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Domestic Wastewater Treatment using Flyash as Adsorbent

P.Saravanakumar, Preethi Gopalakrishnan, M.Sivakamidevi, E.S.Archana

Abstract*: *Wastewater treatment and disposal is a serious issue and need attention for protecting the environment. Over the recent years, flyash has been experimented as an adsorbent for the waste water treatment plants. The abundant availability, high carbon content and adsorption characteristics of flyash lead to application in waste water treatment methods. In this study, experiments were carried out using flyash as adsorbent in domestic sewage water treatment. A filter media was prepared with pebbles, sand and flyash with different thickness, characterized and used for the removal of impurities. The physico-chemical properties of waste water before and after treatment were examined. The experimental results showed significant reduction in the values of BOD from 385 mg/l to 45-55 mg/l, COD from 680 mg/l to 110-150 mg/l, pH from 8.4 to 6.9 and TDS from 715mg/l to 250-300mg/l after treatment. Beneficial effects of flyash utilization as adsorbent was observed for removing various impurities present in wastewater

Index Terms*: *Flyash, adsorbent, domestic sewage water, waste water treatment, physico-chemical parameters

I. INTRODUCTION

Water is a vital component for all known forms of life to be able to survive. Water covers about 71% of earth surface, and is a valuable resource of the earth. There is earth is composed of approximately 30 percent of the world's fresh water is in liquid form and therefore potentially accessible for human use such as drinking to prepare food, washing clothes, and necessary functions which water is a major component. Waste water treatment is the process of converting wastewater (water that is no longer need) into bilge water that can be discharged into the environment.

Fly ash is an industrial by product from thermal power plants and steel industries which is composed majorly of fine particles [1], [2]. The disposal of this waste causes major environmental problem which leads to research on utilization of this waste product for various purposes [3]-[5]. The major elements of fly ash are arsenic, beryllium, boron, cadmium, chromium, mercury, molybdenum, selenium, strontium, thallium etc. The fly ash was basically classified as Class F and Class C fly ash based on the presence of calcium, silica, alumina, and iron content. Coal fly ash is majorly used to produce meso and micro porous materials [6]. The flyash is spherical in shape and it can act an adsorbent as it contains high carbon content with specific surface area between 2000-6000 cm^2/g. These characteristics of flyash increase the adsorbant capacity of the filter media [7]-[10].

In this study, experiments were carried out to find out the thickness of efficient low cost filter bed thickness by using flyash as adsorbent in domestic sewage water treatment. Three different thickness filter media was prepared, characterized and used for the removal of impurities. The physico-chemical properties of waste water before and after treatment were examined and reported in this study.

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II. MATERIALS AND METHODLOGY

A. Effluent collection

Waste water was collected from college hostel bathrooms and canteen outlets. The samples were collected periodically thrice in a week for a month for this study. It has high concentration of COD, TSS, TDS, pH and the dissolved oxygen level would be very low.

B. Fly ash

Fly ash was collected from thermal power plant from Tirunelveli. The collected fly ash was oven dried at 105° C for 24 hours and sieved through 90 micron sieve before preparing filter bed. The chemical composition of the flyash was shown in Table 1

Table 1 Chemical composition of Fly ash used

Chemical composition	Mass Fraction (%)
SiO_2	56.6
Al_2O_3	33.71
CaO	1.07
Fe_2O_3	3.97
Na_2O	0.16
MgO	0.42
K_2O	1.02
TiO_2	2.1
SO_3	0.18
P_2O_5	0.44
BaO	0.08

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C. Pebbles

Pebbles are generally considered larger than granules and smaller than cobbles. In this study small size (maximum 10 mm) pebble were used in the filter media. The pebbles were washed with distilled water and dried

D. Sand

River sand was used in this study to prepare the sand bed in the filtration tank. The river sand was sieved through 2.36 mm sieve before application

III. CHARACTERISATION OF FLY ASH

A. FTIR Analysis

The sample of collected fly was tested using FTIR spectrometer (Perkin Elmer instrument using spectrum two Model). The result (Fig 1) showed that the major transmission peaks were observed in wavelength range of 2500 to 3000 cm^{-1}, 1500-2000 cm^{-1} and 450-750cm^{-1}. The result confirmed the presence of Si-O-Si bonding and C=O bonding and also the presence of some impurities which needs treatment for removal.

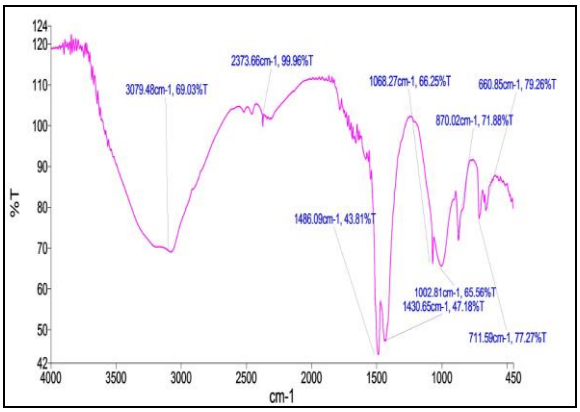

Fig 1. FTIR Analysis of flyash

B. SEM Analysis

To understand the surface morphology of the flyash before treatment was analysed using FESEM analysis. The analysis was done using ZEISS instrument of Field Emission Scanning Electron Microscope. The Fig 2 showed that the flyash was porous in nature and it was efficient to use as adsorbent.

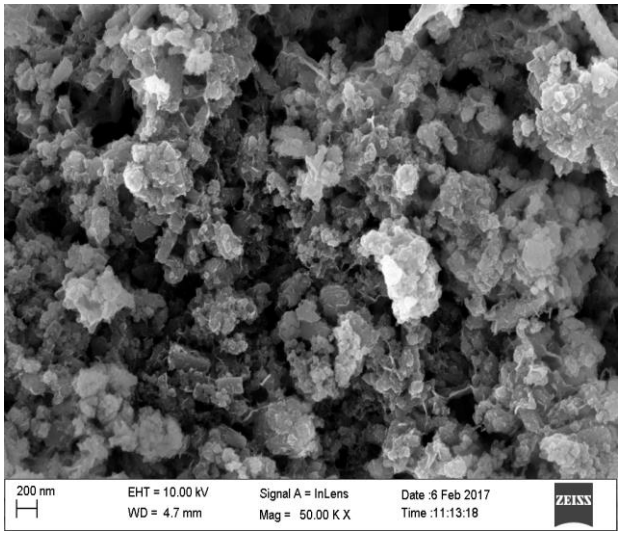

Fig 2. FESEM result of Flyash

C. Particle Size Analysis

The particle size distribution of flyash was analysed using MALVERN particle size analyser instrument with iso-propyl alcohol as dispersing agent. The result (Fig 3) showed that the average particle size distribution of flyash lies in range of 1.3-1.5 µm.

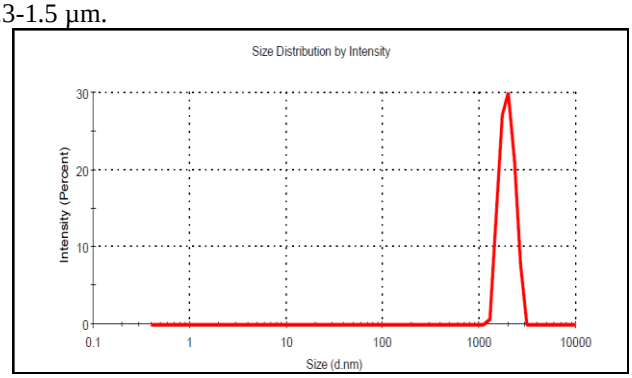

Fig 3. Particle size distribution of Flyash

D. Surface Area Analysis

Flyash sample was analysed for surface area using Belsorp Mini Surface Area Analyser and plotted (Fig 4). The surface area of flyash was observed to be 1.0097 m^2 per gram of sample. Surface area found to be little low when considered to be an adsorbent but its porous structure can improve the efficiency of adsorption. Also the surface area can be increased by some of activation methods in later stage.

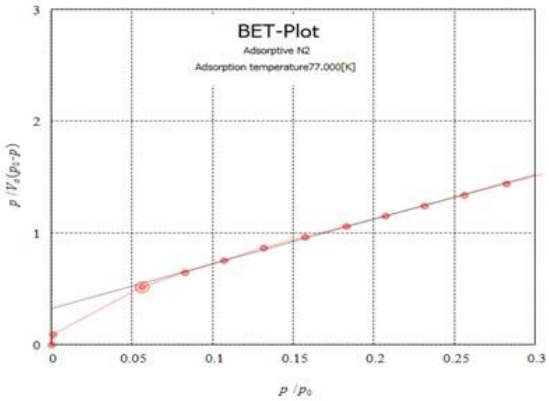

Fig 4. Surface area Analysis of flyash

IV. EXPERIMENTAL METHOD

The domestic sewage water was treated in three stages. In the first stage the waste water was screened through screened chamber. After the process of screening in the second stage the effluent was led into Aeration tank followed with filtration tank. The effluent was allowed to Aeration tank for 6 hours. The filtered water was collected from the outlet of the filtration tank and tested for COD, DO, TSS, TDS and pH.

A. Preparation of fly ash filter bed

The fly ash was conditioned by washed through distilled water to remove the unstable or water-soluble particles present in it. After washing, the flyash was allowed to dry in room temperature followed by vacuum desicator for a day. After this process the dried fly ash was sieved through 900 µm sieve and used in the filter bed.

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The filter media has four layers with pebbles at top and bottom followed by flyash and fine sand (Fig 5). The thickness of the each filter bed was kept uniform. To find the optimum thickness of the layer 10 cm, 15 cm and 20 cm thick layers were tried in this study. Ordinary river sand washed with distilled water, dried and sieved through 2.36 mm sieve was used in sand bed. The pebbles of 10mm in maximum size were the used in this study. The domestic wastewater after screening was allowed to flow into the filter bed vertically from the height of 1m head to maintain constant flow rate and to avoid overflow of water in the filter.

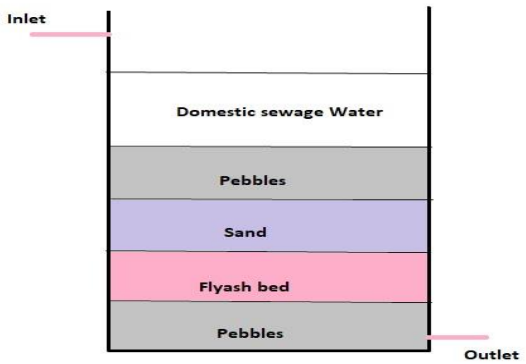

Fig.5. Filtration Tank

V. RESULTS AND DISSCUSSION

The experimental results were presented in Table 2. Comparison among the pretreated and treated domestic sewage water were presented in the following paragraph.

A. Removal of COD from the Waste Water

Chemical oxygen demand is a measurement of the oxygen required to oxidize soluble and particulate organic matter in water. The COD measurement for the domestic waste water was taken before and after passing through the filter beds. The initial level of COD was measured as 680mg/l. The waste water was allowed to pass through the three different thick fly ash filter media and the COD value was measured after treatment. The lower values were observed in the filter media having least (10 cm) flyash bed thickness. The time taken for filtration also found less and from Fig 6 we observed that higher efficiency obtained in least thickness filter media.

Table 2. Physico - Chemical Properties of Treated and Pre-treated water

Parameter	Pre- Treated water quality	Flyash Filter media Thickness		
		10 cm	15 cm	20 cm
COD	680	110	135	150
BOD	385	45	52	55
TDS	715	250	280	310
pH	8.4	6.9	7.1	7.2

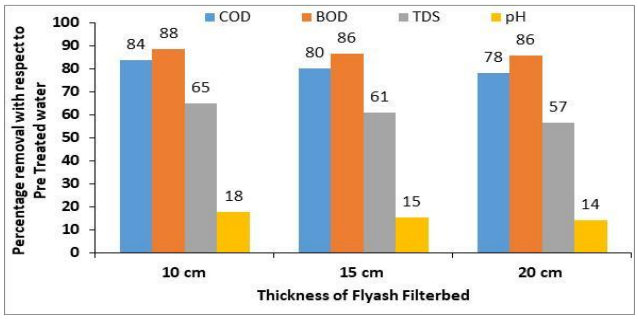

Fig 6. Efficiency of Flyash filter bed

B. Removal of BOD from the Waste Water

Biological oxygen demand is a measure of, the amount of oxygen that requires for the bacteria to degrade the organic components present in water / waste water. Before treatment the level of BOD is 380 mg/l which was above than permissible limit 300mg/l. After filtration through Flyash bed, the BOD value was decreased to 45 – 55 mg/l. Higher efficiency attained in the filter bed having least thickness (10mm).

C. Removal of TDS from the Waste Water

A total dissolved solids (TDS) is an important parameter which decides the usage of water. Depends on the TDS value the water can be used for various purposes like agriculture, industrial and drinking. The term total dissolved solids refer to materials that are completely dissolved in water. These solids are filterable in nature. Estimation of total dissolved solids is useful to determine whether water is suitable for drinking purpose, agriculture and industrial purpose. There was a significant fall in TDS concentration before and after the treatment process. Due to the presence of high carbon in flyash the solids present in the wastewater was absorbed. The initial level of TDS was measured and found as 715mg/l. After passing through the filter media, the TDS value was found to be decreased to the range of 250-300mg/l. Among the three different thick fly ash filter beds, least thick filter bed showed higher performance than the other two.

D. Removal of TSS from the Waste Water

The non-filterable and undissolved matters are referred as total suspended solids. This will affect the product quality by age through scaling, corrosion etc. the TSS level was measured and found as 350 mg/l which was above the limit recommended by CPCB. After treatment, the TSS value decreased to 80 mg/l in the thickness of 10 cm.

E. pH of Waste Water

The pH value is an important parameter in the operation of biological units. In domestic waste water, organic matters decomposition affected the pH value by lowering it. Generally the pH of raw sewage is in the range 5.5 to 8.0. The pH value of the untreated sewage wastewater was found as 8.4 which was slightly higher than the water supplied to the community. After filtration process the pH value was reduced upto 7 which is in the permissible limit for disposal in all the three filter media.

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VI. CONCLUSION

Based on the experimental results the following conclusions were made,

1. Flyash can be used in the effective way to treat the domestic wastewater with simple techniques and low cost.
2. The thickness of the filter media affects the efficiency of the filter bed and from the above results it was clear that among the three different thicknesses experimented the effective filter media thickness was 10 cm.
3. If the thickness increases clogging occurs and the efficiency of the filter bed got affected.

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Dr.P.Saravanakumar is a young dynamic researcher and academician with 20 years of teaching and Industrial experience in Civil Engineering. Currently he is working as Associate Professor in Sri Krishna College of Engineering and Technology, Coimbatore. He has published more than 25 research articles in reputed international journals and conferences. His areas of interest include Sustainable materials, Composite materials, Repair and Rehabilitation.

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