PAINT WASTEWATER TREATMENT USING Fe^{3+} AND Al^{3+} SALTS

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DECLARATION

I solemnly declare that this thesis is my own work. It is being submitted for the Doctoral Degree in Philosophy in the University of the Witwatersrand, Johannesburg. I also declare that it has never been submitted for any degree or examination in another university.

Signature of Irvin Oupa Lesele Ntwampe

------------------------------day of -----------------------------------2013

ABSTRACT

This study involves the investigation of the paint wastewater treatment using inorganic coagulants such as $FeCl_3$, $Fe_2(SO_4)_3$, $AlCl_3$ and $Al_2(SO_4)_3$ in a jar test during rapid and slow mixing for 250 and 100 rpm respectively, settled the samples, measure the pH and turbidity. The pH, turbidity and area covered by the flocs were used as measurements in this study to determine the quality of treated paint wastewater.

In the first experiment, 200 mL sample of 169.2 g of paint wastewater dissolved in 1L of potable water was poured into six 500 mL glass beakers sample dosed with $FeCl_3$ only, combined $FeCl_3$ and $Ca(OH)_2$ or $Mg(OH)_2$ as well as $FeCl_3$-$Ca(OH)_2$ and $FeCl_3$-$Mg(OH)_2$ polymers respectively, run through a jar test with rapid and slow mixing. The supernatant was extracted after 1 hour settling to measure the pH and turbidity. The observations showed that combined $FeCl_3$ and $Mg(OH)_2$ as well as $FeCl_3$-$Mg(OH)_2$ polymers yielded identical and slightly higher turbidity removal than combined $FeCl_3$ and $Ca(OH)_2$ and $FeCl_3$-$Ca(OH)_2$ polymers.

Another batch of experiments was carried out using the same metal salts with $Ca(OH)_2$ and $Mg(OH)_2$ respectively for pH adjustment. The samples were treated in a jar test using various dosing patterns such as dosages, dosing prior or during mixing, combined dosages interchangeably, retention time. A third batch of experiments was carried out by dosing synthetic polymers of $FeCl_2$-$Ca(OH)_2$ and $FeCl_2$-$Mg(OH)_2$

respectively using similar dosing patterns. The results obtained in first set of experiments, were Fe^{3+} and Al^{3+} salts were added in paint wastewater showed that the changing pH correlates with turbidity removal. It was also observed that dosing prior or during mixing do not play any significant role in wastewater treatment. Another observation showed that flocculation of the paint wastewater dosed with $FeCl_2$-$Ca(OH)_2$ or $FeCl_2$-$Mg(OH)_2$ polymers do not show correlation between the pH and turbidity, which indicates that the pH is not an indicator of turbidity removal in a more alkaline solutions such as paint wastewater.

A second study was carried out using the same paint wastewater samples (200 mL) and samples dosed with Fe^{3+} and Al^{3+} salts treated in a jar test and immediately two drops of supernatant were placed on a microscope slide and view it under a microscope connected to a camera, images were captured after 1, 60 and 90 minutes respectively (Exp A). Samples were prepared from the original paint wastewater and the standard solution of Fe^{3+} and Al^{3+} in a small scale using identical metal salt/paint wastewater volume ratios as above. Two drops from the paint wastewater and metal salt solution were place on a microscope slide and images were captured as above using 1, 60 and 90 minutes respectively (Exp B). All the visuals were printed and the visuals obtained in Exp A were compared with their corresponding visuals in Exp B in accordance with time. The results obtained showed that the percentage area covered by flocs treated in a jar test (Exp A) correlates linearly with the percentage area covered by the flocs from a microscope slide (Exp B). The results obtained using this technique also confirm that the reaction between the drops of a sample and the drops of coagulant produces well-developed solid hydrolysis species.

A third study was carried out by pouring 200 mL of the same paint wastewater samples into six 500 mL glass beakers and with Fe^{3+} and Al^{3+} salts as above, run through a jar test during 30, 45 and 60 seconds rapid mixing (250 rpm) only for 2 minutes respectively. The samples settled for 1 hour, and then pH and turbidity were measured. Another experiment was carried out using the similar method as above with samples run through a jar test at 250 rpm during 30, 45 and 60 seconds rapid mixing (250 rpm) for 2 minutes followed by slow mixing (100 rpm) for 10 minutes (combined rapid and slow mixing). The samples settled for 1 hour, and then pH and turbidity were measured. The results obtained from the jar tests (comparison between flocculation during rapid mixing only and combined rapid and slow mixing) showed that the pH in the samples with rapid mixing shows an insignificant change compared to their corresponding samples with combined rapid and slow mixing; turbidity in the samples with 30, 45 and 60 seconds rapid mixing showed that most of the flocs are formed within 30 seconds. There is a correlation between the pH and turbidity when paint wastewater is dosed with Fe^{3+} or Al^{3+} metal ions in their respective metal salts without pH adjustment. The Fe^{3+} and Al^{3+} of the same concentration yield a similar pH and turbidity trend.

PUBLICATIONS AND PRESENTATIONS FROM THIS RESEARCH WORK

1) Influence of flocculation on settlement rate of paint wastewater during treatment using inorganic coagulants. Ntwampe, I.O,; Jewell, L,; Glasser, D,; University of Witwatersrand. (Presented at Water Institute of South Africa Conference, Sun City, South Africa, May 2008).

2) Determination of the effective rate of hydrolysis between coagulation and flocculation process with Fe and Al salts dose. Ntwampe, I.O,; Jewell, L,; Glasser, D,; University of Witwatersrand. Presented as a poster during inter-varsity poster exhibition between the University of Witwatersrand and Tshwane University of Technology, August 2009.

3) Ntwampe, I.O.;Jewell, L.L and Glasser, D.; The effect of mixing on the treatment of paint wastewater with Fe^{3+} and Al^{3+} salts. Journal of Environmental Chemistry and Ecotoxicology (2013) Vol. 5 No. 1, 7-16.

4) Ntwampe, I.O.;Jewell, L.L and Glasser, D.; The effect of water hardness on paint wastewater treatment by coagulation-flocculation. Journal of Environmental Chemistry and Ecotoxicology (2013) Vol. 5 No. 3, 47-56.

5) Ntwampe, I.O.;Jewell, L.L and Glasser, D.; Comparison of a jar tests and microscope slide experiments for flocculation. Journal of Environmental Chemistry and Ecotoxicology (2013) Vol. 5 No. 6, 172-180. .

DEDICATION

I dedicate this work to the team of researchers that accepted me to pursue studies towards a PhD at the University of the Witwatersrand, my supervisor and co-supervisors for believing in me and the quality of work I carried out, external examiners, library staff, God who gave me strength and courage to strive towards success and achieve the set goal and my family.

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