

Original Research Article

Spatial Analysis of Active Dumpsites Distribution Pattern in Port Harcourt Metropolis, Rivers State, Nigeria

Abstract

The study analysed the distribution patterns of active dumpsites in Port Harcourt Metropolis, Rivers state, Nigeria. The study made use of locational data obtained through the use of Global Positioning System (GPS) and the data were subjected to analysis in ArcGIS environment. Nearest neighbour analysis was used to determine the significant distribution pattern. Findings showed that twenty-three active dumpsites were found in the entire Port Harcourt Metropolis and the distribution pattern of these dumpsites were significantly dispersed ($Z=4225.54$; $p=0.0000$). It is concluded that active dumpsites in Port Harcourt Metropolis are scattered all over and it is recommended that proper guidelines must be followed before an area can be sited to become a dumpsite. Also, there should be consideration of the environmental attributes so that the proportion of the effect can be minimized, while periodic monitoring of established dumpsites is essential to reduce the illegal siting of dumpsites.

Keywords: Active dumpsites, Distribution, Pattern, ArcGIS, Nearest neighbour

Introduction

Waste management and disposal has created great concerns of discourse in various sectors of human endeavor. This is largely because in the course of almost all human activities, all sorts of waste materials are generated in magnitudes that raise issues of where they can be effectively disposed. Hence, the urgent need for waste disposal sites or dumpsites to be provided. Man, continuously comes up with new ways of getting rid of waste locally, either by burning them or by disposing them in active dumpsites provided by the government (Ohwor, 2007). According to Johannessen and Boyer, (1999) dumpsites are widespread land disposal area, either exposed directly to the atmosphere or covered improperly with soil layer and without proper bottom liner support. The nature of most dumpsites significantly contributes to the contamination and pollution of the entire environment where they are sighted. Dumpsites have the potentials of impacting on the entire location negatively. Because dumpsites are mostly uncovered, most times it provides home for flies, insects, reptiles and other creatures that have the ability to cause diseases to the people who live near the areas where the dumpsites are located more so on the scavengers who make a living from the dumpsites.

A dumpsite is where waste and unwanted materials of waste are dumped directly to the environment or covered improperly. Due to the nature of its management or mode of disposal in most active dumpsites, it is always an eyesore. The rate of pollution of air in the area is likely to

contaminate the area where the dumpsites are sited. Dumpsites can negatively affect the general situation of the atmosphere, exosphere, and hydrosphere. It is important to note that most active dumpsites are usually open, hence, they attract insects, flies, animals, reptiles that might give rise to incidences of harm to individuals who are living in the area (Ajile, 2014). It is unfortunate that in Nigeria, all sorts of wastes are littered or disposed indiscriminately with no proper form of management. This can be attributed to either ignorance on the part of individuals using the dumpsites irresponsibly, the government and the state authority in charge. It can also be linked to financial constraints but more significantly, the deficiency of political will on the side of the government to improve, protect and to see to it that the environment is not degraded to the extent that individuals cannot function optimally due to the open dumpsites in their environment. According to UN-Habitat on a report on African continent, they observed that Africa is speedily developing, with cities like Lagos, Kinshasa, Cairo, Nairobi, including others moving quickly that would enable them grow thrice their present level come 2050 (UN Habitat, 2010). This growth has consequences for municipal waste management and other social services required in the urbanized communities. Data from most cities in the country including Port-Harcourt, shows insufficiency in city social-services especially management of municipal solid wastes which invariably leaves the cities littered with heaps of dirt's in dumpsite and most often open dumpsites (mostly unapproved) a breeding place for flies, insects, reptiles etc. which are breeders of various life-threatening diseases.

According to Mu (2006), in most countries of the world, particularly in emerging countries, the use of GIS and remote sensing techniques on land suitability assessment for dumpsite is very recent. GIS is applicable on land use planning and evaluation since the 1980's. In time past before the coming and use of GIS and Remote Sensing, decisions relating not just to land suitability for siting of dumpsites, and other urban related activities were handled using the local techniques. However, today, it is unthinkable to assess a suitability of any land outside the help of GIS and remote Sensing system.

According to Siddiqui *et al.* (1996), Geographical Information system is a digital database management system designed to handle and store large amount of data from various sources because of its efficiency in storing, management, analysis, retrieval and display geographical information based on the user-defined specifications. They added that it is a very reliable instrument in site selection studies and project works. Laurini & Thompson (1992), were also on the side that GIS provides a common framework for integrating and analyzing multiple datasets

based on geographic location while Mu. (2006), stated that the main goal of GIS is to collect raw data and transform it, through an overlay and other analytical operations, into new knowledge, that support decision-making processes.

According to Mehdi *et al* (2014), the use of GIS in disposal sites for hazardous wastes which is now known globally as a complex and complicated problem. It added that in the pursuit to develop technologically, industries leave behind materials hazardous not just to the life of humans but also the environment. Certain raw materials used by refineries, power factories, chemical and petrochemical industries create hazardous wastes.

Vesilind *et al.*, (2002); Agamuthu, (1997) and Begum *et al.*, (2015) opined that waste management practices differ from emerging countries to advanced nations, and for villages and city area, and for large volume or producers in manufacturing industries. They added that Management of residential and organized waste in metropolitan areas is usually the duty of local authorities, while management for non-hazardous commercial and waste materials from industries is the duty of the generator subject to local, national or international supervision.

The gathering, and eventual disposal of domestic and commercial waste is the key local government services, essential to maintaining a neat, healthy and disease-free environment and society. The challenge is most severe in the compactly occupied regions especially in Nigeria. The growth in resource consumption pattern has had a negative effect on the urban environment-production of waste far beyond the abilities of urban government.

These problems forced the many residents of communities or locations where dumpsites are located to engage in daily or weekly sanitation or involving private sector into private coalition for the gathering of huge refuse dumps. In relation to the above statement, there are many techniques that will be put in place to overcome disposal of waste and the latest technology to engage as a tool is called Geographic Information System (GIS). Golit, (2001) believed that the handling of solid waste in our cities has posed serious challenges because to the deficiency of the right and organized waste handling values and technologies. This is coming largely from financial and technological constraints.

Hardoy, *et.al*, (2001); Myers (2005); and UN-Habitat, (2009), added that the judicious handling of solid waste is now a national embarrassment mainly because of fast increase in population growth accompanied with high rate of resource consumption, and the incapability of many municipal authorities to give proper waste-disposal services within their jurisdictions.

The spatial distribution analysis of environmental phenomenon has been done by different scholars both at the national and international levels. Uelmen (2010) analyzed the siting wind turbine based on the parameters water depth, wind speed, distance to the coastline, shipping routes, and urban areas; and Abramovich (2012) performed an analysis to determine the location using GIS methods based on maximal distance, travel time, and network analysis, using tools and extensions such as ArcGIS Spatial Analyst and network analyst to determine the location of the fire station. Also in Nigeria, GIS has been equally been applied in locating educational facilities (Aliyu et al, 2013); health issues (Oviasu et al, 2015); ecotourism (Odum et al., 2018) while Omogunloye and Ayeni (2012), and Kika and Ikezam (2022) analysed the hotels in Lagos State and Port Harcourt respectively.

Explaining the distribution pattern of active dumpsite using geospatial tool is not in exemption because of the relevance of the mapping analysis in the recent times. Considering the previous studies, it is realized that very few of them discussed the issue of the spread and distribution pattern of active dumpsite which is the main focus of the present study. The presence of dumpsites in Port Harcourt City is a fact however, their spatial distribution pattern is not yet established in a coordinated manner to determine the risks they could pose to health and the environment where they are found. Therefore, the present study focuses at assessing the spatial analysis of active dumpsites in Port Harcourt Metropolis, Rivers State, Nigeria with a view to deploying nearest neighbour analysis to quantify the distribution pattern.

Materials and Methods

The study was carried out in Port Harcourt Metropolis. Port Harcourt, the Rivers State capital is located in the Southern Nigeria and lies along the Bonny River; an eastern distributaries of the River Niger, 66km upstream from the Gulf of Guinea. Port Harcourt is located geographically between latitudes $4^{\circ} 7' 5''$ N and $4^{\circ} 8' 15''$ N and longitudes between $7^{\circ} 05' 0''$ E and $7^{\circ} 45' 0''$ E (Figure 1). According to Igoni et al. (2007), Port Harcourt, the Rivers State capital is located in the Niger delta region in the southern region of Nigeria. Its population is estimated at about 5,198,716, while the Port Harcourt metropolis is estimated to have 1,356,000 people. Its name was crafted by Lewis Harcourt the then secretary of the English territories. The city has two seasons; the wet season and dry season as also found in other parts of the country. The rainy or wet season is associated with heavy down pour of rain and periodic surge in sea sides and city centers. The wet season starts around the month of April and stops around November whereas the dry season starts toward the end of November and ends around March. Port Harcourt is said

to experience larger period of rainfall annually as likened to other states in the nation. The temperature of the region ranges from 24 degrees to 30 degrees centigrade and is majorly warm for most parts of the year. The city of Port Harcourt is hub to many conglomerates and local companies providing an array of services to the public and the country at large. Port Harcourt has the many popular markets in the nation and attracts people from the neighboring towns and all works of live to patronize them. It is located by off Aba road in Rumuokurushi community.

Binafeigha and Enwin, (2017) opined that Port Harcourt was originally designed to be home to its locals has however experienced a high inflow of individuals after the sighting of hydrocarbon in the city. This incessant growth has lingered and has affected villages like Rumuola, Rumuokwuta, Rumuokwurushi, Rumueme, Woji, etc. There are sections under advancement now called the greater Port Harcourt city. From historical perspective, Ikwerres and Okrikas occupied the land of Port Harcourt city before 1913. However, the Ikwerre occupies the main land area of Obio/Akpor LGA, with three different kingdoms, namely, the Akpor, Obio and Evo Kingdoms. They majorly engage in fishing and subsistence farming. The current day urban center has witnessed developments in socio-economic activities, which thus, promotes transportation (land, air, water), exploration and oil production, crafts and tourism. Port Harcourt is now well known for commerce, industry, farming etc.

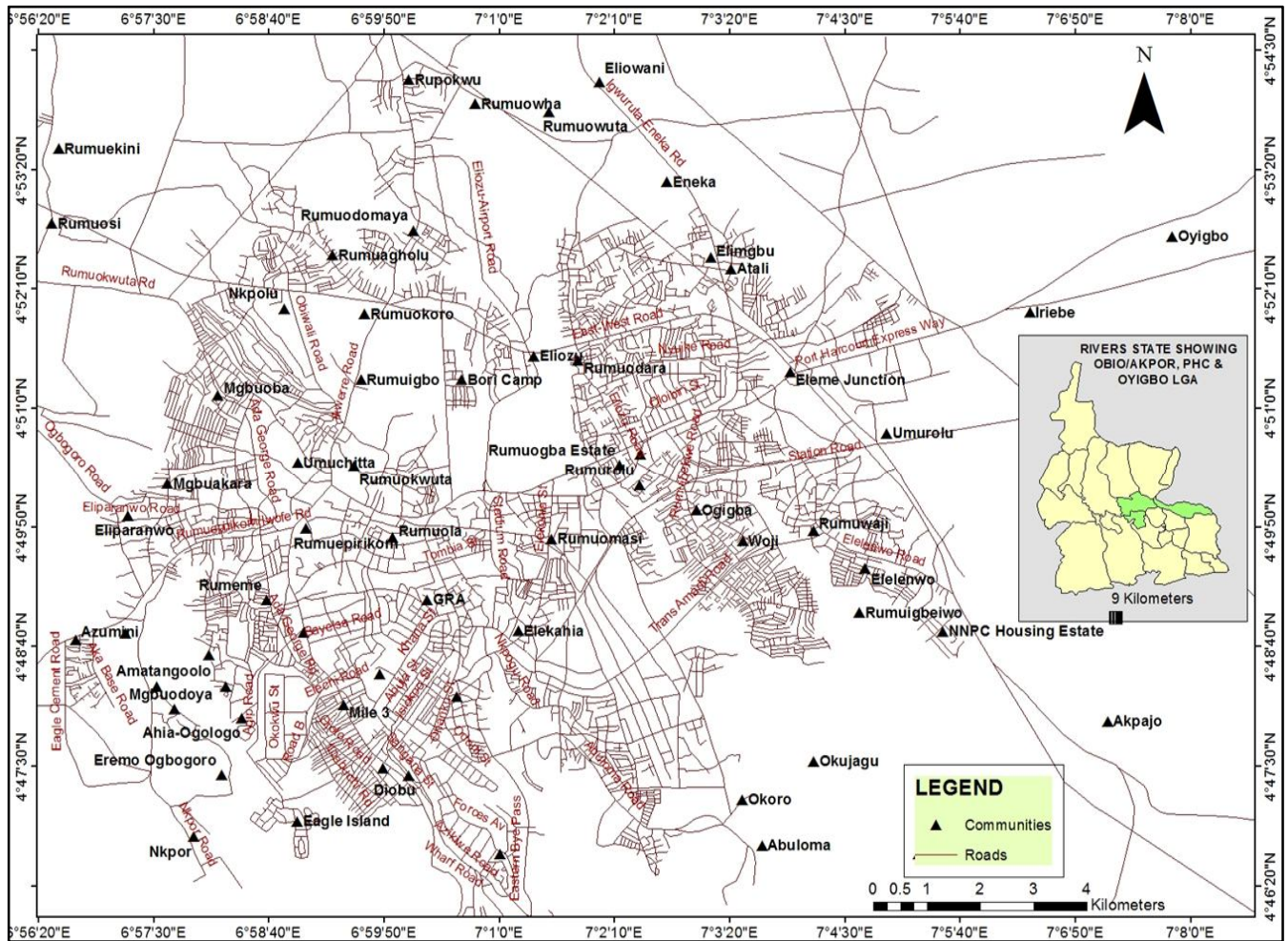


Figure1. Port Harcourt Metropolis

The Global Positioning System (GPS) was used to track the geographic coordinates of the active dumpsites in Port Harcourt Metropolis. The GPS points obtained for the spatial distribution of active dumpsites was used to decide the distribution of active dumpsites in ArcGIS 10.5 environment. Spatial distribution pattern (clustered or dispersed) was analyzed in ArcGIS 10.5 using average nearest neighbor from Spatial Statistics tools. This is a tool used to define the pattern of distribution of both moth and privet in each period considered for this study. The Z score and Nearest Neighbor Index (NNI) were calculated to determine the pattern of distribution. The NNI is conveyed as the ratio of the observed distance divided by the expected distance. The expected distance is the average distance between neighbors in a hypothetical random distribution. If the index is less than 1, the pattern exhibits clustering; if the index is greater than 1, the trend is toward dispersion or competition. When Z-score is less than 0, the pattern of distribution is clustered but when it is greater than 0, it is dispersed. If it is 0, the pattern is

neither clustered nor dispersed; else it is random, (culled from StatTrek.com). Descriptive statistics were deployed for the study.

Results and Discussions

The distribution of active dumpsites in Port Harcourt is displayed in Figure 2 and the analysis of the distribution pattern is displayed in Figure 3. It is observed that twenty three active dumpsites were found in the entire Port Harcourt Metropolis. The distribution pattern reveals that the active dumpsites was significantly dispersed ($Z=4225.54$; $p=0.0000$). This shows that they exhibited a kind of particular distance from each other; and there is less than 1% likelihood that this dispersed pattern could be the result of random chance. This may be attributed to the fact that these active dumpsites served different areas in the study area and they may maintain certain distance from each other to ascertain that they are not conglomerated at a particular place. The pattern of dumpsite distribution might have been responsible for the irregular dumpsite found everywhere. Okpara et al (2021) confirmed that irregular dumpsites serve as a receptor of heterogenous materials which are known as the major threat to groundwater and other environmental resources such as air quality. This may also lead to inefficient management of municipal waste produced which might have linked to different problems to public health concerns. The spatial distributions have established the type of disease spreading across the residential areas from the dumpsites (Okpara et al., 2021).

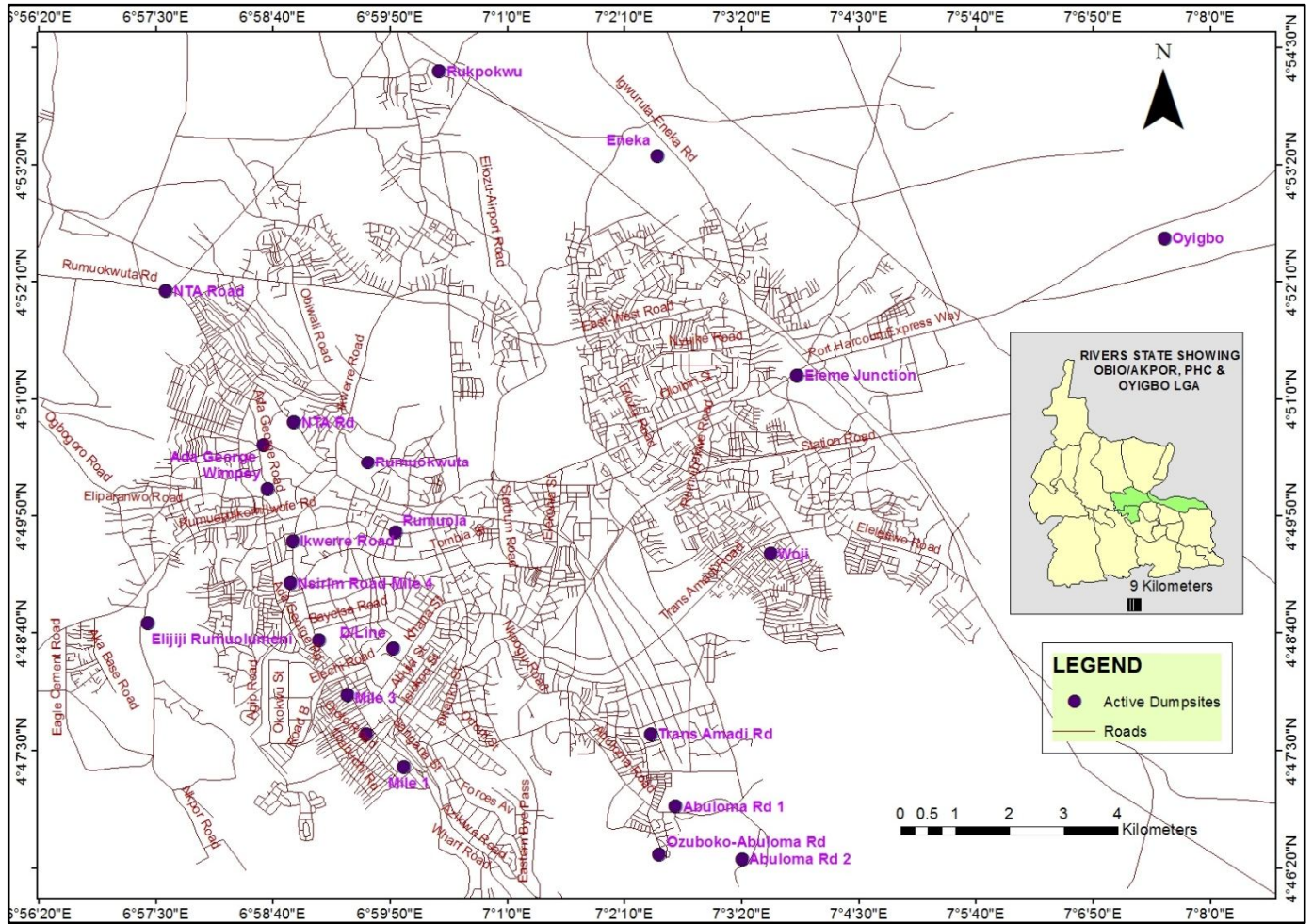


Figure 2: Dumpsite in Port Harcourt Metropolis

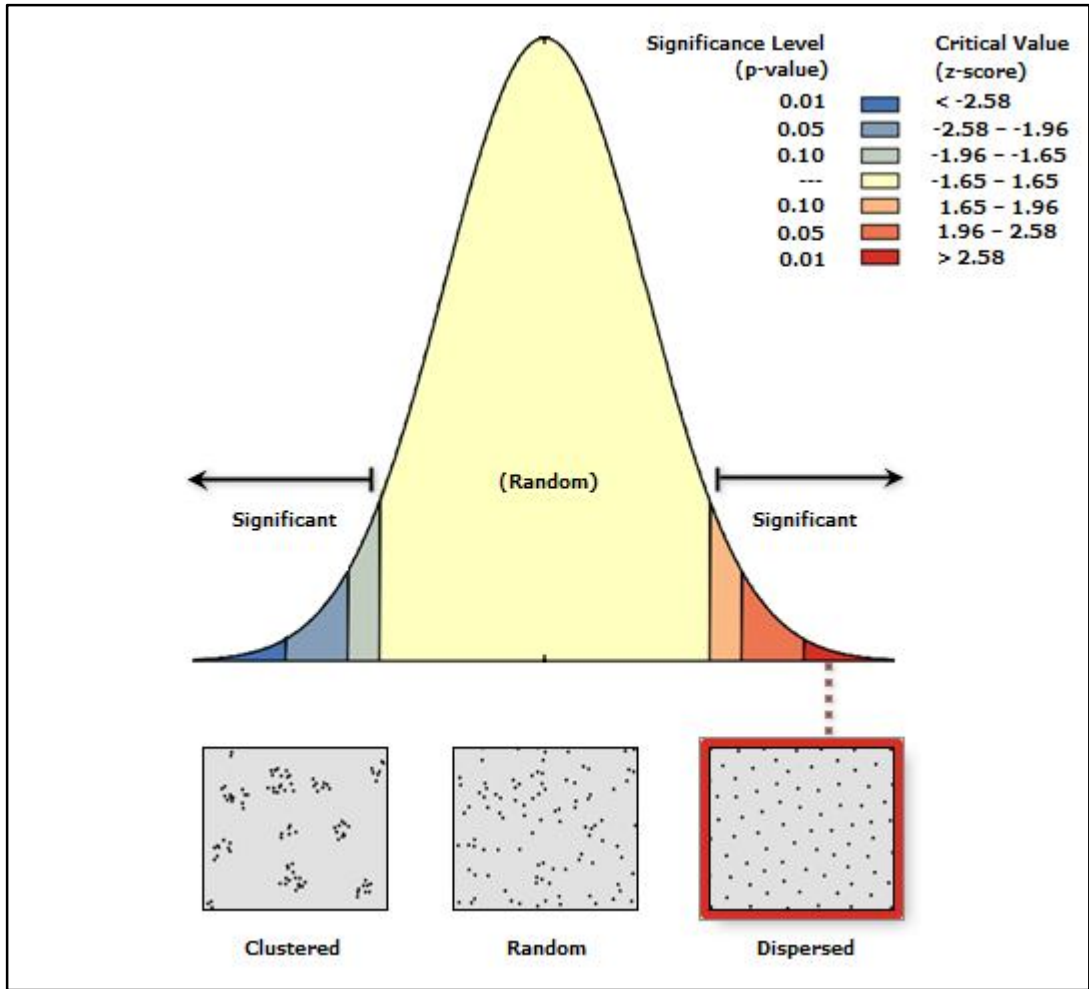


Figure 3: Average Nearest Neighbor Summary

Table 1: Average Nearest Neighbor Summary

Observed Mean Distance:	1580.1449 Meters
Expected Mean Distance:	2.7659 Meters
Nearest Neighbour Ratio:	571.302585
z-score:	4225.536448
p-value:	0.000000

Conclusion and Recommendations

It can be concluded that the study has revealed that active dumpsites are scattered all over in Port Harcourt Metropolis, suggesting that most of the environmental attributes like soil, water, and air may be in great danger if care is not taken. It is therefore recommended that proper guidelines must be followed before an area can be sorted to becoming a dumpsite and also there should be

consideration of the environmental attributes so that the proportion of the effect can be minimized. Periodic monitoring of establishment of dumpsite is essential to reduce the illegal siting of dumpsites.

References

- Agwu, M.O. (2012): Issues and Challenges of Solid Waste Management Practices in Port-Harcourt City, Nigeria- a behavioural perspective. *American Journal of Social and Management Sciences*. Vol 3, No 2, pp 83-92
- Ahrens C.D. (1991): *Meteorology today, an introduction to weather, climate and the environment*. Fourth Edition. West Publishing Company. St. Paul, Minneapolis
- Aliyu A., Shahidah M. A., Aliyu R. M. (2013) Mapping and spatial distribution of post primary schools in Yola North Local Government Area of Adamawa State, Nigeria. *International Journal of Science and Technology*. Vol. 2. No. 5. Pp. 405-422.
- Alloway, B J (1990): *Heavy metals in soils*. Blackie, Glasgow
- Anwarali, F.A., Ketol B., Marni, W., Sait, I., Lakim, M., Yambun,P., Salleh, M., AbdulRahman M and Abdullah M.T.(2009): Checklist of mammals from Gunung Silam, Sabah, Malaysia. *Journal of Tropical Biology and Conservation* 5:61-65
- Berenguer M.J. (2011): Regulations, Recommendations, Guidelines and Standards. In Xavier G.S. and Stellman J.M. (Eds) *Indoor Air Quality, Encyclopedia of Occupational Health and Safety*, International Labour Organization, Geneva.
- Berg, B. L. (2004): *Qualitative Research Methods for the Social Sciences*. 5th ed. Boston: Pearson Education, Inc.
- Berman N.S., D.L. Boyer, A.J. Brazel, S.W. Brazel, R.R. Chen, H.J.S. Fernando, and M.J. Fitch. (1995): Synoptic Classification and Physical Model Experiments to Guide Field Studies in Complex Terrain. *Journal of Applied Meteorology* 34:719-730.
- Blauvelt, A. (2009): *Removal of Ammonia From Landfill Leachate. A Major Qualifying Project submitted to the Faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of Bachelor of Science*. 82p
- Burns, R.G., Rogers, S.; and McGhee, I. (1996): *Contaminants and the Soil Environment in the Australia Pacific Region* (ed Naidu, R; Kookana, RS; Oliver, DP; Rogers, S; McLaughin MJ), - Kluwer Academic Publishers, London. p. 361-410
- California Department of Public Health (CDPH) (1997): *Policy Memo 97-005 Policy Guidance for Direct Domestic Use of Extremely Impaired Sources*.
- Chan L.Y. and Kwok W.S. (2000): Roadside suspended particulates at heavily trafficked urban sites of Hong Kong – Seasonal variation and dependence on meteorological conditions. *Atmospheric Environment*, 35, 3177-3182.
- Chan L.Y., Chan C.Y., and Qin Y. (1998). Surface ozone patten in Hong Kong. *Journal of Applied Meteorology* 37, 1153-1165.
- Chiu T.T., Lam T.H., and Hedley A.J. (2005): A randomized controlled trial on the efficacy of exercise for patients with chronic neck pain. *30(1): 1-7*.
- Chow J.C., Watson J.G., Lowenthal D.H., Egami R.T., and Solomon P.A., Thuillier R.H., Magliano K., Ranzieri A. (1998): Spatial and temporal variations of particulate precursor gases and photochemical reaction products during ozone episodes. *Atmospheric Environment* 32 (26), 2835-2844.
- Corsmeir, U., Behrandt, R., Drobinski, P. and Kottmeir, C (2005): The mistral and its effect on air pollution transport and vertical mixing. *Atmospheric Research*, 74 (1-4): 275-302

- Cossu R. and Reiter M. (1996): Landfill gas condensate production and disposal, In T.H. Christensen, R. Stegmann, R. Cossu, (editors) Landfilling of Waste. Published by Taylor and Francis Books Ltd., p485.
- Dockery D.W. and Pope C.A. (1994): Acute respiratory effects of particulate air pollution. *Annual Review Public Health* 15, 107-132.
- Ellis, A.W., M.L. Hildebrandt, M.L. W.M. Thomas, W.M. and H.J.S. Fernando, H.J.S. (2000): Analysis of the Climatic Mechanisms Contributing to the Summertime Transport of Lower Atmospheric Ozone within Metropolitan Phoenix, Arizona, USA. *Climate Research* 15:13-31.
- Environmental Risk Limited (1995): Evaluation of Air Emissions at the Hartford Landfill. ERL Project No. 4100003346.
- Fleming R. Jr. (1970): The general ecology, flora and fauna of midland Nepal, First Edition, Curriculum Development Center, Tribhuvan University, Kathmandu, Nepal
- Garcia, R., Hart, J. E., Davis, M. E., Reaser, P., Natkin, J., Laden, F., Garshilk, E. and Smith, T. J. (2007): Effect of wind on background particle concentration at truck freight terminals. *Journal of Occupational Environment and Hygiene*, 4 (1): 34-48
- Godish, T. (1997): "Air Quality" Third Edition published by Boca Raton, New York
- Goldberg M.S., Burnett R.T., Bailar J.C., Brook J., Bonvalot Y., Tamblyn R., Singh R., Valois M., and Vincent R. (2001): The association between daily mortality and ambient air particle pollution in Montreal, Quebec: 2. Cause-specific mortality. *Environmental Research* 86(1), 26-36.
- Harold J.P., Hoecker W.H. Jr., and Herbert H.J. (1949): Metrological conditions and atmospheric contaminants. Air pollution in Donora, A different air. B Linsky (eds), Maxwell Reprint Company, New York 149-159.
- Harrop, D.O. (2002): Air Quality Assessment and Management. A Practical Guide. Published by Spon Press, New York USA, pp1-5.
- Hussein, S.M.I., Batada, N., Vuoristo, S., Ching, R.W., Autio, R., Narva, E., Ng, S., Sourour, M., Hamalainen, R., Olsson, C., et al. (2011): *Nature* 471, 58–62
- Hwang J.S. and Chan C.C. (2002): Effects of air pollution on daily clinic visits for lower respiratory tract illness. *American Journal of Epidemiology* 155(1),1-10.
- Ideriah T.J.K. and Stanley H.O. (2008): Air Quality around Some Cement Industries In Port Harcourt, Nigeria. *Scientia Africana*, Vol. 7 (No.2), pp 27-34.
- IPCC (1996): Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, International Panel on Climate Change, Task Force on National Greenhouse Gas Inventories, Hayama, Japan, <http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.html>.
- Johnsson, E. (2010): Correlation between Methane-concentration and -emission from old Landfills in Sweden Master thesis Environmental Engineering submitted to the Department of Water Resource Engineering, Lund University. 71p
- Kim K. H., Lee S., Woo D, and Bae G. (2015). Influence of wind direction and speed on the transport of particle-bound PAHs in a roadway environment. *Atmospheric Pollution Research* (2015): 1024-1034
- Kumar, J.P., Jamal, T., Doetsch, A., Turner, F.R., Duffy, J.B. (2004): CREB binding protein functions during successive stages of eye development in *Drosophila*. [Genetics](#) 168(2): 877-893. ([Export to RIS](#))
- Kumar,S., Mondal, A.N., Gaikwad, S.A., Devotta, S. and Singh, R.N. (2004): Qualitative assessment of methane emission inventory from municipal solid waste disposal sites: a case study. *Atmospheric Environment* 38, 4921–4929

- Kupchella C.E., and Hyland M.C. (1989): Environmental Science, Living within the system of nature. Second Edition. Allyn and Bacon, Massachusetts
- Lai S.C., Ho K.F., Zhang, Y.Y., Lee S.C., Huang Y. and Zou, S.C. (2010): Characteristics of Residential Indoor Carbonaceous Aerosols: A case Study in Guangzhou, Pearl River Delta Region. *Aerosol Air Qual. Res.* 10: 472-478.
- Ljungberg, S.A., Meijer, J.E., Rosenqvist, H. and Mårtensson, S.G. (2009): Detection and quantification of methane leakage from landfills. *Svenskt Gastekniskt Center*. Gävle.
- Lu, R., and Turco R. P. (1995): Air Pollutant Transport in a Coastal Environment- II: Three-Dimensional Simulation over Los Angeles Basin. *Atmospheric Environment* 29:1499-1518.
- Manawadu, L. and Samarakoon, L. (2007): Identification of air pollution potential areas and its temporal and spatial patterns of the city of Colombo- Applying GIS and RS. Pathumthani, Thailand; Asian Institute of Technology
- Metz, B., Davidson, O.R., Bosch, P.R., Dave, R. Meyer, L.A. (2007): Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Mkoma S. L., Kimambo, O.N., Mabiki F.P. and Tungaraza C.T. (2010): Dependence of Air Quality on Meteorological Parameters in Dar es Salaam, Tanzania. *Tanzania Journal of Natural and Applied Sciences (TaJONAS)*, Volume 1, Issue 2, pp148-156
- Mor S, Ravindra K, Dahiya RP, Chandra A (2006). Leachate Characterization and assessment of groundwater pollution near municipal solid waste landfill site. *Environ. Monit. Assess.*, 4: 325-334.
- Mor, S., Ravinda, K., De Visscher. A., Dahiya, R.P. and Chandra, A., (2006): Municipal solid waste characterization and its assessment for potential methane generation: A case study, *Science of the Total Environment* 371, pp 1–10
- Murray F., Mcgranahan G., and Kuylenstierna J.C.I. (2001): Assessing health effects of air pollution in developing countries. *Water, Air, & Soil Pollution* 131(1-4 Part 3, 1799-1804.
- Nebel, B.J. and Wright, R.T. (2000): *Life in a Gas Chamber Environmental Sciences*, 7th edition, p. 532: Mexico City:
- Neidell M.J. (2004): Air pollution, health, and socio-economic status: the effect of outdoor air quality on childhood asthma *Journal of Health Economics* 23, 1209–1236.
- Nielsen A.H, Vollertsen J., Jensen H.S., Madsen H.I., and Hvitved-Jacobsen T. (2006): Aerobic and anaerobic transformations of sulfide in a sewer System – field study and model simulations. *Water Environment Foundation*, pp 3654-3670
- Niger Delta Environmental Survey (NDES) (1997): Environmental and socio-economic characteristics. *NDES* 1: 48-74
- Obafemi, A. A., Eludoyin, O. S. Akinbosola, B. M (2012): Public Perception of Environmental Pollution in Warri, Nigeria. *J. Appl. Sci. Environ. Manage.* Vol. 16 (3) 233 - 240
- Obinna, V.C., Owei, O.B; Davis, B., and Okwakpam, I.O. (2009): Sanitising Port-Harcourt: The phenomenon of urban street hawking and policy implications. *Journal of Nigerian Environmental Society*, Vol.5, No. 2. pp118-135.
- Odum C. J., Akukwe T. I., Andrew-Essien E., Eja I.E. (2018). Spatial Distribution of Ecotourism Resources in Anambra State: A Nearest Neighbour Analysis Approach. *American Journal of Social Sciences*. Vol. 6, No. 3, pp. 29-38.
- Ogba C.O. and Utang P.B. (2009): Air Pollution Climatology in Spatial Planning for Sustainable Development in the Niger Delta, Nigeria. *FIG Working Week 2009 Surveyor's Key Role in Accelerated Development*, Eilat, Israel, 3-8 May, 2009.

- Ogbonna, D.N., Kii, B.L. and Youdeowei, P.O. (2009): Some physico-chemical and Heavy metal levels in soils of waste dumpsites in Port Harcourt Municipality and Environs. *J. Appl. Sci. Environ. Manage.* December, 2009 Vol. 13(4) 65 – 70.
- Ojo. O. (1977): *The climates of West Africa*. London, Heinemann
- Okpara, D.A., Kharlamova, M. & Grachev, V. Proliferation of household waste irregular dumpsites in Niger Delta region (Nigeria): unsustainable public health monitoring and future restitution. *Sustain Environ Res* **31**, 4 (2021). <https://doi.org/10.1186/s42834-020-00077-1>
- O'Leary, P. and Walsh, P. (2003): Landfill Gas Movement, Control and Energy Recovery, *Waste Age* 33 (3) 48-53.
- Olowoporoku D. (2011): How clean is the air Nigerians breathe?- a case for national air quality management framework. *Nigeria world*. <http://nigeriaworld.com/articles/2011/feb/012.html> Accessed on the 4th May, 2012.
- Omogunloye O.G. and Ayeni O. O. (2012). Analysis of Hotels in Lagos State with respect to other Spatial Data. *Research Journal in Engineering and Applied Sciences* 1(6) 393-403
- Oren C. N., (2001): *Air Pollution*. Access Science, The McGraw-Hill Companies. <http://www.accessscience.com/>
- Owen, I.F., and Tapper J.J. (1977): The influence of meteorological factors on air pollution occurrence in Christ Church. *Proceeding of the Ninth New Zealand Geography Conference*, 33-35.
- Oyegun, C.U and Adeyemo, A. (1999): Port Harcourt Region. Department of Geography and Environmental Management. University of Port Harcourt, pp 33-66.
- Oyewole, J. A, Thompson, A. M, Akinpelu, J. A and Jegede O. O. (2014). Variation of Rainfall and Humidity in Nigeria. *Journal of Environment and Earth Science*, 4(2):29-37
- Pepper I.L., Gerba P.C., and Brusseau M.L. (1996). *Pollution Science*. Academic Press, California.
- Pillay B., Zunckel M., Shongwe B and Oosthuizen R. (2011): Air Quality Impact Assessment for the Proposed Upgrade of the Kwadukuza Landfill Site. A report for Metamorphosis Environmental Consulting, uMoya-NILU Consulting (Pty) Ltd, Report No. uMN002-09. 121p
- Pokhrel A.K. and Sharma B.K. (1998): A citizens report on air pollution in Kathmandu: Children's health at risk. Society for Legal and Environmental Analysis and Development Research and Japan Environment Corporation. Kathmandu, Nepal.
- Pongrácz I., E., Phillips, P. S. and Keiski R. L. (2004): *Evolving the Theory of Waste Management: defining key concepts*. Waste Management and the Environment II, V. Popov, H. Itoh, C.A. Brebbia & S. Kungolos (Editors) © 2004 WIT Press, www.witpress.com, ISBN 1-85312-738-8
- Pope, C. A. (2000): Review: epidemiological basis for particulate air pollution health standards. *Aerosol Science and Technology*, 32: 4-14.
- Procházka J, Brom J., Št'astný J. & Pecharová E. (2011): The impact of vegetation cover on temperature and humidity properties in the reclaimed area of a brown coal dump, *International Journal of Mining, Reclamation and Environment*, 25:4, 350-366.
- Purkey, G.S. and Johnson C.G. (2010): Warming of Global Abyssal and Deep Southern Ocean Waters between the 1990s and 2000s: Contributions to Global Heat and Sea Level Rise Budgets. *Journal of Climate*, Vol. 23: 6336-6351
- Rigby, M. and Toumi, R. (2008): London air pollution climatology. Indirect evidence for urban boundary layer height and wind speed enhancement. *Atmospheric Environment*, 42: 4932-4947. www.sciencedirect.com

- Rosenberg, N. J. (1974): Microclimate: the biological environment. New York; John Wiley and Sons
- Rouse, W. R. and McCutchen, J. G (2008): The effect of the regional wind on air pollution in Hamilton, Ontario. *Canadian Geographer*, 14 (4): 271 – 285
- Rushbrook, P. (2001): Australia's first national report on vocational education: the Commonwealth-State Apprenticeship Inquiry (The Wright Report) 1954. *History of Education Review* (30)1: 60-74
- Saksena, S., Joshi, V. and Patil, R. S. (2001): Determining spatial pattern in Delhi ambient air quality data using cluster analysis. Working Paper, East-West Center
- Samet J.M., Dominici F., Curriero F.C., Coursac I., and Zeger S.L. (2000): Fine particulate air pollution and mortality in 20 U.S. cities, 1987-1994. *New England Journal of Medicine* 343(24), 1742-1749.
- Sani S. (1987): Suspended particulate air pollution and meteorology in Bangi. Tropical urban and ecosystems studies. Meteorological and air quality impact evaluation of Klang Valley region working group on urban ecosystems Malaysian national MAB committee, Malaysia, Vol. 3, 43-61
- Schenker U.** (2003): Influence of Meteorological Parameters on Air Quality Simulations in Mexico City. Diploma Thesis Submitted to Ecole Polytechnique Federale de Lausanne (EPFL), Swiss Federal Institute of Technology, Lausanne.59p
- Scheutz, C., Kjeldsen, P., E. Bogner, J., De Visscher, A., Gebert, J., A. Hilger, H., Huber-Humer, M. and Spokas, K. (2009): Microbial methane oxidation processes and technologies for mitigation of landfill gas emissions, *Waste Manag and Research*; 27; 409.
- Scheutz, C., Kjeldsen, P., E. Bogner, J., De Visscher, A., Gebert, J., A. Hilger, H., Huber-Humer, M. and Spokas, K. (2009): Microbial methane oxidation processes and technologies for mitigation of landfill gas emissions, *Waste Manag Res* 27; 409.
- Schwartz J. (1995): Air pollution and daily mortality in Birmingham, Alabam. *American Journal of Epidemiology* 137,1136-1147.
- Schwartz S.H. (1994): Beyond individualism/collectivism: New cultural dimensions of values. In Kim U, Triandis HC, Choi SC, Yoon G (Eds.), *Individualism and collectivism: Theory, method, and applications*. Thousand Oaks, CA: Sage, pp. 85-119
- Scout C. (2016): Convenience Sample: A Brief Overview of the Sampling Technique <http://sociology.about.com/od/Types-of-Samples/a/Convenience-Sample.htm> Accessed on 3/9/2016
- Shusterman, D. (1992): Critical review: the health significance of environmental odour pollution. *Arch. Env. Health* 47: 76-87.
- Smith K.R. (1996): Indoor air pollution in India. *National Medical Journal of India* 9(3), 103-104.
- Tahir M.M. and Yousif T.A. (2013): Effect of Urban Trees on Wind Speed in Khartoum State Hisham. *Journal of Natural Resources and Environmental Studies*, Vol.1(2), pp 1-3.
- Tayanc (2000): An assessment of spatial and temporal variation of sulfur dioxide levels over Istanbul Turkey, *Environmental Pollution* 107, 61-69
- Therese F., Norris G.A., Koenig J.Q., and Larson T.V. (2000): Associations between air pollution and mortality in Phoenix, 1995-1997. *Environmental Health Perspectives* 108(4), 347-353.
- Tsai, C., Aggarwal, S. G., Chang, C. and Hung, I. (2004): Concentration profiles of acidic and basic air pollutants around an industrial part of Taiwan. *Water, Air and Soil Pollution*, 151 (1-4): 287-304

- Turner D.B. (1961): Relationship between 24-hour mean air quality measurement and meteorological factors in Nashville, Tennessee. *Journal of Air Pollution Control Association* 11, 483-488
- United States Environment Protection Agency (USEPA) (2008): Frequently Asked Questions about Landfill Gas and How it affects Public Health, Safety, and the Environment. Office of Air Radiation.
- URBAIR (1997): *Urban air quality management strategy in Asia: Kathmandu Valley report*. J. Shah, T. Nagpal (eds), World Bank Technical Paper NO.378. Kathmandu: World Bank, Kathmandu, Nepal.
- USEPA (1990): National Primary and Secondary Ambient Air Quality Standards. Code of Federal Regulations, Title 40, Part 50.
- USEPA (1991): Air Emissions from Municipal Solid Waste Landfills – Background Information for Proposed Standards and Guidelines. EPA-450/3-90-011a.
- Valsson, S. and Bharat, A. (2011): Impact of Air Temperature on Relative Humidity - A study. *Architecture-Time Space and People*. pp1-4.
- Wan-Li, C. (2001). Spatio-temporal variations of sulphur dioxide pattern with wind conditions in central Taiwan. *Environmental Monitoring and Assessment*, 66 (1): 77-98
- Weiss, A (1974): *Sanitary Landfill Technology*. Noyes Data Corporation, England 204pp.
- Weli, V.E, Wizer, C.H. and Okodudu-Onuigbo E.C. (2009): Liability of residential areas of Port-Harcourt metropolis, implication for urban land use planning. *Journal of Nigerian Environmental Society*, Vol. 5, No. 2, pp102-117.
- WHO (1987): S.I. No. 244/1987 - Air Pollution Act, 1987 (Air Quality Standards) Regulations, 1987.