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Studies on Effluent Characteristics of a Metal Finishing Company, Zaria -Nigeria

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Abstract: Effluent (wastewater) were collected from a metal finishing company, Zaria -Nigeria over a period of 2 years. Physical and chemical characteristics of the effluent were determined using standard methods. The means of: pH (4.5), TDS (4348.00mg/l), TSS(395.00mg/l), NO_3-N(84.50mg/l), SO_4^{2-}(1992.67mg/l), Cl^-(823.87mg/l), Cu(7.97mg/l), Pb(1.10mg/l), Ni (11.85mg/l) and Zn(5.06mg/l) were far outside the limits set by FEPA for the discharge of wastewater from metal finishing company into surface water. Even though FEPA limits does not include electrical conductivity, total alkalinity, total hardness, total solids, and dissolved oxygen for this category of industry, the values of these parameters obtained for the company effluent samples were obviously very high for wastewater to be discharged into surface water.

Key words: Wastewater, discharge, FEPA limits, metals, environment and degradation

INTRODUCTION

Metal finishing and processing is classified as industry group 347 and industry number 3479 in the Standard Industrial Classification Manual of (1987). Physical, chemical and electrochemical processes are all used to finish metal work pieces. Wastes typically generated during these operations are associated with the solvents and cleansers applied to the surface and the metal-ion-bearing aqueous solutions used in the plating tanks (USEPA, 1995). Metal-ion-bearing solutions are commonly based on hexavalent chrome, trivalent chrome, copper, gold, silver, cadmium, zinc, and nickel. Many other metals and alloys are also used, although less frequently. The cleaners (e.g., acids) may appear in process wastewater; the solvents may be emitted into the air, released in wastewater, or disposed of in solid form; and other wastes, metal-bearing sludges, and still bottom wastes, may be generated in solid form (Wang, 1990; USEPA, 1992, 1995; Sukkariyyah *et al.*, 2007).

In Nigeria and other several developing countries, the negative effects of sitting industries in the community are seldom considered as much as the employment created in the process. On the other hand, the industries' primary objective is to produce its product at the lowest possible cost (Akpata, 1986; Adakole, 2000). Installation of devices for its waste treatment falls short of this primary objective. Hence, it views waste treatment plant as an imposed necessity, which it installs usually when it is compelled. At least 20 metals are classified as toxic half of these are emitted into the environment in quantities that pose risks to human health (Nomanbhay and Palanisany, 2005). The aquatic environment is one of the ultimate recipient of pollutants and aquatic organisms, are through bioconcentration and biomagnification, often subjected to high levels of chemical pollutants (Zagorc-Koncan and Cotman, 1996; NBMA, 1999; NWRI, 2002). Human beings are exposed to pollutants through several pathways of infection such as inhalation, ingestion and skin-contact.

Studies aimed at the control of the discharge of toxic substances from point and non-point sources to surface waters has become increasingly important over the last three decades with the realization that these waters have been affected by human activities (Fisher *et al.*, 1998). Each Month, the metal Company being studied, discharges about 5,000.00 liters of its recycled/treated wastewater into the nearby, stream. There is no literature of the standards or of environmental impact assessment of its discharged wastewater, hence the need for this study to create awareness and need for action. To assess the environmental hazard of a complex effluent sample, it is important to identify the toxic ingredients (Wang, 1990). The following report presents results from a two-year study of the characterization of the metal finishing company effluent samples.

MATERIALS AND METHODS

Recycled/treated wastewater, about to be discharged was collected from a metal finishing Company located in Zaria –Nigeria. For each quarter of the two-year study period (July, 1997 to June, 1999), triplicate samples of one-liter-wastewater was collected in polyethylene bottle and transported to the laboratory in Department of Biological Sciences, Ahmadu Bello University, Zaria. The samples, where applicable, were preserved by adding 1.0ml conc. HNO_3 to about 150.0ml and stored under refrigeration to stabilize the metals for up to 2 weeks.

For elemental analysis, 100.0ml wastewater sample was digested, by concentrating it, to about 60.0ml in 100.0ml standard flask and 5.0ml HNO_3 added. It Was then made up to 100.0ml mark with de-ionized water

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followed by analysis with Unicam 919 atomic absorption spectrophotometer (A.A.S.) using 1% HNO_3 as blank. The metal (Na, Cu, Fe, Pb, Mg, Ca, Mn, Ni and Zn) concentrations was read from a standard curve:

Metal concentration, mg/l = A ´ B/C
Where A = concentration of metal in digested solution (mg/l),
B = final volume of digested sample (ml) and C = sample size (ml).

Other physico-chemical parameters that were determined include: Temperature with a mercury thermometer; optical density by measuring sample transmission at 430nm wavelength using spectrophotometer model S101 with distilled water as blank; pH and electrical conductivity by using Kent Eil 7055 pH meter and Jenway 4010 conductivity models respectively. Total solids, total dissolved solids, total suspended solids and free carbondioxide were analyzed as described by Lind (1979). Phosphate-phosphorus, Nitrate-nitrogen, and sulphate were determined by using spectrophotometer while dissolved oxygen, biochemical oxygen demand, total alkalinity, total hardness and chloride were determined by buret titration (APHA, 1992). For each quarter, all analysis were carried out thrice, and mean values obtained.

Statistical analysis: The statistical analysis was carried out using the Gensat release 4.0 package. Statistical procedures used include summary statistics, analysis of variance and correlation.

RESULTS AND DISCUSSION

All samples collected during the study period were clear and without odor except for the December sample of year-2. This was grayish and odorous. Statistical summary of results obtained from the effluent analysis is as presented on Table 1. The table also shows FEPA(Federal Environmental Protection Agency) limits for some parameters for the discharge of wastewater from metal finishing industries into surface waters. The mean temperature of the effluent during the study period was 23.00 ± 0.81ºC .The pH ranged between 1.70 and 11.80. The highest pH was obtained in December of year-2 Temperature and pH are among the physicochemical factors influencing the growth of bacteria in waste stabilization ponds (Mayo and Noike, 1996). The mean electrical conductivity obtained was 6715.00 ± 4244.00mS/cm. Positive high correlation coefficient exists between electrical conductivity and total dissolved solids. Electrical conductance quantitatively reflects the status of inorganic pollution and is a measure of total dissolved solids and ionized species in water. The respective TD, TDS and TSS values obtained during December of year-2 were highest compared to other sampling period. High levels of dissolved and suspended solids in the water systems increase the biological and chemical oxygen demand, which deplete the dissolved oxygen levels in the aquatic systems (Zagorc-koncan and Cotman, 1996; Jonnalagadda and Mhere, 2001). Suspended

substances and organic load as COD contribute major pollutants in rivers, lakes and ponds. Removal of these contaminants in wastewaters is one of the fundamental goals in waste treatment (TNRCC, 1999). The least dissolved oxygen value (0.03mg/l) was recorded in June of year-2. The correlation coefficient between BOD and electrical conductivity was negative but highly significant ($P<0.05$). The mean total alkalinity and total hardness recorded for the effluent samples were 283.00 ± 544.00mg/l.$CaCO_3$ and 722.00 ± 804.00 mg/l.$CaCO_3$ respectively. The level of hardness is dependent on the amount of calcium and magnesium ions dissolved within the water. When using city water or well water to replenish water in a metalworking fluid, cleaner or rinse water, the dissolved solids do not evaporate but build up over time. This boiler effect results in changes in liquid alkalinity and can lead to problems of corrosion, bacteria growth and residues in systems that reuse the specific solution (Krenkel, 1974). Even though FEPA limits does not include electrical conductivity, total alkalinity, total hardness, total solids, and dissolved oxygen for this category of industry, the values of these parameters obtained for the company effluent samples were obviously very high for wastewater due for discharge into surface water.

The means of NO_3-N(84.50 mg/l), SO_4^{2-}(1992.67 mg/l), Cl^-(823.87mg/l), Cu(7.97 mg/l), Pb(1.10 mg/l), Ni(11.85) and Zn(5.06 mg/l) obtained for the company effluent were far above limits set by the Federal Environmental Protection Agency (FEPA,1991).Nutrients (like nitrogen and phosphorus) released by human activity can cause lake eutrophication and nitrite contamination of drinking water (NBMA, 1999). Excess of these nutrients are also known to cause major pollution problem in streams, lakes, and the coastal marine environment in many nations.

Some amount of heavy metals such as Cd, Pb, Cu and Zn in wastewater remain in the solid form throughout treatment processes and cannot be degraded or destroyed (NBMA, 1999; NWRI, 2002). To a small extent they enter human bodies via food, drinking water and air. As trace elements, some heavy metals (e.g. copper, selenium, zinc) are essential to maintain the metabolism of the human body (Annune *et al.,* 1994). However, at high concentrations they can lead to poisoning. Heavy metals are dangerous because they tend to bioaccumulate in living tissues. The effluent discharges from metal finishing companies and the petrochemical industry pose a threat to water quality in many parts of developed and developing countries (NWRI, 2002). This discharge of wastewater that is not compatible with FEPA standards

Table1: Statisticalsummaryofresultsofwaste-watercharacteristics(Resultsareinmg/LexceptforopticaldensityandpHorotherwisestated)

Characteristics.	FEPA+LIMITS	MEAN	SD	SED	MIN	MEDIAN	MAX
Temperature(^{O}C)	NS	23.00	0.81	0.40	22.00	23.00	24.00
pH*	5.5-9.5	4.50	4.89	2.44	1.70	2.26	11.80
Electricalconductivity(µS/cm)	NS	6715.00	4244.00	2122.00	700.00	7755.00	10650.00
Totalsolids	NS	4743.00	6766.00	3383.00	1200.00	1440.00	14890.00
Totaldissolvedsolids	2000.00	4348.00	6539.00	3270.00	745.00	1249.00	14150.00
Totalsuspendedsolids*	15.00	395.00	262.00	131.00	180.00	329.00	740.00
Opticaldensity	NS	0.61	0.16	0.08	0.52	0.53	0.85
Dissolvedoxygen	NS	4.91	3.29	1.65	0.03	6.30	7.00
Biologicaloxygendemand	50.00	5.26	4.99	2.49	1.22	3.66	12.50
Totalalkalinity(mg/l.$CaCO_3$)	NS	283.00	544.00	272.00	3.00	15.00	1100.00
Totalhardness(mg/l.$CaCO_3$)	NS	722.00	804.00	402.00	144.00	426.00	1892.00
Phosphate-phosphorus	5.00	2.36	1.71	0.85	0.65	2.06	4.65
Nitrate-Nitrogen	20.00	84.50	112.20	56.10	18.00	34.00	252.00
Sulphate	500.00	1992.67	1500.00	750.00	720.00	1265.00	3448.00
Chloride	600.00	823.87	658.00	329.00	113.47	581.00	1310.00
Sodium	NS	535.52	428.00	214.00	73.75	378.00	851.00
Copper*	1.00	7.97	3.13	1.56	5.86	6.70	12.62
Iron	20.00	8.32	2.14	1.07	6.12	8.49	10.20
Lead*	0.01	1.10	0.45	0.22	0.51	1.19	1.51
Magnesium	200.00	1.45	0.28	0.13	1.21	1.39	1.79
Calcium	200.00	4.69	2.24	1.12	2.40	4.32	7.70
Manganese	5.00	1.24	0.53	0.26	0.80	1.07	2.01
Nickel*	1.00	11.85	0.41	0.20	11.40	11.80	12.40
Zinc*	1.00	5.06	0.53	0.26	4.32	5.20	5.52

FEPA+:FEPA(1991)limitforeffluentdischargeintosurfacewater, *:Mostsignificantparametersforwhicheffluentlimitsmustoftenbeset, NS:NotStated

should be seen as an environmental problem which must be halted to avoid a disastrous health and irreversible environmental damage situation.

CONCLUSION

The means of pH, TDS, TSS, NO_3-N, sulphate, chloride, Cu, Pb, Ni, and Zn were outside the limits set by FEPA for the discharge of wastewater from metal finishing company into surface water. FEPA must ensure that industrial activities and waste management/discharge practices are compatible to its set limits so as to bequeath a clean and safe environment to the present generations of Nigerians and those yet unborn.

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