Environmental Research Journal 3 (3): 107-112, 2009
ISSN: 1994-5396

Quality of Water Runoff Discharged from Some Industries into the Isolo Canal, Lagos

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Abstract: A study was conducted for the analysis of pollution load in industrial effluents from 6 industries in Ilupeju Industrial Estate, Lagos. Main drains from these industrial units which included chemical, soap and oil, textile, pharmaceutical and steel industries were analyzed for various physical and chemical parameters like temperature, pH, salinity, anions and heavy metals content. Analysis of the samples collected over a period of 7 months showed that most of the parameters investigated exceeded the federal environmental protection standards for effluents.

Key words: Runoff, discharge, pollution, industries, Isolo canal, FEPA standards

INTRODUCTION

Industrialization is considered critical to a nation's socio-economic development as well as to its political standing in the international community. The characteristics and complexity of wastes discharged by industries vary according to the process technology, the size of the industry and the nature of the products (Nasrullah *et al*., 2006). Ideally, the citing of industries should achieve a balance between socio-economic and environmental considerations (FEPA, 1991). In developing countries such as Nigeria, the citing of industries is determined by various criteria, some of which are environmentally unacceptable and pose serious threats to public health (Helmer and Hespanhol, 1997; Farouk, 2000). The establishment of industrial estates beside residential areas in most state capitals and large urban centres in Nigeria is significant in this respect. Surface water and groundwater contamination, air pollution, solid waste dumps and general environmental degradation, including the loss of land and aquatic resources are major environmental problems caused by industrialisation in Nigeria. Improper disposal of untreated industrial wastes has resulted in coloured, murky, odorous and unwholesome surface waters, fish kills and a loss of recreational amenities (Ademoroti, 1996; Adebayo *et al*., 2007). A significant proportion of the populations still rely on surface waters for drinking, washing, fishing and swimming. Industry also needs water of acceptable quality for processing.

Ideally, each effluent should be detoxified with the installation of pollution abatement equipment, because these technologies are not indigenous, they are usually expensive to import. To overcome this problem, uniform effluent limits based on the assimilative capacity of the receiving water have been drawn up for all categories of industrial effluents in Nigeria (FEPA, 1991). Although, water quality is to some extent an index of water pollution, the indices presently used in Nigeria are inadequate to indicate the damage that is done by heavy metals (Arimoro *et al*., 2008). The Nigerian guidelines require industries to monitor their effluents in-house.

Water pollution in Lagos has had a major impact on the city's waterways: rivers, lagoon and ocean. Whether it is by septic systems or poorly designed waste water overflow systems, the detrimental effects of human activities are starting to become apparent. After a heavy rain, runoff floods the water channels, which when unable to handle the extra loading result in untreated raw sewage, industrial wastes and urban water runoff entering rivers, the lagoon and ocean. Huge algal and hyacinth blooms resulting from this causes eutrophication and a subsequent decrease in oxygen and oxygen-poor situations, making it difficult for aquatic life to continue (Larison *et al*., 2000). Furthermore, when industrial disposal of effluents exceed the assimilative capacity of the land there is contamination of the soil and groundwater. Continuous disposal of industrial effluents on land could exceed the hydraulic and pollution loading of the environment. As a result, the effluents can end up in the groundwater through leaching and sub-surface flow. Apart from effluents, during the rainy season industrial wastes (solid wastes and solid sludge of the effluent treatment plants) also end up in the groundwater as nonpoint source pollution, as they are openly dumped within the premises of the industries. The concentrations

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of pollutants in those sludges are comparatively higher than the effluents. As a result during post-rainy season period groundwater pollution is expected to be as high or higher as compared to pre-rainy season period. So, it is to be noted that point sources can act as nonpoint sources.

MATERIALS AND METHODS

Sample area and sample collection: Study the chemical characteristics of some industrial effluent from six industries in Ilupeju Industrial Area of Lagos State. These samples were labeled as, SMB, NCP, MTP, NSF and LYS. Sampling for effluent was carried out in the six study areas at monthly intervals between April and October 2005 covering the dry and rainy seasons. Effluent temperature and pH were measured *in situ*. Composite samples were collected from the surface of the effluent streams emanating from each of the industries in screw-capped plastic containers and were stored in a refrigerator at 4±1°C in the laboratory. The time lapse between sample collection, preparation and analysis was about 2 weeks.

Effluent quality analysis: Standard methods recommended by APHA (1985) were used to determine DO, COD, BOD_5, SO_4^{2-}, NO_3^-, PO_4^{3-}, F^- and Cl^-. Heterotrophic Plate Count (HPC) is also known as Standard Plate Count (SPC) provides a single value that expresses the number of aerobic and facultative microorganism in water. The aerobic plate count was used for heterotrophic bacteria and it was recommended that 30°C for 74 h be adopted as a standard incubating period for bacteria in warm tropical waters. The measurement unit is colony forming unit cm^{-3} (i.e., cfu cm^{-3}). Metals were determined using atomic absorption spectrophotometer (PYE UNICAM Model SP 969) at national Research Institute for Chemical Technology, Zaria, Nigeria.

RESULTS AND DISCUSSION

The results obtained for the analysis of the effluent from PZZ industry is given in Table 1. The temperature of the effluent was fairly constant throughout the period of study (i.e., July to October 2005) and ranged between 28 and 29°C (Arimoro *et al*., 2008). The pH values obtained for the different samples collected ranged from 6.04-6.86 (RSD = 0.003). The values fall within the range recommended by Federal Environmental Protection Agency (FEPA) for industrial effluents, i.e., pH of 6-9. The salinity of the effluents was high (1084-1726 mg dm^{-3}). This is consistent with the values typical of marine environments. There was a general decrease in salinity from July to October and this may be attributed to dilution

Table 1: Result of the chemical analysis of PZZ effluents showing the effluent limits in Nigeria for all categories of industries (mg dm^{-3} unless otherwise stated)

Parameters	Concentration Range	Mean	RSD (%)	*FEPA standard For discharge to surface water
Temperature (°C)	28-29	28.75	0.005	<4
pH	6.04-6.86	6.398	0.003	6-9
Salinity	1084-1726	1474	2.837	-
Sulphates	480-635	572	0.677	500
Nitrates	40-68	58.5	0.125	20
Phosphates	1.0-2.5	1.575	0.007	5
Fluoride	10-12	13.75	0.04	-
Chloride	599.7-949.7	812.2	1.54	600
DO	0.9-2.8	1.775	0.007	
BOD	200-300	255	0.42	50
COD	560-800	665	1.075	150
HPC 10^{2} (cfu cm^{-3})	94-344	212.8	1.28	400
Pb	0.253-10.65	4.09	0.04	<1
Cd	-	-	-	<1
Ni	0.0-0.01	0.06	0	<1
Co	0.0-15.94	2.67	0.06	<1
Cr	0.0-0.89	0.45	-	<1
Agerage	-	-	-	0.01

(-) Below detection level; *Source: FEPA (1991)

of the effluents by increasing rainfall during this period of study. Salinity measures the chlorinity of a sample. This parameter depends on the proximity of a site to the sea, for it decreases away from the sea. The concentration for sulphates was found to be between 480 and 635 mg dm^{-3}. In most cases the values were found to be higher than the values recommended by FEPA (i.e., 500 mg dm^{-3}). The nitrate concentration in the PZZ effluent samples range between 40 and 62 mg dm^{-3}. The values are higher than the FEPA prescribed value of 20 mg dm^{-3} for industrial discharges. The PZZ industrial effluent had the highest concentration of fluoride. This reason attributed to this is that the industry makes use of metal fluorides in the manufacture of some of their products, which include toothpaste.

Phosphate concentrations were low during the period of study, the highest concentration was found to be 2.5 mg dm^{-3}, which is still lower than the FEPA recommended value of 5.0 mg dm^{-3}. This low phosphate concentration in the PZZ effluent may suggest that little or no phosphate salt is used in the processes of PZZ industries. The fluoride concentration was found to be very high compared to the value recommended by FEPA (i.e., 1.0 mg dm^{-3}). These high values may be an indication of the use of raw materials containing this ion in the manufacture of their products. Chloride concentration though higher than the FEPA recommendation (i.e., 600 mg dm^{-3}), showed a monthly decrease similar to the trend observed for salinity. The reason may again be attributed to dilution as a result of rainfall. Dissolved Oxygen (DO) values were found to be low and ranges between 0.9 and 2.8 mg dm^{-3}. These values are lower than

FEPA values of 4.0 mg dm^{-3} for industrial discharges. The low values indicate that the effluent have low oxygen content. This suggests the presence of high organic matter in the effluent (Chapman, 1992). The Biochemical Oxygen Demand (BOD) was found to be between 200 and 300 mg dm^{-3} and FEPA standard for BOD in industrial effluent is 50 mg dm^{-3}. The high values of BOD found in PZZ samples are indicative of the pollutional load of the effluent. Similarly, the values obtained for Chemical Oxygen Demand (COD) were also higher than the FEPA values (200 mg dm^{-3}). Coliform colony count for PZZ industry was found to be within the range 94 and 344 cfu cm^{-3}. The number of colony shows that the effluent can support the growth of colony bacteria. The result of metal analysis for the PZZ industrial effluents showed that it had values higher than FEPA standards for the following metals, Pb, Co, Cr and Ag (Table 1).

The results obtained for the analysis of the effluent of SMB Industry is given in Table 2. The temperature of the effluent is the limit of 27 and 29°C and was found to be fairly constant throughout the period of study. The pH values of the effluents ranged between 6.09 and 6.19 and like those of PZZ industry were found to be within the FEPA limit. Salinity values showed a similar trend as those of PZZ industry by a general monthly decrease. For the SMB industry, sulphate concentration was found to be below detection limit for samples collected during the period of investigation. Nitrate values were not consistent and the range was between 22 and 60 mg dm^{-3}. The values obtained for chloride and fluoride for SMB were found to be lower than the FEPA standards. The values obtained for fluoride are between 0.0 and 1.0 mg dm^{-3}, while for chlorides, it is between 249 and 399 mg dm^{-3}. Again a similar trend was observed between chloride concentration and salinity for the SMB effluent samples. DO values ranged from 5.0-5.8 mg dm^{-3} with a general monthly increase. These values are higher than those obtained for PZZ samples and could be an indication that the SMB samples contain relatively less organic materials compared to PZZ. DO measurement gives an indication of the organic content in water. The higher the DO content of an effluent or water sample the lesser the pollutional load (Chapman, 1992). From this analysis, all the industries except SMB had low DO values, which were found to be below the FEPA standard. BOD values were low (i.e., 10-60 mg dm^{-3}); in the same manner COD values were also low and ranged from 40-200 mg dm^{-3}. This is an indication that the pollutional load of SMB effluents is low and lower than that obtained for PZZ industry when compared. The values obtained for DO, BOD and COD were within the limits set by FEPA for all the months samples were collected. The result of the metal analysis for the SMB effluent samples (Table 2) shows that the industry exceeded the FEPA limits for Pb and Cr.

Table 2: Result of the chemical analysis of SMB effluents (mg dm^{-3} unless otherwise stated)

Parameters	Concentration range	Mean	Relative SD (%)
Temperature (°C)	27-29	28	0.011
pH	6.09-6.19	6.14	0.000
Salinity	442.78-717.60	552.6	0.170
Sulphates	-	-	0.000
Nitrates	22-60	40.5	0.160
Phosphates	-	-	0.000
Fluoride	0.00-1.00	0.75	0.010
Chloride	249.80-399.80	309.9	0.680
DO	5.00-5.80	5.5	0.000
BOD	10-60	35	0.210
COD	40-200	110	0.680
HPC 10^{2} (cfu cm^{-3})	108-224	182	0.520
Pb	0.00-5.13	2.54	0.020
Cd	-	-	0.000
Ni	0.00-0.21	0.04	0.000
Co	0.00-0.87	0.22	0.000
Cr	0.58-1.03	0.64	0.000

(-) = Below detection level

The results for the study pack industry, NCP effluent is presented in Table 3. Values obtained for pH revealed high acidity of the effluent in the month of September and October, while in the month of July and August, the pH of the effluent was close to being neutral. The salinity values were high like those observed for PZZ samples and the values ranged between 901 and 1725 mg dm^{-3}. Sulphate concentration in the NCP effluent samples showed a monthly increase, however, the highest value obtained (230 mg dm^{-3}) was below the limit stipulated by FEPA. All the values for nitrate concentration were higher than the FEPA standards and this ranged from 32-68 mg dm^{-3}. Fluoride and chloride values were also higher than FEPA limits. The concentrations for the two ions ranged from 1.0-3.0 and 499.0-949.7 mg dm^{-3}, respectively. DO values were low (i.e., 2.4-3.5 mg dm^{-3}) and this is indicative of low oxygen concentration in the effluent. BOD values were higher than FEPA standards and ranged between 130-450 mg dm^{-3}. COD values were also higher than the FEPA limits and also ranged between 300 and 940 mg dm^{-3}. These values like values for PZZ industries show that the effluent from this industry is highly polluted. Trace metal analysis of the NCP effluent samples like the PZZ samples did not conform to the FEPA standards for metals like Pb, Co, Cr and Ag. There is no particular trend derived for the metals during the period of study (i.e., April to October).

The results obtained for the analysis of the MTP effluent are presented in Table 4. The temperature of the effluent samples were fairly constant (i.e., 29-30°C) and like for other industries presented above, the salinity of the effluent samples were high (i.e., 2271-2751.9 mg dm^{-3}). Sulphate values were found to be higher than FEPA

Table 3: Result of the chemical analysis of NCP effluents (mg dm^{-3} unless otherwise stated)

Parameters	Concentration range	Mean	Relative SD (%)
Temperature (°C)	29-30	29.5	0.01
pH	3.10-6.82	5.21	0.02
Salinity	901.10-1725	1428	3.69
Sulphates	149-230	189.8	0.37
Nitrates	32-68	52.5	0.16
Phosphates	0.00-1.80	0.48	0.01
Fluoride	1.00-3.00	2	0.01
Chloride	499.9-949.70	787.3	2.02
DO	2.40-3.50	2.78	0.05
BOD	130-450	257.5	1.37
COD	300-940	655	2.74
HPC 10^{2} (cfu cm^{-3})	50-320	191.5	1.26
Pb	0.36-5.82	3.72	0.00
Cd	-	-	0.00
Ni	0.00-0.08	0.02	0.00
Co	0.00-13.93	2.3	0.05
Cr	0.34-0.83	0.51	0.02

Table 4: Result of the chemical analysis of MTP effluents (mg dm^{-3} unless otherwise stated)

Parameters	Concentration range	Mean	Relative SD (%)
Temperature (°C)	29-30	29.8	0.01
pH	6.05-6.53	6.29	0.00
Salinity	2368-2751	2487	2.10
Sulphates	635-665	652.5	0.13
Nitrates	90-120	105	0.14
Phosphates	0.01-2.32	1.66	0.01
Fluoride	1.00-3.00	2	0.01
Chloride	1249.50-1499.50	1362	1.11
DO	1.30-1.60	1.42	0.00
BOD	200-350	237.5	0.75
COD	500-760	570	1.27
HPC 10^{2} (cfu cm^{-3})	148-270	230.5	0.56
Pb	1.31-11.81	5.61	0.03
Cd	-	-	0.00
Ni	0.00-0.17	0.06	0.00
Co	0.00-0.97	0.27	0.00
Cr	0.28-0.96	0.58	0.00

(-) = Below detection level

standards for all the months in which the investigation was carried out. The values obtained represents the second highest of all the industries investigated. Nitrate concentrations were between 90 and 120 mg dm^{-3}, while the phosphate concentrations were found to be lower than the FEPA limits. Fluoride values (i.e., 1.0-3.0 mg dm^{-3}) were a little higher than the limit prescribed by FEPA, while chloride concentrations were high but showed a general decrease within the study period. The DO values for MTP effluents were found to be low (i.e., 1.30-1.60 mg dm^{-3}) and this again indicate a low concentration of oxygen in the effluent samples. The BOD values ranged from 200-350 mg dm^{-3}, which is high in comparison to the FEPA limit. COD values were also found to high (i.e., 500-760 mg dm^{-3}) indicating a high pollutional load of the effluent. The trace metal analysis showed that the concentration of Pb, Cr and Ag were above the FEPA limits for trace element discharges.

The concentration range, mean and relative standard deviation for each parameter measured for NSF is given in Table 5. The pH of the effluent samples were found to tend slightly towards being alkaline (i.e., 8.10-8.67). The values obtained for sulphates, nitrates, fluorides, salinity, chloride, DO, BOD and like most of the industries presented above are higher than the FEPA standards for industrial discharges. These values showed a similar trend to that observed for PZZ and MTP industries. BOD measures the amount of oxygen required by microorganisms, while breaking down organic materials. The results obtained from the BOD analysis showed a lot of variation among the different industries investigated. The industries especially MTP and NSF had much higher values, which mean that the effluents from these industries are rich in organic materials and this agrees with the low DO values obtained for samples collected from these industries. COD gives the measure of oxygen content of water using chemical oxidation. This test gives an indication of pollutants of organic as well as inorganic origin. The COD values for the various industrial effluent samples showed that NCP, MTP and NSF had the highest values and which are above the FEPA Standards. The SMB samples gave COD values within the FEPA limit. The receiving waterbodies also showed low COD values, which are an indication that the water samples contain small amounts of dissolved organic and inorganic compounds. Nitrate levels in water give a general indication of the nutrient status and level of pollution of a given waterbody (Chapman, 1992). High amount of nitrate in water causes eutrophication. The concentration of nitrate in the various industrial effluent examined showed that MTP and NSF samples had the highest concentration of nitrates. Nitrate levels in water give a general indication of the nutrient status and level of pollution of a given waterbody (Chapman, 1992). High amount of nitrate in water causes eutrophication. The concentration of nitrate in the various industrial effluent examined showed that MTP and NSF samples had the highest concentration of nitrates. The result for metal analysis for the NSF effluents showed that the concentration of Pb and Cr are higherthan FEPA standards, while Cd, Co, Ni and Ag are below the FEPA standards.

The results obtained for the analysis of the effluent LYS Industry is given in Table 6. The temperature of the effluent samples was fairly constant throughout the period of study (i.e., between 28 and 30°C), while the pH values ranged between 5.92 and 6.70. Salinity, sulphates and nitrates gave values that were higher than the FEPA standards, while phosphate concentration was not >0.11 mg dm^{-3} throughout the period of study. Fluoride

Table 5: Result of the chemical analysis of NSF effluents (mg dm^{-3} unless otherwise stated)

Parameter	Concentration range	Mean	Relative SD (%)
Temperature (°C)	28-31	29.5	0.01
pH	8.10-8.67	8.49	0.00
Salinity	2094-2368	2230	1.19
Sulphates	620-690	663.8	0.30
Nitrates	57-98	77	0.21
Phosphates	1.60-2.06	1.82	0.00
Fluoride	4.00-7.00	5.5	0.01
Chloride	1150-1300	1225	0.64
DO	1.40-2.40	1.92	0.00
BOD	200-400	287.5	0.85
COD	500-680	570	0.81
HPC 10^{2} (cfu cm^{-3})	113-204	167.3	0.41
Pb	0.00-10.28	4.59	0.03
Cd	-	-	0.00
Ni	0.00-0.19	0.05	0.00
Co	0.00-0.51	0.12	0.00
Cr	0.03-0.81	0.39	0.00

Table 6: Result of the chemical analysis of LYS effluents (mg dm^{-3} unless otherwise stated)

Parameter	Concentration Range	Mean	Relative SD (%)
Temperature (°C)	28-30	28.75	0.01
pH	5.92-6.70	6.03	0.00
Salinity	1176-1360	1291	0.88
Sulphates	570-630	597.5	0.21
Nitrates	46-61	56	0.07
Phosphates	0.00-0.11	0.05	0.00
Fluoride	1.00-3.00	2.25	0.01
Chloride	649.60-749.8	712.2	0.48
DO	2.40-3.60	2.95	0.01
BOD	250-380	282.5	0.65
COD	600-940	715	1.56
HPC 10^{2} (cfu cm^{-3})	157-304	240.8	0.69
Pb	0.21-5.80	3.69	0.02
Cd	-	-	0.00
Ni	0.00-1.07	0.21	0.00
Co	0.00-13.73	2	0.05
Cr	0.00-0.69	0.35	0.00

(-) = Below detection level

concentration was high (i.e., 1.0-3.0 mg dm^{-3}) but showed a monthly decrease. Similarly, the chloride concentration was also high (i.e., 649-749.7 mg dm^{-3}). The DO was found to range from 2.4-3.6 mg dm^{-3}, BOD 250-380 mg dm^{-3} and COD 600-940 mg dm^{-3}. All the values showed that effluent was rich in oxidizable organic compounds and therefore low in oxygen. The result of trace metal analysis of the effluent showed that LYS effluent had concentration values higher than the FEPA standards for the following metals, Cr, Co, Ni and Pb. Microbiological examination of water provides a useful tool for the control of water quality in the environment (Mike, 1998). It is used in the detection of pollution and conditions, which render water unacceptable for various purposes. From this investigation, it was found that the amount coliform bacteria were relatively low and may be as result of the low DO observed in the effluent samples of the industries.

Heavy metals are both extremely toxic and ubiquitous in natural environments and they are readily mobilized by human activities such as dumping industrial waste in natural habitats such as rivers, lakes and ocean (Larison *et al*., 2000). As a result, heavy metals pose a potential threat to terrestrial biota. From elemental analysis carried out in this study for the various samples, it was found that Pb concentration was the highest of all the metals discharged into the environment by all the industries (Table 1-6). This is followed by Co in PZZ, NCP and LYS samples, while the concentration of this metal in SMB, MTP, NSF samples is quite low. Cd is scarcely found in any of the industrial effluents, while the concentration Cr in all the trade effluents is similar except for SMB, where, it is slightly high. The concentration of Ag is also similar for all the effluents suggesting that it is not anthropogenic in nature.

For the purpose of further discussion, correlation analyses were performed on the all the parameters measured to see how they all relate with each other. Statistically, for samples where $n = 4$, $p<0.05$, the critical correlation coefficient, r was found to be 0.81. Therefore, the values found to be >0.81 were adjudged to significant and the values <0.81 are not significant. The values found to be significant were collated and presented in Table 7. It was found that coliform and pH show some degree of relationship in the PZZ, NCP, LYS and Isolo Canal water samples. The values obtained indicated that as the pH increases the number of coliform counted decreased, thus, showing a negative correlation. There was also some correlation between coliform and salinity in PZZ and MTP samples, all showing negative correlation. The relationship between fluoride and salinity was quite high in the SMB and MTP samples. The correlation between coliform and nitrate ions was found to be positive in SMB and LYS samples. This suggests that nitrate may influence the growth of bacteria in these water samples. The BOD and COD were also found to be correlated positively in SMB, MTP and LYS samples. It was also found that DO and salinity is negatively correlated in all the samples but only the values obtained for PZZ, SMB and NCP were significant. This is in agreement with the fact that seawater contains less oxygen and the saltier the lesser the amount of dissolved oxygen. Correlation analyses were also performed on the metals determined in the effluent and water samples. Here the critical correlation coefficient, r was calculated using $n = 7$ and $p<0.05$ and it was found to be 0.66 from the table of critical correlation coefficients. All values found to be equal or greater than r were adjudged to be significant and presented in Table 8. Very few of the metals show some degree of significance. Of all the metals investigated Ag and Pb show some degree of significance in NSF and Ag/Co in SMB samples.

Table 7: Critical correlation analysis showing physicochemical properties that showed significant association in all industrial effluents

PZZ	SMB	NCP	MTP	NSF	LYS
NO_3/SO_4 = 0.96	F^-/pH = 0.85	SO_4/pH = -0.86	Sal/pH = -0.87	NO_3/Sal = 0.81	NO_3/pH = 0.81
DO/Sal = -0.91	F^-/Sal = -0.94	F^-/pH = 0.80	PO_4/Sal = -0.88	PO_4/pH = -0.82	SO_4/Sal = -0.97
Col/pH = -0.88	DO/Sal = -0.98	DO/Sal = -0.84	F^-/Sal = -0.92	F^-/PO_4 = -0.99	NO_3/Sal = 0.87
Col/Sal = -0.81	DO/F^- = -0.99	BOD/NO_3 = 0.87	F^-/PO_4 = 0.85	DO/pH = -0.82	NO_3/SO_4 = 0.76
	COD/BOD = 0.98	BOD/PO_4 = 0.94	BOD/F^- = 0.81	DO/PO_4 = 0.82	PO_4/Sal = -0.87
	Col/pH = -0.87	COD/SO_4 = 0.97	COD/F^- = 0.83	DO/F^- = -0.75	PO_4/SO_4 = 0.92
	Col/NO_3 = 0.85	COD/NO_3 = 0.80	COD/BOD = 0.99	BOD/NO_3 = 0.82	COD/DO = -0.81
		Col/pH = -0.89	Col/Sal = -0.89	COD/pH = -0.92	COD/BOD = 0.96
		Col/SO_4 = 0.99	Col/PO_4 = 0.99	COD/PO_4 = 0.97	Col/pH = -0.94
		Col/COD = 0.97	Col/F^- = 0.89	COD/SO_4 = 0.85	Col/NO_3 = 0.86
				Co/Pb = 0.86	
				Cr/Cd = 0.69	

Table 8: Correlation analysis showing metals with significant level of association in all industrial effluents

PZZ	SMB	NCP	MTP	NSF	LYS
Fe/Mn = 0.92	Mn/Cr = 0.75	Co/Cr = 0.76	Fe/Cr = 0.79	Co/Fe = 0.94	Fe/Mn = 0.68
Co/Mn = 0.71	Co/Cr = 0.71	Ni/Cr = 0.94	Ni/Mn = 0.73	Ni/Cr = 0.83	Co/Fe = 0.89
Cu/Mn = 0.90	Zn/Cr = 0.99	Pb/Cr = 0.77	Cu/Cr = 0.72	Cu/Fe = 0.88	Zn/Mn = 0.92
Zn/Mn = 0.79	Pb/Cr = 0.99	Co/Mn = 0.68	Cu/Fe = 0.78	Cu/Co = 0.76	Pb/Cu = 0.72
Pb/Mn = 0.87	Fe/Mn = 0.93	Zn/Mn = 0.73	Zn/Cr = 0.70	Zn/Cr = 0.80	Cd/Pb = 0.78
Co/Fe = 0.86	Co/Mn = 0.96	Ni/Co = 0.91	Zn/Fe = 0.94	Zn/Fe = 0.97	
Pb/Fe = 0.92	Zn/Mn = 0.82	Zn/Cu = 0.91	Zn/Cu = 0.99	Zn/Co = 0.87	
Cu/Co = 0.77	Pb/Mn = 0.76		Pb/Cr = 0.74	Zn/Cu = 0.97	
Zn/Co = 0.79	Co/Fe = 0.93		Pb/Fe = 0.91	Pb/Cr = 0.81	
Pb/Co = 0.80	Zn/Fe = 0.71		Pb/Cu = 0.88	Pb/Fe = 0.91	
Pb/Cu = 0.89	Zn/Co = 0.77		Pb/Zn = 0.94	Pb/Co = 0.78	
Pb/Zn = 0.81	Zn/Cu = 0.68		Co/Pb = 0.86	Pb/Cu = 0.99	
	Pb/Co = 0.91		Cr/Cd = 0.69	Pb/Zn = 0.98	
	Ag/Co = 0.81			Cr/Cd = 0.84	
				Ag/Pb = 0.72	

CONCLUSION

Though the amount and type of pollutant discharged into the environment may differ from one industry to another, it is evident from the present study that the industries studied in this work did not treat their effluents before finally discharging them to the environment. This fact can be noticed in the concentration of pollutants in the effluent streams of the industries, most of which, exceeded FEPA limits for effluent discharges into the environment. If proper pollution management/abatement practices are not in place, other uses of water are affected.

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