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Research paper



Performance Efficiency of the Zeolite Synthesized from Fly Ash in Wastewater Treatment

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Abstract

In the present study we are exploring the possibility of using fly ash to produce zeolite. In this synthesis process, class F fly ash from Neyveli Thermal Power Plant, Cuddalore district, Tamil Nadu, India was utilized. The fly ash was subjected to fusion process with sodium hydroxide for an hour. The synthesized material was characterized to obtain the mineral composition. The resulting zeolite is competitive with commercially available materials which are used as ion exchangers in wastewater treatment and soil decontamination. In this study, the synthesized zeolite was analyzed for the performance removal efficiency of pollutants from domestic wastewater. The batch method was adopted to study the influential parameters, such as initial pH value of the solution, and dosage of zeolite, in the domestic wastewater treatment process.

Keywords: *Fly ash, zeolite, synthesis, wastewater treatment, pH, dosage.*

1. Introduction

India positioned itself as the world's fourth largest economy with a faster growing energy market. Here, the majority of power production is from the coal and petroleum which is 75% of its total power generation. As a result of rapid economic growth and improved standard of living of population, there is a need for huge amount of power supply. India is one of the major coal producers in the world from which 70% of its production is utilized in the thermal power plants. The coals available in India have about 30 – 40 % of ash content which results in huge generation of fly ash. Due to the varied composition of fly ash from different combustion units, disposing it becomes a major problem. As the time technology is growing and resources are getting depleted, man is aiming for the reuse and recycling of waste materials. As a part of this, the total waste produced from coal production which constitutes 65 % of fly ash, about 50% of it is subjected to various reuse techniques. Recent studies have stated that, fly ash can also be used for the synthesis of zeolite. Increase in population calls for a huge demand of water. To meet this demand, there is a necessity for recycling of the waste water and there are several techniques available for the treatment of waste water. Several research have been made to study the effect of the fusion reaction parameters like NaOH / Fly ash ratio, fusion temperature and crystallization time, where results differ based on the synthesizing condition and the type of product used(Rayalu et al., 2000; Somerset et al., 2005; Molina et al., 2004; Ojhakeka, 2004 and Shaobin Wang et al., 2006). Presently few studies have been made on the application of the fly ash zeolite in waste water treatment (NevinKoshy et al., 2016).

Nitrogen enters into the domestic wastewater through human urine, fecal material, food residue, and personal care products. The total nitrogen present in domestic waste water ranges from 20 to 70 mg N/L (Tchobanoglous et al., 2003).The total nitrogen can be grouped into ammonia/ammonium ($NH_3/NH4^+$), nitrite (NO^{-2}), nitrate (NO^{-3}), and organic nitrogen.Domestic wastewater generally contains 60-70% ammonium nitrogen and 30-40% organic nitrogen.The buildup of total nitrogen in the form of ammonium nitrogen in water results in eutrophication, algae blooms and depletion of dissolved oxygen, effects the aquatic life (Tan et al., 2006; Sarioglu, 2005). Soit is very important to remove nitrogen from the water and wastewater, the methods used to remove nitrogen such as biological nitrification-denitrification, catalytic liquid-phase oxidation, air stripping, struvite precipitation, membrane separation, and selective ion exchange. The ideal method for ammonium removal is the ion exchange systems.Man-made ion exchange resins are expensive for large-scale waste water systems, but using comparatively low-cost indigenous natural resin, such as natural zeolites obtained from fly ash, could be economically.

The naturally synthesized zeolites are micro porous in nature, crystal-like structure having three-dimensional aluminosilicate tetrahedral structure where aluminum (Al^{+3}) and silicon (Si^{+4}) structure atoms are bonded through covalent bonds with common oxygen atoms results in formation ofinternal channels (Englert et al., 2005).

The present work focuses on the synthesis of zeolite from fly ash and its performance in the treatment of waste water. Batch experiments were conducted to optimize the working conditions for total nitrogen exchange of natural zeolite, like - initial total nitrogen concentration, pH and reaction time.

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2. Materials and Methods

2.1 Fly Ash

Fly ash is collected from the thermal power plant (Cuddalore district, Tamil Nadu, India) for which the chemical characterization analysis had done by using X-Ray Fluorescence test as shown in Table1.

Table 1: Chemical Composition of Fly Ash

Formula	Concentration (%)
SiO_2	58.14
Al_2O_3	30.12
Fe_2O_3	5.29
TiO_2	2.16
K_2O	1.46
CaO	1.14
P_2O_5	0.55
MgO	0.53
SO_3	0.17
Na_2O	0.1
BaO	0.06
Cr_2O_3	0.04
MnO	0.04
ZrO_2	0.03
V_2O_5	0.03
PbO	0.03
ZnO	0.02
Cl	0.02
SrO	0.02
NiO	0.01
Ga_2O_3	74 PPM
Rb_2O	70 PPM
Nb_2O_5	53 PPM
Y_2O_3	50 PPM

2.2 Zeolite Synthesis

To synthesis natural zeolite from fly ash the procedure proposed by Doungmanee Rungsuk (DoungmaneeRungsuk et al., 2006) was used. The procedure starts with mixing NaOH with Fly ash by the ratio 2.25.The mixture is kept in a furnace at 450^0C for an hour followed by drying and crushing. The crushed product is dissolved in distilled water and subjected to stirring condition for 24 hours at room temperature. The mixture is allowed for crystallization under static condition of 90^0C for 2 hours and the crystals were collected through filtration technique. The collected crystals were washed several times with distilled water and allowed for drying process at 105^0C overnight.

2.3 Treatment of Waste Water

2.3. 1 Batch Studies

In the batch study, the effect of specific parameters like pH, zeolite dosage, initial concentration and contact time, batch experiment were conducted at room temperature. For batch studies, 100 ml of waste water of known concentration at optimum pH and known concentration of zeolite were taken in 250 ml conical flask. The samples were kept for 24 hours, withdrawn at appropriate time, filter paper is used for filtration process and the total ammonia concentration was analyzed.
The amount of total ammonia observed by the zeolite was calculated from the difference between the total nitrogen concentration at initial time and after appropriate time is in the following equation.

3.2 Effect of PH

The pH of total nitrogen is affected by the surface charges of zeolite. At low pH the zeolite ion competes with the total nitrogen

$$\text{Percentage removal} = \frac{C_0 - c_e}{c_0}$$

where
C_0- initial concentration
C_e- Final concentration at equilibrium time

2.4 Effect of Initial PH

The ion exchange of total nitrogen removal was studied over a range of pH 2 to pH 12. pH of the solution was adjusted using acid and base solution and the ion exchange studies were carried for equilibrium time (90 minutes) and zeolite dosage was kept at 3.1mg/gfor naturally synthesized zeolite.

3. Results and Discussion

3.1 Type of Zeolite

XRD test was conducted for the synthesized zeolite which helps in finding the type of zeolite. The XRD pattern of the synthesized zeolite is represented below. For the study, the synthesized zeolite is matching with zeolite LTA.

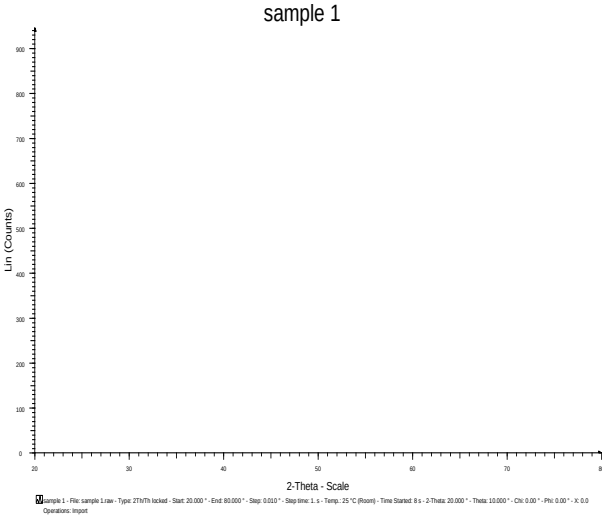

Fig. 1: XRD Pattern of Synthezied Fly Ash

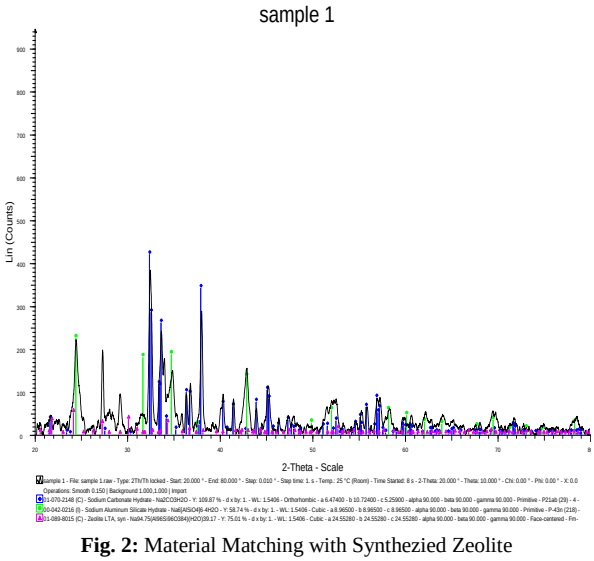

Fig. 2: Material Matching with Synthezied Zeolite

replaces with the sites of zeolite. The optimum pH condition was observed at pH 7. A pH above 8 results in a sharp decrease of exchange capacity of the zeolite.

3.3 Effect of Dosage

The zeolite dosage effect on the removal of total nitrogen is studied at different doses ranging from 1g to 5g to the concentration of 43 mg/l of total nitrogen. The results were shown in the figure 2.



Fig. 3: Percentage Removal Efficiency of Synthezied Zeolite

The figure shows that the exchange capacity of total nitrogen increased at increasing dose of zeolite up to 3.1mg/g and attained equilibrium state.

The other parameters of the treated waste water at optimized dosage were tabulated below.

Table 2: Constituents of Domestic Waste Water

Constituents	Initial concentration (mg/l)	Final concentration (at equilibrium state) (mg/l)	Percentage removal (in %)
Turbidity	65	40	38.461
COD	375	130	65.333
TDS	585	180	69.230
TSS	90	44	51.111
Total Nitrogen	43	2	95.348

4. Conclusion

The zeolite was synthesized using fly ash in this study at NaOH to Fly ash ratio of 2.25 , fusion temperature of 450^0C and fusion time of 2 hours. The synthesized zeolite was found to match with zeolite LTA. For low initial concentration of total nitrogen in domestic waste water, the synthesized zeolite shows higher percentage removal. The optimum dosage of synthesized zeolite was determined by batch process and found to have at pH 7 with a dosage of 3.1 mg/g and the equilibrium time was estimated to be 90 minutes. The removal efficiency of synthesized zeolite for other constituents of domestic waste water at optimum dosage were found. From the study, the efficiency forpercentage removal of synthesized zeolite was found to be efficient which can be practically adopted in the treatment process of domestic waste water. This helps in reducing the load on biological treatment process.

References

[1] Rayalu S.S, Udhoji J.S, Munshi K.N and Hasan M.Z, "Highly crystalline zeolite-A form fly ash of bituminous and linite coal combustion", Journal of Hazardous Materials, 2001, pp. 107-121.

[2] Somerset, Vernon S, Petric, Leslie, White, Richard, Michael J, David Key and Iwuoha Emmanuel I, "Alkaline hydrothermal zeolites synthesized from high siO_2 and AlO_3 co- disposal fly ash filtrates", Fuel 84, 2005, pp. 2324-2329.

[3] Molina A and Poole C , "A comparative study using two methods to produce zeolite from fly ash", Mineral Engineering, 2004, pp. 167-173.

[4] Ojhakeka , "Zeolite from ash: Synthesis and characterization", Indian Academy of Sciences- fly ash thesis, 2004,pp. 55-564.

[5] Shaobin Wang, Lin Li and Zhonghua Zhu, "Geopolymetric adsorbents from fly ash for dry removal from aqueous solution", Journal of Colloid and Interface Sciences, 2006.

[6] NevinKoshy and Singh D.N, "Fly ash zeolites for water treatment applications", Journal of Environmental Chemical Engineering, 2016, pp. 1460-1472.

[7] Tchobanoglous, G., Burton F.L, and Stensel H.D, "Waste water Engineering: Treatment and Reuse", New York, NY: McGraw-Hill, 2003.

[8] Tan X.Y., Tan S.P., Teo W.K., Li K., "Polyvinylidene fluoride (PVDF) hollow fibre membranes for ammonia removal from water", Journal of Membrane Science, 2006, Vol.271, pp. 59-68.

[9] Sarioglu M., "Removal of ammonium from municipal wastewater using natural Turkish (Dogantepe) zeolite", Sep. Purif. Technol., 2005, Vol.41, pp. 1-11.

[10] Englert A. H., Rubio J., "Characterization and Environmental application of a Chilean natural zeolite", International Journal of Mineral Processing, 2005, Vol. 75, pp. 21-29.