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Removal of Copper Ions from Waste Water by Coagulation by Using Magnesium Chloride and Aloe Vera Leaves

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Abstract

Removal of copper ions from wastewater by coagulation by using magnesium chloride and aloe vera leaves was investigated. Analysis of chemical composition of aloe vera leaves gave the following results: moisture 6.94%, ash 15.94%, crude fibre 73.50%, fat 3.10% and protein 9.28% . The FTIR spectrum revealed characteristic bands typical of aloe vera plant. C-H stretch of alkanes and alkyls were shown at 2922.2 and 2851.4 cm^{-1} respectively. The copper uptake by both coagulants was studied. The effects of pH, settling time, temperature, coagulant dosage and initial metal ion concentration were conducted in order to investigate the capacity of both coagulants used in flocculation process. Results obtained from the study showed that magnesium chloride gave better metal uptake than the aloe vera leaves.

Keywords: Aloe vera, Chemical composition, Coagulation, Magnesium chloride, wastewater.

Introduction

Water is a vital substance and of prodigious significance in all natural and anthropogenic activities. It regenerates shape and oceans and seas, rivers, lakes and forests, becoming part of the identity of environments and landscapes and of paramount importance for the development of ecosystems and human life (Vijayaraghvan, Sivakumar & VimalKumar, 2011). It has been considered an infinite good, but has been misuse recently, with growing demand,which has made reserves of fresh and clean water decrease (Telles & Costa, 2007). Abidin, Ismail, Yunus, Ahamad and Idris, (2011) reported that since water has the ability to solubilize, pure water is not found in nature. Dissolved impurities comprise minerals, organic compounds and gases that alter the physical (turbidity, color, temperature, electrical conductivity), chemical (chemical and biological demand for oxygen, pH, alkalinity, total organic carbon) and biological characteristics of water, whose effect depends on the composition, concentration and chemical reactions between pollutants (Annika, Blix, 2011; Richter, 2009). Surface water and groundwater provide a continuous means of water supply to be treated into drinking water (Percival, Walker & Hunter, 2000). These water sources could be contaminated with pathogenic microorganisms, dissolved and suspended solids, colour and odour-causing particles rendering the water to be unsafe for direct human consumption. The presence of such impurities diminishes the quality of the water, and they must be removed effectively. Ndabigengesere & Subba-Narasiah, (1998a) affirmed that adequate water sanitation which comprises the coagulation and flocculation, sedimentation, filtration and disinfection processes remains the key to minimizing the health-threatening potentials from the related water-borne diseases.

Heavy metal ions contained in the industrial waste water are one of the most common pollutants found in major waterways. The heavy metal is highly toxic and can affect human, plant and animal lives and aquatic systems. They are contemplated to be the following elements: Copper, Zinc, Cadmium, Lead, Chromium, Nickel, Arsenic, Tin, Iron, Selenium, Molybdenum, Silver, Gold, Mercury, Cobalt, Aluminium and Manganese (Femina, Senthil, Saravanan, Janet & Naushad, 2017). These symbolize serious threats to the human populace and the animals and plants of the receiving water bodies. These can be soaked up and assembled in human body and cause consequential health issues like organ damage, cancer, nervous system damage, and in extreme cases, death. It's also observed to decrease growth and evolution. In this context, water treatment becomes crucial so as to remove suspended and colloidal particles, organic matter, micro-organisms and other substances that are deleterious to health, seeking the lowest cost of deployment, operation and maintenance and reduced environmental impacts to the surrounding region (Bailey, Olin, Bricka & Adrian, 1999).

Coagulation is typically the first step in the water treatment process. The relevance of the coagulation process centres on its ability to form larger destabilized particles known as microflocs which in turn helps to remove water toxins such as heavy metals. These toxins are harmful to aquatic health. In addition to turbidity, pathogens and other finely dispersed colloids would also be removed to improve the water quality and subsequently leading to better human health. Flocculation takes place as the adjunct to the enhancement of the microflocs formation (Bratby, 2006).

Coagulants play a major role in the treatment of water and wastewater and in the treatment and disposal of sludge. Many coagulants used in conventional treatment process includes inorganic coagulants such as aluminium sulfate, alum, and organic coagulants are polymers that are composed of a single type of charged monomer subunit that may be artificial or natural materials, is the common chemical coagulant used in the coagulation process (Warhurst, McConnachie & Pollard, 1996). Coagulants that are commercialised in the market are mostly chemical-based, which are non-environmental friendly and may create adverse impacts on the surrounding environments (Katayon *et al*., 2006; Ozcan, Omeroglu, Erdogan & Ozcan, 2007). Residue left after treatment process may cause several health hazards. Okuda, Baes, Nishijima and Okada (1999) reported that aluminium based coagulants are linked in the development of neurodegenerative illnesses as sesil dementia and with Alzheimer's disease (Rondeau & Commenges, 2001). As a result, it is important to search for replacement of these inorganic and organic coagulants with alternative natural coagulants. Natural coagulants (bio-polymers), according to Binayke and Jadhav, (2013), would be of great interest since they are natural low-cost products, characterized by their environmentally friendly behavior and presumed to be safe for human health. There has been considerable interest in development and usage of plant based natural coagulants (Miller, Kopfter, Kelty, Strober & Ulmer, 1984).

2. Materials and Methods

2.1. Materials

Aloe Vera obtained from Market, Abakaliki, Ebonyi State was used as natural coagulant. The analytical grade chemicals used include: sodium hydroxide, magnesium chloride in $Mgcl_2$, hydrochloric acid and copper (II) chloride.

2.2. Percentage Composition of the Samples

The parameters moisture, ash, crude fibre, fat and protein contents of the aloe vera leaves were determined using procedures described by the association of Analytical Chemist (AOAC)

2.3. Wastewater: Collection and Simulation

Wastewater samples were collected at River Niger using three litre plastic gallon and the concentration analysed using the atomic absorption apectrometer (AAS). The synthetic wastewater contaminated with copper was hence prepared and concentration was also analysed using AAS in the analysis. To simulate the copper contaminated wastewater, a mass of 2.00g of copper salt (kermal) was incorporated into 1000 ml of distilled water. This was observed so as to simulate standard (wastewater) solution for treatment using the coagulant types respectively. Subsequently, the concentrations (initial and final) of the solution were recorded as detected by the spectrophotometer.

2.4. Fourier Transform Infrared (FTIR) Spectroscopy

The spectrum from the coagulant sample showing the functional present was obtained by placing a little quantity of the sample on the FTIR machine (Agilent Technologies CARY 630). This was to properly detect the respective functional groups in aloe vera and magnesium chloride (the coagulants).

2.5. Coagulation-Flocculation of Simulated Wastewater

During the coagulation/ flocculation process, several parameters can affect the process. They are: pH, settling time, temperature, coagulant dosage and concentration of the target pollutant. These factors individually and collectively have a great influence on the coagulant's optimum performance. The investigation was carried out keeping the volume of 70 ml constant in an Erlenmeyer flasks (250-mL).

3. Results and Discussion

3.1. Percentage Composition

This analysis was carried out to determine chemical composition of Aloe vera leaves. Moisture content of 6.94% was observed, while ash, crude fibre, fat and protein contents were 15.93%, 73.50%, 3.10% and 9.28% respectively. Muaz and Fatma, (2013) reported ash and fibre contents of 16.88% and 73.35%. Investigations by earlier researchers indicated 90-98% moisture in Aloe vera leaf. (Femenia, Sanchez, Simal, & Rossello, 1999; McKeown, 1983; Parks & Rowe, 1941).This could be due to the high quantity of crude fibre contained the aloe vera. The moisture value was greater than that reported by Bradford, (1976), who got moisture content of 4.25% but close to that obtained by Muñoz, Leal, Quitral and Cardemil, (2015) with a value of 6.9%. The aloe vera powder contains leaf tissue without gel. This might have influenced the value obtained for moisture content. The percentage composition of the sample is presented in Table 3.1.

Table 3.1: Percentage Composition of Aloe Vera Leaves

Parameters (%)	Aloe Vera
Moisture Content	6.94
Ash Content	15.93
Crude Fibre Content	73.50
Fat Content	3.10
Protein Content	9.28

3.2. FTIR Spectrum

Characteristic absorption of several classes of compound was well revealed by the FTIR. C-H stretch of alkanes and alkyls were shown at 2922.2 and 2851.4 cm^{-1} respectively. Absorption at 1397.8 cm^{-1} showed the $–CH(CH_3)_2$ bend of same alkanes and alkyls. Presence of carboxylic acids was revealed with the O-H stretch band at 2359.4 cm^{-1}. The peaks at 1244.8, 1148, 1021.3 cm^{-1} represents =C-O-C symmetrical and asymmetrical stretch and C-O-C stretch of ether family accordingly. Alkenes were also detected at absorption 890.8 cm^{-1} with =C-H bend assignment. The band at 1315.8 cm^{-1} revealed the presence of N-O symmetrical and asymmetrical stretch of nitro compounds. These bands were also confirmed by other researchers (Archana & Anubha, 2016; Fatemeh & Sattar, 2012). The FTIR spectrum of Aloe vera used here is shown in Figure 3.1.

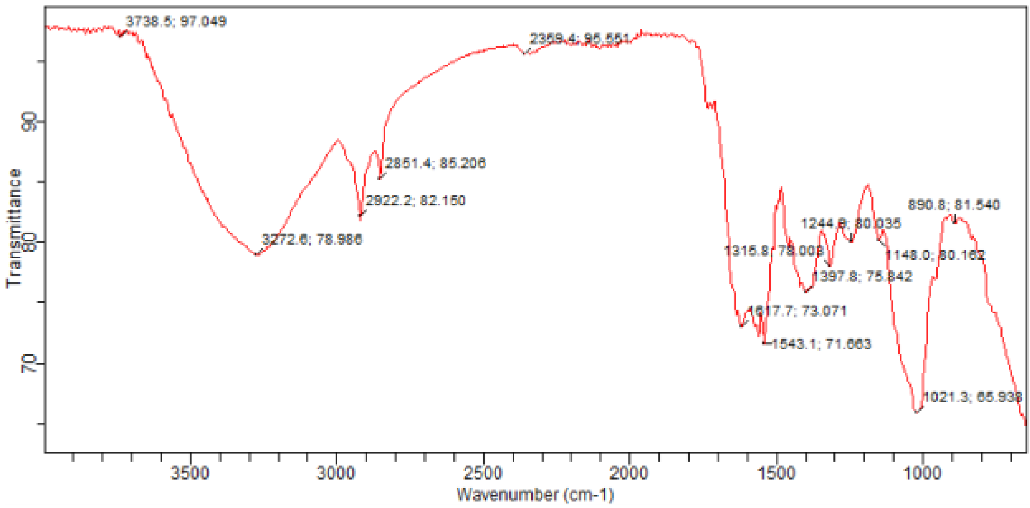

Fig. 3.1: FTIR Spectrum of Aloe Vera Leaves

3.3. Coagulation-Flocculation Studies

The copper uptake by both coagulants was studied. The effects of pH, settling time, temperature, coagulant dosage and initial metal ion concentration are the experiments which were conducted in order to investigate the capacity of both coagulants used in flocculation process. The characteristics of the wastewater from River Niger were as follow:

3.3.1. pH Effect on the coagulation/ flocculation of copper metal ion.

The solution pH is one of the parameters having considerable influence on the coagulation of metal ions, because the surfaces charge density of the coagulant and the charge of the metallic species present on the pH. As shown in Figure 3.2, the extent of copper uptake was studied in the pH range 3-10. For the aloe vera, the optimum pH was 5, with a percentage removal of 30.59%. However, pH 8 was the optimum for the magnesium, with a percentage removal of 39.22%. At pH value above optimum pH, there was a decrease in the percentage removal for both coagulants. Hence, the approach of the positively charged copper ion to the respective coagulant was inhibited above pH 8 and 5 (for magnesium chloride and aloe vera). Similar trends have been reported by other researchers (Reena, Suman & Sushila, 2015; Sag, Ozer, & Kutsal, 1995).

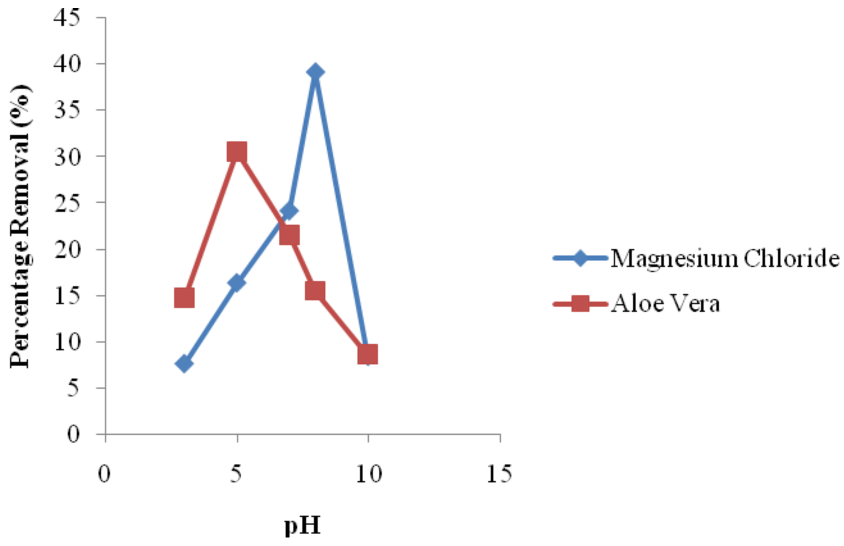

Fig. 3.2: Plot of percentage removal of copper metal ion versus pH.

3.3.2. Settling time effect on the coagulation/ flocculation of copper metal ion.

The time effect was carried out at optimum pH conditions. Figure 3.3 below showed settling time effect on the coagulation/ flocculation of copper metal ion. For the aloe vera, the optimum settling time was observed at 40mins, with a percentage removal of 39.65%. For the magnesium chloride coagulant, the optimum settling time was 80 mins. At 80 mins, its percentage removal was 52.82%. On exceeding these optimum settling times, there was a decrease in the percentage removal for both coagulants. Comparing both coagulants, magnesium chloride gave a higher percentage removal value than aloe vera. It may be because magnesium chloride reacted faster than aloe vera.

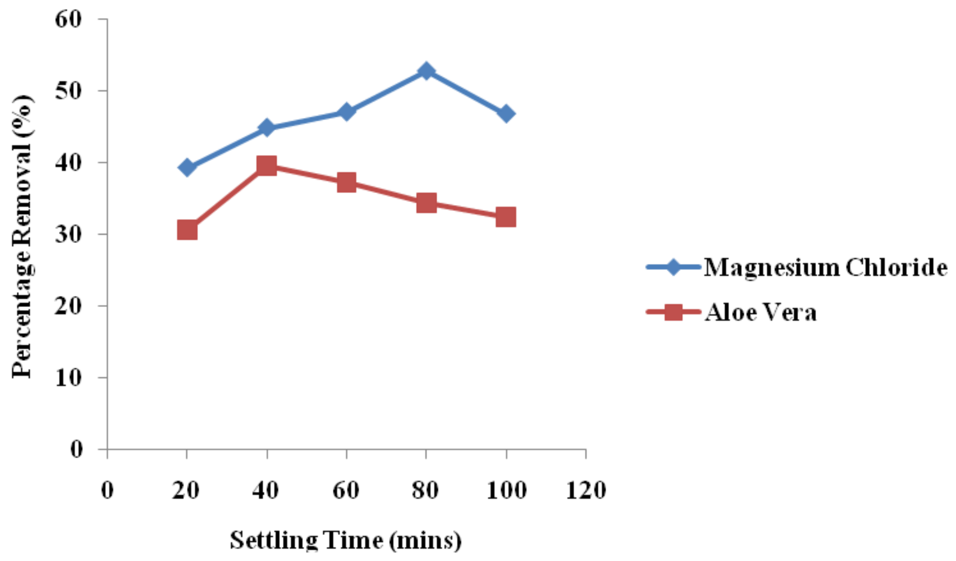

Fig 3.3: Plot of percentage removal of copper metal ion versus settling time.

3.3.3. Temperature effect on the coagulation/ flocculation of copper metal ion.

The temperature effect of both coagulants is shown in Figure 3.4 respectively. For the aloe vera, the optimum temperature was 40^{o}C (i.e. 54.88% removal). Above this temperature, a gradual decrease in the percentage removal was the case. Magnesium chloride had an optimum temperature of 40^{o}C and percentage removal of 64.15%. Though both coagulants had the same optimum temperature, their percentage removals varied. Magnesium chloride clearly flocculated more of copper metal ions than magnesium chloride at 40^{o}C.

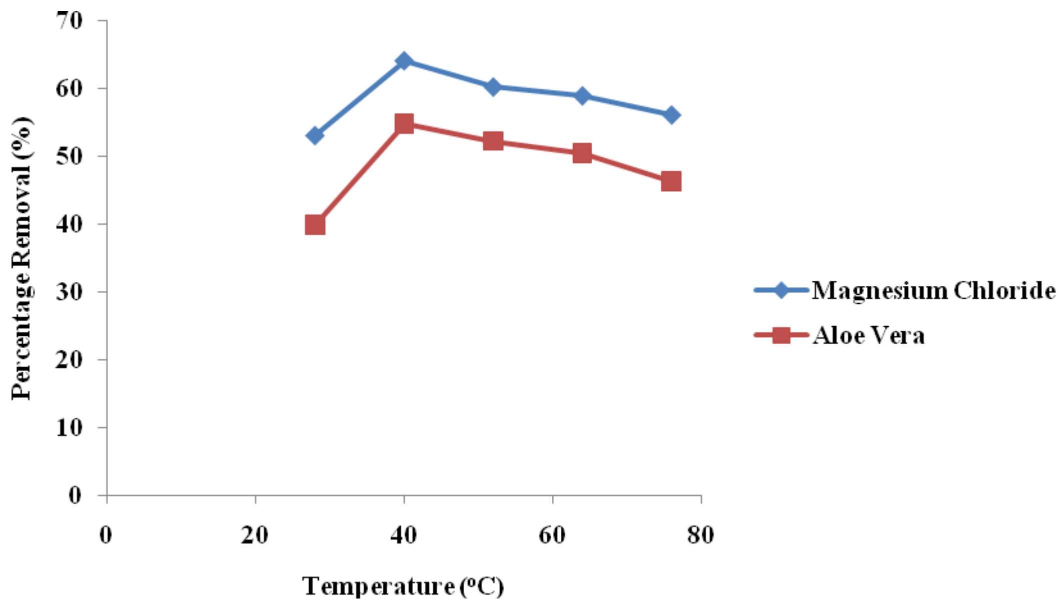

Fig. 3.4: Plot of percentage removal of copper metal ion versus temperature.

3.3.4. Coagulant dosage effect on the coagulation/ flocculation of copper metal ion.

Figure 3.5 showed the coagulant dosage effect on the coagulation/ flocculation of copper metal ion. For aloe vera, the optimum coagulant dosage was 1.20g. Its optimum percentage removal was 58.90%. Above the optimum dosage, there was a decrease in the percentage removal. This can be due to the filling of all the active sites. Magnesium chloride had an optimum percentage removal of 67.96% at 1.50g coagulant dosage. Similar trends have been reported (Reena *et al*., 2015). Comparing both coagulants, magnesium chloride gave a higher percentage removal than magnesium chloride.

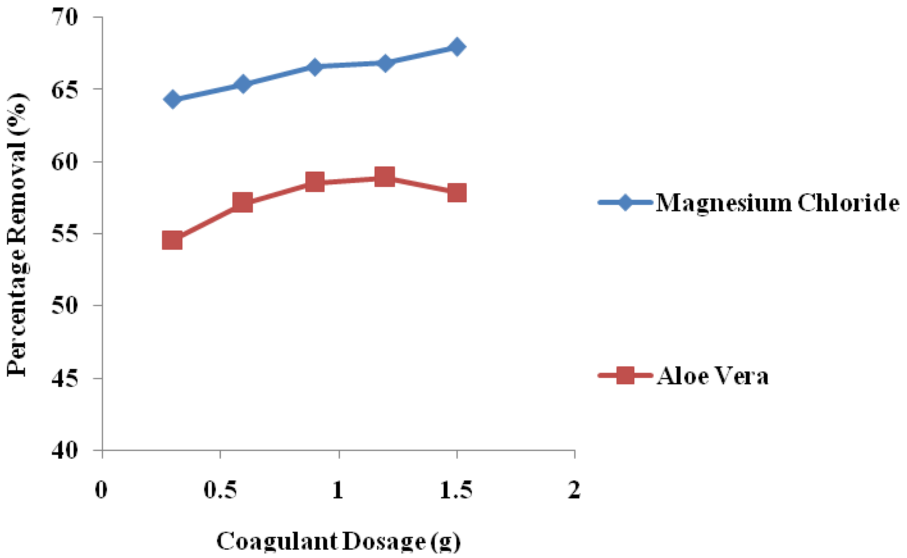

Fig. 3.5: Plot of percentage removal of copper metal ion versus coagulant dosage.

3.3.5. Initial metal ion concentration effect on the coagulation/ flocculation of lead metal ion

The effect of initial metal ion concentration was studied from 130-250 mg/L. The results are shown in Figure 3.6 below. For aloe vera, there was a gradual decrease in the percentage removal from 58.90% (i.e. 130mg/L) down to 52.43% (i.e. 250mg/L). For magnesium chloride, the percentage removal decreased from 69.99% (i.e. 130mg/L) down to 65.07% (i.e. 250mg/L). The decrease in percentage removal with an increase in concentration of copper ions (for both coagulants) is due to the unavailability of active coagulation sites. Similar trends have been previously confirmed by other researchers (Rao, Parwate & Bhole, 2003; Yu, Shukla, Doris, Shukla, & Margrave, 2003)

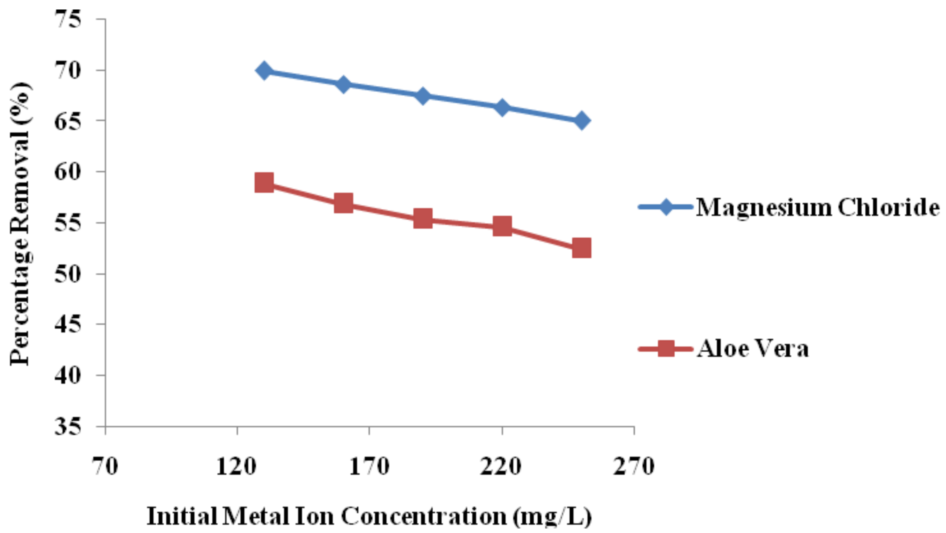

Fig. 3.6: Plot of percentage removal of copper metal ion versus initial metal ion concentration.

4. Conclusion

This investigation has provided a concise resume of information regarding percentage and structural composition of Aloe vera leaves. In addition, a comparison was made between magnesium chloride and aloe vera coagulant when used in treating copper ions of known concentrations. From the results, the performance of the synthetic coagulant (magnesium chloride) was better than the aloe vera used.

5. Recommendation

It would be worthwhile embarking on an intensive scientific experimentation and investigation on this apparently valuable plant (aloe vera) and to promote its large-scale utilization. Treatment of this plant can be encouraged so as to compare performance.

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