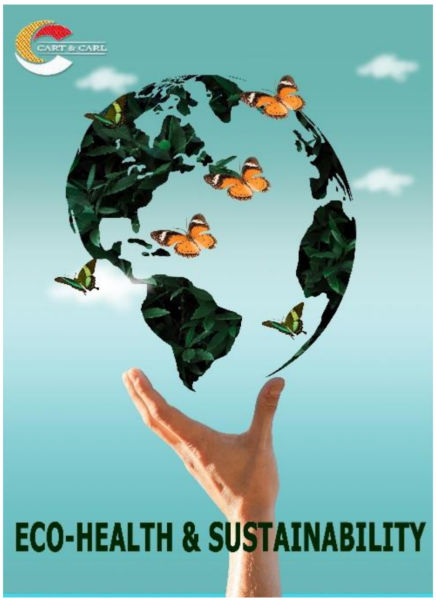
Original Research

Eco-Health And Sustainability
https://cartcarl.com/journal/eco-health-and-sustainability

E-ISSN: 0331-8516



Assessment of Air Pollutants Concentration around Port Harcourt Metropolis, Rivers State, Nigeria

Authors

[a]Ugwa, C.D.*, [ab] Adesope, O.M., [ac] Numbere, A.O.

[a] Institute of Natural Resources, Environment and Sustainable Development, University of Port Harcourt, Port Harcourt, Nigeria
[b] Department of Agricultural Economics and Extension, University of Port Harcourt, Port Harcourt, Nigeria
[c] Department of Animal and Environmental Biology, University of Port Harcourt, Port Harcourt, Nigeria

Corresponding Author
Ugwa, C.D
(deborahugwa89@gmail.com)

Received: 22 October 2024
Accepted: 04 November 2024
Published: 18 November 2024

Citation
Ugwa, C.D., Adesope, O.M., Numbere, A.O. (2024). Assessment of Air Pollutants Concentration around Port Harcourt Metropolis, Rivers State, Nigeria. Eco-health and Sustainability, 1(1), 69-74.
https://doi.org/10.70726/ehs.2024.101006

Abstract

Air quality monitoring and management remain important to environmental sustainability and public health issues. The study assessed the air pollutants concentration around Port Harcourt metropolis, Rivers State, Nigeria. Based on human-related activities peculiar to different locations in the metropolis, Slaughter-Trans Amadi (STA), Refinery-Eleme Junction (REJ) and Petrochemical-Akpajo Junction (PAJ) were selected for the study. Air pollutants such as nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), particulate matter (PM_1, $PM_{2.5}$, PM_{10}), Hydrogen sulphide (H_2S), Methane (CH_4), Ammonia (NH_3), Ozone (O_3), Carbon IV oxide (CO_2) were assessed during the morning (8:30 am - 11:30 am) and evening (4:15 pm - 7:15 pm) hour in the of May to July 2024 using Aeroqual 500 Multi-Gas Analyzer, with up-to-date calibration. The mean concentration of NO_2 (0.01ppm), SO_2 (0.02ppm), H_2S (0.22ppm), O_3 (0.13ppm) and CO (0.28ppm) are within the WHO-AQG limit for individual pollutants while the mean concentration of CH_4 (29.33ppm), $PM_{2.5}$ (17.00ppm), PM_{10} (56.02ppm) and TVOC (8.46ppm) was highest in the morning period of May while the concentration exceeded the WHO-AQG limit. The concentration and trend of PMs concentration indicates anthropogenic influence. There is a need for strict and appropriate vehicle emission management, industrial air pollution control, and close burning management of wastes to reduce the risks associated with these pollutants.

Keywords : Air Quality, Air Pollutants, Particulate Matters, Port Harcourt, Rivers State

Introduction

Air pollution releases chemicals, particulate matter, or biological substances that result in adverse effects or discomfort to humans, other living organisms, or the natural and constructed environment. This occurs when these substances are introduced into the atmosphere (Osaiyuwu and Ugbebor, 2019). The atmospheric environment is very susceptible to many forms of pollution caused by three factors: global warming, depletion of the ozone layer, and, primarily, local air pollution (Komolafe et al., 2014). The latter, primarily caused by human activities such as burning coal, releasing vehicle emissions, and generating dust from roadworks and building sites, significantly contribute to the changes in air pollution levels over time and space (Mao et al., 2022). As a result, the air quality has drastically worsened, and the overall environment is highly contaminated (Osaiyuwu and Ugbebor, 2019). Besides the direct impact of emission sources, air pollution is strongly linked to meteorological conditions. Consequently, anthropological change affects the concentration of air pollutants (Ingole et al., 2022; Leão et al., 2023).

Anthropological change can impact precipitation, air circulation, temperature, radiation levels, and ventilation. Among the pollutants, particulate matter and ozone are particularly vulnerable to anthropological change (Kinney 2021; Leão et al., 2023).

Research has shown that the city experiences air pollution from various sources, including emissions from vehicles (Okonkwo et al., 2014; Zagha & Nwaogazie, 2015), burning of vegetation, combustion of biomass, emissions from petrochemical plants, industrial emissions (Tawari & Abowei, 2012), flaring of petrol, explosions of oil pipelines (Jack et al., 2016), and illegal activities such as oil bunkering and artisanal refinery (Zibima, 2015; Jack & Zibima, 2020). The study of anthropological change effects in urban settings has recently gained significant importance and urgency (Jiang et al., 2017; Coelho et al., 2022). During a five-year evaluation conducted by the World Health Organisation (WHO) from 2008 to 2013, four major Nigerian cities were among the top 20 most polluted cities in the world regarding the average annual concentration of PM10, which refers to particle pollution in the air. Onitsha exhibited the highest pollution level among cities, surpassing the World Health Organization's recommended yearly mean of $20gm^{-3}$ by 30, as documented by Yakubu (2018) and Echendu et al. (2022). The extensive industrial and socio-economic operations concentrated in Port Harcourt render it susceptible to several types of environmental contamination, notably air pollution, which the city's inhabitants must endure daily. Therefore, air quality monitoring and management remain important to environmental sustainability. The study assesses the air pollutants concentration around Port Harcourt metropolis, Rivers State, Nigeria.

Materials and Method

Study Area

Port Harcourt is the capital of Rivers State. It is the main city in the state and has one of the largest seaports in the Niger Delta region of Nigeria. It is the hub of the state's industrial, commercial, administration, and other activities. The city lies between latitude 04^0 43' and 04^0 57' North of the Equator and between 06^0 53' and 07^0 08' East of the Greenwich Meridian. The city is surrounded by patches of islands and creeks of the Niger Delta, such as the Dockyard Creek, Bonny River and Amadi Creek, at a height of about 12m above sea level. It is approximately 60km from the crest upstream of the Bonny River and covers an estimated 1811.6 km^2. The city is bounded to the north by Oyigbo and Etche Local Government Areas, to the south by Okrika Local Government Area, to the east by Okrika and Eleme Local Government Areas and to the west by Emohua Local Government Area (Obafemi, 2006).

Sample Collection

The samples were collected during the morning (8:30 am—11:30 am) and evening (4:15 pm—7:15 pm) hours from May 2024 to July 2024, while designated points were randomly selected based on various human activities associated with the area. The areas selected for the study include Slaughter-Trans Amadi (STA), Refinery-Eleme Junction (REJ), and Petrochemical-Akpajo Junction (PAJ).

i *Micro Climatic Parameters*: The parameters include wind speed (WS), air temperature (^{0}C) and relative humidity (RH). A Digital Anemometer (Taylor wind scope) measured the WS in meters per second (m/s). A hand-held digital thermometer measured the air temperature in degrees Celsius (^{0}C). A logger (Testo 450) was used to determine the relative humidity. The logger has an atmospheric pressure probe (Barometer) and a relative humidity probe (Hygrometer). The logger measures and stores the value in percentage (%).

ii *Air Quality Parameters*: Sampling and measurements of the chemical constituents of atmospheric pollutants were measured in-situ with hand-held air quality monitors. Ambient air quality measurements were carried out on site using Aeroqual 500 Multi-Gas Analyzer, with up-to-date calibration. The Aeroqual handheld monitors are specifically designed to give accurate ambient gas measurement, with a dedicated sensor per parameter. The parameters measured include nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), particulate matter PM_{10}, $PM_{2.5}$, Hydrogen sulphide (H_2S), Methane (CH_4), Ammonia (NH_3), Ozone (O_3), Carbon IV oxide (CO_2).

Data Analysis

The study adopted descriptive statistics in mean value, and the findings were presented using tables. Aside from the tabular representation of findings, the study also used graphs and charts to summarise and describe findings in a manner that better understood their attributes, differences, and patterns. Also, the concentration of the pollutants was compared with the World Health Organisation Air Quality Guideline (WHO-AQG) of 2018 (WHO, 2018).

Result and Discussion

The concentrations of air pollutants across the months (May to July) were assessed in the morning and evening at designated points in selected locations; the outcome was presented in Table 1, and the mean concentration was presented in Table 2. . The NO2, SO_2, and H_2S concentrations reported across the month were 0.01 ppm, 0.02, and 0.22, respectively, and within the WHO-AQG limit. .

Table 1: Air Pollutants Concentration Across Months and Selected Locations

	May						June						July					
	Slaughter		Refinery		Petrochemical		Slaughter		Refinery		Petrochemical		Slaughter		Refinery		Petrochemical	
	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E
NO_2	0	0.012	0.013	0.014	0.026	0.012	0.002	0.003	0	0	0.013	0.011	0.001	0.007	0	0	0.012	0.011
SO_2	0	0	0	0	0	0	0	0	0	0	0.045	0	0	0	0	0	0.044	0
H_2S	0.03	0.13	0.35	0.13	0.29	0.19	0	0	0	0	0	0	0	0	0	0	0	0
CH_4	44	24	26	17	18	17	5	5	5	4	5	4	6	4	6	5	6	3
O_3	0.16	0.13	0.14	0.13	0.1	0.13	0.1	0.12	0.15	0.16	0.11	0.1	0.14	0.11	0.14	0.18	0.11	0.1
CO	0	1.8	0	0	0.5	0.2	0	0	0	11	0	0	0	0.9	0	12	0	0
CO_2	0	0.02	0.03	0	0.02	0	0	0.01	0.01	0.8	0.01	0	0	0.01	0.01	0.83	0.01	0
PM_1	0.05	0	0.016	0.03	0.03	0.08	11	5	3	6	6	0.02	7	2	4	9	6	0.02
$PM_{2.5}$	23	0.1	23	0.04	5	0.1	19	8	12	23	8	5	20	0.03	11	20	9	5
PM_{10}	17	0.15	151	5	0.05	0.56	22	19	9	23	12	0.5	14	0.17	8	22	12	0.5
TVOC	0.33	0.11	25	0.03	0.05	0.12	0.036	0.067	0.053	0.002	0.144	0.13	0.33	0.08	0.054	0.002	0.142	0.13
RH	65	69	67	66	63	66	79	72	67	71	62	60	65	64	67	71	62	60
WS	0.2	0.1	1.6	0	2.6	0	0.3	0.2	0.4	0.3	0.4	0.1	0.4	0.2	0.3	0.5	0.4	0.1
NOISE	67.1	58.8	58	73.3	56.5	52.5	70.7	74.2	69	76	55	51.3	70.1	62.8	68	78.3	56.5	50.2
Temp.	-	-	-	-	-	-	28	29	28	28	29	31	31	33	29	28	31	30

M:Morning, E: Evening

All parameters readings are ppm except PM and TVOC in μg/m^3, RH in %, WS in m/s and Noise in DB

Table 2: Mean Concentration of Air Pollutants Across the Months

	May		June		July		
	Morning	Evening	Morning	Evening	Morning	Evening	WHO
NO_2	0.01	0.01	0.01	0.00	0.00	0.01	25
SO_2	0.00	0.00	0.02	0.00	0.01	0.00	40
H_2S	0.22	0.15	0.00	0.00	0.00	0.00	42
CH_4	29.33	19.33	5.00	4.33	6.00	4.00	
O_3	0.13	0.13	0.12	0.13	0.13	0.13	100
CO	0.00	0.67	0.00	3.67	0.00	4.30	4
CO_2	0.02	0.01	0.01	0.27	0.01	0.28	
PM_1	0.03	0.04	6.67	3.67	5.67	3.67	
$PM_{2.5}$	17.00	0.08	13.00	12.00	13.33	8.34	15
PM_{10}	56.02	1.90	14.33	14.17	11.33	7.56	45
TVOC	8.46	0.09	0.08	0.07	0.18	0.07	0.5
RH	65.00	67.00	69.33	67.67	64.67	65.00	
WS	1.47	0.03	0.37	0.20	0.37	0.27	
NOISE	60.53	61.53	64.90	67.17	64.87	63.77	
Temp	-	-	28.33	29.33	30.33	30.33	

The reported concentration of NO_2 in this study was lower than that reported by Gobo et al. (2012) around the living environment and Njoku et al. (2016) around road traffic points. According to Giunta (2020), vehicle exhaust emission is recognised to amplify the atmosphere's NOx level. The concentration of SO_2 reported is lower than those reported by Onwuna et al. (2022) around an environment where artisanal refinery activities are taking place and Gobo et al. (2012) around the living environment. As suggested by Ipeaiyeda and Adegboyega (2017), breathing in SO2 is linked to heightened respiratory symptoms and illness, impaired breathing, and untimely mortality. The air pollutant H_2S was undetected in June and July, and the reported concentration was lower than those reported by Osaiyuwu and Ugbebor (2019) for oil communities but higher than those reported by Gobo et al. (2012). The primary source of H_2S is the microbial decay of organic matter and the reduction of sulphate ions, which causes respiratory tract irritation and damage to the central nervous system (Gobo et al., 2012).

The highest concentration of CH_4 was reported in May, while slaughter showed the highest concentration at 44 ppm during May. The CH_4 reported for the study was lower than those reported by Osaiyuwu and Ugbebor (2019) for oil facilities hosting communities. Also, the CH_4 reported by Akhionbare et al. (2020) in their study was higher than those reported in the present study. Osaiyuwu and Ugbebor (2019) suggested that a high concentration of CH4 is unhealthy for the public. The pollutants O_3 was detected across the months and locations at a mean concentration of 0.13 ppm during May, 0.12 ppm and 0.13 ppm during June, and 0.13 ppm during July. The concentrations reported are within the WHO-AQG, while the reported concentrations are within the range of those reported by Akhionbare et al. (2020) for locations with similar attributes to the study area. Also, the reported concentration was lower than those reported by Onwuna et al. (2022) around an environment where artisanal refinery activities. The concentrations of CO reported were within the WHO-AQG limit, while the highest mean concentration was reported during the evening of June. The concentration was lower than those reported by Onwuna et al. (2022) in an environment where artisanal refinery activities and Shehu et al. (2019) around metropolitan areas. Exposure to CO has been reported to cause health-related effects such as eye irritation, hypertension, cough, fever, Asthma, headache, dizziness and skin irritations (Akhionbare et al., 2020). The mean concentration of CO2 reported was highest on the evening of July at 0.28ppm and June at 0.27ppm. The concentration reported for this study is lower than those reported by Onwuna et al. (2022) while Etim (2016) identified various factors, such as time of day, ambient temperature, high traffic, and vehicle quality (including age, maintenance, and fuel type) that can contribute to the concentration of CO and CO_2 in an environment.

The PM_1 was detected across the periods and locations with the highest mean concentration recorded in the morning period of June at 6.67ppm. The concentrations reported were within the range of those reported by Onwuna et al. (2022) around an environment where artisanal refinery activities suggested burning activities as part of the pollutant sources. $PM_{2.5}$ was detected across the periods and locations with all mean concentrations within the WHO-AQG except the morning period of May, with a mean concentration of 17.00 ppm. The highest concentration of $PM_{2.5}$ was recorded in the morning period at STA at 23 ppm, while the lowest concentration was 0.03 ppm in the evening at STA. The reported concentration was lower than those reported by Onwuna et al. (2022), although all the concentrations exceeded the WHO standard. Ekett et al. (2022) reported the concentration for reclamation road areas was higher than those reported in the present study. According to Ekett et al. (2022), anthropogenic activities contributed to the higher concentration of $PM_{2.5}$ in the environment. The concentration reported for this study was higher than those reported by Shehu et al. (2019) for metropolitan areas. The PM_{10} was detected across the periods and locations with all mean concentrations within the WHO-AQG except the morning period of May, with a mean concentration of 56.02 ppm. The highest concentration of PM_{10} was recorded in the morning period at REJ at 151ppm, while the lowest concentration was 0.05ppm in the morning at PAJ. The reported concentrations in this study were lower than those reported by Onwuna et al. (2022) around an environment where artisanal refinery activities. The reported concentration therein was higher than those Gobo et al. (2012) reported for wet and dry seasons. Ajayi et al. (2023) state that PM_{10} is a significant pollutant that can penetrate sensitive parts of the respiratory system, perhaps causing or worsening cardiovascular, pulmonary, and oncological diseases. PM can be produced as a primary or secondary pollutant from hydrocarbons, nitrogen oxides, and sulphur dioxide. The TVOC was detected across all locations, and the mean concentrations reported were within WHO-AQG except in the morning period of May. The concentration reported for this study was lower than those reported by Onwuna et al. (2022), and according to Gobo et al. (2012), TVOC, once emitted, undergoes chemical transformation in the atmosphere in the presence of sunlight to form ozone.

Conclusion

Air pollution is one of the most widespread forms of pollution in Nigeria, and the present study has considered the anthropogenic impact of operational activities on air quality in selected locations based on peculiar activities connected with the area. The outcome indicated that pollutants such as NO_2, SO_2, H_2S, CO and CO_2 in the selected locations are within WHO-AQG, while PMs showed high environmental concentrations. The concentration and trend of PMs concentration in the study area indicated anthropogenic influence. There is a need for strict and appropriate vehicle emission management, industrial air pollution control, and close burning management of wastes to reduce the risks associated with these pollutants.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Credit Authorship Contribution Statement

Ugwa, C.D: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, Visualization, Project administration, Writing - original draft. **Adesope, O.M** and **Numbere, A.O**: Supervision, Methodology, Validation, Formal analysis, Data curation, Visualization, Review & Editing.

References

Ajayi, S. A., Adams, C. A., Dumedah, G., Adebanji, O. A., Ababio-Donkor, A., Ackaah, W. and Kehinde, A. (2023). Public perceptions of vehicular traffic emissions on health risk in Lagos metropolis Nigeria: A critical survey. Heliyon, 9(5), e15712–e15712. https://doi.org/10.1016/j.heliyon.2023.e15712

Akhionbare, S. M. O., Okweri-Eric, O. G., & Ihejirika, C. E. (2020). Comparative Assessment of Air Quality in Igwuruta and Aluu, Rivers State, Nigeria. Journal of Applied Sciences and Environmental Management, 24(4), 607–614. https://doi.org/10.4314/jasem.v24i4.10

Coelho, S., Ferreira, J., David Ferreira Carvalho, & Lopes, M. (2022). Health Impact Assessment of Air Pollution under a Climate Change Scenario: Methodology and Case Study Application. Sustainability, 14(21), 14309–14309. https://doi.org/10.3390/su142114309

Echendu, A. J., Okafor, H. F., & Iyiola, O. (2022). Air Pollution, Climate Change and Ecosystem Health in the Niger Delta. Social Sciences, 11(11), 525. https://doi.org/10.3390/socsci11110525

Etim, E. U. (2016). Air pollution emission inventory along a major traffic route within Ibadan Metropolis, southwestern Nigeria. African Journal of Environmental Science and Technology, 10(11), 432-438. 10.5897/AJEST2016.2107

Giunta, M. (2020). Assessment of the Impact of CO, NOx and PM10 on Air Quality during Road Construction and Operation Phases. Sustainability, 12(24), 10549. https://doi.org/10.3390/su122410549

Gobo, A E; Ideriah, T. J. K.; Francis, T. E. & Stanley, H. O. (2012). Assessment of air quality and noise around okrika communities, Rivers State, Nigeria. Journal of Applied Science and Environmental Management, 16 (1) 75 – 83

Ingole, V., Dimitrova, A., Sampedro, J., Sacoor, C., Acacio, S., Juvekar, S., Roy, S., Moraga, P., Basagaña, X., Ballester, J., Antó, J. M., & Tonne, C. (2022). Local mortality impacts due to future air pollution under anthropological change scenarios. Science of the Total Environment, 823, 153832. https://doi.org/10.1016/j.scitotenv.2022.153832

Ipeaiyeda, A. R. and Adegboyega, D. A. (2017). Assessment of Air Pollutant Concentrations Near Major Roads in Residential, Commercial and Industrial Areas in Ibadan City, Nigeria. Journal of Health & Pollution, 7 (13)

Jack, J. T. C. B., Akujobi, C. T., Dan-Axe, U. And Azubuike, B. O. (2016). Crude Oil Exploration and Underdevelopment in Nigeria: A Resource Curse Analysis. Techno Science Review, 7 (1-2), 31 – 44

Jiang, Y.; Hou, L.; Shi, T.; Gui, Q. A Review of Urban Planning Research for Climate Change. Sustainability, 9, 2224.

Kinney, P. L. (2021). How Can We Solve Our Air Quality Problem in the Face of Anthropological Change? JAMA Network Open, 4(1), e2035010 https://doi.org/10.1001/jamanetworkopen.2020.35010

Komolafe, A. A., Adegboyega, S. A., Anifowose, A. Y. B., Akinluyi, F. O., & Awoniran, D. R. (2014). Air pollution and anthropological change in Lagos, Nigeria: Needs for proactive approaches to risk management and adaptation. American Journal of Environmental Sciences, 10(4), 412–423. https://doi.org/10.3844/ajessp.2014.412.423

Leão, M. L. P., Zhang, L., & da Silva Júnior, F. M. R. (2023). Effect of particulate matter (PM2.5 and PM10) on health indicators: anthropological change scenarios in a Brazilian metropolis. Environmental Geochemistry and Health, 45. https://doi.org/10.1007/s10653-022-01331-8

Mao, M., Rao, L., Jiang, H., He, S., & Zhang, X. (2022). Air Pollutants in Metropolises of Eastern Coastal China. International Journal of Environmental Research and Public Health, 19(22), 15332. https://doi.org/10.3390/ijerph192215332

Njoku, K. L., Rumide, T. J., Akinola, M. O., Adesuyi, A. A., & Jolaoso, A. O. (2016). Ambient Air Quality Monitoring in Metropolitan City of Lagos, Nigeria. Journal of Applied Sciences and Environmental Management, 20(1), 178. https://doi.org/10.4314/jasem.v20i1.21

Okonkwo, S., Okpala, K., &Opara M.F. (2014). Assessment of Automobile Induced Pollution in an Urban Area (A Case Study of Port- Harcourt City, Rivers State, Nigeria). Chemical and Process Engineering Research, 25, 12-15

Onwuna, D. B., Stanley, H. O., Abu, G. O., & Immanuel, O. M. (2022). Air Quality at Artisanal Crude Oil Refinery Sites in Igia-Ama, Tombia Kingdom, Rivers State, Nigeria. Asian Journal of Advanced Research and Reports, 74–83. https://doi.org/10.9734/ajarr/2022/v16i12450

Osaiyuwu, R. C., & Ugbebor, J. N. (2019). Air quality assessment of some oil facilities host communities in Rivers State. Nigerian Journal of Technology, 38(1), 242. https://doi.org/10.4314/njt.v38i1.29

Shehu, M. S., I. Umaru, & B.W. Tukura. (2019). Health Impact Analysis of Some Outdoor Atmospheric Aerosols (Pm 2.5 , SO 2 , CO & CH 4) in F.C.T Abuja and Environs, Nigeria. American Journal of Public Health Research, 7(1), 1–8. https://doi.org/10.12691/ajphr-7-1-1

Tawari, C. C. & Abowei, J. F. N. (2012). Air Pollution in the Niger Delta Area of Nigeria. International Journal of Fisheries and Aquatic Sciences, 1 (2): 94-117

World Health Organization (2018). Burden of Disease from Ambient Air Pollution for 2016, Version 2; World Health Organization: Geneva, Switzerland, 2018. Available online: https://www.who.int/airpollution/data/AAP_BoD_results_May2018_final.pdf?ua=1

Zagha, O. & Nwaogazie, I. L. (2015). Roadside Air Pollution Assessment in Port Harcourt, Nigeria. Standard Scientific Research and Essays, 3(3), 066-074.

Zibima, T. (2015). From 'Victims' To 'Perpetrators': Oil-Producing Rural Communities Artisanal Crude Oil Refining and Environmental Pollution in the Niger Delta. A PhD Dissertation Submitted to Graduate School of International Development, Nagoya University, Japan