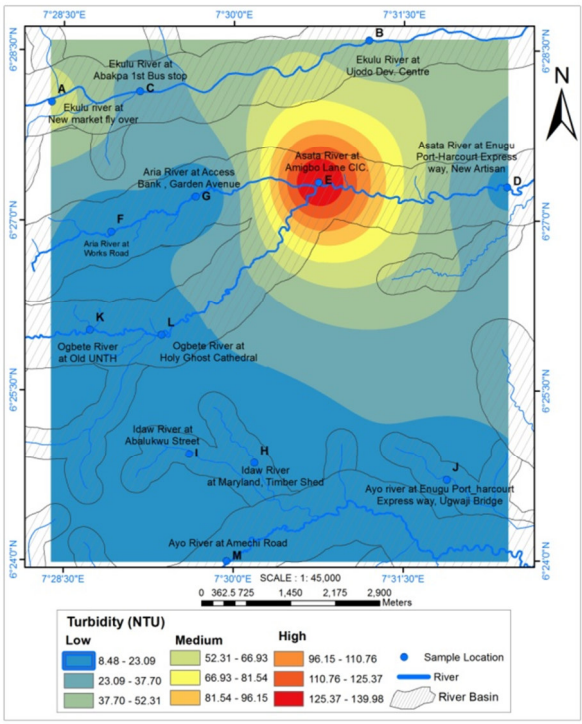
TDS concentration of the river basin



Temperature concentration of the river basin



Conductivity concentration of the river basin



Turbidity concentration of the river basin

Figure 3.2: The spatial mapping of Physical characteristic of runoff pollution in the study area.

Table 3.3: High Concentration of Physico-Properties of runoff water on landuse.

High Concentration of Physico-Properties (m^2)					
Class Name	**PH**	**TDS**	**Temp**	**Conductivity**	**Turbidity**
Urban Area	9279000	3420000	2627100	5652000	2412000
Agricultural Land	23400	900	14400	79200	8100
Water Body	45900	8100	9900	35100	6300
Vegetation	641700	243900	448200	1015200	373500
Bare land	304200	120600	180000	330300	39600
Total	**10294200**	**3793500**	**3279600**	**7111800**	**2839500**

Source:

It has revealed in table 3.3 above that the urban area is mostly caused the degradation of urban waterways. The major pollutants found in runoff from urban areas include pH, TDS, Temperature, Conductivity and Turbidity. The runoff water with high concentrateion of physico-properties was recorded in urban area. The coverage including pH covered 9,279,000 m^2, the TDS highly concentrated in surface water occupied 3,420,000m^2, the temperature is very high around 2,627,100m^2 of the urban, the conductivity of surface water in urban area occupied 5,652,000 m^2 while the turbidity covered 2412000 m^2. Suspended sediments constitute the largest mass of pollutant loadings to receiving waters from urban areas. The Asata River (Amigbo Lane CIC), Ekulu River (New market fly over), Ekulu River (Abakpa 1st Bus), Ogbete River (Holy Ghost Cathedral), Ayo river (Enugu Port Harcourt Express way Ugwuaji Bridge), are highly acidic pollutants. The conductivity of Idaw River at Abalukwu Street, Idaw River at Maryland, Timber Shed and Ogbete River at Holy Ghost Cathedral are very high. The TDS the temperature and turbidity are also very high in urban area (see figure 3.3). The urban surface runoff shows that most sites are located on surfaces identified by their different land use, such as typical residential areas, commercial areas and agricultural area.

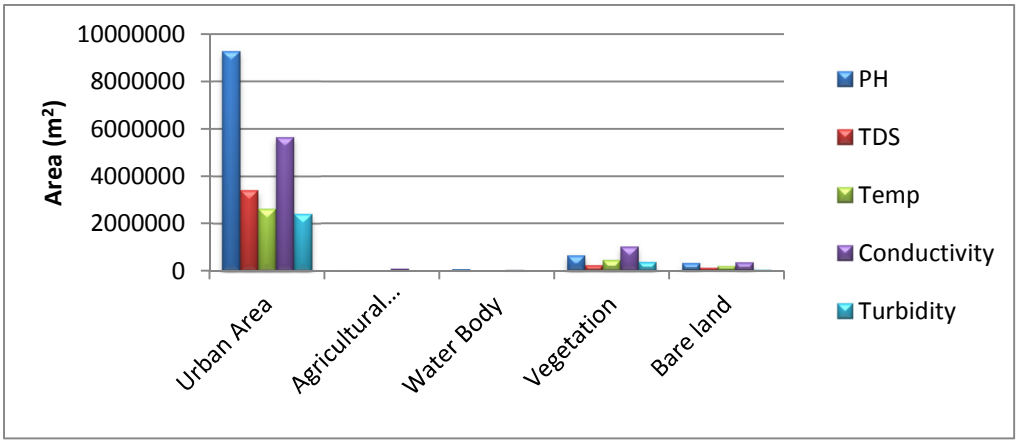


Figure3.3: Histogram of High concentration of Physico-properties of runoff on Landuse land cover

Enugu has various land use activities that are commonly noticed in the area. These urban activities seemly generate different kinds of debris and deposits (Davis, 2010) (plate 1). This could result to having different effects in the quality of rivers that these deposits from different land use activities drain their waste.

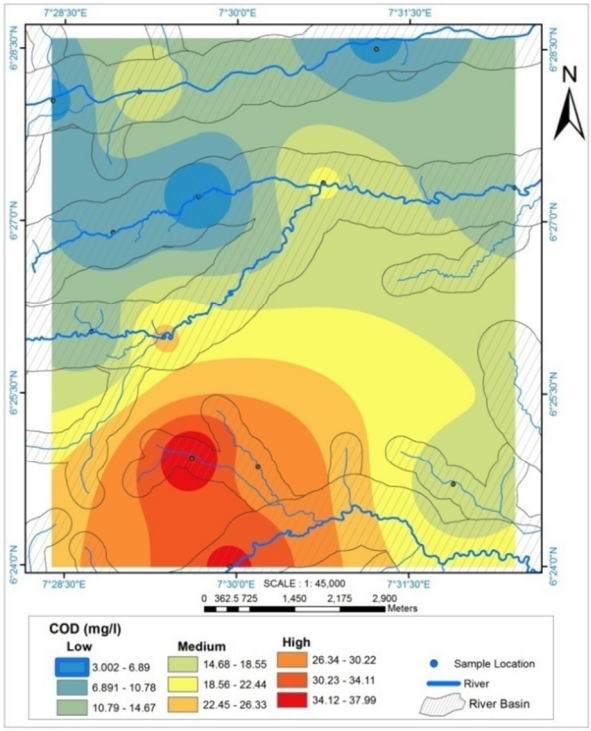
Plate 1: Ogbete River at Holy Ghost Cathedral.

3.3 Effect of Land use land cover runoff on Chemical-properties of surface water along the River Basin.

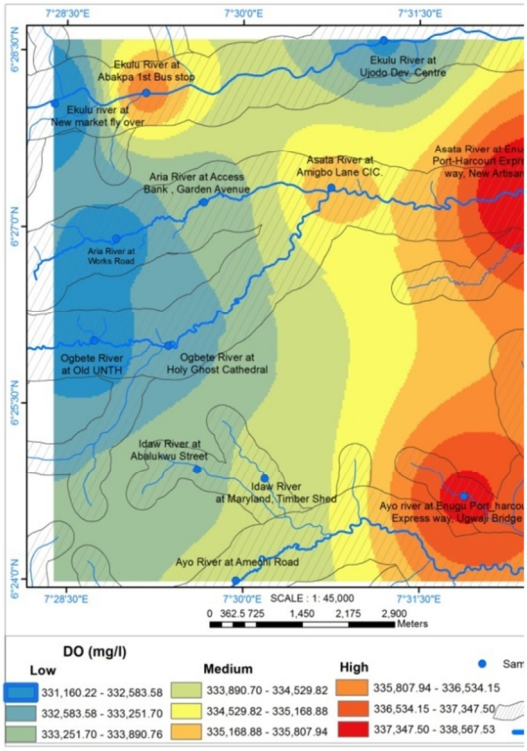
The chemical characteristics in surface water embrace the individual and combined impacts of the substances occurring in the water. The utility of a given river for any particular purpose is mainly determined by the constituents found in the water as well as its properties (Schultz and Okun, 1992, WHO 2011). The table 3.4 shows the chemical properties of Runoff water in the study area. The COD range from 6-35 mg/l, the DO is between 4 -7.39mg/l the nitrate varies from 0.02 to 4.46 mg/l while the phosphate is between 0.12 to 0.48 mg/l , the BOD varies from 1.5 to 30 mg/l. the figure 3.4 below show the spatial concentration of chemical-properties of runoff water in the stud area.

Table 3.4: Chemical-parameter of runoff surface water in Enugu urban.

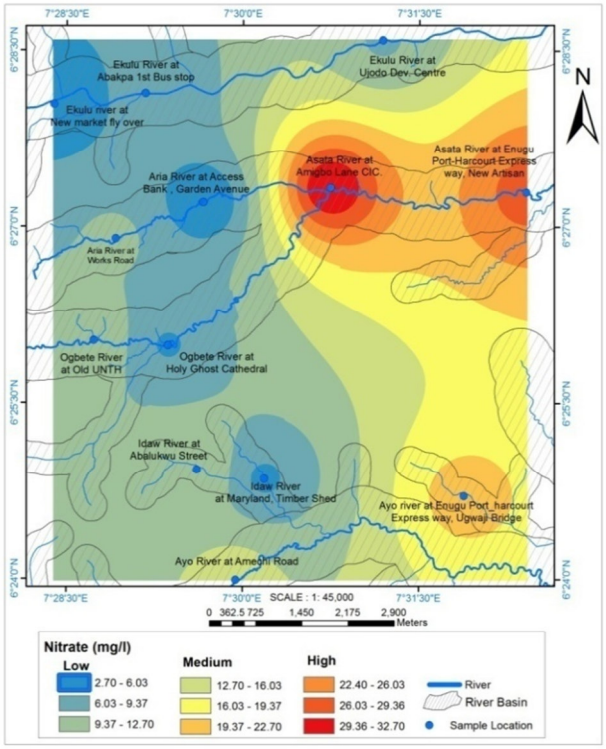
River	COD in (mg/l)	DO (mg/l)	Nitrite (mg/l)	Phosphates (mg/l)	BOD (mg/l)
Ekulu River	6	7.39	0.02	0.09	1.5
Asata River	19	6.93	3.41	0.16	13.9
Aria River	7	6.44	0.85	0.16	3.7
Idaw River	29	4	3.3	0.48	30
Ayo River	35	7.29	4.46	0.12	7.6
Ogbete River	23	5.13	0.84	0.32	10.8
Mean	**19.83**	**6.20**	**2.15**	**0.22**	**11.25**



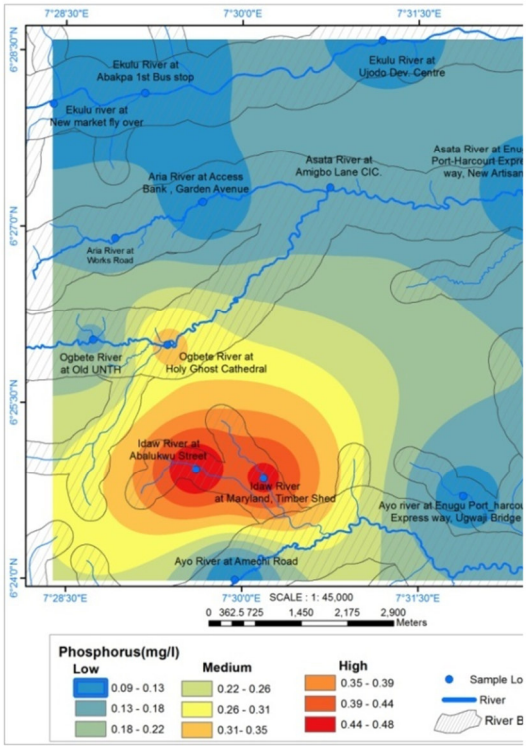
COD concentration of the river basin



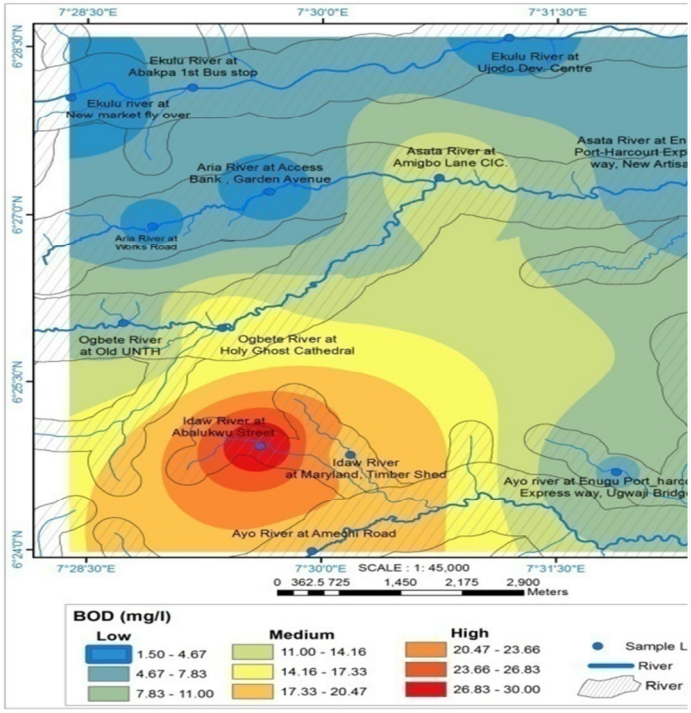
DO concentration of the river basin



Nitrate concentration of the river basin



Phosphorus concentration of the river basin



BOD concentration of the river basin

Figure 3.4: The spatial mapping of Chemical characteristic of runoff pollution in the study area.

Table 3.5: High Concentration of Chemical-Properties of runoff water on land use.

High Concentration of Chemical -Properties (m^2)					
Class Name	**COD**	**DO**	**Nitrite**	**Phosphates**	**BOD**
Urban Area	4087800	5231700	4756500	2260800	4975200
Agricultural Land	131400	213300	15300	2700	117900
Water Body	27000	58500	18900	3600	33300
Vegetation	1500300	2084400	357300	138600	1544400
Bare land	374400	134100	61200	94500	443700
Total	**6120900**	**7722000**	**5209200**	**2500200**	**7114500**

It has revealed in the figure 3.5 that urban area and vegetation area were the most highly pollutants land use in the study area because of its high concentration of chemical-properties. The contributions from both pollutants can greatly degrade the chemical water quality, often transporting "dirty" water over vast areas into downstream, estuarine and coastal environments (Rahmanian *et al*, 2015). The table 3.5 shows that the quantity of COD covered 4087800m^2 and 1500300m2 in urban and vegetation runoff respectively because the vegetation and urban runoff, acts as a food source for water-borne bacteria. Bacteria decompose these organic materials using Dissolved oxygen (DO) which extended over 5,231,700m^2 of urban runoff and 2084400m^2 of vegetation runoff . Biochemical oxygen demand (BOD) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions. Its covered 4,975,200m2 of urban runoff while 1,544,400m2 in Vegetation runoff. Phosphates are essential for the growth of organism and a nutrient that limits primary productivity of the water body. When the phosphate is in low concentration behaves like most important nutrient, when it is excess causes algal blooms. The urban and vegetation runoff concentration in phosphate covered respectively 2260800m2 and 138600m^2.Phosphorus gets into the water through various sources including leached or weathered soils from igneous rocks and domestic sewage containing human excrement. The Nitrite content on water runoff covered 4756500m^2 of urban river basin and 2084400m^2 vegetation runoff.

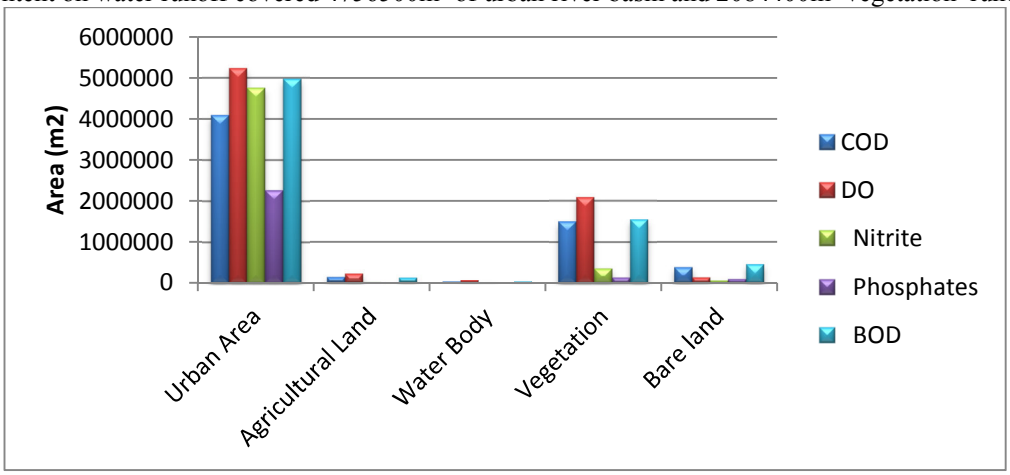


Figure3.5: Histogram of High concentration of chemical-properties of runoff on Land Use Land Cover

The study revealed that surface water quality of the study area were polluted because of runoff from various land use type. Analysis showed that Ekulu and Ayo river are fed from runoff from agricultural (vegetation) land use type, therefore agricultural debris and pollutant load were high (see plate2) Also Idaw and Asata river are fed of runoff from residential areas, hence organic, kitchen waste, human and animal induced pollutants were noticed. The Ogbete and Aria river are surrounded with so many commercial activities which is taking place in and around the area. Therefore, commercial pollutants were found to be very high in runoff water when tested in the laboratory.

Plate 2: Ekulu River at New Market Flyover
Source: author's Fieldwork 2016.

4.0 Conclusion

Findings from the study revealed that the nature of the quality of surface water from runoff in various land use in the study area using remote sensing image classification shows that the land use land cover of the area has been drastically affected by physico-chemical properties of surface water runoff and this is evidently clear from land use land cover Maps of Enugu urban Subcatchment area. There are more urban land use affected by the anthropogenic activity and waste and they contribute to increase runoff pollution in surface water quality in the area. The Geostatistical Analysis shows that the pH, Total Dissolved Solid, Total Coliform had affected the land use/ land cover of river basin and the concentration of pollutants were found to be highest in urban area (residential land use) than others. Duncan multiple comparison test shows that the significant difference found was between residential and the other land use.

5.0 Recommendations

The Remote Sensing and Geographical Information System provide vital information on the runoff area, land use activities and concentration of chemicals in the river channel. This study combined physico-chemical data and Satellite Imagery to study the variation of hydrochemistry of runoff in surface water quality. Based on the findings and the above mentioned limitations the study concluded with the following recommendations.

1. Application of Laboratory data and GIS techniques in runoff/water quality monitoring and planning; this will reduce the cost of maintaining eroded land and runoff displaced victims, it will also gives a historical and recent information for large areas, with the necessity to improve the awareness and access of available satellite imagery and spatial information to local remote sensing technicians.
2. Additional studies should be conducted to cover the rural areas of Enugu state for land use and cover analysis, for extraction runoff /land degradation prone area in order to educate and evacuate inhabitants of the environs before runoff lead land failure occurs.
3. To improve in construction of modernize drainage channel which will collect discharge instead of channeling waste to rivers.

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