Assessment of Electromagnetic Field on Bacteriological and Physicochemical Properties of Brewery Effluent from Ilesha

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Abstract: The present study was designed to enumerate and identify microorganisms and to determine physicochemical properties of industrial effluents. Samples were collected from four different industries in Oriade local government (Ilesha, Ikeji-Arakeji and Ipetu Ijesha). The Industrial effluent samples were subjected to microbiological and physicochemical analyses. Bacteria isolated from industrial effluent sample 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 bacteria load before treatment was (2.25×10^5cfu/ml) and reduced after application with EMF. Palm oil mill effluent had higher mean values for pH (8.87), colour (14.33 Pt/co), temperature (27.33˚C), conductivity (63 (µS/cm) otatl hardness (262 mg/l), sodium (14mg/l) and total soluble solids (322 mg/l) before treatment with Electromagnetic field reduced afterwards. The mean iron value decreased from (3.67± 0.02 mg/l) to (1.86± 0.02 mg/l) after application of Electromagnetic field.The presence of these microorganisms and chemical substances pose a potential threat to the health of populace inhabiting these places and also the industrial effluent can affect the aquatic microbiota and macrofauna and soil inhabiting microorganisms.

Key word: Physicochemical conditions, electromagnetic field, bacteria and brewery effluent

INTRODUCTION

Industrial effluent is an out flowing of water or gas to a natural body of water, from a structure such as a wastewater treatment plant, sewer pipe, or industrial outfall. Effluent, in engineering, is the stream exiting a chemical reactor (Adefemi and Awokunmi, 2010). It is also water that has been adversely affected in quality by anthropogenic influence, urban or agricultural run-off into stream. Effluent is one of the most critical problems of both middle and low income countries i.e. improper management of vast amount of wastes. Industrial effluent can originate from a combination of domestic, industrial, commercial or agricultural activities, surface runoff or storm water and from sewer inflow or infiltration (Abdullah and Khalik, 2012). The characteristics of effluent vary depending on the source. Types of effluent include: domestic effluent from households, municipal effluent from communities (also called sewage) or industrial effluent from industrial activities. Effluent can contain physical, chemical and biological pollutants (Adetuyi *et al*., 2017). Effluent can originate from human waste (such as faeces, used toilet paper or wipes, urine, or other bodily fluids).

Microorganisms in activated sludge play a key role in the degradation of pollutants. However, there is a dearth of information effect on the magnetic field on the microorganism functional gene and metabolism of activated sludge (Adeyeye, 2020). Electromagnetic field could decrease the bacterial diversity from study by Boboye *et al*. (2017) which affect the microbial cell membarane, the structural stability and diversity of microorganisms (Aleem and Malik, 2020). Therefore, to fully reveal the mechanism of the magnetic field in improving the effluent treatment performance, it is necessary to deeply study the microbial community structure and function in activated sludge (WHO, 2018). In recent studies, the UN reported consumable water levels at 2.7% of earth’s water, with ground water being a major contributor. Present estimates quantify consumable water levels at 1% (Balogun *et* *al*., 2019). However, sustainable utilization of the earth's water is therefore being defined as the use of water resources which imposes no cost whatsoever on future generations, which might arise through depletion of the resource or through a reduction in its quality (Mansouri *et al*., 2017). This study was designed to determine the bacteria present in the industrial effluent from brewery and to assess the physicochemical property of the effluents discharge from palm oil mill and to investigate the effect of Electromagnetic field on the microbial load, identities and physicochemical properties of effluent from brewery.

MATERIALS AND METHODS

Collection of effluent samples: Brewery effluent samples were collected from International brewery in Ilesha town in Oriade local government Area Osun State, Nigeria. It is situated Latitude 7˚55'N and longitude 5˚19'E.

Effluent were collected from the holding tank of a company using sterile container at a sampling point and transported to the laboratory for analysis in the afternoon at 2pm during rainy season. Ilesha has tropical climate of the rainforest most people living are civil servants.

Characterization and identification of bacterial isolates: The effluent samples were analysed for microbial properties using standard procedures. The microbiological analyses were done as describe as Cheesbrough (2000). The effluent samples were subjected to ten-fold serial dilutions, then 1 ml of the diluted samples were taken from the test tubes 10^{-4} were dispensed into the petri dishes labelled with the same diluted factor and the nutrient agar was poured into each plates at 45°C, the plate were rocked and allowed to set (or solidify and incubated for 24 hours. Nutrient agar was used for total bacteria count, McConkey agar and *Salmonella Shigella* agar was used for total coliform count, mannitol salt agar was used to know Staphylococcus spp. present in the effluent samples. The isolates were characterized using microscopy and morphological characteristics such as shape, arrangement and Gram staining. Also it was characterised using biochemical reactions such as motility, sugar fermentation, urease, citrate test etc. (Olutiola *et al*., 2019).

Determination of the impact of electromagnetic field on bacterial load of brewery effluent samples: The electric circuit that generated the electromagnetic field intensities used this research work. It was designed and constructed in the Department of Physics at the Nigeria Institute of Science and Technology Samonda Ibadan. Twenty five (25 ml) portion of the brewery effluent in a and transferred into conical flask which was exposed to EMF of different intensities (70 nT, 80 nT, 100 nT, 110 nT, 120 nT and 130nT). Microbial analysis were done before exposure and also it was expose the sample to EMF at 6 hours interval exposure for 24 hours and after 24 hours it was done after 12 hours interval till 96 hours. The triplicate values of the bacteria colony for each sample were counted and recorded. Physicochemical analysis such as Temperature, pH, conductivity, turbidity, total dissolved solid, total solid, total soluble solid and so on. The mineral composition such as cadmium, chromium, lead, manganese and so on. The effluent sample were also carried out and subjected to Electromagnetic field for (ninety six hours) before exposure to EMF and after exposure to EMF. The physicochemical parameters were analyzed in triplicate and the mean values were recorded.

Physicochemical analysis: The physicochemical qualities of the brewery sample were determined by the methods described by WHO (2023). The physicochemical parameters evaluated were Total dissolved solids, Total solids, Chloride, Sulphate, Nitrate, Sodium, DO Dissolve oxygen Biochemical oxygen demand and Chemical oxygen demand.

Mineral composition of effluents: The mineral composition of effluents were determined using standard methods described by WHO (2021). The heavy metal values were investigated from Atomic Absorption Spectrometer (AAS). Alkali metals were using flame photometer. Therefore the absorbance and concentration of the metals were recorded.

Statistical analysis: Research values and results were generated before and after exposure to EMF and it was subjected to analysis of variance and mean using minitab. The mean difference was considered significant at p<= 0.05.

RESULTS

Table 1 showed the colonial and biochemical characteristics of bacteria isolated from brewery effluent. It is based on arrangement, shape, citrate, urease, sugar fermentation, methyl red and hydrogen sulphide etc. Twelve bacteria isolates were isolated from brewery effluent.

Table 2 showed the effect of different EMF intensities (70 nT, 80 nT, 100 nT, 110 nT, 120 nT and 130 nT) on the occurrence and types of bacteria isolated from brewery effluent from 0 hours to 96 hours. 130nT had more inhibiting effect than other EMF intensities such as 70 nT, 80nT, 100nT, 110nT and 120nT on the microorganisms isolated. It had similar denaturing effect on *Lactococcus lactis* similar to 70 nT. At 100 nT had denaturing effect on *Lactococcus lactis*, *Shigella flexneri*, *Escherichia coli* and it also had inhibitory effect on *Bacillus subtilis* because it was at this intensity that *Bacillus subtilis* was not seen. At 110 nT It had more inhibiting effect than 100 nT on the microorganisms isolated. It had more denaturing effect on *Lactococcus lactis*, *Shigella flexneri*, *Escherichia coli* and it also had inhibitory effect on *Bacillus subtilis*. Exposure to 120 nT more denaturing effect on *Lactococcus lactis*, *Escherichia coli* and It also had inhibitory effect on *Bacillus subtilis*. It had more inhibitory effect on *Shigella flexneri* and *Staphylococcus aureus*. It was at 120 nT that *Pseudomonas aeruginosa* was inhibited.

Table 3 showed heavy metal composition of effluent from different industries. The heavy metal composition includes the iron, zinc, lead, chromium, cadmium, copper, manganese and Nickel. Brewery effluent had high values while the treated samples values had reduced values.

Figure 1 showed bacterial load of effluent sample. This study showed high bacterial load which indicate that the effluent sample contains a large number of bacteria**.**

Figure 2 showed the microbial loads of effluent samples from brewery industrial site that were subjected to different EMF strengths (70 nT, 80 nT, 100 nT, 110 nT, 120 nT and 130 nT) at various time. The samples were collected from effluent from brewery industry. The triplicate values of the bacteria colony count and physicochemical value was recorded, the mean values were statistically analysed. Bacterial count were 210 cfu/ml before exposure to EMF and it reduces at all EMF intensities but at 130nT it had highest inhibitory effect on the bacterial load. The triplicate values of the bacteria colony count were recorded which indicated that effluent sample contains a large number of bacteria.

Figure 3 showed the physicochemical analysis of raw and treatment effluent. It was observed that EMF also reduces the values of physicochemical composition. The temperature was 27ºC for the raw effluent but after treatment with EMF it was reduced to 25ºC, the temperature of the environment will also have an influence on the temperature of the effluent. Colour of the drinking water is a physical characteristic that cannot be noticed unless it is one of high concentration. The raw effluent color also reduces which show the efficient level of Electromagnetic field. The turbidity was 5.93 mg/l and it was reduced to 0.166 mg/l. Total hardness had the highest value which was 266mg/l which was reduced to 23.16mg/l. he COD of industrial effluent before treatment was 10.26 mg/l which was reduced to 2.266 mg/l after application of electromagnetic field.

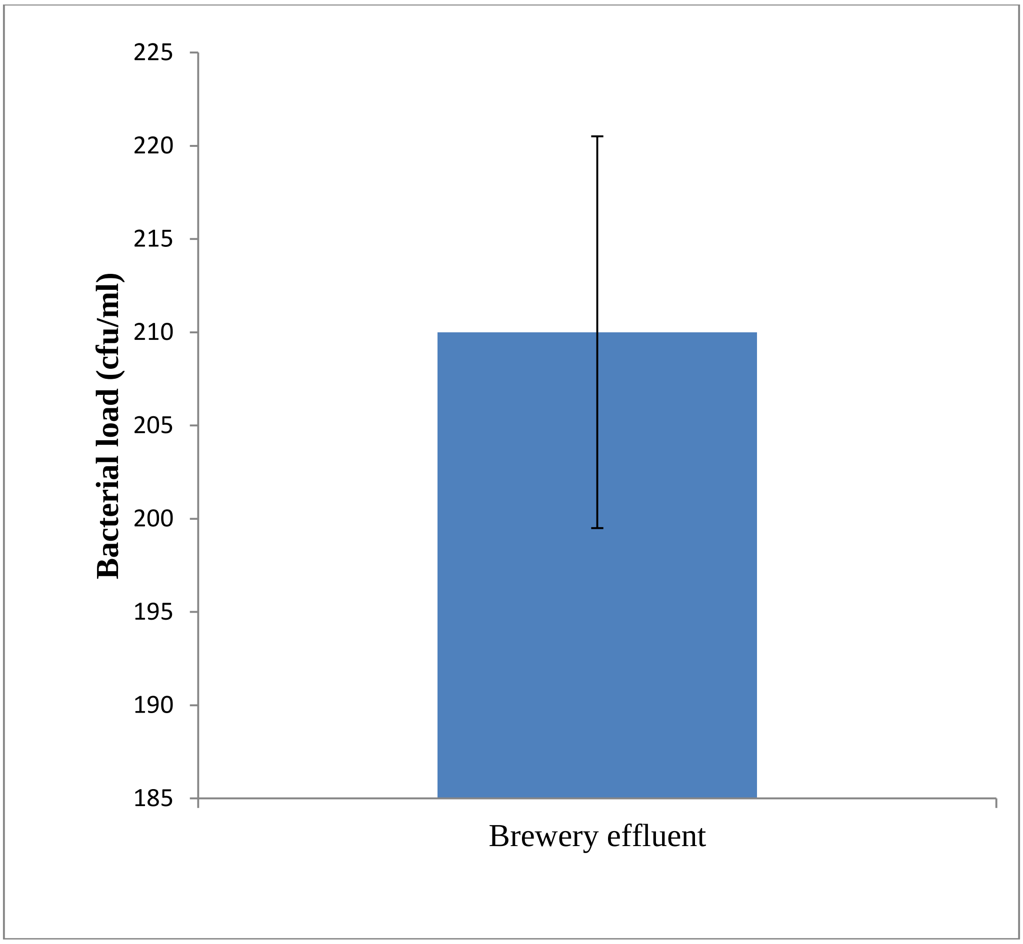

Figure 1: Bacterial load of brewery effluent

Table 1: Colonial and biochemical characteristics of bacteria isolated from brewery effluent

	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	PROBBLE ISOLATES
IO1	-ve	Rod	Chain	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	C	C	C	NA	NA	NA	NA	NA	*S. flexine*
IO2	-ve	Rod	Chain	+ve	-ve	+ve	-ve	+ve	+ve	-ve	+ve	P	C	C	AG	AG	AG	AG	AG	*E. aerogenes*
IO3	+ve	Cocci	Cluster	+ve	-ve	-ve	-ve	+ve	+ve	-ve	+ve	C	C	Y	AG	A	A	AG	A	*S. aureus*
IO4	+ve	Rod	Chain	-ve	+ve	+ve	-ve	-ve	+ve	-ve	-ve	C	C	C	-ve	A	A	AG	AG	*B. cereus*
IO5	-ve	Rod	Chain	+ve	-ve	+ve	-ve	+ve	+ve	-ve	+ve	G	C	P	AG	AG	AG	AG	AG	*E. coli*
IO6	-ve	Rod	Chain	+ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	C	C	C	-ve	-ve	-ve	-ve	-ve	*P. aeruginosa*
IO7	-ve	Rod	Chain	+ve	-ve	-ve	+ve	+ve	-ve	+ve	-ve	C	C	B	AG	AG	AG	AG	A	*S. typhi*
IO8	-ve	Cocci	Chain	-ve	-ve	+ve	+ve	-ve	+ve	+ve	+ve	C	C	C	AG	AG	AG	AG	A	*L. lactis*
IO9	+ve	Cocci	Cluster	+ve	+ve	-ve	+ve	-ve	+ve	-ve	+ve	C	C	C	AG	AG	AG	AG	A	*M. varians*
IO10	+ve	Cocci	Cluster	+ve	-ve	-ve	-ve	-ve	+ve	-ve	+ve	C	C	C	AG	AG	AG	A	A	*E. faecalis*
IO11	+ve	Rod	Chain	-ve	+ve	+e	-ve	-ve	+ve	-ve	+ve	C	C	C	-ve	A	-ve	AG	AG	*B. subtilis*
IO12	+ve	Cocci	Cluster	+ve	-ve	-ve	-ve	-ve	+ve	-ve	+ve	C	C	C	AG	AG	AG	A	A	*S. viridans*

Key: A = Acid production, AG = Acid and Gas production, MSA=Mannitol salt agar, EMB=Eosin methylene blue, SSA=*Salmonella Shigella agar*, + = Positive reaction, - = Negative reaction, C = Colourless, B = Black, P = Pink, G = Green, Y = Yellow

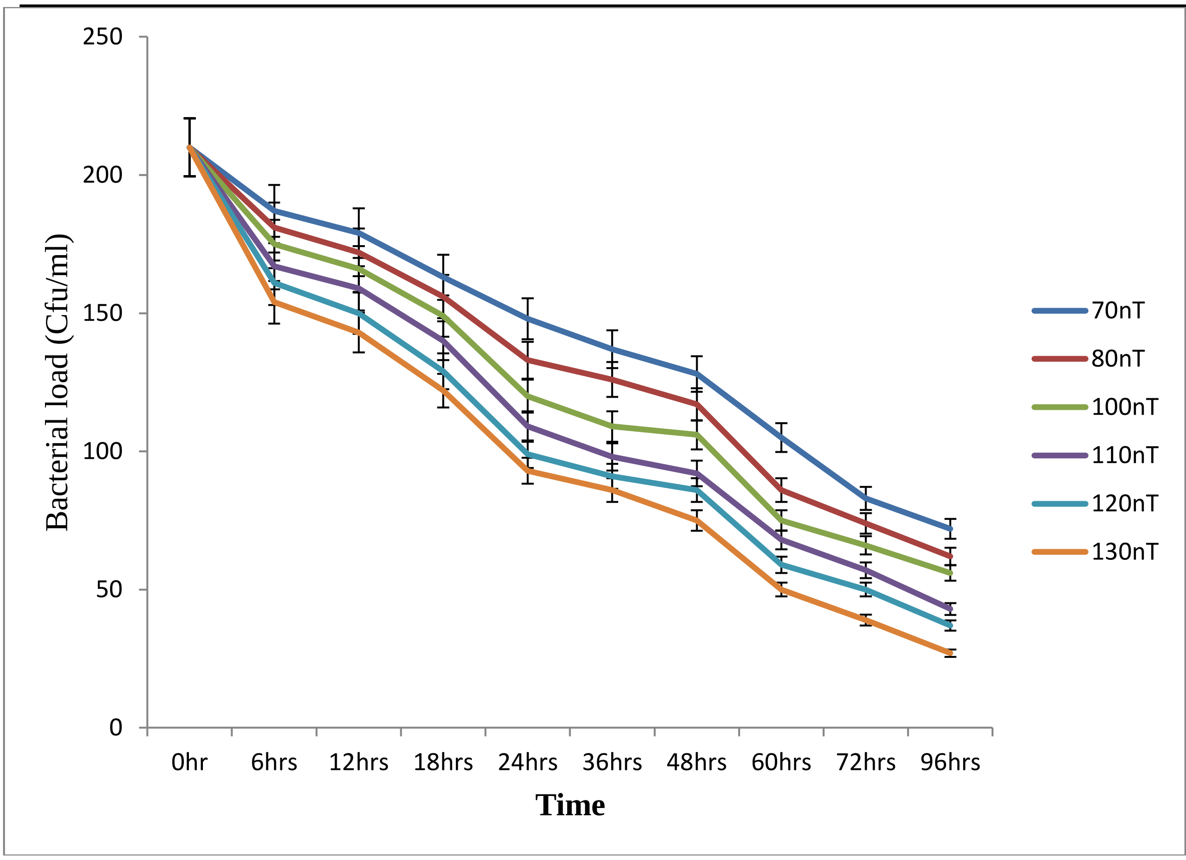

Figure 2: Effect of EMF at different intensities and time intervals on bacterial loads of brewery effluent

Table 2: Effects of EMF intensities (70 nT, 80 nT, 100 nT, 110 nT, 120 nT, 130 nT) on occurrence and types of the bacteria in an effluent from brewery

Isolate code	0 96 70 nT	0 96 80 nT Hrs	0 96 100 nT	0 96 110nT	0 96 120 nT	96 130nT
Shigella fleneri	+ +	+ -	+ -	+ -	+ +	+ +
Enterobacter aerogenes	+ -	+ -	+ -	+ -	+ -	+ +
Staphylococcus aureus	+ -	+ -	+ -	+ -	+ -	+ -
Bacillus cereus	+ +	+ +	+ +	+ +	+ +	+ +
Escherichia coli	+ -	+ -	+ -	+ -	+ -	+ -
P. aeruginosa	+ +	+ +	+ -	+ -	+ -	+ -
Salmonella typhi	+ +	+ +	+ -	+ -	+ -	+ -
Lactococcus lactis	+ -	+ -	+ -	+ -	+ -	+ -
Micrococcus varians	+ +	+ +	+ +	+ +	+ +	+ -
Enterococcus faecalis	+ -	+ -	+ -	+ -	+ -	+ -
Bacillus subtilis	+ +	+ +	+ +	+ +	+ -	+ -
Streptococcus viridans	+ +	+ -	+ -	+ -	+ -	+ -

Key: +: Positive - : Negative

Table 3: Heavy metal composition of brewery effluent

SAMPLE	Cu	Cr	Zn	Fe	Cd	Pb	Mn	Ni
RAW	1.42 ± 0.03^{ab}	0.89 ± 0.02^{e}	0.90 ± 0.02^{b}	3.44 ± 0.02^{a}	0.53 ± 0.01^{c}	0 ± 0	0.933 ± 0.03^{b}	0.90 ± 0.02^{cd}
70nT	1.29 ± 0.02^{c}	0.88 ± 0.02^{e}	0.86 ± 0.02^{b}	2.88 ± 0.02^{a}	0.43 ± 0.01^{c}	0 ± 0	0.61 ± 0.01^{bc}	0.75 ± 0.02^{bc}
130 nT	1.01 ± 0.01^{de}	0.71 ± 0.02^{ed}	0.70 ± 0.02^{a}	1.86 ± 0.02^{a}	0.22 ± 0.01^{d}	0 ± 0	0.23 ± 0.01^{d}	0.32 ± 0.02^{c}

Key: Data are presented as Mean ± SD (n=2) from triplicate determinations. Different superscripts in the same column are significantly different ($P\leq 0.05$).

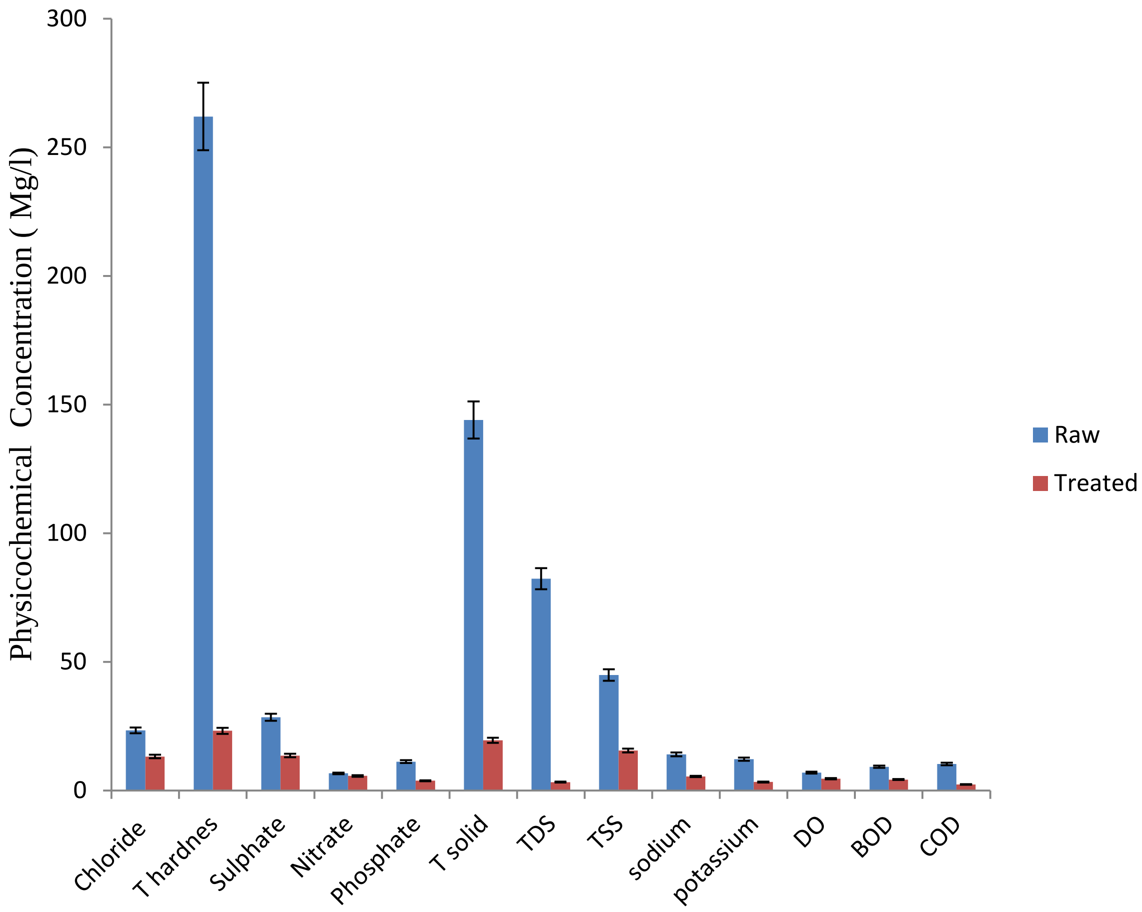

Figure 3: Physicochemical properties of raw and EMF treated effluent

DISCUSSION

Water pollution is one of the major consequences of urbanization and industrialisation. In the quest for higher standards for life, humans are degrading and depleting the natural resources. Anthropogenic urban-industrial effluents discharge, domestic waste discharge and agricultural waste discharge can add significant amounts of contaminants to surface water and sediments (Olowe *et al.*, 2005). It was reported that high microbial population in an aquatic system is a reflection of the input of microorganisms from extraneous sources and availability of growth supporting organic matter. Balogun *et al*. (2019) noted that high counts of bacterial load reflected the level of water pollution as it gave indication of the amount of organic matter present. In the study isolation of *Staphylococcus aureus* and *Micrococcus varians* are opportunistic organisms, gram positive, circular in shape and capable of causing pneumonia (Oladipo *et al*., 2023). The presence of *Escherichia coli, Shigella flexneri*, *Enterobacter aerogenes* and *Salmonella typhi* in the effluent shows that when the effluent is washed into other waterbodies and it can contaminate this waterbodies especially when this waterbodies are used for domestic activities (Omoigberale *et al*., 2009). The presence of *Lactobacillus lactis* present in the effluent are capable of causing bacteremia. The presence of total coliforms, *E. coli* and faecal *Streptococci* in the brewery effluent indicated faecal pollution of the water which is in line with Okonko *et al*. (2016). Studies have accumulated over the years to emphasize the importance of magnetic fields, which are used as an effective choice to improve the effluent treatment performance. The effluent with exposure to Electromagnetic field at 0 hours, it had the highest bacterial load at 210 cfu/ml. After exposure of bacterial load to 70nT intensity there was a gradual reduction in the bacterial population. At 130nT the EMF had highest inhibiting effect the bacterial load was reduced to lowest count. Increase in EMF intensities and exposure time reduced the bacteria load to a significant level which is consistent to the findings of Adetuyi *et al*. (2017). *Enterobacter aerogenes*, *Staphylococcus aeruginosa*, *Escherichia.coli*, *Enterobacter faecalis*, *Salmonella typhi*, *Lactococcus lactis* and *Streptococcus viridans* which was inhibited after exposure to 70 nT. *Bacillus subtillis* and *Shigela flexneri*, *Pseudomonas aeuginosa* and *Micrococcus varians* was also inhibited at 96 hours but after exposure to 130 nT. The growth rate decreased across the increasing EMF intensities. Electromagnetic field possesses some inhibitory effects on bacterial load which is in similar to the findings Konopacki and Rakoczy (2019) that certain bacteria responds positively well in terms of increased growth rate and activities to electromagnetic field treatment. In correlation with the findings of Mansouri *et al*. (2017), electromagnetic field treatments significantly reduced the growth and multiplication of bacteria. The temperature, pH, turbidity and colour of the effluent also reduces after application of EMF which correlate to the findings of Balogun *et al* (2022). The high pH value recorded could be as a result of the brewery operation, which employs the use of detergents like caustic soda. High turbidity is often associated with higher levels of disease causing microorganism such as bacteria and other parasites. Industrial effluent are contaminated with microorganisms which can contaminant other forms of environment. Total hardness had the highest value which was 266 mg/l which was reduced to 23.16 mg/l which was inline to the findings of Balogun *et al*. (2017), which showed that EMF reduces the total hardness of wastewater from Akure metropolis. The values for sulphate, nitrate and phosphate was higher before treatment with EMF (Okonko *et al*., 2016). The biological oxygen demand and chemical oxygen demand also reduces after application of EMF because it reduces the organic nutrient of the effluent which is similar to the findings of Ikuesan and Balogun (2022). The chloride value of effluent from brewery was reduced after treatment with EMF. Electromagnetic field had an inhibiting effect on mineral composition. Iron had the highest value for raw effluent 3.44±0.02 after exposure to 70 nT it was reduced to 2.88±0.02 (Boboye *et al*., 2017). It was reduced to least value at 1.86±0.02 at 130 nT. parametersd Lead,Magnessium, Manganese, Nickel, Gold, Chromium values were reduced Mansouri (2017).

CONCLUSION

From the research there was heavy load of microorganisms present in the effluent and it is very clear that electromagnetic field play an important role to inhibit pathogenic microorganisms present in the effluent which can cause health peril. It help in the biodegradation of organic and inorganic matter which reduces both the physicochemical and mineral composition of the effluent**.**

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