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Land Use Pattern Correlated With Surface Water Pollution in Rivers State, Nigeria.

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ABSTRACT: *This study is aimed at correlating the land used pattern in Port Harcourt with surface water quality. Analysis was performed for 13 parameters ranging from physico-chemical properties, microbiological at 4 locations. High pH was found in the industrial and Agricultural areas as compared to the residential area and commercial area. The level of NO_3 and PO_4 follow the trend agriculture>industrial> commercial>residential.The values of total alkalinity and DO follow the trend of industrial>commercial>residential>agriculture and conductivity and TDS of water quality follow the trend of commercial >residential>industrial>agriculture. Residential source are maximum on Temp., EC, TDS, Turbidity and Total hardness, industrial source are maximum on pH, Chloride, Total alkaline and sulphate and Agricultural source are maximum onBOD, nitrate and phosphate. The land used along various water bodies has its effects on water depending on the uses, from the findings commercial and industrial area is found to have more effect on nearby surface water. This necessitates the need for water treatment plant, a constant monitoring of the land use pattern and waste disposal habit in the study area.*

KEYWORDS: *Land use pattern, Surface water quality, Port Harcourt, Nigeria.*

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I. INTRODUCTION

Land is defined as the earth's surface, including both land and water, and the natural resources in their original states. Land use involves both the manner in which the biophysical attributes of the land are manipulated. Land covers 29% of the earth's surface while water is one of the most important of all natural resources. Water covers 71% of the earth's surface and is vital for all known form of life. Human existences are threatened by inadequate quantity of good quality water.Uncontrolled human activities have led to significant modification of the natural biodiversity in the world over the years. Consequentially, land use has changed abruptly without adequate consideration for future developments and its adverts of water quality. There is continuous deterioration from the rich biodiversity. The effects of land uses on the environment ranges from minor land cover changes and soil modification to severe desertification, deforestation, erosion, and river encroachment problems. The incessant need for human development via rapid urbanization has led to a wide spread horizontal development especially in the developing countries. As a consequence, river banks are encroached, vegetal covers are removed, soil properties are modified and many micro to macro ecosystem have gone into extinction. Where these changes are not met with complementing planning and management measures, challenges such as water pollution, high risk to disaster (flood), and unstable food production are unavoidable, particularly in the riverine areas.The study of Pinelands stream-water quality was found that including the proximity of developed and upland-agricultural land to a monitoring site, using inverse-distance-weighted land-use values, did not improve the relationship between land use and water quality beyond that obtained using watershed-wide land-use data which has been evaluated on how landscape patterns might influence land-use-proximity and water-quality relationships in Pinelands streams by relating pH and specific conductance to the percentage of altered land (developed land and upland agriculture) in a succession of cumulative stream buffers and describing land-use relationships among the buffers. River water can be contaminated by human activities in two ways: point sources and non-point sources pollutions. Point sources pollutants are directed and released into water bodies in man-made pipes, whereas non-point source pollutants are washed from the earth's surface by storm runoff and enter water bodiesof their own accord [1]. Generally, non-point sources are difficult to detect since they encompasslarge areas in drainage basins and involve complex biotic and abiotic interactions. Many studies havedemonstrated that non-point source pollution, like diffuse pollutants due to land use practices, is one ofthe major causes of contamination of river [1].

A study of water quality, land-use changes, and population growth trends in several watersheds of eastern Massachusetts since the 1970s has been conducted to examine the impact of land use changes on water quality at sub-watershed and stream buffer-zone scales through GIS and statistical analyses [2], a study on how to evaluate landscape patterns (including Number of Patches, Edge Density, Percentage of Rangelands and Forests) influence on the water quality indices (including BOD5, EC, NO_3, P and TDS) measured in 10 stations along the Zayandehroud river was conducted [3]. Surface water sources of nitrogen (N) (total, nitrate [NO_3^-], ammonium [NH_4^+], and dissolved organic N) and sediment active within 40 subbasins of the Calapooia River

Basin in western Oregon in monthly samples over three cropping years was characterized [4]. Inadequate land-use planning in areas adjacent to the drainage basin and uncontrolled river encroachment are vital factors adding to the consequences of water challenges and security in the country.

Pollution prevention requires a better understanding of water quality and the impact by land use and land cover in the basin level as well as land along river side. Land along rivers, especially undisturbed vegetated land along rivers, might mitigate nutrients, sediment from surface and groundwater flow through the processes of deposition, absorption and denitrification. Pollution of this major water supply has become an increasing source of concern due to contamination by various toxic substances[5]. For effective restoration of water quality of river, the policy makers or managers should focus on land use area adjacent to surface water and understand interrelation of land uses and water quality.

Rivers constitute the main inland water resources for domestic, industrial and irrigation purposes and often carry large municipal sewage, industrial wastewater discharge and seasonal run-off from agricultural land and coastal region. It has also been observed that pathogenic contamination of Nigeria's rivers comes from aquaculture practices in the used land involving fertilization of ponds with cow and poultry manures and direct dumping of feacal matters into the rivers [6]. The presence of microbial pollutants in surface water could pose risks to public health and waterborne diseases such as cholera, diarrhea, hepatitis, dysentery, poliomyelitis, typhoid etc. Assessment of water is not only for suitability for human consumption but also in relation to land use pattern base on agricultural, industrial, residential, and commercial uses and its effects on water quality. Land use and water quality monitoring is therefore a fundamental tool in the management of both land and surface water resources. For a sustainable river basin management policy to be implemented, a corresponding effort must be attained through effective land use planning and management at the adjoining areas around the water channels. Analysis of the land use pattern in the drainage basins using geospatial technology is an approach that would provide reliable information for effective planning and implementation of management policies for both river basins development and land use planning for urban and agricultural development in these areas.

Different types of pollutants are generated from different landuse type. In a city like Delhi, the non-point pollution generated from the domestic landuse type (residential) are organic in nature therefore it is important to measure the BOD, COD and DO of the urban runoff from a domestic site. Other parameters which are generated in storm water runoff from a land use with both industrial and domestic activity are nitrogen and its compounds, phosphates, chlorides, sulphates and solids. Nothing is more fundamental to life than water. Not only is water a basic need, but adequate, safe water underpins the nation's health, economy, security, and ecology. The strategic challengefor the future is to ensure adequate quantity and quality of water to meet human and ecological needs in the face of growing competition among domestic, industrial, commercial, agricultural, and environmental uses [7].

Industrialization and urbanization have brought prosperity, and at the same time resulted in many environmental problems. Land use involves both the manner in which the biophysical attributes of the land are manipulated and the intent underlying that manipulation – the purpose for which the land is used [8]. The pattern which land is utilized matters a lot. Land is the habitat of man and man uses land in a variety for his economic, social and environmental advancement. Land is the fundamental basis of all human activities, from it we obtain the food we eat, our shelter, our water, the space to work, the room to relax and lots more.Although there have been some studies on the impacts of land use on water owns and quality [9], the complex intrinsic relationships of land use, water yields and water quality in different geographical areas under different scales are yet to be elucidated. Current methods on predicting water quality in river catchments based on land-use patterns are still developmental. Different factors contributing to the quality of urban runoff have been studied and it has been concluded that surface water quality is indeed affected by urbanization and industrialization [10], [11].

Over the past three decades, land use change caused by urban sprawl had a considerable impact on water quality in eastern Massachusetts. The spatial relationship was also scale dependent. Population and developed land adjacent to streams had stronger influence on water quality. Population change and land development at smaller scales (steam buffers) were more important to evaluate the impact of land use change on spatial variability of water quality. Land development and population change at larger scales (sub-watershed and 1,000 m stream buffer scales) were more important to assess the impact of long-term land use change on water quality [2].

Over the last decade, the combination of different factors affected the water quality of U-tapao Riverand turned it into a polluted ecosystem. Among them, the changing pattern of land uses in riparian zonehad a considerable impact on water quality. It was found that there was significant decrease of agricultureland use, whereas significant increment of urban land use in riparian zone area and such changes haveconsiderably influenced on runoff quality and quantity of river and may be responsible for the increase ofvarious pollutants. The study also indicated that the lack of forest in riparian zone might be anotherreason of increasing pollution in river. Therefore, maintaining and developing vegetation in riparianbuffer zone areas is considered an important step to control non-point source pollution due to surfacerunoff.[12].

Worldwide, it is estimated that industry is responsible for dumping 300-400 million tons of heavy metals, solvents, toxic sludge, and other waste into waters each year [13].Agricultural expansion is one of the proximate causes of land use/land cover change [14]. Today, roughly a third of the world landscapes are being used for growingcrops or grazing cattle [15]. Major changes in human activities, particularly through largescale agriculture have been identified as the major cause of the dramatic changes in land cover and land use patterns globally. Changing land use and land managementpractices are therefore regarded as one of themain factors in altering the hydrological system, causing changes in runoff [16], aswell as the quality of receiving water [17].

One of the most important factors that can affect the quality of surface water is the land use within a watershed [18]; which the increasing growth in urban development has begun to put under serious threats. Taiwo[19] observed that environmental monitoring of surface water indicated that streams and rivers in the country are showing increasing trend of water pollution due to increase population, industrialization and urbanization. The River was monitored for heavy metals such as Fe, Cu, Ba, Pb, Cd, Cr, Ni and Co. Results showed elevated values of these metals at sampling point located near an industry. Correlation analysis of the metals also suggested common source. Other water quality parameters showed elevated values indicating pollution by the nearby industry.

The assessment of water pollution and the quality of water is based on the three main characteristics of water, which is classified in the physical, chemical and biological characteristic.

II. MATERIALS AND METHODS

2.1 Location of Study

Rivers state as a primary case study is located within the Niger Delta Basin of Southern Nigeria. Port Harcourt being the capital of Rivers state is located within the eastern lower Niger Delta in South Eastern part of Rivers State of Nigeria. Geographically, it is situated at the right bank of the Bonny River approximately 65km (40 miles) in land from the Bight of Bonny. It is bounded on the east and West by meandering Creeks and large area of land, on the south by first the block yard creeks, then the Bonny River, and finally mangrove swamps, of the south east with large area of land and creeks and on the north by Abia State. The area covered is about 290 sq.km and the mean annual temperature is about 28^0C in the area. Huge oil exploration and exploitation dominate economic activities in the area and the main occupation of the people of Rivers state is fishing and small scale agriculture.

2.2 Sample Location

The correlation of land use pattern with surface water pollution adopted both field and laboratory based procedure to collect required data. In order to have clear knowledge of how the use of land affects our water, four water samples were collected at different locations in Rivers state. The study area is divided into 4 zones; three zones in Port Harcourt and a zone in Ogoni. Port Harcourt zone is limited to Agip axis (industrial), Borikiri axis (Commercial) in Port Harcourt town, Old G.R.A axis (residential) and Ogoni axis (Agricultural). The samples points on surface water were the Agip creek, bonny/Nembe creek with Ntawogba stream and the water Sogho in Nonwa of Ogoni.

The three creeks located in the heart of Port Harcourt were also link with other streams and rivers like Amadi creek which with Ntawogba stream drains the marshy swamp forest up stream of (Rumueme and Rumuepirikom), empties into Amadi creek. Miniweja Stream system drains the Freshwater (Rumuigbo/Rumuola) forest and empties into Agip /Diobu Creek of Bonny River. Agboncha drains the freshwater swamp forest and empties through Obufe/Elelenwo creek into the Bonny estuary. Miniokoro stream drains the freshwater swamp forest into Woji creek and empties into the Bonny estuary. Minichida drains the freshwater swamp forest and empties into Elelenwo creek in Bonny estuary. The selected areas are for clear correlation of land use pattern and surface water pollution.

2.3 Sample Collection

Surface Water samples were collected at the sample points at Agip/Diobu creek, bonny/Nembe creek, Ntawogba stream (Old GRA) and Sogho of Ogoni. Samples for other parameters such as TSS, alkalinity, total hardness, nitrate, ammonia, sulphate phosphate, and chloride were collected in a 500ml plastic bottle from each station and stored in an ice chest and transported to the laboratory.

DO and BOD samples are collected in 2 separate 250ml samples bottle; one opaque and the other wrapped in foil for DO and BOD samples are collected in 2 separate 250ml samples bottle; respectively. The DO samples was fixed immediately after collection with Winkler I and II reagents while the BOD_5 was stored alongside the DO samples after collection before taking to the laboratory for further analysis.

III. RESULTS AND DISCUSSION

3.1 Evaluation of Results

The evaluation of results based on the 4 locations namely Agricultural, Residential, Industrial and the Commercial areas of Port Harcourt are shown in Table 4.1.Water quality analysis was performed on 13 variables of physico-chemical properties at the 4 locations to identify how land use pattern affects nearby water bodies.

3.2 Evaluation of Surface Water

In the surface water analysis, a comparative analysis of the physical and chemical characteristics of the sample in Port Harcourt creeks (Table 1) indicates that most of the physico-chemical parameters investigated in surface water are above desirable limits. Others like pH in the study areas range from 5.8 to 6.6 indicating the acidity of the water body. Temperature range from 28^0C to 30.5^0C.The pH of the water body is an important factor that determines the suitability of water for various purposes, including toxicity to animals and plants. The pH was found to have slight variations between stations and all above standard value. In terms of the pH of water the order for the different types of land use was: industrial > agriculture > residential > commercial. The conductivity and TDS values varied from 309 µS/cm (agricultural) to 1459µS/cm (commercial) and 206 mg/l to 839mg/l respectively. The high concentration of EC and TDS in urban land use can be attributed to urban runoff and pollutants resulting from human activities, and due to the presence of high value of chlorine ranging from 237.9mg/l (agricultural) to 536.7 mg/l (industrial). This value is high due to the limited effectiveness of treatment of this station, once they found organic residues in the water. These residues explain high concentrations of dissolved salts. In terms of the conductivity and TDS of water quality, the order for the different types of land use was: commercial > residential > industrial > agriculture.

An objectionable low concentration of DO may be associated with municipal discharges, attendant organic load and utilization in bacterial decomposition of organic matter. The more waste import, the decline in DO concentration and the high BOD is an indication of high organic load in water sample. From the result, station 1 and 2 (agricultural and residential) have a low DO of 3.5mg/l and 5.0mg/l and of high BOD of 10.5mg/l and 9.0mg/l respectively.

Sulphates and phosphates ranges from a minimum of 10 mg/l (residential) to 55 mg/l(agricultural) and 13 mg/l (residential) to 50 mg/l(agricultural) respectively.The agricultural runoff mainly contains high amount of nitrogenous compounds, phosphates and sulphates. It was also observed that the agriculture runoff adds more nitrogen (its compounds), phosphates etc to the river directly than the runoff from the urban sectors. This could be associated with the use of fertilizers in the agriculture fields.

Electrical Conductivity and turbidity are within the limit set by WHO. From the result, turbidity in commercial and residential has a high value of 12 and 10 respectively and this can be attributed to urban runoff from the city. The result for EC shows that there is no salinity hazard in the study area at the time the samples were collected. This is because the mean value of EC is below the maximum permissible limit by WHO in correlation with the land use it is high in commercial and residential areas.

BOD, nitrate and phosphate are higher than the permissible value of WHO of 5mg/l, with Agricultural zone recording the highest value of 10.5, 55 and 50mg/l respectively compared to the urban sectors. The increase in the value is due to fertilizer application from farmers.

Chloride, DO and sulphateare higher in industrial zone with 536.7, 8.0, 100mg/l respectively. These parameters indicate pollution by industrial waste from metal processing, pharmaceutical or chemical manufacturing plants.

The high concentration of TDS, total hardness and total alkaline in the commercial source in urban land use can be attributed to urban runoff and pollutants resulting from human activities like organic waste deposit from the neighboring market.

3.3 Statistical Variation

The descriptive statistics of surface water quality in all the land use is presented in Table I. The result shows that pH ranges between 5.8 and 6.6 with a mean of 6.23 while EC is from 309 to 1459µS/cm with a mean of 763.3µS/cm. TDS is between 206 and 839mg/l with a mean of 490.5mg/l. Chloride, turbidity, total hardness, total alkaline, DO,BOD, NO_3, PO_4 and SO_4 ranged between 309-1459mg/l, 6-12NTU, 110- 276.6mg/l, 14.2 - 408mg/l, 3.5-8.0mg/l, 7- 10.5mg/l, 10 - 55mg/l, 13 - 50mg/l and 40 - 100mg/l, respectively. Corresponding mean values are 365.4, 9 NTU, 194.3, 155.9, 5.6, 8.9, 25, 25.5, and 60mg/l, respectively. The pH of the surface water indicates an acidic condition; with residential zone of 6.2 being more acidic compare to agricultural, industrial and commercial.

From Table II and fig. 1, the relationship between land use pattern and water pollution, and descriptive analysis of variables, it is found that residential source has maximum on 5 parameters viz: Temp., EC, TDS, Turbidity and Total hardness. Industrial source has a maximum of 4 parameters which are pH, Chloride, Total alkaline and sulphate and Agricultural source recorded maximum of 3 parameters namely BOD, Nitrate and Phosphate. The land use along various water bodies has its effects on water depending on the uses. From the findings, commercial and industrial areas are found to have more effect on nearby surface water.

Table I: Characteristics of surface water quality in Agip/Diobu creek, Bonny/Nembe creek, Ntawogba stream (Old GRA) and the water Sogho of Ogoni.

Parameters	Agricultural	Residential	Commercial	Industrial	WHO 2004
pH	6.3	6.2	5.8	6.6	6.5 -8.5
Conductivity	309	914	1459	371	1500
Temp. (^oC)	28	30	29.6	30.5	
Chlorine	237.9	250.2	436.7	536.7	Nil
TDS	206	669	839	247	500
Turbidity (NTU)	6	10	8	12	200
Total Hardness	110	167	276.6	221.4	
Total Alkaline	14.2	96.00	105.2	408	
DO	3.5	5.0	6.0	8.0	5
BOD	10.5	9.0	8.5	7.0	5-7
Nitrate	55	10	15	20	5
Phosphate	50	13	18	21	5
Sulphate	60	40	70	100	

All parameters in mg/l except where stated.

Table II: Descriptive Statistics of surface water

	Minimum		Maximum		Mean	Standard deviation
	Min	Sample point	Max	Sample point		
pH	5.8	Commercial	6.6	Industrial	6.23	0.27
Conductivity	309	Agricultural	1459	commercial	763.3	564.2
Temp. (^oC)	28	Agricultural	30.5	commercial	29.5	1.03
Chlorine	237.9	Agricultural	536.7	Industrial	365.7	161.8
TDS	206	Agricultural	839	commercial	490.5	351.7
Turbidity (NTU)	6	Agricultural	12	commercial	9	2.7
Total Hardness	110	Agricultural	276.6	commercial	194.3	73.7
Total Alkaline	14.2	Agricultural	408	Industrial	155.9	168
DO	3.5	Agricultural	8.0	Industrial	5.6	1.8
BOD	7.0	Residential	10.5	Agricultural	8.9	1.3
Nitrate	10	Residential	55	Agricultural	25	20
Phosphate	13	Residential	50	Agricultural	25.5	16.3
Sulphate	40	Residential	100	Industrial	60	23.3

All parameters in mg/l except where stated.

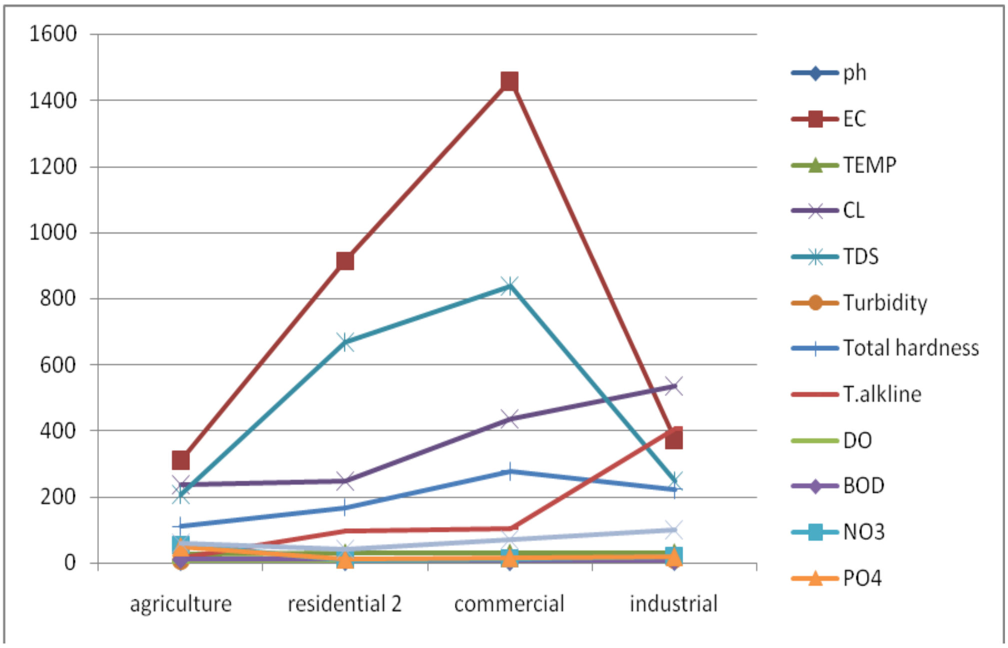

Fig.1: Descriptive variation of surface water parameters and land use pattern

IV. CONCLUSION

It has been found that there are combinations of different factors affecting the water quality and in turn the polluted ecosystem. The changing pattern of land uses in Port Harcourt had a considerable impact on water quality. The present study of physical, chemical and biological characteristics of water provides a considerable insight into the quality of surface water. It was found that there was significant decrease of agriculture land use, whereas significant increment of commercial and industrial land use in Port Harcourt. Such changes have considerably influence runoff quality and quantity into rivers and may be responsible for the increase of various pollutants. Therefore, maintaining and developing control measures in the use of land is considered an important step to control non-point source pollution due to surface runoff.

In this study, all four types of land uses showed significant relationship with water quality parameters and the knowledge of these relationships is very important to manage healthy ecosystem of the river. Water quality parameters, like temperature, dissolved oxygen, biological oxygen demand, TDS and the nitrogen compound, were analysed by using descriptive analysis on various combinations land use. It was noticed that commercial and industrial land use was the most important parameter to predict water quality parameters. This study not only helps for better understanding of relationship between land use and water quality, but also helps to select the appropriate parameters for effective surface water pollution management. Overall, the study illustrated the importance of integrating land uses and water quality parameters of some selected locations in Port Harcourt for sustainable development of surface water.

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