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Analysis of Post-Treated Paint Production Waste Water at Global Company, Namanve Industrial Area

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ABSTRACT

Paint is a liquid mixture of pigments, binders, solvents, and additives used for decorative, protective, and functional purposes. It forms a solid film upon drying or curing, providing color, protection against corrosion, and enhancing the aesthetic appeal of structures. However, paint manufacturing plants produce waste with high concentrations of ions, organic debris, high Chemical Oxygen Demand (COD), biological oxygen demand, turbidity, suspended solids, and heavy metals, which are harmful to the environment. Wastewater is a significant challenge for urban authorities and industries today. The study highlights the estimation of wastewater generated and the pollutants arrangement adopted by city authorities, suggesting long-term recommendations for proper waste management in Kampala. The majority of water used in paint production comes from municipal public supply, followed by well and surface water sources. Around 70% of the total water is discharged untreated, with 25% not discharged but disposed off by evaporation or other methods. Most of the water generated in paint production comes from cleaning equipment used in water-based paint production, which contains high levels of pollutants that pose significant environmental risks when inadequately treated.

Keywords: Paint production, Wastewater, Global company, Namanve Industrial Area, Environmental risks

INTRODUCTION

In 1997, from the passion for painting and curiosity of how paints are made, founder Mr, Kayiwa Steven started using locally available raw materials which were obtained from Nairobi, Dubai to produce paint in his home premises [1–3]. The operation grew, the search for a new location started and a plot at Kireka Vandal (1097) was secured and constructed and bigger additional machines were acquired. The factory started by producing 8500 liters of decorative paints employing over 150 people. As the operations widened production increased to 150,000 liters of paint due to the increased demand for paint by the growing population, production increased to about 1000,000 liters of paint currently one of the leading paint producers in Namanve [4, 5]. The company produces paints under the brand name "Global Paint". These locally produced paints are sold to consumers in nearby locations within Uganda and others outside the country such as Congo. The paint manufacturer produces a lot of wastewater with a very high chemical oxygen demand (COD), Turbidity as well as organic debris, suspended particles, and Heavy metals which are all harmful to the environment. Wastewater is one of the greatest challenges facing urban authorities and industries today which if not properly treated causes a lot of harmful effects to both the environment and Human Health [6, 7]. Therefore, this study was done at the Global Paint company, lighting the existing estimation of the contaminants in the waste post-treated water where samples were taken at different time intervals and analyzed for the ions concentration that is, chlorides, sulfates, pH, Biological Oxygen Demand (BOD) and the chemical oxygen demand (COD). The different management arrangements are also pointed out and recommendations for the proper treatment of wastewater and solid wastes[8]. For the past 10 years at Namanve industrial area, the Global company has been producing paint and other products for domestic use which serves over 2-3 million people relying Globally on their products. The plant generates a lot of wastewater mainly from the production of water-based paints. These wastes are generated from cleaning up equipment such as the mixture machine, Tinting tanks, Batch reactors, and filling machines. Therefore, the discharge of untreated or inadequately treated waste water from paint production poses significant environmental risks due to its high level of pollutants [9, 10]. These pollutants include ions, chlorides, sulfates, chemical oxygen Demand (COD), Total suspended solids (TSS), and Biological Oxygen Demand (BOD). These pollutants contaminate water bodies and harm aquatic ecosystems [11–14]. Therefore, an urgent need to evaluate the efficiency of pretreatment methods in reducing the concentration of these pollutants to mitigate Environmental impact.

MATERIALS AND METHODS

Sulphate Ion (SO_4^{2-}) Analysis

The gravimetric method was utilized using a volumetric flask, burette, plate, analytical, balance, conical flask, barium chloride solution, distilled water, hot plate/stirrer, filteration apparatus, and glass fiber/filter paper.

Sample Preparation

The paint wastewater sample was filtered to remove suspended solids.

The paint wastewater sample was diluted to ensure sulphate ion concentration fell within the linear range of the titration method. The procedure involved preparing a 0.1M Barium chloride solution by dissolving it in distilled water and diluting it to the volumetric flask mark [15].

Preparations of Sulfates

25.0 mL of filtered and diluted waste paint water was pipetted into a clean conical flask. The flask was heated in a hot plate while stirring it gently to ensure uniform mixing.

An excess of Barium chloride solution was added to the heated sample to precipitate out sulfates ions as Barium sulphate ($BaSO_4$). Continuous heat was applied for about 5 minutes to ensure complete precipitation of sulfates. The precipitate was allowed to settle and cool to room temperature.

Filtration and Washing of the Precipitation:

A filtration apparatus with a glass fiber filter paper in a funnel was set. The liquid containing the precipitate was transferred to the filtration apparatus and allowed to filter under gravity. Washing was continued till it was free from chloride ions (confirmed by testing with silver Nitrate solution)

Drying and Weighing of Precipitate

The filter paper with washed precipitate was transferred to a pre-weighed crucible. The precipitate was then dried in an oven at a temperature of 100- 110℃ until when a constant weight was achieved. Cooling of the crucible containing dried precipitate in a desiccator, the precipitate was weighed to determine the mass of Barium sulfate formed.

Calculations,

The sulphate ions concentration in the paint waste was then calculated using the formulae

Sulphate ion concentration $(Mg/L) = \frac{W_2 - W_1}{V_s} x1000$

Where;

W_1 = mass of empty crucible (g)

W_2 = mass of crucible with dried $BaSO_4$(g)

V_s = volume of waste of water sample used (ML)

Conclusion/deduction

The calculated sulphate ion concentration in the paint wastewater for the different samples was compared against regulatory limits. Evaluated sulphate concentration may indicate contamination or inadequate treatment of the wastewater necessitating further investigation and Remediation measures.

Chloride Ions Analysis

The argentometric titration method was used to analyze chloride ions in paint wastewater. The apparatus used included a conical flask, burette, pipette, analytical balance, volumetric flask, standard sliver Nitrate solution (0.1M), potassium chromate indicator solution, and distilled water. The sample was filtered to remove suspended solids and diluted to ensure the chloride concentration fell within the linear range. The standardization of silver Nitrate solution involved weighing 0.1g of sodium chloride, dissolved in distilled water, and transferring it to a 100-volumetric flask. The solution was then titrated with the standard silver Nitrate solution until a reddish-brown color persisted with constant stirring for 30 seconds. The volume of silver Nitrate required for the titration was recorded. Observations included the color change of the indicator from yellow to reddish-brown [15].

Calculations,

The chloride ions concentration of the paint waste was then calculated using the formula,

Chloride ion concentration (mg) = $\frac{VxNxM}{V_s} x35.45.$

where,

V =Volume of silver Nitrate solution used (ml)

N= Normality of the silver Nitrate solution (0.l M)

M= Molarity of chloride ions in the standard solution (0.1M)

Vs= volume of wastewater sample used (ml)

The calculated chloride ions concentration in the paint wastewater was compared for the different samples against regulatory limits. High chloride concentration may indicate contamination or inadequate treatment of the wastewater, Necessitating further investigation and remediation measures.

PH Analysis of the Paint Wastewater

The pH analysis of paint wastewater was conducted using a potentiometric method, using a pH meter with a calibrated glass electrode, pH calibration buffers (pH 4, 7, and 10), a stirrer, a magnetic stir bar, a wash bottle with distilled water, and sample containers. The paint wastewater sample was collected in a clean, labeled container and mixed to obtain a homogeneous composition. The pH meter was calibrated by rinsing and drying the electrode with distilled water, then immersed in a pH 7 buffer solution and adjusted to read the pH 7 butter value. The electrode was then fined with distilled water and repeated calibration processes using pH 4 and 10 buffer solutions. The pH reading was then measured by immersing the electrode in the paint wastewater sample, allowing it to stabilize for about 5 minutes [16, 17].

Observation

The changes in the pH reading were noted as the electrode stabilized in the paint wastewater sample. The pH value observed on the meter display was then recorded.

Deduction

The measured pH values of the different samples were compared against the regulatory limits of process requirements. pH values outside the accepted range may indicate the need for pH adjustment or further treatment of the wastewater to meet the process specifications. The pH measurements are interpreted in the context of other water quality parameters and potential environmental impacts.

RESULTS

The tables present a detailed analysis of the physicochemical parameters of various samples, focusing on sulfate ions, chloride ions , and pH levels. The results show that Sample 3 exceeds the standard of 500 mg/L, with a concentration of 510.850 mg. Samples 1 and 2 are within the acceptable limits. Sample 1 exceeds the standard of 350 mg/L, with a concentration of 358.500 mg. Samples 2 and 3 are within the acceptable limits. The pH of raw effluent is higher (8.9) compared to treated water (7.3), indicating successful pH adjustment during treatment. The sulfate and chloride levels vary across samples, with some exceeding the NWSC standards. Proper treatment is necessary for samples that exceed the standards for sulfate and chloride ions to ensure compliance with NWSC guidelines. Regular monitoring and adjustment are crucial for maintaining the quality of the effluent, particularly for parameters that frequently exceed the standards. Proper treatment is necessary for samples that exceed the standards for sulfate and chloride ions to ensure compliance with NWSC guidelines. Regular monitoring and adjustment are crucial for maintaining the quality of the effluent, particularly for parameters that frequently exceed the standards.

Table 1 Showing SO_4^{2-} ion concentrations in the different samples

Sample	Values (mg)
1	222.610
2	356.510
3	510.850

Table 2: $Cl^{-}mgl$ concentrations in the different samples

Sample	Values (mg)
1	358.500
2	240.000
3	115.700

Table 3: pH of the obtained samples

Sample	Values (mg)
1	7.372
2	8.570
3	6.900

Table 4: Showing standards of the parameters analyzed

Parameters	Standards
pH	6.0-8.0
$SO_4^{2-}(mgl)$	500mgl
$Cl^{-}mgl$	350mgl

Table 5: The results of the physicochemical parameters of the effluent

Parameters	Samples	Sample 2	Sample 3	NWSC standards
pH	7.372	8.570	6.900	6.0-8.0
$SO_4^{2-}(mgl)$	222.610	356.510	510.850	500
$Cl^{-}mgl$	358.500	240.000	115.700	350

Table 6: Showing the pH of raw effluent in comparison to treated water

Parameter	Raw effluent	Treated water
pH	8.9	7.3

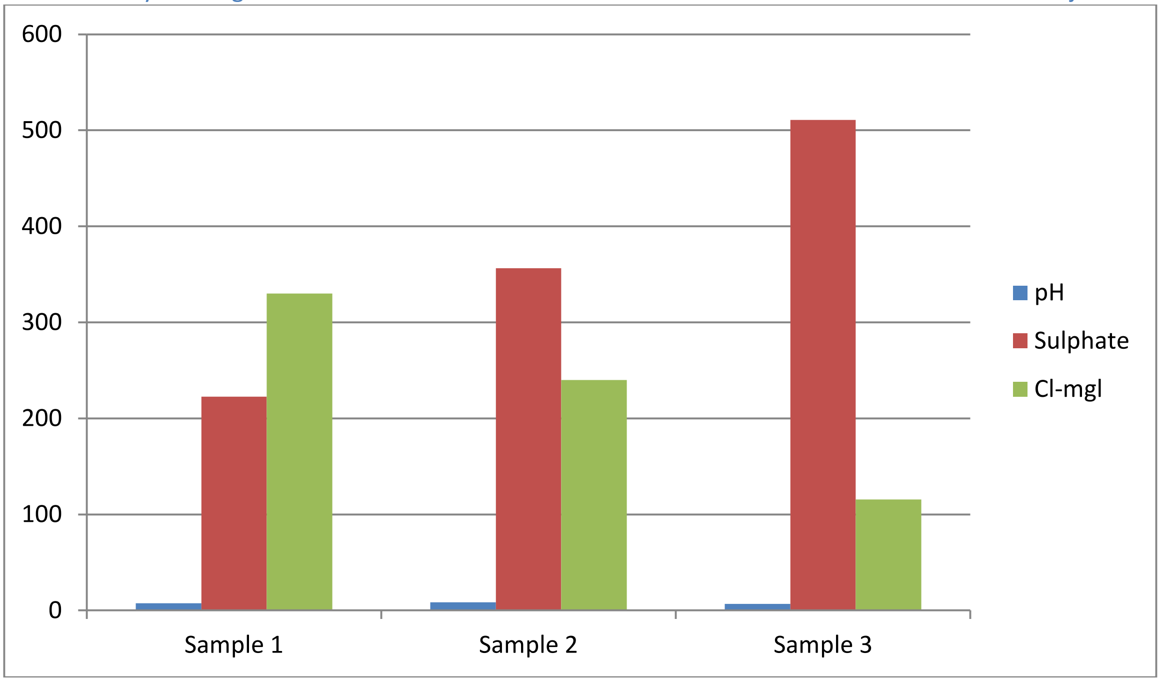

Figure 1: Showing comparison of pH, Sulphate, and Chlorides in different samples

DISCUSSION

The pH values obtained in the study ranged from 8.57 to 6.90 with a raw efficient of pH scale 8.9 while the treated water had a pH of 7.3. Both were alkaline but the raw efficient was more alkaline than the treated water. The obtained pH values were mostly within the Uganda Nation Water and Sewage Corporation standard (NWSC) with the exception of sample 2 which indicated some adjustments to be rectified.

The study conducted a comparison of the pH levels of untreated and treated water, demonstrating that the untreated water exhibited a pH of 8.9, suggesting higher alkalinity, whereas the treated water displayed a pH of 7.3, which was closer to neutral but still slightly alkaline. The majority of the pH readings complied with the guidelines established by the Uganda National Water and Sewage Corporation (NWSC). However, sample 2 failed to satisfy these norms, suggesting the necessity for modification or correction. The treatment process successfully decreased the alkalinity of the raw water, moving it towards a pH that is closer to neutral. Ensuring that the pH remains within the permitted range is essential for maintaining water safety and quality, as excessively high or low pH levels can have adverse effects on human health and the integrity of the water supply system. Nevertheless, the analysis indicates the presence of inconsistencies or sporadic deviations that require attention. Regular and ongoing monitoring and adjustment of the treatment process are essential to guarantee that all water samples conform to the relevant requirements[18–20].

The obtained sulphate values for the post-treated wastewater range from 222.61mgl to 510.850mglL highest in the 3rd sample. The rest of the obtained sulfate value falls within the Uganda National Water and Sewerage Corporation standard with the exception of the last sample which called for an adjustment to be within the standard ranges However sulfates is an essential nutrient for tissue growth in plants and animals. The reduction-oxidation ability of sulfates via chemical and microbiological pathways makes them an important line in the global sulphur cycl. The sulfate content in post-treated wastewater ranged from 222.61 mg/L to 510.85 mg/L. Most sulfate values fall within Uganda National Water and Sewerage Corporation standards, but the last sample exceeds these limits, indicating the need for further treatment. Sulfates are essential nutrients for plant and animal tissue growth and play a significant role in the global sulfur cycle. Regular monitoring and adjustment of sulfate levels are necessary for water quality management, treatment process evaluation, and environmental impact. Further research is needed to develop effective treatment methods [21–23].

The chloride amount in the post-treated waste water Ranges from 115.700 to 358.500mgl, however, for reasons, the chlorides in wastewater should not exceed 350mgl as directed by the WHO standards and World Health Organization. The samples had values that included 358.500mgl, 240mgl, and 115.79mgl. However, the first sample had an elevation of chloride values, which calls for adjustment since very high chloride levels can threaten the sustainability of ecological food sources, hence posing a risk to species survival, growth, and reproduction of aquatic organisms and water quality. For the past few years, there have been several changes due to environmental Regulations and consumer preference for paint containing lower Volatile Organic Compound (Voc's) no smell reduction of toxic heavy metal solutions coatings. Efforts are to be put into the reuse of process water and wash water in applications such as cooling towers process water / solid disposal cost water reuse for pigment production in paint [24–26]. This would save over 50% of the previous water / solid disposal cost water reuse is one of the key components of these initiatives in sustainable goals to reduce operations (costs and comply with increasing strict regulations). Paint industries produce wastewater containing elevated levels of suspended solids color from their operations in addition to non-biodegradable contaminants. Therefore, the higher the levels of contaminants discharged the higher the municipal charge cost for paint manufacturers. Reusing of this water provides a significant Return on investment for paint producers by also reducing in cost purchase of freshwater as well. This would be an important goal in environmental pollution prevention reduction practices in the paint industrial, most companies specialize in organic pollutant pigments coating for cars and commercial applications, and they have been using chemical coagulant/flocculation, however, this approach generated substantial sludge volume discharge cost and High COD levels.

CONCLUSION

In conclusion to this report, elevated levels of chlorides and sulfates in comparison to the permissible level by the World Health Organization, were observed. This indicates that the water is unsafe for both aquatic and human consumption. Addressing the challenge associated with paint wastewater is a multi-fasted approach that includes process optimization, wastewater treatment upgrades, regulatory compliance, and continuous monitoring. By implementing the recommendations above, paint production facilities can mitigate environmental impact, improve operational efficiency, and ensure sustainable wastewater management practices.

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