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Assessment of Heavy Metal Pollution of Effluents from three (3) Food Industries in Nnewi/Ogidi areas of Anambra State, Nigeria

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Abstract: *The heavy metal pollution of effluents from three food industries in Nnewi/Ogidi areas of Anambra State was carried out. Effluents from three food processing industries within Nnewi and Ogidi were sampled for a period of eight months, four months rainy season and four months dry season, for effective comparison. The wastewater samples were analyzed for heavy metal pollution using atomic absorption spectrophotometer. Results obtained were compared with the Federal Ministry of Environment industrial effluent limit in Nigeria, to ascertain the level of conformity of these effluents with this standard. Results showed that the total mean level of all the heavy metals were generally above the allowable limit. Values obtained showed that the concentrations of the heavy metals in the effluent samples were higher in the dry season than in the rainy season. The trend for Fe in the effluents were KP< Obisco < RIMCO (rainy season) against values obtained in the dry season of RIMCO<KP<Obisco. Ttwo sample paired t-test showed that there was no significant difference (p>0.05) in the mean levels of Pb, Cr, As, Cd and Zn in both seasons except for Hg and Fe where the reverse was the case. Analysis of variance showed that there were no significant difference (p>0.05) in the concentrations of Hg, Fe, Pb, Cd and Zn among the different effluent samples except arsenic. Pollution index showed significant degree of pollution by these heavy metals.*

Key words: *Effluent, Food industry, Heavy metal, Pollution.*

I. Introduction

The problems facing the environment are vast and diverse. Environmentalists have expressed concern about issues such as global warming, depletion of the ozone layer, population growth, destruction of rain forests, air pollution, water pollution, ground water depletion and contamination. The discharge of industrial effluents into water bodies is one of the main causes of environmental pollution and degradation in many cities, especially in developing countries. Many of these industries lack liquid and solid waste regulations and proper disposal facilities, for harmful wastes. Such wastes may be infectious, toxic or radioactive [1].

Effluents are liquid waste materials that are by-products of human activities such as liquid industrial discharge or sewage [2]. Water pollution is a serious problem globally involving the discharge of dissolved or suspended substances into ground water, streams, rivers or oceans. A major source of pollution in developing countries is industrialization which is vital to a nation's socio-economic development as well as its pollution stature in the international committee of nations [3]. Ironically, this has gradually increased the problem of waste disposal as these effluents have a hazard effects on water quality, habitat quality and complex effects on flowing waters [4,5,6]. Untreated effluents from food processing factories are discharged into inland water bodies, resulting to stench, discoloration and a greasy oily nature of such water bodies [7]. Industrial wastes and emission contain toxic and hazardous substances, most of which are detrimental to human health [8,9,10]

Although industrialization is inevitable, research showed that various devastating ecological and human disasters have continuously occurred over the last four decades implicating industries as major contributions to environmental degradation and pollution problems of various magnitude [11]. Untreated or incompletely treated industrial waste water contains algae materials, non-biodegradable organic matter, heavy metals and other toxicants that deteriorate the environment, and the receiving stream [12]. Biodegradable pollutants constitute those that can be broken down by micro-organisms and hence, their effects are short-lived in the environment. Problems set in when input into the environment exceeds the environment capacity or threshold to decompose. Non-biodegradable pollutants are those that cannot be broken down by micro-organisms and hence, persist in the environment and become toxic to life. Example includes heavy metals such as mercury, lead, cadmium, chromium among others. Discharge of effluents containing heavy metals and some non-metals into water bodies have serious environmental effects. Lead, a prime environmental pollutant, is a multi-organ poison which in addition to well known toxic effects depresses immune status, causes damage to the central nervous system, kidney and reproductive system [13]. Ingestion of lead leads to a disease known as plumbism [5], which was associated with symptoms such as headache, irritability, abdominal pain and various symptoms related to the nervous system [14], while Cadmium, Copper And Zinc poisonings showed symptoms such as gastro-intestine disorders, diarrhea, stomatitis, tremor, ataxia, paralysis, vomiting, convulsion, depression and pneumonia [15].

The town, Nnewi, has been known as the Japan of Africa because of a wide range of automobile fabrications going on there and it also harbors some food processing industries, the most prominent of which is Resource Improvement and Manufacturing Company (RIMCO), located at Akwu Uru, in Umudim village, Nnewi North Local Government Area. The company produces Life Vegetable Oil, Soaps, Plastic tanks, Jerry cans, Master feeds and A-Z engine oil. Their wastewater is channeled through a drainage system that empties into 'Mmiri Ele'. Before now, this was the only source of water for the people inhabiting that area. Ogidi, a town in Idemili North Local Government Area has some distilling factories among which are King size Pharmaceutical Industry (KP) and Obisco Beverage Industry.

KP beverages, Ogidi is located at kilometer 15, Enugu/Onitsha express road and produces the following: KP brandy, dark rum, Schnapps, Sachet and bottled water, drugs such as aspirin, syrup and paracetamol. In the same vein, Obisco is situated at Umuonyejekwe layout, Otigba crescent, Ogidi and produces flavored Black Gold Wisky, Sir Peter dry gin and Ponche. Both factories had their wastewater channeled through drainage system (open gutter).

Thus this investigation was aimed at assessing the heavy metal pollution of effluents from the three food processing industries in Nnewi/Ogidi areas of Anambra State.

II. Materials and Method

2.01 Industrial Effluent Sampling and Preparation

The industrial wastewater samples were collected from three different food processing industries within Nnewi and Ogidi areas of Anambra State. The food industries are Resource Improvement and Manufacturing Company (RIMCO), Akwu Uru, Umudim Nnewi, King size Pharmaceutical Ltd, Ogidi and Obisco Beverage Company, Ogidi. Samples were collected at one month interval starting from June 2010 to September 2010 (Rainy season) and October 2010 to January 2011 (Dry season). A total of eight sampling trips were made on each of the companies comprising four months rainy season and four months dry season for easy comparison. Samples were collected at three different spots along the discharge of the effluent, starting with the point of discharge (PI) to 60 meter away from the point of discharge (P_3).

The first sample was collected at the point of discharge of the effluent (P_1), then, 30 meters away from the point of discharge (P_2) and finally, 60 meters away from the point of discharge (P_3), making a total of three sampling points per food industry per month. Samples were collected using a 2-litre plastic container with a screw cap. The container was initially washed with detergent, rinsed with distilled water and at the point of collection it was rinsed three times with the sample before collection.

2.02 Determination of Heavy Metal

Each wastewater sample was wet digested with a 2:1 mixture of nitric acid and perchloric acid. The digested sample was evaporated to almost dryness and then made up to 100ml with distilled water. 50ml of standard solution of different metals were prepared from their respective salts. From each stock – solution was prepared 1,2,3,4 and 5ppm of each metal for calibration study. Concentrations of the working ranges were obtained by diluting an appropriate volume of the stock solution. The concentrations of the metals were determined in an air acetylene flame using Atomic Absorption Spectrophotometer (AAS) UNICAN Sp 1900. The equipment was previously standardized and corrected for background metal impurities using a blank determination.

2.03 Analysis of Data

Means of triplicate readings obtained in this work were subjected to statistical analysis using statistical package for social science (SPSS version 20 computer software) to see if there were significant difference in the mean levels of the heavy metals between the two seasons and to see if the mean concentrations of the heavy metals varied among the three different effluents monitored. Significance was accepted at the $P<0.05$ level.

III. Results and Discussion

Table 1 showed the mean concentration values (mg/l) of the various metals in the effluents from the three food industries sampled in both rainy and dry seasons compared with the Nigeria Federal Ministry of Environment limitation guideline. Also, figures 1.1 - 1.10 represent the mean levels of the heavy metals by season and location

Table 1: Mean concentration values (mg/l) of the heavy metals in the effluents

Rainy Season				**Dry Season**			
Heavy metals (mg/l)	**RIMCO effluents**	**KP effluents**	**Obisco**	**RIMCO**	**KP**	**Obisco**	**FMENV (1991) Limit**
Mercury	1.564± 0.497	1.252± 0.497	1.874± 0.497	0.878± 0.497	2.727± 0.497	3.182± 0.497	<0.050

Lead	2.446± 0.719	1.645± 0.719	0.875± 0.719	2.465± 0.719	3.313± 0.719	2.763± 0.719	< 1.000
Iron	2.772± 0.999	1.178± 0.815	2.567± 0.815	1.830± 0.706	4.107± 0.706	4.428± 0.706	1.000
Chromium	1.692± 0.699	1.044± 0.571	0.701± 0.571	1.082± 0.494	1.692± 0.444	2.801± 0.494	1.000
Arsenic	2.211± 0.447	0.281± 0.547	0.628± 0.547	1.836± 0.387	0.602± 0.387	0.878± 0.387	1.000
Cadmium	0.818± 0.385	1.368± 0.471	1.828± 0.471	0.306± 0.385	1.308± 0.385	1.270± 0.385	1.000
Zinc	9.657± 3.406	6.303± 3.406	5.107± 3.406	8.262± 1.703	6.476± 1.703	3.783± 1.703	<1.000
Nickel	0.599± 0.234	1.129± 0.234	0.757± 0.234	BDL	BDL	BDL	<1.000
Copper	0.930± 0.294	0.872± 0.294	1.040± 0.294	BDL	BDL	BDL	<1.000
Cobalt	0.083± 0.159	0.207± 0.225	0.523± 0.225	0.693± 0.225	0.230± 0.225	0.783± 0.225	NA

Values are means of triplicate readings ± SE
NA – Not available
BDL – Below Detection Limit

From Table 1, it was observed that the mean concentrations of Hg, Pb, Fe, Cr (except Obisco effluent, rainy season), Zn, and Cd (except RIMCO effluent, both seasons) were higher than the effluent limitation guidelines recommended by the Nigeria Federal Ministry of Environment (EMENV) [16], in all the effluent samples monitored in both seasons. Though Nickel and Copper were not detected (BDL) in the dry season in all the effluents, values obtained for these two heavy metals in the rainy season were higher than the allowable limit for industrial effluents to be discharged into the environment. This implied that any unscrupulous and uncontrolled discharge of the effluents into the environment could impact significantly on the health of the inhabitants and the general biota considering the toxic nature of these heavy metals.

Again, the mean levels of Hg, Fe, Cr, As, Zn and Cd were higher in rainy season than that of dry season in the effluent samples from RIMCO, while other effluents had the levels of the same heavy metals higher in the dry season than that of rainy season. Higher values of these heavy metals in RIMCO effluents in the rainy season could be an indication that RIMCO effluents was highly concentrated with these toxicants that even rain/precipitation could not dilute them.

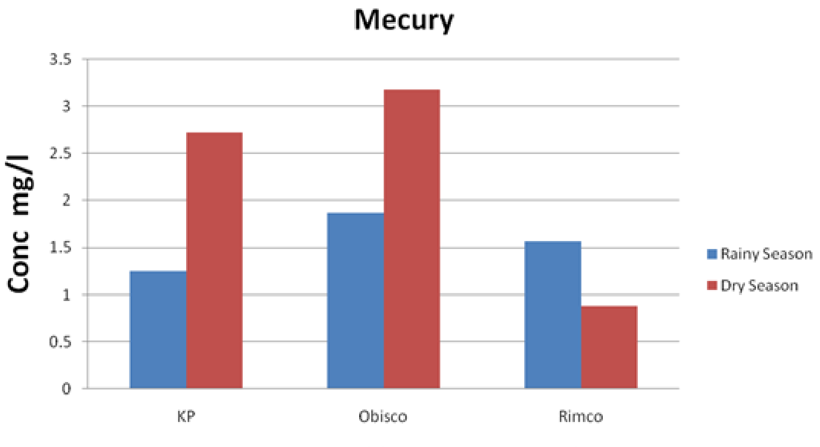

Fig: 1.1 Mercury level by season and locations

Fig 1.1 showed that Hg concentrations in the effluents were highest in Obisco effluent (dry season), while RIMCO effluent gave the least value of Hg in the same season. Concentrations of Hg in effluents were higher in the dry season than in the rainy season (apart from RIMCO effluent). Hg levels in the dry season decreased in the order Obisco >KP>RIMCO compared to the rainy season levels of Obisco>RIMCO>KP respectively (Table 1). Statistical result confirmed that there was significant difference ($P<0.05$) in the levels of Hg in the effluents between rainy and dry seasons though no significant difference ($P>0.05$) was observed in the mean concentrations of this heavy metal among the effluents from the three (3) food industries monitored with the exception of Obisco and RIMCO with coefficient of variations of 71.8329 and 106.8414 respectively.

Mercury is known to interfere with metabolism and functions of living things by combining with phosphoryl, carboxyl, amides and amine groups, resulting in the enzymes inhibition and protein precipitation [17].

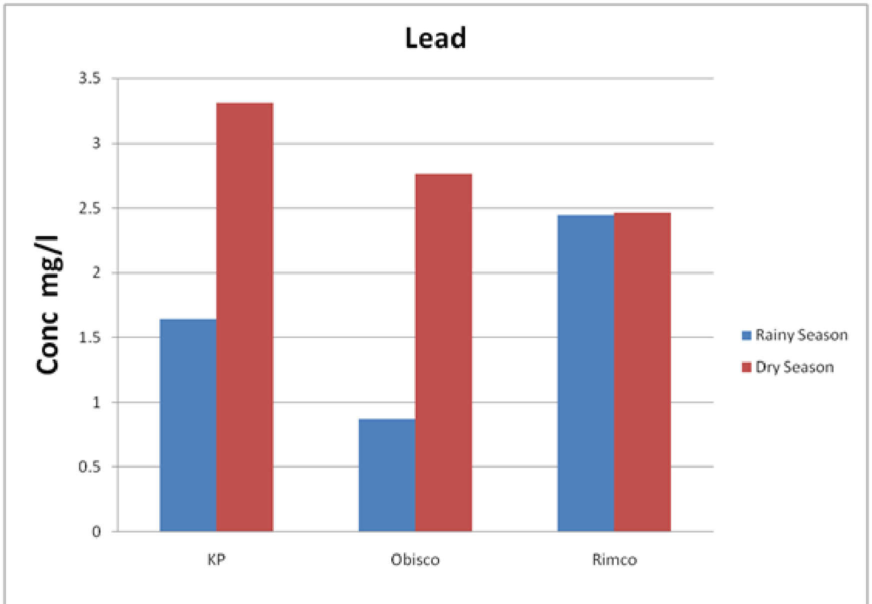

Fig: 1.2 Lead level by season and locations

The mean concentrations of Pb in the effluents were all higher in the dry season than that of rainy season. Highest concentration was obtained in KP effluent in the dry season (Table 1), while Obisco effluent had the least value (dry season). Though the concentration of lead was higher in the dry season than that of the rainy season in the three effluent samples monitored, statistical analysis showed that there was no significant difference ($p>0.05$) in the mean levels of this heavy metal between the two seasons (f-value 2.578, p-value 0.111).

The mean levels of lead obtained from these effluents which was found to be above the maximum permissible limit, could exert toxic effects on human beings if consumed from water or irrigated agricultural products. Lead interferes with functions performed by essential mineral elements such as calcium, iron, copper and zinc [18]. Lead also causes disruption of the biosynthesis of haemoglobin, rise in blood pressure, kidney and brain damage [12,13].

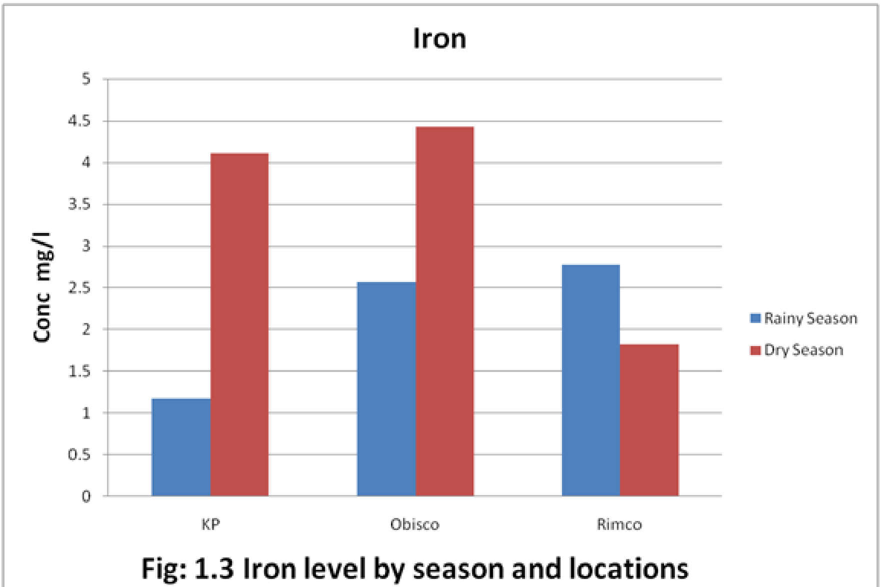

Fig: 1.3 Iron level by season and locations

With the exception of RIMCO effluent, the other two effluents recorded lower mean iron levels in the rainy season than the dry season. Obisco effluent had the highest value of iron in the dry season while RIMCO effluent gave the highest value in the rainy season (Table 1). Low level of iron in the rainy season could be as a result of dilution through precipitation, short residence time and continuous exchange of water. Statistical analysis confirmed that the levels of iron were highly significant ($p<0.05$) between rainy and dry season but did not differ ($p>0.05$) among the three effluent samples monitored.

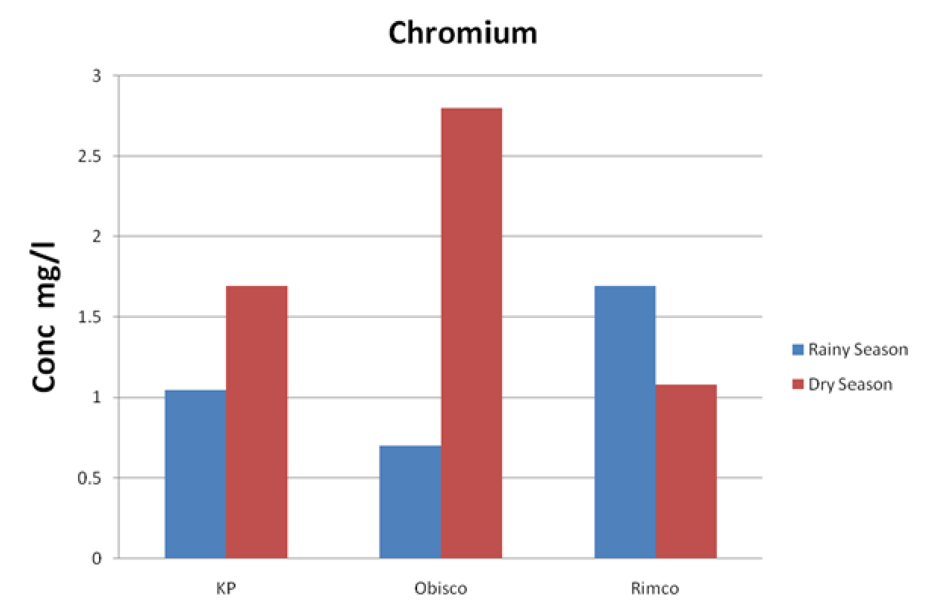

Fig: 1.4 Chromium level by season and locations

Mean chromium levels were higher in the dry season (apart from RIMCO effluent) than in the rainy season. Chromium levels obtained in this work in the rainy season were in the increasing order of Obisco <KP<RIMCO compared to the values obtained in the dry season of RIMCO<KP<Obisco. Total chromium levels obtained in this work were higher than the total mean chromium level (0.534mg/l) reported by Egborge, (1991) [19] for Warri River. Nevertheless, the mean Cr levels obtained in this work showed no significant difference (P>0.05) between the two seasons under investigation (f-value, 3.074; p-value 0.83), though higher coefficient of variation was obtained in the rainy season (135.742%) compared to the dry season (99.814%).

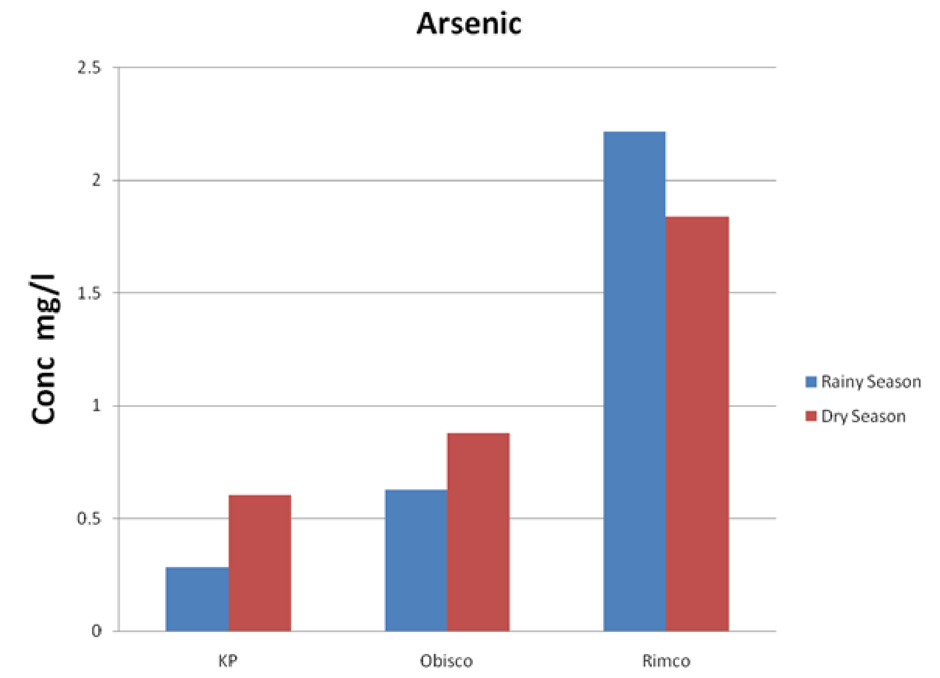

Fig: 1.5 Arsenic level by season and locations

With the exception of RIMCO effluent, the total mean Arsenic levels were higher in the dry season than in the rainy season. Values obtained for this heavy metal ranged from a minimum of 0.282±0.547mg/l (KP) to a maximum of 2.211± 0.447mg/l (RIMCO) for the rainy season compared to the minimum value of 0.602±0.387mg/l (KP) to a maximum of 1.836±0.387mg/l (RIMCO) for the dry season respectively (Table 1). This showed that KP effluent had the least value of Arsenic while RIMCO had the highest values in both seasons. There was no significant difference (p>0.05) in the mean concentration of arsenic between rainy and dry season though this heavy metal showed significant difference (p<0.05) among the different effluent samples monitored, especially between RIMCO and KP with coefficient of variation (CV) of 132.562 and 93.254; and RIMCO and Obisco with CV of 132.562 and 69.490 respectively. Arsenic is actually toxic to man and if detected in drinking water, should give cause for concern.

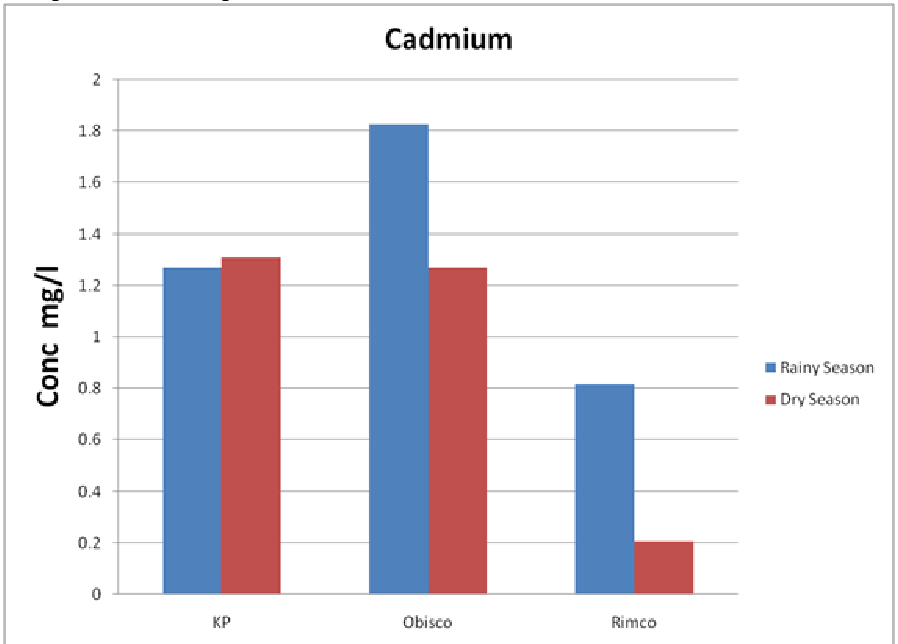

Fig: 1.6 Cadmium level by season and locations

Cadmium level was highest in Obisco effluent (rainy season) and KP effluent (dry season), the least in cadmium concentration being RIMCO effluent (in both seasons). Though the levels of cadmium obtained in this work was slightly higher in the rainy season than in the dry season (apart from KP effluent), statistical result showed that there was no significant difference (p>0.05) in the level of this heavy metal between the two seasons. There was also no significant difference (p>0.05) in the mean levels of cadmium among the three effluent samples except the difference observed between Obisco and RIMCO (p-value 0.018). Values of cadmium obtained in this work were higher than the value reported by Obasohan et al., (2006) [20] for Ogbor river.

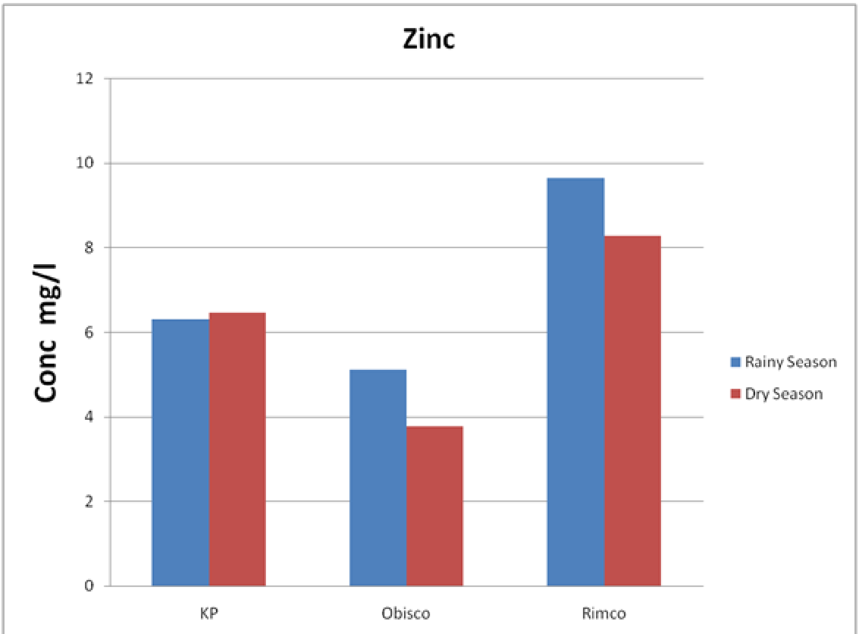

Fig: 1.7 Zinc level by season and locations

Zinc, on the other hand, recorded values that were significantly high in the effluent samples monitored in both seasons when compared to the allowable limit recommended by the Federal Ministry of Environment in effluents (Fig 1.7). Values of zinc obtained was in decreasing order of RIMCO>KP>Obisco in both seasons. Nevertheless, though the total mean concentrations of zinc were high, they were below the value (15,000mg/l) recommended by the World Health Organization (W.H.O), (1989) [21] in drinking water. In as much as the levels of zinc obtained in this work were high, there was no significant difference (p>0.05) in the level of this metal between rainy and dry season but deferred significantly (<0.05) among the three effluents especially between Obisco and RIMCO (p-value, 0.040).

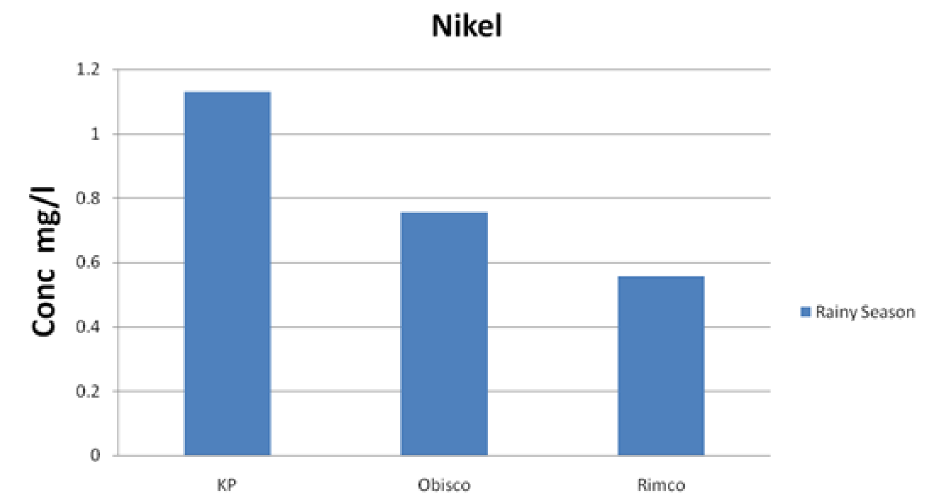

Fig: 1.8 Nikel level by season and locations

Fig 1.8 showed that nickel was not detected in the dry season from the three effluent samples monitored. Highest concentration of this metal in the rainy season was recorded in KP effluent while RIMCO effluent had the least value (Table 1).

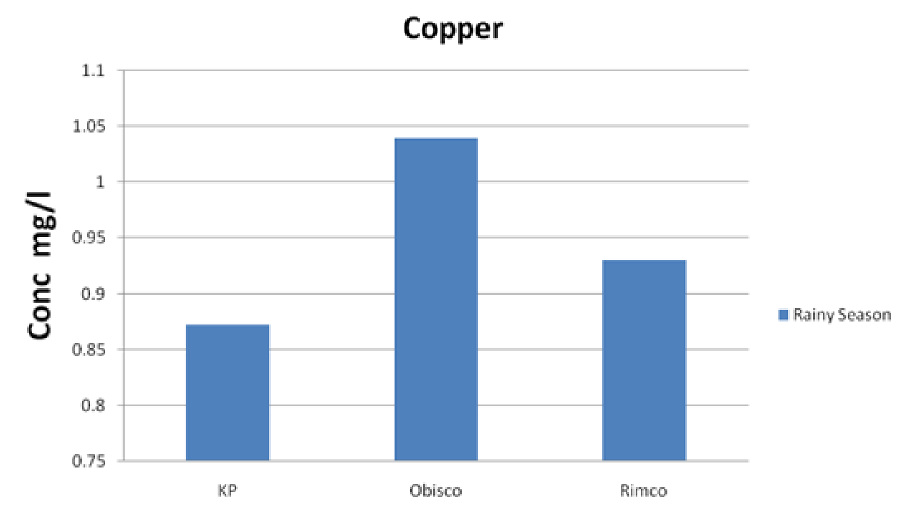

Fig: 1.9 Copper level by season and locations

Copper on the other hand was not detected in the dry season in all the effluents monitored (Fig 1.9). The two metals (Ni and Cu) were below the detection limit (BDL) of the instrument. This could probably be as a result of accumulation of these metals in the air around the food industries as sprays, droplets and dust particles, hence with the arrival of rain, they were washed down by precipitation, mixing with the effluents and thus increase in the levels of these metals in the rainy season.

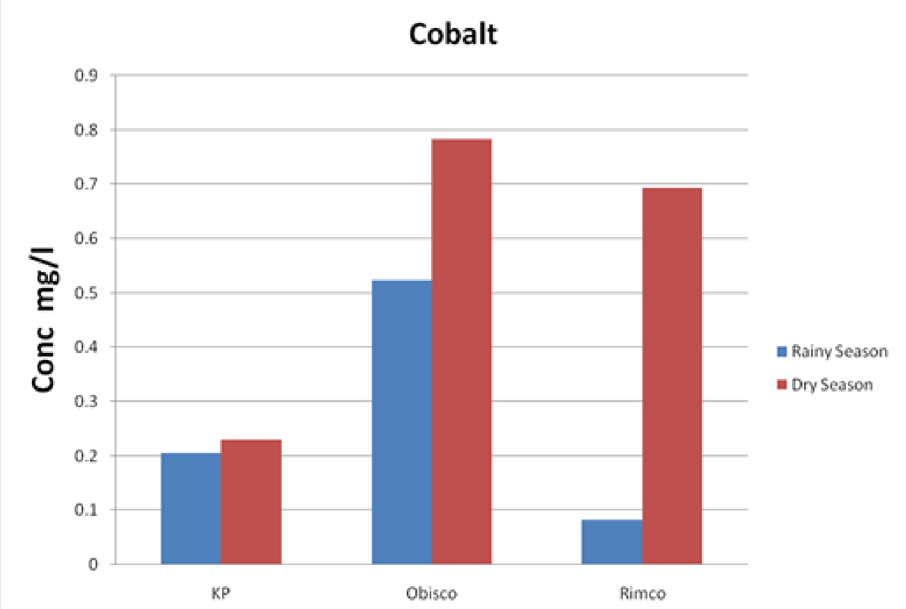

Fig: 1.10 Cobalt level by season and locations

Fig 1.10 showed that cobalt concentration was higher in the dry season than in the rainy season. Low levels of this metal in the rainy season could be as a result of dilution through precipitation. The trend of cobalt concentrations in the effluents in the rainy season was Obisco>KP>RIMCO while for dry season, the trend was Obisco >RIMCO>KP. However, statistical analysis showed that there was no significant different ($p>0.05$) in the mean concentrations of cobalt between rainy and dry season. The implications of the forgoing is that the indiscriminate discharge of these industrial effluents could lead to contamination of the soils, death of the aquatic organisms and even death of the inhabitants of these areas.

Table 2: Pollution index of the heavy metals

	Hg	Fe	Cr	Pb	Cd	Zn	As	Pi
RIMCO	0.8778	1.8300	1.0817	2.4650	0.2064	8.2817	1.8358	4.75104
KP	2.1242	4.1075	1.6917	3.3133	1.3078	6.4758	0.6017	10.28302
Obisco	3.1817	4.428	2.8008	2.7633	1.2833	3.7833	0.8783	11.36536

Table 2 showed the pollution index (Pi) of the heavy metals in the effluent samples monitored. Pollution index showed the relative pollution contributed by each heavy metal. It is expressed as a function of the concentration of the individual heavy metal against the baseline standard or tolerable limit [16]. Pollution index of more than one ($pi>1.000$) indicated that average heavy metal concentration were above the permissible limit, while values less than one ($pi<1.000$) showed no pollution.

From Table 2, it was observed that all the effluent samples monitored were polluted since the pollution index values were above the tolerable limit of 1.000. Pollution in the food industries investigated ranked in the order Obisco>KP>RIMCO. This showed that Obisco effluent was the most polluted while RIMCO effluent was the least polluted. These effluents, thus, need to be properly treated before being discharged into the environment as toxic heavy metals may be absorbed by crops affecting their yield and finally enter the food chain at high concentrations capable of causing serious health risk to consumers.

IV. Conclusion and Recommendations

This work revealed abnormal concentrations of Hg, Pb, Fe, Cr, As, Cd, and Zn in the effluents monitored. The concentrations of these heavy metals were higher than the value recommended by the Nigeria Federal Ministry of Environment in industrial effluents to be discharged into the environment. Moreover, these heavy metals were higher in the dry season than rainy season in all the effluent samples investigated except nickel and copper which were below the detection limit of the instrument in the dry season but were detected in the rainy season. Nevertheless, only the mean levels of Hg and Fe were significantly different between rainy and dry season, while Pb, Cr, As, Cd, Zn and Co were not significant between the two seasons.

It is pertinent to note that soils contaminated by these effluents will produce unhealthy crops/food as heavy metal can enter the food chain and thus be consumed by human beings. This calls for caution in the discharge of untreated wastewater into the environment.

Thus, it has been recommended that research be conducted on the soils, crops and the receiving water bodies to assess the extent of pollution occasioned by these effluents. Again, regulatory bodies should be put in place to guide waste disposal in order to prevent health dangers for aquatic, plant and human lives.

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