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ARTICLE

Geo-spatial Analysis of the Impacts of Urbanization-induced Activities on Soil Quality in Port Harcourt Metropolis, Rivers State-Nigeria

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ABSTRACT

The study examined the impacts of urbanization-related activities on soil quality in Port Harcourt Metropolis-Rivers state, Nigeria. Experimental and survey research designs were implored in the study utilizing GIS and spatial analysis approaches. Both primary and secondary sources of data were used. The primary data were generated through laboratory analysis of soil samples from 15 randomly selected sites within the metropolis; and 800 valid copies of a socio-economic questionnaire administered to 800 respondents. Also, public hospitals were visited to ascertain the commonest soil-borne diseases in the area. Four research questions, four specific objectives and two hypotheses guided the study. The hypotheses were tested with one sample t-test and one sample chi square using SPSS. Standard scientific and laboratory procedures were followed in the collection and analysis of soil samples. Findings of the study include: urbanization-related activities (e.g. waste dumpsites, mechanic workshops, abattoirs, etc.) cause significant changes in soil quality in the area; and this results in the emergence of soil-borne diseases (e.g. Vascular witts, Ascaris lumbricoid, Trichuris trichiura, Strongloids stereoralis) which affects residents' wellbeing. However, there is a significant difference in the perceived socio-economic effects of the diseases across the area. Specifically, laboratory results for soil analysis show that (mean values): pH 7.22, temperature 25.62 °C, PO_4 0.342 mg/kg, Pb 120.62 mg/kg, K 66.81 mg/kg, NO_3 mg/kg. The study recommended for enforcement of physical planning and development control laws; regular evaluation of the quality of the soil, and restriction on the location of mechanic workshops and waste dumpsites around the metropolis.

1. Introduction

This study examined the impacts of urbanization-induced activities (such as mechanic workshops, refuse disposal/wastes dumpsites, abattoirs, disposal of industrial effluents and other chemicals on the earth's surface) on soil quality status in Port Harcourt metropolis, Rivers state; using GIS-based maps and spatial analysis approach

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to present the discussions.

Soil samples were collected and examined (in the laboratory) from 15 randomly selected sites/locations where the various land use activities outlined above, are taking place. These include: Egbelu, Mgbuosimini-Agip, Rumuekini, Rumuodara, Eneka, Nkpor, Eagle cement road-Rumuolumeni, East-West road by Nkpolu, Industry by NPA, Abuloma, Mile III mechanic village, Trans Amadi IA, GRA II, Old GRA by Forces Avenue, and D-Line. The various soil parameters examined in the work include pH, temperature, nitrate, phosphorus, lead, and potassium. In the analysis that follows, Figure 1 shows the soil sampling points while Figures 2 to 7 showcase the spatial occurrence of the various parameters in the soils of the area. While Table 5 summarizes the laboratory analytical report for the various parameters examined in the soils of the area.

1.1 Background to the Study

Urbanization is synonymous with urban outward growth (which is a reflection of urban land use activities). As a spatial process, the physical and social manifestations of urbanization bring about an increase in urban land use activities and outward growth (physical expansion) of the urban center, growth in economic activities, rise in population and demographic characteristics as well as the sophistication of towns and cities. It represents a functional relationship between the existing population and available land. It is been influenced by changes in technology, state policy, economic, demographic and cultural values [1,2]. It is also associated with modernism and improvement in means of production and the wellbeing of the citizenry.

Nevertheless, an increase in urban land use activities or urbanization is a two-sided coin that is associated with both positive and negative impacts. The outward growth and intensification of the internal structure of towns affect the physical environment through the impacts of the activities that go on in that space. It has negative consequences on human health and the environment including the development of slums [3,1].

As a process, urbanization and the growth of towns or cities did not start today nor did it just happen overnight. Rather, it is a long process that starts from the initial gathering of a few persons and later on a high number of people in one location (space), and the need to survive or change their lifestyles through engagement in economic activities.

The evolution of cities from their earliest origins more than 5, 500 years ago through the Industrial Revolution which began (in the English Midlands) in the mid-1700s, marked the origin of urban development or urbanization, which later trickled down into other parts of the world. A lot of changes (social, cultural, economic, political, technological and environmental processes; including merchant capitalism, colonialism, and industrialization) took place during this long span of urban development and redevelopment [1,3-5].

Notably, five regions of the world provided the earliest evidence for urbanization and urban civilization. These are Mesopotamia, Egypt, the Indus Valley, Northern China, and Mesoamerica. Examination of the internal structure of these cities – their street patterns, religious precincts, different neighboruhoods, etc., reveals a great deal about their evolution and the political, economic and social changes that can be seen in them [3,5]. In Nigeria, evidence of the impacts of such changes can also be seen in the internal structures of ancient cities and towns like Benin, Kano, Ibadan, Abeokuta, Ile-Ife, Osogbo, Zaria, Ilorin, etc. [1].

Many scholars argued that urbanization in these ancient Nigerian cities predated western civilization. Long before the Europeans and Portuguese came to Nigeria and some West African States, there were already existing well-planned street layouts, broad roads and well-organized systems. This fact was also acknowledged by the Whites themselves when they saw the level of planned layouts and roads especially around the Kings (as in Benin) and Emirs (as in Kano, Zaria) Palaces [1,6,7].

It is pertinent to reiterate here that, urbanization has been a dynamic process, leading to environmental pollution. Major forms of urban pollution in Port Harcourt include an increase in the volume of sewage and solid waste generation and the burden of effective disposal; a rise in urban noise pollution levels from factory machinery, transportation vehicles, and the rising cases of sleeplessness and hearing impairments; soil pollution and the contamination of food crops cultivated on polluted soils; water pollution and contamination of sea foods and drinking water sources; air pollution and increase cases of respiratory disorders, itching eyes and defacing of buildings and material objects. Others include urban sprawl and disappearing urban-fringe green areas including the loss of rural forested lands [8,9].

This is a result of the uncontrolled high rate of urban expansion that is taking place within the Port Harcourt region. At its inception in 1912, Port Harcourt which was established just about 66 km from the Atlantic Ocean was just about 180,000 hectares or 25 km^2; it grew to 16.25 km^2 in 1976 and 282.25 km^2 by 1995. Today, the city has grown to engulf more distant fringes like Nkpor, Aluu, Rukpokwu, Eneka, Eliozu, Elelenwo, Woji, Akpajo etc. [1,10-15].

The main reasons for this high rate of outward expansion of the city of Port Harcourt include its strategic location on a plain topography with good natural harbours, abundance of groundwater (freshwater) reservoirs of great horizontal and vertical extent, an abundance of hydrocarbon deposits within the Port Harcourt region and fertile soils for agriculture at the fringes for a constant supply of food for the growing urban population, presence of crude oil and gas multinational corporations and allied industries. Others are favourable climate and conducive environment that is not harsh, presents of many institutions, including the hospitality industry, high level of commercial activities, very high population concentration which provides large and cheap labour pool, relative political stability, social activities and verse land (at the fringes) for housing and infrastructural development.

This high rate of urbanization in Port Harcourt is associated with a rise in pollution levels with severe consequences on the health of the residents and the environment generally. It is on this premise that this study seeks to examine the impact of urbanization on the soil pollution status of the Port Harcourt metropolis.

Walker (2007) [16] examined the effects of urbanization across the globe and argued that an efficient system of coordination of urban activities is lacking especially in the less developed world. Urbanization in these developing economies is associated with a rise in environmental deterioration and the proliferation of slums and squatters. Obnoriz in his study of urban development and urbanization processes in Africa, postulated that most traditional African cities lack a well-planned system to monitor and control urban growth and development. Hence, most cities in Africa, are seldom with the problem of uncoordinated urban growth and development of ghettoes, environmental pollution and degradation, resources over-exploitation, lawlessness and rise in crime rate [17].

The doyen of African urbanization, Mabogunje in his study of African urbanization and Ukpere in work on urban environmental management crisis Africa, argued that the drive towards urbanization in Nigeria and in Africa in general, led to an unprecedented rise in urban population and economic activities in most of the earliest urban centres especially the capital cities, coastal towns with good harbours (e.g. Lagos, Port Harcourt, Calabar, Dakar, Lome, Mauritius, Port Said, Durban) and other towns associated with solid mineral mining activities like Jos, Abeokuta, Enugu, Johannesburg, Cape Town, Monrovia, Darfur, Khartoum, etc. [7,18]. That, urbanization in Africa is characterized by growing social and environmental challenges or crises such as a rise in urban population and unemployment, high cost of living, increase in crime rate, housing inadequacies and the emergence of slums and squatter settlements, rise in pressure on natural resources utilization and available infrastructures, increase in industrial related activities and rising cases of pollution of urban airspace, land (soil) and drinking water sources [7,18].

Lastly, Ukpere and Igwe examined the environmental and social effects of air pollution in Port Harcourt; and argued that urbanization-induced activities have resulted in a steady increase in the level of air pollution with severe consequences on the health of residents and properties in the city. They called for the immediate adoption of measures aimed at cutting down activities that promotes air pollution in the area [19]. Other works which x-tray the side effects of urbanization include Wizor and Elekwachi who 2020 studied the impacts of urbanization and wetlands loss in Obio/Akpor; Wizor and Mpigi in 2020, studied the emergence of flood in the Port Harcourt metropolis due to uncontrolled urbanization and poor physical planning; and Weli, Okoli and Worlu in 2020 examined the impacts of urban sprawl dynamics on surface temperature characteristics variability in the Greater Greater Port Harcourt Region [20-22].

There are identified gaps (scope, spatio-temporal and methodological) in the previous works. The works cited so far did not actually examine the effects of urbanization on the soil pollution status of Port Harcourt as a topic. Again, most of the studies [16,23,7] were carried out outside the shores of Port Harcourt. This forms the gap in the literature which this study seeks to address by holistically examining the effects of urbanization on the soil pollution status of Port Harcourt using GIS, survey and experimental research designs.

1.2 Research Questions

Arising from the statement of the problem, the following questions were raised in order to guide the study:

i. Does urbanization-induced activities pose any significant threat to soil pollution in the City?

ii. What are some of the urbanization-induced activities that pose threat to soil quality in the City?

iii. What are some of the pollution-induced are diseases prevalent in the Metropolis?

iv. Does the emergence of the perceived pollution-induced soil-borne diseases pose any significant effect on the socio-economic development of the people of the area?

1.3 Aim and Objectives of the Study

The aim of this study was to examine the impact of urbanization-induced activities on soil quality status in the

Port Harcourt metropolis, Rivers State using geo-spatial techniques. The following specific objectives guided the study. To:

(i) examine the impacts of urbanization-related activities on the soil pollution status of Port Harcourt Metropolis through laboratory analysis of soil samples;

(ii) find out the types of pollution-induced soil-borne diseases that are prevalent in the area;

(iii) ascertain the perceived effects of the diseases on the socio-economic development of residents of the study area.

(iv) produce geo-spatial maps of the soil pollution status of the area.

1.4 Hypotheses

The following hypotheses were postulated to direct the study:

H_1: Urbanization-related activities do not cause any significant change in soil-borne (soil pollution) and the emergence of certain soil borne diseases in the area.

H_2 there is no significant difference in the perceived effects of pollution-induced soil-borne diseases on the socio-economic lives of residents in the area.

1.5 The Study Area

Location and Extent

The present-day Port Harcourt metropolis is comprised of Obio/Akpor and Port Harcourt local government areas. It is located between latitudes 04^0 43′ and 04^0 57′ N and between longitudes 06^0 53′ and 08^0 08′ E. It is approximately 664 km^2 (i.e. Obalga 392 km^2 and Phalga 272 km^2). It is ever-expanding and has since exceeded its initial limits (of 25 km^2 in 1912) nearly 27 times. It is now made up of Obio/Akpor and Port Harcourt City Council Local Government Areas, with an increasing trend to engulf major parts of Ikwerre, Etche, Omuma, Oyibo, Eleme and Okrika local government areas, which are part of what is now called Greater Port Harcourt region. Its westward expansion is gradually sprawling to Emohua local government area. It shares a boundary with the following local government areas: it is bounded to the north by Ikwerre and Etche, north-east by Ecthe; to the south by Okrika; to the east by Oyigbo and Eleme; and to the west by Emohua and Degema.

Port Harcourt falls within the limits of the humid tropics. Its climate is predominantly tropical humid and is being influenced by land and sea breezes and the two

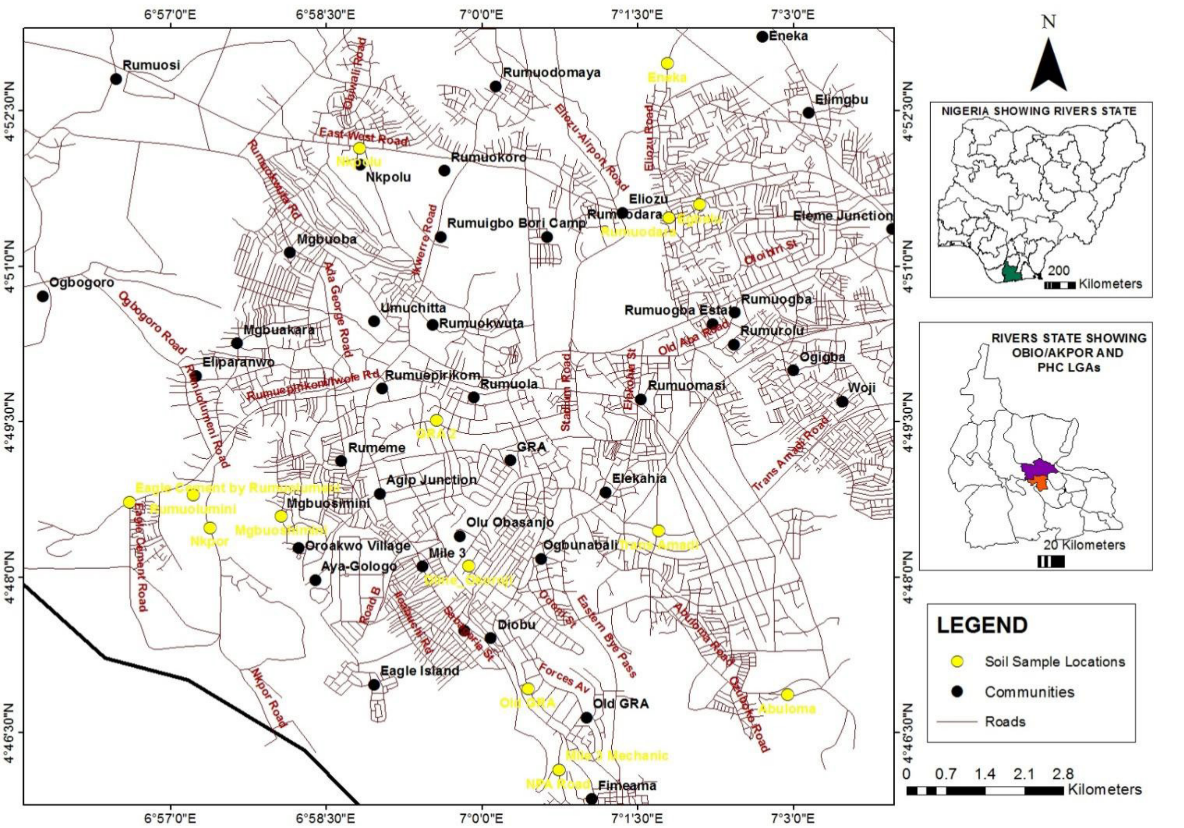

Figure 1. Port Harcourt Metropolis showing soil sampling points

Source: Researcher's field work and analysis, 2020 digitized from the original map, Ministry of Lands & Survey, Port Harcourt major pressure and wind system namely the South-West (S-W) and North –East (N-E) trade winds. The moist south-west trade wind originates over the South Atlantic Ocean and blows over Port Harcourt between the months of February to November, bringing the rains.

The north-east trade wind brings dry conditions having passed over the hot, dry Sahara desert to reach Nigeria from the north and blows over Port Harcourt between the months of November/ December and January /February of the year. These two wind systems meet at the Inter-Tropical Convergence Zone (ITCZ) when the contact is on land and Inter-Tropical Discontinuity (ITD) when the contact is over the ocean. The mean daily temperature does not exceed 32 ^oC, while the mean monthly maximum temperature is 33 ^oC, the mean monthly minimum temperature is 28 ^oC, mean annual temperature is 28 ^oC with an annual range of 3.08 ^oC. The humidity content in the area is 85%. Also, the intensity of the harmattan is very low mainly due to the nearness of the city to the moderating influences of the sea [1].

Ukpere in his study, revealed that, February has the highest intensity (5.68%) followed by January and December (5.50%). That, the effective temperature index (ET.) and wind chill index for the harmattan periods is not below 27% (mean E.T) in each month. Consequently, Port Harcourt is said to be less conducive during these periods of effective temperature index and wind chill index. The mean wind chill figures viz (20.29 K. 33.45 K, 63.21 K and 68.94 K) in January, February, November and December respectively reveal relatively low wind chill which has a small soothing effect on the high E.T of December to February which show slight higher variations. Rainfall in the area exhibits a double maxima regime with peaks in July and September with a little dry season in August (August break). The highest monthly rainfall of 3,496.1 mm and 3, 578.4 mm occurs in July and August respectively. The mean onset date of rainfall in Port Harcourt is 27 February while the end of the rains is 26th November; also, the mean length of the rainy season is 272 days [1].

About vegetation, there is hardly any vegetation in Port Harcourt apart from a few mangroves. This is because; the vegetation of the area is fast disappearing due to urban sprawl which has resulted in a functional succession and invasion (colonization) of the neigbourhood lands and reclamation of low/wetlands.

2. Methodology

Experimental and survey research designs were adopted for the study; utilizing both primary and secondary sources of data. The primary data which is the main focus of this study, were generated through laboratory analysis of soil samples collected from 15 different sites within the city and GIS soft wares (Arch GIS, Erdas imager, QGIS, etc), were deployed to produce GIS-based maps in order to showcase the spatial dimension of the level of occurrence of the various parameters in the soils of the area.

Man and his activities in any location are at the centre of environmental pollution across the globe. Thus, an increase in population causes a corresponding increase in land use activities. Apart from the main city center where different land use activities exist, there are over 30 fringe settlements located within and around Port Harcourt, where there are lots of urbanization-induced activities taking place. According to the National Population Commission (NPC, 2010), Port Harcourt's population as projected for 2010 was 1,146,721 while the total number of regular households was 298,180. At the national growth rate of 2.7%, the researchers projected the NPC 2010 population figures of 1,146,721 to 2020 which is 3,019,981 persons while an approximate number of regular households is 596,359 (based on the National average household size of 6 persons per household). However, the United Nations Global Urban Population estimates, put the population figure of the Port Harcourt metropolis to be 3,020,000 in 2020 [24].

However, through the use of a simple random sampling technique, a sample size of 800 respondents was used to gather basic socio-economic data regarding main economic activities, soil borne diseases arising from soil pollution, etc.

2.1 Soil Samples Collection and Analysis

Basic tools were implored for soil sample collection. These include calibrated meter rule, clean cellophane bags and small transparent rubber plates with cover, GPS, open auger, masking tape, bold-pen, hand trowel and shovel. The earth at each of the sites was dug out and soil samples were collected at 0-30 cm depths. Soil samples were collected from 15 randomly selected sites/areas prone to intense land-use activities like mechanic garages, motor parks, refuse disposal points, commercial and institutional centres. Each sample was appropriately labeled at the site before moving to the laboratory. Parameters examined included microbial and certain physicochemical parameters such as temperature, pH, Nitrogen, TOC, Phosphorus, Potassium, Lead, Iron, Calcium, Magnesium, and particle characterization. The 15 randomly selected sites/locations include: Egbelu, Mgbuosimini-Agip, Rumuekini, Rumuodara, Eneka, Nkpor, Eagle cement road-Rumuolumeni, East-West road by Nkpolu, Industry by NPA, Abuloma, Mile III mechanic village, Trans Amadi IA, GRA II, Old GRA by Forces Avenue, and D-Line.

2.2 Methods of Data Analysis

A simple percentage was used to analyze the questions which were framed in tandem with the objectives of the study which centred on basic social issues of the research. While the stated hypotheses were analyzed with one sample students' t-test and chi square at the 0.05 level of significance using SPSS.

3. Results and Discussion

Table 1. Urbanization-related Activities and Soil Pollution in Port Harcourt Metropolis

S/N	Statement: Urbanization-induced activities causes soil pollution in Port Harcourt	Frequency of Response				Total
		SA	A	D	SD	
1.	Obalga Freq.	300	87	08	05	**400**
	%	75	21.75	2	1.3	**100%**
2.	Phalga Freq.	304	72	14	10	**400**
	%	76	18	3.5	2.5	**100%**
Grand Total		**604**	**159**	**22**	**15**	**800**
Percentage		**75.5**	**19.8**	**2.8**	**1.9**	**100%**

Source: Researcher's Fieldwork and analysis, 2021

From Table 1, 75.5% of the respondents strongly agreed that urbanization-related activities cause soil pollution in the city, another 19.8% also agreed; 2.8% disagreed and another 1.9% others also strongly disagreed. Since the agreed responses (95.38%) are more than the disagreed responses (4.63%), the study therefore concluded that urbanization-induced activities cause soil pollution in the metropolis.

From Table 2, 48% of the respondents strongly agreed that urbanization-induced soil pollution causes the emergence of soil-borne diseases in the city. Another 45.6% of others also agreed; while 3% disagreed and another 3.4% others also strongly disagreed. Since the agreed responses (93.63%) are more than the disagreed responses (6.38%), the study therefore concluded that urbanization-induced soil pollution causes the emergence of soil-borne diseases in the metropolis.

Table 2. Urbanization-induced Pollution and the emergence of soil borne diseases in Port Harcourt Metropolis

S/N	**Statement:** Urbanization-induced Pollution causes the emergence of soil borne diseases in Port Harcourt	Frequency of Response				Total
		SA	A	D	SD	
1.	Obalga Freq.	200	183	10	07	**400**
	%	50	45.75	2.5	1.75	**100%**
2.	Phalga Freq.	184	182	14	20	**400**
	%	46	45.5	3.5	5	**100%**
Grand Total		**384**	**365**	**24**	**27**	**800**
Percentage		**48**	**45.6**	**3**	**3.4**	**100%**

Source: Researcher's Fieldwork and analysis, 2021

From Table 3, 3.1% of the soil-borne diseases occurred in January, 4.6% in February, March (14.8%), April (17.6%), May (14.2%), June (6.1%), July (4.4%), August (15.3%), September (8.9), October (5.5%), November (3.7%), and December (1.9). In terms of spatial spread, the dry season months of December have the least occurrence (1.9%) followed by January (3.1%) and November (3.7%). While the rainy season month of April has the highest rate of 17.6%, followed by August (15.3%) and May (14.2%). While most of the diseases occur during the rainy season months (which are also the peak period where microbial pollutants in the soil are spread in the area under the aid of the rains and poor sanitary conditions of most places), Ascaris lumbricoid and Trichuris trichiura thrives well in the soil of the area especially in the wet season months of April–August.

From Table 4, 52% of the 800 respondents strongly agreed that the emergence of pollution-induced diseases affects the socio-economic development of the people of the area, another 44.9% also agreed; 1.6% disagreed and another 1.5% strongly disagreed. Since the agreed responses (96.88%) are by far more than the disagreed responses (1.66%), the study therefore concluded that the emergence of the diseases affects households' socio-economic development in the study area.

3.1 Urbanization-related Landuse Activities that Pose Threat to Soil Quality in Port Harcourt Metropolis

An increase in urban population will result in an increase in land use or urbanization-related activities which in the long run, result in the tampering of the status of the soil around our urban centres Port Harcourt metropolis

Table 3. Hospital Records on common Soil-borne diseases often suffered by household members

Diseases	Reported cases (Monthly summary) 2019-2020													
	Jan 1	Feb 2	Mar 3	Apri 4	May 5	Jun 6	Jul 7	Aug 8	Sep 9	Oct 10	Nov 11	Dec 12	Total	%
Vascular witts	24	57	27	8	32	34	3	30	39	12	17	2	**285**	**13.0**
Strongloids stereoralis	11	12	23	42	33	45	34	38	47	39	2	-	**326**	**14.9**
Ascaris lumbricoids	18	19	172	183	123	27	30	137	58	38	31	20	**856**	**39.0**
Trichuris trichiura	14	13	102	153	123	27	30	131	50	32	31	20	**726**	**33.1**
Grand total	**67**	**101**	**324**	**386**	**311**	**133**	**97**	**336**	**194**	**121**	**81**	**42**	**2193**	
%	**3.1**	**4.6**	**14.8**	**17.6**	**14.2**	**6.1**	**4.4**	**15.3**	**8.9**	**5.5**	**3.7**	**1.9**		**100**

Source: Researcher's fieldwork 2020, compiled from Public Hospital/Primary Health Centres in the area, 2015-2020

Table 4. Perceived Socio-economic impacts of Pollution-induced diseases on households in the area

S/N	**Statement:** The emergence of the diseases/ illnesses affects the socio-economic development of your household	Frequency of Response				Total
		SA	A	D	SD	
1.	**Obalga**	204	184	05	07	**400**
2.	**Phalga**	212	175	08	05	**400**
Grand Total		**416**	**359**	**13**	**12**	**800**
Percentage		**52**	**44.9**	**1.6**	**1.5**	**100%**

Source: Researcher's Fieldwork and analysis, 2020

is not an exception. From our investigations, the main urbanization-induced land use activities that threaten soil quality in the Port Harcourt metropolis include: industrial manufacturing and processing activities, urban agriculture (use of agrochemicals), mechanic workshops, waste disposal activities, abattoir activities, etc. The various soil parameters examined in the work include pH, temperature, nitrate, phosphorus, lead, and potassium. In the analysis that follows, Figure 1 shows the soil sampling points while Figures 2 to 7 showcase the spatial occurrence of the various parameters in the soils of the area. While Table 5 summarizes the laboratory analytical report for the various parameters examined in the soils of the area.

3.2 Urban Land Use Activities and Spatial Variability of Soil Quality in Port Harcourt Metropolis

The spatial variability in soil quality of the area is presented in the table below and as displayed in the various GIS-based maps.

Method Source "American Society for Testing and Materials" (ASTM) 2010

"American Public Health Association" (APHA) 20th Edition 2005.

The spatial occurrence of the various parameters in the soils of the area is described below with the aid of GIS maps.

Table 5. Result of Laboratory Analysis for Soil Samples

S/N	Coordinates	Date/ Time	Sample ID	Depth (cm)	pH APHA 4500-H+	Temp APHA 2550-B	NO-3 APHA 4500-B mg/kg	PO4 APHA 4500-P mg/kg	Pb ASTM D3559 mg/kg	K ASTM D4192 mg/kg
	DPR								210	
1	N:04.76911º	9/11/21	Mile 3 Mech.	0-15	7.1	25.3	2.2	0.29	116.2	35.62
	E:007.01235º	1:45pm		15-30	7.1	24.7	6.3	0.47	118.0	38.45
2	N:04.81016º	10/11/21	Eagle Cem. Rd	0-15	6.6	25.8	0.0	0.03	99.63	86.90
	E:006.94325º	11:53am		15-30	6.8	25.3	0.5	0.15	104.5	98.22
3	N:04.80556º	10/11/21	Nkpor	0-15	7.3	25.5	0.8	0.03	<0.001	78.43
	E:006.95705º	12:05am		15-30	5.7	24.8	1.8	0.02	<0.001	80.12
4	N:034.84415º	10/11/21	Egbelu	0-15	5.9	25.1	0.3	0.00	91.48	86.42
	E:006.94042º	1:10pm		15-30	6.4	25.6	1.2	0.08	69.47	78.43
5	N:04.80264º	10/11/21	Mgbuoshimiri	0-15	6.8	25.5	0.6	0.24	46.81	76.42
	E:006.07278º	13:50pm		15-30	6.9	26.1	0.9	0.63	52.35	65.78
6	N:04.78116º	11/11/21	Abuloma	0-15	6.7	25.5	1.3	0.15	22.52	56.42
	E:007.04910º	10:30am		15-30	6.6	25.1	2.0	0.36	28.93	62.13
7	N:04.80752º	10/11/21	Trans Amadi	0-15	6.7	25.3	0.7	0.10	29.71	35.43
	E:007.02839º	10:41 am		15-30	7.7	25.8	0.9	0.40	30.94	40.13
8	N:04.78215º	12/11/21	Old GRA/	0-15	6.4	24.9	0.1	0.01	<0,001	74.12
	E:007.00735º	9:50am		15-30	6.5	25.1	0.1	0.01	<0.001	76.14
9	N:04.80187º	12/11/21	Dline/Okokoji	0-15	7.7	25.5	0.5	0.05	87.57	89.57
	E:006.99783º	11:05am		15-30	6.5	25.5	1.2	0.05	90.24	86.13
10	N:04.82536º	12/11/21	GRA II	0-15	6.2	25.6	0.7	0.08	45.76	56.35
	E:006.9927º	11:35am		15-30	6.4	25.6	1.3	0.17	50.08	55.48
11	N:04.86021º	13/11/21	Rumudara	0-15	7.8	25.1	0.4	0.16	198.5	80.56
	E:006.02929º	10:10am		15-30	6.9	25.0	0.8	0.38	209.1	80.44
12	N:04.88258º	13/11/21	Eneka	0-15	8.2	25.4	0.9	0.15	4.001	70.41
	E:006.03002º	10:30am		15-30	7.7	25.3	1.8	0.38	5.327	68.42
13	N;04.88256º	13/11/21	Rumuekini	0-15	7.0	25.5	1.3	0.26	119.0	62.80
	E:006.94113º	11:20am		15-30	6.2	25.4	2.6	0.41	144.5	64.78
14	N:04.86912º	13/11/21	Nkpolu	0-15	6.7	25.3	1.0	0.10	97.54	79.55
	E:006.9803º	12:16		15-30	6.3	25.4	1.2	0.28	26.82	80.45
15	N04.76911º	9/11/21	NPA Rd	0-15	6.6	25.6	0.1	0.00	63.37	32.46
	E007.01235º	10:55am		15-30	6.7	25.3	0.0	0.02	183.5	34.13

Source: Researcher's fieldwork and analysis, 2020

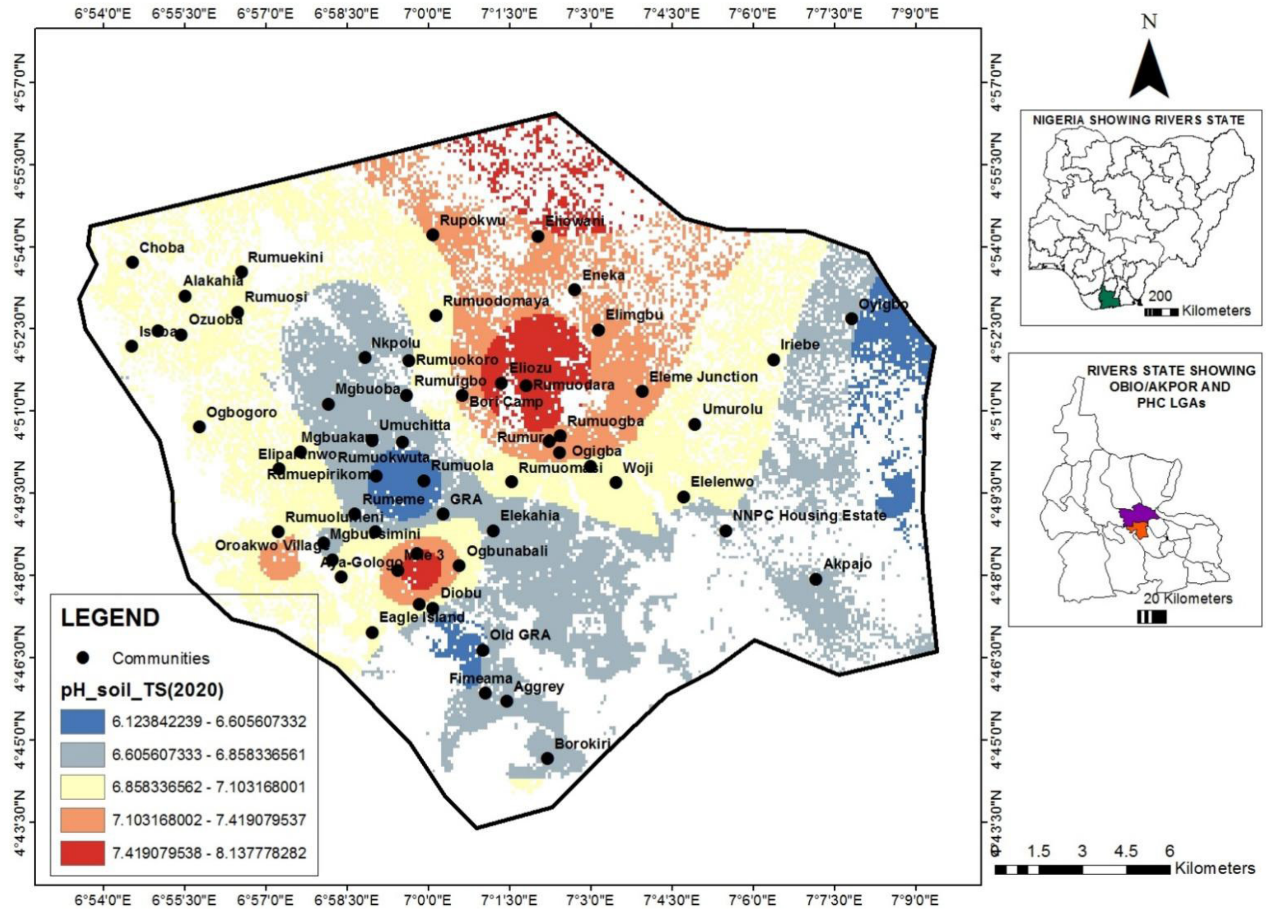

Figure 2. Port Harcourt Metropolis showing soil pH level

Source: Researcher's field work and analysis, 2020

pH level in the soil of the area ranges from 6.1 to 8.14; and a mean occurrence of 7.22 in 2020. In terms of spatial spread, soil pH ranges from 6.12 to 6.61 around the central part of Rumuola and north-east near Oyigbo; 6.61 to 6.86 in virtually all around the eastern and southern parts of the metropolis; 6.86 to 7.10 around the west, south-west, north-east and north-western parts of the area; 7.10 to 7.42 at the Diobu area and Ogbunabli, north and central spots. It ranges from 7.42 to 8.14 in the north-central part of the metropolis.

While some of the soils indicated alkaline, others were neutral and a few others acidic. pH value was 7.1 around Mile 3 mechanic village, 6.6 at the Eagle cement area, Abuloma, and NPA road; 7.3 at Nkpor; 5.9 at Egbelu; 6.8 at Mgboshimini Agip; 6.7 around Trans-Amadi; 6.4 around Old GRA/Forces Avenue; 6.5 in D/Line; 6.3 at GRA Phase 2; 7.7 around Rumuodara. The highest figure of 8.2 was recorded at Eneka while the least figure of 5.7 was recorded at Nkpor.

Soil temperature is almost the same across the metropolis. It ranges from 24.31 to 26.10 ^oC with a mean of 25.6 ^oC. Soil temperature ranges from 24.31 to 24.95 ^oC around the North Central, South-West, and south-Eastern parts; 24.95-25.39 ^oC around the entire west, north and eastern spots. The temperature rises from 25.0 to 25.58 ^oC mostly around the central, extreme northeast, and eastern flank. The highest values 25.57 to 26.10 ^oC occurs around the central spot near Elekahia and Ogbonabli and the western flank near Rumuolueni and Mgbuosimini. Some of the sites with the highest temperature values include Ogbuosimini (26.1 ^oC), Egbelu (25.6 ^oC), and Eagle cement area (25.3 ^oC). The least value was recorded at mile 3 mechanic village.

Phosphorous (PO_4) values range from 0.010 to 0.629 mg/L and a mean of 0.342 mg/L in 2020. PO_4 values are lower (0.0100 - 0.146mg/L) at the south around Diobu, Eagle Island and Fimeama; low (0.146 - 0.233 mg/L) at the extreme North-West, North-North, North-East, and eastern parts of the metropolis Moderate (0.233-0.294 mg/L) around the north, entire east; high (0.294-0.408 mg/L) at the centre and west of the metropolis; it is relatively very high (0.418-0.629 mg/L) west of the central bloc. Some

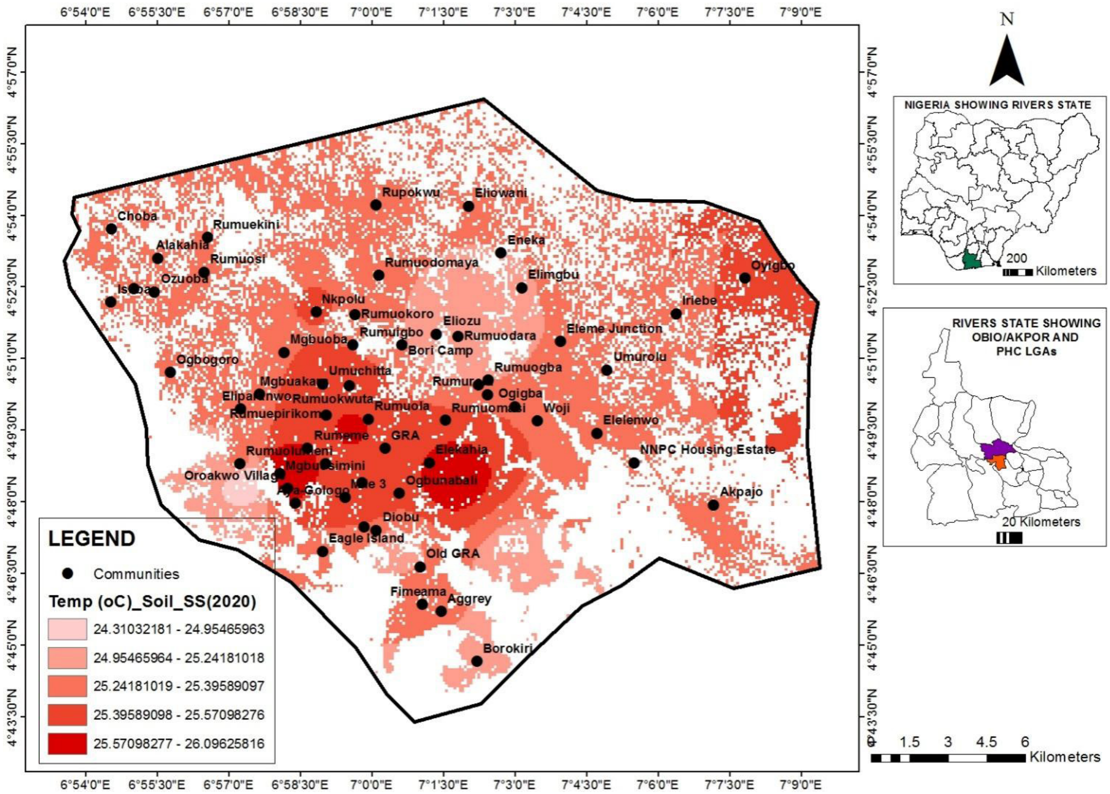

Figure 3. Port Harcourt Metropolis showing soil Temperature (^{o}C) level

Source: Researcher's field work and analysis, 2020

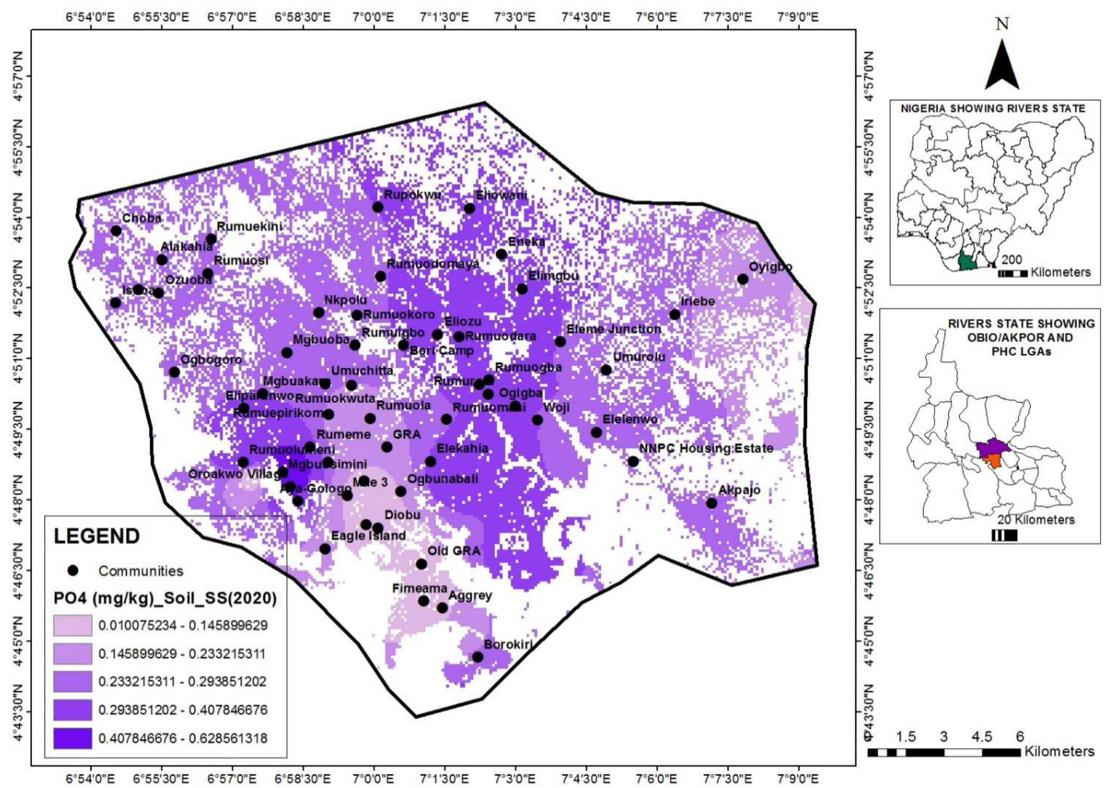

Figure 4. Port Harcourt Metropolis showing soil Temperature (^{o}C) level

Source: Researcher's field work and analysis, 2020 of the communities/sites with relatively very high soil temperature figures include Mgbuosimini-Agip (0.63 mg/L), mile 3 mechanic workshop (0.47 mg/L), Rumuolumeni (0.41 mg/L), Trans-Amadi 1. A (0.4 mg/L), Abuloma (0.38 mg/L), Rumuodara (0.38 mg/L) and Eneka (0.38 mg/L). Whereas some sites recorded the least values e.g NPA (0.02 mg/L), Nkpolu (0.10 mg/L), D/line (0.05 mg/L), GRA I (0.08 mg/L), Nkpor (0.02mg/L), Egbelu (0.08 mg/L), etc.

Lead (Pb) occurrence level in the soils ranges from 0.075-208.90 mg/kg and a mean of 120.62 mg/kg for the 15 sampled sites in the area. At the moment (2020), Pb values range from 0.074-56.58 mg/kg west of the north-central, south-central around Ogbunabali and Eastern-by-pass; 56.58-79.51 mg/kg in most places stretching from north-west, west, north-north, and east in a ring of 79.51-108.17 mg/kg at the north-central and down south-south of the metropolis surrounding Borokiri and near Orakwo village at the western flank. It is within the range 108.17-149.94 mg/kg at the north-central and south around Aggrey and Finema.

Urbanization-induced land use activities (agriculture, mechanic workshops, industries, refuse disposal, etc.) can either cause an increase or lowering of the amount of Potassium in the soil. When it is low, it affects crop yield and when it is in excess, it results in pollution; and under the influence of surface run-off, it is watched into streams thus polluting surface water. The level of Potassium in the soil of the metropolis ranges from 34.19 to 89.57 mg/kg with a mean occurrence level of 66.81 mg/kg. The figures are higher (65-89 mg/kg) around the west, north and north-eastern parts; and low (50-55 mg/kg) around the east and southern parts; very low (34-50 mg/kg) around the most central part of the south.

Nitrates level ranges from 0.001 to 3.30 mg/L with a mean of 1.65 mg/kg. The level of nitrates varies across the 15 sampling points of the areas. At the extreme eastern, western and south-western area, the values range from 0.00 to 0.68 mg/kg; 0.68 to 1.11 mg/kg at the centre around Eliozu, Rumuodara, Bori camp, and Oginigba, also at the west near eagle island, southern communities of Aggrey, old GRA;1.11 T0 1.38 mg/kg around most of the north, east, and west flank; 1.38 to 1.81 mg/kg at the west, east

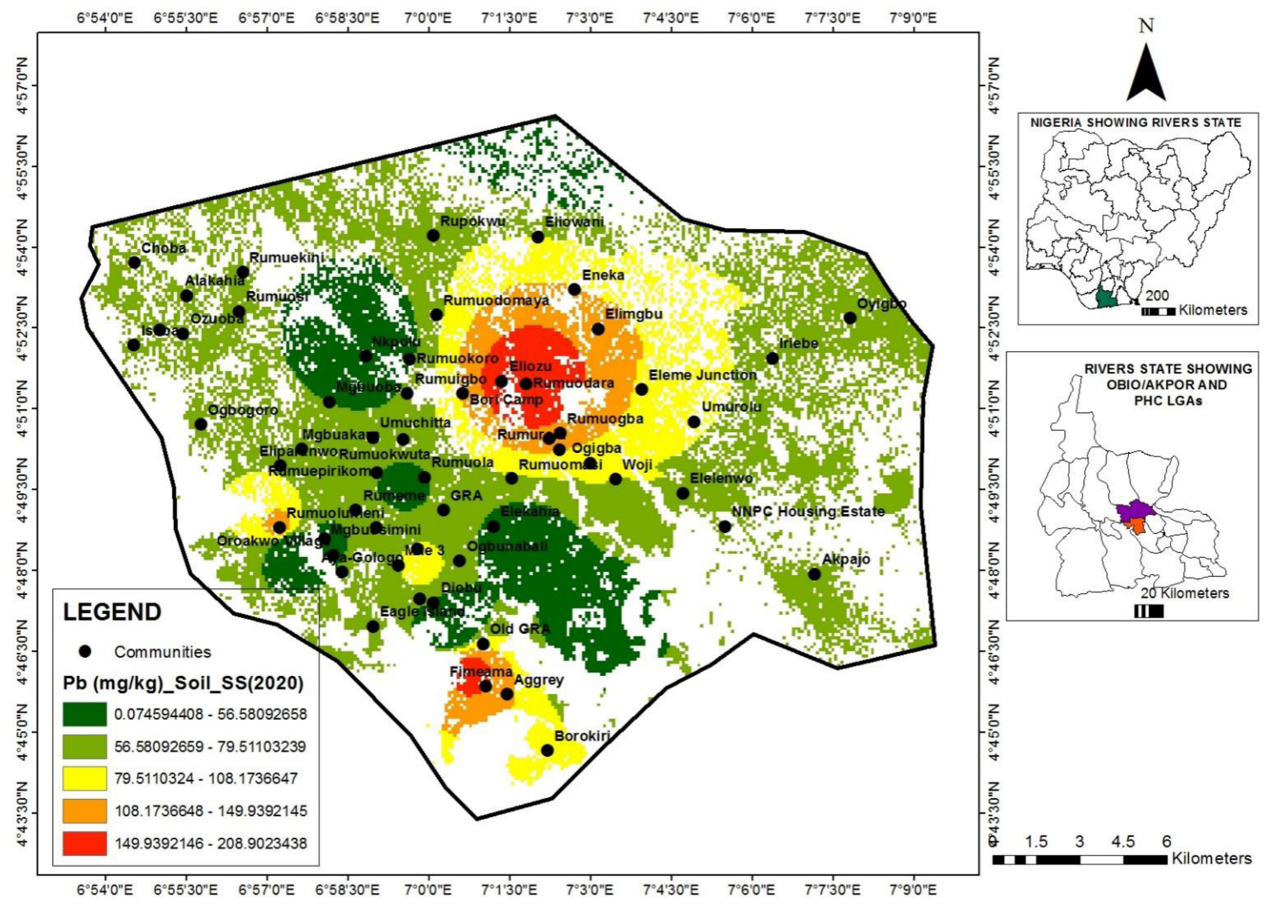

Figure 5. Port Harcourt Metropolis showing soil Lead (Pb) (^oC) level

Source: Researcher's field work and analysis, 2020

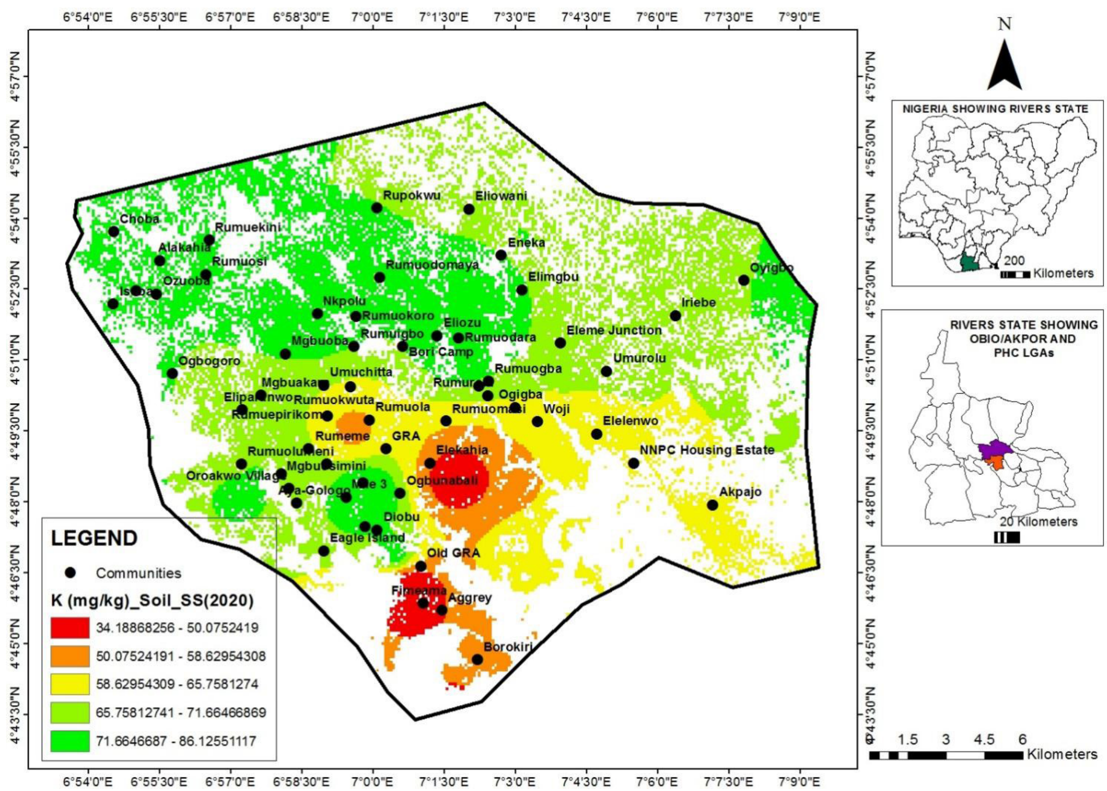

Figure 6. Potassium (mg/kg) Concentration (ug/m^3) in the soils of Port Harcourt Metropolis

Source: Researcher's fieldwork and analysis, 2020

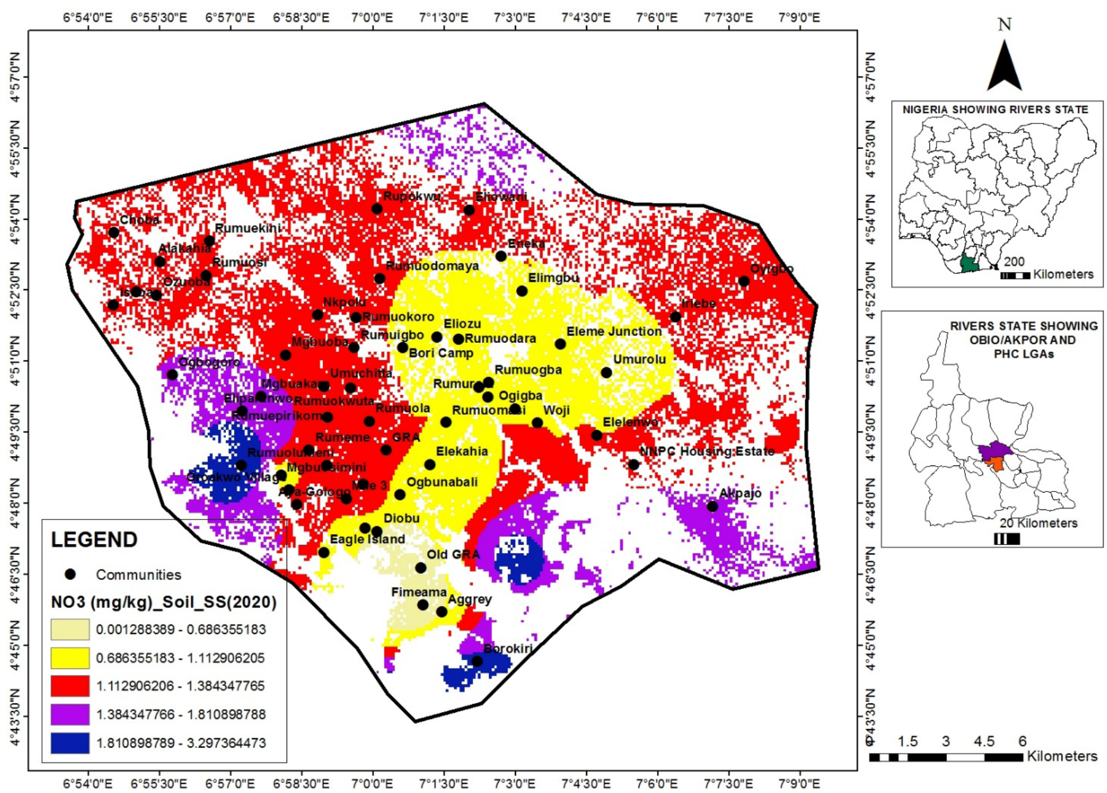

Figure 7. Nitrates (mg/kg) Concentration (ug/m^3) in the soils of Port Harcourt Metropolis.

Source: Researcher's fieldwork and analysis, 2020 and south-eastern bloc; and between 1.8 to 3.30 mg/kg around the extreme south of the metropolis.

One striking fact about the soil analysis is that, in almost the 15 sampled points, most of the parameter values increase with an increase in depth from 0-15 and 15-30 cm. For example, while pH (7.1) was the same for mile 3 mechanic workshops, NO_3 in 2020 increased from 2.2 mg/kg (at 0-15 cm depth) to 6.3 mg/kg (at 15-30 cm depth). PO_4 rose from 0.29 mg/kg (0-15 cm) to 0.47 mg/kg (15-30 cm); Pb increased from 116.2 mg/kg (0-15 cm) to 118 mg/kg (15-30 cm), K rose from 35.62 mg/kg (0-15 cm) to 38.45 mg/kg (15-30 cm).

3.3 Hypotheses Testing

Ho_1: urbanization-related activities do not cause any significant change in the soil quality of the Port Harcourt metropolis between 2000-2020.

This hypothesis seeks to establish the impacts of urbanization-related activities on soil quality (cause and effect) in the area hence, a one-sample t-test was applied to the mean values of the parameters of the data in Table 5 (laboratory results for soil sample analysis).

Detail of the calculation is in the appendices while a summary of the result is presented here below.

Table 6. Summary of t-test calculation for Ho_1

t-cal.	Df	Sign. Level	t-critical	Decision
2.91	5	0.05	2.57	$_Ho_{1.}$ Rejected

From Table 6 above, at the degree of freedom of 5, the calculated *t* was 2.91 while under the 0.05 significance level, the critical *t* is 2.57. Hence, the null hypothesis which stated that urbanization-related activities do not cause any significant change in the soil quality of the metropolis is hereby rejected while upholding the alternate hypothesis. This implies that urbanization-related activities cause significant changes in the quality of the soil in the area.

Ho_2: there is no significant difference in the perceived effects of pollution-induced soil-borne diseases on the socio-economic lives of residents in the area.

This hypothesis seeks to establish if there is any significant difference in the perceived effects of pollution-induced soil-borne diseases on the socio-economic lives of residents in the area hence, the one-sample chi square statistical tool was applied to the data.

A detail of the computation is presented in the appendices section while a summary is presented here below.

Table 7. Summary of x^2 calculation for Ho_2

Cal. x2	Df	x2-critical	Sign. Level	Decision
711.26	3	7.81	0.05	Ho_3 Rejected

From Table 7, the calculated x^2 of 711.26 is by far greater than the x^2 critical value of 7.81 under a degree of freedom 3 of the 0.05 significance level hence, the null hypothesis which stated that there is no significant difference in the perceived effects of pollution-induced soil-borne diseases on the socio-economic lives of residents of the area is hereby rejected while the alternate hypothesis is upheld. In conclusion therefore, there is significant variation in the perceived effects of the diseases on the socio-economic lives of the people of the area.

4. Discussion of Findings

4.1 Urbanization-induced Activities and Soil Pollution in the Area

Objective 1: To examine the impacts of urbanization-induced land use activities on the soil quality status of Port Harcourt Metropolis

The result of the laboratory analysis indicated that certain land use activities (e.g. mechanic workshops, waste dumpsites) affect soil quality in the area. The pH level in the soil of the area ranges from 6.1 to 8.14 and has a mean occurrence of 7.22. While some of the soils indicated alkaline, others were neutral and a few others were acidic. In terms of spatial spread, soil pH value was 7.1 around Mile 3 mechanic village, 6.6 at the Eagle cement area, Abuloma, and NPA road; 7.3 at Nkpor; 5.9 at Egbelu; 6.8 at Mgboshimini Agip; 6.7 around Trans-Amadi; 6.4 around Old GRA/Forces Avenue; 6.5 in D/Line; 6.3 at GRA Phase 2; 7.7 around Rumuodara. The highest figure of 8.2 was recorded at Eneka while the least figure of 5.7 was recorded at Nkpor. Soil temperature is almost the same across the metropolis. It ranges from 24.31 to 26.10 °C with a mean of 25.6 °C. The highest values 25.57 to 26.10 °C occur around the central spot near Elekahia and Ogbonabli and the western flank near Rumuolueni and Mgbuosimini. Some of the sites with the highest temperature values include Ogbuosimini (26.1 °C), Egbelu (25.6 °C), and Eagle cement area (25.3 °C). The least value was recorded at mile 3 mechanic village.

Phosphorous (PO_4) values range from 0.010 to 0.629 mg/L and a mean of 0.342 mg/L. Some of the communities/sites with relatively very high figures include Mgbuosimini-Agip (0.63 mg/L), mile 3 mechanic workshop (0.47 mg/L), Rumuolumeni (0.41 mg/L), Trans-Amadi 1. A (0.4 mg/L), Abuloma (0.38 mg/L), Rumuodara (0.38 mg/L) and Eneka (0.38 mg/L). Whereas some sites recorded the least values e.g NPA (0.02 mg/L), Nkpolu (0.10 mg/L), D/line (0.05 mg/L), GRA I (0.08 mg/L), Nkpor (0.02 mg/L), Egbelu (0.08 mg/L), etc.

Lead (Pb) mean occurrence level in the soils of the area is 120.62 mg/kg. Pb values range from 0.074-56.58 mg/kg west of the north-central, south-central around Ogbunabali and Eastern-by-pass; 56.58-79.51 mg/kg in most places stretching from north-west, west, north-north, and east in a ring of 79.51-108.17 mg/kg at the north-central and down south-south of the metropolis surrounding Borokiri and near Orakwo village at the western flank. It is within the range 108.17-149.94 mg/kg at the north-central and south around Aggrey and Finema.

The level of Potassium in the soil of the metropolis ranges from 34.19 to 89.57 mg/kg with a mean occurrence level of 66.81 mg/kg. The figures are higher (65-89 mg/kg) around the west, north and north-eastern parts; and low (50-55 mg/kg) around the east and southern parts; very low (34 – 50 mg/kg) around the most central part of the south. Nitrates level ranges from 0.001 to 3.30 mg/L with a mean of 1.65 mg/kg. At the extreme eastern, western and south-western areas, the values range from 0.00 to 0.68 mg/kg; 0.68 to 1.11 mg/kg at the centre around Eliozu, Rumuodara, Bori camp, and Oginigba, also at the west near eagle island, southern communities of Aggrey, old GRA;1.11 T0 1.38 mg/kg around most of the north, east, and west flank; 1.38 to 1.81 mg/kg at the west, east and south-eastern bloc; and between 1.8 to 3.30 mg/kg around the extreme south of the metropolis.

One striking fact about the soil analysis is that, in almost the 15 sampled points, most of the parameter values increase with an increase in depth from 0-15 and 15-30 cm. For example, while pH (7.1) was the same for mile 3 mechanic workshops, NO_3 in 2020 increased from 2.2 mg/kg (at 0-15 cm depth) to 6.3 mg/kg (at 15-30 cm depth). PO_4 rose from 0.29 mg/kg (0-15 cm) to 0.47 mg/kg (15-30 cm); Pb increased from 116.2 mg/kg (0-15 cm) to 118 mg/kg (15-30 cm), K rose from 35.62 mg/kg (0-15 cm) to 38.45 mg/kg (15-30 cm).

It is pertinent to state here that the result of the tested hypothesis ($Ho_{.2}$) revealed that urbanization-related activities cause significant changes in the soil quality of the area. This study was able to examine the potential impacts of urbanization-related activities on soil quality within the metropolis. From the study, the soil quality of those areas nearer to waste dumpsites (e.g. Eagle cement road, Woji, East-west road axis of Rumuosi-Rumuekini and Alakahia, Mile 3 mechanic area, etc.) have higher values than the samples from other sites. Again, the soil structure and texture of the samples from those areas with heavy urban activities are looser and smaller in size than those at the fringes of the metropolis.

The finding of this objective is in line with earlier studies by Narayanan (2011) in his work "*environmental pollution: principles, analysis and control";* Ottoh (2019) in his study of "*the impact of deforestation on soil physicochemical properties in Andoni Local Government Area of Rivers State",* noted that deforestation as a land use activity exposes the soil to the works of erosion and denudation and this results in changes in soil physicochemical properties; and Jaja (2020) in her work on *"the impacts of deforestation and soil physicochemical parameters in Ukwa East Local Government Area of Abia state",* also noted that soils in forested areas are richer in soil nutrient and are of better quality than those from deforested lands.

4.2 Urbanization-induced Activities and Emergence of Soil Borne Diseases in the Metropolis

Objective 2: To find out the pollution-induced soil borne diseases that are prevalent in the area

This objective was also achieved. The study was able to determine the various pollution-induced diseases prevalent in the area, and their perceived effects on the socio-economic development of the people of the area. From the interactions with the residents and available hospital records, the commonest soil-borne diseases in the area include vascular witts (13%), Strongyloides stereoralis (14.9%), Ascaris lumbricoid (39%) and Trichuris trichiura (33.1%). Although, the occurrence of soil-borne diseases in the area does not pose a severe threat to public health like water-related and airborne diseases, it is important to checkmate their occurrences because of their potential effect on the socio-economic development of the people. The finding of this objective is in line with the works of Narayanan (2011) in his work "*environmental pollution: principles, analysis and control"; and Amadi* (2016) in his study on *disease burden and access to health care in Emohua and Ikwerre Local Government Areas of Rivers State.*

4.3 Perceived Effects of Emergence of Soil Borne Diseases in the Metropolis

Objective 3: To find out the perceived effects of the pollution-induced soil-borne diseases on the socio-economic development of the people of the area

Objective three was also actualized as the study was able to opine that the emergence of diseases in the area posed a significant threat to public health. It affects the socioeconomic lives of the people. However, the result of the tested hypothesis (Ho_2) revealed that there is a significant difference in the perceived effects of pollution-induced diseases on the socio-economic development of the people of the area. The people waste time and resources (hard-earned income) treating ailments (especially, protracted sicknesses); and this affects their productivity and economic development. The finding of this objective corroborates with earlier postulations by other researchers. For instance, Amadi postulated that the poor environmental condition of most surroundings in Ikwerre Local Government Area leads to the emergence of soil-borne diseases [25].

4.4 Production of GIS-based Maps

Objective four was also achieved. The study was able to produce geo-spatial digitized maps of the soil pollution status of the area using GIS as shown in Figures 2 to 7. It is therefore one of the first attempts with a holistic overview of soil pollution in the area.

5. Conclusions

The study was able to do justice to all the stated specific objectives as they were all achieved; and the key findings were in line with previous studies. Urbanization-induced land use activities are causing significant changes in the soil quality of the area. The main urbanization-related land use activities causing changes in the quality of the soil of the area include: industrial manufacturing and processing, urban agriculture, domestic, mechanic workshops, soil waste disposal activities. Soil pollution causes the emergence of certain soil-borne diseases such as vascular witts, Strongloids stereoralis, Ascaris lumbricoid and Trichuris trichiura. These soil pollution-induced diseases affect the socioeconomic development of the people of the area. Based on the tested hypotheses, the stated null hypotheses were rejected at the 0.05 significant level of the chi square and t-test statistical tables. Specifically, urbanization-induced land use activities affect the quality of the soil of the metropolis (Ho_1); and there is a significant difference in the perceived effects of the diseases on the socioeconomic well-being of the people of the area (Ho_2). The laboratory results of the soil analysis revealed thus (mean values): pH 7.22, temperature 25.62 ^oC, PO_4 0.342 mg/kg, Pb120.62 mg/kg, K 66.81 mg/kg, NO_3 mg/kg.

Based on the findings of the study, the researchers concluded by recommending thus:

1) The state government should help in the enforcement of physical planning and development control laws; as well as imposing heavy taxes on developers to curtail the rate of outward growth the as well as an attempt to re-direct development to other parts of the state;

2) To reduce the impacts of urbanization-related activities on the soil quality of the area, all relevant Agencies of government should ensure proper monitoring of land use activities including regular evaluation of the quality of the soil of the area;

3) Both government and the organized private sector should collaborate especially in the adoption and implementation of proactive measures and strategies aimed at controlling soil pollution in the metropolis such as restriction of certain land use activities which threaten soil quality to certain locations and under strict supervision (e.g. mechanic workshops, waste dumpsites, mineral mining and other industrial activities).

Limitations to the Study

The study was limited by a number of factors nevertheless. These limitations did not pose any serious effect on the outcome of the investigations as adequate precautions were taken to curb their effects. These limitations include funding of elaborate and comprehensive experimentations and wider scope; time factor; bureaucratic bottlenecks and secrecy on data gathering from hospitals and government ministries; etc.

Areas for Further Research

It is our suggestion, that there should be an expanded study to cover if possible, the entire urban space of Port Harcourt to include all the fringe areas as well as commercial/market centres, hospital premises, institutions, etc. Again, the government should fund a comprehensive study to include water, air, noise and other environmental factors around the metropolis.

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