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QUALITY ASSESSMENT OF EFFLUENT DISCHARGES FROM VEGETABLE OIL PLANT

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Abstract

The quality of effluent discharges from a vegetable oil processing company, located in Anambra State – South east Nigeria, was evaluated relative to regulatory body – Federal Environmental Protection Agency (FEPA) standard. Wastewater quality parameters namely; biochemical oxygen demand (BOD), dissolved oxygen (DO), total hydrocarbon content (THC), oil and grease, total dissolved solids (TDS), pH, and temperature were determined weekly on effluent samples, for a period of 12 weeks, using standard methods. The effluent data were subjected to statistical correlation. BOD values ranged from 10.80 – 94.20 mg/L, with 90% occurrence value of 81.20 mg/L, which exceeded FEPA set limit of 50mgLl by 62.40% for about 14% of the time. DO level ranged from 2.70 – 4.60 mg/L which was below the saturation point of 7.5mg/L at 30^{0}C. THC, Oil and Grease consistently exceeded the set limit of 10 mg/L. Effluent pH range of 4.60 - 9.60 was outside FEPA range of 6-9. However, TDS and temperature levels were consistently within permissible limits through out the period under investigation. There is need for proper treatment and monitoring of effluent to ensure consistent quality that meets environmental standard.

Keywords: *Quality parameters, set limits, percent occurrence value, period, regulatory*

Introduction

Industries play an important role in the socio-economic development of any nation. However, global industrialization, Africa inclusive, has put much demand on natural resources. In addition to causing various devastating ecological and human disaster, contributing greatly to environmental degradation and pollution problems of various magnitude. It is generally recognized that in many developing countries, industrial environmental standards are lacking, and where they do exist, the instruments of control are not efficient. This is largely explained by the absence of reliable and comprehensive system of monitoring of industrial emissions and enforcement of compliance with the industrial standards (Aluyor and Badmus, 2003a).

Pollution from industrial disposal and effluent discharges is becoming a serious environmental issue in many developing countries of Africa (Uzoukwu *et al*., 2004). The ultimate recipient of all forms of pollution is the natural water body (Otaraku and Nkwocha, 2010). Many industries are located near water bodies, presumably, to facilitate easy disposal of effluents and other wastes into them.

The perceived consequences of unregulated waste disposal into water bodies used for potable water sources has stimulated various studies on industrial effluent (Aluyor and Badmus, 2003a; Aluyor and Badmus 2003b; Eletta *et al.*, 2005; Otukunefor and Obiukwu, 2005; Aisien *et al*., 2003; Nkwocha and Okoye, 2007; Nkwocha and Okoye, 2008; Nkwocha *et al*., 2010), and the impact on aquatic ecosystem (Akpan and Offein, 1991; Kuehn *et al*., 1995; Sikkema *et al*., 1991; Grant and Briggs, 2002).

Treatment of waste prior to its discharge into the environment is desirable to avoid pollution. In Nigeria, the Federal Environmental Protection Agency (FEPA) has established guidelines and standards for industrial emissions and effluent discharges (FEPA, 1991). Industries are required by law to monitor their effluent to ensure

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compliance. This involves treatment of the effluent where necessary, before discharge into the environment.

Due to the ineffectiveness of purification systems, wastewaters may become seriously dangerous leading to the accumulation of toxic products in the receiving water bodies, with potentially serious consequences on the ecosystem (Beg *et al*., 2001; Beg *et al.,* 2003). This study examined the quality of the effluent discharges from a vegetable oil processing plant, to investigate whether it conforms to statutory standard.

Materials and Methods

Effluent Sample Collection and Analyses

The effluent samples were collected at the point of discharge from the plant. Sample Collection was done with 2 litre plastic bottles pre-treated by washing with dilute hydrochloric acid and rinsed with distilled water. The bottles were later dried in an oven for 1 hour at 110 ± 5^0C, and allowed to cool to ambient temperature. Before use, they were rinsed with the sample twice. Sample collection was done weekly, for 12 weeks, starting from September 2011. Three samples were collected at 1 hour intervals and pooled together to form the composite sample for the week, preserved in ice-chests and transported to the laboratory for analysis. The samples were analyzed using standard methods for the examination of water and wastewater (APHA, 1995). The wastewater quality parameters determined were biochemical oxygen demand (BOD), dissolved oxygen (DO), total hydrocarbon content (THC), total dissolved solid (TDS), others include oil and grease. pH and temperature. Temperature was measured at the point of sample collection. BOD and DO were analyzed electro-analytically using an Oxyscan Light oxygen measuring meter. TDS was determined by weighing the deposit after evaporation of a known volume of filtrate of the sample. A chloroform extract of a known volume of the sample was evaporated and the deposit used for estimating the THC. Oil and grease was determined by acidifying a known volume of sample with hydrochloric acid, this was followed by extraction with trichlorofluoroethane and distillation.

Statistical Analysis of Data

As a result of variations in effluent characteristics, it becomes necessary to subject the laboratory data to statistical analysis. The data were reported in terms of frequency of occurrence of a particular characteristic. This is the value of the characteristic that may be expected to be equaled or not exceeded 10, 50, and 90 percent of the time. The frequency of occurrence was determined according to Tchobanoglous and Schroeder (1995) and Eckenfelder (1989), for data with less than 20 datum points.

From the statistical correlation, the following parameters were established.

Set limit excedance – This is the magnitude by which the 90% occurrence value of the characteristic exceeds its FEPA set limit. When expressed in percentage it is given by -

$$\text{Set Limit Excedance (\%)} = 100(C\text{-}F)/F \qquad (1)$$

Where C is the characteristic 90% occurrence and F is FEPA Set Limit.

Time excedance – This is the percentage of time by which the 90% occurrence value exceeds the FEPA Set limit occurrence for a particular characteristic.

Results and Discussion

The results of the effluent laboratory analysis, the 90 percent occurrence values and comparative assessment of effluent quality are presented in Tables 1-3 respectively. While the trend analysis of effluent parameters are presented in Figures 1-6.

Biochemical Oxygen Demand (BOD_5): As can be observed in Table 1 and Figure 1, the effluent BOD values ranged from 10.80 - 94.20 mg/L, with 90% occurrence value of 81.20 mg/L. When compared with the FEPA set limit of 50 mg/L (Table 3), the following inferences can be made: the 90% BOD value exceeded FEPA limit by 31.2 mg/L, that is, 62.4% and had a time

excedance of 14%. Implying that the set limit was exceeded by 62.4% for about 14% of the time.

Dissolved Oxygen (DO): From Table 1, the DO concentration of the effluent ranged from 2.70 – 4.60 mg/L, with a 90% occurrence value of 4.46mg/L. The values for DO are lower than the saturation value which is 7.5 mg/l at 30^0C (Gaujous, 1995). These low values are due to the presence of suspended matter (Briton Bi *et al.,* 2006). The elevated levels of oil and grease in the effluent form surface films which reduce the quantity of oxygen in the effluent via oxidation reaction.

Total Hydrocarbon Content (THC): The investigation further revealed that the THC level ranged between 10 – 120 mg/L, with 90% occurrence value of 92mg/L. This is higher than the 10 mg/L limit set by FEPA. The THC profile (Figure 2) rose to the highest level of 120 mg/L in the 11^{th} week. The high effluent THC level may probably be due to spillage clean up in the industry that was channeled into the effluent.

Total Dissolved Solids (TDS): TDS range of 15.40 – 80.20 mg/L was within FEPA limit of 2000 mg/L. Thus, the effluent TDS conformed to FEPA standard through out the experimental period (Figure 3).

Oil and Grease: On the other hand, oil and grease ranged from 10.80 – 40.60 mg/L (Table 1 and Figure 4). These values are higher than the set limit of 10 mg/L. As can be observed in Figure 4, the oil and grease levels consistently exceeded the set limit throughout the period under investigation. This could be attributed to product spillages that were washed into the effluent and poor house keeping.

pH: Furthermore, the effluent exhibited a pH range of 4.60 – 9.60 relative to the range of 6.0 – 9.0 set by FEPA. Figure 5 indicates that the effluent pH was below 6.0 for 6 weeks, and above 9.0 for 1 week. This confirms the fact that for more than half of the period under investigation, the pH was outside prescribed range and the effluent discharges may be having adverse effect on the pH levels of the recipient stream. Similar results have been obtained by Uzoukwu *et al.* (2004) in a previous study.

Temperature: With reference to Table 1 and Figure 6, the temperature ranged between 28.8 - 35.3^0C, while FEPA specified 40^0C for effluent for discharge into our environment. It is therefore, significant to note, that the temperature was within permissible limit throughout the period. Thus, the effluent cannot be associated with thermal pollution (Bhatia, 2005).

Conclusion

The investigation has shown that based on 90% occurrence value of 81.20 $mg0_2$/L, the effluent BOD exceeded FEPA limit of 50$mg0_2$/L by 62.4%, for about 14% of the time. An effluent DO range of 2.70 – 4.60$mg0_2$/L was below the saturation value of 7.5$mg0_2$/L at 30^0C. The low DO concentration was attributed to the presence of elevated levels of oil and grease in the effluent which reduces oxygenation. In addition, THC exceeded FEPA limit of 10mg/L, while pH was outside the FEPA range of 6 - 9 for more than half of the period. However, the TDS and temperature of the effluent were consistently within FEPA recommended levels throughout the period. Generally, the effluent can be characterized as oxygen demanding, hydrocarbon laden, acidic and oily, low in dissolved substances, and not associated with thermal pollution. Thus, there is need for proper effluent monitoring to improve quality in order to meet stipulated standard.

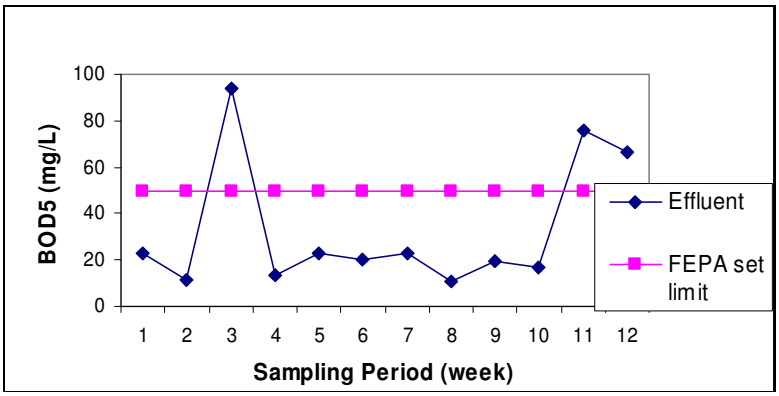


Figure 1 A trend plot of BOD_5 compared with FEPA set limit

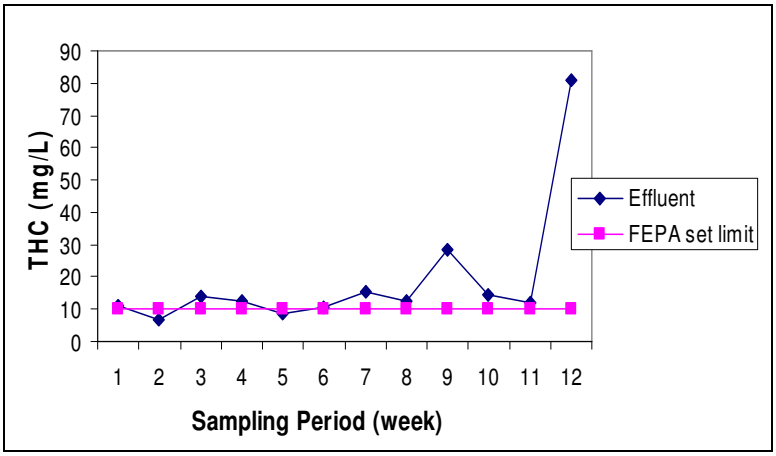
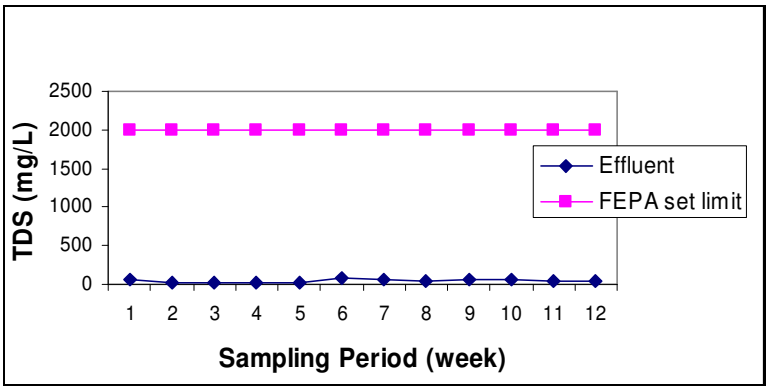


Figure 2 Atrend plot of effluent THC compared with FEPA set limit



Fihure 3 A trend plot of effluent TDS compared with FEPA set limit

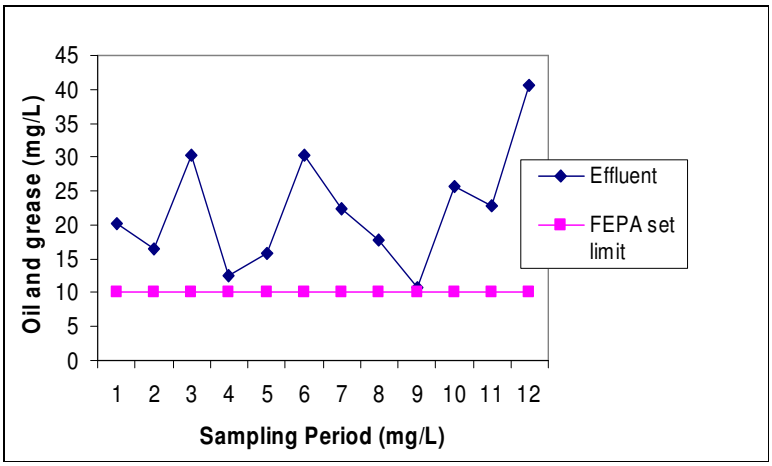


Figure 4 A trend plot of effluent Oil and grease compared with FEPA set limit

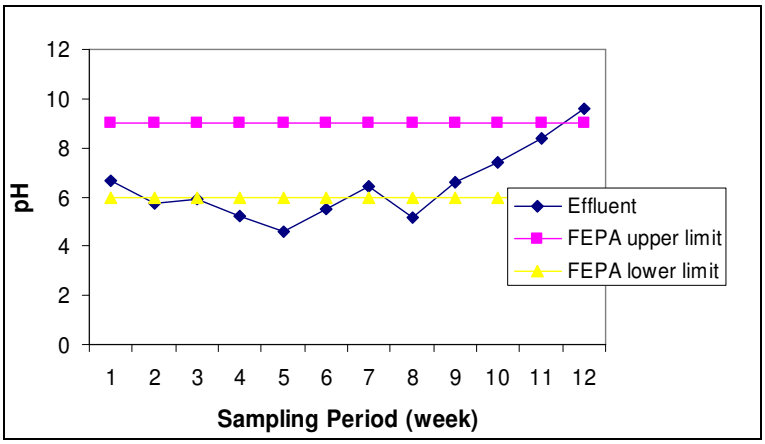


Figure 5 A trend plot of effluent pH compared with FEPA set limit

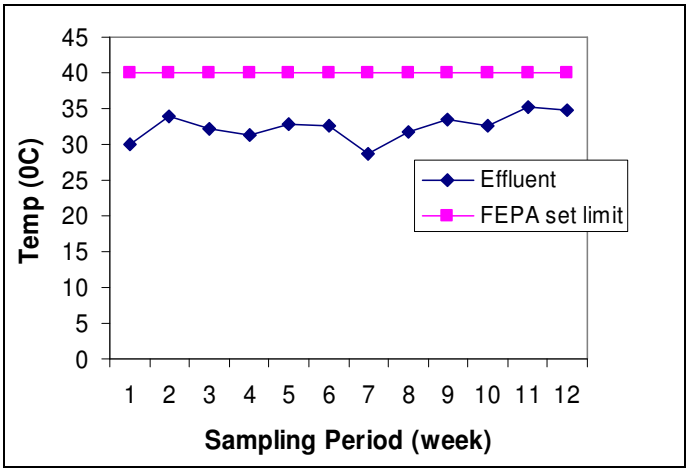


Figure 6 A trend plot of effluent temperature compared with FEPA set limit

Table 1 Results of Effluent Laboratory Analysis

Sampling Period (Week)	Effluent Parameter						
	BOD	DO	THC	TDS	OIL/GREASE	pH	Temp.
	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)		^{0}C
1	23.0	2.70	11.20	58.40	20.20	6.68	30.00
2	11.20	3.00	6.60	20.90	16.40	5.72	34.00
3	94.20	3.20	13.80	15.40	30.20	5.90	32.20
4	13.50	3.20	12.70	26.40	12.50	5.20	31.40
5	22.60	3.40	8.80	23.30	15.70	4.60	32.80
6	20.00	3.60	10.80	80.20	30.40	5.52	32.20
7	22.80	3.60	15.20	70.20	22.30	6.42	28.80
8	10.80	3.70	12.30	30.40	17.70	5.15	31.80
9	19.40	3.80	28.50	60.80	10.80	6.60	33.40
10	16.80	4.00	14.60	70.40	25.60	7.40	32.70
11	75.60	4.40	12.00	44.20	22.80	8.40	35.30
12	66.50	4.60	80.8	46.10	40.60	9.60	34.80

Values are means of triplicate determination

Table 2 90 Percent Occurrence Values of Effluent Parameters

Parameter	90% Value
BOD, mg/l	81.2
DO, mg/l	4.46
THC, mg/l	92.0
TDS, mg/l	73.4
Oil/Grease, mg/l	33.5
pH	8.70
Temp. ^{0}C	35.0

Table 3 Comparison of 90 percent values of effluent parameters with FEPA set limits

	BOD (Mg/l)	THC (Mg/l)	TDS (Mg/l)	OIL/GREASE (mg/l)	pH	Temp. ^{0}C
90 % Value*	81.2	92	73.4	33.5	8.7	35.0
FEPA Set Limit*	50	10	2000	10	6-9	40
Set Limit Excedance, %	62.4	820	-	235	-	-
Time Excedance, %	14	72.8	-	86	-	-

*Values are in mg/L except for pH and Temp (^{0}C)

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