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EFFECTIVENESS OF LIGNITE COAGULANT FOR REMOVAL OF TEXTILE DYES FROM AQUEOUS SOLUTIONS AND TEXTILE WASTE WATER

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ABSTRACT

Lignite soil was found to be an effective coagulant aid for color removal of textile dyes from aqueous solutions. A comparative study with conventional coagulant had been done. Results show that lignite soil can effectively remove reactive, vat and disperse dyes from their 50mg/L aqueous solutions. Parameters such as color, settled sludge volume have been evaluated. Results showed an increase of color removal, reduction in settled sludge volume when lignite soil was used as coagulant aid with alum and $MgCl_2$. It was found that color removal for reactive blue, vat blue and disperse red was 93%, 92%, 96% for alum, 100% respectively for all dyes with alum and lignite, 100%, 80%, 92% for $MgCl_2$ and 100% respectively for all dyes with magnesium chloride and lignite. For the textile waste water, the color removal was found to be 85% and 91% for alum and alum with lignite, 84% and 90% for $MgCl_2$ and $MgCl_2$ with lignite. The mechanism for coagulation by lignite was found to be a charge adsorption neutralization process. The optimum pH range for lignite coagulant was from 3 to 6. It was found that the settled sludge volume reduced from 90ml to 55ml, and 150ml to 75ml when lignite was used as coagulant aid for alum and $MgCl_2$, for reactive dyes, 50ml to 10ml and 80ml to 30ml when lignite was used as coagulant aid for alum and $MgCl_2$ for vat dyes, 78ml to 55ml and 92ml to 78ml when lignite was used as coagulant aid for alum and $MgCl_2$ for disperse dyes and 84ml to 55ml and 100ml to 80ml when lignite was used as coagulant aid for alum and $MgCl_2$ for textile waste water.

Keywords: Color removal, lignite, chemical coagulation, dyes.

INTRODUCTION

The wastewater is a major environmental issue of the textile industries. In typical dyeing processes, 50-95% of the dye is fixed on to the fibre, and unfixed dyes from subsequent washing operations are discharged in the spent dye bath or in the waste waters (Jiratananon, 2000). These waters must be treated prior to discharge in order to comply with the environmental protection laws for the receiving waters. Biological treatment processes are frequently used to treat textile effluents. These processes are generally efficient for biochemical oxygen demand (BOD) and suspended solids (SS) removal, but they are largely ineffective for removing color from the wastewater (McKay, 1979) because dyes have slow biodegradation rate (Bennett and Reeser, 1988).

The treatment technologies now recommended to meet color removal requirements are physicochemical treatment operations, including adsorption (Ahmad and Ram, 1992; McKay, 1979), ozonation (Lin, 1993), oxidation (Boon *et al*., 2000), chemical precipitation (Dziubek and Kowal, 1983) etc. Each has its merits and limitations in applied decolorization treatment operations. But coagulation-flocculation is the most common chemical treatment method for decolorization (Bennet and Reeser, 1988; Beulkar and Jekel, 1993; Klimiuk, 1999; Helal Uddin, 2003; Seluk, 2005; Nabi Bidhendi, 2007; Yue, 2008). Coagulation is a process for combining colloidal and suspended particles and/or dissolved organic matter in to large aggregates, thereby facilitating their removal subsequently. Chemical coagulants can destabilize particles by four distinct mechanisms: double layer compression, charge neutralization, enmeshment in a metal hydroxide precipitate and inter-particle bridging.

Aluminium sulphate (alum) is the most widely used coagulant in wastewater treatment industry. Using alum, particle destabilization is believed to be brought about by Alpolymers which are kinetic intermediates in the eventual precipitation of a metal hydroxide. These polymers are adsorbed on colloidal particles. The amount of polymer adsorbed and consequently the dosage of alum coagulant necessary to accomplish destabilization of colloidal particles depend on the concentration of colloids. If pH is below the zero point of charge (z.p.c) of the Al hydroxide, positively charged polymers will prevail and adsorption of these positive polymers can destabilize negatively charged colloids by charge neutralization. At high doses of alum, a sufficient degree

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of oversaturation induces rapid precipitation of a large quantity of aluminum hydroxide to form "sweep floc". $MgCl_2$ is a less commonly used coagulant in the industrial waste water treatment. A number of researchers have revealed that enhanced removal of impurities or pollutants has been observed in the presence of magnesium (Liao and Randtke, 1986; Tan *et al*., 2000). Good coagulation could be achieved if enough Mg^{2+} ion was present in the system of lime treatment (Folkman and Wachs, 1973). Dolomite and bittern, which are enriched in magnesium, are found to be very effective in the removal of turbidity and coloring matters.

Lignite soil is a naturally occurring polyelectrolyte, which is mainly the resultant product of the decayed vegetation over a period of time. It is organic in nature and major components are humic acid, lignin and carbohydrates. The aim of the present investigation was to study the effectiveness of this lignite as coagulant aid to remove, reactive, vat and disperse dyes from their aqueous solution and from textile waste water.

MATERIALS AND METHODS

Lignite soil was collected from Neyveli Lignite Corporation, TamilNadu, India. The alum and $MgCl_2$ of commercial grade were used. Analytical grade HCl and NaOH were used for this study. Textile wastewater was collected from one of the textile industry in Erode, Tamil Nadu, India. Lignite coagulant solution used in this study was 4%(w/v) solution, while for alum and $Mgcl_2$, solution of 1 %(w/v) was used.

Coagulation experiments were carried out with rapid

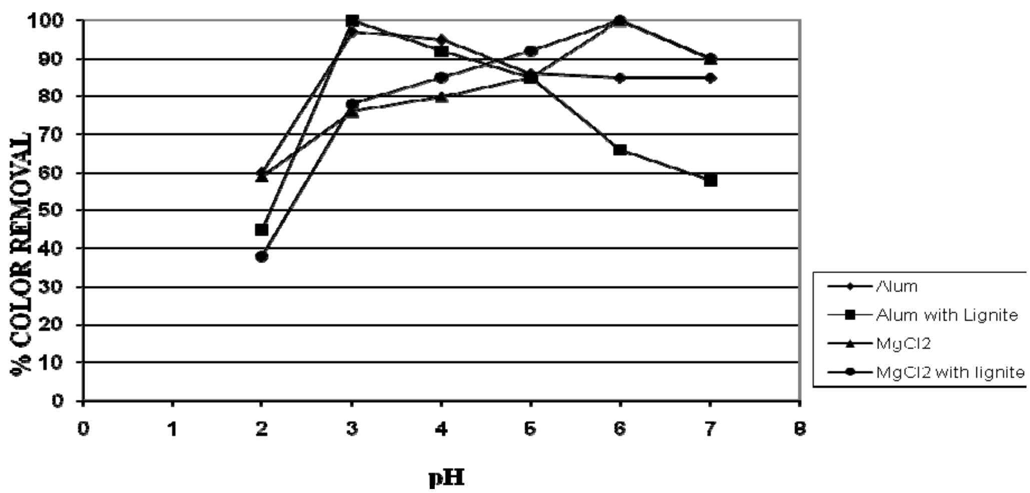

Fig. 1. Effect of pH on color removal of Vat Dyes.

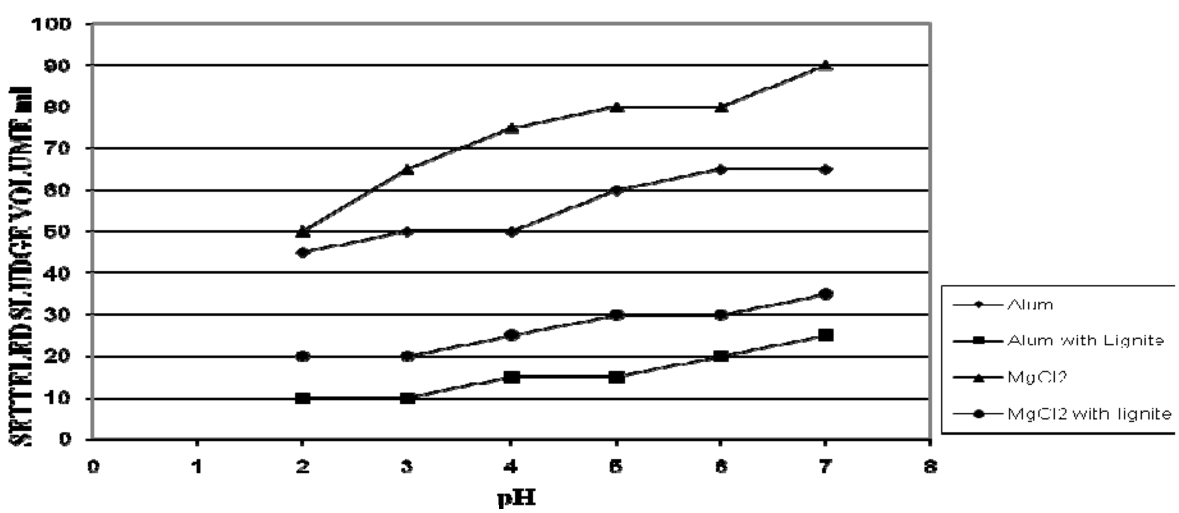

Fig. 2. Settled sludge volume Vs pH for different coagulants for Vat Dyes.

agitation at 500rpm for 2 minutes for thorough mixing, followed by slow mixing at 60rpm for 10 minutes and settling time of 45 minutes. All the experiments were carried out at room temperature. Coagulation studies were conducted in a one litre beaker. Sample volume for dye solution and textile wastewater used was 500ml. After settlement of the sludge, the supernatant was collected for the absorbance measurement and the percentage color removal calculated. Dye Concentration used was 50mg/L for all the dyes. Concentration of the dye samples was measured at the wavelength of the maximum absorbance (λ_{max}), which was determined using a UV-Vis spectrophotometer. The percentage removal of a dye was calculated from the absorbance of the supernatant to the standard curve of each dye obtained from its concentration. For textile wastewater, the λ_{max} was determined by similar method and the percentage removal of the color was calculated considering the original wastewater absorbance value as 0% removal.

RESULTS AND DISCUSSION

In this study, coagulation process was used to decolorize aqueous dye solutions and textile wastewater. The optimum pH and the settled sludge volume were determined by comparing the effectiveness of alum, $MgCl_2$, with Lignite soil for obtaining maximum color removal. At optimum pH and coagulant dose, the effect of coagulant aid has been evaluated. Figures 1,3,5,7 show the percent removal of color at different pH. Figures 2, 4, 6 and 8 show the volume of settled sludge at different pH.

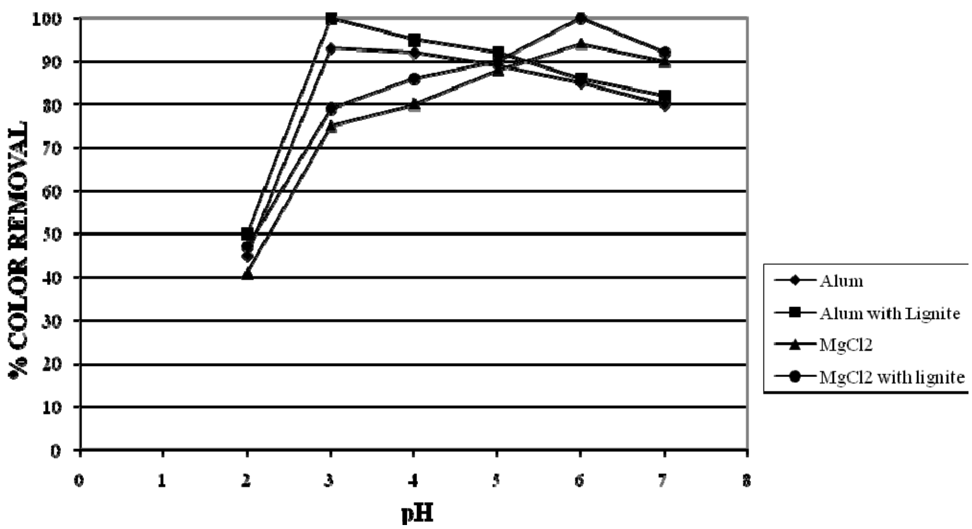

Fig. 3. Effect of pH on color removal of Reactive Dyes.

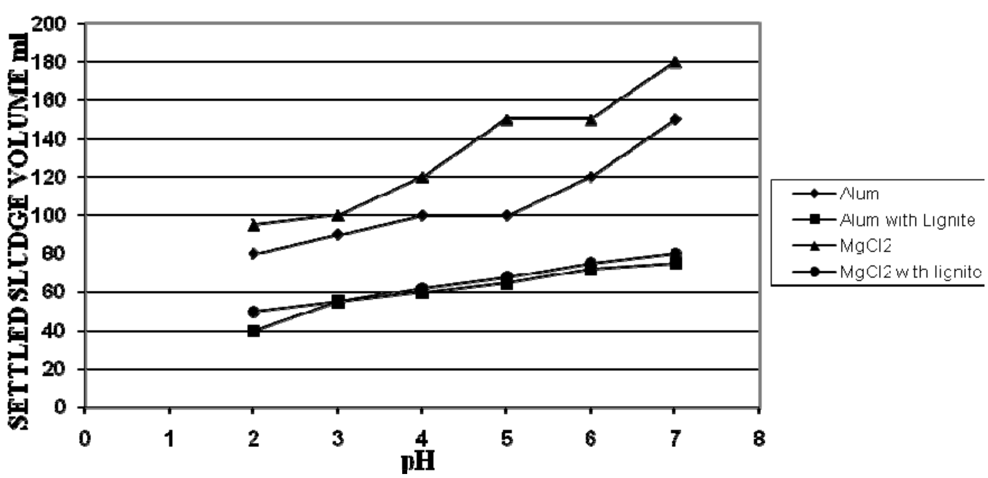

Fig. 4. Settled sludge volume Vs pH for different coagulants for Reactive Dyes.

Alum effect

Vat dyes

Figure 1 shows an increase in color removal from 60% at pH 2 to 97% at pH 3. As the pH was increased from 3 to 7, the percentage color removal decreased from 97 % to 85 %. The settled sludge volume increased from 45 ml to 65 ml as pH was increased from 2 to 7 (Fig. 2). With lignite soil as coagulant aid, there was an increase in color removal from 45 % at pH 2 to 100% at pH 3 (Fig. 1). As the pH was increased from 3 to 7, the color removal decreased from 100% to 58 %. The settled sludge volume increased from 10 ml to 25 ml as pH was increased from 2 to 7 (Fig. 2). At the optimum pH 3, for alum and alum with lignite, the color removal percentage and settled sludge volume were 97%, 100% and 50ml, 10ml respectively.

Reactive dyes.

Figure 3 shows an increase in color removal from 45% at pH 2 to 93 % at pH 3. As the pH was increased from 3 to 7, the percentage color removal decreased from 93% to 80 %. As the pH was increased from 2 to 7, the settled sludge volume increased from 80ml to 150ml (Fig. 4). With lignite soil as coagulant aid, an increase in color removal from 50% at pH 2 to 100 % at pH 3 occurred (Fig. 3). As the pH was increased from 3 to 7, the percentage color removal decreased from 100 % to 82 %. The settled sludge volume increased from 40ml to 75ml as pH was increased from 2 to 7 (Fig. 4). At the optimum pH 3, for alum and alum with lignite, the color removal percentage and settled sludge volume were 93%, 100% and 90ml, 55ml respectively.

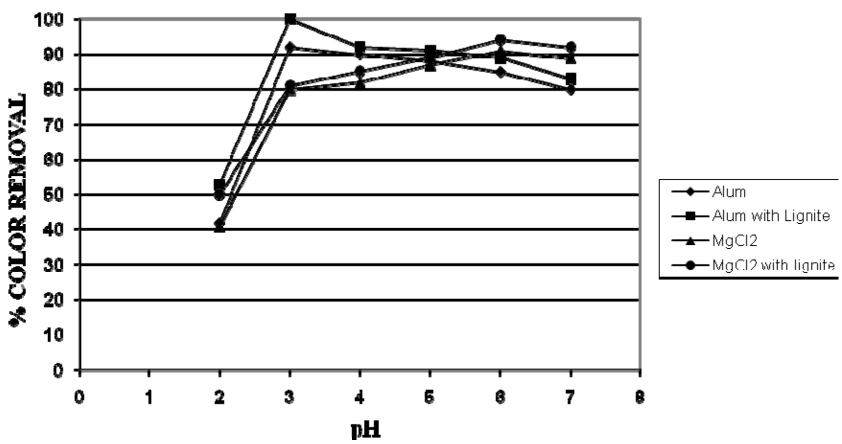

Fig. 5. Effect of pH on color removal of Disperse Dyes.

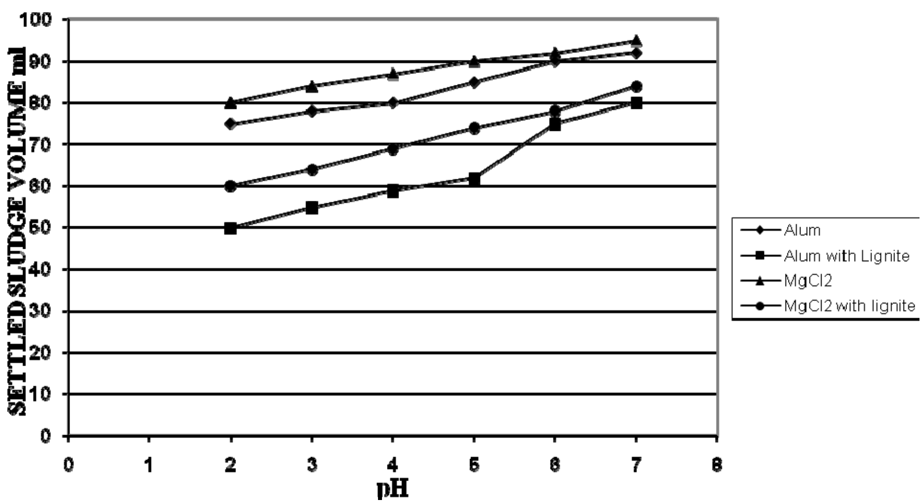

Fig. 6. Settled sludge volume Vs pH for different coagulants for Disperse Dyes.

Disperse dyes

Figure 5 shows an increase in color removal from 42% at pH 2 to 92% at pH 3. As the pH was increased from 3 to 7, the percentage color removal decreased from 92% to 80%. The settled sludge volume increased from 75ml to 92ml as pH was increased from 2 to 7 (Fig. 6). With lignite soil as coagulant aid, an increase in color removal from 53% at pH 2 to 100% at pH 3 was observed (Fig. 5). As the pH was increased from 2 to 7, the percentage color removal decreased from 100% to 83%. The settled sludge volume increased from 50ml to 80ml as P_H was increased from 2 to 7 (Fig. 6). At the optimum pH 3, for alum and alum with lignite, the color removal percentage and settled sludge volume were 92%, 100% and 78ml, 55ml respectively.

Textile dye effluent

Figure 7 shows an increase in color removal from 42% at pH 2 to 85% at pH 3. As the pH was increased from 3 to 7, the percentage color removal decreased from 85 % to 58 %. The settled sludge volume increased from 78ml to 105ml as pH was raised from 2 to 7 (Fig. 8). With lignite soil as coagulant aid, an increase in color removal from 50% at pH 2 to 91% at pH 3 was found (Fig. 7). As the pH was increased from 2 to 7, the percentage color removal was decreased from 91% to 70%. The settled sludge volume increased from 50ml to 80ml as pH was increased from 2 to 7 (Fig. 8). At the optimum pH 3, for alum and alum with lignite, the color removal percentage and settled sludge volume were 85%, 91% and 84ml, 55ml respectively.

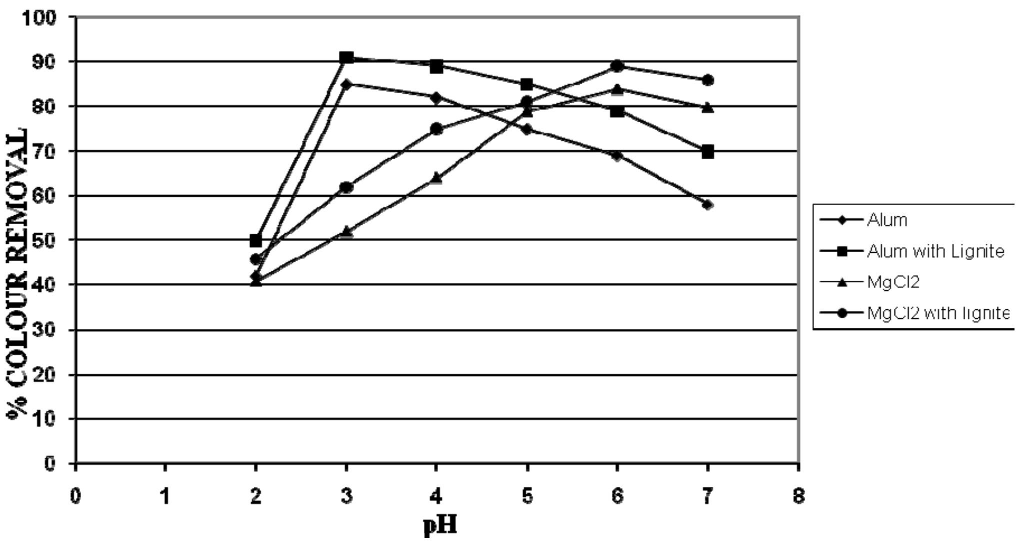

Fig. 7. Effect of pH on color removal of Textile dye effluent.

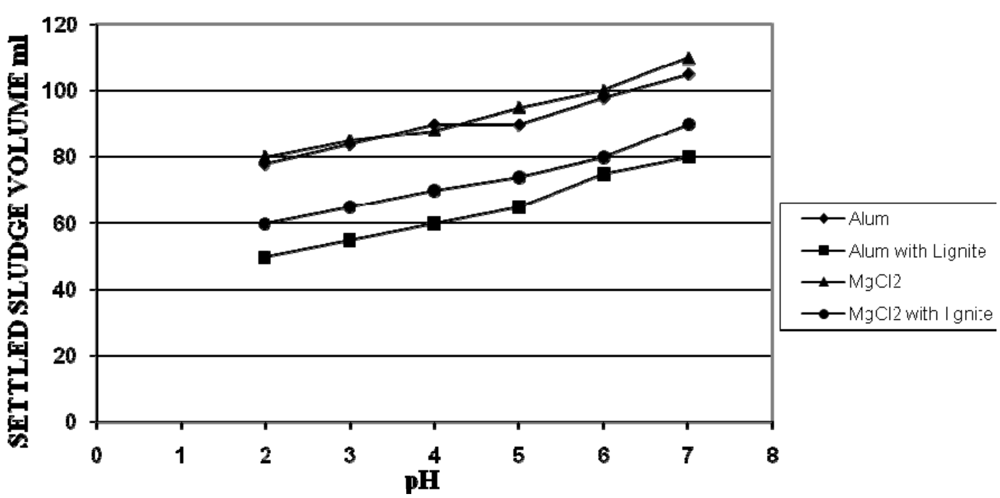

Fig. 8. Settled sludge volume Vs pH for different coagulants for Textile dye effluent.

$MgCl_2$ effect

Vat dyes

Figure 1 shows an increase in color removal from 59% to 100% as the pH was increased from 2 to 6. As the pH was increased from 6 to 7 the color removal decreased from 100% to 90%. The settled sludge volume increased from 50ml to 90ml as pH was increased from 2 to 7 (Fig. 2). With lignite soil as coagulant aid, an increase in color removal from 38 % to 100 % occurred as pH was increased from 2 to 6 (Fig. 1). As the pH was increased from 6 to 7 the percentage color removal decreased from 100 % to 89 %. The settled sludge volume increased from 50 ml to 90 ml as pH was increased from 2 to 7 (Fig. 2). At the optimum pH 6, for $MgCl_2$ and $MgCl_2$ with lignite, the color removal percentage and settled sludge volume were 100%, 100% and 80ml, 30ml respectively.

Reactive dyes

Figure 3 shows an increase in color removal from 41% to 94% as the pH was increased from 2 to 6. As the pH was increased from 6 to 7 the color removal decreased from 94% to 90%. The settled sludge volume increased from 98ml to 180ml as pH was increased from 2 to 7. With lignite soil as coagulant aid, an increase in color removal from 48 % to 97 % occurred as pH was increased from 2 to 6 (Fig. 3). As the pH was increased from 6 to 7, the percentage color removal decreased from 97% to 92%. The settled sludge volume increased from 95ml to 180ml as pH was increased from 2 to 7 (Fig. 4). At the optimum pH 6, for $MgCl_2$ and $MgCl_2$ with lignite, the color removal percentage and settled sludge volume were 94%, 100% and 150ml, 75ml respectively.

Disperse dyes

Figure 5 shows an increase in color removal from 40% to 91% as the pH was increased from 2 to 6. When the pH was increased from 6 to 7 the color removal decreased from 91% to 89%. The settled sludge volume increased from 80ml to 95ml as pH was increased from 2 to 7. With lignite soil as coagulant aid, an increase in color removal from 50 % to 95 % was observed as pH was increased from 2 to 6. When the pH was increased from 6 to 7, the percentage color removal decreased from 95% to 92%. The settled sludge volume increased from 80ml to 95ml as the pH was raised from 2 to 7 (Fig. 6). At the optimum pH 6, for $MgCl_2$ and $MgCl_2$ with lignite, the color removal percentage and settled sludge volume were 91%, 94% and 92ml, 78ml respectively.

Textile dye effluent

Figure 7 shows an increase in color removal from 40% to 91% as the pH was increased from 2 to 6. When the pH was increased from 6 to 7 the color removal decreased from 91% to 89%. The settled sludge volume increased from 80ml to 95ml as the pH was increased from 2 to 7 (Fig. 8). With lignite soil as coagulant aid an increase in color removal from 46 % to 90 % was observed as pH was increased from 2 to 6 (Fig. 1). As the pH was raised from 6 to 7, the percentage color removal decreased from 90 % to 86 %. The settled sludge volume increased from 60 ml to 90 ml as the pH was increased from 2 to 7 (Fig. 8). At the optimum pH 6, for $MgCl_2$ and $MgCl_2$ with lignite, the color removal percentage and settled sludge volume were 84%, 90% and 100ml, 80ml respectively.

CONCLUSIONS

Lignite coagulant is able to remove efficiently 100% of vat and disperse dyes and 96% of reactive dyes from their 50 ppm aqueous solutions. pH plays an important role in coagulation for all the 3 dyes. In the pH range of 3-6, coagulants showed a higher color removal percentage. There was a considerable decrease in settled sludge volume with lignite soil as coagulant aid. The mechanism of coagulation with lignite was found to be charge adsorption neutralization. We can conclude that lignite soil which is freely available can be used as coagulant aid for effective removal of colour and reduction in sludge volume. Lignite also reduces the amount of coagulant used.

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