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RESEARCH ARTICLE

Impact of Electromagnetic Field on Bacteriological and Physicochemical Qualities of Palm Oil Mill Effluent from Ikeji-Arakeji

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ABSTRACT

Effluent from industries contains physical, chemical and biological pollutants which can occur from anthropogenic activities. This study investigated the microorganisms present in effluent from palm oil mill and to know the impact of Electromagnetic field (EMF) treatment on bacterial population and physicochemical characteristics of palm oil mill effluent. Microbiological investigation on effluent was carried out using standard methods. Collection of samples were done from palm oil mill in Ipetu Ijesa. Bacteria isolated from industrial effluent samples during raining season were *Bacillus cereus*, *Bacillus subtilis*, *Enterobacter aerogenes*, *Enterococcus faecalis*, *Klebsiella oxytoca*, *Lactococcus lactis*, *Micrococcus luteus*, *Salmonella typhi*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Staphylococcus saprophyticus*, *Shigella flexneri*, *Streptococcus viridians* and *Pseudomonas aeruginosa*. The fungi isolated were *Aspergillus niger*, *Aspergillus flavus*, *Aspergillus fumigates*, *Fusarium culmorum*, *Rhizopus stolonifer* and *Saccharomyces cerevisiae* had the highest bacterial load 2.45×104cfu/ml and Cassava processing plant had lowest bacterial load 1.78×104 cfu/ml. Bacillus cereus was the dominant bacterial specie while Aspergillus flavus was the dominant fungal specie. Palm oil mill effluent had the highest mean for colour (19.15Pt/co), pH value (10.48), temperature (27.33°C), conductivity (240µS/cm) total soluble solids (322 mg/l) total hardness (251mg/l). Effluent from the brewery had highest value for iron (3.67±0.02). Therefore, from the study the effluents from all industries had high microbial load and physicochemical parameters that exceeded the tolerable levels set by WHO standards. The availability of some isolates and toxic substances can serve as of populace inhabiting these places.

Contents

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1. Introduction

Effluent is the discharge of fueloline or liquid from artificial infrastructure or herbal waters. Effluent can contain physical, chemical and biological pollutants [1]. Effluent can come from waste disposed by man, such as emiction, faeces, latrine and also from cesspool leakage; sewage discharge [2]. Effluent will also be conveyed in a sanitary sewer or mixed sewer which conveys simplest sewage pollutants after use [3].When effluent is not properly treated and it is discharged to the surroundings it can be as a source of threat to ecological and environmental especially aquatic lives [4]. Palm oil mill effluent (POME) are effluent that flow from small scale industry which oil is extracted from palm kernel. If palm oil effluent is not handle well by providing a good storing system so that it can be treated before discharging into environments [5]. In palm oil milling method, POME is produced from processing of palm oil. In this process in production of palm oil milling, it requires a large amount of steam and warm water are used. POME appears thick brownish liquid this is compiled with excessive concentrations of total solids. It also contains some chemical substances such as chemical oxygen demand (COD), and organic oxygen demand (BOD) [6]. Pollutants from palm oil mill can lead to global `water crisis` which contains toxic substances and trace elements in form of carcinogens. Effluent from palm oil if is move into the water our bodies is certainly considered one as a significant environmental pollutants which can affect human being coming in contact directly to man [7].Release of effluent from palm oil into the surrounding water which make the depositing water not suitable for various domestic uses [8]. The study is to assess the physical and chemical constituents of palm oil mill effluent and also to discover the impact of Electromagnetic field on microorganisms isolated and physicochemical properties of effluent from palm oil mill [9].

2. Methodology

2.1. Area of study

Palm oil mill effluent were collected in Ikeji Arakeji, one of the town that make up of oriade local government area of Osun state Nigeria, part of Yoruba ethnic group. It is situated at 37 km before Akure (Capital of Ondo State). It is situated Latitude 7˚55′N and longitude 5˚19′E.

2.2. Collection of effluent

Effluent were collected from a big container of palm oil mill using disinfected bottle and conveyed to the laboratory for analysis.

2.3. Characterization and identification of bacterial isolates

The bacteria isolated were characterized using microscopy and morphological characteristics such as shape, arrangement and gram staining. Also it was characterized using biochemical reactions such as motility, sugar fermentation, urease, citrate test etc. It is described in Benson's microbiological application and identify of bacteria were done using Bergey's manual for identification of bacteria [9, 10].

2.4. Determination of the impact of EMF on bacterial load of waste waters

A circuit from electricity that initiated the electric and magnetic field intensities were used for this investigation and it was produced at the Physics department in Nigeria institute of Science and Technology. 25ml of effluent was brought from palm oil mill and it was introduced on a conical flask which was exposed to EMF at different EMF intensities 70nT, 80nT, 100nT, 110nT 120nT and 130nT. Microbial analyses were done before exposure to EMF and 6-hour interval exposure to EMF after 24 hours it was done after 12-hour interval.

2.5. Analyses of raw and treated water

Microbiological analysis was carried out on the sample and later the sample was subjected to Electromagnetic field between 0 hours to 96 hours. The triplicate values of the bacteria colony and physicochemical analysis for the sample were counted and recorded.

2.6. Physicochemical examination

The physicochemical characteristics of the effluent were determining by the methodology which is in accordance to [11]. The physicochemical parameters that was study was total dissolve solid, total soluble solid, chloride, sulfate, nitrate, sodium etc.

2.7. Determination of metals

Heavy metals of the effluents that was studied were Cadmium, Iron, Chromium, Copper, Nickel, Lead, Zinc, Manganese. The mineral analyses were carried out using the methods by [11].

2.8. Statistical survey

Experimental numerical data were exposed to mean and mean separated using excel 13.0 version. Mean difference was considered significant at $p <= 0.05$.

3. Results

Table 1 Point out the morphological and biochemical analysis of bacteria isolated from palm oil mill effluent. It is based on shape, arrangement, urease, citrate, sugar fermentation, methyred etc. Ten bacteria isolates were isolated from palm oil mill effluent.

Table 1 Cultural and biochemical characteristics of bacteria isolated from effluent from palm oil mill

	MICROSCOPY			BIOCHEMICAL								MEDIA			SUGAR FERMENTATION					
Isolate Code	**Gram Staining**	**Shape**	**Arrangement**	**Catalase**	**Coagulase**	**Motility**	**Hydrogen Sulphide**	**Citrate**	**Urease**	**Mr**	**Vp**	**Emb**	**Ssa**	**Msa**	**Lactose**	**Sucrose**	**Maltose**	**Glucose**	**Mannitol**	**Probable Isolates**
IL1	+ve	Cocci	Cluster	+ve	-ve	-ve	-ve	+ve	+ve	-ve	-ve	C	C	Y	AG	A	A	AG	A	SS
IL2	+ve	Rod	Chain	-ve	+ve	+ve	-ve	-ve	+ve	-ve	-ve	C	C	C	**-ve**	A	**A**	AG	AG	BC
IL3	+ve	Cocci	Cluster	+ve	+ve	-ve	+ve	+ve	+ve	-ve	+ve	C	C	Y	AG	A	A	AG	A	SA
IL4	-ve	Rod	Chain	+ve	-ve	+ve	-ve	+ve	+ve	-ve	+ve	P	C	C	AG	AG	AG	AG	AG	EA
IL5	-ve	Rod	Chain	+ve	-ve	+ve	-ve	+ve	+ve	-ve	+ve	G	C	P	AG	AG	AG	AG	AG	EC
IL6	-ve	Cocci	Chain	-ve	-ve	+ve	+ve	-ve	+ve	+ve	+ve	C	C	C	AG	AG	AG	AG	A	LL
IL7	+ve	Cocci	Cluster	+ve	+ve	-ve	+ve	-ve	+ve	-ve	+ve	C	C	C	AG	AG	AG	AG	A	ML
IL8	+ve	Cocci	Cluster	+ve	-ve	-ve	-ve	-ve	+ve	-ve	+ve	C	C	C	AG	AG	AG	A	A	EF
IL9	+ve	Rod	Chain	-ve	+ve	+e	-ve	-ve	+ve	-ve	+ve	C	C	C	-ve	A	-ve	AG	AG	BS
IL10	+ve	Cocci	Cluster	+ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	C	C	Y	AG	A	AG	AG	-	SS

LEGEND: A = Acid production, + = Positive reaction C=Colourless- P= Pink Y= Yellow , AG = Acid and Gas production, MSA=Mannitol salt agar EMB=Eosin methylene blue B= Black, G= Green, - = Negative reaction. SSA=Salmonella Shigella agar *Isolates*: SS: S. saprophyticus, BC: B. cereus, SA: .S. aureus, EA: E. aerogenes, EC: E. coli, LL: L. lactis, ML: M. luteus, EF: E. faecalis, BS: B. subtilis, SS: S. saprophyticus

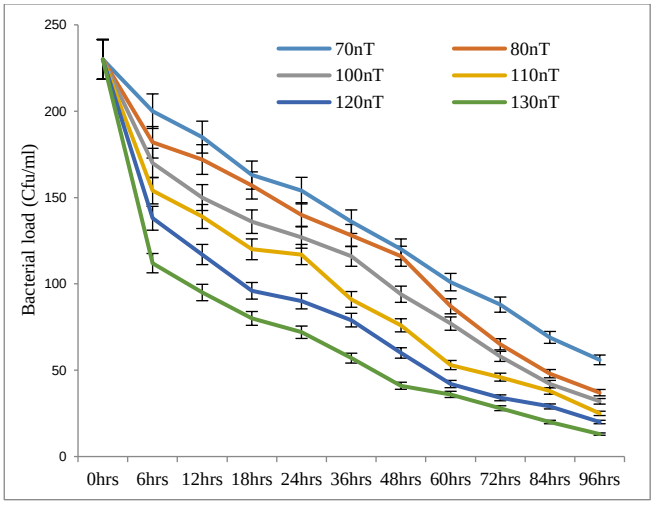

Figure 1 Impact of EMF at different intensities and time intervals on Bacterial loads from palm oil effluent.

Presented in In Figure 1, are the impact of EMF at different intensities versus time interval. The error bars in the figure correspond to ± 1 SE.

On the other hand, the effects of EMFs (70nT, 80nT, 100nT, 110nT, 120nT, 130nT,) on the existence and types of bacteria isolated from palm oil mill effluent from 0 hours to 96 hours are presented separately in the Tables Table 2, Table 3, Table 4, Table 5, Table 6, and Table 7, respectively.

The tables detail the impacts of EMF intensities on the appearance and existence of the isolates in different time intervals, i.e. 0, 6-hour, 12-hour, 24 hour, 36-hour, 48-hour, 60-hour, 72-hour, 84-hour, and 96-hour, in an effluent from Palm oil mill.

Table 2 Impacts of EMF intensity (70nT) on appearence and existence of the isolates in an Effluent from Palm oil mill

Probable isolates	**0**	**6**	**12**	**24**	**36**	**48**	**60**	**72**	**84**	**96**
Staphylococcyus saprophyticus	+	+	+	+	+	+	+	+	-	-
Bacillus cereus	+	+	+	+	+	+	+	+	+	+
Staphylococcus aureus	+	+	+	+	+	+	+	+	-	-
Enterobacter aerogenes	+	+	+	+	+	+	+	+	-	-
Lactococcus lactis	+	+	+	+	+	+	+	-	-	-
Micrococcus luteus	+	+	+	+	+	+	+	+	+	+
Enterococcus faecalis	+	+	+	+	+	+	+	-	-	-
Escherichia coli	+	+	+	+	+	+	+	-	-	-
Bacillus subtilis	+	+	+	+	+	+	+	+	+	+

Legend: +: Positive - : Negative.

Table 3 Impacts of EMF (80nT) on the appearence and existence of the isolates in an Effluent from Palm oil mill

Probable isolates	0	6	12	24	36	48	60	72	84	96
Staphylococcyus saprophyticus	+	+	+	+	+	+	+	+	-	-
Bacillus cereus	+	+	+	+	+	+	+	+	+	+
Staphylococcus aureus	+	+	+	+	+	+	+	+	-	-
Enterobacter aerogenes	+	+	+	+	+	+	+	+	-	-
Lactococcus lactis	+	+	+	+	+	+	+	-	-	-
Micrococcus varians	+	+	+	+	+	+	+	+	+	+
Enterococcus faecalis	+	+	+	+	+	+	+	-	-	-
Escherichia coli	+	+	+	+	+	+	+	-	-	-
Bacillus subtilis	+	+	+	+	+	+	+	+	+	+

Legend: +: Positive - : Negative.

Table 4 Impacts of EMF (100nT) on the appearence and existence of the isolates in an Effluent from Palm oil mill

Probable isolates	0	6	12	24	36	48	60	72	84	96
Staphylococcyus saprophyticus	+	+	+	+	+	+	+	+	-	-
Bacillus cereus	+	+	+	+	+	+	+	+	+	-
Staphylococcus aureus	+	+	+	+	+	+	+	+	-	-
Enterobacter aerogenes	+	+	+	+	+	+	+	+	-	-
Lactococcus lactis	+	+	+	+	+	+	+	-	-	-
Micrococcus lsuteus	+	+	+	+	+	+	+	+	+	-
Enterococcus faecalis	+	+	+	+	+	+	+	-	-	-
Staphylococcus epidermidis	+	+	+	+	+	-	-	-	-	-
Escherichia coli	+	+	+	+	+	+	+	-	-	-

Legend: +: Positive - : Negative

Table 5 Impacts of EMF (110nT) on the appearence and existence of the isolates in an Effluent from Palm oil mill

Probable isolates	0	6	12	24	36	48	60	72	84	96
Staphylococcyus saprophyticus	+	+	+	+	+	+	+	-	-	-
Bacillus cereus	+	+	+	+	+	+	+	+	-	-
Staphylococcus aureus	+	+	+	+	+	+	+	-	-	-
Enterobacter aerogenes	+	+	+	+	+	+	+	-	-	-
Lactococcus lactis	+	+	+	+	+	+	+	-	-	-
Micrococcus varians	+	+	+	+	+	+	+	+	+	-
Enterococcus faecalis	+	+	+	+	+	+	+	-	-	-
Bacillus subtilis	+	+	+	+	+	+	+	+	+	+
Staphylococcus epidermidis	+	+	+	+	-	-	-	-	-	-

Legend: +: Positive - : Negative

Table 6 Impacts of EMF (120nT) on the occurrence and existence of the isolates in an effluent from Palm oil mill

Probable isolates	0	6	12	24	36	48	60	72	84	96
Staphylococcyus saprophyticus	+	+	+	+	+	+	+	-	-	-
Bacillus cereus	+	+	+	+	+	+	+	+	-	-
Staphylococcus aureus	+	+	+	+	+	+	+	-	-	-
Enterobacter aerogenes	+	+	+	+	+	+	+	-	-	-
Lactococcus lactis	+	+	+	+	+	+	+	-	-	-
Micrococcus varians	+	+	+	+	+	+	+	+	+	-
Enterococcus faecalis	+	+	+	+	+	+	+	-	-	-
Bacillus subtilis	+	+	+	+	+	+	+	+	+	+
Staphylococcus epidermidis	+	+	+	+	-	-	-	-	-	-

Legend: +: Positive - : Negative.

Table 7 Impacts of EMF (130nT) on the occurrence and existence of the isolates in an effluent from Palm oil mill

Probable isolates	0	6	12	24	36	48	60	72	84	96
Staphylococcyus saprophyticus	+	+	+	+	+	-	-	-	-	-
Bacillus cereus	+	+	+	+	+	+	+	-	-	-
Staphylococcus aureus	+	+	+	+	+	+	+	-	-	-
Enterobacter aerogenes	+	+	+	+	+	+	-	-	-	-
Lactococcus lactis	+	+	+	+	+	+	+	-	-	-
Micrococcus varians	+	+	+	+	+	+	+	+	+	-
Enterococcus faecalis	+	+	+	+	+	+	-	-	-	-
Bacillus subtilis	+	+	+	+	+	+	+	+	+	-
Staphylococcus epidermidis	+	+	+	+	-	-	-	-	-	-

Legend: +: Positive - : Negative.

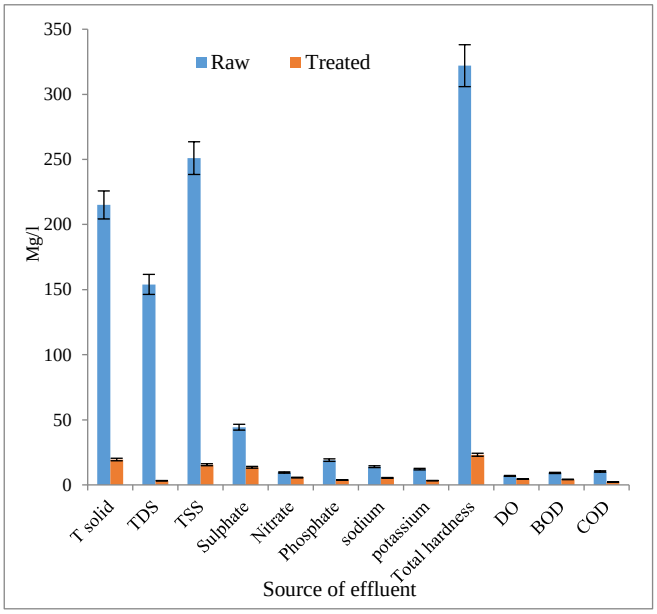

Figure 2 Physicochemical analysis of raw and treatment effluent

Figure 2 shows the microbial loads of effluent samples from different industrial site that was subjected to different EMF strength (70nT, 80nT, 100nT, 110nT, 120nT and 130nT) at various time. The samples were collected from palm oil mill effluent. The triplicate values of the bacteria colony count were counted and recorded. Palm oil mill effluent had the highest mean values of microbial count with EMF strength 70nT, the bacterial count was 225 Cfu/ml.

Legend: Temp; Temperature, Cond; Conductivity, TS; Total solid; TDS; Total dissolved solid;

DO; Dissolve oxygen, BOD; Biological oxygen demand, COD; Chemical oxygen demand

Table 8 exhibits mineral composition of effluent from different industries. The mineral composition includes the iron, zinc, lead, chromium, cadmium, copper, manganese and nickel. Effluent from brewery industry had the highest value for raw sample, the treated sample values were reduced during the research.

Table 8 Metallic composition from palm oil mill effluent

SAMPLE	Cu	Cr	Zn	Fe	Cd	Pb	Mn	Ni
RAW	1.54±0.03^{ab}	0.68±0.02^{a}	0.79±0.02^{b}	4.11±0.02^{a}	1.27±0.01^{c}	0±0	0.86±0.03^{b}	1.36±0.02 ^{a}
70nT	1.49±0.02 ^{ab}	0.65±0.02^{a}	0.76±0.02^{b}	4.07±0.02^{a}	1.23±0.01^{c}	0±0	0.84±0.01^{b}	`1.32±0.02 ^{a}
80nT	1.44±0.02 ^{ab}	0.61±0.01^{a}	0.73±0.02^{b}	4.01±0.02^{a}	1.18±0.02^{a}	0±0	0.80±0.02^{b}	1.29±0.02^{a}
100 nT	1.28±0.01^{c}	0.49±0.02^{b}	0.52±0.02^{bd}	3.19±0.0^{b}	1.06±0.01^{de}	0±0	0.74±0.01^{b}	1.27±0.02^{a}
110 nT	1.23±0.02^{c}	0.48±0.02^{b}	0.47±0.01^{bd}	3.03±0.1^{c}	1.02±0.01^{de}	0±0	0.59±0.01^{c}	1.19±0.02^{b}
120 nT	1.16±0.01^{c}	0.42±0.02^{b}	0.45±0.02^{bd}	2.36±0.02^{c}	0.75±0.01^{de}	0±0	0.54±0.01^{c}	1.12±0.02^{b}
130 nT	1.06±0.01^{de}	0.37±0.02^{b}	0.30±0.02 ^{a}	2.21±0.02^{c}	0. 71±0.01^{d}	0±0	0.51±0.01^{c}	1.00±0.02^{c}

Legend:Data are presented as Mean ± SD (n=2) from triplicate determinations, different superscripts in the same column are significantly different (P< 0.05).

4. Discussion

Effluent can serve as a source of habitat to pathogenic microorganism, when there is effluent discharge by man into the water bodies had led to changes of water quality, which decline the rate usage of water for various purpose. Discharge of effluent from the commercial sectors has come to be an environmental problem for many nations specifically growing international locations like Nigeria [12]. Characteristics of effluent should be study by the use of widespread techniques which is used to ascertain the viable impact of effluent in the environment. Such analysis regularly contains figuring out the organic and physicochemical additives of the effluents [13]. The excessive amount of BOD and COD of the palm oil mill effluent because of is excessive polluting potential. The excessive awareness of nutrient in palm oil mill effluent similarly explains why POME are used for agricultural practices It can also serve as a source of pathogenic microorganisms [14]. It was observed that some microorganisms were isolated from cassava processing plant and bakery effluent and these microorganisms are *Staphylococcus saprophyticus*, *Bacillus cereus*, *Staphylococcus aureus*, *Enterobacter aerogenes*, *Lactobacillus lactis*, *Micrococcus varians*, *Enteococcus faecalis*, *Bacillus subtillis* and Staphylococcus epidermidis.

In this present study the findings that electromagnetic fields had denaturing or inhibiting effects on microorganisms were similar to the research carried out by Sale and who investigated that there is lethal effect on the microorganisms observed. The reduction of microbial population after subjected to high pulses of electric current which increase the rate of cellular membrane permeability of the microorganisms exposed to the electric field. The virulent effect of the field intensity resulted depend mainly on exposure and time of duration. Both Staphylococcus aureus and *Micrococcus varians* are opportunistic organisms, gram positive, circular in shape and capable of causing pneumonia. The ubiquity of Escherichia coli, *Shigella flexneri*, *Enterobacter aerogenes* and Salmonella typhi in the effluent shows that the effluent can run-off to nearby waterbodies such as stream, river if these waterbodies are used for domestic activities and it could serve as source of diseases especially when consumed for drinking water [15]. Similarly, the presence of *Lactobacillus lactis* present in the effluent are capable of causing bacteremia. The presence of E. coli and *Enteococcus faecalis* in the sample indicating potential of water pathogens is in congruent to the analysis of [16]. The presence of *Bacillus subtillis* and Staphylococcus epidermidis can cause disease in humans which can lead to a source of outbreaks [17]. The effect of Electromagnetic field on the microorganisms could depend on the types of microorganism and the time of exposure. It

was *Bacillus subtillis* and *Micrococcus varians* that was not inhibited at 70nT and 80nT. It was at 110nT that *Bacillus subtillis* and *Micrococcus varians* was inhibited after exposure to EMF which was in consistent to the findings of [14]. After exposure to EMF at 130nT it had highest inhibitory effect. Exposure of the isolates to magnetic and electric field intensity at 70nT had least effect on the metabolites been generated by the cells of the organisms which is in line to the investigation of [17]. The impact of magnetic intensity on total hardness, total dissolved solid and total soluble solid from palm oil mill effluent is experimentally studied by varying the magnetic field strength between 70nT and 130nT which reduced the values and this is in accordance to the findings of [18]. Total hardness value was 251 mg/l and it was reduced to 15.5 mg/l, while the total dissolved solid values was reduced from 154 to 3.21 mg/l and the values of TSS values was 251 to 15.5 mg/l and all this values are in congruent to the findings of [19]. The COD of industrial effluent before treatment was 10.3 mg/l which was reduced to 2.266 mg/l, the BOD values was 9.2mg/l to 4.2mg/l and dissolved oxygen was also reduced from 6.9mg/l to 4.55mg/l after application of electromagnetic field which is in conformity to the findings of [20]. The Chloride of effluent from palm oil mill was lower after treatment with EMF [21]. Thus from the foregoing discussion it is very clear that EMF play a degradative role in the presence of organic and inorganic matter from palm oil mill effluent [22]. Sulfate results was reduced from 44.33 mg/l to 13.55 mg/l, the values for nitrate were reduced from 9.5mg/l to 5.6mg/l which is uniform to the findings of [23]. Electromagnetic field had an inhibiting effect on mineral composition. Iron had the highest value for raw effluent 3.44±0.02a while at exposure to 70nT it was reduced to 2.88±0.02a, and it was reduced to least value 1.86±0.02a at 130nT. Lead had the lowest value for raw and treated effluent from palm oil mill which is harmonious to the research work by [23]. It was iron that had the highest value 4.11±0.02a at 70nT and it was reduced to 0.71±0.01d at 130nT which was similar to the findings of [3]. Lead had lowest value before and after application of Electromagnetic field [24]. Copper also had high value 1.54±0.03ab after application with 70nT which was reduced to 1.06±0.03de. After application to EMF the other mineral composition values were reduced. From the research it is very clear that the effluent had high microbial load, physicochemical composition and it shows that Electromagnetic play an important role in the bio-degradative activity of organic and inorganic matter when exposed to the fields and it can also inhibit pathogenic microorganisms [25].

Conclusion

Effluent can be a source of pathogenic microorganisms and if not properly treated before release into the environment especially into stream during runoff which can be used for domestic purposes, it can serve as potential peril or hazard to those that depend on the stream for domestic purposes. It was observed that EMF treatment has a significant effect on the microorganisms and physicochemical parameters of the industrial effluent and it doesn't have harmful effect at the long run. Also the research projected that use of EMF can be used for disinfection purposes compared to other form that may lead to potential threat to human being. For future purpose, electromagnetic field can be generated and can be power using solar, so that it can cost effective and a larger size can be produced.

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Author Contributions

Research Conceptualization: Akinyosoye FA, Arotupin DJ, and Balogun O.B; *Research Design*: Akinyosoye FA; *Supervision*: Akinyosoye FA, Arotupin DJ; *Materials*: Balogun OB; *Data Collection*: Balogun OB; *Data Analysis and Interpretation*: Balogun OB; *Literature Survey*: Balogun OB; *Writing Article*: Balogun O.B; *Critical Review*: Akinyosoye FA and Arotupin DJ; *Article Editing*: Balogun OB; *Final Approval*: Akinyosoye FA and Arotupin DJ.

Declaration of Conflict of Interest

Authors declare that they have no conflict of interest with any person, institution, or company.

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