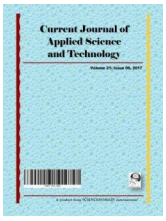

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# Effects of Fuel of Electric Power Generators on Soil Properties

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***Authors' contributions***

*This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.*

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## 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 which are sources of pollution to various components of the environment. The objective of this study was to assess the impact of fuel of generator on the selected biophysical and chemical properties of soil to which it comes in contact. The study was carried out in Ibadan Metropolis, Oyo State, Nigeria. Five sampling points that were contaminated by the fuel and oil of generators and control points not contaminated and mixed with its fuel were purposively selected in the study area. The soil samples collected were put in labelled 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 the significance of the effect of fuel of generating sets on biophysical and chemical properties of the 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 fuel of generating sets disposed of on soil mass would negatively affect its properties necessary for the sustainable growth of flora component of the ecosystem and could cause pollution potential

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inunder ground water sources to be explored by the building occupants. It was therefore recommended that there is need to use environment-friendly power sources and the associated fuel waste of generators must be properly managed so as not to be a source of threat to the functions and properties of soil resources in the environment.

*Keywords: Electricity; supply; generators; soil resources; environment; sustainability.*

## 1. INTRODUCTION

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

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

Nigeria has the highest concentrations of generators globally despite its rich energy source and more than 60 million people own generators to provide electricity for homes and businesses [9]. The impact of the various types of generators used by occupants of buildings is enormous on environmental quality and people's health. This has elicited major concerns among environmentalist and other players in the built environment [10]. The use of generators is very common in most parts of 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 an irreversible impact 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 the 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 7º22' 47" North of the Equator and 3º53' 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 the 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 24ºC to 27ºC. 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].

## 3. MATERIALS AND METHODS

The study employed an experimental design which involved taking samples of soil in different environmental conditions, subjecting them to standard laboratory procedures so as to investigate relationships between activities carried out and the resultant outcomes. The experiment design type employed also allowed in deciding what was to be measured and the measurements made were based on the known condition of validity by using the objective method of research design. A preliminary survey was carried out to purposively determine five (5) sites that were contaminated or otherwise by the residues and oil of generating sets in the study area. The objective method adopted involved taking samples of soil at locations observed to be contaminated by the residues of fuel of generating set and its used engine oil that might lead to cases of soil, ground/underground water pollution and reduced filtration rate. Control samples which have not to be mixed with the fuel and that didn't have the history of contamination with the fuel of generating sets were also purposively collected and analyzed in the laboratory (Plate 1). This helped in assessing the effect of the fuel of generating set and its oil residue on the biophysical and chemical properties of soil that could have ecological and environmental implications on the ability of soil mass to support the growth of flora and its effect on the pollution of underground water sources by using standard laboratory procedures.

Samples of soil mixed and contaminated by the residues of oil/fuel of generating sets that might affect properties of soil, lead to cases of ground/underground water pollution and reduced filtration rate was collected in 5 sample sites in triplicates in the study area. The control samples which have not been mixed and uncontaminated by the used engine oil and fuels of the generating sets were also collected from 5 sample sites intriplicates across the study area. The soil samples collected were put in labelled polythene

**Plate 1. Air drying of sections of collected samples of soil mixed and unmixed with the fuel of generators prior to analysis in the laboratory**

bags and taken to the laboratory for the analyses of soil pH, moisture content, porosity, bulk density, particle size distribution and organic matter respectively. The soil samples collected were air-dried, crushed and passed through a 2 mm sieve. Particles less than 2 mm in diameter were stored in polythene bags (Plate 1). Soil pH was determined in 1:2 soil solution by using 0.01 M $CaCl_2$ solution. Soil moisture and porosity were obtained by the oven dry method by drying the samples collected in an oven at a temperature of about 105ºC for 24 hours, weighed to determine the moisture content and expressed as percentage of the oven-dry weight of the soil, while soil porosity was expressed as a percentage of the total volume of the soil material by determining the number of pores present. Bulk density was established by the core method [19] after oven drying and the mass of soil particles over the core volume. Particle size distribution was ascertained by the hydrometer method [20] with sodium hexametaphosphate (Calgon) as the dispersing agent and the organic matter was also determined by the method of [21] by using chromic acid oxidation method. These laboratory procedures helped to assess the effect of the fuel of generating set and its oil residue on the biophysical and chemical properties of soil that could affect the growth of flora components of the ecosystem. The effect of soil mass contamination by the fuel of generating set was analysed by comparing mean values of the properties of both control and uncontrolled samples with the use of T-test and Analysis of Variance (ANOVA).

## 4. RESULTS AND DISCUSSION

The results of the effect 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. Table 1 shows mean values of soil properties in the two environments; at the soil sites purposively selected that were not mixed with the generator fuel and those contaminated by the fuel and oil of generators. The mean values of pH of soil mixed with the fuel of generating sets (7.2 - 7.3) were sparingly higher than that of soil that was not mixed with oil/fuel of generators (7.1 - 7.9). This was due to the chemical reactions that could have caused a reduction in the alkalinity level of the soil by the reactive process of chemical compositions of oil content. The study found that the mean values of porosity level of soil samples that were not mixed with fuel/oil of generating sets particles (32 – 44) were significantly higher than those of soil that was mixed with its fuel (10 – 32). Equally, the mechanical impact being transmitted and caused by movement of people on sites of soil samples that were mixed with fuel of generating sets would have made it to have higher bulk density values (1.77 – 1.97) than soil samples of sites that were not mixed with the oil of generating sets (1.07 – 1.63). Thus, this would have an 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 an 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 the result of the analysis is shown in Figs. 1 to 8.

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, at P= 0.05, 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 a 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 Figs. 1 to 8. The results of this study which showed the 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 the 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 biophysical and chemical properties which could also affect its functions and applications in the environment.

**Table 1. Mean values of properties of soil samples mixed and not mixed with fuel ofgenerating sets**

| Type of environment | Sample number | pH | Moisture % | Porosity % | Bulk density g/cm$^3$ | 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 |

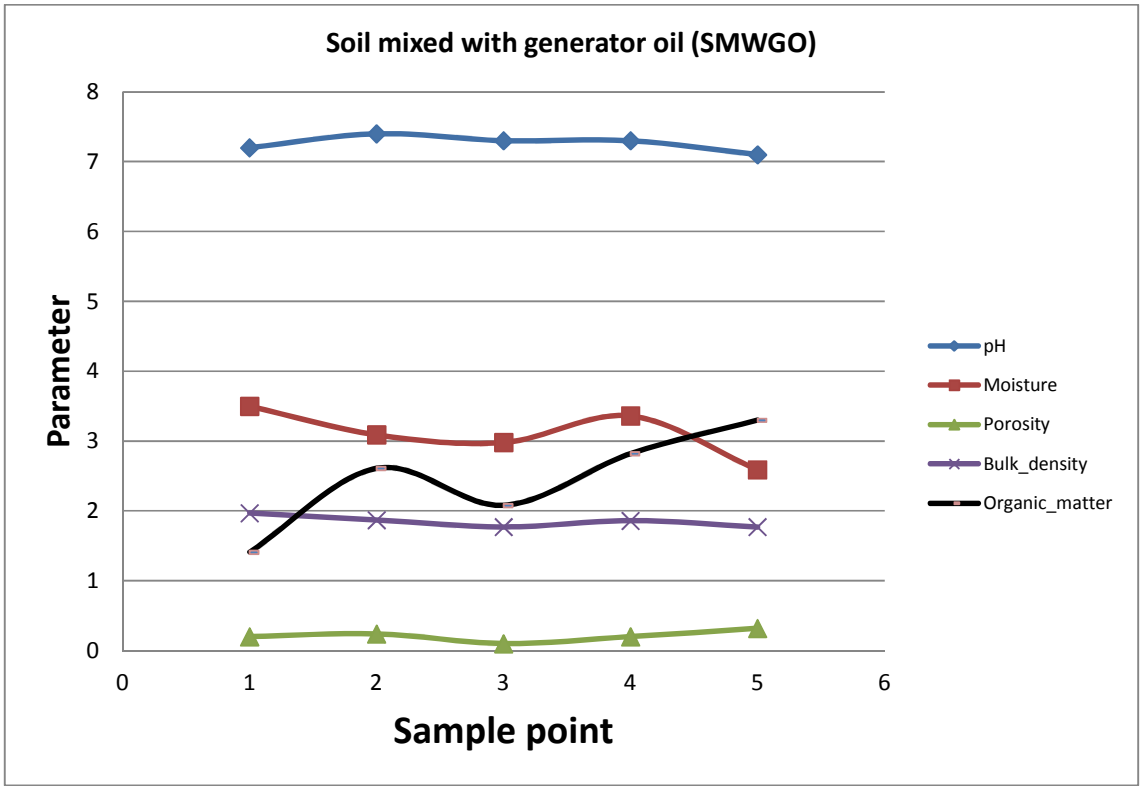


**Fig. 1. Trend of properties of soil samples mixed with fuel and oil of generating sets**

**Table 2. Variation in the mean values of soil samples collected in the two environments**

| Property | Environment type | N | Mean | Std. deviation | Std. error mean |
|---|---|---|---|---|---|
| $_P$H | Soil mixed with generator oil (SMWGO) | 5 | 7.2600 | .11402 | .05099 |
| | Soil not mixed with generator oil (SNMWGO) | 5 | 7.3800 | .33466 | .14967 |
| Moisture | Soil mixed with generator oil (SMWGO) | 5 | 3.1040 | .35430 | .15845 |
| | Soil not mixed with generator oil (SNMWGO) | 5 | 8.2840 | 2.45378 | 1.09736 |
| Porosity | Soil mixed with generator oil (SMWGO) | 5 | .2120 | .07950 | .03555 |
| | Soil not mixed with generator oil (SNMWGO) | 5 | .4040 | .04980 | .02227 |
| Bulk density | Soil mixed with generator oil (SMWGO) | 5 | 1.8480 | .08319 | .03720 |
| | Soil not mixed with generator oil (SNMWGO) | 5 | 1.4400 | .21794 | .09747 |
| Particle size distribution: % sand | Soil mixed with generator oil (SMWGO) | 5 | 78.80 | 6.099 | 2.728 |
| | Soil not mixed with generator oil (SNMWGO) | 5 | 60.00 | 8.124 | 3.633 |
| Particle size distribution: % silt | Soil mixed with generator oil (SMWGO) | 5 | 8.00 | 4.899 | 2.191 |
| | Soil not mixed with generator oil (SNMWGO) | 5 | 19.60 | 10.526 | 4.707 |
| Particle size distribution: % clay | Soil mixed with generator oil (SMWGO) | 5 | 13.20 | 2.280 | 1.020 |
| | Soil not mixed with generator oil (SNMWGO) | 5 | 20.40 | 6.693 | 2.993 |
| Organic matter | Soil mixed with generator oil (SMWGO) | 5 | 2.4440 | .72514 | .32429 |
| | Soil not mixed with generator oil (SNMWGO) | 5 | 5.0200 | 1.86414 | .83367 |

*SMWGO: Soil mixed with generator oil and fuel*
*SNMWGO: Soil not mixed with generator oil and fuel*

**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*

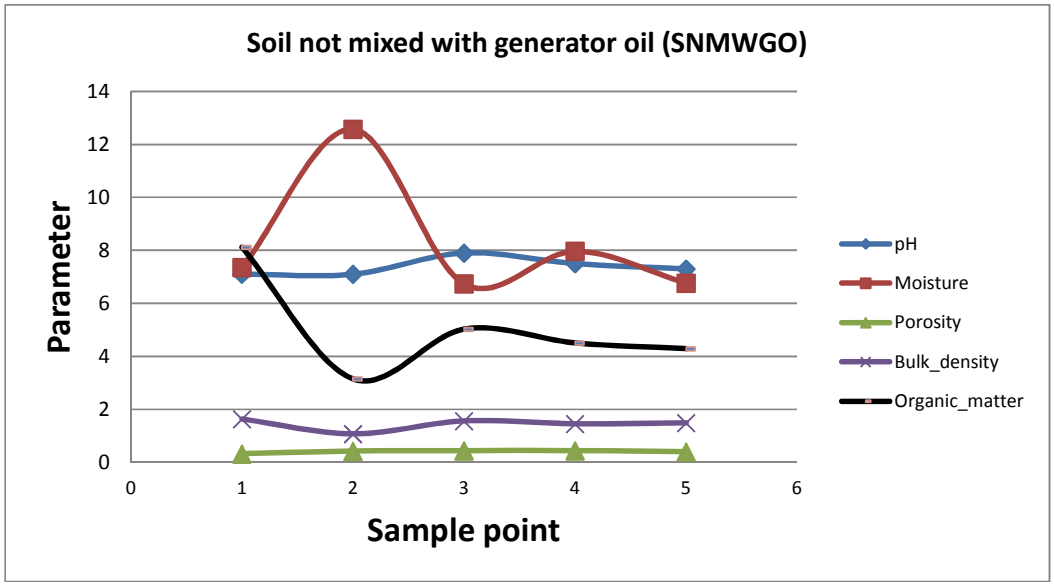


**Fig. 2. Trend of properties of soil samples not mixed with fuel and oil of generating sets**

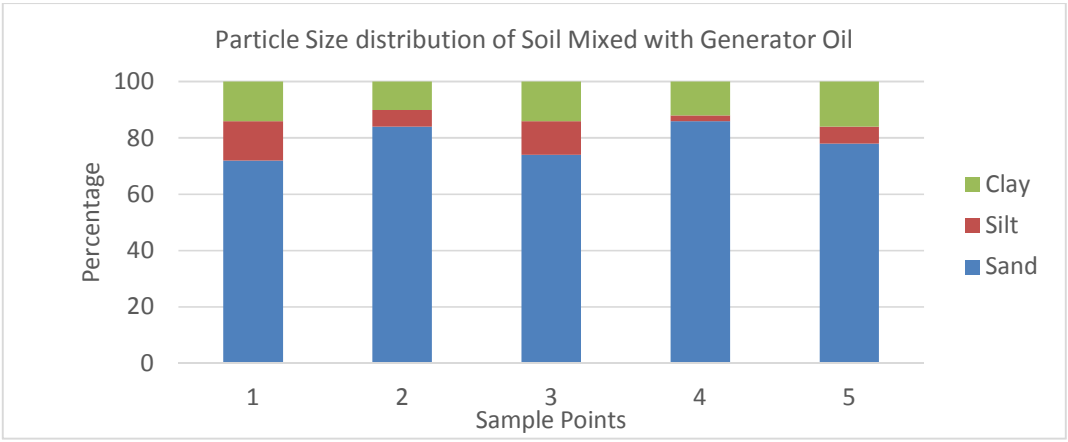


**Fig. 3. Particle size distribution of soil samples mixed with fuel and oil ofgenerating sets**

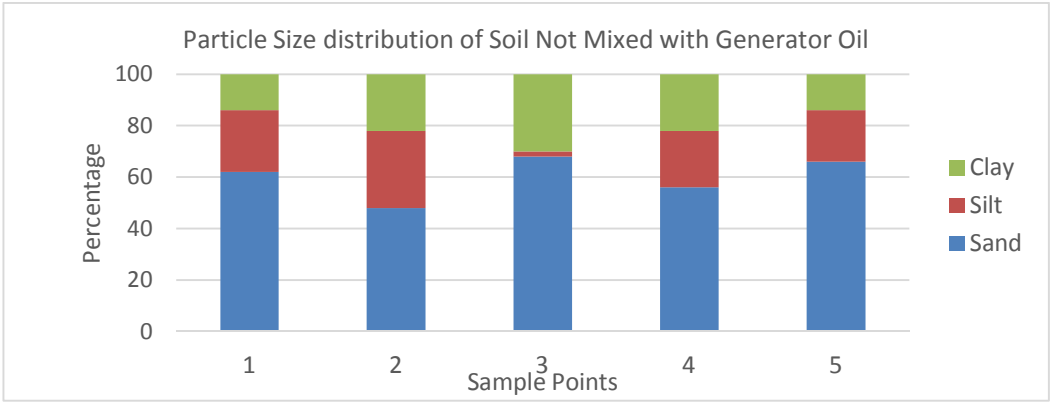


**Fig. 4. Particle size distribution of soil samples not mixed with fuel and oil of generating sets**

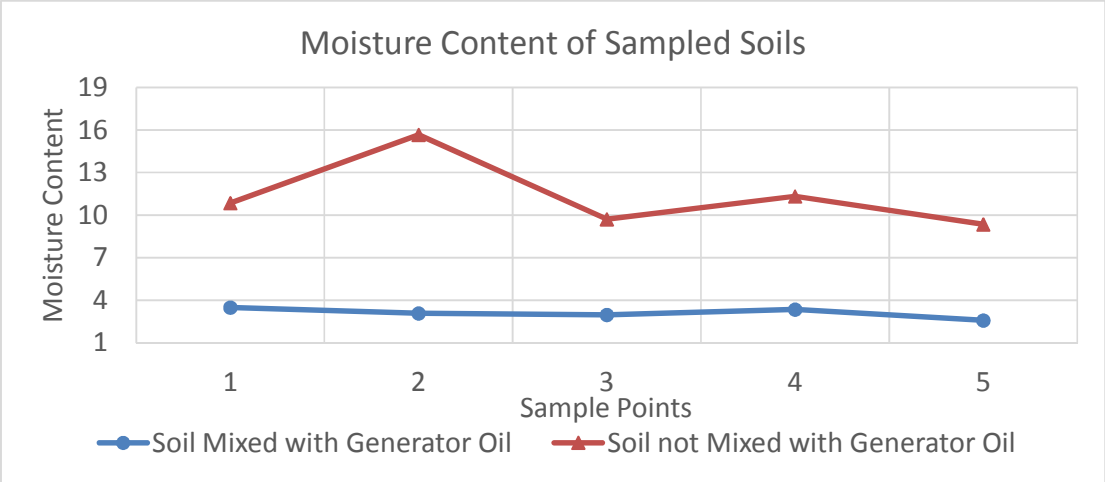


**Fig. 5. Variation of moisture of soil samples mixed and not mixed with fuel of generating sets**

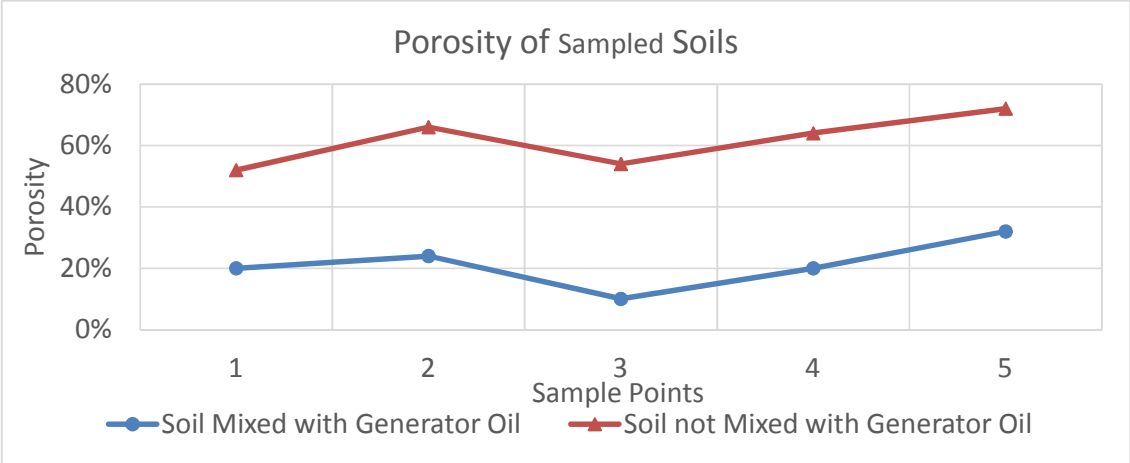


**Fig. 6. Variation of porosity of soil samples mixed and not mixed with fuel of generating sets**

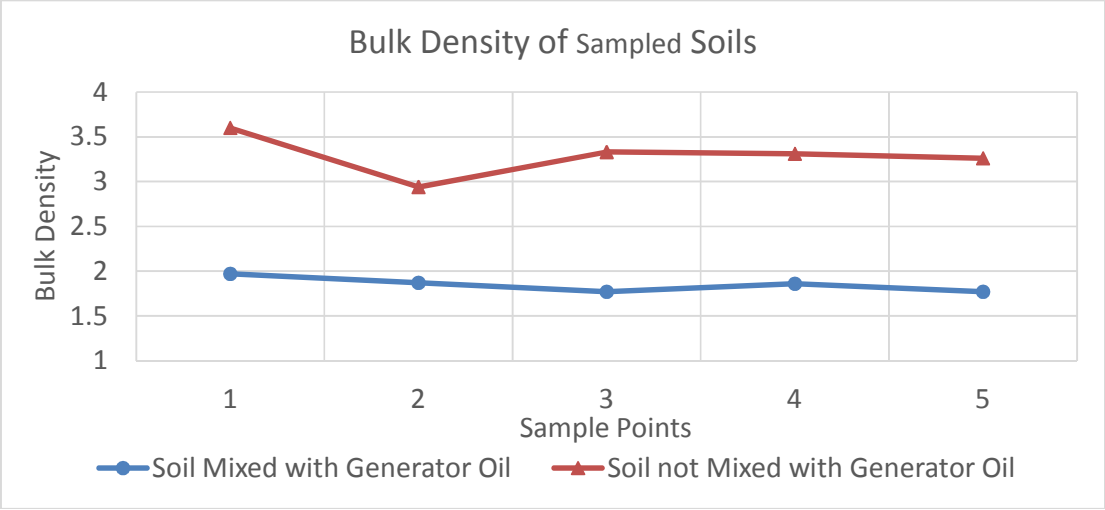


**Fig. 7. Variation of bulk density of soil samples mixed and not mixed with fuel of generators**

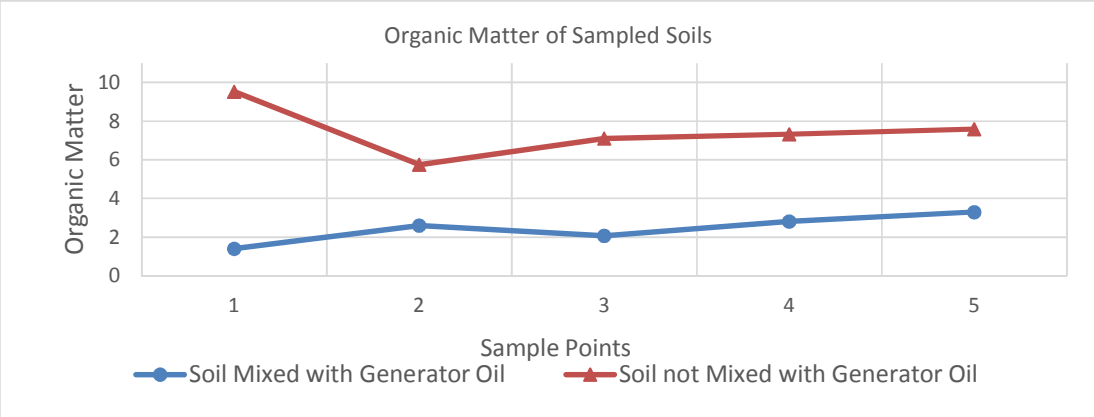


**Fig. 8. Variation of organic matter of soil samples mixed and not mixed with fuel of generators**

## 5. CONCLUSIONS AND RECOMMENDATIONS

The study showed that the proliferation of generators and the attendant disposal of its fuel and oil waste on soil mass has a significant effect on its properties that would affect the sustainability of the environment. This is evident in the results of the study that showed effects of the residue of oil and fuel of generators that was mixed with soil on its biophysical and chemical properties. The analysis indicated that moisture, porosity, particle size distribution (silt) and organic matter content of soil were most significantly affected by the contamination of soil with the fuel/oil residue of generating sets deposited on soil environment by building occupants. 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 with, it would thus subject soil and underground water sources to pollution potentials and also affect the 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 need to make environment-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.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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