OPEN ACCESS INTERNATIONAL JOURNAL OF SCIENCE & ENGINEERING

Chemical Leaching of Aluminium from Aluminium workshop waste and its reuse in drinking water treatment

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Abstract: Aluminium (Al) is one of the most valuable metals in the world. Unfortunately, many Al workshops in the world dispose of a large portion of their Al as waste. This study experimented the use of chemical leaching method to extract Al from waste produced in Al workshops and its reuse in drinking water treatment. The Al content in AWW was found out to be 956.4 mg/g using acid digestion method. This study used low strength nitric acid as a leaching solution. The strength of acid was varied between 0.1 N to 0.6 N with an increment of 0.1. The leaching process was carried out using Jar Test Apparatus at agitation speed equals to 180 rpm for 120 minutes. The optimized recovery of Al was found to be equal to 55.36% at 0.5 N strength of leaching solution. The leached solution was then used as a coagulant in treatment of water samples collected from natural sources. The optimized coagulant dose for Kolar river sample to achieve turbidity less than 5 NTU was found at 3 ml/L of recovered coagulant. Similarly the optimized coagulant dose for Ambazari lake water sample was found to be 3 ml/L.

Keywords: Aluminium, Nitric Acid, Jar Test.

I. INTRODUCTION

The Alumnium (Al) workshop industry produces huge amounts of scrap as a waste. This generated waste is directly disposed of to the landfills. The untreated disposal of waste leads to the permanent loss of natural resource like Al. Recent studies experimented the recovery of Al from various types of waste. The recovery of metals from waste can be achieved using the leaching process. Leaching is the process of Dissolution of metals from its strong oxide form into dissolved ionic form. The process of leaching is achieved in a strong acidic medium. Numerous studies shown the use of strong mineral acids (1- 4 N) in leaching.

Metal containing waste, a kind of new wastes, has a great potential for recycling and is also difficult to deal with. Many countries pay more attention to develop the metal recovery process and equipment of this kind of waste as raw material, so as to solve the environmental pollution and simultaneously utilize the discarded metal resources. Leaching is an efficient and environmentally friendly technique for metal recovery from waste. As more and more solid waste is generated in industrial processes due to constant increase in demand, there is increase in metal waste in solid waste.

Al is a valuable metal widely used in various industrial processes, including the automotive and construction sectors. However, the aluminium workshop industry is major contributor to the waste generation. The disposal of such huge amount of generated waste is major concern to the society.

Water scarcity is one of the major problem presents around the globe. The reason behind water scarcity is the uncontrolled growth in population and hence ultimately safe drinking water demand. As per WHO (World Health Organization) by the end of 2050 the 70% of globe will not have drinking water rather safe drinking water. Report during the World Economic Forum in 2015, water was ranked first in terms of global risk, with the highest economic impact for the next decade. This high importance of the water issue is closely reflected in the Sustainability Development Goals (SDGs), not only by mentioning the water goal as the sixth goal (SDG 6), but also by considering its effect on other goals of the development agenda.

II.LITERATURE SURVEY

Aniket Dahasahastra et al 2023

This study aimed at exploring the potential for recovery of coagulant from WTR using Acidithiobacillus ferroxidans (ATF) and reusing the recovered coagulant for turbidity removal from water. The activity of ATF was measured by monitoring the pH and Al recovery (in %, AlR %). The effects of two factors (Water treatment residue and sulfur dose) on the activity of ATF were studied using central compound design (CCD) and response surface methodology (RSM). The RC was reused for the turbidity removal from lake water and synthetic turbid water (STW) and compared with the turbidity removal. The results obtained indicate that the RC is efficient in turbidity removal.

Aniket Dahasahastra et al 2022

The present study focused drinking water treatment without hampering the treated water quality. The study used low strength nitric acid to leach Al from WTS. The leaching studies were performed using a Box-Behnken Design (BBD) with three factors: acid strength (M), reaction time and sludge dose. The RC in removing turbidity was evaluated on synthetic turbid water and was compared with turbidity removal obtained with

1% (w/v) solution of commercial alum. The environmental significance of the study is that, it shows that the RC has potential to be used as a coagulant in drinking water treatment study proposes a method to recover coagulant from WTS, and reuse it safely as a coagulant.

Zohra Bensaadi-Ouznadji et al 2021

The main objective of this study is the application of electrocoagulation to produce a coagulant for drinking water treatment using Al plates recovered from waste of Al door and window manufacturing workshop. The results showed that 47.6 g of coagulant was obtained for pH equal to 4 and electrolyte concentration of 0.04 mol L^{-1} with four electrodes for the period of 1 day. The produced coagulant was characterised by structural analysis, analysis by scanning electron microscopy (SEM) and physical analysis by BET. The coagulant prepared was used in conjunction with the commercial flocculant (polymer) to evaluate their performance to removal efficiency of organic matter (~97%), turbidity (82.61%) and the Al ions (Al3+) concentration (50%) in raw water.

Naga Raju Batti, N. R. Mandre 2021.

This study has been made to investigate and optimize the recovery of Ni and Al through sulphuric acid leaching under different operating conditions. The leached liquor Al was separated by selective crystallization using 1.4 mol/L KOH and Ni was separated by selective precipitation using 0.3 mol/L H2C2O4. M. from the studies, it is possible to recover around 97.9% of NiO having 98.3% purity, around 25% of Al2O3 was also recovered as alum having 99% purity. 14.7% of Al2O3 as a salt of Al−K−C2O4−SO4. Sulphuric acid was found to be a suitable leaching agent for selective leaching it was also observed that alum-(K) can be selectively crystallized from sulphate solutions.

III.METHODOLOGY

Material

The scraped Al was collected from Sainath Aluminium window workshop Industry located at Vasudev nagar Nagpur, India. The chemical used in the study: nitric acid, hydrochloric acid, alum, the reagents were used of AR grade and obtained from Loba Chemie Pvt Ltd, India. All reagents were prepared with distilled water. The pH meter (ionix, model361), turbidity meter (Deluxe model335), jar test apparatus (EIE instruments), weighing balance with least count of 0.0001 g (Wensar model), Filter paper (Whatman filter paper no. 42) ICP-OES (Thermo scientific, I-CAP 6300 DUO) were used for analysis.

Acid digestion:-

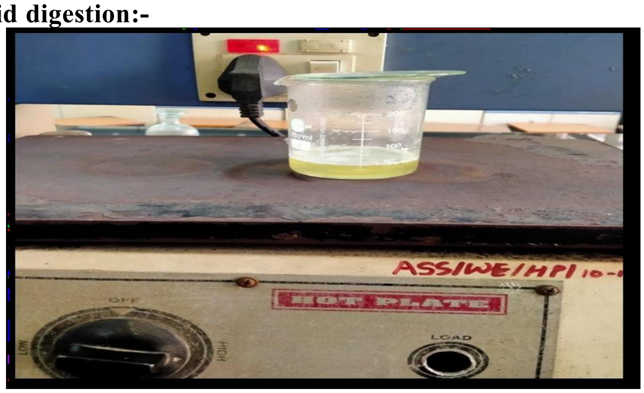

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Fig 3.1: Acid Digestion process

The metal content in the AWW was determined by leaching the metals from the AWW into aqueous phase by acid digestion method as per Standard Methods for the Examination of Water and Wastewater, followed by analysis on ICP-OES according to Method 6010D .Briefly, for acid digestion, 1 g of AWW was mixed with 10 ml of nitric acid (1:1 v/v) and boiled for 10 minutes

The process of leaching:-

Leaching is the process of extracting metal from its strong oxide form into the dissolved ionic form. This process was performed using nitric acid with strengths of 0.1 N, 0.2 N, 0.3 N, 0.4N ,0.5N and 0.6N The minimum value of AWW dose (i.e. 1gm) and maximum value of reaction time (i.e. 120 min) were the fixed parameters. The experiments were performed on jar test apparatus. In each set of experiment, 1gm of AWW was added in 1000 ml of specified acid strength (N) solution. The mixture was then stirred at 180 rpm for 120 min.

3.1.4 The process of Filtration;-

In filtration process, the insoluble solid particles of an Al are separated from solution by using filter paper. The process of removing insoluble solid from liquid by using filter paper is known as filtration. The solid which remain behind on the filter paper is called the residue. The liquid which passes through the filter paper is called the filtrate. When solution of leached Al is passed through the filter paper, the liquid solution travel through the tiny pores of filter paper, but insoluble particles of Al cannot pass through the filter paper. Hence, Al particle will left behind on the filter paper as residue and leached Al solution will be filtered out as filtrate.

Performance Evaluation of RC as a Coagulant

The efficiency of the RC in removing turbidity was evaluated by performing jar test on lake and river water. The result obtained were compared with the turbidity removal obtained with sulfate solution on the same water sample. The resulting solution was rapidly mixed at 180 rpm for 5 min and then mixed at 30 rpm for 120 min. The sample was analyzed for initial turbidity using a turbidity meter, and then that value was used for coagulation experiments. The lake water sample was collected from the Ambazari Lake located at 21.1287° N and 79.0405° E in Nagpur. The coagulation experiments using both aluminum sulfate solution and RC were performed according to the Standard Practice for Coagulation Flocculation Jar Test of Water. The jar test consisted of adding the desired dose of coagulant and flash mixing at 150 rpm for 2-3 min followed by slow mixing at 25 rpm for 20 min. The solution was then allowed to stand still for 45 min. The supernatant was withdrawn from roughly 2 cm below the liquid level and then analyzed for residual turbidity. The coagulant using aluminum sulfate was prepared by adding 1 g aluminum sulfate in 1000mL distilled water (i.e., 0.1%w/v). The RC was added directly to turbid water. To perform the jar test, the RC was added to the turbid solution in doses of 1, 2, 3, 4, 5, and 6 mL/L the corresponding residual turbidity was noted. The optimum dose required to bring the residual turbidity levels to less than 5 NTU (as per IS: 10500:2012 and WHO guidelines for drinking water quality)

Requirements

3.2.1 Hot plate

Hot plates are frequently used in the laboratory to perform chemical reactions, to heat samples, and for numerous other activities. Hot plates are conceptually simple – a flat surface with heating elements.

They do not produce open flames and are well suited for oil or sand bath use. But there are key considerations on the proper choice of hot plates and important safety factors that users should be aware of.

Fig 3.2.1: Hot plate

EXPERIMENTAL RESULTS

Result

The metal content in AWW are shown in Tables 4.1 respectively. It can be seen that the major components preset in the AWW were Al, Fe,Pb and Cu.

Table No 4.1 Metal Content in AWW

Metal	Al	Fe	Pb	Cu
Concentration (mg/g)	956.4	42.5	0.4	0.75

Table No 4.2 Recovery of Al with nitric acid concentration

Sr.No	Acid Strength (N)	% Recovery
1	0	0
2	0.1	21.38
3	0.2	32.67
4	0.3	40.51
5	0.4	44.96
6	0.5	55.36
7	0.6	58.29

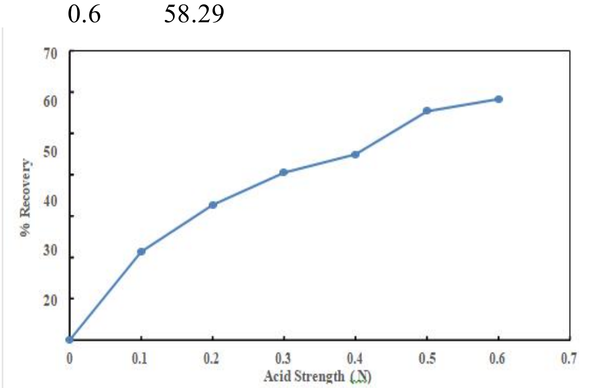

Fig 4.1: Recovery of Al with nitric acid concentration

The figure 4.1 indicates the graph for % Recovery of Al with respect to Acid Strength (N). In fig 4.1 when acid strength increases from 0.1 to 0.6 N the %R increases. For acid strength 0.1 N he percentage recovery was equal to 21.9%. However after that further increase in strength causing low rate of recovery between 0.2 to 0.4. The % recovery for 0.5 N and 0.6 N acid strength was 55.36% and 58.29% respectively. As only 3% increase in recovery between 0.5 and 0.6 N. The 0.5 N acid strength was finalized as optimum value for acid strength:

Table No.4.3: Doses of RC and residual turbidity for Kolar River water sample

Sr.No.	RC Doses (ml/L)	Kolar River Water Sample Turbidity (NTU)
1	0	37
2	1	21
3	2	12
4	3	4.5
5	4	6.7
6	5	9

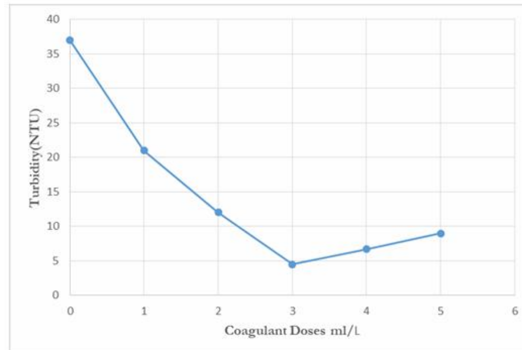

Fig 4.2Jar test result using RC as a coagulant on kolar river water.

IV.CONCLUSION

1. Acid Strength: An acid solution with a strength of 0.5 N (Normality) was used in the procedure. An indicator of the acid's concentration is normalcy. A 0.5 N acid solution was employed in this instance.
2. Reaction Time: A 120-minute reaction time was required for the process. This indicates that a duration of two hours was involved in the chemical reaction.
3. The 58% recovery indicates that, under these conditions, only 58% of the total Al present in the original material or solution was successfully extracted or recovered. The effectiveness of the extraction process, the solubility of Al in the specified acid strength, and the reaction kinetics over the specified time could all contribute to this.
4. More details regarding the precise procedure, the makeup of the starting material, and the required purity of the extracted Al would be required in order to better comprehend or optimize the process.

The Kolar River and Ambazari Lake water were the two distinct water sources used in the RC's performance evaluation. This helped determine the RC system's suitability for treating various water quality and sources by evaluating how well it could filter and purify these water samples. The outcomes of these tests would shed light on how well the RC system works and how well it can generate clean, safe drinking water

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