Impact of Palm Oil Mill Effluent Discharge on Biotic and Abiotic Concentrations in Elele Farmland, Nigeria

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Abstract

The impact of palm oil extraction waste water on biotic and abiotic concentration of Elele farmland, Rivers State, Nigeria was investigated. Investigation involved determining the biotic concentrations of bacteria, fungal, algae and protozoa population in the palm oil effluent discharge and non-discharged sites. Similarly, the electrical conductivity and hydrogen ion concentration were determined and considered as abiotic properties. All analysis were carried out using standard microbiological and biological procedures. The study showed varied mean population of biotic and abiotic concentrations in the soil. Result showed a mean population of 3.9 x10^5cfu/g, 1.8 x10^5cfu/g, 37 cyst and 1x10^3g^{-1} for total heterotrophic bacteria, fungi, protozoa and algal respectively for non-palm oil discharged sites while for palm oil discharged sites a mean load population of 7.2 x10^5cfu/g, 2.9 x10^5cfu/g, 49 cyst and 1x104g^{-1} for total heterotrophic bacteria, fungi, protozoa and algal respectively. Furthermore, result of the abiotic concentrations of the non- palm oil effluent discharged and discharged soil varied. Hence, the discontinued discharge of palm oil effluent on arable or cultivated land should be encouraged as this significantly affect biotic and abiotic concentrations of the soil environment. Dug wells should be adopted or employed for safe disposal of oil mill effluents without coming in contact with arable land (farmland).

Keywords

Palm Oil, Waste Water, Abiotic, Biotic, Soil

1. Introduction

Palm oil tree is a plant belonging to a family of perennial flowering plants (that is plants that flowers and fruit after three years). As a monocot plant, the plant belongs to the order, Arecales. The plant grows at a height of 60 meters mostly in the tropical and subtropical regions of the earth [1]. The tree produces fruits, which when extracted produces oil. [1] noted that the palm oil as it is edible and derived from the pulp of the fruit of oil palm (*Elaeis guineensis*). It is the most productive oil-producing plant in the world so far recorded [2]. Processing the palm oil requires the use of large quantities of water in mills where oil is extracted from the palm fruits [2]. Extraction of palm oil from fruits involves two processes such as field operations and factory operations. The field processes involve cutting-up ripe fruit bunches from the palm tree and carrying them to the factory, in the factory the fruits are further processed by digestion and squeezing the oil out of the fruit pulp [3]. In Nigeria, palm oil is produced principally by farmers who adopt different extraction methods that vary from one locality to another [4]. Some mill extract oil using manual labor while mechanized method still remained un-taped due to huge capital of establishment. Palm oil production has existed since the ancient times to this present time and the process very tedious, most especially in the third world countries and developing countries. The process involves harvesting from the palm tree and extraction of the oil [1]. During the extraction of the oil from the fresh fruits, about 50% of the water used in processing of the palm oil result as waste or effluent. These wastes are usually discharged into the environment raw [5]. Palm oil waste is of many kinds and component, some of the waste which includes: palm oil mill sludge/effluent, dung, palm kernel shell, oil palm fronds, oil palm trunks, waste shaft, the residue and palm fiber [5]. Palm oil waste by-product is a major waste derived from palm oil production process and it has high detrimental effect on the environment. The residual liquid waste or effluent generated from the mill is discharged indiscriminately into the environment, particularly on farmlands which could turn out as potential pollution impacted on streams, rivers or ecosystem [6]. [6] pointed out that the ecosystem changes when new or foreign materials are added to the soil. This foreign material tends to eliminate microorganisms in their habitat, and it is either the microorganism dies off or it moves away from the pollutant (foreign material) [6]. The presence of palm oil effluent discharge on land affects negatively the general soil characterization and life of micro /macro fauna. The presence of waste inhibits proper aeration and in addition cut off light penetration which leads to refraction of light [5]. During extraction, putrefied oil palm fruits give rise to poor quality oil that go rancid than those oil produce from fresh palm fruits [2]. Palm oil mill effluent discharged untreated into the soil environment of Elele Community of Rivers State is allerged to distort the soil ecosystem and to a large extent farmland. The discharged waste sinks beneath the ground and remain attached to the soil particle for several months before it is biodegraded [7]. Palm oil mill effluent has the capacity to reduce the biotic population of organism and also affect the abiotic function of some bacteria such as phosphate-solubilizing bacteria, lipolytic bacteria, cellulolytic bacteria and palm-oil utilizing bacteria [7],[8]. The discharged waste which is no longer useful is composed of water, organic matter (sluge) and several chemical elements and is discharged from the production line as it is not well managed [9]. This senerio is alleged to cause loss of economic crops, hence the loss of arable hand and poor aesthetics as well as the resulting differences/variation in physicochemical characteristics in the soil water and air permeability [10]. The abiotic environment variability will also result in regional and temporal differences in soil biotic activity. Soil abiotic variables influence and control a variety of biological processes which includes decomposition, nitrification and enzyme activity [8]. They impact soil biota, which reflect biotic concentration, occurrence, distribution and density as well as their competition for space and time. Today society is increasingly worried with soil deterioration, the sustainability of soil productivity, the preservation of biodiversity and effective soil repair countermeasures [10]. A good quality soil with a standard concentration of biotic and abiotic value not only produces food in-return but also serves as an environmental filter for purifying air and water [11]. Soil is the ultimate receiver and incubator for the breakdown and recycling of nutrients from organic materials as well as the detoxification of organic contaminants for the benefit of man. However, if distorted, the soil would function against its purpose polluting the air, water and food/plants it comes in contact with [11]. Sequel to this challenges, there is need to evaluate the impact of palm oil extraction waste water on biotic and abiotic components of Elele farmland.

1.1 Study Area

The study area for the study is the Elele community of Ikwerre Local Government Area, Rivers State, Nigeria. The area is a rural settlement however; industrialization and urbanization have cribbed into the area exponentially. The study area is known for high commercial activities with huge commerce and trade activity traversing from Port Harcourt city, South Nigeria to Owerri, East Nigeria. Elele community was chosen for the high presence of palm oil mill stations and high production output thereof following the rich loamy soil of the community. During palm oil production, the palm oil mill discharges large quantum of waste into surrounding farmland.

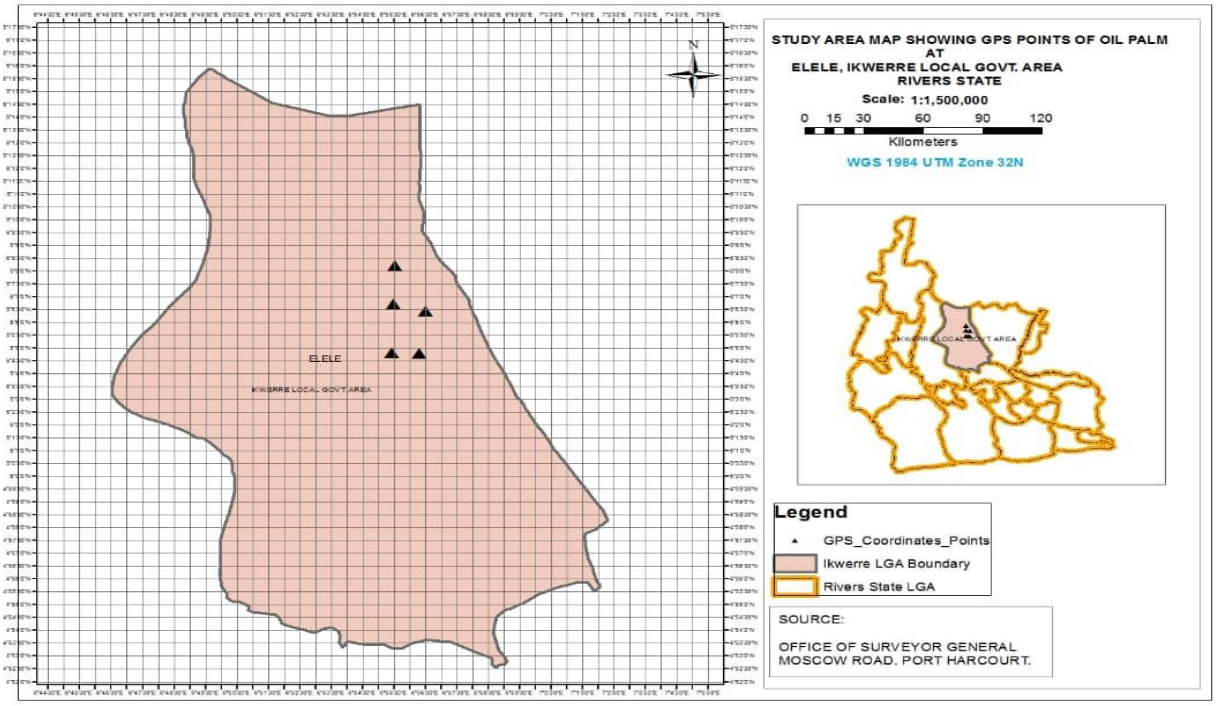

Figure 1. Study Area Showing GPS Points in Elele, Rivers State, Nigeria

1.2 Preparation of Plot

In preparation of study site, a plot of land measuring 50 x 50 meters was used for the study. The plot was divided into two parts. One part labeled, Part A (625m^2) served as un-treated part while the other part labeled part B (625m^2) served as the experimental part or the treated part. The experimental part was treated with 1000ml volume of the palm oil discharged effluent.

1.3 Collection of Soil Samples

Soil samples were collected / obtained aseptically, from each of the prepared parts with the aid of a trowel; and the soil dug to a depth of 2 meters to the get the samples. A total of 30 soil samples were collected in three batches, 15 samples each were collected from the study area. The samples as collected were put in a sterile bag and enclosed in an ice-block cooler to prevent external contaminant. The soil was then transferred to the Biology Laboratory of Ignatius Ajuru University of Education, Rumuolumeni, Port Harcourt, Nigeria.

2. Determination of the Heterotrophic Bacterial Population

In determining the bacteria load from the soil samples, the soil samples underwent a serial dilution process. The process involved the use of a sterile liquid and sodium chloride. A (4.2g) sodium chloride was weighed and dissolve in a 500ml volume of water. The component was dispensed 9ml into test tube and autoclaved to achieve sterility. The component now known as diluent was used for the dilution process. The dilution process was aimed at reducing the population of viable cells in the samples. 1g (one) of the soil sample was dissolved in a sterile prepared 9 ml normal saline, (which was dispensed in a test tube) and the composition referred as 10^{-1} dilution. Thereafter, 1ml from the 10^{-1} dilution tube was aseptically transferred again to another 9ml normal saline, following this dilution another set of dilution was achieved. The third dilution otherwise called the third dilution factor (10^{-3}) was used for the study. In preparing the media, some amounts of Nutrient agar, a general-purpose agar for growth of wide varieties of non-fastidious microorganisms was weighed, autoclaved and dispensed in a petri dish. The Spread Plating Technique was adopted as carried out [12]. The technique involved inoculating the sample on the freshly prepared Nutrient agar medium. A 0.1ml aliquot of the 10^{-3} dilution was transferred onto the nutrient media with the aid of sterile pipette and thereafter a sterile bent glass rod was used to spread the inoculum evenly over the surface of the nutrient medium. followed by incubation of the media at 37 ^{o}C for 24 hours. Growth was observed after incubation and the colonies counted and recorded as colony forming unit per gram (cfu/g)

2.1 Determination of the Fungal Population

To determine the fungal population in the soil samples before and after the treatment with the palm oil effluent discharge. In preparing the media for fungal isolation, some amounts of sabouraud dextrose agar (SDA), an agar for the growth of wide varieties of fungi was weighed, autoclaved and dispensed in a petri dish. Thereafter, the Spread Plating Technique was adopted as carried out [12]. The technique involved inoculating the sample onto the freshly prepared Sabouraud dextrose agar medium. A 0.1ml aliquot of the 10^{-3} dilution was transferred onto the SDA agar medium with the aid of sterile pipette and thereafter a sterile bent glass rod was used to spread the inoculum evenly over the surface of the SDA medium. followed by incubation of the media at 37 ^{o}C for 5 days. Growth was observed after incubation and the colonies counted and recorded as colony forming unit per gram (cfu/g).

2.2 Determination of the Protozoa Population

The population of protozoa present in the soil sample was determined by quantifying the number of protozoa present before and after the oil mill discharged effluent was treated on the soil. Soil samples were suspended in water and then observed under an optical microscope [13]. The microscope analysis involved the scoop of 40g of the soil sample and subsequent introduction into a 100ml distilled water in a conical flask. Following this, the component was mixed uniformly and 1 ml of the component transferred into a Sedge-Wick Rafter Counting Chamber using a pipette. Thereafter the ciliates were counted. The counts were repeated three times and an average count obtained. In identifying the ciliates, a slide preparation of the component (soil/water) was made on a clean slide and viewed under a 40x objective of an optical microscope (dark-field and phase contact microscope). Images obtained were compared with standard identification key for proper and more accurate identification [14].

2.3 Determination of Algal Population

In determining the soil algal population from the soil treated with palm oil mill discharged effluent and non-treated. The debris on the surface of the soil was scraped or removed and about 500g of the soil scoped into a sterile polyetene bag and taken to the laboratory. Thereafter 10g of the soil sample were diluted with distilled water for 10-^{2} fold, agitated for one (1) hour and 1% formaldehyde solution added to the suspension. The suspension was then boiled in 10% H_2O_2 solution to remove any organic matter. The solution thereafter was repeatedly rinsed with distilled water to obtain clean diatom frustules. Algea were identified by direct examination using an Axio Star microscope equipped with transmitted light phase contrast microscope [12].

2.4 Determination of Soil Hydrogen ion Concentration

In determining the Soil hydrogen ion concentration (pH) before and after the treatment with palm oil mill discharged effluent. one gram (1g) of the soil sample will be dispensed into 10ml of distilled water, agitated and thereafter the pH of the solution or sample was determined or recorded. The assay was repeated three times to get an average, for both non- palm oil effluent discharged and the effluent discharged soil [12].

2.5 Determination of the Electrical Conductivity

The test was done to determine the electrical conductivity of the soil treated with palm oil mill discharged effluent and non-treated. Fifty gram (50g) of the soil sample after collection from the site were introduced into a 100ml distilled water and the component agitated uniformly. Thereafter the device, Horiba Water Checker was used placed in the component to determine the parameter of conductivity and the values or readings recorded. The process was repeated three times to get an average reading [12].

3. Results

3.1 Mean Population Counts of Heterotrophic Bacteria, Heterotrophic Fungi, Protozoa and Algal from the Soil Samples

Table 1 showed the mean population counts of heterotrophic bacteria protozoa and algal, all of which were significantly different from the palm oil mill effluent discharged samples (soil) and the non-palm oil mill effluent discharged samples (soil).

Table 1. Mean Population Counts of Heterotrophic Bacteria, Heterotrophic Fungi, Protozoa and Algal (Biotic Concentrations)

Biotic Parameters	Non- palm oil mill effluent discharged Soil	Palm oil mill effluent discharged Soil	T-Test Probability value set at 0.05
Heterotrophic Bacteria (cfu/g)	3.9×10^5	7.2×10^5	P<0.05
Heterotrophic Fungi (cfu/g)	1.8×10^5	2.9×10^5	P<0.05
Protozoa (cyst)	37	49	P<0.05
Algal (per gram)	1×10^3	1×10^4	P<0.05

3.2 Determination of the Abiotic Concentrations

Table 2 showed the abiotic properties of the palm oil mill effluent discharged samples and non-palm oil mill effluent discharged samples. The result of the soil hydrogen ion concentration varied across the soil samples so also, the result of the electrical conductivity.

Table 2. Determination of the Abiotic Concentrations

Abiotic Parameters	Non palm oil mill effluent discharged Soil	Palm oil mill effluent discharged Soil
Electrical Conductivity	+	-
Hydrogen Ion Concentration	6.0	7.0

+ = Present; - =Absent

4. Discussion

Total heterotrophic bacteria and fungi in the palm oil impacted site were noted higher as compared to the non- oil impacted site. Basically, the variation may be pointed to the hydrogen ion concentration of the sites at that time. Hydrogen ion concentration of the soil and its environs has effect on microbial growth [15]. Thus, the high bacteria and fungi growth in the palm oil impacted site may be as a result of the soil acidity. Similarly, in a study carried, palm oil degrading bacteria increased after the soil has been impacted with palm oil in the dry season while during the raining season the quantity of bacteria degrading palm oil decreased [4]. The study quite reveals while the heterotrophic bacteria in this present study is increased, thus as noted the study was done in the dry season. It is therefore in consonant with this study where they showed that soils where palm oil mill effluents were freshly discharged had very scanty microbial population and diversity [16]. It is important to note, that the ecosystem changes when new materials are added to the soil [16]. Even at this, in a study to determine the seasonal bacteria load of impacted soil, the un-impacted soil had greater number of bacteria than the impacted soil [4]. Some studies also have pointed out that total heterotrophic bacteria decreased from 6.4×10^5 to 6.1×10^3[15]. So also, the population of phosphate solubilizing bacteria, nitrifying bacteria, lipolytic bacteria, cellulolytic bacteria and palm oil utilizing bacteria [16]. Algea presence in the palm oil mill effluents discharged site were noted higher as compared to the non- oil mill effluents discharged site. Basically, the variation may be pointed also to the hydrogen ion concentration of the sites at that time [3]. Accordingly, hydrogen ion concentration of the soil and its environs has effect on microbial growth [16]. Thus, the high bacteria and fungi growth in the palm oil mill effluents discharged site may be as a result of the soil ph. The decrease in microbial population specifically the bacteria in the palm oil mill effluents discharged site may have originated from the increased presence of protozoa as noted in this study [6]. Protozoa feeds on crude oil degrading bacteria [17], which therefore regulates bacteria population [17]. Reports have it that Protozoa enhance rate of decomposition of organic matter in the soil, and hence speeds up the breakdown of oil spillage [18]. The presence of protozoa in the soil is unique, as the organism plays a significant role in polluted natural ecosystem as seen in this study. Indeed, the evidence that protozoa feed on oil degrading bacteria [17], is also assumed with the fact that they feed on the palm oil. However, despite the presence of sodium and chloride ion, it is noted that the palm oil mill effluents discharged site is devoid of nutrient, texture, salinity and moisture as recorded [19]. The non-palm oil mill effluents discharged site was bound to have increased sodium chloride due to the presence of green growing plants [19]. Hence, the electrical conductivity of the soil is a direct function of its total dissolve salts [19]. It is an index to represent the total concentration of soluble salts in soil. The electrical conductivity as determined in the soil of the effluent discharged site and non-effluent discharged site showed conductivity varied in the soil property or concentration. On the basis of the soil hydrogen ion concentration, the effluents discharged site and non-effluents discharged site were less acidic, where in a study carried out [20], acidic soil were noted to support plant growth readily unlike alkaline soil, the study quite revealed the presences of less acidity to neutral futures on the treated soil [20]. Consequently, the alkaline soil is noted damp and moistured. Thus, the implication of the variation in hydrogen ion concentrations of the two sites may also affect crop production as observed from [21], where they pointed out that the hydrogen ion concentration influenced nutrient uptake by crop for optimum growth and harvest. The organic matter supposedly present in the non-effluent discharged site were numerous, basically, a non- effluent discharged site consists of a range of materials from the intact original tissue of plants and animals to soil microbes, cells and tissues of microbes [22]. This constituent may not be found in an effluent discharged site. The significance of the supposedly organic matter in soil is to increase crop yield and facilitate extant nutrient to crop [22], thus the absence of a desired organic matter deregulates root biosynthesis and thereby calls for extensive growth of new roots. The electrical conductivity of the treated soil, showed a negative trend which implies the soil needs nutrient [22]. The non-treated soil may not need nutrient to be added, since the electrical conductivity is positive [22].

5. Conclusion

Farmlands are indispensable resources for sustaining life on earth, serving as vital resources for both biotic and abiotic components of the ecosystem. Biotic and abiotic availability and quality have always played a crucial role in the well-being and development of farmlands for the good of humanity. A country's farmland resources represent one of its most valuable economic assets. However, human activities such as the discharge of effluent onto farmland pose significant environmental threats, leading to degradation, destruction, and the depletion of these vital resources. As noted in this study, the palm oil discharge effluent increased the heterotrophic bacteria, fungi, protozoa and agal population in the soil environment against the non-effluent discharged palm oil. Following the increased population of micro and macro biota present in the soil after palm oil effluent discharge, the study noted a negative or disadvantaged effect on the soil hydrogen ion concentration and electrical conductivity. The hydrogen ion concentration of the impacted soil recorded a neutral environment which was quite not good for crop production and farming activities.

6. Recommendation

The study therefore recommends the discontinued discharge of palm oil effluent on arable or cultivated land. Hence dug wells or other alternatives should be adopted or employed for safe disposal of effluents without coming in contact with arable land.

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