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Application of renewable technology for mitigating environmental hazards of palm oil industry: Strategy for climate change and adaptation

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Improper disposal and burning of agricultural residues are commonly practiced in some developing countries in which harmful gaseous products released into the atmosphere and some are depleted and reacted with the soil causing environmental pollution. Renewable technology can therefore be introduced for the utilization of the residues and ensure proper storage medium of the residues. An investigation was carried out on the pollution potential of oil palm residues on surface and underground water resources at the processing centre. Oil palm residues and water samples from the stream and well located near the oil processing site were used for the experiment. Water samples were collected during the raining and dry season to determine the level of pollution caused by the residues. Physical, chemical and bacteriological parameters of the water samples were determined. The chemical compounds of the palm residues were investigated. Results showed that aromatics compounds are mainly dominant of the palm fruit fiber which was characterized for bio-fuel production. It is revealed that effect of pollution on water bodies is significant at p<0.05. Hence, results showed that some parameters like colour, total solids, pH, amine contents, *Escherichia coli* exceeded World Health Organization (WHO) levels for drinking water. The amine content with (0.35 mg/L) of the samples was higher than the level recommended (0.1 mg/L) for drinking. For colour, the least value of 15.5 mg/l of the total samples was higher than the recommended value (15.0 mg/L). Also, the values of *E. coli* which ranged between 0.03-0.15 were far above zero count/100ml of World Health Organization (WHO) maximum permissible level for drinking water. Therefore, oil palm waste should be properly disposed and ensure improved storage of the residues for further processing. Conversion of the residues to useful products through renewable technology will alleviate environmental pollution.

Key words: Residues, climate change, pollution effect, renewable technology.

INTRODUCTION

Climate change refers to as a change of climate which is directly or indirectly attributed to human activity that affects the composition of the global atmosphere, while climate change includes global warming and everything else that will be affected by increasing greenhouse gas (GHG) levels (UNFCCC, 1994). The level of these GHGs has increased beyond natural level Awosika et al., 1992). There is a scientific consensus that the gradual increase in the average temperature of earth's average temperature of Earth has risen between 0.4 and 0.8°C in the last 100 years (IPCC, 2005). The increased volume of carbon dioxide and other GHGs released from the burning warming is caused by increase in the emission of GHGs of fossil fuels, deforestation, agriculture and other human activities are sources of global warming that have occurred in the last 50 years (IPCC, 2005).

GHGs are good absorbers of heat radiation coming from Earth's surface acting like a blanket over its atmosphere, keeping it warmer than it should be. Enhanced GHGs effect however, is not natural as it acts to destabilize the Earth's radiation balance due to anthropogenic accumulation in Earth's atmosphere of radioactive GHGs especially anthropogenic ozone (Awosika et al., 1992). It has been suggested that if the current trend of anthropogenic GHG emissions continues through 2030, Earth is likely to experience an average rise in temperature ranging from 1.5 to 4.5°C (Idowu et al*.,* 2011). The global issues of increasing energy prices, dwindling reserves of fossil fuels and impacts of climate change have led to intense global support for bioenergy and chemicals from agricultural crops and residues (Schroeder, 2009). Nigeria has numerous agricultural resources and generates large quantities of wastes daily. Unfortunately, these residues are unutilized properly as they are left to decompose at the dump site (Jekayinfa and Scholz, 2007) and a large percentage is used as land fill while some are burnt. This has environmental implications as stated by Jekayinfa and Omisakin (2005) that pollution rate will be increasing if the residues are not utilized.

Pollution from the activities of oil multinational mostly has to do with air, land and water. Air pollution affects humans and other living organisms. Land pollution affects the land soil and destroys plants and living organisms in the soil while water pollution affects aquatic life (Onifade et al*.,* 2017). Air, water and land pollution can be caused by oil spillage, gas flaring, above or below ground oil pipe line leakage and oil waste dumping (Elum et al*.,* 2017). Agricultural wastes have a high chemical content that is injurious to health (US-EPA, 1992). Any waste that contains 20% of more solid or with a moisture content up to 50% (wet basis) is considered to be solid waste while those with less than 5% solid are regarded as liquid waste (Lawrence and Henry, 1991). Pollution of adjacent surface and underground water systems depends on the composition of the waste, distance apart and the medium or layer through which the discharge travels. The atmospheric condition of the immediate environment is altered by the presence of pollution elements like carbon and nitrogen making the environment un-conducive for man and his activities.

Climate can be affected with a slight change in temperature from human activities (Onifade et al*.,* 2017) and at the right moment can cause outbreaks of epidemic diseases or insect pests, which can destroy entire landscapes, forest or farmlands nevertheless everything in nature is related, changes in one area may trigger changes in other areas (Osagie, 2002; Adejuwon and Odekunle, 2006). For example, the immediate survival of many coastal areas, population, forests and wildlife may now depend on our ability to study, understand and share the small changes that are observed in the environments and ecosystems around man. The aspect of weather variability has been correlated with the activities of man which have in turn generated micro weather variation, pollution of environment by forest fuels burnt daily from industries and automobiles all of which generate heat, thereby altering the heat balance (Osagie, 2002; Adejuwon and Odekunle, 2006).

Many countries have plenty biomass that can be processed as an energy resource. Various categories of biomass are widely available from agriculture residues, wood residues, and dedicated energy crops to municipal solid waste (Jekayinfa and Omisakin, 2005). Among the categories, agricultural residues represent significant potential for developing the bio-energy industry (Elum et al*.,* 2017). The main advantage of using agricultural residues is that they have little or no market value and ready for production in large quantities. These residues generated through direct harvest of crops at the growing site (field residues), or as a by-product of processing at a processing facility USEPA (2006). Several researchers have explored the potency of agriculture residues for energy, and the results are encouraging (Elum et al*.,* 2017).

This work focuses on alleviating and coping with the negative effects that emanate from fossil fuel-based energy sources. Proper utilization of renewable energy plays a vital role in meeting current and future energy and chemical demands. It can be observed that abundant agricultural residues are dumped on the farm and processing site in most developing countries, as this is commonly practiced in South-western Nigeria. It is observed at different processing sites visited in the author's community, that the selected agricultural residues (palm fruit fiber and physic nut shell) used in this work are improperly disposed due to lack of storage facilities while some are burnt and eroded by rain as a result of poor orientation about renewable technology that is climate-friendly.

Consequently, the residues dump over a long period have caused land pollution as shown in Figure 1 and may also cause water pollution if residues are eroded into water bodies (rivers, streams and dams) by runoff water

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Figure 1. Burning of residue causes air pollution.

during heavy rain. This may lead to blockage of drainage, canals and water ways which might cause flood and other natural disasters. Sometimes, the residues are burnt which causes air pollution as shown in Figure 2; consequently, the burning activities might release some greenhouse gases from residues into the atmosphere which can attribute to the problem of climate change and global warming. The burning exercise might also kill living organisms in the soil needed for plant growth. Figure 3 shows the effect of improper disposal of wastes on environment, as a result of non-utilization of wastes which leads to natural disaster like flood and water pollution. This study investigates the effect of residues disposal on surface and underground water and employed renewable technology for the purpose of converting waste to energy and greatly contribute to global climate change mitigation. The detrimental effects of climate change require that alternative forms of energy such as biogas to avoid environmental catastrophes. The renewable technology activities can improve social development and economy identity and strength of the villages and cities and it also has beneficial and better environmental implications on the nation.

Renewable technology

Renewable technology is defined as the technology available for the conversion of cellulose in agricultural residues into fuel and chemical feedstock. The possible technologies include incineration, combustion in controlled atmosphere, hydro carbonization, anaerobic digestion and pyrolysis (Ren et al*.,* 2013; Faisal et al*.,* 2007; Bello et al., 2009). Of these renewable technologies, pyrolysis offers the most visible root for the generation of fuel and chemical feedstock. This process implies decomposition of cellulose by heating in the absence of oxygen to produce gases, liquid and char; which has been the source of many basic organic chemicals such as acetone and methanol (Faisal et al*.,* 2007). Pyrolytic products can be used as fuels, with or without prior upgrading, or they can be utilized as feedstock for chemical or material industries.

Pyrolysis is a process of the thermo-chemical conversion of biomass to char, bio-oil and gas, in the absence of oxygen and other reactants (Balat et al*.,* 2009). It is a non-equilibrium process where the biomass undergoes multistage decomposition resulting in large changes in specific volume. In this conversion process, combustion and gasification occur where complete or partial oxidation is allowed to proceed. The reaction rate, order and product yields depend on parameters such as temperature, heating rate, pre-treatment, catalytic effects, particle size etc (Bridgewater and Peacookie, 2000) and these parameters influence the optimum value in a fast pyrolysis process (Faisal et al*.,* 2018). Also, Tsai et al*.*

Figure 2. Improper disposal of residue causes land pollution.

Figure 3. Improper disposal of waste causes flood and water pollution.

(2006) reported that fast pyrolysis is the most suitable process route to maximize the yield of liquid product. It is on this note that the paper emphasizes the importance of pyrolysis on the extract lignocellulosic content of two agricultural residues to simultaneously respond to bioenergy and chemical production.

The root cause of energy situation is that in the recent years, while there has been no limit on growth in energy demand, the production of energy from the existing sources has come under increasing mounting pressure. It seems probably therefore, that the shortage of fuel (energy) supplies is an actual fact of life and the fossil fuel supplies in our planet may not last forever (Bello et al*.,* 2009). There is energy crisis in our hand, henceforth source of energy supply is far below energy consumption. There is environmental pollution on the release of green gas house emission from fossil fuel burning which is causing health hazard. This has led to an increase in research on development of renewable energy and technology which plays vital roles for future energy and chemical supply. However, there are various renewable energy sources which could reduce the demand on fossils fuels. The renewable technology saves time and it is usually more environmentally friendly, especially on air emissions (Schroeder, 2009). There is great potential in the utilization of renewable biomass for energy and chemicals production to develop human life prosperity to address the crisis of energy security and sustainable economics in the world (Schroeder, 2009; Ren et al*.,* 2013).

Agricultural materials can be converted to liquid by thermal, biological and physical methods. Thermal conversion methods used are combustion, gasification, liquefaction, pyrolysis and carbonization. Pyrolysis is the most popular technique of biomass because it can produce liquid yield up to 75% wt on a dry-feed (Guillain et al., 2009; Bridgwater, 2006).

METHODOLOGY

This section describes the sample preparation, renewable technology and proximate analysis of the residue. The palm fruit fiber is a waste product of palm kernel fruits and after oil processing. The samples were collected from rural area (Iranyin village) near Ogbomoso town (8°07' N, 4°16'E), South western, Nigeria. The samples used for the study were sun dried and ground into fine particle size. The samples were then screened to give various fractions using different wire mesh sizes. The diameter of the particle size of palm fruit fiber used ranged from 0.250 to 0.550 mm in form of 0.250, 300, 0.425 and 0.550 mm. Each sample was mixed with Sodium Anhydrous in order to make it dried and remove totally the moisture in it. Extraction of oil from the samples (residues) and characterization of bio-oil were carried out at the laboratory of the Department of Chemistry, University of Nairobi, Kenya.

Also, the water samples were collected from surface and underground source near the oil processing centre. The water samples used were collected from the point of discharge, 1 m distance away from discharge centre and from a nearby stream and well. 2 litres of each sample were collected with clean plastic bottles. The samples were taken twice during the raining season between August and September 2017 and dry season in December (2017). The experiment was replicated and the average values were recorded. The samples were analyzed for physical properties such as colour, turbidity, odour, taste, total solid, dissolve solid and suspended solid. The chemical examination of water is performed to detect the quantity of chemical substances in water which could affect its portability. Such chemical properties carried out were Ammonia, Carbodioxide and Calcium, Copper, Chlorine, Lead, Iron, Manganese, Nitrate, Sulphate, pH, phenolphthalein, Alkalinity, Melthy Orange and total hardness. Bacteriological Tests (temperature, cyaninde, bacteria count) were carried out immediately on the sample collected on getting to the laboratory.

Characterization of bio-oil

The bio oil obtained from lignocellulose of palm fiber was used for characterization. Litmus papers blue and red were used to check its acidity and alkalinity. A microprocessor pH meter (HANNA pH 211) was used to measure the pH of the oil. Analysis was done at room temperature; the meter was calibrated by measuring pH of buffer solution to be 7.03 at 23.6°C. The density of oil was conducted at room temperature of 23.6°C. The density is defined as sample mass divided by a fixed empty volume of pycnometer. Then a 2 ml pycnometer was used to determine the density; the bio-oil was filled into the flask and weighed the mass. Viscosity of bio-oil was measured using Ostwald Viscometer (a U shape glass viscometer). All experiments were carried out three times and average readings were recorded.

A separate constituent of the pyrolysis mixture together with helium carrier gas goes to the flame ionization detector. It was at this zone that the separated organic compounds ionized at a high temperature in contact with hydrogen or air flame. A polarized electric grid captures the resultant ions which generate a current that will be recorded as a chromatogram. Peak areas of individual gases were measured and the abundance was determined from the prepared calibration. The calibration which is an external standardization has a technique involving essentially, the injection of known amounts of pure compounds as reference substance at the same conditions with that of the sample (pyrolytic products). The sample peak was compared with that of the standard. Also, individual compound was identified by matching their elution times along the base line with that of the standard. So, different components in the liquid solvent and their retention time are displayed on the screen of the GC-MS monitor.

RESULTS AND DISCUSSION

Physical characterization of bio-oil

The liquid extracts were acidic in nature because it turned blue litmus paper to red. This indicated that the samples had been burnt under inert condition. The pH values of oil, which ranged from 4.64 to 6.43, increased with increase in temperatures. This means that oil obtained at high temperature are slightly acidic while oil obtained at low pyrolitic temperatures indicate low pH readings which is more acidic. The density of the oil is 0.8319 g/ml (831.99 kg/m^3) at 23.6°C. It was observed that all density values at different temperatures and particle sizes gave similar readings. The density and viscosity are related to phenomenon of liquid floatation which can have

Table 1. Chemical compounds in the bio-oil of palm residues analyzed by GC-MS.

Chemical compounds	Molecular formula	Molecular weight (g/mol)	Peak probability %
3-methyl Pentadecanoic acid	$C_{16}H_{32}O_2$	256	1.47-2.85
2,16-methyl Hexadecanoic acid	$C_{18}H_{34}O_2$	284	1.30-10.15
Methyl Hexadecanoic acid	$C_{17}H_{34}O_2$	270	81.3
14-methylPentadecanoic acid	$C_{17}H_{34}O_2$	270	9.92-28.7
Tridecanoic acid	$C_{17}H_{34}O_2$	270	2.58
Ethyl Pentadecanoic acid	$C_{17}H_{34}O_2$	270	6.53
EthylEicosanoic acid	$C_{22}H_{44}O_2$	340	3.53-11.3
Ethyl Hexadecanoic acid	$C_{19}H_{38}O_2$	298	2.84
Ethyl Tridecanoate	$C_{15}H_{30}O_2$	242	1.46
MethylOctadecanoic	$C_{19}H_{38}O_2$	298	4.04-66.6
16-methyl heptadecanoate	$C_{19}H_{38}O_2$	298	10.5
Ethyl Octadecanoic acid	$C_{20}H_{40}O_2$	312	60.7
Nonadecanoic aci d	$C_{21}H_{42}O_2$	326	0.93
Cyclopropanepentanoic	$C_{20}H_{38}O_2$	310	3.73
Tetradecanoic	$C_{16}H_{32}O_2$	256	2.7- 4.63
Ethyl Heptadecanoic	$C_{19}H_{38}O_2$	298	5.48
2-2-hydroxyethoxy	$C_{22}H_{44}O_4$	372	2.71-12.3
Hexadecanoic acid	$C_{18}H_{36}O_2$	284	49.4
Isopropyl palmitate	$C_{19}H_{38}O_2$	298	7.31-41.0
Ascorbic 2,6-dihexadecanoic	$C_{38}H_{68}O_8$	652	7.1-14.3
Ascorbic acid, 6-octadecanoate	$C_{24}H_{42}O_7$	442	2.8

significant effect on fluid atomizers. The bio-oil produced in this study gave viscosity of 0.695 cPa at room temperature; this value was less than that of water used as standard. This indicated that the viscous period of bio-oil is less than that of water. Hence, this could be due to low value of water content (5.93%) which caused it to be less viscous. The presence of water content in bio-oil shows the presence of lignin in the raw material which is 60.36%.The calorific value of the bio-oil is 22.33 kJ/g, as shown in Table 4. This shows the amount of energy produced by the complete combustion of 0.291 g of the oil. The calorific value is an important factor to determine the energy content of the fuel. Compared to other common fuel, gasoline (47 kJ/g), Diesel (45 kJ/g), Ethanol (29.7 kJ/g), wood (15 kJ/g) coal (15 kJ/g) and natural gas (54 kJ/g) (NIST), this indicates that bio-oil from palm fruit fiber is a potential source of energy and can be upgraded first before using it as fuel.

Chemical characterization of bio-oil

Table 1 presents the results of the spectra obtained from GC-MS which was used to characterize the bio-oil produced from palm fruit fiber. The O-H stretching vibrations between 3200 and 3400 cm^{-1}, show the presence of phenols and alcohols. The C-H stretching vibrations between 2800 and 3000 cm^{-1} and C-H deformation vibrations between 1350 and 1450 cm^{-1} show the presence of alkane groups. The C=O stretching vibrations between 1680 and 1750 $cm^{-1}$are compatible with the presence of ketones, quinones, aldehyde groups. The peaks between 1500 and 1645 cm^{-1} represent C=C stretching vibrations, indicating the presence of alkenes. Besides, mono and polycyclic and substituted aromatic groups can be identified by the absorption peaks between 690-900 and 1350-1450 cm^{-1}. Then, Ethers can be identified by a strong C-O stretching band near 1100 cm^{-1} due to the C-O-C linkage in the compound. Aromatic ethers show a strong band near 1250 cm^{-1}, while cyclic ethers show a C-O stretching band in the range of 1250-900 cm^{-1}. A broad N-H wagging band appears at 750-650 cm^{-1} representing secondary amides.

GC-MS was used to analyze and identify the chemical components in the liquid. The most abundant products and highest peak area achieved by hexadecanoic (81.3%). Other prominent products are pentadecanoic acid (1.47-14.5%), octadecanoic (2.6-70.1%), eicosanoic (3.5-11.3%), 2-2-hydroxyethoxy (2.71-12.3%), Ascorbic 2,6-dihexadecanoic (7.1-14.3) and Isopropyl palmitate (7.31-41.0). It was observed that different values were obtained at various temperature and particle sizes. This shows effect of experimental parameters (temperature and particles sizes) on the chemical compounds produced from palm fruit fiber. For instance, highest peak of methyl-hexadecanoic, 81.3% was obtained at 158.8°C, 0.42 mm, methyl-pentadecanoic acid was high, 14.5%, at

Table 2. Analysis of underground water samples during rainy season.

	Sample A	Sample ^{B}	Sample C
TH (mg/L)	9.05^{a}	25.00^{b}	50.50^{c}
$^{C}a^{2+}$ (mg/L)	7.20^{a}	18.80^{b}	38.80^{c}
Mg^{2+} (mg/L)	1.80^{a}	6.20^{b}	12.20^{c}
^{C}hloride (mg/L)	8.60^{a}	10.40^{b}	12.70^{c}
Mn (mg/l)	0.80^{a}	0.50^{b}	1.90^{c}
SO_4^{2-} (mg/L)	16.45^{a}	18.60^{b}	21.30^{c}
pH	6.39^{a}	4.22^{b}	4.40^{c}
^{C}olour	15.50^{a}	17.50^{b}	18.00^{c}
BOD (mg/L)	5.50^{a}	5.40^{a}	5.20^{a}
E.^{C}oli	0.08^{a}	0.03^{b}	0.06^{a}
Turbidity	5.20^{a}	$5.50^{a,b}$	5.80^{b}
DS (mg/L)	350^{a}	480.50^{b}	540^{c}
SS (mg/L)	690^{a}	700.50^{b}	860^{c}
TS (mg/L)	1041.5^{a}	1179^{b}	1400^{c}

Values in the same row and sub-table not sharing the same subscript are significantly different at $p< 0.05$ in the two-sided test of equality for column means. Sample A: A nearby well (unlined); Sample B: Point of discharge Sample C: 1 m distance away from discharge point

441.42°C, 0.42 mm, eicosanoic had value of 11.3% at 300°C, 0.25 mm. Heptadecanoic has highest peak at 200°C, 0.55 mm. Only 300°C, 0.25 mm and 400°C, 0.25 mm contained Ascorbic 2,6-dihexadecanoic.There are a great number of other compounds but their peak areas are low, so this study did not examine them further. Every compound in Table 5 is classified as aromatic oxygenated and hydrocarbon compounds which are dominant compounds in the palm fruit fiber oil. Oxygenated content is favorable to be used for fuels while other compounds can be useful for chemical productions. The results obtained in this study are different and values are higher than those obtained from palm kernel shell by Faisal et al. (2018).

Pollution effect of the residues on underground water

The results of the physical, chemical and bacteriological analyses carried out on water samples are shown in Tables 2 to 5. The results of the analysis were compared with that of World Health Organization (WHO, 2015)'s standard. This shows the rate of pollution and contamination from palm residues on underground (well) water sources located near the palm oil processing site.

The physical properties considered were turbidity and colour. The value of 5.6 mg/L for turbidity was recorded for the water samples collected from a nearby well. This was because of higher production capacity and direct discharge of waste effluent around the well. This value was far above World Health Organization (WHO, 2015)'s permissible level (5 mg/L). The colour of water samples was not so attractive; the sample that was taken from the point of discharge was yellowish while the sample collected at 1m distance from the discharge point was orange. The value of the colour 15.8 mg/l was recorded for well water samples. This value was not corresponding to the level by WHO (2004)'s standards of 15 mg/L. The difference in the colour was due to the distance of the water sources from the point of discharge. This implies that the water is not potable, but can be treated by some processes like screening, filtration and sedimentation.

The results of some chemical parameters like methyl orange alkalinity, the total hardness, Calcium hardness, magnesium hardness, sulphate hardness and manganese ions are shown in Tables 2 to 5. High values of ions were recorded during dry season because there was higher concentration of chemical parameters than in the raining season with diluted solution. The values of Manganese ions recorded during the dry season and raining season were 1.1 and 0.9 mg/L respectively. The values of total hardness of water were 9.0 and 9.5 mg/L during the raining season and dry season respectively. The treatment processes like aeration can remove the ions while coagulation process will reduce the hardness. The pH value of 6.40 mg/L was recorded for water samples collected from well. This indicated that the water samples were acidic and needed to be neutralized. The values of total solid with 1200, 1080 and 1040 mg/L were recorded for water samples collected at the processing site. The values are not in conformity with WHO recommended value (1000 mg/L) this is because of high production at site per day.

The values of coliform count were above the zero count/100 ml of WHO recommended level for drinking water. The values ranged between 0.03-0.15 as shown in

Table 3. Correlation analysis of underground water samples during rainy season.

	Cn	TH	Ca^{2+}	Mg^{2+}	Cl	Mn	SO_4	pH	Colour	BOD	E.Coli	Turbidity	DS	SS	TS
TH	0.389	1													
Ca^{2+}	0.373	0.999**	1												
Mg^{2+}	0.433	0.998**	0.998**	1											
Cl	0.445	0.993**	0.993**	0.995**	1										
Mn	-0.184	0.818**	0.830**	0.795**	0.785**	1									
SO_4	0.445	0.995**	0.993**	0.994**	0.997**	0.777**	1								
pH	-0.898**	-0.746**	-0.731**	-0.771**	-0.778**	-00.24	-0.785**	1							
Colour	0.745**	0.888**	0.876**	0.900**	0.910**	00.478	0.919**	-0.960**	1						
BOD	-0.169	-0.675*	-0.657*	-0.633*	-0.665*	-00.557	-0.703*	00.494	-0.665*	1					
E.Coli	-0.858**	-0.252	-0.227	-0.269	-0.315	0.283	-0.335	.766**	-0.656*	0.438	1				
Turbidity	0.477	0.848**	0.859**	0.879**	0.854**	0.644*	0.829**	-0.697*	0.746**	-0.187	-0.103	1			
DS	0.677*	0.940**	0.934**	0.954**	0.959**	0.583*	0.960**	-0.924**	0.984**	-0.609*	-0.528	0.845**	1		
SS	0.068	0.942**	0.950**	0.928**	0.918**	0.954**	0.915**	-0.482	0.685*	-0.614*	0.064	0.787**	0.776**	1	
TS	0.383	0.998**	0.996**	0.992**	0.991**	0.818**	0.995**	-0.745**	0.893**	-0.718**	-0.273	0.815**	0.937**	0.938**	1

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Tables 2 to 5. The well was not properly lined though covered. The bacteriological pollution occurs as a result of residues disposal found around the site. The bacteriological characteristics of the water are as a result of food waste, faeces and urine around. This shows the presence of *E. coli* and pathogens in the water samples. The value of BOD indicates the amount of micro-organism present in the water samples. In the case, the treatment process self-purification should be adopted by locating wells at about 500 m away from any processing site.

Table 3 presents correlation analysis of water samples collected in a well near oil palm processing site. Most of the parameters apart from BOD and *E. coli* showed significant difference ($p < 0.05$) across the sampling points. The pH was negatively correlated ($p < 0.01$) with most of the parameters, the most significant being colour ($r = 0.96$). BOD also showed negative correlation ($p < 0.05$) with total hardness (TH), $Ca^{2+,}$ Mg^{2+}, chloride, sulphate (SO_4^{2-}), colour, dissolved solid (DS), suspended solid (SS) and total solid (TS) which was the most significant ($p < 0.05$). Table 5 shows the correlation analysis of water samples collected from a well at the processing site. Most of the parameters across the sampling points were significantly different ($p < 0.05$). The pH and BOD from the sampling point within the stream were significantly different ($p < 0.05$) from the sampling points at the exit area (sample B and C). This could be attributed to the significant correlation ($r = 0.873$) between them. Similar trend was observed for the soluble solid (SS) which also correlated with pH and BOD. Conversely, in terms of the dissolved solid (DS), the sampling point within the stream was significantly different ($p < 0.05$) from the sampling points at the exit area. This could be attributed to its negative correlation with BOD and pH. There was no significant difference ($p < 0.05$) in turbidity across the sampling points.

Conclusions

This study explores the potential of renewable energy as remedy to environmental hazard. The research explores the nexus between climate change impacts, energy and pollution potentials of agricultural residues on the environment. The renewable technology of palm fruit fiber was experimented and hence examined the current and potential adverse effects of residue burning on climate change. It is observed and concluded from the results that the pollution potential of the palm oil processing site located near water source

Table 4. Analysis of underground water samples at during the dry season.

	Sample A	Sample B	Sample C
Cn (mg/L)	3.25[a]	2.70[b]	1.40[c]
TH (mg/L)	9.50[a]	25.20[b]	51.20[c]
Ca^{2+} (mg/L)	7.50[a]	19.20[b]	39.00[c]
Mg^{2+} (mg/L)	2.00[a]	6.10[b]	12.20[c]
Cl (mg/L)	9.05[a]	10.00[b]	13.00[c]
Mn (mg/L)	1.00[a]	0.60[b]	2.20[c]
SO_4^{2-} (mg/L)	19.35[a]	21.00[b]	23.45[c]
pH	6.40[a]	4.20[b]	4.33[b]
Colour	15.80[a]	18.00[b]	20.00[b]
BOD	5.80[a]	5.00[b]	5.10[b]
E.Coli	0.19[a]	0.80[b]	0.80[b]
Turbidity	5.40[a]	5.80[a]	6.00[a]
DS (mg/L)	47.00[a]	50.00[a]	630.00[b]
SS (mg/L)	675.00[a]	780.00[b]	790.00[b]
TS (mg/L)	1141.50[a]	1280.00[b]	1420.00[c]

Note: Values in the same row and sub-table not sharing the same subscript are significantly different at $p < 0.05$ in the two-sided test of equality for column means.
Sample A: Nearby well; Sample B: Point of discharge; Sample C: 1 m distance away from discharge point

Table 5. Correlation analysis of underground water samples during the dry season.

	Cn	TH	Ca^{2+}	Mg^{2+}	Cl	Mn	SO_4^{2-}	pH	Colour	BOD	*E. coli*	Turbidity	DS	SS	TS
Cn	1														
TH	-0.968**	1													
Ca^{2+}	-0.970**	0.999**	1												
Mg^{2+}	-0.970**	0.999**	0.999**	1											
Cl	-0.958**	0.983**	0.987**	0.978**	1										
Mn	-0.850**	0.796**	0.804**	0.781**	0.878**	1									
SO_4^{2-}	-0.900**	0.945**	0.947**	0.940**	0.949**	0.774**	1								
pH	0.640*	-0.741**	-0.735**	-0.759**	-0.628*	-00.19	-0.674*	1							
Colour	-0.837**	0.924**	0.910**	0.919**	0.870**	0.607*	0.892**	-0.790**	1						
BOD	0.511	-0.640*	-0.646*	-0.653*	-0.579*	-0.17	-0.721**	0.873**	-0.663*	1					
E.Coli	-0.642*	0.721**	0.725**	0.733**	0.660*	0.307	0.825**	-0.845**	0.740**	-0.954**	1				
Turbidity	-0.413	0.334	0.361	0.345	0.381	0.378	0.529	-0.186	0.137	-0.486	0.613*	1			

Table 5. Contd.

DS	-0.923**	0.928**	0.928**	0.916**	0.965**	0.942**	0.862**	-0.455	0.815**	-0.355	0.452	0.228	1		
SS	-0.785**	0.821**	0.817**	0.839**	0.719**	0.36	0.788**	-0.942**	0.835**	-0.823**	0.894**	0.386	0.559	1	
TS	-0.935**	0.985**	0.982**	0.986**	0.951**	0.710**	0.963**	-0.807**	0.955**	-0.732**	0.816**	0.368	0.865**	0.884**	1

**. Correlation is significant at the 0.01 level (2-tailed). *.Correlation is significant at the 0.05 level (2-tailed).

at Iranyin village is high which affects the water potability.

In this framework, climate stewardship becomes a partnership between the public, higher educationist and the government. To implement the findings, it is important that strong enforcements of environmental protection laws are needed to ensure the stoppage of palm residues burning and discharge of effluent improper. Finally, this study encourages the practice of renewable technology to alleviate the emission of greenhouse gas and global warming, hence the use of bio-energy will enhance Nigeria's economy diversification, reduce dependence on crude oil and create a strong synergy between the agriculture and energy sectors.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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