BACTERIAL EMPIRE

2021, VOL. 4, NO. 4, e325

MICROBIAL ANALYSIS OF INDUSTRIAL EFFLUENT ON UTEKON RIVER IN OVIA NORTH-EAST LOCAL GOVERNMENT AREA OF EDO STATE

*[1,2]IYARE, HARRISON E., [1,3]OGUNBIYI, OLUWAGBENGA J., [2]UGIAGBE OSAZUWA K. & [3]OMORINOLA, ALAKE A.

Address (es):
[1]Department of Biochemistry, Faculty of Life Sciences, University of Benin, Benin-City, Nigeria.
[2]Department of Science Laboratory Technology, Shaka Polytechnic, Benin-City, Nigeria.
[3]Biology Unit, Faculty of Science, Air Force Institute of Technology, P.M.B. 2104, Kaduna, Nigeria

*Corresponding author: harryportal15@gmail.com

https://doi.org/10.36547/be.325

ABSTRACT

The microbial analysis of industrial effluent on Utekon River in Ovia North-East local government area of Edo State was investigated in this study. The study assesses the extent of pollution of the water due to discharged effluent from the industries in the area. The bacteriological analysis of water samples collected from five different stations (A-E) revealed the presence of bacteria genera such as *Escherichia coli*, *Staphylococcus epidermis, Staphylococcus aureus, Klebsiella* sp and *Streptococcus* sp. The most widely distributed bacteria was *Escherichia coli* indicating faecal pollution of the river. The total bacteria count was observed to range from $12\times 10^3 - 83 \times 10^3$ cfu/ml. The highest bacteria count 83×10^3 cfu/ml was recorded in sample B1 obtained from station 2, which was the point of discharge of effluent. The total coliform count was observed to range from 12 – 79. Antibiotic susceptibility testing revealed that the most resistant and susceptible bacteria isolates were *Escherichia coli* and *Staphylococcus aureus.* The most susceptible bacteria isolate was *Streptococcus* sp. Due to negative impact of the effluent discharge in Utekon River it will be necessary if policies are provided to ensure proper treatment of waste effluent before discharge into the river in other to preserve the safety of the river and conservation of the aquatic life. Thus helping the sustainability of the aquatic life of the river and preventing hazardous threat this polluted river may pose to human health who consume this aquatic life.

Keywords: River, pollution, bacteria, effluents and microbial

INTRODUCTION

Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of high quality for domestic purposes and economic activities (**UNEP, 2000**). The quality of any body of surface or ground water is a function of either or both natural influences and human activities (**Stark *et al.*, 2001**; **Kolawole *et al.*, 2008**). It is now generally accepted that aquatic environments cannot be perceived simply as holding tanks that supply water for human activities. Rather, these environments are complex matrices that require careful use to ensure sustainable ecosystem functioning well into the future (**UNEP, 2000**).

Rivers are the most important freshwater resource for man. Unfortunately, river waters are being polluted by indiscriminate disposal of sewage, industrial waste and plethora of human activities, which affects their physico-chemical characteristics and microbiological quality (**Koshy and Nayar, 1999**). Pollution of the aquatic environment is a serious and growing problem. Increasing numbers and amounts of industrial, agricultural and commercial chemicals discharged into the aquatic environment have led to various deleterious effects on aquatic organisms. Aquatic organisms, including fish, accumulate pollutants directly from contaminated water and indirectly *via* the food chain (**Hammer, 2004**; **Mohammed, 2009**).

Owing to the large quantity of effluent discharged to the receiving waters, the natural processes of pathogen reduction are inadequate for protection of public health. In addition, industrial wastes that alter the water pH and provide excessive bacterial nutrients often compromise the ability of natural processes to inactivate and destroy pathogens (**Gerardi and Zimmerna, 2005**). The extent of discharge of domestic and industrial effluents is such that rivers receiving untreated effluent cannot provide the dilution necessary for their survival as good quality water sources. The transfer of unfavourable releases from industries is detrimental to human and animal health and safety (**Adekunle and Eniola, 2008**).

Prevention of river pollution requires effective monitoring of physico-chemical and microbiological parameters (**Chandra *et al.*, 2006**). In most countries, the principal risks to human health associated with the consumption of polluted water are microbiological in nature. The bacteriological examination of water has a special significance in pollution studies, as it is a direct measurement of deleterious effect of pollution on human health. Coliforms are the major microbial indicator of monitoring water quality. The detection of *Escherichia coli* provides definite evidence of faecal pollution; in practice, the detection of thermotolerant (faecal) coliform bacteria is an acceptable alternative (**WHO, 1997**).

However, the aims and objectives of this study is to evaluate the microbial quality of river water sample, estimate the microbial load content of the river water samples, determine if the microbial load content is pathogenic at the level detected and evaluate selected physicho-chemical parameters of the river water samples obtained from Utekon River in Ovia North East Local Government Area of Edo State.

MATERIALS AND METHODS

Sample Collection

Samples of water obtained from Utekon River were collected using sterile plastic bottles in duplicate and taken to the laboratory for microbial investigation.

Preparation of Culture Medium

Nutrient agar

Twenty-eight grams of nutrient agar (NA, Oxoid, England) were measured into a conical flask and 500 ml of water added. The conical flask was then heated after which additional 500 ml of water added to make it up to 1 litre. The medium was then sterilized by autoclaving at 15 psi (121ºC) for 15 minutes. Fulscin (10 gm per 200 ml of medium) was introduced by pouring to inhibit the growth of fungi. Inoculation and transfer of culture were carried out on sterile inoculating bench CRC model HSB 60*180, after wiping with methylated spirit.

Macconkey agar

This was prepared by measuring 49.53 grams into a conical flask and 500 ml of water added. The conical flask was then heated after which additional 500 ml of water added to make it up to 1 litre. The medium was then sterilized by autoclaving at 15 psi (121ºC) for 15 minutes. Fulscin (10 gm per 200 ml of medium) was introduced by pouring to inhibit the growth of fungi. Inoculation and transfer of culture were carried out on sterile inoculating bench CRC model HSB 60*180, after wiping with methylated spirit.

Sterilization

All glass wares and slides after washing were sterilized in an electric oven at a temperature of 60ºC for 24 hours. Cover slips were flame-sterilized just before use. Droppers, pipettes, cotton wool and plugs were covered with aluminum foil to prevent entry of condensed water vapour into the media.

Preparation of sterile water blank

Nine milliliters of distilled water were pipetted into McCartney bottles representing the samples. McCartney bottles representing each stock solution was labeled according to the sample names.

Preparation of stock solution

This was prepared by weighing one gram of the collected soil samples into the McCartney bottles representing each stock.

Serial dilution

McCartney bottles was divided into various groups representing the sample locations arranged with the already sterilized McCartney bottles labeling 10^1 to 10^6 with the stock bottle representing each samples. With a sterile pipette, 1ml each was transferred from the stock bottles into the bottles labeled 10^1 to 10^6 containing nine milliliters of sterilized distilled water for serial dilution preparation.

Method of inoculation

The pour plate method of inoculation was used in the isolation of the microorganisms associated with the samples. One ml each of the serial dilution prepared samples was pipetted with the aid of a syringe and transferred into the corresponding labeled Petri dishes. Nine ml of molten prepared nutrient agar (NA) and potato dextrose agar (MA) was dispensed into the Petri dishes. The Petri dishes was inoculated under room temperature for bacteria and fungi within 24 hrs and 72 hrs respectively.

Determination of microbial load

The microbial load of the samples was determined visibly by counting the colony forming unit after 24 hrs and 72 hrs for bacteria and fungi respectively.
The microbial load/ml was determined by the formula

$$\text{Count/ml} = \frac{\text{No of colonies on plate} \times 1}{\text{Amount plated d} \qquad \text{ilution factor}}$$

Characterization and Identification of Bacterial Isolates

Cultural characteristics

For the bacterial isolates, cultural characteristics were observed on Nutrient agar plates. The cultural characteristics such as size, shape, surface, opacity, texture, elevation and pigmentation were determined by visual observation.

Gram staining

The Gram staining technique was used for differentiation between gram positive and gram negative bacterial strains based on technique described by **Benson** (**1974**). A drop of sterile distilled water was placed on a neat and clean glass slide and a single isolated colony of 24 hours old culture was mixed in it. The smear was made by spreading the culture. This smear was air dried and fixed by rapidly passing the slide three times over the flame. It was then flooded with crystal violet for 1 minute and then washed off with distilled water. Then gram's iodine solution was added to the smear and the glass slide was left for one minute and rinsed with distilled water. This step was followed by the application of decolorizing agent (ethanol) for 30 seconds. Decolorizing agent was immediately washed with distilled water and the smear was counter stained with safaranine for one minute. The slide was washed with distilled water; air dried and was observed under the microscope.

Gram reaction

This was carried out to differentiate gram positive from gram-negative bacteria.

Method

A wire loop was sterilized in Bunsen burner and allowed to cool then a loopful of growth was collected from the agar plate and applied on a clean grease-free slide then a drop of normal saline was added, emulsified and heat fixed by passing over a flame three times. The smear was flooded with crystal violet for 30-60 seconds and then covered with iodine for 30-60 seconds and then washed off; it was decolorized with acetone until no colour runs off the slide and rinsed immediately. The slide was covered with safranin for 1 minute and then washed off with clean water. The slide was kept in a rack to air dry after wiping the back with cotton wool. The stained smear was then examined microscopically under oil immersion at x100 magnification objective lens. Gram-positive bacteria appeared dark purple while gram- negative bacteria appeared pink.

Motility test

Motility test was done by stabbing a slant with the isolated bacteria. A growth along the stab line indicates that the bacteria are not motile.

Biochemical Characteristics

Catalase test

Thee milliliters (3 ml) of hydrogen peroxide solution was poured into a sterile test tube. Then a sterile glass rod was used to collect several colonies of the test and inoculate into the hydrogen peroxide solution. It was observed for immediate active bubbling for positive test.

Coagulase test

A drop of sterile distilled water was placed on each end of a sterile slide. Then a colony of the test organism was emulsified on each spot to make two thick suspensions. A loopful of plasma was added to one of the suspensions and mixed gently. The slide was examined for clumping or doting of the organisms within 10 seconds. Plasma was not added to the second suspension which serves as control.

Oxidase test

A piece of filer paper was placed in a clean Petri dish and 2-3 drops of fresh or nascent oxidase reagent was added. A colony of test organism was collected using a glass rod and smeared on the filter paper and observed. Blue-purple color within few a seconds showed a positive test.

Urease test

The test organism was heavily inoculated onto Christensens urea broth in a bijou bottle using a sterile wire loop and incubated at 35°C- 37°C for 18- 24 hours and examined, thereafter a pink color in the medium showed positive test.

Citrate test

Simon's citrate agar medium was prepared in a slant bijou bottle, then using a sterile wire loop was used to inoculate the test organism onto the slant medium and incubated at 35°C for 48 hours after which it was examined for color formation. A bright blue color in the medium gave a positive citrate test. *K. pneumonia* and *E. coil* were employed as positive and negative controls respectively.

Vogues -Proskauer Test

Buffered glucose broth was inoculated with the test organism and incubated at 37°C for 3 days. Three milliliters (3 ml) of nephtol was then added followed by 3 m1 of sodium hydroxide solution, mixed well and allowed to stand for I hour at room temperature. The formation of a pink color in the medium within 1 hour indicates a positive result. *Klebssiella pneumonia* and *Escherichia coli* were used as positive and negative controls respectively.

Indole test

A sterile wire loop was used to inoculate a colony of test organism into 2 m1 of peptone water containing tryptophan. The tube was stoppered and incubated at 37°C for 24 hours. Kovac's reagent was added to the medium. Observation of red coloration on the surface layer within 10 minutes showed a positive result.

Carbohydrate fermentation test

The four sugar solutions were prepared and poured into test tubes well stopped with Durham tube for gas collection. The sugar was autoclaved after which a

loopful of test organisms was introduced into the sugar solution (**Buchanan and Gibbons, 1984**). A change in color from pink to yellow shows fermentation and collection of gas bubbles in the Durham tube shows gas production which is a positive test. A control was set up without the organism inoculated.

RESULTS

Water samples collected from Utekon River were analyzed for bacteria contaminants. Results obtained from the analysis are presented in Table 1. This result revealed the identity of bacteria present in the fifteen water samples analyzed to include *Escherichia coli, Staphylococcus epidermis, Staphylococcus aureus, Klebsiella* sp and *Streptococcus* sp.

Table 1 Cultural, Morphological and Biochemical characteristics of bacteria isolates from water sample from Utekon River

Characteristics		**Samples**						
		A1	A2	A3	B1	B2	B3	C1
Cultural	Elevation	Flat	Convex	Convex	Convex	Convex	Convex	Flat
	Margin	Lobate	Entire	Entire	Entire	Entire	Entire	Entire
	Colour	colorless	Colorless	Colorless	colorless	Colorless	colorless	colorless
	Shape	irregular	irregular	Circular	Circular	irregular	circular	irregular
	Gram stain	+ve cocci	+ve cocci	+ve cocci	+ve cocci	+ve cocci	-ve rod	+ve cocci
Biochemical	Glucose	-	-	-	-	+	+	+
	Lactose	-	+	-	-	-	-	-
	Sucrose	-	+	-	-	-	-	-
	H_2S Prod.	-	-	-	-	+	+	-
	Gas Prod.	-	-	-	-	-	-	-
	Cat	-	+	-	+	+	+	+
	Citrate	-	+	+	-	+	+	-
	Indole	-	-	-	-	-	-	-
		Streptococcus sp.	*S. aureus, E. coli*	*Staphylococcus* sp.	*Staphylococcus epidermis, E. coli*	*Staphylococcus aureus*	*Klebsiella* sp	*Staphylococcus epidermis*

Table 1 (contd.) Cultural, Morphological and Biochemical characteristics of bacteria isolates from water sample from Utekon River

Characteristics		**Samples**							
		C2	C3	D1	D2	D3	E1	E2	E3
Cultural	Elevation	Flat	Flat	Convex	Convex	Flat	Raised	Convex	Convex
	Margin	Entire	Entire	Entire	Entire	Entire	Filliform	Entire	Entire
	Colour	Colorless	colorless	Colorless	Colorless	Dark purple	Colorless	colorless	Colorless
	Shape	irregular	irregular	irregular	irregular	Irregular	Irregular	circular	irregular
	Gram stain	+ve cocci	+ve cocci	+ve cocci	+ve cocci	+ve cocci	+ve cocci	+ve cocci	+ve cocci
Biochemical	Glucose	+	+	+	-	-	+	-	-
	Lactose	-	-	-	-	-	-	-	-
	Sucrose	-	-	-	-	-	-	-	-
	H_2S Prod.	-	-	-	-	-	-	-	-
	Gas Prod.	-	-	-	-	-	-	-	-
	Cat	+	+	+	+	+	+	+	+
	Citrate	-	-	-	-	-	-	-	-
	Indole	-	-	-	-	-	-	-	-
		Staphylococcus epidermis	*Staphylococcus epidermis*	*Staphylococcus epidermis*	*Staphylococcus epidermis, E. coli*	*Staphylococcus epidermis*	*Staphylococcus epidermis*	*Staphylococcus aureus*	*Escherichia coli*

Water samples collected from Utekon River were observed for distribution pattern of bacteria contaminants and the results are presented in Table 2. Distribution pattern revealed that the most distributed bacteria in the fifteen water samples analyzed were *Escherichia coli, Staphylococcus epidermis, Staphylococcus aureus, Klebsiella* sp and *Streptococcus* sp.

Table 2 Distribution of bacteria isolates in water samples from Utekon River

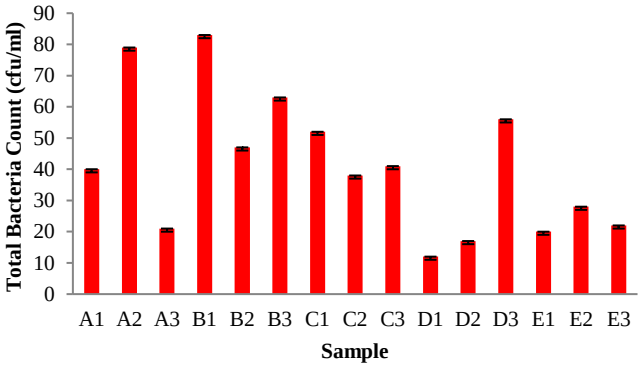
Sample	Bacteria isolates				
	Streptococcus sp.	*Staphylococcus aureus*	*Staphylococcus epidermis*	*Escherichia coli*	*Klebssiella* sp
A1	+	-	-	-	-
A2	-	+	-	+	-
A3	-	+	-	-	-
B1	-	-	+	+	-
B2	-	+	-	+	-
B3	-	-	-	-	+
C1	-	-	+	-	-
C2	-	-	+	-	-
C3	-	-	+	+	-
D1	-	-	+	-	-
D2	-	-	+	+	-
D3	-	-	+	+	-
E1	-	-	+	+	-
E2	-	+	-	+	-
E3	-	-	-	+	-

The total bacteria count in water samples collected from Utekon River were evaluated to determine the bacteria load content and the result obtained is presented in Table 3. The total bacteria count was observed to be within the range of $12\times 10^3 - 83 \times 10^3$ cfu/ml. The lowest bacteria count 12×10^3 cfu/ml was recorded in sample D1 collected station 4 while the highest bacteria count 83×10^3 cfu/ml was recorded in sample B1 obtained from station 2.

Table 3 Total Bacteria Count in water samples from Utekon River

Samples	Total count ($\times 10^3$ cfu/ml)	
	Mean	±S.E
A_1	40	±0.007
A_2	79	±0.004
A_3	21	±0.001
B_1	83	±0.013
B_2	47	±0.004
B_3	63	±0.009
C_1	52	±0.004
C_2	38	±0.006
C_3	41	±0.012
D_1	12	±0.001
D2	17	±0.001
D3	56	±0.004
E1	20	±0.001
E2	28	±0.005
E3	22	±0.000

Key: S.E = Standard error



The total coliform count in water samples collected from Utekon River were evaluated to determine the coliform load and the result is presented in Table 4. The total coliform count was observed to be within the range of 12 – 79. The lowest total coliform count of 12 was recorded in sample D1 collected station 4 while the highest total coliform count 79 was recorded in sample A2 obtained from station 1.

Table 4 Total Coliform Count in water samples from Utekon River

Samples	Total Coliform count
A_1	40
A_2	79
A_3	21
B_1	83
B_2	47
B_3	63
C_1	52
C_2	38
C_3	41
D_1	12
D2	17
D3	56
E1	20
E2	28
E3	22

Result obtained for antibiotic sensitivity test against the test bacterial isolates is presented in Table 5. *Escherichia coli* exhibited resistance against perfloxacin, ampiclox, zinnacef, amoxacillin, streptomycin and septrin. In the case of *Staphylococcus aureus*, resistance was revealed to occur against perfloxacin, gentamycin, zinnacef, rocephin, streptomycin, septrin and erthromycin antibiotics. In the case of *Staphylococcus epidermidis*, resistance was revealed to occur against gentamicin, ampiclox, zinnacef, streptomycin, septrin and erthromycin. In the case of *Streptococcus* sp. resistance was revealed to occur against perfloxacin, amoxacillin, rocephin and ciprofloxacin. Resistance against *Klebsiella* sp was observed for zinnacef, amoxacillin, rocephin, ciprofloxacin, streptomycin, septrin and erthromycin.

Table 5 Antibiotic susceptibility test of bacteria isolates from water samples from Utekon River

Isolate	PEF	CN	APX	Z	AM	R	CPX	S	SXT	E
Escherichia coli	R	I	R	R	R	S	S	R	R	R
Staphylococcus aureus	R	R	I	R	S	R	I	R	R	R
Staphylococcus epidermidis	S	R	R	R	S	I	I	R	R	R
***Streptococcus* sp.**	R	S	S	S	R	R	R	I	I	I
***Klebsiella* sp**	I	S	I	R	R	S	R	R	R	R

Key: **PEF** :Perfloxacin, **CN** : Gentamycin, **APX** : Ampliclox, **Z** : Zinnacef, **AM** : Amoxacillin, **R** : Rocephin, **CPX** :Ciprofloxacin, **S** : Streptomycin, **SXT**: Septrin, **E** : Erythromycin. Resistance (R) = 0-10mm, Intermediate (I) = 11-16mm, Sensitive (S) = 17mm and above.

DISCUSSION

It is evident from the results obtained in this study that water samples from Utekon River are contaminated with microorganisms. Analytical investigation of water samples from Utekon River revealed the presence of bacteria genera during isolation known to be pathogenic in man, calls for a serious concern. These include *Escherichia coli, Staphylococcus epidermis, Staphylococcus aureus, Klebsiella* sp and *Streptococcus* sp. Human carriers introduced these human pathogens into the river and the subsequent population bloom as a result of effluent discharged into the rivers, this becomes worrisome as it affects the quality of the water. Apart from the fact that users of the water can easily get infected by these human pathogens, the aquatic life forms particularly the fishes can also be adversely affected. Though not all members of known pathogens of fishes were isolated in this study, it is not enough to state that the fishes are not affected by those isolated. This is because research on bacteriology of fishes in relation to water pollution is rarely undertaken in this part of the world. This may also be the main reason for which etiological agents of different freshwater fish diseases are not described yet (**Boon and Huisman, 1996**).

The presence of faecal coliform and *Escherichia coli* in most of the water samples clearly shows that the river is not free of human feacal materials. This agrees with the study of **Bakare *et al.*** (**2003**) who observed that the presence of *E. coli* in water samples is an indication of faecal contamination of the river. Thus it can be assumed that Asa River is exposed to both site and non-site pollution. Thus the presences of the pollutants in the River can encourage the spread of microorganism which can degrade the pollutants (**Okafor, 1985**).

The index of the microbial load (10^3) is slightly high indicates bacterial pollution. The comparative analysis of the microbial load indicates that more bacterial were encountered at site A2, where effluent is discharged into the river. Similar reports have been made in the study of **Adewoye** (**2010**) who noticed increased bacteria content during the dry and rainy seasons. Also similar result was obtained in the study of **Bakare *et al.*** (**2003**) who reported bacteria content as high as 10^4 cfum/ml in Oba River that was exposed to human and agricultural wastes.

Observation from this study revealed that high microbial load obtained in sites A2, B1, C1, D3 and E2 might not be unconnected with the abundance of nutrients from effluent discharge. Thus, effluent discharged at site B1 is capable of enhancing growth of microorganisms in the river. This agree with the observation of **Chukwura and Okpokwasili** (**1997**) and **Eniola and Olayemi** (**1999**) who also recorded the microbial load in the order of 10^5, they submitted that the washing of wastes into water bodies encourages an outbreak of microbial loads. The observation made in this study is also similar to the report of **Akpata** (**1990**) that effluent normally increases the bacteria count in any water body but appeared to cause a decrease in the number of total heterotrophic bacteria.

Sayler *et al.* (**1975**) 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. **Ekhaise and Anyasi** (**2005**) noted that high counts of bacterial load reflected the level of water pollution as it gave indication of the amount of organic matter present. These findings are in

consonance with the results of the effect of breweries discharge into Ikpoba River, Benin City, Nigeria in the study of **Ekhaise and Anyasi** (**2005**).

This work complements previous studies on the toxicity of industrial effluents on aquatic life. The study however revealed that the volume of effluents discharged into Utekon River was gradually overtaxing their capacity for self-purification. It has been shown that the discharge of effluent by industries can constitute dense growth of microbial population due to the changes in physical status and presence of anions and cations in the receiving water bodies which hampers the quality of water and also affects the aquatic life form. The prevailing practice of unregulated and uncontrolled discharge of effluent into water bodies constitutes serious abuse and portends serious danger to microbial count and beneficial use to the municipality.

It could be seen from this work that water of Utekon River was polluted and the level of pollution decreased downstream, and it was much higher upstream. This indicates the dilution effect of the flowing river. The effluent, apart from making the river unsightly, rendered the water useless for domestic usage, instilled undesirable effects on the biotic community. **Ekhaise and Anyasi** (**2005**) attributed this to the flushing action of deep water and also this site of the river is not surrounded by trees and therefore is exposed to bactericidal effect of sunlight as reported by **Okoronkwo and Odeyemi** (**1985**).

Antibiotic susceptibility testing revealed that the most resistant and susceptible bacteria isolates were *Escherichia coli* and *Staphylococcus aureus.* The most susceptible bacteria isolate was *Streptococcus* sp.

CONCLUSION

This study revealed that the discharge of industrial effluents into the Utekon River has negative impacts on the microbiological parameters of the river. The discharge of waste effluent into the river makes the water unfit for human consumption without treatment as it is currently being practiced in this area. Therefore, the need to treat the industrial effluents prior to discharge into the river should be a great concern and importance. However, the water from this river needs to be chemically treated before consumption or use domestically.

RECOMMENDATIONS

(i) All forms of industrial effluents discharged into Utekon River should be effectively treated before disposal to the outside as they pose threat to human health and safety of the river ecosystem.

(ii) Strict environmental regulations should be encouraged to ensure that environmental pollution are minimized if not abolished in our ecosystem.

(iii) Treatment of human wastes, domestic wastes, run-off from agricultural wastes should be encouraged by private individuals and public organizations.

(iv) Public awareness on the dangers of water pollution should also be encouraged.

REFERENCES

Adekunle, A.S. and Eniola, I.T.K. (2008). Impact of industrial effluents on quality of segment of Asa River within an industrial estate In Ilorin, Nigeria. *New York Science Journal* 1(1):17-21.

Adewoye, S.O. (2010). Effects of detergent effluent discharges on the aspect of water quality of Asa River, Ilorin, Nigeria. *Agriculture and Biology Journal of North America* 1(4): 731-736.

Akpata, T.V. (1990). Pollution flora of some wetlands in Nigeria. Nigeria wetlands. *Emmi Press*; Ibadan. pp. 130-137.

Bakare, A.A, Lateef, A., Amuda, O.S. and Afolabi, R. (2003). The aquatic toxicity and characterization of chemical and microbiological constituents of water samples from Oba River, Odo-oba, Nigeria. *Asia Jr. of microbial. Biotech. Env. Sc.* 5(1): 11-17.

Benson H. J. (1994). *Microbiological Applications: a Laboratory Manual in General Microbiology*, 6th edn. Dubuque, lowa:W.C. Brown.

Boon, J. H. and Huisman, N.E. (1996). Viral, bacterial and fungal diseases of siluroidei, cultured for human consumption. *Aquatic Living Resources* 9: 153-164.

Buchanan, R. M. and Gibbons, N. E. (1974). Bergey's Manual of Determinative Bacte-riology. 8th Ed. The *Williams and Wilkins Company*, Baltimore. ISBN 0-68301117-0.

Chandra, R., Singh, S. and Raj, A. (2006). Seasonal bacteriological analysis of Gola River water contaminated with pulp paper mill waste in Uttaranchal, India. *Environmental Monitoring Assess* 118: 393-406.

Chukwura, E.I. and Okpokwasili, G.C (1997): Impact of brewery wastewater on recipient aquatic environments. In: N. Okafor, G. Okereke, E. Miambi and S. Odunfa (Eds), *Biotechnology for Development in Africa*: Proceedings of an international conference organized by foundation for African Development through International Biotechnology (FADIB) held at Enugu, Nigeria, 9 – 13 Feb., 1997. Ochumba Press Ltd., Enugu, Nigeria. ISBN 9782791199 pp. 225-233.

Ekhaise, F.O. and Anyansi, C.C. (2005). Influence of breweries effluent discharge on the microbiological and physiochemical quality of Ikpoba River, Nigeria. *African Journal of Biotechnology* 4: 1062-1065.

Eniola, K. I. T. and Olayemi, A. B. (1999). Impact of effluents from detergents producing plants on some water body in Ibadan, Nigeria. *Int. Jour of Env*. Health Research, 9: 335 – 340.

Gerardi, M.H. and Zimmerman, M.C. (2005). *Wastewater Pathogens*; John Wiley and Sons, Inc.: Hoboken, NJ, USA. pp. 3-4.

Hammer, M.J. (2004). *Water and Wastewater Technology*, 5th ed.; Practice-Hall Inc.: Upper Saddle River, NJ, USA. pp. 139-141.

Kolawole, O.M., Ajibola, T.B. and Osuolale, O.O. (2008). Bacteriological Investigation of a wastewater discharge run-off stream in Ilorin, Nigeria. *Journal of Applied and Environmental Science* 4: 33-37.

Koshy, M. and Nayar, T.V. (1999). Water quality aspects of River Pamba. *Pollution Research 18*: 501-510.

Mohammed, F.A.S. (2009). Histopathological studies on *Tilapia zilli* and *Solea vulgaris* from lake Quran, Egypt. *World Journal of Fish and Marine Science* 1: 29-39.

Okafor, A. (1985). Aquatic and Waste Microbiology: first edition. Fourth edition Dimension Publishing Company Ltd, Enugu, Nigeria. pp 1-14.

Okoronkwo, N. and Odeyemi, O. (1985). Effect of a sewage Lagoon effluent on the water quality of the receiving stream. *Environ. Pollut. Series A.* 37: 71–86.

Sayler G.S., Nelson, J.O., Justice, A. and Colwell, R.R. (1975). Distribution and significance of faecal indicator organisms in the upper Chasepark Bay. *Appl. Ind. Microbiol.* 30(4): 625–638.

Stark, J.R., Hanson, P.E., Goldstein, R.M., Fallon, J.D., Fong, A.L., Lee, K.E., Kroening, S.E. and Andrews, W.J. (2001). *Water Quality in the Upper Mississippi River Basin, Minnesota, Wisconsin, South Dakota, Iowa, and North Dakota, 1995–1998*; United States Geological Survey: Reston, V.A., USA.

United Nations Environmental Programme (UNEP) (2000). Global Environment Monitoring System/Water Programme. *Water Quality for Ecosystem and Human Health*; National Water Research Institute: Burlington, ON, Canada.

World Health Organization (WHO) (1997). Guidelines for Drinking Water Quality: Surveillance and Control of Communities Supplies (2nd ed.). WHO: Geneva, Switzerland, Volume 3.