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Effluent and Receiving Water Quality near Food Processing Industries in Ibadan Metropolis

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Abstract: The effluent and receiving water quality from ten food processing industries, comprising beverage, confectionery and oil processing industries, in Ibadan metropolis was investigated. The heavy metal, minerals and physicochemical properties of the effluents and receiving waters were determined using standard methods. Results show that cobalt, chromium, copper, iron, magnesium, manganese, lead and zinc contents range between 0.46-2.75, 0.06-0.11, 0.01-0.02, 0.02-0.06, 0.20-1.81, 0.09-1.38, 0.11-0.14 and 0.07-0.29 mg L^{-1} respectively. Anions (chlorides and nitrates) , cations (phosphate, ammonium), biological and chemical oxygen demand were higher in the effluents. Sodium and potassium were the most predominant minerals in the effluents and receiving waters. Receiving water quality was significantly ($p<0.05$) influenced by effluent discharge by these industries.

Key words: Effluents, receiving water, food industries, Ibadan

INTRODUCTION

The need to process and preserve foods is an integral part of the development process in many countries of the world. With the ease and extended shelf life of industrial product comes the issue of waste generation and management. Industrial waste consists of both organic and inorganic substances. Organic wastes include pesticide residues, solvents and cleaning fluids, dissolved residue from fruit and vegetables and lignin from pulp and paper to name a few. Effluents can also contain inorganic wastes such as brine salts and metals. Industries which use large amounts of water in their processes (chemical manufacturers, steel plants, metal processors, textile manufacturers and fruit and vegetable processing industries) generate waste water containing high concentrations of dissolved organic matter and may be highly alkaline from the use of lye. Run-off from crops contains pesticides, fertilizer and sediment while those from animal production facilities contain bacteria, organic matter, nitrates and phosphates (US EPA, 1980; Anonymous, 2006).

Kakulu (1985) reported that pollutants in the Niger Delta area of Nigeria were the results of the activities of petroleum industries around the area. (Okoye *et. al.,* 1991) showed that minerals and heavy metals are contained in the Lagos lagoon sediments. The results revealed largely anthropogenic heavy metal enrichment and low mineral levels which was attributed to

- Urban and industrial waste and run off water transporting metals from land derived wastes and
- The lagoon's continued renewal of water, high dilution and sedimentation.

Food processing industries release of large quantity of wastes (effluents) into streams and rivers (receiving waters). These discharges are capable of influencing aquatic and terrestrial ecosystems. Presently, there is limited information on the quality of effluent discharged by food processing industries in Ibadan and its impact on receiving water quality. Ibadan is a city in the hilly (3,500-5,000 m above sea level) forested region of Southwestern Nigeria.

The objective of this work was to assess effluent quality from food industries in Ibadan and its effect on receiving waters in the metropolis.

MATERIALS AND METHODS

This study was conducted in Ibadan metropolis located between latitudes 7° 22[1] and 7° 24[1] north and longitudes 3° 50[1]– 3°53[1] east of the Greenwich Meridian. The study involved collection of effluents from ten food processing industries as follows: two oil processing, three beverage and five confectionery industries. Water samples were collected at receiving waters at locations down and upper the water course adjacent to the carriage system around the effluents outfall of the industries. Samples were collected in acid-leached 1-litre polyethylene sample bottles and stored under refrigeration at 4° C. Water samples collected upstream before the discharge of the effluent into the stream served as control.

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Table 1: Heavy metal mg L^{-1} composition of effluents from confectionery industries in Ibadan metropolis

Industry	Cobalt	Chromium	Copper	Iron	Magnesium	manganese	lead	Zinc
Diamond foods	2.75±0.08b	0.06±0.01a	0.02±0.003b	0.03±0.004b	0.20±0.01a	0.31±0.01b	0.14±0.01c	0.16±0.01c
Sword sweets	0.46±0.01a	0.09±0.01b	0.01±0.002b	0.06±0.01c	1.44±0.04c	1.38±0.04b	0.13±0.01bc	0.09±0.01b
EFCO	0.60±0.02a	0.10±0.01c	0.01±0.003a	0.02±0.002a	1.81±0.05d	0.09±0.01a	0.12±0.01ab	0.07±0.01a
Sumal foods	2.03±0.06b	0.11±0.01d	0.01±0.01a	ND	0.80±0.02b	0.47±0.01c	0.11±0.01a	0.29±0.01d

Values are means of triplicate readings±SEM, Means followed by different lowercase letters are significantly different ($p<0.05$)

Table 2: Heavy metal mg L^{-1} composition of receiving water from confectionery industries in Ibadan

Industry	Cobalt	Chromium	Copper	Iron	Magnesium	Manganese	Lead	Zinc
Diamond foods	0.33±0.03b	0.42±0.01c	0.18b±0.05c	1.74±0.54b	2.19±0.34ab	1.51±0.06a	0.11±0.01ab	0.84±0.22
Sword sweets	0.15±0.07a	0.04±0.01a	0.01±0.003a	0.53±0.18a	0.65±0.08a	3.48±0.72ab	0.13±0.02ab	1.34±0.23
EFCO	0.46±0.05b	0.04±0.01a	0.25±0.02c	0.95±0.18ab	1.83±0.47ab	7.31±0.16c	0.09±0.01a	1.45±0.23
Sumal foods	0.37±0.06b	0.08±0.01b	0.12±0.01b	0.95±0.03ab	2.89±1.13b	5.75b±1.65c	0.16±0.02b	1.36±0.23

Values are means of triplicate readings±SEM, Means followed by different lowercase letters are significantly different ($p<0.05$)

Table 3: Heavy metal (mg L^{-1}) content of effluent and receiving waters from oil processing industries in Ibadan

Oil industry	Location	Cobalt	Chromium	Copper	Iron	Magnesium	Manganese	Lead	Zinc
Best oils ltd	Effluent	2.08±0.06cD	0.06±0.01aA	ND	0.01±0.001aA	1.35±0.04cD	0.43±0.01aA	0.10±0.01aA	0.040.01aA
	Receiving (Upper)	0.22±0.01bB	0.13±0.01bC	0.21±0.01bC	0.78±0.02bC	0.61±0.02bC	11.70±0.34bB	0.10±0.01aA	0.760.02bB
	Receiving (Lower)	0.36±0.01bC	0.68±0.02cD	0.09±0.01aA	0.37±0.01bB	3.78±0.11dE	10.98±0.32bB	0.20±0.01bB	1.76±0.05cC
Premier agro oils	Effluent	0.48±0.01cC	0.07±0.01bA	0.02±0.003aA	ND	2.17±0.06cE	0.15±0.01aA	0.14±0.01bB	0.10±0.01aA
	Receiving (Upper)	0.17±0.01bB	0.05±0.01bA	0.14±0.01bB	0.19±0.01aB	1.83±0.05bcD	11.67±0.34bcB	0.08±0.01aA	1.46±0.04bC
	Receiving (Lower)	0.20±0.0bB1	0.02±0.01aA	0.06±0.01aA	0.93±0.03bC	1.36±0.04bD	10.33±0.30bB	0.16±0.01bB	2.46±0.07bDSS

Values are means of triplicate readings±SEM, Means followed by different lowercase letters under each industry are significantly different ($p<0.05$), Means followed by different uppercase letters in each column are significantly different ($p<0.05$)

Table 4: Heavy metal (mg L^{-1}) composition of effluents from beverage industries

Industry	Cobalt	Chromium	Copper	Iron	Magnesium	Manganese	Lead	Zinc
FAN milk	0.75±0.02c	0.06±0.01b	0.01±0.003a	0.03±0.001a	0.39±0.01b	1.29±0.04b	0.13±0.003a	.08±0.002a
Nig. brew. Plc	0.13±0.01a	0.05±0.01a	0.02±0.004b	0.03±0.002a	0.10±0.01a	0.78±0.02a	0.18±0.01c	0.32±0.01c
Quality foods	0.20±0.01b	0.09±0.01c	0.02±0.003b	0.06±0.001b	2.28±0.07c	ND	0.15±0.01b	0.22±0.01b

Values are means of triplicate readings±SEM, Means followed by different lowercase letters are significantly different ($p<0.05$)

Table 5: Heavy metal (mg L^{-1}) composition of receiving waters from beverage industries in Ibadan

Industry	Cobalt	Chromium	Copper	Iron	Magnesium	Manganese	Lead	Zinc
FAN Milk	0.24±0.04	0.10±0.01ab	0.09±0.04	0.54±0.03	0.83±0.02a	1.00±0.45	0.12±0.03a	0.59±0.24
Nig. Brew. Plc	0.29±0.04	0.14±0.05b	0.09±0.02	0.49±0.11	3.57±0.95b	2.86±0.06	0.15±0.02a	1.49±0.61
Quality Foods	0.19±0.01	0.05±0.001a	0.04±0.001	0.65±0.08	0.62±0.01a	2.30±1.03	1.02±0.39b	0.82±0.34

Values are means of triplicate readings±SEM, Means followed by different lowercase letters are significantly different ($p<0.05$)

Samples were analyzed for physical and chemical characteristics. Temperature was measured using a standard size field thermometer; pH was measured as described by Anderson and Ingram using a Model 3020 pH meter (JENWAY, UK). Heavy metals (Ca, Cr, Cu, Fe, Mg, Mn, Pb, and Zn) were determined using AAS (Buck Scientific model 500A) as described by Juo. A Conductivity meter (Model 4010, JENWAY, UK) calibrated with a conductivity standard (0.01 m KCl with conductivity 1413 μscm^{-1}) was used for conductivity measurements at 25°C. Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were determined as described by Turner and Carawan APHA (1992). Hardness, turbidity, total dissolved solids, total solids, dissolved oxygen, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) were determined using standard methods. Sodium and potassium were determined using a flame photometer. Phosphate, nitrate, ammonium and chlorides were determined using standard methods (APHA 1992 and Taras 1950). The results are expressed in mg kg^{-1}. Means of triplicate readings obtained in the study were subjected to analysis of variance (ANOVA) and Duncan's multiple range test using the Statistical Package for Social Scientist (SPSS 10.0) computer software (Oloyo, 2001).

RESULTS AND DISCUSSION

The average temperatures of receiving waters before and after discharge of effluents are 25 2° and 35 1°C respectively. The temperature differentia shows an increase of between 6–13°C rise in temperature. At higher temperatures, the ability of water to solubilise and hold oxygen is reduced. Low oxygen levels may handicap some species while higher temperatures can kill animals and plants accustomed to living at lower temperatures, thus disrupting the biological balance of aquatic systems.

Heavy metals: Mean heavy metal composition of effluents and receiving waters from confectionery, oil processing and beverage industries in Ibadan, Nigeria are presented in Tables 1 to 5. There are significant differences ($p<0.05$) in the heavy metal composition of effluents from confectionery industries studied in Ibadan. The chromium, copper, manganese, lead and zinc contents are within allowable range. The chromium content of receiving water from Diamond Foods is significantly higher than others. The value obtained for this industry is higher than the recommended 0.1 mg L^{-1} (FEPA 1991) but within the range specified by Tang and Ferris. All other heavy metals are within recommended ranges. A comparison of Tables 1 and 2 showed that cobalt contents are generally higher in the receiving waters than in the effluent discharged into receiving waters by confectionery industries. Chromium, copper, iron, manganese and zinc were lower in the effluents discharged, while lead content did not differ remarkably. Among oil processing industries (Table 3), cobalt content is highest in effluents from Best Oils Ltd. Chromium, copper, iron and lead values obtained for receiving waters are comparable and within recommended limits. Manganese contents are higher in the receiving waters than in the effluent and are higher than recommended values (< 10 mg L^{-1}). Zinc is highest in receiving waters from Premier Agro Oils (2.46 mg L^{-1}). This value is higher than 1.0 mg L^{-1} recommended by FEPA, 1991 but lower than 5.0 mg L^{-1} recommended by Significant increases were observed in the lead and zinc contents following effluent discharge into receiving waters by the oil processing industries. They are, however within Residual[l]. allowable limits. Chromium, copper, iron, magnesium and zinc contents of effluents from beverage industries (Table 4 and 5) are lower than values obtained for receiving waters. Lead contents in the effluent and receiving waters are comparable. However, values obtained fo effluents from beverage industries are within recommended values.

Table 6: Mineral composition (mg L^{-1}) of effluents and receiving waters from confectionery industries in Ibadan.

Industry	Location	Sodium	Calcium	Potassium	Phosphate	Ammonium	Nitrate	Chloride
Diamond Foods	Effluent	60.45±1.75d	3.61±0.10e	25.79±0.74d	1.44±0.04e	2.48±0.07f	5.23±0.15g	80.00±2.31e
	Receiving (Upper)	108.43±3.13h	1.94±0.06b	88.79±2.56i	0.01±0.001a	0.02±0.001a	0.19±0.01b	40.00±1.15b
	Receiving (Lower)	126.84±3.66i	2.82±0.08cd	75.56±2.18h	0.03±0.001a	0.02±0.001a	0.52±0.02c	60.00±1.73c
Sword Sweets	Effluent	24.70±0.71b	3.61±0.10e	35.45±1.02e	1.91±0.06e	37.72±1.09j	0.71±0.02c	96.00±2.77fg
	Receiving (Upper)	85.05±2.46f	2.82±0.08cd	110.80±3.20j	0.08±0.01a	0.98±0.03d	0.08±0.01a	58.00±1.67c
	Receiving (Lower)	251.08±7.25j	2.68±0.08c	246.18±7.11k	2.15±0.06f	1.82±0.05e	0.58±0.02c	50.00±1.44bc
EFCO	Effluent	14.92±0.43a	3.79±0.11e	29.22±0.84d	3.83±0.11g	18.01±0.52i	1.33±0.04d	100.00±2.89gh
	Receiving (Upper)	67.87±1.96de	10.61±0.31j	218.18±6.30k	0.12±0.01b	ND	0.03±0.001a	48.00±1.39b
	Receiving (Lower)	115.23±3.33h	6.58±0.19h	142.48±4.11	0.52±0.02c	0.65±0.02c	0.32±0.01c	56.00±1.62c
Sumal foods	Effluent	67.40±1.95de	2.50±0.07c	41.32±1.19f	0.96±0.03d	55.67±1.61k	0.42±0.01c	108.00±3.12h
	Receiving (Upper)	94.67±2.73fg	5.32±0.15g	88.58±2.56i	0.01±0.001a	0.07±0.003a	1.02±0.03d	104.00±3.00h
	Receiving (Lower)	136.34±3.94i	7.64±0.22h	84.85±2.45i	0.80±0.02d	2.48±0.07f	2.14±0.06e	128.00±3.70i
Quality foods	Effluent	83.79±2.42f	7.74±0.22h	11.38±0.33bc	15.61±0.45h	0.03±0.002a	3.28±0.09f	ND
	Receiving (Upper)	383.28±11.06k	0.45±0.01a	58.86±1.70g	ND	0.92±0.03d	0.03±0.002a	104.00±3.00h
	Receiving (Lower)	480.84±13.68l	2.46±0.07c	210.21±6.07k	0.08±0.01a	1.28±0.04e	0.01±0.002a	60.00±1.73e
Nigeria eagle flour mills	Effluent	13.70±0.40a	2.42±0.07c	7.58±0.22a	ND	1.12±0.03e	0.21±0.01b	44.00±1.27b
	Receiving (Upper)	181.27±5.23	4.18±0.12f	18.44±0.53c	ND	2.18±0.06f	0.02±0.001a	58.00±1.67c
	Receiving (Lower)	72.14±2.08e	4.62±0.13f	44.84±1.29f	0.03±0.002a	0.02±0.001a	0.04±0.002a	120.00±3.46i

Values are means of triplicate readings±SEM, Means followed by different l owercase letters in each column are significantly different ($p<0.05$)

Table 7: Mineral composition (mg L^{-1}) of effluents and receiving waters around oil processing industries in Ibadan

Industry	Location	Sodium	Calcium	Potassium	Phosphate	Ammonium	Nitrate	Chloride
Best oils ltd	Effluent	26.85±0.78b	2.55±0.07c	9.13±0.26b	0.01±0.002a	2.23±0.06f	0.24±0.01b	36.00±1.04a
	Receiving (Upper)	43.84±1.27c	3.10±0.09de	4.05±0.02a	0.03±0.002a	0.05±0.01a	55.00±1.59h	38.00±1.10a
	Receiving (Lower)	22.58±0.65b	2.27±0.07c	8.63±0.25a	3.24±0.09g	0.46±0.01bc	2.69±0.08e	44.00±1.27b
Premier agro oils	Effluent	64.58±1.86de	4.63±0.13f	25.97±0.75d	14.32±0.41h	0.25±0.01b	0.72±0.02c	268.00±7.74j
	Receiving (Upper)	35.60±1.03c	2.90±0.08cd	14.00±0.40c	0.08±0.01a	1.06d±0.03e	6.81±0.20g	98.00±2.83fg
	Receiving (Lower)	109.65±3.17h	0.89±0.03a	42.58±1.23f	0.42±0.01c	1.08±0.03de	5.21±0.15g	42.00±1.21b

Values are means of triplicate readings±SEM, Means followed by different lowercase letters in each column are significantly different ($p<0.05$)

Table 8: Mineral composition (mg L^{-1}) of effluents and receiving waters around beverage industries in Ibadan

Industry	Location	Sodium	Calcium	Potassium	Phosphate	Ammonium	Nitrate	Chloride
FAN Milk	Effluent	67.25±1.94b	1.67±0.05a	34.04±0.98c	1.33±0.04b	0.78±0.02c	0.83±0.02c	60.00±1.73c
	Receiving (Upper)	123.20±3.56d	2.80±0.08b	34.63±1.00c	0.06±0.003a	0.21±0.01a	0.01±0.002a	44.00±1.27b
	Receiving (Lower)	85.65±2.47c	3.83±0.11b	28.68±0.83b	0.01±0.002a	0.58±0.02b	0.01±0.002a	62.00±1.79c
NBL	Effluent	17.27±0.50a	1.32±0.04a	5.42±0.16a	0.01±0.002a	4.49±0.13f	0.17±0.01b	32.00±0.92a
	Receiving (Upper)	120.78±3.49d	6.08±0.16c	53.50±1.54d	0.02±0.002a	3.26±0.09e	0.29±0.09b	68.00±1.96c
	Receiving (Lower)	72.06±2.08b	8.64±0.25d	31.78±0.92c	0.04±0.002a	2.06±0.06d	0.14±0.01b	92.00±2.66d

Values are means of triplicate readings±SEM, Means followed by different lowercase letters in each column are significantly different ($p<0.05$)

Table 9: Mean heavy metal (mg L^{-1}) contents of effluent and receiving water from food processing industries in Ibadan

Source	Cobalt	Chromium	Copper	Iron	Magnesium	Manganese	Lead	Zinc
Effluent	0.99±0.16b	0.07±0.01a	0.10±0.05	0.15±0.07a	1.11±0.14a	0.53±0.08a	0.13±0.01a	0.15±0.02a
Receiving (Upper)	0.27±0.02a	0.15±0.03a	0.15±0.02	0.92±0.14b	1.43±0.26a	5.26±0.67b	0.08±0.01a	1.17±0.11b
Receiving (Lower)	0.29±0.02a	0.24±0.05c	0.10±0.01	0.61±0.05b	1.98b±0.31	5.35±0.80b	0.33±0.10b	1.53±0.18b

Values are means of 3 readings each from 5 industries (3×5)±SEM, Means followed by different letters are significantly different ($p<0.05$)

Mineral composition: The mineral composition of effluent and receiving waters from confectionery, oil processing, beverage industries are presented in Table 6-8. The phosphate, ammonium (cations), nitrate and chloride (anions) contents of effluents and receiving waters are within recommended limits. However, potassium content is very much higher in all the industries. The only exception is the potassium content of effluents from NBL (a brewing industry) which falls within recommended limits 5 mg L^{-1}. Generally, significant increases were observed in the sodium, potassium, phosphate, nitrate and chlorides following the discharge of effluents (lower receiving) in some confectionery industries (Table 6). In receiving waters from oil industries (Table 7), decreases were observed in the calcium and nitrate contents while other minerals measured increased significantly. In beverage industries (Table 8), significantly lower ($p<0.05$) values were obtained following discharge of effluent (lower receiving) for sodium, potassium and phosphate while other parameters increased.

Moors *et. al* . (1979) stated further that certain foods cooked in water containing lead have been shown to concentrate the metal and hence be a potential hazard to the populace. Thus, it is essential that Pb contamination be minimized via adequate treatment so that rivers and streams, which serve many communities in the area, do not become a source of public health concern.

Table 9 summarises the impact of food processing industries on receiving waters in the environment. Results show that Co, Cr, Mn and Zn contents were not significantly influenced by the discharge of effluents into receiving waters. Although Co content is significantly higher ($p<0.05$) in the effluent discharged, the level in the receiving waters remains comparable. Effluent levels of Cr, Mn and Zn are significantly lower ($P<0.05$). Pb content was accentuated following effluent discharge. The high levels of some of these heavy metals in the receiving water before effluent discharge may be due to other urban and industrial waste
and run-off water transporting metals from land-derived wastes (Okoye, 1991).

Physicochemical properties: The physicochemical properties of effluents and receiving waters from all food processing industries studied are shown in Tables 10-12.

Table 10: Physicochemical properties of effluents from different food processing industries in Ibadan, Nigeria

Industries	pH				Dissolved	Total	Dissolved		
	Conductivity	Electrical	Hardness	Turbidity	Solids	Solids	Oxygen	BOD	COD
Confectionery									
	9.10±0.26c	12.00±0.35e	27.50±0.79a	35.21±1.02d	1000.00±28.87e	2800.00±80.83g	.50±0.22v	41.00±1.18a	52.00±1.50b
Diamond foods									
Sword sweets	7.50±0.22b	8.40±0.24c	125.00±3.61g	21.10±0.61c	1000.00±28.87e	2400.00±69.28f	5.22±0.15a	142.00±4.10e	160.00±4.62e
EFCO	7.40±0.21b	10.00±0.29d	85.00±2.45e	18.41±0.53c	800.00±23.09d	1800.00±51.96d	14.15±0.41d	161.00±4.65f	180.00±5.20e
	7.50±0.22b	10.00±0.29d	80.00±2.31de	5.17±0.15b	1000.00±28.87e	3600.00±103.92h	8.00±0.23b	59.00±1.70b	36.00±1.04a
Sumal foods									
Quality foods	5.20±0.15a	16.00±0.46f	135.00±3.90g	144.00±4.16f	1300.00±37.53f	1800.00±51.96h	11.34±0.33c	48.00±1.39a	59.00b±1.70c
Nigeria eagle flour mills	7.00±0.20b	3.10±0.09b	70.00±2.02cb	3.84±0.11a	200.00±5.77a	800.00±23.09a	6.00±0.17a	46.00±1.33a	61.00±1.76c
Beverage									
FAN milk	10.20±0.29c	14.00±0.40e	100.00±2.89f	152.00±4.39f	1600.00±46.19f	3400.00±98.15h	17.41±0.50e	95.00±2.74d	136.00±3.93d
NBL	6.50±0.19ab	1.70±0.05b	50.00±1.44b	ND	300.00±8.66b	1000.00±28.87b	13.00±0.38cd	72.00±2.08c	63.00±1.82c
Oil processing									
Best oils ltd	6.70±0.19b	2.10±0.06a	65.00±1.88c	2.65±0.08a	400.00±11.55c	1200.00±34.64c	31.62±0.91g	149.00±4.30e	172.50±4.98e
Premier Agro Oils	5.50±0.16a	17.00±0.49c	55.00±1.59b	96.40±2.78e	800.00±23.09d	2200.00±63.51e	24.00±0.69f	180.00±5.20g	130.00±3.75d

Values are means of triplicate readings±SEM, Means followed by different lowercase letters are significantly different ($p<0.05$)

Table 11: Physicochemical properties of receiving water before effluent discharge by food industries.

Industry	pH	Electrical conductivity	Hardness	Turbidity	Dissolved solids	Total solids	Dissolved oxygen	BOD	COD
Upper diamond foods	7.20±0.21b	29.30±0.85l	100.00±2.89g	21.91±0.63d	400.00±11.55ef	170.00±4.91a	8.40±0.24e	39.17±1.13a	29.41±0.85a
Sword sweets	7.80±0.23bc	16.40±0.47i	44.00±1.27b	2.77±0.08a	550.00±15.88g	1750.00±50.52f	7.20±0.21d	120.30±3.47f	65.80±1.90c
EFCO	7.40±0.21b	3.65 0.11d	36.00±1.04a	4.92±0.14b	200.00±5.77b	1200.00±34.64c	6.40±0.18c	91.50±2.64e	50.24±1.45b
Sumal foods	7.30±0.21b	0.53±0.02a	600.00±17.32k	128.00±3.70g	150.00±4.33a	1400.00±40.41d	6.00±0.17bc	90.90±2.62e	70.20±2.02d
Quality foods	7.90±0.23bc	10.37±0.30g	92.00±2.66fg	54.70±1.58f	850.00±3.22h	3100.00±23.45	5.60±0.10b	110.50±2.18f	62.55±1.89c
Nigeria eagle flour mills	8.60±0.25cd	3.08±0.09d	46.00±1.33b	23.10±0.67d	1100.00±31.75i	2300.00±66.40h	12.40±0.36i	52.50±1.52b	78.64±2.27d
FAN milk	8.60±0.25cd	29.131±0.84	61.00±1.76d	6.29±0.18c	300.00±8.66d	800.00±23.09b	7.80±0.23de	53.00±1.53b	125.00±3.61f
NBL	5.20±0.15a	18.73±0.54j	800.00±23.09l	182.00±5.25h	1700.00±49.07k	3850.00±111.14j	4.00±0.12a	110.00±3.18f	70.62±2.04d
Best oils ltd	7.30±0.21b	24.00±0.69k	70.00±2.02e	202.00±5.83i	350.00±10.10de	1100.00±31.75c	4.52±0.13a	56.80±1.64b	130.00±3.75f
Premier agro oils	9.50±0.27d	15.75±0.45i	160.00±4.62h	33.20±0.96e	550.00±15.88g	1600.00±46.19e	7.11±0.21d	95.00±2.74e	25.10±0.72a

Values are means of triplicate readings±SEM, Means followed by different lowercase letters are significantly different ($p<0.05$)

The pH range obtained falls within 5–9 recommended by (FEPA 1991). There were marked variations in the electrical conductivity, hardness, turbidity, total and dissolved solids of effluents from the various industries; they did not follow clearly discernible pattern. Dissolved oxygen is significantly higher in effluents from oil processing industries (Table 10). Significant decreases were obtained in the electrical conductivity, hardness, turbidity, total solids, dissolved solids and BODs of receiving water around some food processing industries following effluent discharge. COD increased with effluent discharge into receiving water. There are no (FEPA 1991) recommended values for conductivity, total solids, turbidity and dissolved oxygen. The highest BODs were obtained for effluents from Sword sweet (142.00 mg L^{-1}), EFCO (161.00 mg L^{-1}) (confectionery industries), Best Oils (149.00 mg L^{-1}) and Premier Agro Oil (180.00 mg L^{-1}) (Oil processing industries). The BOD and COD values obtained for all the industries are significantly higher than FEPA (1991) recommended values (30 and 40 mg L^{-1} respectively). A comparison of values in Tables 10- 12 show that BOD levels of receiving wasters around sword sweets, EFCO, FAN milk, Best Oils and Premier Agro Oils dropped after discharge while others increased with effluent discharge. With the exception of NBL (a beverage industry), all other industries which brought about increases in BOD are confectionery industries. COD levels were higher after effluent discharge by Diamond Foods, Sword Sweets, EFCO, Sumal Foods, Quality Foods, NBL and Premier Agro Oils. Many of the wastes in the effluent from food processing plants are organic compounds and some lost product. As these substances undergo oxidation, they combine with some of the oxygen dissolved in the water. The amount of

Table 12: Physicochemical properties of receiving water after effluent discharge by food industries

Industry	pH	Electrical conductivity	Hardness	Turbidity	Dissolved solids	Total solids	Dissolved oxygen	BOD	COD
Diamond foods	6.90±0.20b	18.50±0.53j	84.00±2.42f	ND	350.00±10.10de	850.00±24.54b	11.10±0.32h	68.00±1.96c	51.00±1.47b
Sword sweets	7.40±0.21b	2.05±0.06c	40.00±1.15b	ND	350.00±10.10de	1050.00±30.31c	8.40±0.24e	98.00±2.83e	125.00±3.61
EFCO	7.20±0.21b	1.76±0.05b	46.00±1.33b	ND	300.00±8.66d	1100.00±31.75c	9.60±0.28f	70.60±2.04cd	70.62±2.04d
Sumal foods	7.10±0.21b	0.37±0.01a	240.00±6.93j	ND	250.00±7.22c	1550.00±44.74d	10.80±0.31gh	181.00±5.23i	78.80±2.27de
Quality foods	7.60±0.22b	1.67±0.05b	70.00±2.02e	55.70±1.61f	450.00±12.99f	2400.00±69.28h	5.00±0.14ab	130.00±3.75g	80.00±2.31e
Nigeria eagle flour mills	8.20±0.24cd	2.18±0.06c	70.00±2.02e	ND	1050.00±30.31i	2000.00±57.74g	10.00±0.29fg	106.38±3.07f	60.42±1.74c
FAN milk	7.30±0.21b	7.25±0.21f	53.00±1.53c	7.29±0.21d	250.00±7.22c	950.00±27.56c	9.60±0.28f	37.69±1.09a	84.00±2.42e
NBL	4.80±0.14a	8.45±0.24f	600.00±17.32k	183.00±5.28h	1350.00±38.97j	2700.00±77.94i	7.40±0.21d	161.00±4.65h	180.00±5.20g
Best oils ltd	7.20±0.21b	13.10±0.38h	50.00±1.44c	203.00±5.86i	350.00±10.10de	1400.00±40.41d	5.60±0.16b	32.25±0.93a	78.34±2.26de
Premier agro oils	9.30±0.27d	4.86±0.14e	182.00±5.25i	34.20±0.99e	450.00±12.99f	1850.00±53.40f	7.00±0.20f	76.26±2.20d	32.00±0.92a

Values are means of triplicate readings±SEM, Means followed by different lowercase letters are significantly different ($p<0.05$)

oxygen used is therefore a good indicator of the amount of organic waste present. The BOD values obtained following discharge of the effluents into receiving water by flour and confectinery industries indicates that the amount of oxygen (mg L^{-1}) needed to oxidize these products is high. COD values are generally higher since it measures oxygen demand by biodegradable and non-biodegradable p ollutants (Turner and Carawan, 1996). The high BOD and COD values obtained may suggest that a high amount of biodegradable and non- biodegradable product is lost to the receiving waste stream.

CONCLUSION

This study has shown that the quality of receiving water is influenced significantly by the chemical composition of effluents discharged into them. Processing industrial waste before discharge into streams and rivers is essential since a large number of the population still rely on surface waters for drinking, washing, fishing and swimming. This is important so that pollutants which may pose health risks and hazards are not discharged into the surrounding ecosystems.

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