

EFFECTS OF FUEL OF ELECTRIC POWER GENERATORS ON SOIL PROPERTIES

Abstract

Inadequate supply of energy to buildings has informed the use of service items like generators that depend on different types of fuel for its operations. The fuels are likely sources of pollution to various components of the environment. The objective of this study was to to assess impact of the fuel of generators on the bio-physical and chemical properties of soil that it was in contact with. The study was carried out in Ibadan Metropolis, Oyo State, Nigeria. Five soil sample points that were contaminated by the fuel and oil of generators and control sample points not contaminated and mixed with its fuel were purposively selected in the study area respectively. The samples collected were put in labeled polythene bags and taken to the laboratory for the analyses of soil pH, moisture content, porosity, bulk density, particle size distribution and organic matter respectively. Descriptive and inferential statistical techniques such as frequency distribution T-test and Analysis of Variance (ANOVA) were used to analyze significance of the of effect of fuel of generating sets on bio-physical and chemical properties of soil mass. The results of the analyses established that there were significant variations in the mean values of moisture, porosity, particle size distribution-silt content and organic matter content of soil not mixed with fuel/oil of generators (8.2840, 0.4040, 8.00 and 5.0200) and soil mixed with fuel/oil (3.1040, 0.2120, 19.60 and 2.4440) respectively. The study concluded that the fuel of generating sets would negatively impact soil mass necessary for sustainable growth of flora component of the ecosystem and could have pollution potential on underground water sources to be explored by building occupants. It was therefore recommended that there is need to use environmentally friendly power sources and the associated fuel waste must be properly managed so as not to be source of threat to the functions and properties of soil resources in the environment.

Keywords: Electricity, Supply, Generators, Soil resources, Environment, Sustainability

29 **1. Introduction**

30 The built environment owes its existence to earth's resources and environment which supplies it with
31 the resources needed. Buildings are constructed to serve as a unit of environment, meet housing and
32 shelter needs and also have much influence on the health and efficiency of the occupants. It is also
33 considered as one of the three most fundamental human needs [1, 2]. All building activities involve
34 use, redistribution and concentration of some components of the earth's resources such as water,
35 energy and materials [3]. During these activities, a process occurs that changes part of the biosphere
36 and thus affects sustainability of the built environment. During life span of buildings; its occupants use
37 various service items which can have impact on the environment. Also, built environment has a
38 profound impact on the natural environment, economy, health and productivity of building occupants
39 through its associated characteristics and functions [4].

40 Buildings are really meant to provide shelter for the occupants, but there is need for the procurement
41 and installations of engineering and service systems that are meant to give occupants the required
42 comfort. These installations depend mostly on the use of one form of energy or the other to power
43 them [5]. In spite of Nigeria's huge resource endowment in energy and enormous investment in the
44 provision of energy infrastructure, performance of the power sector has remained poor in comparison
45 with other developing economies. According to [6], Nigeria had the highest percentage of system
46 losses at 33 to 41%, with the lowest generating capacity factor at 20%; the lowest average revenue at
47 US dollars of 1.56 KWh, the lowest rate of return at 8%, and the longest average accounts receivable
48 period of 15 months when compared with those of other developing countries. As a result of this
49 fundamental problem, households, businesses and industrial premises rely on their self-produced
50 electricity from generators that have attendant operating and capital costs [7, 8].

51 Nigeria has the highest concentrations of generators globally despite its rich energy source and more
52 than 60 million people own generators to provide electricity for homes and businesses [9]. The
53 impacts of the various types of generators used by occupants of buildings are enormous on
54 environmental quality and people's health. This has elicited major concerns among environmentalists
55 and other players in the built environment [10]. The use of generators is very common in most parts of
56 Nigeria, and most small scale businesses that would have been essentially noiseless produce heavy

noise pollution from generators [11]. This has resulted in the exposure of building users to a number of hazards associated with the use of generators in buildings. Common hazards are air, soil, noise and water pollution. The production of electric power, regardless of the source, whether non-conventional (wind, solar, tidal etc.) or conventional (generator, hydro, nuclear) has potentially adverse effects on the environment. These adverse effects arise at each stage of the fuel cycle as well as in the transmission and consumption of electricity through the emission of carbon dioxide, sulphur dioxide and nitrogen oxides. These emissions can cause irreversible impacts on the environmental components [12].

In an effort to assess likely effects that the use of generators can have on the environment and in the study area, studies have been carried out by [5, 13, 14, 15, 16] on its availability, operations, dynamic and emission effects. These studies did not focus on the likely impact of the use of generators and its fuel on soil which is a resource needed for sustainability of the environment, hence the need for this study. The object of this study was therefore to assess impact of the fuel of generators on the biophysical and chemical properties of soil through its ecological and environmental implications on the functions and properties of soil mass that it was in contact with.

2. The Study Area

The study was carried out in Ibadan Metropolis, Oyo State, Nigeria. It is in the south-western geopolitical zone of the country. It is one of the fastest growing cities in Nigeria in terms of its spatial and geographical spread in the country [17]. The geographical location of Ibadan falls between coordinates $7^{\circ} 22' 47''$ North of the Equator and $3^{\circ} 53' 0''$ East of the Greenwich Meridian. The city ranges in elevation from 150 m in the valley area to 275 m above sea level on the major north-south ridge which crosses central part of the city. The city is characterized by a warm rainy season between 100 mm to 200 mm of annual rainfall extending from March to October, and a constantly high temperature of 24°C to 27°C . The entire area of Ibadan is largely well-drained, though many of its rivers are seasonal. Developed land increased from only 100 ha in 1830 to 12.5 Km^2 in 1931, 30 Km^2 in 1963, 112 Km^2 in 1973, 136 Km^2 in 1981 and 214 Km^2 in 1988 [18].

85 3. Materials and Methods

86 The study was carried out by using objective method. A preliminary survey was carried out to
87 purposively determine five (5) sites that were contaminated or otherwise by the residues and oil of
88 generating sets in the study area. The objective method adopted involved taking samples of soil at
89 locations observed to be contaminated by the residues of fuel of generating set and its used engine oil
90 that might lead to cases of soil, ground/underground water pollution and reduced filtration rate.
91 Control samples observed not to be mixed with the fuel and that didn't have the history of
92 contamination with the fuel of generating sets were also purposively collected and analyzed in the
93 laboratory (Plate 1). This helped in assessing effect of the fuel of generating set and its oil residue on
94 the bio-physical and chemical properties of soil that could have ecological and environmental
95 implications on the ability of soil mass to support growth of flora and its effect on the pollution of
96 underground water sources by using standard laboratory procedures.

97 Samples of soil mixed and contaminated by the residues of oil/fuel of generating sets that might affect
98 properties of soil, lead to cases of ground/underground water pollution and reduced filtration rate were
99 collected in 5 sample sites in triplicates in the study area. Control samples observed not to be mixed
100 and uncontaminated by the used engine oil and fuels of the generating sets were also collected from 5
101 sample sites in triplicates across the study area. The samples collected were put in labeled polythene
102 bags and taken to the laboratory for the analyses of soil pH, moisture content, porosity, bulk density,
103 particle size distribution and organic matter respectively. The soil samples collected were air dried,
104 crushed and passed through a 2 mm sieve. Particles less than 2 mm in diameter were stored in
105 polythene bags until required (Plate 1). Soil pH was determined in 0.01 M CaCl_2 solution, soil
106 moisture and porosity were determined by the oven dry method, bulk density was determined by the
107 core method [19]. The particle size distribution was determined by the hydrometer method [20] and
108 the organic matter was determined by the chromic acid oxidation method [21]. This helped to assess
109 effects of the fuel of generating set and its oil residue on the bio-physical and chemical properties of
110 soil that could affect growth of flora components of the ecosystem. The effects of soil mass
111 contamination by the fuel of generating set were analysed by comparing mean values of the properties
112 of both control and uncontrolled samples with the use of T-test and Analysis of Variance (ANOVA).

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115 Plate 1: Air Drying of Sections of Collected Samples of Soil Mixed and Unmixed with
116 Fuel of Generators Prior to Analysis in the Laboratory
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4. Results and Discussions

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The results of the effects of fuel and oil of generators on the trend and behaviour of pH, moisture, porosity, bulk density, particle size distribution and organic matter of soil are presented in this section.

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Table 1 showed mean values of soil properties in the two environments; at the purposively selected soil sites that were not mixed and those contaminated by the fuel and oil of generators. The mean values of pH of soil mixed with fuel of generating sets (7.2 - 7.3) was sparingly higher than that of soil not mixed with oil/fuel (7.1 - 7.9). This was due to the chemical reactions that could have caused

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reduction in the alkalinity level of the soil by the reactive process of chemical compositions of oil

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content. The study found that mean values of porosity level of soil not mixed with fuel/oil of generating sets particles (32 – 44) were significantly higher than those of soil that were mixed with its

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fuel (10 – 32). However, the probable movement of people and mechanical impact transmitted on soil

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samples that were mixed with fuel of generating sets would have made it to have higher bulk density

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values (1.77 – 1.97) than soil samples that were not mixed with oil of generating sets (1.07 – 1.63) and

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this would have effect on percolation/filtration rate of water through its pores. The study also found

that the impact of contamination of soil by oil was responsible for the significant difference in the

mean values of organic matter of soil mixed and not mixed with oil of generating sets used in buildings and this ought to have impact on flora growth. In view of this, as shown in Table 1, the organic matter content of soil samples not mixed with oil/fuel of generating sets (3.15 – 8.12) was significantly higher than those of samples of soil that were contaminated by fuel/oil of generators (1.41 – 3.30). It was also found that the soil environment notwithstanding, the mean percentages of sand was significantly high in the samples collected and there was low variation in the silt and clay constituents. The trend of result of the analysis is shown in Figures 1 to 8.

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Table 1: Mean Values of Properties of Soil Samples Mixed and Not Mixed With Fuel of Generating Sets

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Type of Environment	Sample Number	pH	Moisture	Porosity %	Bulk Density	Particle Size Distribution			Organic Matter
						% Sand	% Silt	% Clay	
Soil Mixed With Fuel/Oil of Generating Set (A)	1	7.2	3.50	20	1.97	72	14	14	1.41
	2	7.4	3.09	24	1.87	84	6	10	2.61
	3	7.3	2.98	10	1.77	74	12	14	2.08
	4	7.3	3.36	20	1.86	86	2	12	2.82
	5	7.1	2.59	32	1.77	78	6	16	3.30
Soil Not Mixed With Fuel/Oil of Generating Set (B)	1 ¹	7.1	7.36	32	1.63	62	24	14	8.12
	2 ¹	7.1	12.58	42	1.07	48	30	22	3.15
	3 ¹	7.9	6.74	44	1.56	68	2	30	5.03
	4 ¹	7.5	7.97	44	1.45	56	22	22	4.51
	5 ¹	7.3	6.77	40	1.49	66	20	14	4.29

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Results of the analysis of properties of soil samples mixed with and otherwise with fuel and oil of generators showed the level of deviation that occurred in the mean values of the properties of soils in the two environments (Table 2). The results also showed that there was significant variation in the values of moisture, porosity, particle size distribution (silt) and organic matter component of the soil samples mixed with oil of generating sets (3.1040, 0.2120, 8.00 and 2.4440) relative to the samples not mixed with oil/fuel of generating sets (8.2840, 0.4040, 19.60 and 5.0200) (Table 2). Table 3 also indicated that t-test analysis revealed that moisture, porosity, particle size distribution (silt) and organic matter content were most significantly affected by the contamination of soil by the fuel/oil residue of generating sets used in buildings that it was in contact with. Hence, this shows that, there was significant impact of the use of generating sets when the residue of its oil and fuel were in contact with soil samples with the seemingly effect on the properties of soil that support plant growth and likely pollution effect on the underground water sources. Graphical illustrations of the relationship and trend in the results of soil properties in the two environments are as shown in Figures 1 to 8. The results of this study which showed effect of the fuel of generating set on the soil component of the environment that it was in contact with which led to the deterioration of the core parameters that could support growth of flora species are also related to past works in related environmental studies. The works of [22, 23, 24] also showed in their studies that land use patterns based on exposure of soil to activities caused deterioration to its bio-physical and chemical properties which could also affect its functions and applications in the environment.

Table 3: T-Test of the Properties of Soil Samples in the Two Environments

Properties	t	Df	P	Decision
pH	.759	8	.470	NS
Moisture	-4.672	8	.002	S

Porosity	-4.577	8	.002	S
Bulk density	3.911	8	.004	NS
Particle size distribution: % sand	4.138	8	.003	NS
Particle size distribution: % silt	-2.234	8	.056	S
Particle size distribution: % clay	-2.277	8	.052	NS
Organic matter	-2.880	8	.021	S

NS-Non-significant

S-Significant

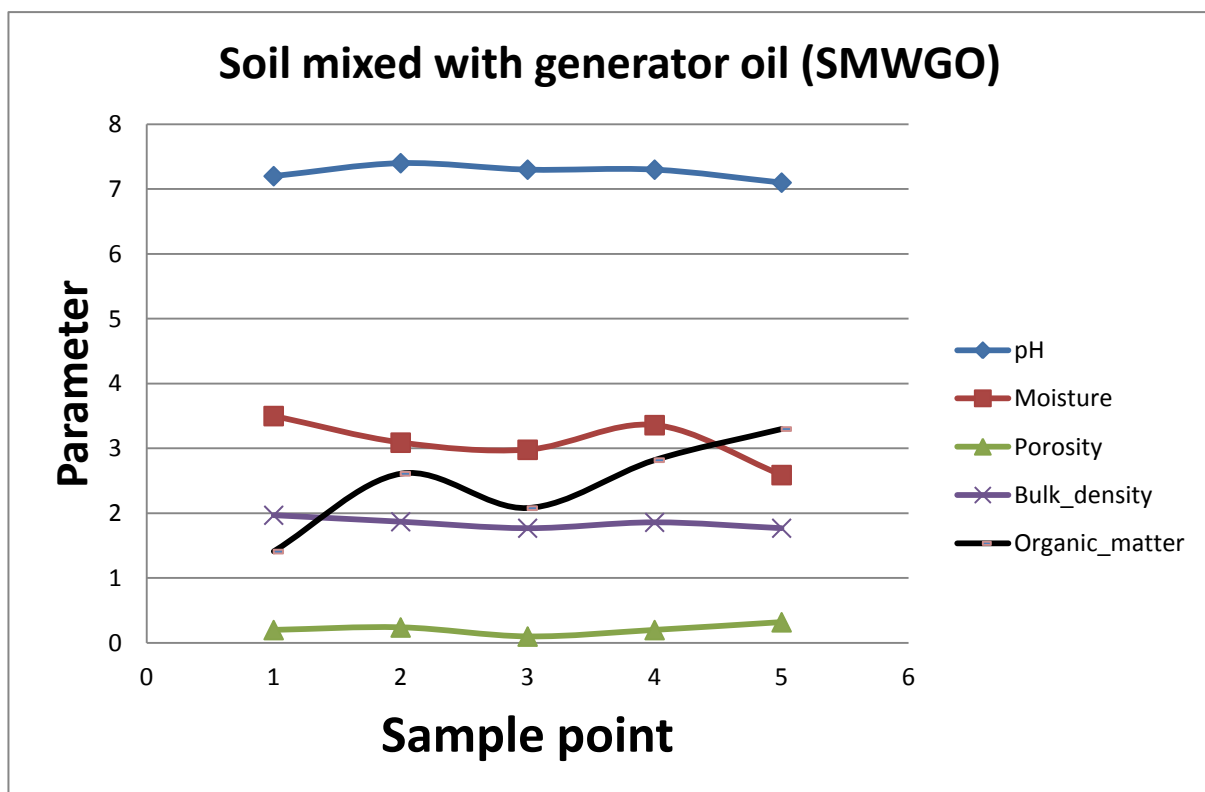


Figure 1: Trend of Properties of Soil Samples Mixed with Fuel and Oil of Generating Sets

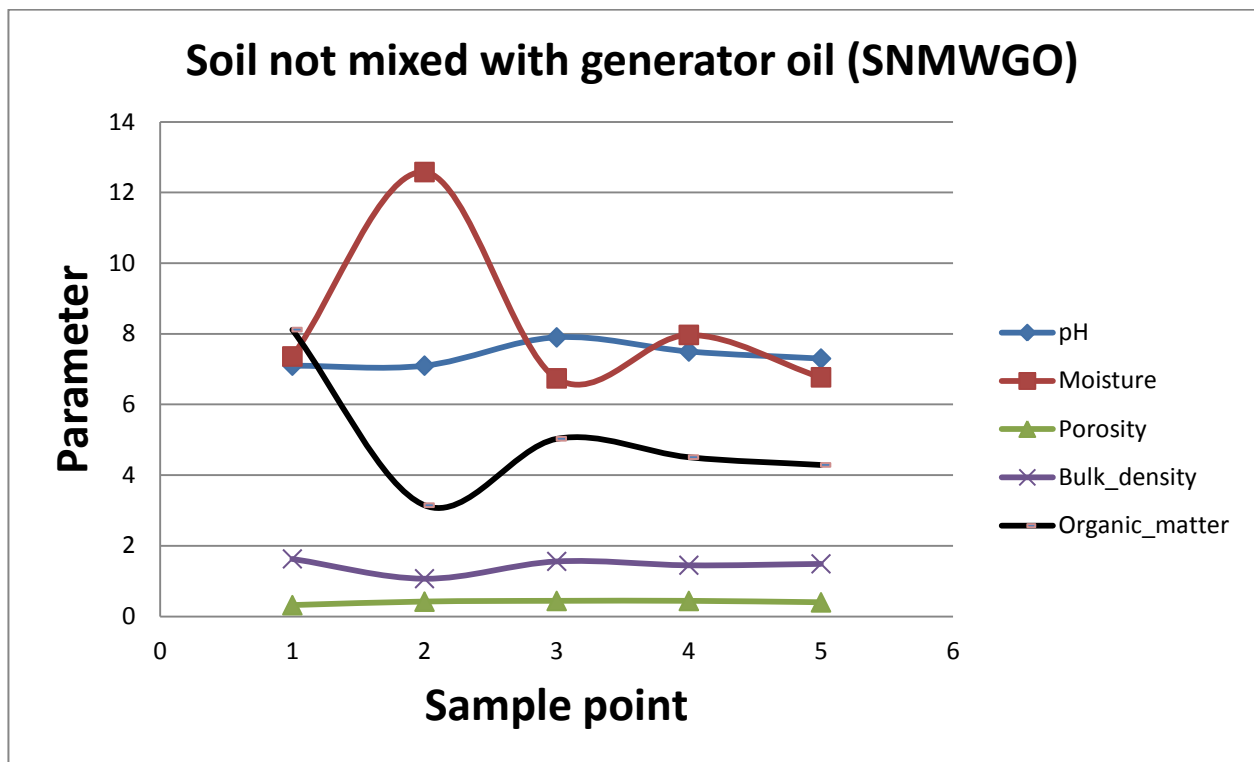


Figure 2: Trend of Properties of Soil Samples Not Mixed with Fuel and Oil of Generating Sets

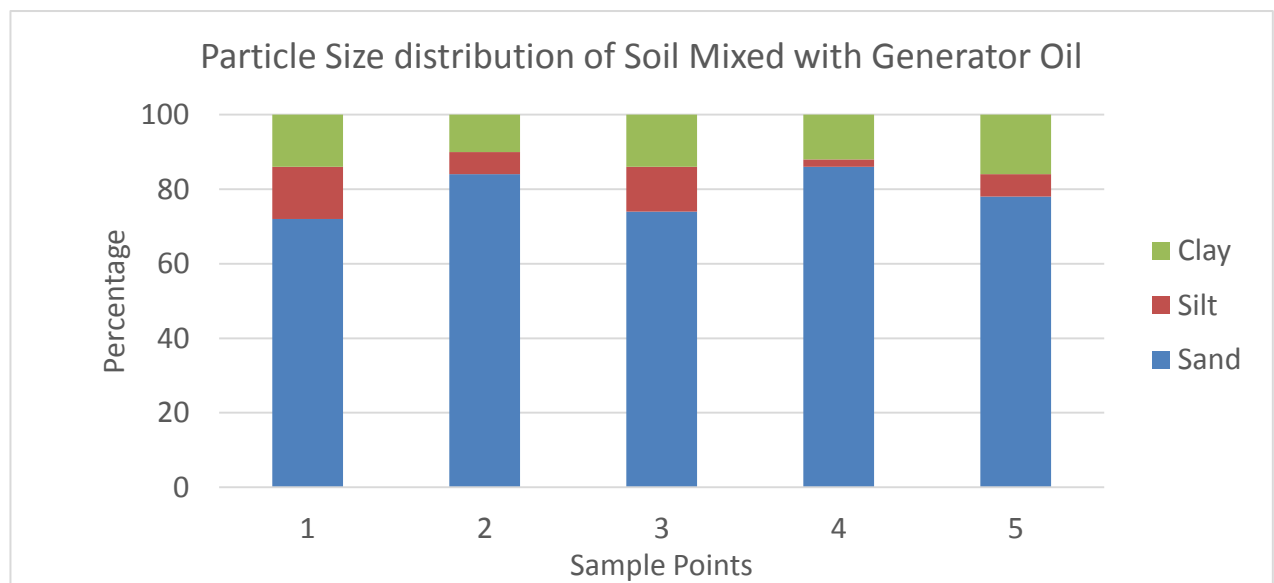


Figure 3: Particle Size Distribution of Soil Samples Mixed with Fuel and Oil of Generating Sets

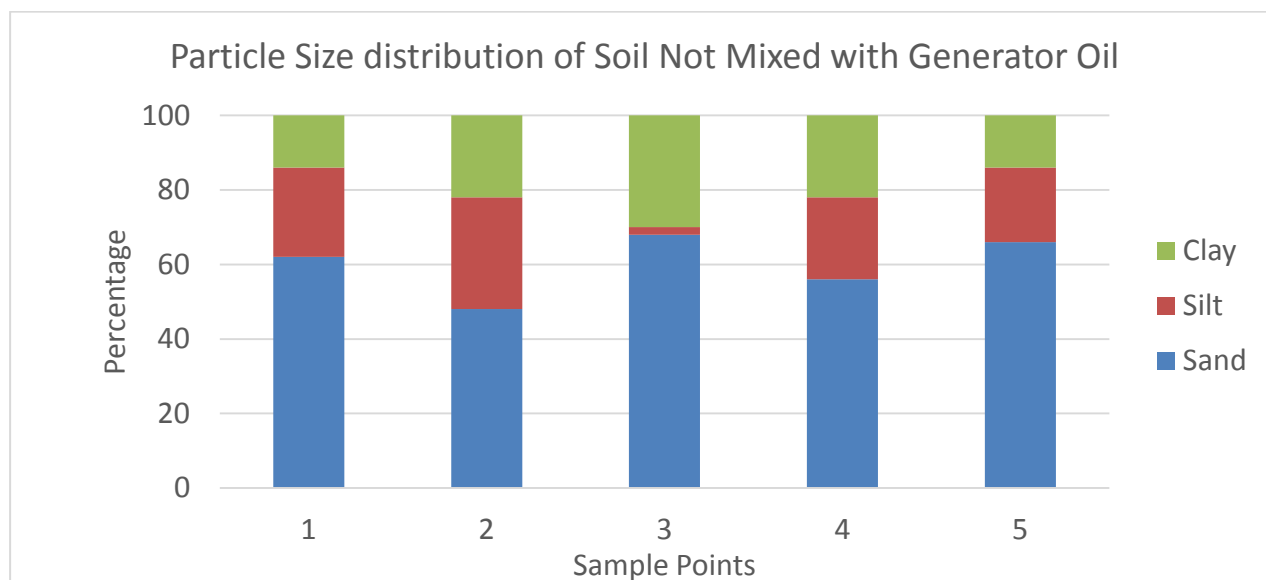


Figure 4: Particle Size Distribution of Soil Samples Not Mixed with Fuel and Oil of Generating Sets

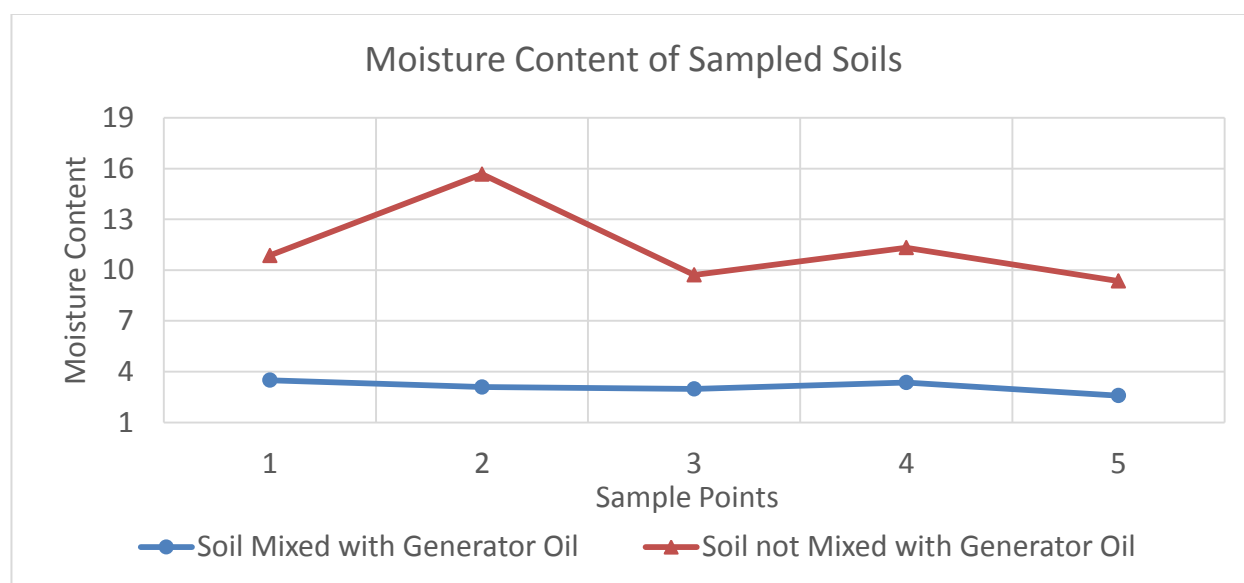


Figure 5: Variation of Moisture of Soil Samples Mixed and Not Mixed with Fuel of Generating Sets

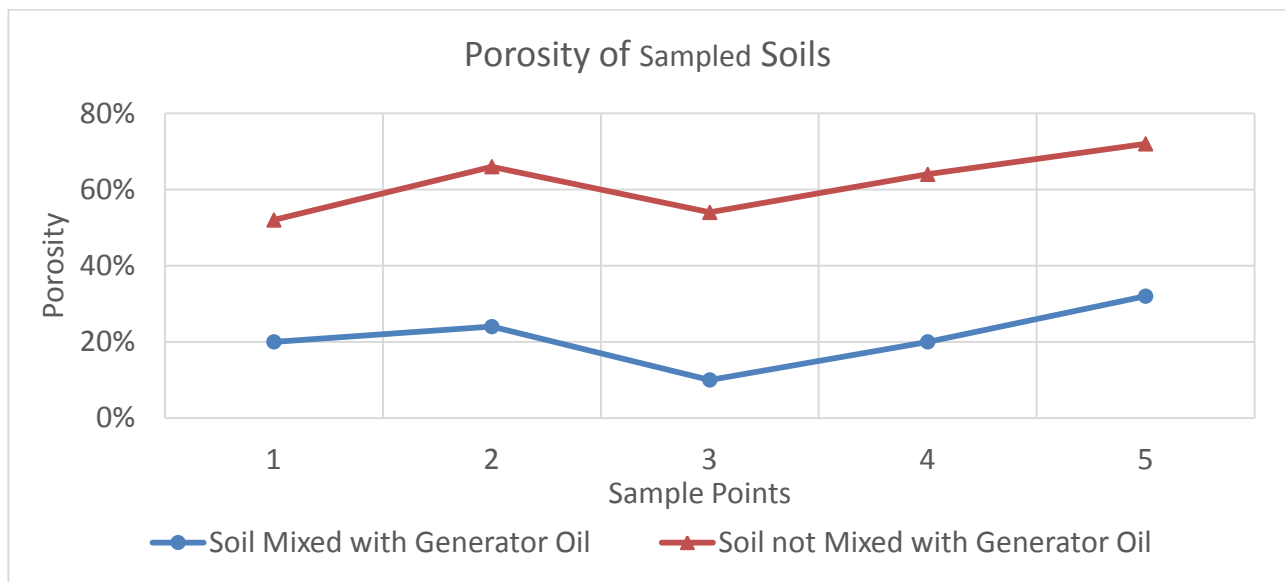


Figure 6: Variation of Porosity of Soil Samples Mixed and Not Mixed with Fuel of Generating Sets

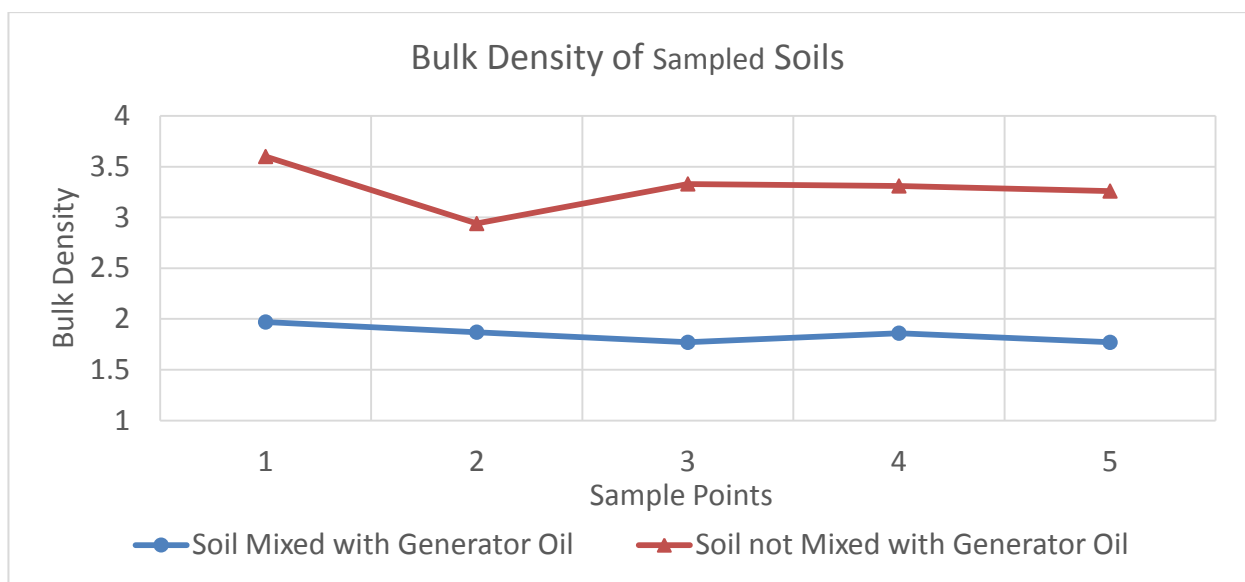


Figure 7: Variation of Bulk Density of Soil Samples Mixed and Not Mixed with Fuel of Generators

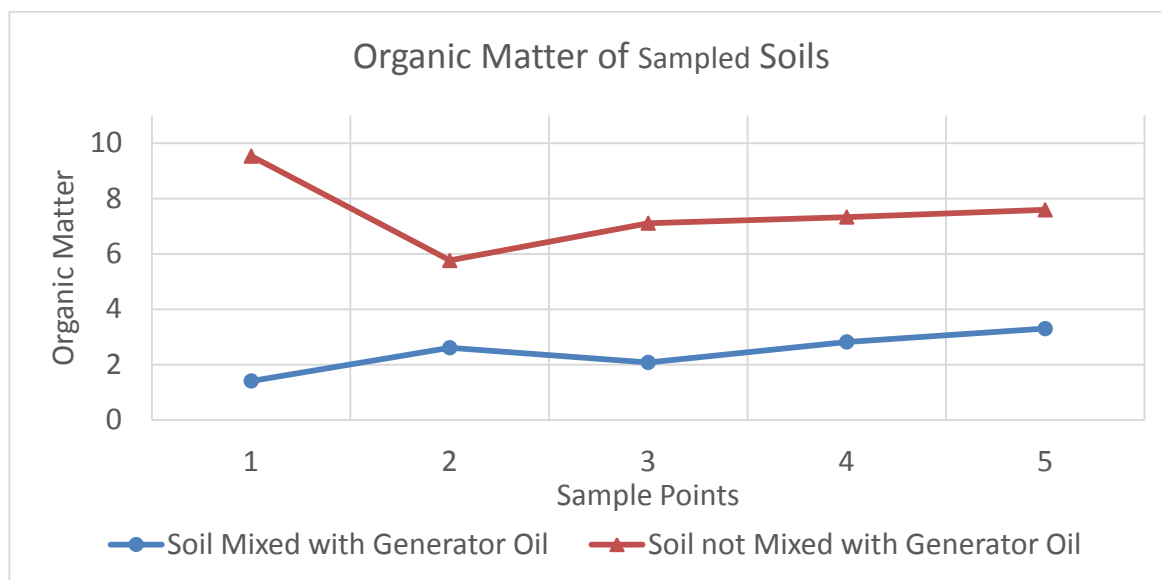


Figure 8: Variation of Organic Matter of Soil Samples Mixed and Not Mixed with Fuel of Generators

5. Conclusions and Recommendations

The study showed that inadequate quality and quantity of electricity informed wide use of electric power generators by respondents in the study area which posed major threat to sustainability of the environmental components. This is evident in the results of the study that showed effects of the residue of oil and fuel of generators mixed with soil on the bio-physical and chemical properties of soil mass. With the associated effects of substances of the fuel of generators on the properties of soil mass that it was in contact with or contaminated, it would thus subject soil and underground water sources to pollution potentials and also affect rate of growth of floral species. In view of the supposed impacts and pollution potentials associated with the contamination of soil by the fuel and oil of generators used by the building occupants, there is a strong need to make environmentally friendly power sources available that would not pose threat to the uses of soil and its associated features. Also, building occupants must be educated on how to properly manage and dispose of fuel of their generators through best house-keeping practices.

242 **References**

- 243 [1] Mabogunje, A.L. “Developing Mega Cities in Developing Countries”. Geography Students
244 Colloquium, University of Lagos, 2007.
245
- 246 [2] Adedokun, O.A., Akinradewo, F.O., Adegoke, J.O. and Abiola-Falemu, J.O.
247 “Evaluation of the Performance of National Housing Food Scheme Towards
248 Housing Delivery in Nigeria”. Journal of Emerging Trends in Economics and
249 Management Sciences, Vol. 2 No. 6, pp. 467-471, 2011.
250
- 251 [3] Sev, A. “How Can the Construction Industry Contribute to Sustainable Development? A
252 Conceptual Framework”, Sustainable Development, Vol. 17, pp. 161-173, 2009.
253
- 254 [4] United States Green Building Council. “USGBC Green Building Research”.
255 <http://www.usgbc.org / Display>, 2010.
256
- 257 [5] Komolafe, A. “Availability of Generators for Electricity Supply to Selected Large Residential and
258 Office Buildings in Kaduna and Abuja, Nigeria”. An Unpublished M.Sc. Thesis Submitted to the
259 Department of Building, Faculty of Environmental Design, Ahmadu Bello University, Zaria,
260 Nigeria, 2011.
261
- 262 [6] World Bank. “Energy Sector Management Assistance Programme in Nigeria: Expanding
263 Access to Rural Infrastructure: Issues and Options for Rural Electrification, Water Supply and
264 Telecommunications”, The International Bank for Reconstruction and Development,
265 Washington D.C., USA, 2005.
266
- 267 [7] Idiata, D.J., Omoruyi, F.O., Agbonalor, N.N. and Ohonba, S.U. “Environmental Effects
268 of Fossil Fuel Usage”. The Nigeria Academic Journal. Vol. 13, No. 2, 2007.
269
- 270 [8] Awofeso, N. “Generator Diesel Exhaust: A Major Hazard to Health and the Environment
271 in Nigeria”. Amer J Respiratory Critical Care Med. Vol. 183, pp. 1437-1438, 2011.
272
- 273 [9] British Broadcasting Corporation- Africa. “Shame: More than 60 Million People Own
274 Generators in Nigeria”. In a Report of Tomi Oladipo, November 22, 2013.
275
- 276 [10] Obadote, D.J. “Energy Crisis in Nigeria”. Rasheen Publisher, Lagos, Nigeria, 37-51, 2009.
277
278
- 279 [11] Akande, T.M., and Ologe, F.R. “Awareness of Commercial Grinding Machine Operators in Ilorin
280 to Noise Induced Hearing Loss”. Tropical Journal of Health Sciences, Vol. 8, No.1, pp. 28-31,
281 2001.
282

- 283 [12] Macrae, K.M. “Critical Issues in Power, Planning in the 1990s”, Volume I, Study No. 33,
 284 Published by the Canadian Energy Research Institute, Calgary, Alberta, Canada, T24
 285 2A6, 1989, 1990.
 286
- 287 [13] Komolafe, A. “Availability of Generators for Electricity Supply to Selected Large
 288 Residential and Office Buildings in Kaduna and Abuja, Nigeria”. An Unpublished M.Sc.
 289 Thesis Submitted to the Department of Building, Faculty of Environmental Design,
 290 Ahmadu Bello University, Zaria, Nigeria, 2011.
 291
- 292 [13] Stanley, A.M., Mbamali, I.M. and Dania, A.A. “Effect of Fossil-Fuel Electricity
 293 Generators on Indoor Air Quality in Kaduna, Nigeria”. Symposium on Indoor Air
 294 Quality in Developing Countries (Ed.) Carter et al, June 6-7, Austin, TX 78712, pp. 46-50, 2011.
 295
- 296 [14] Orumu, S.T. and Ephraim, M.E. “Dynamic Effect of Generating Sets on Suspended Building
 297 Floors”. The International Journal of Engineering and Science, 2(10), pp. 23-26, 2013.
 298
- 299 [15] Ana, G., Olowolade, A.T., Abimbola, A.F., Ige, O. and Nriagu, J.O. “Generator Emissions Profile
 300 and the Lung Function Status of Workers within Selected Small-Scale Business Premises in
 301 Ibadan, Nigeria”. Global Health Perspectives, <http://dx.doi.org/10.5645/ghp2014.02.003>,
 302 2014.
 303
- 304 [16] Sonibare, J.A., Jamiu, A.A., Bamidele, S.F., Ismaila, O.L., Lukuman, A.J., and Olusesan, A.A.
 305 “Ambient Noise from Off-Grid Diesel Engine Electric Power Generators in an Urban
 306 Environment”. International Journal of Management of Environmental Quality, Vol. 25, No.
 307 2, pp. 185-199, 2014.
 308
- 309 [17] Ayeni, B. “The Metropolitan Area of Ibadan, its Structure and Growth”. In: Filani, M.O.,
 310 Akintola, F.O. and Ikporukpo, C.O. (eds) Ibadan Region. Rex Charles Publications,
 311 Ibadan, pp. 72-84, 1994.
 312
- 313 [18] Mabogunje, A.L. “*Urbanization in Nigeria.*” University of London Press, London, 1968.
 314
- 315 [19] Blake, G.R. “Bulk Density”: In Black C.A (ed.), Methods of Soil Analysis, Part 1, Madison
 316 Wisconsin, American Society of Agronomy, Agronomy, Vol. 99, pp. 374-394, 1965.
 317
- 318 [20] Bouyoucos, G.H. “A Calibration of the Hydrometer for Making Mechanical Analysis of
 319 Soils”. Agronomy Journal, Vol. 43, pp. 434-448, 1952.
 320
- 321 [21] Walkey, A. and Black, I.A.”An Examination of the Pegjareff Method for Determining Soil
 322 Organic Matter and a Proposed Modification of the Chromic Acid Titration Method”. Soil
 323 Science, Vol. 37, pp. 29-32, 1934.
 324
- 325 [22] Bada, S. “Heavy Metal Concentration of Soil and Vegetation Associated with Highways
 326 of Two Different Traffic Densities in Osun State”. An Unpublished M.Sc. Thesis Submitted
 327 to the Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ife, 2000.
 328
 329

331 [23] Wahab, A.B. “An Assessment of the Dynamics of Soil Properties in Preserved and
332 Built-Up Environments in Egbeda Local Government Area of Oyo State, Nigeria”.
333 An Unpublished M.Sc. Thesis Submitted to the Institute of Ecology and Environmental
334 Studies, Obafemi Awolowo University, Ile-Ife, Nigeria, 2003.
335

336 [24] Postel, S. “Air Pollution, Acid rain and the Future of Forests”. World Watch Institute
337 Paper, No. 58, Washington D.C., USA, 1984.
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