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Research

Keywords: atomic absorption spectroscopy, fly ash, adsorption, magnetic filtration

Posted Date: July 17th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-41413/v1>

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POTENTIALITY OF MAGNETIC FILTRATION ON WASTEWATER TREATMENT WITH FLYASH MEDIA

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Abstract

Water being one of the most precious resources for the Survival of life is on the verge of depletion and hence various treatment processes to treat wastewater are being researched. Speaking about waste, another solid waste comes into the picture which is available in abundance and easily accessible i.e. “FLY ASH”. Many researches have been done to utilize the fly ash for removal of heavy metal like Arsenic, Cadmium, and Nickle etc. for the past years. This paper is based on the idea of utilization of the magnetic property of the Nano iron particles present in the fly ash as well as the adsorption capacity of the carbon particles present in the fly ash. The magnetic property harnessed by the means of magnetic filtration lead to a decrease in the settlement time of the sludge to 35 seconds in 1000ml of wastewater with a fly ash concentration of 12 g/l. Turbidity removal was 95% in most cases at variable settlement time. The wastewater used for the experiment/study was obtained from an Educational University in Gandhinagar, having various organic and inorganic contents. This sewage water initially having an over range turbidity which was reduced to a limit of 50 to 100 NTU by Fly ash treatment process induced with magnetic filtration. Atomic spectrometric test for Fe^+ ions was done and the result obtained has slight decrease in the Fe^+ concentration in the treated water. The whole treatment process done by the adopted method lead to a huge decrease of time span for treatment as compared with the standard adopted process for the treatment of sewage water at the university treatment plant.

Index Terms—atomic absorption spectroscopy, fly ash, adsorption, magnetic filtration

1. INTRODUCTION

Fly ash is one of the most abundant waste product, produced by the geothermal power plants powering a country. It has been used to treat different metal concentrations in the water, conditioning of the wastewater sludge etc. for the past years. One of the most impressive property of fly ash is its adsorption and coagulation tendency due to high carbon, alumina and silica content. In general a fly ash sample will be having silica content as 44% by weight and alumina content as 20-25% by weight [1]. Fly ash and wastewater both contain certain pollutant level, especially heavy metals depending upon their characteristics and wastewater in addition may contain high concentration of pathogenic microorganisms which may produce foul and pungent smell. Keeping the environmental concern in mind the leachate from these waste product should not contaminate ground water, for survival of surrounding life.

The fly ash comprising of approx. 25% Si and between 10 to 15% alumina in various samples tested for concentrations, with Ca and Fe concentration varying over a tenfold range [2]. Magnetic field has been adopted for treatment of metallic/ magnetic contents within various oil purification process and industries

refining oil from heavy machineries. The utilization of the magnetic filtration with the help of fly ash having materials with magnetic properties in treatment of high sludge concentration wastewater for better economic and feasible treatment were never studied. The complete treatment process worked on basis on two fundamental principle of magnetic loading and gravitational loading settlement of solid matter with variables as time and solids concentration.

The Nano Fe⁺ present in the fly ash would react to the magnetic field produced from the magnet which would lead to a faster rate of settlement. The adsorption property of fly ash will create flocks in water having high concentration of organic and inorganic waste due to Si and Al concentration. Fly ash exhibits strong ability to fix Cd, Cr, Cu, Ni and Zn. The three major heavy metal fixation mechanism are sorption, hydroxide and silicate precipitation [1].

Fly ash is a residue predicted to increase significantly in the coming years. Only a small percentage of fly ash is used in concrete production, road base construction, soil amendment and zeolite synthesis; the large majority is still discharged into ash ponds, lagoons or landfills [3]. In terms of chemical composition, fly ash consists of more than 70% silicon, aluminum and iron oxides (SiO₂ + Al₂O₃ + Fe₂O₃). In recent years, other possible applications to pozzolans have been proposed, including wastewater treatment [4]. Many studies have shown that pozzolanic material can act as an adsorption substrate for phosphate, heavy metals and organic pollutants, indicating a potential application as a low cost adsorbent for wastewater treatment [4, 5, 6, 7].

Scanning electron microscopy of fly ashes from different conditions were done and it was verified to the forms that the material particle can acquire. Spherical particles made up most of fly ash which are vitreous and transparent indicating the complete melting of the silicate minerals. These spheres could be of shapes such as hollow, solid or filled with other smaller spheres, amorphous particles or crystals [8]. Magnetic technology is a method for the magnetization of matters by the magnetic field. It is widely used for wastewater treatment. In recent years, the effects of magnetic technology on activated sludge process have been studied [9].

Furthermore, the removal of particles from solution with the use of magnetic fields is more selective and efficient (and often much faster) than centrifugation or filtration [10, 11]. Lately there has been an increase of interest to use magnetic materials based on iron oxide (fly-ash) for magnetic filtration for organic, arsenic & phosphorous removal.

The sole purpose of this research was to understand the potentiality of the magnetic filtration on wastewater treatment with fly ash acting as a media to improve the overall feasibility of the process in accordance to the traditional process of treatment.

2. METHODOLOGY

❖ GRILL FILTRATION

Done in order to remove any non-biodegradable impurities like plastic wastes or any synthetic materials like cloths or other non-biodegradable waste.

Specially designed and constructed from recycled plastic grill cage was installed to purposefully remove any particles having a diameter of more than 0.05 – 0.06 meters. Also the construction of the cage by means of plastic lead to no degradation within its structure as it's generally observed in steel or iron grill cages due to

presence of water or moisture.

❖ FLY ASH ADDITION (COAGULATION & FLOCCULATION)

Fly ash having coagulative and adsorption tendencies due to carbon, alumina and silica. Addition in adequate amount will lead to the flock formation in highly turbid water and after wards the Fe⁺ particles present in the mix will be trapped in between the flocs which will start to settle under the gravitational loading releasing water and concentrating sludge at the bottom of the tank/storage unit.

The fly ash concentration were taken on random basis of concentration in 1000ml of wastewater samples. The range varied from **1gm/l to 16gm/l**.

❖ MAGNETIC FILTRATION

Permanent magnets of different intensity of 6.48uT and 3.45uT were used to increase the effect of solid (floc) settlement in wastewater on addition of fly ash.

Permanent magnets were considered to be feasible for laboratory scale treatment process, for large scale treatment process high strength electromagnets were considered to be more beneficial.

The **magnetic property of metals** present in the fly ash used to treat wastewater having high concentration of organic and inorganic pollutants, were optimized and utilized for faster settlement of the solid wastes by the addition of **magnetic settlement over gravitational settlement**.

Gauss meter was used to check for the intensities of the different magnets used and their effect over the range to which settlement was happening. All the permanent magnet used had their magnetic field intensities in uT (micro tesla).

Under the effect of a magnetic field the magnetic particles of fly ash, stuck within the floc of solids in wastewater will start to get attracted to the magnetic source at the bottom of the tank.

S.No.	TYPE OF MAGNET	MAGNETIC INTENSITY (uT)
1	PERMANENT MAGNET 1	6.48*
2	PERMANENT MAGNET 2	3.45*

*Magnetic field mentioned is the MAX obtained due to variation of magnetic intensity with time.

3. RESULTS

The result represented in terms for figures and table for better visualization and understanding of the nature of analysis done for the study.

I. DATA REPRESENTING TIME VS SLUDGE VOLUME

Time interval	Volume(mL)
2	1000
3	970
4	860
5	760

6	680
7	600

TABLE-1- TIME DURATION & SLUDGE VOLUME

GRAPH-1: Variation in the gravitational settlement of sludge in the absence of fly ash and magnetic field. Settlement is almost linear.

II. DATA REPRESENTING FLY ASH VS VOLUME OF WATER RECOVERED:

Fly ash (g)	Volume(mL)
2	380
4	400
6	430
8	420
10	450
12	410

TABLE-2- FLY ASH DOSE VS WATER VOLUME

GRAPH 2: Amount of water recovery Vs fly ash dose. With the maximum volume recovery at 10g fly ash.

III. DATA REPRESENTING FLY ASH VS pH:

Fly ash(g)	pH
1	8.05
2	8.03
4	8.13
6	8.14
8	8.04
10	8.08
12	7.75
14	7.95
16	7.9

TABLE 3: FLY ASH Vs pH

GRAPH 3: Variation in amount of Fly ash Vs pH of the water. The lowest pH is achieved in 10 g.

IV. DATA REPRESENTING FLY ASH VS TURBIDITY

Fly ash(g)	Turbidity(NTU)
1	33
2	186
4	476
6	690
8	974
10	957
12	979

TABLE 4: FLY ASH Vs TURBIDITY

GRAPH 4: This graph shows the amount of Fly ash with respect of the turbidity of the water. The optimum dosage is 10 g.

V. VARIATION OF SETTLEMENT TIME UNDER GRAVITY VS MAGNETIC FIELD

Fly ash	Settlement time (under gravity) (minutes)	Settlement time (with magnet) (minutes)
2	47	30
4	53	10
6	10	4
8	3	2
10	2	1
12	1	0.83

TABLE 5: FLY ASH Vs SETTLEMENT TIME WITH AND WITHOUT MAGNET

GRAPH 5: This graph shows the amount of Fly ash with respect of the settlement time of sludge.

VI. DATA RELATING RAW WATER AND TREATED WATER Fe^{+} CONCENTRATION:

Type of water	Fe ⁺ Concentration(mg/l)
Raw sewage water	3.556
Treated water	3.515

TABLE 6: Fe+ ion concentration before and after treatment with Fly-ash

4. DISCUSSION

The tables and graphs for the sample shows the settlement of discrete particles. In terms of the settlement rate of the water, it is faster with a magnetic field. The magnetic field is of 6.48 & 3.45 micro Tesla. Magnetic filtration can be an effective way of settling of the sludge at a faster rate. The settlement of the sludge is concentrated in the central area of magnet. Out of 1000 ML, almost 900 ML of water is recovered. The sludge obtained is assumed to be rich in iron content. However heavy metals might be embedded in the sludge. This has not been mentioned in this paper and will require another research in it. Iron concentration in the wastewater after treatment remained the same with some minor variation, proving that addition of fly ash doesn't affect the iron concentration. The viability of the treatment of water is mentioned in terms of the coagulation done with alum. High alum dosage was required for flocculation. However with the introduction of the fly ash and magnetic filtration, the entire process becomes economical.

5. CONCLUSION

This experiment proves to be better in a practical point of view because of its cost effectiveness and abundant availability of fly ash. This will be an extremely faster way of treatment in terms of material usage because fly ash is a waste product and its disposal becomes an issue. The time span for treatment process is reduced by 50% of the standard time taken. The sludge obtained from the treatment process is highly stable at higher concentration and can be disposed or utilized easily without any precautionary measures. The adopted process would further lower the cost of water and sewage purification leading to lower bills incurred by the end-user associated to both resources and waste water disposal. Hence this paper shows the utility of fly ash as a means of treatment matter and proving to be more economic than usual treatment process up to a certain limit.

The pictorial image below is the final result of proof that Addition of fly-ash in different dosage acts as a natural coagulant with Nano Fe⁺ ions under the influence of magnets as coagulants leading to faster settlement of flocs or organic and inorganic pollutants present in water.

The representation of the experimentation proved that Fly-ash type F containing higher iron contents will act as an coagulant and adsorbent for the organic and inorganic pollutant in the wastewater. Hereby utilizing the waste generated from thermal power plants and domestic household to be used to counteract each other and reuse them.

6. DATA AVAILABILITY

All data, models, and code generated or used during the study appear in the submitted article.

7. ACKNOWLEDGEMENT

We would like to express our gratitude to our mentors Dr. T.S. Anantha Singh and Dr. Anurag Kandya for giving us the opportunity and motivation to proceed with this idea. I would also like to thank Pandit Deendayal Petroleum University for providing us with all the necessary equipment's for carrying out this research work and also allowing us to use the environmental lab for experimentation.

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Figures

Figure 1

GRAPH-1: Variation in the gravitational settlement of sludge in the absence of fly ash and magnetic field. Settlement is almost linear.

Figure 2

GRAPH 2: Amount of water recovery Vs fly ash dose. With the maximum volume recovery at 10g fly ash.

Figure 3

GRAPH 3: Variation in amount of Fly ash Vs pH of the water. The lowest pH is achieved in 10 g

Figure 4

GRAPH 4: This graph shows the amount of Fly ash with respect of the turbidity of the water. The optimum dosage is 10 g.

Figure 5

GRAPH 5: This graph shows the amount of Fly ash with respect of the settlement time of sludge

Figure 6

The representation of the experimentation proved that Fly-ash type F containing higher iron contents will act as an coagulant and adsorbent for the organic and inorganic pollutant in the wastewater. Hereby utilizing the waste generated from thermal power plants and domestic household to be used to counteract each other and reuse them.