

Physico-chemical Analysis of Effluent Samples from Hermas Paint Industry Enugwu-Ukwu, Anambra State

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Abstract: Hermas Paint Industry limited, Enugwu-ukwu, Anambra State, Nigeria is a polymer based industry that produces different types of paint from raw materials. Several hazardous and non-hazardous waste loads are produced during the paint manufacturing processes. Effluent generated by paint industries is one of the sources of pollution. Air, soil and water contaminated by effluent from the paint industry are associated with heavy disease burden resulting in short lifespan. Ground water and surface water contamination are also detrimental to health as aquatic life is jeopardized and in return, man is jeopardized. The aim of this work is to study the physico-chemical and Fourier Transform Infra-red (FTIR) analyses of effluent samples from the industry. The concentrations of the physico-chemical parameters were determined for three sampling periods: August, September and October, 2014, using standard chemical methods and Atomic Absorption Spectrophotometer (AAS). The Fourier Transform Infra-red analysis (FTIR) of the effluent samples was used to detect the organic functional groups present in the samples. The results obtained showed that the concentration of the mean physico-chemical parameters such as odour, pH, temperature, TDS, TSS, DO, CO_3^{2-} , OH^- , HCO_3^- , Cl^- , NO_3^- , SO_4^{2-} acidity and total alkalinity, cobalt, sodium, zinc, and calcium are within the recommended limits for WHO and NESREA with the exception of BOD, COD, TS, total hardness, cadmium, iron, lead, mercury, arsenic and chromium, some of which are slightly above the accepted limits, resulting in adverse effects on human health, plants and animals. The results of FTIR analysis showed the presence of the following functional groups: C-H of benzene, C=O stretch of amides, N-H, C-H stretch for amide and nitriles and O-H stretch for H-bond in alcohol and phenol and then N-H stretch of amides. Therefore, adequate and continuous monitoring should be conducted so as to prevent the bioaccumulation of waste loads which could be detrimental to human health. The WHO and NESREA should ensure that the effluents are well-treated so that the parameters remain within the permissible limits.

Keywords: Physico-Chemical, Analysis, Effluent Samples, Hermas Paint

1. Introduction

One of the efforts to control industrial pollution resulting from effluent is various industries is to see that Nigerians live in a disease-free environment [1, 2]. Effluents are waste water: treated, partially treated or untreated that flows out of a treatment plant; sewer that reduces the wholesomeness and quality of the environment [3-5]. The four types of effluent are: Municipal effluents which include wastewater from homes, schools, hospitals and run-off from sewers. Industrial effluents which come from various industrial processes and

contains acids, alkali, salts, solvents, metals, polymeric materials, colourants, aromatic compounds etc; effluents resulting from agricultural activities such as dissolved fertilizers, herbicides, fungicides, insecticides etc are called agricultural effluents. While institutional and research laboratory effluents include spent reagents, solvents and samples, rinse water, spent detergents etc. [6, 7].

Today, a number of paint industries are known and located around homes, water bodies and farmlands. The effects of

industrial effluent on the environment are not far-fetched. The reclamation, recycling and reuse of effluents from domestic or from agricultural processing activity have created small and medium scale enterprises [3, 8]. Effluents rich in nutrients when discharged into farmland could boost the fertility of the soil as well as develop shells and bones in aquatic animals if the effluent is rich in calcium and magnesium. Also, effluents could be recycled to regenerate potable water and the organic residue resulting from such treatment are converted to fertilizer for crop production [7, 9]. Eutrophication is attributed to the discharge of nutrient-rich effluents into water bodies which depletes the dissolved oxygen in the body of water [3, 10]. Heavy metals could cause health problems in animals, plants and human beings [11-13]. The aim of this work is to study the physico-chemical analysis of effluent samples from Hermas Paint Industry, Enugwu-ukwu, Anambra State, Nigeria.

2. Experimental

2.1. Materials

The samples effluents were collected from discharge point of Hermas Paint Industry, Enugwu-ukwu, Anambra State, Nigeria for three sampling periods: August, September and October, 2014. The pH, temperature, colour and odour of the samples were tested insitu at the point of collection and were refrigerated at 4°C.

2.2. Methods

The following physico-chemical parameters of the samples were determined using standard methods [14-16]: total suspended solid (TSS), total dissolved solid (TDS), total solid (TS), acidity, total alkalinity and total hardness. Others include dissolved oxygen (DO), biochemical oxygen demand (BOD) chemical oxygen demand (COD), hydroxyl ion (OH^-), bicarbonate ion (HCO_3^-), trioxonitrate (v) ion (NO_3^-), chloride ion (Cl^-) and tetraoxosulphate (vi) ion (SO_4^{2-}). The samples were digested and Atomic Absorption Spectrophotometer (AAS) (Model AA 280) was used to determine the concentration of metal ions in the samples [17, 18]. The results obtained were compared with WHO and NESREA. Further tests were conducted to determine the organic functional group present in the samples using Fourier Transform Infra-red analysis (FTIR) and interpreted [19, 20].

3. Results and Discussion

3.1. Physico-Chemical Parameters

The results of the analyses are shown in Tables 1 and 2. The results of the physico-chemical determination and metal levels of the effluent samples were discussed in comparison with WHO and NESREA accepted limits. The results of the physico-chemical analysis of effluent samples are shown in Table 1.

Table 1. The mean physico-chemical parameters of the effluent samples analyzed.

Parameter	August 2014	September 2014	October 2014	Mean±%RSD	WHO Limit	NESREA Limit
pH	6.5	6.6	6.63	6.58±1.04	6.5 – 8.5	6 – 9
Temperature (°C)	27.33	26	26.33	26.53±2.61	20 – 32°C	<35
Odour	Acceptable	Acceptable	Acceptable	-	Acceptable	Acceptable
Colour	Pacific blue	Red	Cream	-		
TSS (mg/l)	1.17	3.17	1.0	1.78±67.80	50	10
TDS (mg/l)	1165.5	2163.5	1665.67	1664.89±29.97	500	2000
TS (mg/l)	2000	1833.33	1666.67	1833.33±9.09	500	500
Acidity (mg/l)	0.13	0.09	0.11	0.11±18.18	-	-
OH^- (mg/l)	13.6	235.67	332.33	193.87±84.39	-	-
HCO_3^- (mg/l)	240	4160	5280	3226.66±82.03	-	-
Total alkalinity (mg/l)	40	693.33	880	537.78±82.02	100	
NO_3^- (mg/l)	2.0	4.17	3.5	3.22±34.51	50	20
Cl^- (mg/l)	3.98	29.82	29.15	20.98±70.21	250	100
SO_4^{2-} (mg/l)	25.83	24.67	37	29.17±23.34	200	100
Total Hardness (mg/l CaCO_3)	676	1066.67	320	687.56±54.32	100	-
DO (mg/l)	4.27	3.47	4.0	3.91±10.41	30	5
BOD (mg/l)	422.4	636.53	636.0	564.98±21.85	20	20
COD (mg/l)	426.67	640	640	568.89±21.65	10	40

The mean pH value of 6.58±1.04 has no adverse effect on the receiving environment because it is within WHO permissible limit of 6.5 – 8.5 and NESREA limit of 6.0-9.0 and is in line with earlier work (Onuegbu et al., 2013). High pH value leads to eutrophication. The mean pH can support fish life.

The mean temperature value of the effluent samples, 26.53±2.61°C satisfied the recommended standard for WHO and NESREA which are 20-32°C and <35 respectively. High temperature will pose a risk to the environment because it will destroy aquatic life and kill plants. It also causes a

decrease in the solubility of oxygen needed for biodegradation of wastes.

The odour from the effluent sample was acceptable. The Mean TSS value for the effluent samples, 1.78±67.80mg/l satisfies the values recommended by WHO and NESREA. High TSS contributes to high quality of the receiving water body. High turbidity prevents adequate penetration of sunlight into water bodies which seriously affects aquatic life. Visibility is impaired and may lead to death. The mean TDS for the effluent samples, 1664.89±29.97 mg/l was high when compared to WHO maximum allowance value of 500mg/l

but within NESREA limit, which is 2000mg/l. The mean TS value, 1833.33 ± 9.90 mg/l was higher than the WHO and NESREA standards which is 500mg/l.

The mean total alkalinity and hardness of effluents, 537 ± 82.03 mg/l and 687.56 ± 54.32 mg/l were higher than WHO limit which is 100mg/l. Since the value for the mean total hardness of the samples was higher than their mean total alkalinity. It implies that the mean total hardness was both carbonate and non-carbonate hardness.

The mean NO_3^- , Cl^- and SO_4^{2-} values of the effluent sample were within the permissible limit for both WHO and NESREA. High concentrations of nitrates in water bodies result in eutrophication. High sulphate content results in acidity of water bodies.

The dissolved oxygen mean value, 3.91 ± 10.41 mg/l was within the acceptable limit for both WHO (30mg/l) and NESREA (5mg/l). The low levels of the DO could be attributed to the following: high percentage of organic matter in the effluent, which used up the oxygen molecules as they biodegrade; reducing agents which used up the oxygen molecule as they biodegrade and finally, high percentage of oil-grease content which inhibits the dissolution of oxygen molecules from the atmosphere into the effluent. Low level of DO means high BOD level. The mean BOD value of the

effluent samples was appreciable high, 564.98 ± 21.85 mg/l compared to WHO (250mg/l) and NESREA (100mg/l) recommended specifications. Effluent of high BOD has high biodegradable organic matter present and is starved of dissolved oxygen resulting in low productivity i.e the inability to support living organisms. The mean COD, 568.89 ± 21.65 mg/l is higher than the standard recommended by both WHO (200mg/l) and NESREA (100mg/l). High level of COD showed the presence of chemical oxidant in the effluent and could cause nutrient fixation in the soil which may result to reduced rate of nutrient availability to plants. The COD may introduce rust to water treatment plant thereby reducing the service life of the plant. When BOD is equal to COD, it means that only biodegradable organic matter is present (non-biodegradable organic matter is absent). The mean COD is higher than the mean BOD showing that non-biodegradable organic matter is contained in the effluent samples. COD is the measure of the quantity of oxygen required to oxidize all organic matter, both biodegradable and non-biodegradable, in a water sample or effluent to CO_2 and H_2O by a strong oxidant.

The average metal ion concentrations of the samples are shown in Table 2.

Table 2. Average metal level in milligram per litre (mg/l).

Parameter	August 2014	September 2014	October 2014	Mean \pm %RSD	WHO Limit	NESREA Limit
Cd^{2+} (mg/l)	0.41	0.20	0.24	0.28 ± 39.85	0.1	0.1
Co^{2+} (mg/l)	0.56	0.59	0.26	0.47 ± 45.53	0.05	0.5
Fe^{3+} (mg/l)	8.42	0.52	0.64	$3.19 \pm > 100$	0.3	2.0
Na^+ (mg/l)	8.48	5.36	3.84	5.89 ± 40.16	200	200
Pb^{2+} (mg/l)	4.05	0.16	0.95	1.72 ± 84.53	0.05	0.1
Hg^{2+} (mg/l)	1.84	0.31	0.04	$0.73 \pm > 100$	0.001	0.01
As^{3+} (mg/l)	0.83	0.37	0.13	0.44 ± 80.85	0.05	0.1
Zn^{2+} (mg/l)	0.73	0.41	1.05	0.73 ± 43.84	3	5
Ca^{2+} (mg/l)	3.44	7.92	4.19	5.18 ± 46.32	100	200
Cr^{3+} (mg/l)	3.98	0.67	1.14	1.93 ± 92.79	0.05	0.01

As can be seen in Table 2, the mean concentrations of metal ions have no definite variation pattern. With the exception of Fe^{3+} and Cr^{3+} , the heavy metals occurred in trace amounts. The iron is present in significant amount because it is present in insoluble form of iron (iii) oxide. The mean sodium ion concentration (5.89 ± 40.16 mg/l) is appreciably much lower than standard (200mg/l) recommended by NESREA and WHO leading to low soil permeability. The mean elemental calcium concentration in the effluent sample was below the standard as recommended by NESREA and WHO. Since the hardness level is contributed by the levels of calcium and magnesium contents of the effluent, the mean levels of calcium in the effluent samples compared with the mean total hardness. The lower mean calcium levels in the sample limit the formation of excessive scale the mean sodium levels contained in the samples were below the acceptable standard for the WHO. As a result, no adverse effect will occur. With the exception of the mean levels of the heavy metal such as Zn, the mean levels of the other heavy metals in both the soil and effluent

samples all exceeded the recommended levels for NESREA and WHO. This have detrimental effect on human health, plant and animal due to bioaccumulation of the heavy metals which are non-biodegradable. Zinc in trace level is beneficial for body growth while iron plays a special role in respiration. Mercury is a cumulative poison which causes nerve damage, hepatitis, anaemia and even death. Arsenic may cause cancer. Cadmium could lead to lung cancer and bone defects. Lead is a cumulative poison which causes brain damage and even death.

3.2. FTIR Analysis

The infrared spectrum is used to detect the functional groups in a molecule as well as to identify two samples that have identical spectra in the finger print region $1300 - 650\text{cm}^{-1}$. One limitation of the IR spectrum is that it cannot be used to distinguish a pure sample from an impure sample. Tables 3–5 showed the suspected chromophores /functional groups that are present in the effluent samples for the months

of August, September and October, 2014.

Table 3. FTIR results for the month of August.

Wave Number (cm ⁻¹)	Functional Group	Intensity
465.82	C – I of halogen compounds	0.276
739.73	C-H bend of benzene	15.065
895.96	C-H bend of benzene	68.638
1265.35	C=O stretch of carboxylic acid	43.78
1425.44	H-C-H bend of alkanes	67.08
2984.94	H-C-H asymmetric and symmetric stretch of alkanes	67.749
3065.35	=C-H of asymmetric stretch of alkenes	65.999

Table 4. FTIR results for the month of September.

Wave Number (cm ⁻¹)	Functional Group	Intensity
445.57	C – I of halogen compounds	0.059
735.87	C – H of benzene,	3.100
1641.48	C=O stretch of amides	1.876
2094.76	N-H, C-H stretch for amide and nitriles	35.505
3224.12	O-H stretch for H- bond in alcohol and phenol and N-stretch of amides	0.62
3572.29	O-H stretch for H- bond in alcohol and phenol	0.281

Table 5. FTIR results for the month of October.

Wave Number (cm ⁻¹)	Functional Group	Intensity
468.72	C – I of halogen compounds	0.365
739.73	C – H of benzene	32.403
896.93	C – H of benzene	77.585
1206.36	C-Ostretch of alcohol and phenol, acid anhydride	56.62
1424.48	H-C-H bend of alkanes	75.6
2305.01	N-H stretch for tertiary amine	77.373
3055.35	=C-H asymmetric stretch of alkenes	74.025
3445.91	O-H stretch for H- bond in alcohol and phenol	74.885

From the FTIR results in Tables 3-5, it shows that the intensities of absorptions of samples obtained in August and October are higher than the intensities of absorptions of samples obtained in September. In August, the wave number 895.96 cm⁻¹ has the highest intensity (68.638). Other absorptions in August with high intensities are 1265.35 cm⁻¹, 1425.44 cm⁻¹, 2984.94 cm⁻¹ and 3065.35 cm⁻¹. The main functional groups in August are C-H bend of benzene, C=O stretch of carboxylic acid, H-C-H bend of alkanes and=C-H of asymmetric stretch of alkenes. The wave number with insignificant intensity is 465.82 cm⁻¹ with the intensity of 0.276. In September, the wave number with the highest intensity is 2094.76 cm⁻¹ (35.505) followed by 735.87 cm⁻¹ (3.100) while wave numbers of 445.57 cm⁻¹, 1641.48 cm⁻¹, 3224.12 cm⁻¹ and 3572.29 cm⁻¹ have low intensities. The functional groups in September are C – H of benzene, C=O stretch of amides, N-H, C-H stretch for amide and nitriles and O-H stretch for H- bond in alcohol and phenol and then N-stretch of amides.

The October, C – H of benzene is the functional group with the highest wave number (896.93 cm⁻¹). Other functional groups that feature prominently in the effluent are

C-Ostretch of alcohol and phenol, acid anhydride (1206.36 cm⁻¹), H-C-H bend of alkanes (1424.48 cm⁻¹), N-H stretch for tertiary amine (2305.01 cm⁻¹), =C-H asymmetric stretch of alkenes (3055.35 cm⁻¹) and O-H stretch for H- bond in alcohol and phenol (3445.91 cm⁻¹).

4. Conclusion

This research assessed the physico-chemical parameters and functional groups present in the effluent from Hermas paint industry Enugwu-ukwu for a period of 3-months: August, September and October 2014, using standard chemical methods, Atomic Absorption Spectrophotometry and FTIR analysis. The results of the physico-chemical parameters and AAS analysis were compared with the WHO and NESREA standards. The results revealed that the physico-chemical parameters of the effluent samples are generally good, most of the parameters conformed to WHO and NESREA limits while the results of the elemental analysis using Atomic Absorption Spectrophotometer revealed that most of the heavy metals concentration did not conform to the limits for WHO and NESREA. The results of the FTIR analysis revealed the presence of the main functional groups such as C – H, O-H, C-O, C=O, N-H and=C-H in the effluent samples. As a result, the effluent in the study area should be treated to meet the various WHO and NESREA limits for effluent before discharge into water bodies or into the soils.

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