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Physico-chemical analysis of effluent water from paint manufacturing company in Umuahia, Abia state, Nigeria

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ABSTRACT
Environmental pollution has been a rising concern in many nations.Effluents from paint industries is a major source of environmental pollution, hence the need for this study. The physico-chemical parameters of effluent water from paint manufacturing company in Ubakala Umuahia,Abia state, Nigeria were analysed at two months (December and January) interval. The analyses were done in triplicate and the results presented as mean standard ±deviation, and compared with WHO standard. Statistical analysis (student T-test at α = 0.05) was carried out on the results using SPSS software. From the results, colour (TUC) ranged from 13.4±0.9 - 14.0±0.25;Turbidity(NTU), 120±0.82 - 121±1.63; Electrical conductivity(mS/m), 221±1.25 - 227±0.47;TDS (mg/L), 201±0.82 - 209±0.47; Nitrates (mg/L), 7.5±0.008 - 8.6±0.012; Chlorides (mg/L), 248±0.47 - 256±0.81;BOD (mg/L), 19.0±0.02 - 19.3±021 and pH,8.01±0.08- 9.01±0.01. These values were within WHO permissible limit except turbidity that was higher. Also there was no significant difference (α > 0.05) between the months of study although December recorded higher values of the analysed parameters. It can be inferred that the paint industry does not constitute much pollution to water bodies as at the period covered by the study. It is therefore recommended that the industry should always treat their waste products before disposal into water bodies and Federal Ministry of Environment (FME) should always monitor industries to ensure that they adhere to proper waste management and disposal.

Keywords:physico-chemical analysis, effluents, pollution, paint industry

I. INTRODUCTION

The continuous increase in industries has become sources of pollution across the world (Oladeleet al., 2011).Water pollution due to discharge of untreated industrial effluents into water bodies is a major problem in the global context (Aniyikaiyeet al., 2019; Chidozie and Nwakanma, 2017).Effluents released from the industries into water bodies can cause serious environmental degradation and deterioration; especially with the ongoing increase in the industrialization around the world, water pollution too is becoming rampant (Orimoloye, 2019; Shresthaet al., 2017). The discharge of wastes into the water bodies by man has brought about modification of the environmental water quality, hence making substantial quantities of water unsuitable for various uses (Aniyikaiyeet al., 2019). Over the years, wastes generated due to industrial growth and complicated by its indiscriminate disposal has been a major concern in the developing countries (Orimoloye, 2019; Olaoye&Oladeji, 2015).

According to EPA as cited in Ekute and Etim (2021) effluent means water sullied or contaminated by any matter in solution or suspension resulting from domestic, industrial or other activities, industrial development manifested due to setting up of new industries or expansion of new industries or expansion of existing industrial establishments. Worldwide water bodies are primary means for disposal of waste, especially the effluents from industrial, municipal sewage and agricultural practices that are near them. This effluent can alter the physical, chemical, and biological nature of receiving water body (Aminu&Hamed, 2021). In Nigeria, the disposals do not always comply with pre-treatment requirements, less than 10% of industries treat their effluents before being discharged, usually into rivers. Consequently, there is a high load of inorganic and hazardous substances in many of the receiving water bodies (Obetaet al., 2019).

Human activities give rise to water pollution by introducing various categories of substances or waste into a water body. The common types of polluting substances include pathogenic organisms, oxygen demanding organic substances, plant nutrients that stimulate algal blooms, inorganic and organic toxic substances (Chidozie&Nwakanma, 2017)

It is well established that pollution lowers the quality of life in various aspects and affects health and life span (Orimoloye, 2019; Chidozie and Nwakanma, 2017). Water contaminated by effluents from various sources is associated with heavy disease burden and this could influence the current shorter life expectancy in the developing countries compared with developed nations (Orimoloye, 2019).

Emulsion paints are complex mixtures composed of both organic and inorganic pigments, latexes, extenders, cellulosic and non-cellulosic thickeners, emulsifying agents, etc. Paint effluent often contains all components of precursor paints with insignificant dilution. They could be clean-up water composed of residual acids, plating metals and toxic chemicals. The numerous chemicals used for the production of paint are responsible for the high concentrations of organic compounds, suspended solids, pigments and hazardous pollutants like heavy metals in the generated wastewater (Aniyikaiyeet al., 2019).

The paint waste water has salinity, sulfate and high level of suspended solids. The release of such wastewater into the environment slows down the penetration of light, damages the quality of the streams and may be toxic microorganisms and also affects aquatic life. The paint wastewater must be required to release after treatment due to legal restrictions in organized industrial zone and environment conservation (Sharmila, 2016).

In Nigeria, paint production utilizes large volume of water without adequate wastewater treatment plant. Hence, large quantities of both hazardous and non-hazardous wastes are inherently released to the environment, thus causing health related problems, ecological imbalance and bioaccumulations in aquatic organisms (Olaoye&Oladeji, 2015).

II. MATERIALS AND METHODS

2.1 Sample collection/preparation

Wastewater was collected from Tomag paint company NsirimoUbakala, Umuahia South, Abia state. The sample was labelled appropriately and the pH of the waste was determined using hand digital pH meter at the point of the paints sample collection. The samples were transported to the chemistry laboratory, Department of Science Laboratory Technology, AkanuIbiam Federal Polytechnic, Unwana in an ice chest and refrigerated until needed for further analysis. A measured quantity of the sample was taken and assayed for each of the physico-chemical parameters.

2.2 Determination of pH

The pH of the water samples was determined at the point of sample collection; this is in line with the formula described by USEPA (2018).

2.3 Determination of colour

Colours were determined with calibrated colour disc as adopted byChidozie and Nwakanma (2017).

2.4 Turbidity determination

Turbidity of the water samples was measured using Lutron turbidity meter (Model Tu 2016) described in Okekeet al. (2018).

2.5 Determination of Conductivity

The electrical conductivity of the wastewater samples obtained was determined at the point of sample collection and was done with the aid of a salinometer (Aniyikaiyeet al., 2019).

2.6 Determination of Total Dissolved Solids (TDS)

The method adopted by Aniyikaiyeet al. (2019) was used for the determination of total dissolved solids of the sample. A clean Petri dish was subjected to a temperature of 100 ^{o}C in an oven, cooled in a desiccator and then weighed to constant weight. The collected wastewater sample was filtered into a clean conical flask using a pre-weighed filter paper. A known volume of the filtrate was poured into the petri-dish and heated in an oven at temperature 180 ^{o}C. The obtained residue was then cooled in the desiccator and weighed to a constant weight. The TDS was calculated with the formula below:

$$\text{TDS (mgL}^{-1}) = \frac{(A-B)\ X\ 1000}{\text{volume of water sample (mL)}}$$

Where

A = weight of dried residue + evaporating dish (mg)

B = weight of evaporating dish (mg)

2.7 Determination of Chlorides

The concentration of chloride ions in the wastewater was determined using Mohr's method as described by Aniyikaiyeet al. (2019). The method uses chromate ions as an indicator in the titration of chloride ions with a silver nitrate standard solution. A known volume of wastewater sample was titrated against a known concentration of silver nitrate. After all the chloride has been precipitated as white silver chloride, the first excess of titrant resulted in the formation of a brownish

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red silver chromate precipitate, indicating the end point.

2.8 Determination of nitrate

Nitrate in wastewater was determined using a UV spectrometric method. A 100 mg/L standard solution of nitrate was made by dissolving 0.72 g of anhydrous potassium nitrate in 1 L of distilled water. Serial dilutions from nitrate stock solution were done for the preparation of calibration standards for nitrate in the range 0.1 – 1.0 mg/L. A series of reaction tubes was set up in test tube stand and placed in a cold-water bath. Measured volume of wastewater sample was poured into the reaction tubes, with NaCl solution and sulphuric acid added sequentially. Brucine-sulphanilic acid reagent was added and the mixture heated for some minutes in a boiling water bath. The samples were then allowed to cool and the absorbance of each sample at 410 nm in the UV spectrometer was measured, in comparison with the reagent blank. Nitrate- Nitrogen (NO_3-N) concentration in the wastewater samples was determined by extrapolation from the calibration curve (Aniyikaiyeet al., 2019).

2.9 Determination of Biochemical Oxygen Demand (BOD)

BOD was determined using Winkler's method according to USEPA (2018). BOD in water is determined by the difference in the dissolved oxygen (DO) levels of water samples prior incubation and after 5 days of incubation. The BOD of the collected wastewater samples was determined by the dilution method. Dilution water was prepared by addition of 10 mL of each of the reagents; phosphate buffer, magnesium sulphate, calcium chloride, ferric chloride, sodium sulphite and ammonium chloride into 10 L of water. A measured volume of wastewater sample was topped up with dilution water to 1 L mark of a standard flask. Two 300 mL amber bottle were completely filled with the diluted water. One of the bottles was incubated at 20 ^oC for 5 days. $MnSO_4$ solution, alkali-iodide-azide reagent and concentrated sulphuric acid were added into the other amber bottle. DO in the wastewater sample was derived through iodometric titration. For dissolved oxygen at day zero (DO_0), 50 mL aliquot of the solution was titrated against sodium thiosulphate solution using starch solution as indicator, until a colourless end-point was attained. At the end of the 5 days, the sample in the incubator was brought out; dissolved oxygen at day five after incubation (DO_5) was determined by following the same procedure used for the determination of DO_0. A blank was prepared in a transparent bottle for DO_0. Another blank was prepared in an amber bottle and incubated with the sample for DO_5:

$$BOD5\ (mgL^{-1}) = \frac{(DO_0 - DO_5) \times \text{Volume of BOD bottle}}{\text{Volume of water}}$$

2.10 Statistical analysis

All determinations were performed in triplicate, and the data were presented as means ± standard deviations using SPSS software (IBM, version 22). Student T-test was carried out to analyze the data, and the difference was considered significant at p = 0.05.Also the results were presented in a bar chart using the same software.

III. RESULTS

Below are the results obtained from the analyses of various water quality parameters of effluent water at two months (December, 2021 and January, 2022) interval

Table 1: Mean±SD of parameters measured for effluent water within two months interval compared with WHO permissible limit

Water Quality Parameter	December 2021	January 2022	*WHO Permissible Limit (1993/1994)
Colour (TCU)	14.00±0.25[a]	13.40±0.09[a]	15
Turbidity (NTU)	121±1.63[a]	120±0.82[a]	5
Electrical conductivity (mS/m)	227±0.47[a]	221±1.25[a]	250
TDS (mg/L)	209±0.47[a]	201±0.82[a]	2000
Nitrates (mg/L)	8.60±0.012[a]	7.50±0.008[a]	10
Chlorides (mg/L)	256±0.81[a]	248±0.47[a]	250
BOD (mg/L)	19.30±0.21[a]	19.00±0.02[a]	NG
pH	9.01±0.012[a]	8.01±0.008[a]	6 – 9

Footnote: NG = No Guideline. Mean±SD followed by the same letterson the same row arenot significantly different (p < .05). * = FAO/WHO (1993/1994) standards.

The results of the physico-chemical analysis shown in table 1 and figure 1 indicate that there is no statistically significant difference between the months of December and January, although the month of December recorded higher values in all the analyzed parameters.

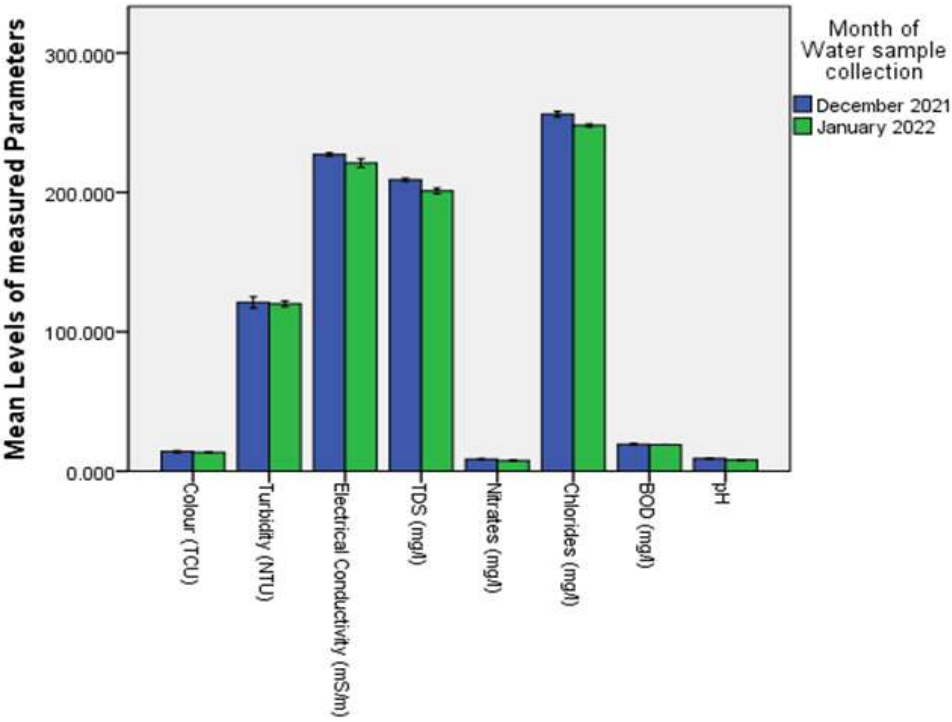

Figure 1: Results of Effluent water quality analyses at two months interval

IV. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

4.1 Discussion

The results obtained are shown in table 1 and figure 1 above. The results of various physico-chemical parameters analyzed of the effluent water from paint manufacturing company in Umuahia, Abia state, Nigeria within two months (December, 2021 and January, 2022) interval showed no marked variations within the period of the study.

Colour (TCU): the result obtained showed that the colour was 14.0±0.25 TCU at December which was higher than the value (13.4±0.09 TCU) obtained at January. These values were both below the WHO permissible limit of 15 TCU. Chidozie andNwakanma (2017) obtained similar values in their study on saclux paint industrial effluents in Nkoho River in AbiaState, Nigeria in the range of 13.03±0.05 – 15.8±0.20 TCU.Excessive colour is an indication of the presence of large amount of organic chemicals, inadequate treatment of the discharged effluents and high disinfection demand Olaoye andOladeji (2015).

Turbidity: High turbidity is an indication of the presence of dissolved solid in water (Okeke et al., 2018).The turbidity of the water ranged between 121±1.6 NTU and 120±0.82 NTU for the months of December and January respectively. These values exceeded the 5 NTU WHO permissible limit indicating high dissolved solid. These values obtained from the study were above the values (0.59 – 4.18 NTU) obtained by Rahmanianet al. (2015).Chidozie andNwakanma (2017) reported similar range (119.43±1.61 – 131.47±1.65 NTU) of turbidity values from saclux paint industrial effluents in Nkoho River in AbiaState, NigeriaOlaoye andOladeji (2015) on the other hand reported an average turbidity of 1.96 NTU and a maximum turbidity value of 7.93 NTU which they opined that it probably suggests occurrence of localized contamination.

Electrical Conductivity (mS/m): The conductivity of an electrolyte solution is a measure of its ability to conduct electricity(Okekeet al., 2018). Inorganic ions majorly influence on the conductivity of water. High values of electrical conductivity (EC) show that inorganic ions are in abundance in the wastewater. EC is directly proportional to the total dissolve solids (TDS) concentration. Thus, high EC in wastewater is an indication of high total dissolved solids concentration. This also implies that the ability of an electric current to pass through the wastewater is proportional to the concentration of ionic solutes dissolved in the water (Aniyikaiyeet al., 2019).The electrical conductivity of the wastewater was 227±0.47 mS/m for the month of December which was higher than that of January that was 221±1.25 mS/m January. The values were below 250 mS/m WHO permissible limit. Chidozie andNwakanma (2017) reported similar values in the range of 221±3.21 – 231±2.00 mS/m.The values obtained from the study were above the 46.5±2.4 – 64.2±2.7 mS/m obtained by Fagbayide and Abulude (2018) but below the 149.1 – 881.3 mS/m reported by Aniyikaiyeet al. (2019) on wastewater discharge from selected paint industries in Lagos, Nigeria, and the 276.0 – 780 mS/m obtained from Oladeleet al. (2011).

Total Dissolved Solid (mg/L): TDS refers to the inorganic salts and small amount of organic matter present in solution in water. The total dissolved solid which ranged between 201±0.82 mg/l and 209±0.47 mg/L for the months of January and December respectively. These values were below WHO permissible limit of 2000 mg/L. Aniyikaiyeet al. (2019) reported a range of 1100 – 6510 mg/L on wastewater discharge from selected paint industries in Lagos, Nigeria.Obetaet al., (2019) reported lower values in the range of 0.5 – 6.10 mg/L from industrial effluents on surface water in Onitsha urban area, southeastern Nigeria.ChidozieandNwakanma (2017) however reported higher values in the range of 208±3.46 – 270±3.21 mg/L.

Nitrate (mg/L): Nitrates are the end product of the aerobic decomposition of organic nitrogenous matter (Aniyikaiyeet al., 2019). The result obtained showed that the nitrate was 8.60±0.012mg/L at December which was higher than the 7.50±0.008mg/L obtained at the month of January. These values were within WHO permissible limit of 10 mg/l. The result was below the 12.89 – 211.2 mg/L reported by Aniyikaiyeet al. (2019) on wastewater discharge from selected paint industries in Lagos, Nigeria, and 26 mg/L reported by Aminu andHamed (2021) on paint industry effluent on nearby rivers. The most highly oxidized form of nitrogen compounds is extensively found in surface and groundwater because it is the end product of aerobic breakdown of organic nitrogenous materials. Nitrate levels are generally quite low in unpolluted natural streams. The effluent from the treatment facility could be a source of nitrate in the receiving water body (Aminu&Hamed, 2021).Chidozie andNwakanma (2017) reported the nitrate levels of saclux paint industrial effluents in Nkoho River in AbiaState for the months of September, October, and December in the range of 8.54±0.09 – 9.13±0.2 mg/L. Obeta et al. (2019) on the other hand reported a lower range (0.15 – 1.31 mg/L) of value of nitrate from industrial effluents in Onitsha urban area, southeastern Nigeria

Chloride (mg/L): The result obtained showed that the chloride was 256±0.81mg/L at December which was higher than the 248±0.47 mg/L gotten on the month of January.The December result was slightly above the WHO permissible limit of 250 mg/L while the January result was within WHO permissible limit.In water bodies, elevated chloride levels can threaten the sustainability of ecological food sources, hence posing a risk to species survival, growth as well as reproduction. Bioaccumulation and persistence of chloride may affect aquatic organisms and water quality (Aniyikaiyeet al., 2019). Ekute and Etim (2021) reported a range of 124.20±91.5 to 128.59±110.40 mg/L of chloride in Ota industrial estate effluents on surface water quality of Oruku River, Ota; South Western Nigeria which was attributed to effluent discharges containing hydrochloride acid, common salt or other chloride containing compounds used in the production/treatment process. Also Chidozie andNwakanma (2017) reported the chloride levels of saclux paint industrial effluents in Nkoho River in AbiaState for the months of September, October, and December as 243.20±1.38, 256.47±6.81 and 262.33±3.86 mg/L respectively.

Biochemical Oxygen Demand (mg/L): BOD is not a pollutant in and of itself, it is a measure of organic pollution, and a high BOD load poses a threat to the aquatic environment as it lowers dissolved oxygen levels to levels that are harmful to aquatic organisms (Aminu&Hamed, 2021). The discharge of wastewater with high levels of BOD into waterbodies can cause serious dissolved oxygen depletion and death of aquatic animals in the receiving water bodies (Aniyikaiyeet al., 2019). The result obtained showed that the BOD was 19.30±0.21mg/L at December which was higher than the value 19.00±0.02 mg/L obtained at January; both were within the FEPA (1991) permissible limit of 20 mg/L. The values were below the 162.8 – 974.7 mg/L recorded by Aniyikaiyeet al. (2019) on wastewater discharge from selected paint industries in Lagos, Nigeria.Obetaet al. (2019) and Ekute and Etim (2021) recorded lower range of values BOD values of 0.16 – 41.9 mg/L and 1.94±0.95– 3.78±1.61

mg/L respectively. Aminu and Hamed (2021) however recorded higher BOD level of 180 mg/L from effluent.

pH: This determines the alkalinity or acidity present in a solution. It has been reported that pH is among the physicochemical factors influencing the growth of bacteria in waste stabilization ponds (Aminu&Hamed, 2021). The result in table 1 showed that pH was 9.01±0.012 at December and 8.01±0.008 at January. These values were within WHO permissible limit of 6 – 9.Chidozie and Nwakanma (2017) got similar range of values; 8.83±0.05 – 9.03±0.05.Ekute and Etim (2021) reported lower range of pH (5.53±0.31 – 6.40±0.41) while Obetaet al. (2019) reported a pH range of 6.5 – 8.2 from effluent water in Onitsha urban area.Aniyikaiyeet al. (2019) recorded more acidic and alkaline pH of 4 – 12.2 on wastewater discharge from selected paint industries in Lagos, Nigeria.

4.2 Conclusion

Industrial effluents discharge into water bodies result in the presence of high concentrations of pollutant in the water. The results of various physico-chemical parameters analysed of the effluents from the paint manufacturing company in NsirimoUbakala, Umuahia showed no marked variations between the two months periods of the study. These physico-chemical parameters were within WHO permissible limit except turbidity which exceeded the acceptable limit. The rising pH shows that the wastes are alkaline in nature and must be appropriately treated before discharge into water bodies, although it can be inferred that the paint manufacturing industry, to a great extent, treat their wastes before disposal. This study has revealed that the industry is not involved in causing serious environmental hazard but could constitute a grave pollution to the environment if the wastes are not properly managed over a certain period of time.

4.3 Recommendation

Adequate preventive measures should be applied in industrial activities with a view to ensuring a healthy environment. The adverse effect of industries is severe, but considering the benefits we cannot ignore the industrial sector. Therefore the following recommendations were made to mitigate the problems.

- It is recommended that each industry must have a functional Effluent Treatment Plant (ETP) to enhance the degree of treatment of effluent.
- Proper operation and maintenance of ETP should be monitored continuously.
- Federal Ministry of Environment (FME) and related government bodies should be proactive in ensuring that industrial activities do no constitute serious pollution to the environment and water bodies.

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APPENDIX 1
T-Test

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means
		F	Sig.	T
Colour (TCU)	Equal variances assumed	1.450	.295	3.911
	Equal variances not assumed			3.911
Turbidity (NTU)	Equal variances assumed	.788	.425	.949
	Equal variances not assumed			.949
Electrical Conductivity (mS/m)	Equal variances assumed	1.365	.308	7.782
	Equal variances not assumed			7.782
Total dissolved solid (mg/L)	Equal variances assumed	.549	.500	14.661
	Equal variances not assumed			14.661
Nitrates (mg/L)	Equal variances assumed	.308	.609	132.106
	Equal variances not assumed			132.106
Chlorides (mg/L)	Equal variances assumed	.527	.508	14.796

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	Equal variances not assumed			14.796
Biological oxygen demand (mg/L)	Equal variances assumed	3.245	.146	2.463
	Equal variances not assumed			2.463
pH of wastewater	Equal variances assumed	.308	.609	120.096
	Equal variances not assumed			120.096