Online Journal of Renewable Energy, 2020, 1, 23-32

EFFECT OF EFFLUENT CONTAMINATION AT OJI RIVER USING LOW TECH METHOD

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ABSTRACT

This research work aimed at assessing the impact of waste effluents on water quality of Oji River Enugu State Nigeria to determine the physical, chemical and biological characteristics of Oji River. The method involves collection of sample in a sterilized bottle and construction of a low tech prototype. The system consists of a vessel of five liters water, a car battery, an electrode and connection wire. The system uses the principle of Chlor-alkali electrolysis. Five liters of water of water was mixed with 30 grams of table salt after wards car battery deliver needed electricity for electrolysis. After Exposure time the salted water contains a chlorine solution with concentration depending on exposure time. Statistical tool known as Pearson product moment correlation test were carried out to check for validation and reliability of the Experiment and the model. The parameters where compared with the acceptable WHO standard for drinking water quality (x) was taken as dependent variable, while (y) is the laboratory result which is independent variable. Sample of Oji River was added with aluminum sluphate as a coagulation agent, after four hours the sample was sieved and 0.5 concentration of the produced sodium hypochlorite was added to the sieved sample. The water was left for three hours and the sample was again tested. Correlation result with acceptable limit of WHO shows that low-tech produced chlorine is able to improve drinking water quality. The permanent use of this low-tech chlorination could improve drinking water quality.

Key Words: *Effluent, Contamination, Low-tech.*

INTRODUCTION

Development process, industrialization, anthropogenic activities and population explosion have affected environmental quality in many ways with attendant negative impacts on the environment and human health.

Waste generated and disposed off to the environment without proper monitoring and management become public nuisance overtime, with technological development in manufacturing industries, chemicals have become important substances for human development. Industrialization is a major activity promoted by the Nigeria government as a developing nation in her development strategies to make meaningful and significant contributions to the enhancement of human welfare. Industrial operation normally involves the conversion of raw materials and resources into finished and/or semi-finished products, with attendant residues in the form of energy and matter. If these residues are not utilized, they become waste, and if discharged into the biosphere without proper treatment, can become pollutants. The degree to which the pollutants affect the physical environment depends on their

* Chinaedu, M. S., Echezona, O. F. and Kingsley, A. (2020). Effect of Effluent Contamination at Oji River Using Low Tech Method. *Online Journal of Renewable Energy,* 1: 23-32.

quantitative and qualitative characteristics as well as the receiving media. This is so because some pollutants are readily biodegradable, while others persist for a long time and may not even decompose. Also some pollutants have low toxicity whereas others are highly toxic.

Water is an essential natural resource for agriculture, manufacturing, transportation and many other anthropogenic activities. It is essential for all forms of life and makes up 50 - 97% of the weight of plants and animals and about 70% human body (Buchhloz, 1998). The WHO estimates that more than 20% of the world population has no access to safe drinking water and that more than 40% of all population lack adequate sanitation (Ogwu *et al*., 2014). Poor water quality is still a significant problem in many parts of the world. It can often limit the use of the vital resource and in more extreme cases can harm human and other life forms. Water can be polluted by substances that dissolve in it or by solid particulates and insoluble liquid drinking water is also used for fish and aquaculture, irrigation, hydropower generation and many more.

Pollution of water bodies is increasing steadily due to rapid population growth, industrial proliferation, urbanization, increasing living standard and wide sphere human activities. The rapid urbanization has caused population explosion in urban centers and the generation of wastes both liquid and solid has grown to commendable proportions. The pace of development of waste disposal schemes could not match the rapid rate of urbanization in these urban centers during the last few decades. As a result, the wastes not properly disposed reaches the water sources and therefore our water sources like rivers, lakes and reservoirs that are in close proximity of these urban centers are highly polluted.

STATEMENT OF THE PROBLEM

The problems of Oji River with respect to effluent contamination are stated below:

- Inability of Oji community to access portable water from Oji River and its tributaries among others.
- Improper management of waste in Oji River local government.
- Poor growth of children in Oji local government area and use of agricultural chemicals by farmers in Oji.
- Discharge of waste water effluent in Oji River and high rate of skin infection.
- High rate of respiratory disease in communities within Oji local government area and bad odour from water fetched in Oji River.
- High mortality rate in communities within Oji local government and High rate of typhoid disease in communities within Oji local government
- Increase in patients suffering from malaria and Objectionable colour of Oji river
- Decline in fish production from Oji River wish is experienced by fishermen and poor hygiene and human activities in river.

CONCEPTUAL FRAMEWORK

According to (WHO, 2004), each day 25,000 people are said to die from their everyday use of contaminated water and many millions more suffer from frequent and devastating water borne illness. Water quality has become a subject of concern to every nation of the world, since without water life cannot exist (Adamu 2003; Madu and Okoronkwo, 2018).

Sekabira, *et al*, (2010) have recently investigated the heavy metals concentration and contamination of the Nakivubo Channelized stream water in Kampala Uganda. The result revealed the concentration of Pb, Cu and Mn have exceeded the WHO (2008) standard for drinking water in most site.

Contamination of natural water bodies has emerged as a major challenge in developing and densely populated countries like Nigeria (Nsiah and Gyabaah, 2003; Oyebola and Odueso, 2017).

Jaji, *et al* (2007) examined the water quality of Ogun River, in which industrial effluent from Lagos and Abeokuta is discharged. It was reported that the level of turbidity, Oil and grease, faecal Coliform and Iron were very high in all the sampling sites. Water pollution due to discharge of untreated industrial effluents into water bodies is a major problem in the global context (Mathuthu *et al.,* 1997).

A study carried out by the management of industrial and municipal Effluents and Urban Runoff components of Lagos Environmental Management project (LEVMP 2002) Industrial that most factories in Lagos and its environs do not have effluent treatment plant, even where they exist.

(UNESCO, WHO 1996) explained pH as a measure of the acid balance of solution and is defined as the negative of the logarithm to the base 10 of the hydrogen ion concentration. Lekwot *et al* (2012) examined the socio-economic impact of Kaduna Refinery and petrochemical company (KRPC) on Rido Area of Kaduna Metropolis and the result revealed that air and water pollution is the common environmental problem.

SAMPLING

Sampling was carried out in February 2019. The sample where collected every two weeks for each month and in triplicates. The sampling locations were carefully selected to isolate effect of discharges from two major different activities (1) abattoir and defunct coal power station. Sampling location A was about 200m upstream the abattoir while sampling location B is by the Abattoir.
Sampling location C was about 400m downstream the Abattoir and 150m upstream the defunct coal power plant. Water samples were collected the river water. The water samples were collected into a one litre HNO_3 pre-washed polyethylene containers preservation of the heavy metals in the water samples was achieved by acidifying the sample using 5ml HNO_3 prior to transportation to the laboratory for analysis. The water samples were held in a sampling box filled with Ice cubes for maintaining sample temperature below 4^0C and transported to laboratory for analysis.

METHODOLOGY

Types of Data

i. Concentration level of pollutants at both upstream and Downstream
ii. Physical, chemical and biological parameters
iii. Data on Socio-economic activities like swimming, farming, fishing etc.

SOURCES OF DATA

Both primary and secondary data have been sourced for this study

Primary Source of Data: The primary sources include results derived from the laboratory analysis of water quality of the water samples taken from Oji River. Other sources for this study include field observations, on socio-economic activities carried out on/along river such as fishing, swimming, irrigation, etc. The main target group are the fishermen and close by residence communities. The field concerns the physical characteristics of the river like colour, odour etc.

Secondary Source of Data: This involved sourcing of information through the review of relevant literatures from document and materials such as journals, proceeding of seminars, textbooks and other research findings.

CONCEPTION OF THE MODEL FOR ANALYSIS

In this work the method of least square, the Pearson product moment correlation (r) model is used. Two variables y (dependent) and x (independent) were correlated by plotting them on x and y axis. If they fall on a straight plot, there is a close linear relationship; on the other hand if the points depart appreciably (without a definite trend), the graph is called a scatter diagram or plot.

If the trend is a straight line, the relationship is linear and has the equation

$$Y = a + bx \qquad [1]$$

Number of lines can be obtained depending on the values of a and b. the method of least squares is used to select the line that fits the data best. The principle of least squares states that the best line for fitting a series of observation is the one which the sum of the squares of the departures is minimal. A departure is the difference between the observed value and theoretical expected value (the line). Since x is the independent variable, the departures of y are used. The least squares line Equation (1) may be obtained by solving for a and b, the two normal equations are:

$$\Sigma y = na + b\ \Sigma x \qquad [2]$$

$$\sum xy = a\sum x + b\sum x^2 \quad [3]$$

When n = number of pairs of observed values x and y. The most commonly used statistical parameter was used in the work for measuring the degree of association of two linear dependent variables x and y, is the correlation coefficient, r

$$r = (n\sum xy - \sum x \sum y)/\sqrt{(n\sum x^{2} \mid [(\sum x)]^{2}][n\sum y^{2} - (\sum y)^{2}]} \quad [4]$$

LABORATORY TESTING FOR DETERMINING OPTIMUM COAGULANT

The best coagulant dose is determined first in the laboratory and then adjusted by actual observations. The test which is performed is known as the jar test. The sample of raw water to be tested is placed in a number of jars each having a capacity of 1 litre. Six jars were used. Different amounts of coagulant were then added to each jar. The formation of the floc in each jar was noted. After laboratory test it was observed that 10 mg of alum can be used for coagulation.

Quantity of Alum needed on a daily basis amount needed = Qxdose

= 200 x 10mg/L = 2000mg of alum

Or 2kg of alum is needed to treat 200 litres of water.

MATERIAL

Components needed to construct a functional prototype for water disinfection:

i. Car battery,
ii. bolt,
iii. dry wood,
iv. electrode,
v. connection wire,
vi. (solar panel or adopter)

METHOD

In general both of the tested low tech chlorination prototypes are constructed similar. The system consist of a containment vessel with a known volume of at least six liters, a rechargeable (car battery or comparable), electrodes, connection cord and a non-conductive fixation device for the electrodes.

The system is using the principle of chlor-alkali electrolysis with a low-tech approach. Six liters of water are mixed with 30 grams of table salt (NaCl) after wards car battery delivers the needed electricity for the electrolysis of the solution. After exposure time within the salted water, the vessel contains a chlorine solution with concentrations depending on the chosen exposure time.

Electrolysis in general describes the process of using a direct electric current (DC) to start another wise non-spontaneous chemical reaction within conductive aqueous solutions (electrolysis). When the DC is applied to the electrodes the anode (positive charge) has an excess of electrons the cathode (Negative charge) has a deficit of electrons. Because of that, the negatively charged molecules or ions dissolved in the electrolyte are attracted by the anode, which is giving away excess electrode to the molecules or ions (reduction).

Simultaneously the cathode attracts the positively charged molecules and ions within the solution and takes electrodes from them (oxidation) with this attributes it is suitable for the separation of elements and compounds within these solution. The materials of both anode and cathode highly influence the reaction and separation of the elements and substances.

According to ROESKE (2007), the chlor – alkali electrolysis can be described as:

$$2\,NaCl + 2H_20 \Rightarrow Cl_2 + NaOH + H_2 \quad [5]$$

$$2\,NaOH + Cl_2 \Rightarrow NaClO + NaCl + H_20 \quad [6]$$

The development of the actual disinfecting hypochlorite acid (HOcl can be described as:

$$NaClO + H_20 \Leftrightarrow HOCl + NaOH \quad [7]$$

In this case the electrolysis is used to produce chlorine in different forms. The electrolysis itself separates NaCl (sodium chloride, better known as table salt) and H20 In the first step and creates Cl_2 (chlorine gas) and NaOH (sodium hydroxide) within the electrolyte. At the same time H_2 and Cl_2 escape from the electrolyte into the air. Nevertheless Cl_2 and NaOH react to form NaCl, NaClO (sodium hypochlorite) and H_20. The produced Cl_2 is important to form the actual disinfecting hypochlorite acid while parts of it simultaneously and permanently escape from the chlorine solution. The actual disinfecting HOCl (hypochlorite acid) is developed in a balance reaction of NaOH, Cl_2 and HOCl, NaOH. This balance reaction depends on pH and temperature of the water and it takes place independently from the process of electrolysis.

DISINFECTION OF CONTAMINATED WATER FROM OJI RIVER USING HYPOCHLORITE (NAOCL)

To make a 0.5% solution of hypochlorite from 5% sodium chloride (NaCl)

$$\frac{0.5}{74.4} x \frac{1000}{1} = 6.7g.$$

6.7g of sodium chloride should be added to 1 litre of water to produce 0.5% dilute solution of hypochlorite

Concentration of hypochlorite added to water

Concentration = $\frac{mass\ of\ solute}{mass\ of\ solution}$

$$\frac{6.7}{1006.7} = 0.0066$$

Percentage concentration = 0.0066 x 100% = 0.66%

The prepared solution hypochlorite solution was 0.5% solution of hypochlorite 15ml of 0.5% chlorine solution was able to treat one litre of contaminated water from Oji River

To treat 1,000 litres of contaminated water 1000ml = 1 litre

15ml = 0.015 litres

To treat 1000 litres of contaminated water = 0.015 x 1000 = 15 litres.

THE LEVEL OF CONTAMINATION OF OJI RIVER

The result of the laboratory analysis carried out at Oji River at four sampling points are presented

Table1: Results of Physico-chemcial Samples

Parameters	A	B	C	D	Average
pH	5.80	6.0	5.90	6.20	5.98
Temperature(%)	27.50	30.00	28.45	29.80	28.93
Colour	Objectionable	Objectionable	Objectionable	Objectionable	Objectionable
Odour	Objectionable	Objectionable	Objectionable	Objectionable	Objectionable
Conductivity at 29^ocms/cm	290	200	189.40	245.35	231.18
Total dissolved solid; mg/L	380.00	269.45	345.60	350.00	336.26
Calcium, ca mg/L	150.00	200.10	178.45	211.00	184.86
Chloride, cl mg/L	750.00	1100.00	800.00	945.00	918.75
Sulphate $S0_4$ mg/L	100.00	130.00	115.00	125.00	117.5
Phosphate $P04^3$mg/L	1.50	1.20	0.99	1.0	1.172
Sodium Na (PPm)	54.15	60.00	57.40	50.30	55.46
Potassium K (PPm)	<0.0001	0.0001	0.0001	0.0015	0.00045
Turibidity NTU	15.60	10.45	18.45	12.30	14.2

The laboratory test result of physic-chemical properties for the four sampled points. The Average of the four samples is calculated.

Table 2: Laboratory result analysis of heavy metal for the collected samples

Heavy metal	A	B	C	D	Average
Mercury Hg	0.001	0.001	<0.0001	0.0001	0.0001
Lead (Pb)	0.21	0.25	0.40	0.35	0.302
Zinc (Zn)	0.30	0.26	0.45	0.28	0.322
Manganese (mn)	0.03	0.08	0.06	0.03	0.05
Copper (Cu)	0.25	0.98	0.36	0.40	0.49
Iron (fe)	1.50	1.00	0.90	1.25	1.16
Cadium (cd)	0.034	0.018	0.025	0.020	0.024
Chromium	0.15	0.23	0.26	0.30	0.235

The laboratory test results of heavy metals.

Table 3: Laboratory Result of Microbiological Analysis of Collected Sample from Oji River

	Sample A		Sample B		Sample C		Sample D	
Microbial Group	Plate Reading	Unit Cfu/ml	Plate Reading	Unit Cfu/ml	Plate Reading	Unit Cfu/ml	Plate Reading	Unit Cfu/ml
Colifor	0.01	0.01	0.01	0.01	0.001	0.001	0.002	0.002
Ecoli	0.03	0.03	0.03	0.03	0.1	0.1	0.1	0.1
Streptococci	0.15	0.015	0.19	0.19	1.0	1.0	1.05	1.05
Salmon ell asp	0.004	0.004	0.10	0.10	0.03	0.03	0.14	0.14
Shigella sp.	1.00	1.00	1.01	1.01	1.09	1.09	098	0.98
Clostri di asp	0.10	0.10	0.12	0.12	0.11	0.11	0.8	0.8
Yeast mold	0.001	0.001	0.13	0.13	0.01	0.01	0.01	0.01

DISCUSSION OF RESULT FROM TABLES

PH: The analysis conducted on pH of the water sample shows 5.80 at the portion near Oji thermal station while at the point of fetching it was 6.0, also it was found that the pH near washing, point was 5.90 and 6.20 at the swimming site. These pH value shows that at the thermal station the water was slightly acidic and tends to be more neutral at the point of fetching and swimming. This shows that the water quality standard tends to be stable at the swimming and fetching Area but tend to decrease at Area near the thermal station and washing point.

Temperature: Temperature of water at the four sampled points was 27.50^{o}c, 30.00^{o}c, 28.45^{o}c and 29.80^{o}c. This implies that temperature of Oji River is tolerable when compared with the WHO (2008) which reported safe drinking water quality temperature to be 30oC. It also shows that the Area of fetching has the best temperature when compared to WHO (2008) standard.

Electrical Conductivity: The result of electrical conductivity (EC) was found to be 290µm/cm, 200µm/cm 189.40µm/cm and 245.35 respectively. Generally the water has a high rate of conductivity which is not acceptable when compared with WHO (2008) Standard.

Total Dissolved Solid: TDs result was observed to be 380.000mg/L, 269.45mg/L, 345.60mg/L and 350.00mg/L. These values are quite high when compared to WHO (2008) water quality Standard. This increase could be as a result of waste from thermal station and discharge of sewage into the river by many individuals living within the river banks.

Turbidity: The turbidity result of the water samples where 15.60 NTU near the thermal station, 10.45 at the fetching site, 18.45 at the washing portion and 12.30 NTU at the swimming Area. This shows that the Turbidity level of Oji River is higher when compared to WHO (2008) standard of 2 NTU as maximum permissible limit for portable water. It was observed that the Turbidity terms to increase during the day's activities, this might be due to many activities carried out within the river during the day.

Colour: Colour of the water sample was observed to be light brown in appearance near the thermal station, but then to be clear at the fetching portion. This shows that Oji River is still contaminated when compared to WHO (2008) water quality standard which states that water should have unobjectionable colour.

Odour: It was observed that Oji River water has an objectionable odour, this occur can cause vomiting to one who is not use to the area, the odour tends to increase when a speed boat passes on the river. The odour indicates a poor water quality.

Iron: The concentration of Iron measured were 1.50mg/L 1.00mg/L, 0.90mg/L and 1.25mg/L respectively. These values are high when compared to WHO (2008) standard of 0.1. Therefore Oji River is polluted with Iron concentrations.

Copper: The result obtained for copper where 0.25mg/L 0.98mg/L 0.36mg/L 0.40mg/L. This shows a low value which may be as a result of natural purification in the river.

Zinc: The concentration of zinc observed in water samples where 0.30mg/L, 0.26mg/L, 0.45mg/L and 0.28mg/L respectively. These results indicated low values which are far below the allowable range. The reason for this low values may be use to dilution of effluent discharged into Oji River with eroded soil materials due to intensive cultivation.

Lead: The results obtained for lead measured in water samples where 0.21mg/L, 0.25mg/L, 0.40mg/L and 0.35mg/L which is quite high when compared to permissible WHO (2008) water quality standard for lead as 0.01. This high concentration of lead might be as a result of Agricultural sewage discharged and use of pesticide by farmers which contains a quite high amount of lead.

Manganese: The results obtained for manganese in water sample are 0.03mg/L, 0.08mg/L, 0.06mg/L and 0.03mg/L.

This indicates a low rate of manganese in the River WHO (2008) standard for manganese is 0.1mg/L.

Cadmium: Cadmium concentration were observed to be 0.034mg/L, 0.018mg/L, 0.025mg/L and 0.020mg/L. cadmium concentration tends to be slightly normal at the Area where water is fetched but remain high at other points. This increase may be due to use of fertilizers, pesticides and manure which are likely to contain cadmium element.

Chromium: Chromium concentration was observed to be 0.15mg/L, 0.23mg/L, 0.26mg/L and 0.30mg/L. this indicates an increase in chromium. According to WHO (2008), the recommended amount of chromium for good drinking water is 0.05mg/L. From this result it indicates that Oji River is contaminated with high amount of chromium.

$$r = \frac{n \Sigma xy - \sum x \ \Sigma y}{\left(\sqrt{(n \sum x^2 - (\sum x)^2][n \sum y^2 - (\sum y)^2]}\right)}$$

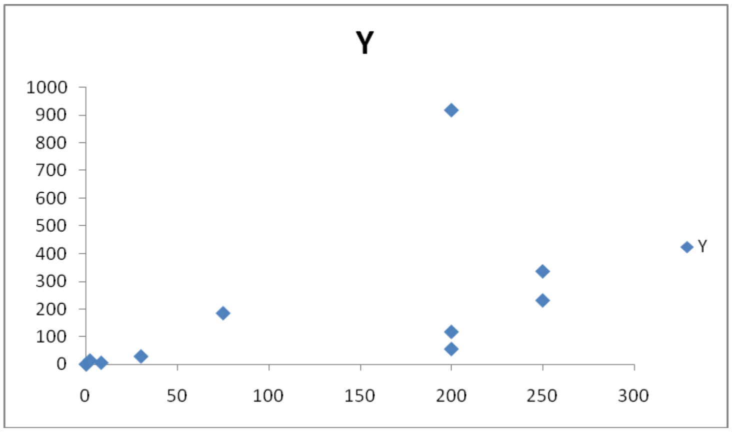
$$= \frac{11\ (375011.8) - (1215.2)(1894.2)}{\sqrt{11\ (251596.2)^2 - (1215.2)^2\ 11\ (1062664.3 - 1894.2)^2}}$$

$$= \frac{1823297.96}{3223{,}251.93} = 0.56$$

$$r = 0.56$$

Table 4: Raw data approach of the Pearson product moment correlation model (r) between WHO and mean values of physico-chemical properties.

	X	Y	Xy	X^2	Y^2
1	8.2	5.98	49.036	67.24	35.76
2	30	28.93	867.9	900	836.94
3	250	231.18	57.795	62,500	53.361
4	250	336.26	84.065	62,500	113,070.78
5	75	184.86	13865.5	5,625	34173.21
6	200	918.75	183,750	40,000	844101.56
7	200	117.5	23,500	40,000	13806.25
8	0.01	1.172	0.0117	0.0001	1.373
9	200	55.46	11,092	40,000	3075.81
10	0.00001	0.00045	0.0000000045	0.1x10-9	0.2x10-7
11	2	14.2	28.4	4	201.64
	∑x=1215.2	∑y=1894.2	∑xy=375011.8	X^2=251,596.2	Y^2= 1,062664.3



Graph of WHO against untreated sample for physio-chemical parameters.

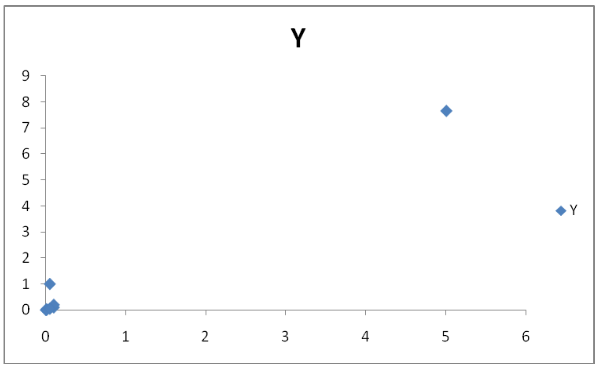
Table 5: Raw data approach of the Pearson product moment correlation model (r) between WHO and mean values of heavy metals.

	X	Y	Xy	X^2	Y^2
1	0.001	0.0001	0.0000001	0.000001	1x10-8
2	0.01	0.302	0.0030	0.0001	0.09
3	5	0.322	1.61	25.00	0.103
4	0.1	0.05	0.005	0.01	0.0025

5	0.05	0.49	0.024	0.0025	0.240
6	0.1	1.16	0.116	0.01	1.3456
7	0.01	0.024	0.00024	0.0001	0.000576
8	0.05	0.235	0.0117	0.0025	0.552
	$\sum x$=5.321	$\sum y$=2.583	$\sum xy$=1.759	X^2=25.025	Y^2= 1.835

$r = (8(1.759) - (5.321)(2.583)/\sqrt{((8(25.025)^{2} - (5.321)^{2}\ 8\ (1.835 - 2.583}$

$r = 0.008$



Graph of WHO against untreated sample for heavy metals parameters

DISSCUSION OF RESULT

From the result of correlation of physico-chemical and Heavy metals with WHO standard it shows that for physico-chemical parameters correlated with WHO standard the Pearson product moment (r) where 0.56 for physico-chemical and 0.00 for heavy metals this shows that the water quality of the river is contaminated to some extent and needs to be treated before it is satisfied to be safe for consumption for both animals and humans.

CONCLUSION

The laboratory test shows that:

1. Application of chlorine achieved a mean disinfection efficiencies of 100% on E.coli and total coliform.
2. The analysis conducted on pH show that Oji River is slightly acidic.
3. Turbidity increases during the day activities.
4. Colour of the water sample was objectionable.
5. Total dissolved solid and other elements where high above WHO stipulated standard.
6. Result of Pearson moment correlation shows that (r) was 0.56 which shows that the water was contaminated.
7. Laboratory test shows that some microbiological pathogens are present.
8. Result shows that microbiological pathogens where removed when the sample was treated.
9. Pearson moment correlation for heavy metals was 0.00 which shows that Oji River is highly contaminated with heavy metals.
10. Pearson moment correlation for heavy metals after laboratory treatment shows that (r) was 1.0.
11. Graph of untreated samples of heavy metals against WHO shows that the graph was positive, but not perfect.
12. Contaminated water was the reason for high mortality rate and other water borne diseases in Oji River.
13. Laboratory test have shown that low – tech produced chlorine is able to significantly improve microbial drinking water quality.
14. Low tech produced chlorine relatively removes a majority of bacteria in drinking water.
15. The improvements in water quality were immense when treated with low-tech chlorine.

RECOMMENDATIONS

In order to meet the requirements of WHO regulatory guidelines and standards it is recommended that the government and community implement the following:

1. The waste treatment plant should be established and a clean water retention tank should be build so the water should be treated before distribution to the villages.

2. Proper waste disposal materials should be kept near so the villages can dispose waste properly inside of using the river as source of waste disposal.

3. Laws and appreciate punishment for offenders should be put in place for those who dispose waste in the river industries should ensure that they complies with the federal Environmental protection Agency and National standard Drinking water Quality guidelines on industrial effluent discharge. Oji River should be sampled at regular interval and the result of the sample quality should be reported in Newspapers.

4. Proper orientation should be given to farmers and communities in the study area on effect of chemical inputs on water quality. Sewage should not be disposed directly to the river without treatment.

5. The O & M of chlorination system by teachers, pastors or other highly accepted persons within the villages will have a good influence to improve acceptability and chances of success of engineered solutions for drinking – water treatment in the long-term.

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