Bioremediation: Data on Biologically-Mediated Remediation of Crude Oil (Escravos Light) Polluted Soil using Aspergillus niger

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Chemical Data Collections

Title: Bioremediation: Data on Biologically-Mediated Remediation of Crude Oil (Escravos Light) Polluted Soil using *Aspergillus niger*

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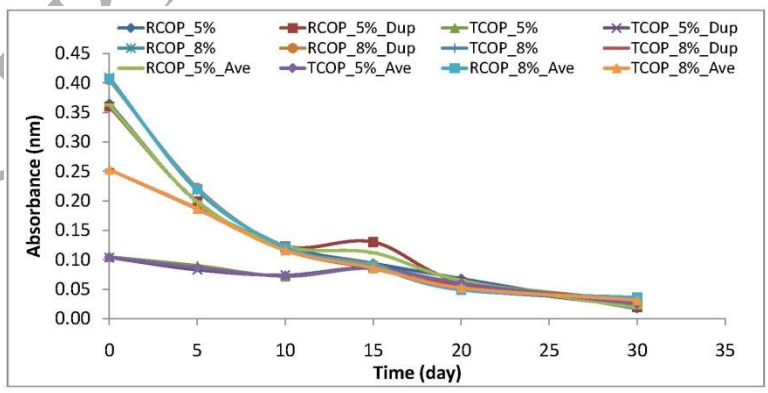
Abstract

This article presents data on *Aspergillus niger* effects on the biologically-mediated remediation of soil polluted by raw and treated crude oil (Escravos Light blend). Absorbance of different concentrations of polluted soil samples (5% and 8% w/w) and types (raw and treated), for simulating different onshore crude oil spill, were obtained from the *Aspergillus niger* inoculated samples using ultra violet-visible (UV-Vis) spectrophotometry. This measurement was carried out for each sample at selected intervals for the 30-day measurements. The bioremediation data, presented in the article, were subjected to descriptive/analytical statistics of probability density functions and goodness-of-fit test-statistics for dataset-detailing and dataset-comparisons. Information details from these data of biologically-mediated remediation of crude oil polluted soil are useful for furthering research on bioremediation kinetics such as hydrocarbon content analyses, crude oil pollutant removal performance, biodegradation rate parameter and biostimulant efficiencies by the *Aspergillus niger* effects on the different concentrations of polluted soil.

Graphical abstract



Keywords: Bioremediation, *Aspergillus niger*, Absorbance, UV-Vis Spectrophotometry, Crude oil polluted soil, Onshore oil pollution simulating system

Specifications Table

Subject area	*Engineering, Chemical Engineering, Sustainable Environment Engineering*
Compounds	*Petroleum hydrocarbon*
Data category	*Absorbance data of bioremediation and the statistical data modeling*
Data acquisition format	*Numerical data of absorbance monitoring from* a Jenway 6405 *ultra violet visible (UV-Vis)* spectrophotometry instrument
Data type	*Raw from experimental monitoring, analyzed*
Procedure	*Absorbance data was obtained using the* Jenway 6405 *ultra violet visible (UV-Vis)* spectrophotometer instrumentation on different concentrations of two types of crude oil polluted soil samples, for simulating light and heavy onshore oil spill systems, and which were inoculated with *Aspergillus niger*
Data accessibility	*A comprehensive dataset of biologically-mediated remediation of crude oil polluted soil using Aspergillus niger is provided in this article*

Rationale

Petroleum (i.e. rock oil) is a source of energy extensively used for lighting, heating, and in internal combustion engines, and, when and after being explored, this crude oil flows through piping and vessels under pressure from the reservoir or from mechanically assisted pumps [1]. The discharge of this liquid petroleum hydrocarbon into marine (offshore) or land (onshore) is toxic/injurious to living biota in the ecosystem of the spill even as it exhibits potential risks of normal soil processes interference, fire hazards and further contaminations of air and water [1-8]. Oil spills by any of accidental leakages, material ruptures or improper handling from production installations such as the well-heads leading to raw crude oil spillage, or from flow lines towards storage and refinement, after the removal of impurities, which translates to treated oil spillage [9-11]. Hydrocarbons, the major constituents from petroleum, persists in the environment as recalcitrant contaminants of which removal and treatments are highly problematic and constitute challenges to stakeholders and researchers globally [10,12-13].

Soil amendment technologies, known as remediation, include physical separation, chemical treatments, photodegradation and biologically-mediated remediation (bioremediation) but among these the use of bioremediation techniques is attracting preference [7,10,14-16]. This is due to the combined advantages of relatively lower cost, higher effectiveness and resultant lower adverse impacts on the ambient environment, ensuing from the use of bioremediation instead of the other methods that could rather lead to further environmental-toxicity [7,10,16-17]. The technique of bioremediation exhibits these potencies from the abilities of employing metabolic activities of animals, plants and microorganisms for removal or conversion from toxic to non-toxic compounds, i.e. detoxification, of the recalcitrant hydrocarbon pollutants from oil spills [7,13,15-16]. In spite of these advantageous potentials of bioremediation usage, problem persists from the consideration that contaminating pollutant removal efficiencies from different biological species or organisms that could be used for bioremediation are highly variable [10,15-16]. Also, while studies have proposed the use of fungi species, including *Aspergillus* spp., among useful microorganisms for oil polluted soil bioremediation [2,11-12,15,18] no dataset exists on *Aspergillus niger* usage for bioremediation of raw and treated crude oil polluted soil. Additionally, while reported works employ bacteria strains, *Enterobacter cloacae* and *Burkholderia cepaciam* [11], or activated carbon from coconut shell [16] for remediating Nigerian Escravos Light

pollution, there is dearth of study using *Aspergillus niger* for this form of soil pollutant. Therefore, the dataset in this article constitutes the raw, from experimental monitoring, and statistically analyzed data obtained in the course of biologically-mediated remediation of raw and treated crude oil (Escravos Light) polluted soil using *Aspergillus niger* fungus strain.

Procedure

Air dried loamy soil samples collected from Covenant University Farm, at the sample location 6° 39' 48.4668" N, 3° 9' 19.62" E, were polluted with two different pollution concentrations of raw and treated crude oil (Escravos Light) obtained from Chevron® Nigeria Limited, Delta State, in the Southern part of Nigeria. The two concentrations of pollution designs for the study include 5% w/w for simulating light oil spill and 8% w/w for simulating heavy oil spillage of each of the raw and treated crude oil pollution of the soil samples. Each of the systems was inoculated with *Aspergillus niger* fungus strain of microorganism that was obtained from the culture collection centre of the Applied Biology and Biotechnology Unit, Department of Biological Sciences, Covenant University, Ota, Ogun State, Nigeria [19-22]. The sub-culturing of the fungus strain on Sabourad Dextrose Agar (SDA) slant was as detailed in [23]. Sample of selected mass was taken from each of the raw and treated crude oil polluted soil for dissolution in hexane via stirring with a magnetic stirrer. From this, a measured portion was obtained for making up with *n*-hexane and consequent determination of absorbance, after requisite dilution screening procedure, using a Jenway 6405 UV/VIS Spectrophotometer at 420 nm wavelength. These measurements of absorbance, used for the present case of dataset presentation, were taken in duplicates from the zeroth day, in five days interval for the first 20 days and, thereafter, in 10 days interval, for the 30-day experimental monitoring.

Each dataset of absorbance from the tested systems was subjected to the statistical analyses of the Normal, the Gumbel and the Weibull probability density functions [24-29]. For each of these distributions, dataset compatibility was tested using the Kolmogorov-Smirnov goodness-of-fit, KS-GoF, test-statistics [30-35], also at the $p \geq 0.05$ threshold of significance level.

For ascertaining whether the duplicated raw data of absorbance measurements from each system of crude oil polluted soil design exhibited significant difference, or otherwise, from one another, the analytical method of the Student's *t*-test statistics was applied to the data [24,36-38]. For this between-duplicate test-of-significance statistical technique, the homeoscedastic (equal variance) and the heteroscedastic (unequal variance) assumptions [38-41] were employed as between-duplicate data validation tool [25]. The test-of-significance threshold for the *t-test* statistics is at $p \geq 0.05$. In similar manner of application, the Student's *t*-test statistics also find usefulness for investigating whether the absorbance data from the raw crude oil polluted soil is significantly different, otherwise, from soil having the treated crude oil as pollutant [25,38]. Likewise, this test-statistics was also applied for testing significance of absorbance data difference between the light, 5% w/w, and the heavy, 8% w/w, crude oil pollutant in the soil samples [25,38].

Data, value and validation

The raw data obtained from the absorbance measurements, in nm unit, of soil polluted with different concentrations of crude oil (Escravos Light), and into which was *Aspergillus niger* was inoculated, are as presented in Table 1. The table also includes averaged absorbance of the duplicated measurements of absorbance for each measured system of crude oil polluted soil in the course of the 30-day

measurement period. Nomenclature introduced for abbreviating the soil sample systems in Table are RCOP: Raw Crude Oil Polluted; and TCOP: Treated Crude Oil Polluted. By these, therefore, RCOP_5% refers to 5% w/w/raw crude oil polluted soil, RCOP_5%_Dup refers to the duplicate measurement, while RCOP_5%_Ave refers to the measured average absorbance for the 5% w/w crude oil polluted soil. The same representations of nomenclature hold for the 8% w/w polluted soil design but with the 5% replaced by the 8%.

Table 1: Absorbance data from crude oil (Nigerian Escravos Light) polluted soil having *Aspergillus niger*

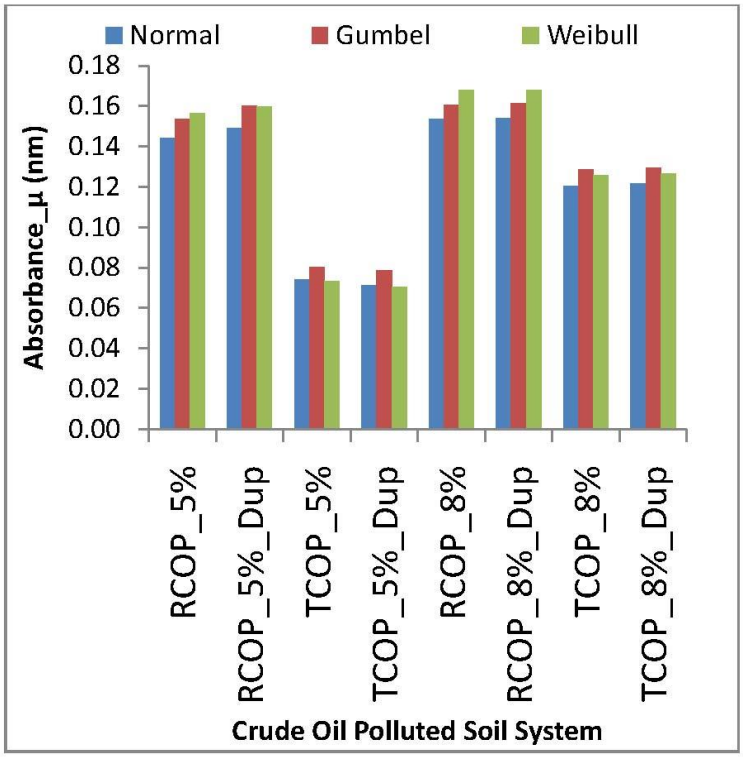
Crude Oil Pollution Concentration in Soil (w/w)	Time (day)	Raw Crude Oil Polluted Soil (**RCOP**)			Treated Crude Oil Polluted Soil (**TCOP**)		
		Absorbance (nm)	Absorbance {Duplicate} (nm)	Periodic Average Absorbance (nm)	Absorbance (nm)	Absorbance {Duplicate} (nm)	Periodic Average Absorbance (nm)
5%	0	0.365	0.36	0.3625	0.105	0.104	0.1045
	5	0.198	0.199	0.1985	0.09	0.083	0.0865
	10	0.123	0.123	0.123	0.072	0.074	0.073
	15	0.094	0.13	0.112	0.0857	0.0862	0.08595
	20	0.068	0.062	0.065	0.061	0.059	0.06
	30	0.017	0.02	0.0185	0.03	0.02	0.025
8%	0	0.409	0.405	0.407	0.253	0.253	0.253
	5	0.218	0.222	0.22	0.186	0.187	0.1865
	10	0.122	0.12	0.121	0.116	0.116	0.116
	15	0.0876	0.092	0.0898	0.087	0.085	0.086
	20	0.049	0.049	0.049	0.05	0.055	0.0525
	30	0.036	0.036	0.036	0.03	0.033	0.0315

Proceeding from Table 1, therefore, are the descriptive statistics, mean (μ) and standard deviation (σ), of the absorbance data which are presented in the graphical plots for the duplicates of raw measured data in Figure 1 and for the periodic averaged measurements of absorbance data in Figure 2. For this descriptive statistics, the modeling of the absorbance data to the fittings of the Normal, Gumbel and the Weibull probability density functions are presented in Figure 3, while the plots of the Kolmogorov-Smirnov goodness-of-fit tests of dataset fittings to the distributions are shown in Figure 4.

The values of the presented data are as follows.

- Absorbance data from the UV-Vis instrumentation to crude oil polluted soil is useful for estimation of total petroleum hydrocarbon in the soil system; this estimation physically indicates extent of pollution from the spillage of crude oil onto the soil system [42].
- The periodic measurement of absorbance data from crude oil polluted soil system having *Aspergillus niger* fungus strain is useful for indicating the effectiveness or otherwise, of this strain of microorganism on the crude oil pollutant removal from the soil system [4,15-16].
- Combination of the datasets from the *Aspergillus niger* fungus strain inoculated soil that had been polluted with dataset from control sample is useful for detailing bioremediation kinetics such as biodegradation rate parameter and biostimulant efficiencies of the microbial strain being employed for the soil remediating the crude oil polluted soil [4,15-16].

- Dataset detailing performance of different concentrations of pollutant level in the soil system is useful for indicating remediation performance from crude pollution that could result from light and from heavy oil spill [11,15-16].
- Data analyses test-methods employed in this article are useful procedure that could be employed for detailing and predicting performance of remediation technique application to system of crude oil polluted soil [25,38].
- The descriptive statistics plots of the analyzed absorbance data are useful for gaining important insights on the solution approach of using biologically-mediated remediation technique such as the destruction of pollutant contaminants that is possible via usage of this remediation technique, instead of the transference of the contaminants to another medium [5].
- The Kolmogorov-Smirnov goodness-of-fit analyses validates that the dataset comes from the probability density model of application for probability values (p-values) ≥ 0.05, otherwise the dataset having Kolmogorov-Smirnov goodness-of-fit p-value < 0.05 does not follow the probability density model of application [21,28-32].



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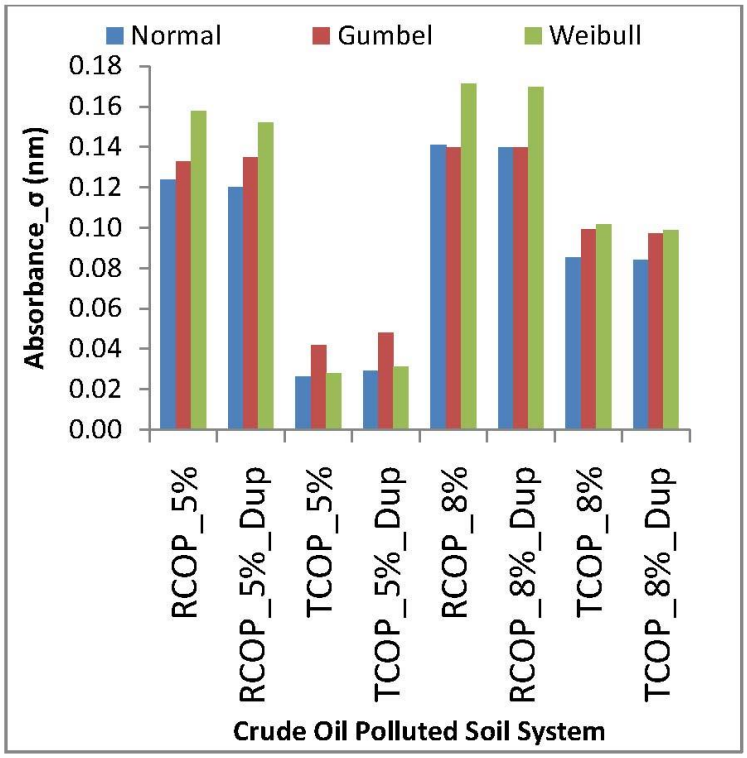
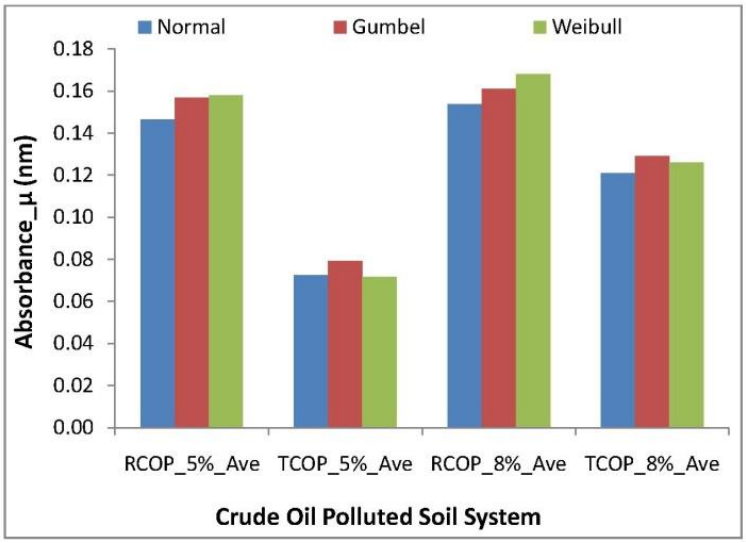


(b)

Figure 1: Descriptive statistics of the Normal, Gumbel and Weibull distribution applications to raw measurement of absorbance data from crude oil polluted soil having *Aspergillus niger* (a) mean absorbance (b) standard deviation of absorbance



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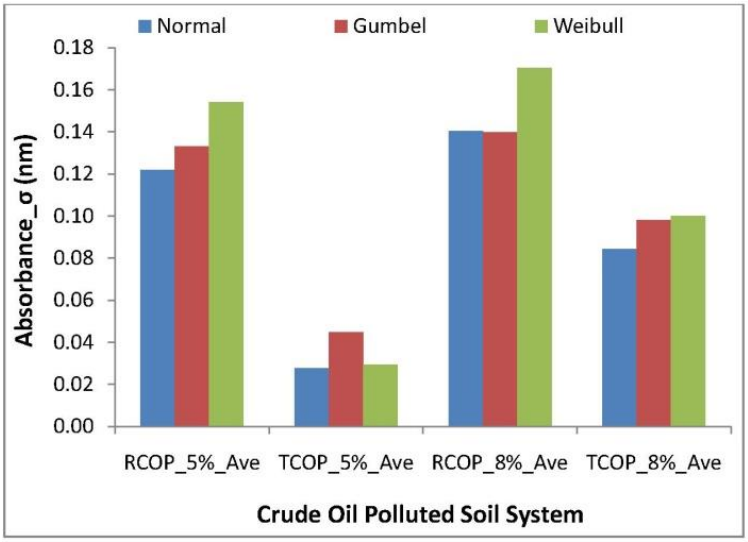
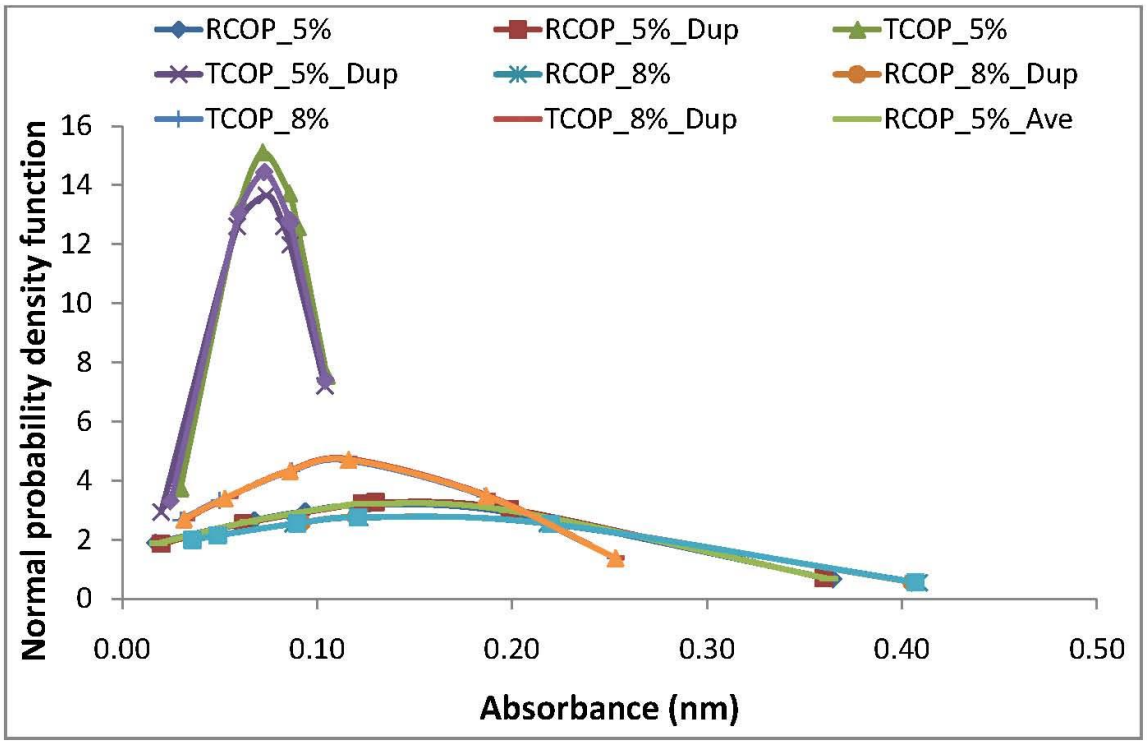


(b)

Figure 2: Descriptive statistics of the Normal, Gumbel and Weibull distribution applications to periodically averaged measurement of absorbance data from crude oil polluted soil having *Aspergillus niger* (a) mean absorbance (b) standard deviation of absorbance



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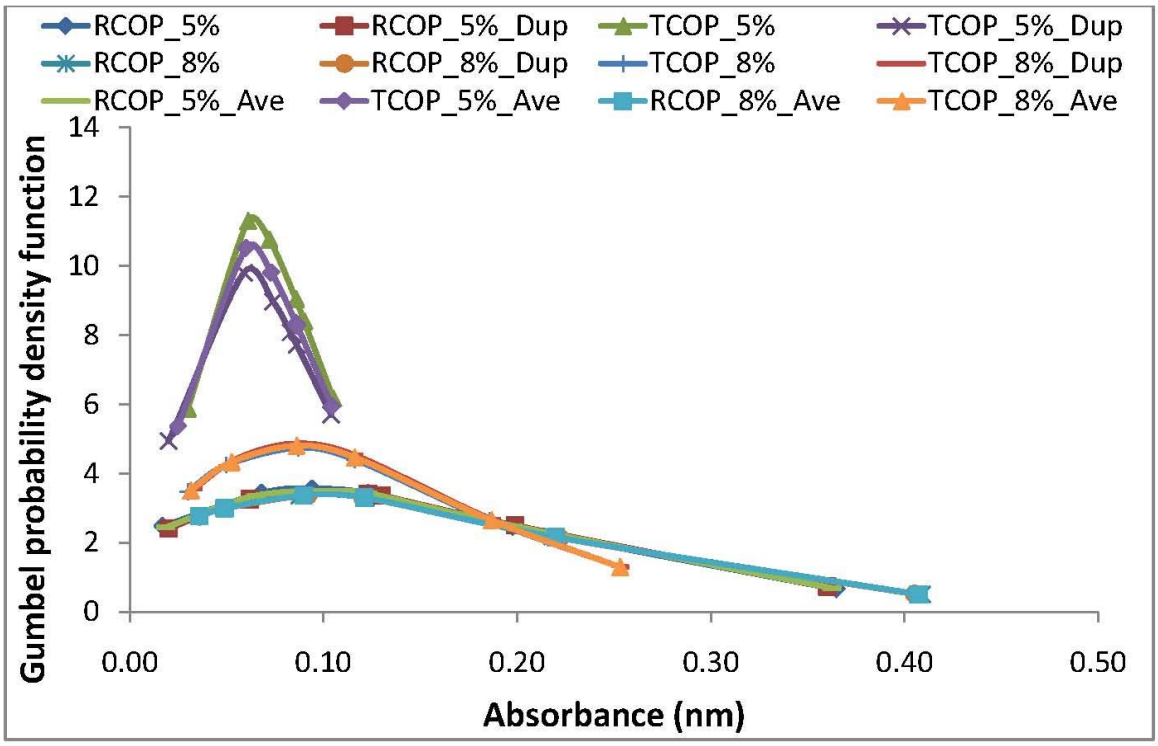

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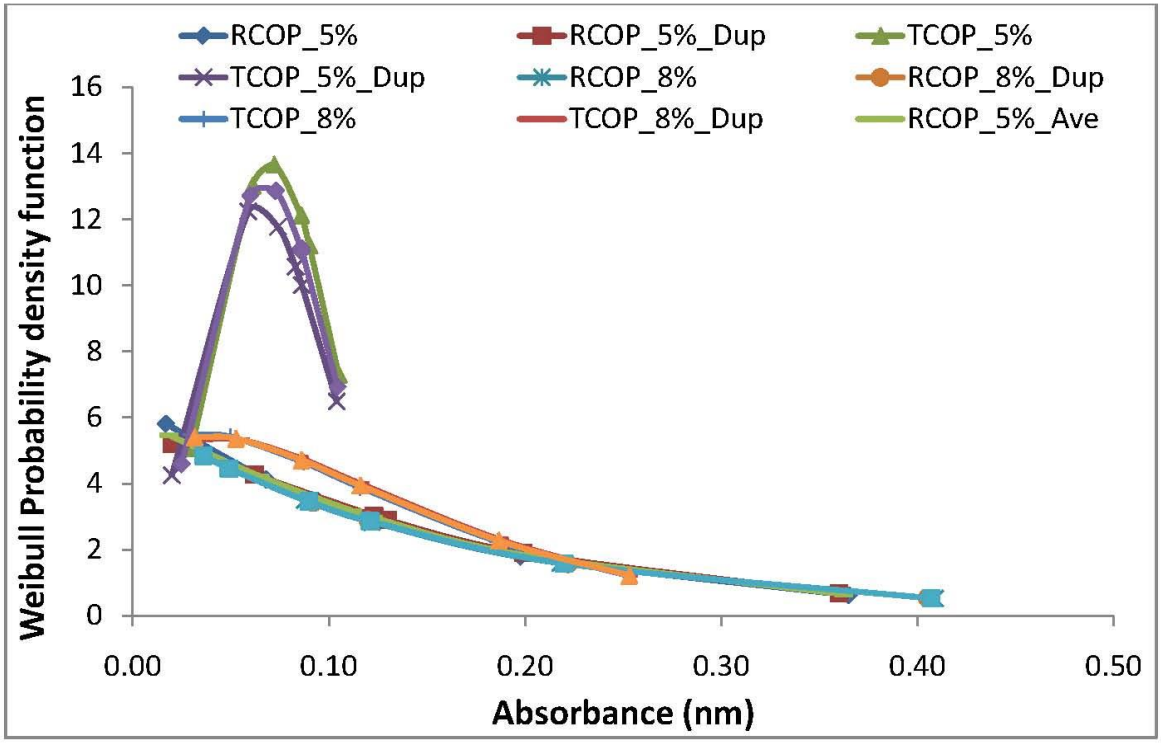
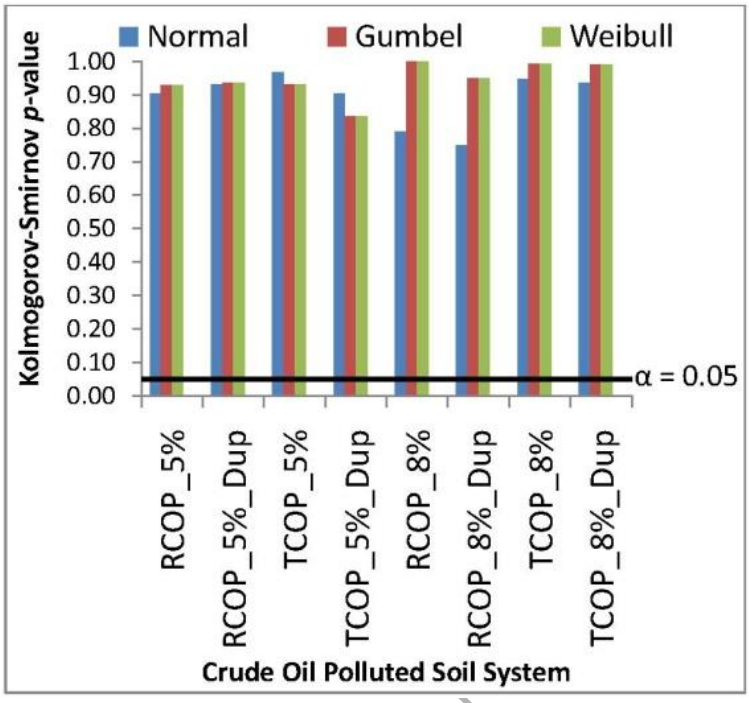
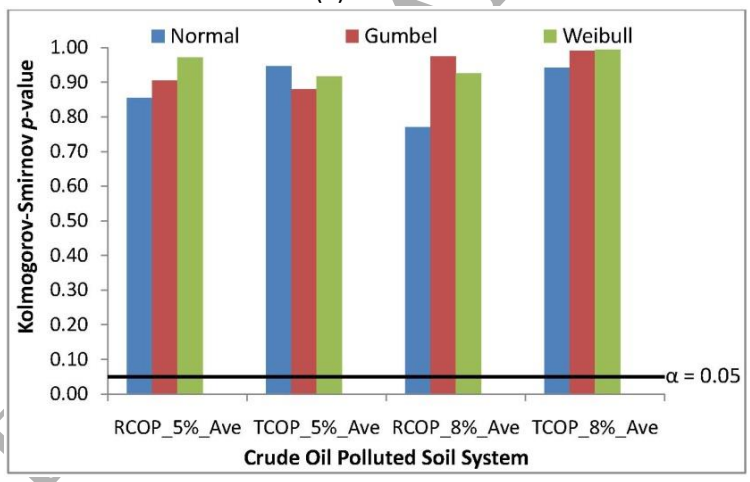


(c)

Figure 3: Probability density fittings of absorbance data from systems of crude oil polluted soil having *Aspergillus niger* (a) Normal probability density model (b) Gumbel probability density model (c) Weibull probability density model



(a)



(b)

Figure 4: Kolmogorov-Smirnov goodness-of-fit of absorbance data compatibility with the Normal, Gumbel and Weibull probability density functions (a) compatibility fitting model of the measured absorbance data from crude oil polluted soil systems having *Aspergillus niger* (b) compatibility fitting model of the periodically averaged absorbance data

Figure 5 present the plots of the Student's *t*-test statistics application for validating that the absorbance datasets from duplicated measurements are not significantly different from one another at α = 0.05 significant level, as indicated in the linear plot in the plot. Similarly, Figure 6 details plot also of the Student *t*-test for indicating significant of difference in the effectiveness or otherwise of the *Aspergillus niger* fungus strain on the different systems of crude oil polluted soil in this data article.

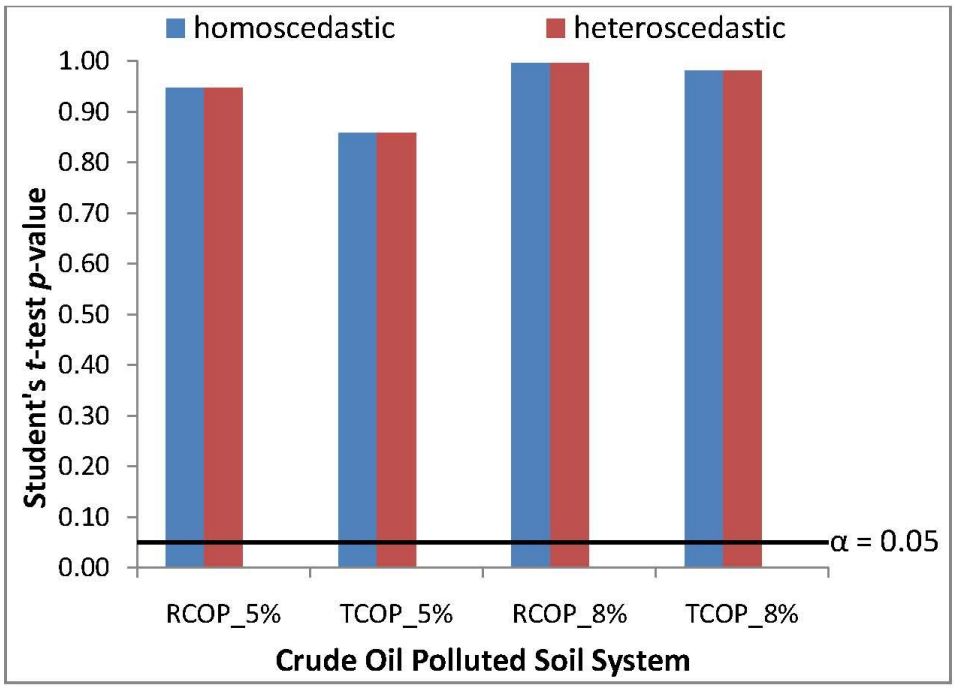


Figure 5: Student's *t*-test probability value (*p*-value) for testing significance of difference between duplicates of absorbance data from the systems crude oil polluted soil having *Aspergillus niger*

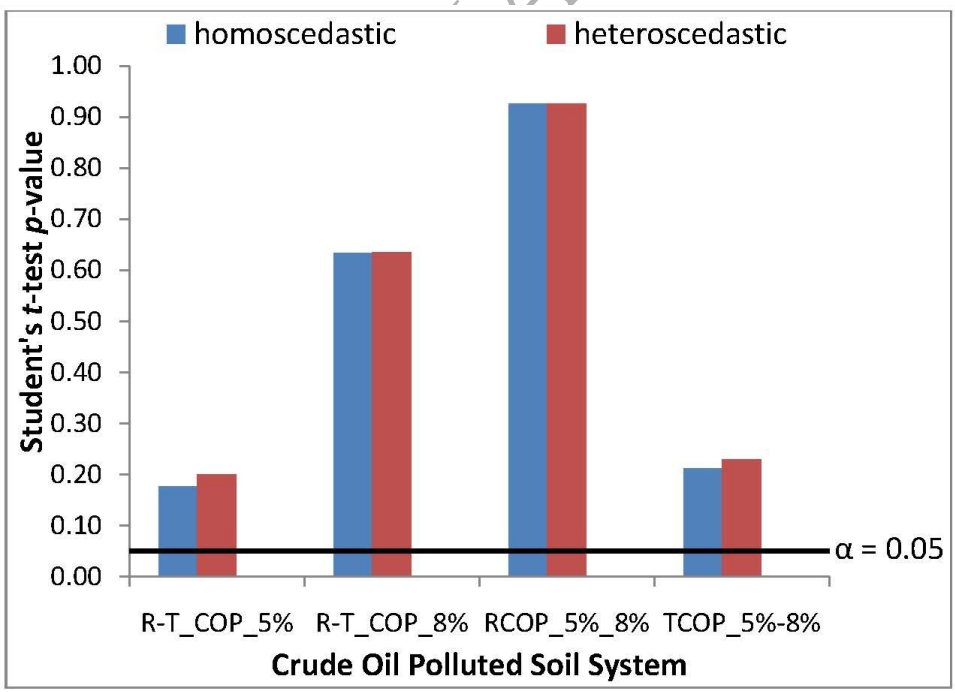


Figure 6: Student's *t*-test probability value (*p*-value) for testing significance of difference between the absorbance data from the different pollution system designs of crude oil polluted soil having *Aspergillus niger*

Therefore, in Figure 6, R-T_COP_5% indicates comparison between datasets from raw and treated crude oil polluted soil having 5% w/w Escravos Light pollution, while R-T_COP_8% compares the raw and treated crude oil polluted soil system with 8% w/w pollution. In furtherance to these, the RCOP_5%_8% details comparison between the soil systems polluted with 5% w/w and with 8% w/w raw crude oil pollutant, while the TCOP_5%-8% compares soil system polluted with 5% w/w and with 8% w/w treated crude oil pollutant.

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