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Physicochemical Characteristics of Diesel-Contaminated Soil along Iwofe–Ada George Road, Port Harcourt, Rivers State

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Abstract
This research investigated the levels of some physicochemical parameters like pH, electrical conductivity, particle size distribution and alkalinity at selected points along the Iwofe-Ada George Road where the soil has been contaminated with diesel due to the operation of heavy duty generators installed for lighting-up the road at night. The parameters were analyzed and examined using suitable laboratory methods to verify the levels of the studied physicochemical parameters in the soils of the studied area. The results showed that the average value of pH in the soils ranged from 6.40±0.07 to 6.77± 0.05, electrical conductivity ranged between 196.51±12.50 to 470.24±7.88µS/cm, soil alkalinity ranged from 7.46±0.01 to 8.05±0.01 mg/Kg, Particle size distribution analysis in the soils revealed that sand ranged from 84.51±0.41 to '85.92±0.33%, clay ranged from 8.50±0.10 to 9.80±0.35% and silt ranged from 5.02±0.19 to 6.70±0.24.The textural class observed for the soils analyzed in all the stations were sandy soil. The study showed that the soil contaminated with diesel has greatly affected the levels of the physicochemical parameters study and that such effects could be dangerous to both animals and plants that occupy the studied soil environment.

Keywords: Diesel, Soil Alkalinity, Ph, Electrical Conductivity, Soil Particle Sizes

Introduction

The soil is a very indispensable component in the terrestrial environmental system. The prominence of soil to man is as a result of the fact that the top soil is where plant grows and it plays a major role in the food chain (Ojo et al., 2017). Soil is important in its constituents and through it, the basic need actualized in its constituents and other living creatures. The quality of any soil type is a direct measure of its productivity in any given ecosystem and the existence of certain physicochemical considerations at a certain limit also affect the soil quality greatly (Mahajan & Billore, 2014). Soil offers the basic support for agricultural systems and production. Enhancing productivity require the upkeep of the ecosystem which rely on the soil than any other resource and the physicochemical nature, characteristics and biological content of the soil are very significant aspects in agricultural productivity. In order to protect the quality of the soil from deterioration, control measures need to be put in place. Pollution of the soil produced by industrial activities, mining, agricultural and other associated activities could be reduced by suitable and sustainable planning (Mobar, 2015). Agricultural soil and its fertility can be monitored statistically and scientifically by laid down monitoring procedures by the administrators of soil fertility (Patel, 2014). For proper conservation of soil for the sustainability of the ecosystem, the important parameters needed to be analyzed in order to enhance soil quality (Schoenholtz, 2000). The soil is composed of several minerals, broken rock and organic constituent and that have resulted in the alteration of reaction in the environment. The various contaminated and pollutants naturally are absorbed by the soil, no matter the quantity, this has made the soil to become a natural sink to all pollutants. This has resulted in changes in the chemical and physical properties of soil. The capacity of the soil to remove impurities to the atmosphere has made it a natural purifier.

The soil which is very significant for the existence of life when contaminated or polluted by petroleum components poses severe effect and hazard to the environment worldwide and therefore draws the attention of the public. One key

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way in which petroleum hydrocarbon components enter into the environment is by human activities, which is not appropriately checked, controlled or managed (Edori & Kpee, 2019). Agricultural and industrial activities release waste into the environment (air, water and soil) (Adipah, 2019). Human activities and influence have resulted into an untold increase in the degree of contamination of the soil, such contamination and pollution has led to certain concerns in life that is hazardous to humans' animals' and plants' life (Edori et al., 2022). These human activities comprise the application of pesticides and fertilizers, release of industrial wastes, mining, manufacturing, of goods and rupture of storage tanks (Seifi et al., 2010) has brought in changes into the natural physical and chemical nature of the soil of the environments. The alterations in the nature of soil as a result of contamination by hydrocarbon components sometimes results in the blocking of air spaces that make air available to the soil through diffusion from the pores of the soil particles (Sutton et al., 2013) and thus creating variations in the physical properties of the soil by altering the permeability and Atterberg limits of the soil (Nazir, 2011; Akunwumi et al., 2014; Devatha et al., 2019). The progress and development of plants and other soil creatures are greatly affected which came as a result of the changes in the chemical characteristics of the soil, like pH, total organic carbon and mineral nutrients (Yalin et al., 2006; Akugugwo et al., 2009; Wang et al., 2010). The persistent deficiency of these physical and chemical necessities is unfavorable and yields critical consequences which could lead to inappropriateness in soil settings that can bring about in poor crop development and growth.

Component of diesel oil permeate the soil and destroy its structure disrupting oxygen conditions and the ability of the soil to retain water. In addition, the presence of diesel in the soil negatively affect the physicochemical and biochemical characteristics of soil, as well results in the decrease of the production capacity (Edori et al., 2020). There are changes in the content of macro and micro elements, usually results in the bioaccumulation of trace element and also the presence of petroleum substances in the soil has high impact on plants and hence food production. Soil contamination with diesel oil causes decrease in the capacity of sorption complex, as well as the ability to exchange calcium, magnesium and potassium, while limiting the availability of these micro element to plants. Petroleum hydrocarbon discharged into the environment lead to degradation of soil, delayed germination and disturbance of water retentions and its exchange with plants. Petroleum substance also poses significant danger to animals and humans. Oil component migrate deep into 'the soil and into surface and ground water, threatening the safety of drinking water source from the root to the above ground parts of plants, where they can produce grievous consequences that leads to inappropriate soil conditions thereby resulting in poor crop growth.

The ineptitude and ineffectiveness of the power generating sector in Nigeria to make available electricity all over the country to serve the huge power and energy requirement needed has occasioned the installation of heavy-duty diesel generators in industries, estates, universities, markets, streets and even government houses all over the nation (Edori et al., 2021). This condition or state has led to the pollution, deterioration and eventual degradation of the environments especially by petroleum hydrocarbons. The problems and consequences triggered by this anomaly in short fall of electricity supply via the National Grid as it is called in Nigeria has produced harmful effects, which has eventually led to the contamination of the soil, water and air and resultant costly health challenges on human and plants (Edori et al., 2021). At very great degree of occurrence of petroleum hydrocarbons in the soil, it results into health threat to animals, plants and even humans (Okop & Ekpo, 2012). The pollution and contamination of the environments (soil, air and water) by hydrocarbon component has resulted into the presence of dangerous wastes, chemicals and substances that are toxic and hazardous into the environments (Ekundayo & Obuekwe, 2004; Chukwujindu et al., 2008). Crude oil easily contaminates the soil and several sources that produces the contamination comprises fuel leakages from storage tanks, discharge of waste products, oil spills and deliberate release of petroleum products into the soil environment (Schwab et al., 1999).

Due to the inability or the power generating and distributing companies in Nigeria to adequately singly electricity to the people, there arose the necessity or electricity provision by the individual and government the use or power meats. Also the requirement for the roads to be adequately lit up in the in-flight has brought about the installation of heavy duty generators at strategies area along major roads in Port Harcourt. These generators use diesel oil which affect the soil at the various points where the generators are kept. The diesel flow from the generator to the soil during the process of filling the tank and also add to the contamination level of the soil by depositing gases from the exhaust. Anthropogenic influence and activities such as this help in affecting the soil physicochemical properties such as soil pH, electrical conductivity, soil particle sizes and soil alkalinity there is therefore the need to document the level of

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deterioration of the soil occasioned by these heavy duty generating sets that abound on the highways of Port Harcourt and hence proffer adequate remedy to the situation.

Materials and Methods

Collection and preparation of samples

Soil samples were collected randomly from three different locations along Iwofe-Ada George Road, Port Harcourt with the aid of soil auger. The samples were collected at three different point at a particular sampling site or location and then was properly mixed together to form a composite sample. After each sampling the auger was thoroughly washed and cleansed in water and then dried in order that the samples from one location does not influence or contaminate another location. Polythene bags already prepared and labeled were used in putting the collected the sample before being transported to the laboratory for pretreatment, digestion and further treatment before analysis and determination of the concentration of some physicochemical properties of the soil. The samples were collected at Police Station (1) (4° 48' 42.856" N 6° 56'35.412" E) and Specialist Hospital (2) (4° 49' 4.706" N 6° 57'20.273" E) in Iwofe axis while the third point was at Sure Foundation School (3) (4° 48' 33.750" N 6° 58'56.316" E) in Ada George axis of the road.

Determination of pH, alkalinity and electrical conductivity.

The procedure of Bamgbose et al. (2000) was used in the determination of the pH of the soil. Soil samples previously air dried was weighted into a 100ml beaker then distilled water of 200ml volume was added to the soil in the beaker. The mixture was stirred with a glass rod and allowed to stead for 30 minutes, and the pH of the soil was then measured. The level of alkalinity in the soil was determined by the use of pH meter.

The electrical conductivity of the soil was measured using a conductivity meter the conductivity of the soil of the soil was determined using a ratio of 1:5 of soil and distilled water solution. The model of the conductivity meter used was with model (Fomenky et al., 2018).

Particle size determination

The hydrometer method (Bouyoucos, 1962; Bekee & Edori, 2021) was used for the determination of particle size analysis. Air dried sample (51g) was transferred into a 500ml dispersing cup. Thereafter, 100ml of water was added to the sample on a shaker and then 20g of sodium hexametaphosphate was again added. A Bouyoucos hydrometer was then used to measure the density in grams of particles/L of the suspension after selected settling times. Within a 40 second settling time, the buoyant force was due for the concentration of all the particle sizes. However, after 40 seconds settling time, the buoyant force on the hydrometer came from the concentration of clay and silt. After a settling time of 2 hours, the silt particles settled at the bottommost of the cylinder and the hydrometer reading was noted. A blank calibration of the hydrometer was prepared for that containing water and the dispersing agent only. The Bouyoucos hydrometer was calibrated at 20 °C (68° F). Readings were corrected for variations in temperature and density, which were as a result of alterations in viscosity and temperature of water respectively. Then the percentages of clay, silt and sand were calculated thus,

$$\% \text{ clay} = \frac{corrected\ 2\text{–hr}\ hydrometer\ reading}{dry\ weight\ of\ soil} \times 100$$

$$\% \text{ silt} + \% \text{ clay} = \frac{corrected\ 40\text{–sec.}\ blank\ hydrometer\ reading}{dry\ weight\ of\ soil} \times 100$$

% sand = 100 - % silt + % clay.

Results

The results obtained for the studied physicochemical parameters during investigation around soils that is contaminated with diesel at the various stations are provided in Tables 1 to 3 while the mean concentrations within the stations at the same time are provided in Table 4.

The mean results recorded for pH within the months from the different stations where the soil has been contaminated with diesel ranged from 6.40±0.07 to 6.77± 0.05 during the time of investigation. The mean results obtained and recorded for electrical conductivity within the months from the different stations where the soil has been contaminated with diesel ranged from 196.51±12.50 to 470.24±7.88 µS/cm during the' time of investigation. The analysis of particle size distribution showed that the mean results recorded for sand in the soil contaminated with diesel fell between

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84.51±0.41 to 85.92±0.33%, clay values fell between 8.50±0.10 to 9.80±0.35% and silt values fell between 5.02±0.19 to 6.70±0.24% in the different stations at the time of study. The mean results recorded for alkalinity within the months from the different stations where the soil has been contaminated with diesel ranged from 7.46±0.01 to 8.05±0.01 mg/Kg during the time of this investigation.

Table 4.1: Levels of physicochemical parameters of soils contaminated with diesel in June

Sample identity	Stations		
	1	2	3
pH	6.70	6.30	6.50
Conductivity	186.00	463.00	336.00
% sand	86.00	84.00	85.00
% clay	8.60	9.10	10.00
% silt	4.40	6.90	5.00
Textural class	Sandy soil	Sandy soil	Sandy soil
Alkalinity	8.04	7.53	7.45

Table 4.2: Levels of physicochemical parameters of soils contaminated with diesel in July

Sample identity	Stations		
	1	2	3
pH	6.81	6.42	6.63
Conductivity	189.46	466.52	341.34
% sand	85.49	84.51	85.12
% clay	8.54	9.13	10.08
% silt	5.97	6.36	4.80
Textural class	Sandy soil	Sandy soil	Sandy soil
Alkalinity	8.06	7.61	7.47

Table 4.3: Levels of physicochemical parameters of soils contaminated with diesel in August

Sample identity	Stations		
	1	2	3
pH	6.79	6.48	6.66
Conductivity	214.07	481.20	357.40
% sand	86.28	85.01	85.42
% clay	8.36	8.15	9.31
% silt	5.36	6.84	5.27
Textural class	Sandy soil	Sandy soil	Sandy soil
Alkalinity	8.04	7.53	7.45

Table 4.4: Mean levels of physicochemical parameters of soils contaminated with diesel during the period of study

Sample identity	Stations		
	1	2	3
pH	6.77± 0.05	6.40±0.07	6.60± 0.07
Conductivity	196.51±12.50	470.24±7.88	344.91±9.09
% sand	85.92±0.33	84.51±0.41	85.18±0.18
% clay	8.50±0.10	8.79±0.46	9.80±0.35
% silt	5.24±0.65	6.70±0.24	5.02±0.19
Textural class	Sandy soil	Sandy soil	Sandy soil
Alkalinity	8.05±0.01	7.56±0.04	7.46±0.01

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Discussion

pH

The results recorded for pH were within the allowable or permissible limit required by World Health Organization (WHO) (2004) which fall between 6.5-8.5. The recorded values of pH in this investigation were below that which was reported by Elemile et al. (2019) which ranged from 7.19±0.25-7.83±0.02 in soils impacted by abattoir activities, and that which was reported by Ediene and Iren (2017) which ranged from 6.22-7.52 in an investigation on the influence of abattoir effluents on soil pH. The values recorded in this work were observed to be higher than that which was reported in the work of Osakwe and Okolie (2015) with pH value of 5.15±0.48. Soil pH influences the dynamics or the underlying forces of metals in the soil as a result of its capacity to control the process of adsorption and precipitation which are very crucial and indispensable factors in metal retention in the soil. At low pH value metals exist in a more soluble form and hence more cationic form that could be readily made available for plants absorption and use (Abdulhamid et al., 2015). pH range of 6-8.5 is a sign or suggestion of a normal soil (Kekane et al., 2015; Edori et al., 2022). The recorded results for pH in this study showed therefore that the diesel have not negatively affected the soil pH at the time investigation was carried out.

Electrical conductivity

The recorded values for electrical conductivity in the soils contaminated with diesel were above the results recorded in the work of Igwe and Bekee (2021) around steel markets in Port Harcourt that fell between 51.6±0.51 to 165±1.47 µS/cm, but fell between ranged recorded by Edori and Iyama (2017) that ranged from 280.00±11.21-404.34±7.18 µS/cm from three different abattoirs in Port Harcourt. The results obtained in this research were lower than that which was recorded in an investigation undertaken by Edori and Edori, (2012) in automechanic works villages in Port Harcourt and also that which was obtained in Guraj, India in a site contaminated with gasoline by Khan et al. (2013). Electrical conductivity is vital in the measurement and estimation of soil quality. The levels of electrical conductivity of soil increases when there is resultant increase in the levels of ions present in the soil. Conductivity measures the level of existence of ions in any given soil environment and also provides information on the likely amount of ions in any particular soil environment (Tale & Ingole, 2015; Igwe & Bekee, 2021). The combination of soil electrical conductivity and soil pH influences the mobility of ions in the soil and also affects the usage and accessibility by plants and animals in the soil (Adelekan & Abegunde, 2011; Igwe & Bekee, 2021).

Particle size analysis

The recorded results in this work indicated that the textural class of the soil in all the stations contaminated with diesel at the time of study were all sandy soil. The results obtained for sand were above that reported in the work of Edori and Iyama (2017) and also that which was reported in the work of Khan et al. (2013), but the results obtained in this investigation for clay and silt were lower than the values reported in the work of Edori and Iyama (2017) and also that which was reported in the work of Khan et al. (2013). The textural class reported in the work of Edori and Iyama (2017) was sandy clay loam and that reported in the work of Khan et al. (2013) was clay loam. The elevated level of sand in the soils contaminated with diesel indicated that the soil has low ability of water retention owing to the fact that sand is porous and allows water to percolate through it easily and hence low moisture content. There is high aeration of such soil but it has the inability to support the planting of crops (Igwe & Bekee, 2021; Edori et al., 2022). Soil texture estimates the physical properties of soil which includes soil plasticity, soil permeability, toughness or ease of soil tillage, water retention capacity and soil productivity (Amos-Tautua et al., 2014). The soil in this work is more of sand and therefore has low potential of holding water and allows much water percolation through it easily and hence promotes the contamination of groundwater as compared to soil that is more of clay and silt that has the potential of holding water and preventing it from permeating or penetrating without difficulty through it (Ahn, 1993) and thereby providing natural means of filtration of contaminants and pollutants of the natural ground water.

Alkalinity

Alkalinity is referred to as the potential to neutralize acids. In the soil environment, alkalinity majorly comes from salts of weak acids such as hydroxides, carbonates and bicarbonates. Some chemical reactions that are natural or can be enabled by humans are such as concern CO_2, $CaCO_3$ and $MgCO_3$ which may result into the production of substantial quantities of bicarbonates (Wokoma & Edori, 2020). Additional sources of alkalinity in the soil might be from organic acids such as humic acid which reacts and bring about the formation of salts which might result into an increase in the level of alkalinity in the soil environment (Kumar & Chopra, 2012).

Conclusion

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The results recorded in this investigation indicated that the pH, electrical conductivity, soil particle sizes and soil alkalinity have been affected and compromised as a due to the soil of the studied area being contaminated with diesel. The level of occurrence of these physicochemical parameters in the studied environment have impacted negatively on the soil, soil organisms and even on humans. The soil may not be good enough for agricultural purposes. The level of the studied parameters have also led to the degradation and deterioration of the soil and its immediate environments and has brought about environmental imbalance to the terrestrial ecology of the area investigated.

Anthropogenic activities had influenced the levels of the studied physicochemical parameters. This was as a result of the uncontrolled human such as the operation of the heavy duty diesel generators installed within the area investigated.

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