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Wastewater Treatment Using Fly Ash

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ABSTRACT

In the treatment of waste water to remove impurities, highly porous power plant waste ashes can be utilized. An indigenous bed is made which could replace expensive treatment facilities such as activated sludge process and oxidation pond. A lot of work has been reported on fly ash for adsorption and other construction related uses. But a little or no work so far has been reported for the use of fly ash for the treatment of wastewater. The use of fly ash resolved the environmental issues and disposal by treating wastewater. The treatment bed comprised of three layers of sand, fly ash, pebbles. Each layer has equal thickness. A low- cost filter media is prepared and used for the removal of impurities such as Chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS) and pH of the waste water and biochemical oxygen demand (BOD). Organic and inorganic pollutants in wastewater are cause of concern in current scenario of rapid urbanization. Fly ash as an adsorbent is very good alternative and attracts great application.

Keywords— fly ash bed, low-cost filter media, chemical oxygen demand, total suspended solids, total dissolved solids and dissolved oxygen.

1. INTRODUCTION

Wastewater pollution is one of the critical problems that the world is facing in this era. Water quality is extremely important because constant access to good quality water is necessary for life as well as the economy. Water is the major abundant natural resources of the ecosystem. The planet earth is having 79% of water. In India, major problem leading to waste pollution is increasing population, industrialization and urbanization. The entire living organism in the environment requires water for their growth and development. Water pollution occurs when the pollutants are discharged directly or indirectly into water bodies without adequate treatment. Collection, treatment and disposal of domestic and industrial wastewater are the serious issues to be handled for preventing damage to the environment. Conventional process of wastewater are very much costly so the wastewater treatment is not possible everywhere .To overcome the financial issue the less costly treatment technology is introduced in this report. Instead of using commercial activated carbon or zeolites, a lot of researches have been conducted using fly ash for adsorption of nitrogen oxides, oxides of sulphur, organic compounds, and mercury in air, and cations, anions, dyes and other organic matters in waters. It is recognized that fly ash is a promising adsorbent for removal of various pollutants. Chemical treatment of fly ash will make conversion of fly ash into a more efficient adsorbent for gas and water cleaning.

Fly ash is a pulverized fuel ash. It is a coal combustion product that is composed of the particulates that are driven out of coal-fired boilers together with the flue gases. Ash that falls to the bottom of the boiler is called bottom ash. Fly ash contains high carbon content with specific surface area between 2000 to 6800 cm2. It is examined that the fly ash in wastewater treatment is used to remove COD, reduce TSS, TDS and pH level. This project work include, fly ash filter used for wastewater treatment.

2. USER BASED PROBLEMS

Solid waste and water quality have become major environmental problems in recent years. Increased urbanization and industrialization lead to excessive release of wastes into the environment. If it is not effectively and properly managed, it can result in adverse impacts on both environmental and human health causing air, soil, and water pollution and disease. The first one is the leaching of metals from the waste to the land and surrounding waters which poses a serious environmental risk.

The second problem relates to the storage of coal ashes. In this situation, the thermal power plant has used a new long-term ash disposal site. However, storage remains an expensive solution to the economic level and poses an environmental problem which relate to the toxicity associated with heavy metals leaching to groundwater. Several solutions exist for the management of these wastes but the choice depends on the cost. Building materials is one filed where it's possible to recycle coal ashes. The CFA can application in manufacture of bricks, roofing sheets and other building components, part replacement of cement in mortar and concrete.

The high percentage of silica and alumina in CFA and it physical properties such as porosity, particle size distribution and surface area make it a good adsorbent in wastewater treatment Coal, like most

other naturally available materials on the earth, contains natural Uranium, one the most abundant natural radioactive elements. Due to this, fly ash and bottom ash coming from the coal combustion contains varying amount of natural radioactivity.

3. LITERATURE STUDY

Syed Farman Ali Shah *et al* (2015) had conducted experiment in wastewater treatment using bed of coal fly ash for dyes and pigment industry. The treatment bed comprises of briquettes of coal fly ash coupled with commercial coagulant ferrous sulfate -lime reduced COD, colour, turbidity and TSS of effluent remarkably. In coagulation treatment, coagulant FeSO4-lime influenced reduction of COD, colour, turbidity and TSS by 32%, 48%, 50% and 51% respectively. The CFAB coupled with coagulant, resulted an excessive removal of colour, TSS, COD and turbidity by 88%, 92%, 67%, and 89%.

Dr. Pankaj Singh *et al* (2014) studied domestic was water treatment using fly ash alone and in combined form. This study reports the use of fly ash alone and in combined state in different ratios with wood ash for the treatment of domestic laundry wastewater. Affect of various parameters such combination ratio of fly ash and wood ash, contact time, adsorbent dosage and particle size of adsorbent have been studied. It is found that TSS reduced from 350ppm to 15-20 ppm, BOD from 250pm to 10-20ppm and pH dropped from highly alkaline range to 8.5-9.5 range.

Shaobin Wang Fly ash is the major solid waste produced from coal-fired power stations. More than 150 million tons of fly ash is generated each year in the world. Currently, fly ash is mainly used as civil construction materials, and there is a limit to the demand for coal ash by construction industries. Any successful utilization of waste is of both economical and environmental interests. The major chemical compounds of fly ash are SiO_2 and Al_2O_3, which are highly thermo stable, thus offering the property as catalyst supports.

5. PROBLEM IDENTIFICATION AND SPECIFICATION

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 into treated 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. The disposal of this waste causes major environmental problem which leads to research on utilization of this waste product for various purposes. 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. The fly ash 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 fly ash increase the adsorbent capacity of the filter media.

6. METHODOLOGY OF THE TREATMENT

1. Material collection:

- **Fly ash:** Fly ash is collected from thermal power plant of PARAS, Akola Maharashtra.
- **Pebbles:** Pebbles are generally considered larger than granules and smaller than cobbles. Here we used small size pebble to make the filter media slighter effective. Fly ash act an adsorbent as it contains high carbon content with specific surface area between 2,000 to 6,800 cm^2 per gram.
- **Sand:** Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. A layer of sand is also used in the filter media to make it effective. Here locally available River sand was used which was sieved with 2.45 mm sieve for the experimental purpose.
- **Effluent Collection**

Domestic waste water sample collected from area nearby college campus. The sample will be collected only after screening process.

7. PREPARATION OF FLY ASH FILTER BED

The Coal Fly Ash Bed (CFAB) is designed for the effluent effective treatment and removal results. The filter bed has inlet and outlet. Initially the filter bed consists of three layers. The first and the bottom layer is pebbles. The second layer is fly ash and the third layer is sand. The filter bed comprises sand,

pebbles, and fly ash. The sand, pebbles will make the filter bed more effective. The COD, DO, TSS, TDS, and pH will be reduced by increasing the layer of fly ash. The fly ash medium is sandwiched between the layers of pebbles and sand to get beneficial results. Fly ash was made as a filter bed of 10mm, 20mm, 30mm, and 40mm thick. The thickness of the each layer is similar. Fly ash act as adsorbent as it contains high carbon content.

7.1 Design of unit in the form of a multi-stage column:
It has four stages:

- **First stage**: Decanting operation: It consists of a separation, under the action of gravitation. The objective of this step is to sediment the suspended matter present in the wastewater.
- **Second stage:** Coal Bottom Ash filtration: This stage contains a layer of bottom ash. This filter plays an important role in wastewater treatment especially in removal of organic pollutants. Water coming out of the CBA filters is pumped to the next stage.
- **Third stage:** In this step of treatment, Coal Fly Ashes are used as filters. This stage constitutes the essential step of treatment because heavy metals are removed due to the chemical composition of CFA and their physical properties like porosity, surface area.
- **Fourth stage:** Sand filtration. This stage contains a layer of sand. The process of this WWTP is only based on a physical treatment which consists on filtration through three materials: -Coal Bottom, Ash, Coal Fly Ash and Sand respectively.

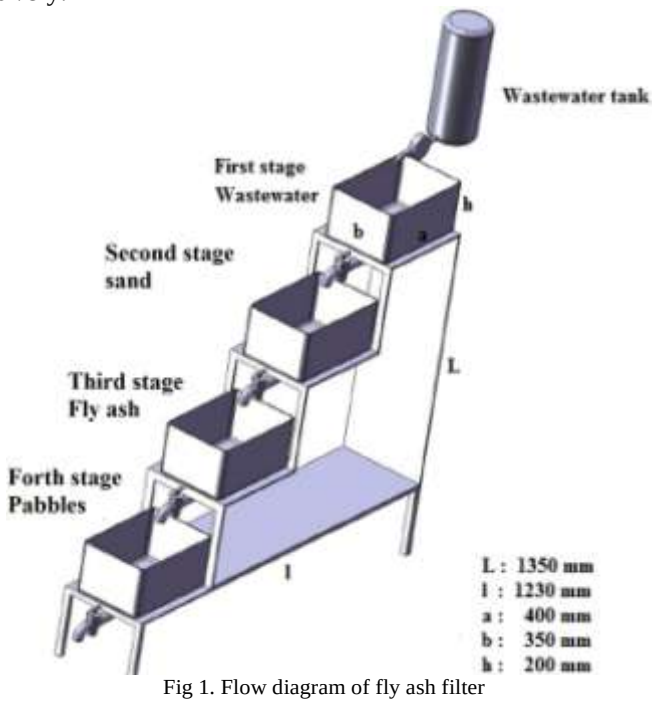

Fig 1. Flow diagram of fly ash filter

Actual model that was fabricated consisted of plastic containers the image of the reactor used for the experimentation.

7.2 Design of Filter Bed

Four circular reactors were used for the first stage each. Each circular reactor was of 0.20m diameter and the depth of the reactor used was 0.16m. Each reactor was packed with four layers of filter media of 0.04m layer each.

8. PROCEDURAL TREATMENT OF WASTEWATER WITH FLY ASH AS FILTER BED

Initially, the filter bed will be cleaned well. Fly ash is sieved in micrometer sieve and taken up. The pebbles which are to be laid in the bottom layer should be washed with distilled water and dried in the sunlight for few minutes. The river sand taken is sieved in 2.45 mm. The untreated wastewater should be tested to get initial readings of pH, TDS, DO and BOD. At First the bed of 40mm thick with pebbles of 25 mm size was laid at bottom. Then the layer of fly ash is laid above pebbles. After that the layer of sand 40 mm thick is laid on fly ash bed, then again the layer of pebbles will be laid. Then the waste water is poured into the bed. After the filtering of waste water from the fly ash bed the treated water will be tested for the values of pH, TDS, DO and BOD.

8.1 Reduction of TDS from the Waste Water

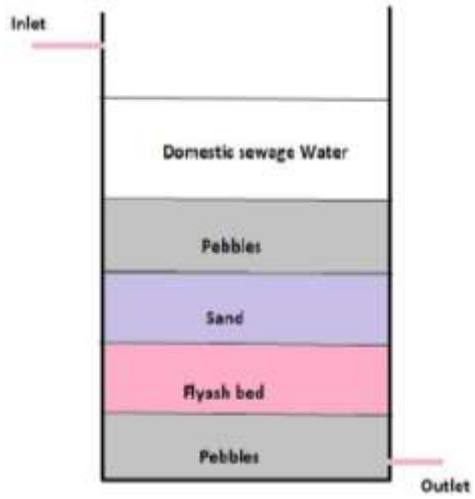

Fig 2 .Design of filter bed

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. Before treatment the level of TDS is above than permissible limit 880mg/l. After treatment, the TDS value decreased to a 412 mg/l.

9. OBSERVATIONS AND RESULTS

The pH was measured using digital pH meter, TDS was measured using digital TDS meter and DO was measured with DO meter as shown below.

9.1 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 6.8 after treatment process the pH value was increased up to 7.2. Hence, the wastewater pH value permits itself to be released into the receiving screen or to the farm for agricultural purpose.

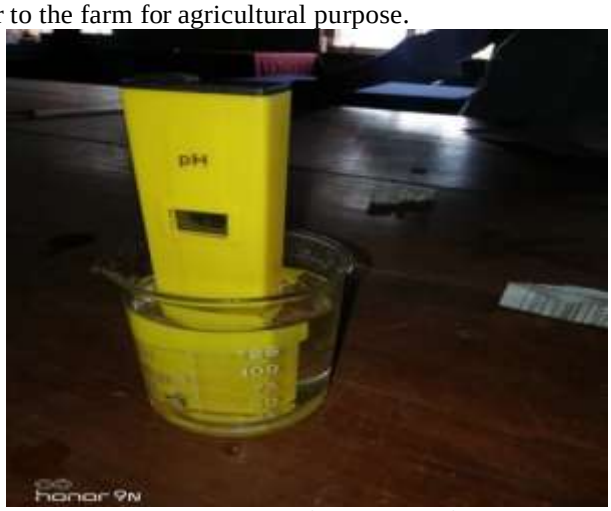

Fig 3. Digital pH meter used for testing pH of wastewater

9.2 DO level of Waste Water

Dissolved oxygen determination is used to describe the amount of oxygen dissolved in a unit volume of water. Dissolved oxygen is essential for the maintenance of healthy lakes and rivers. Analysis of dissolved oxygen is an important step in water pollution control and wastewater treatment process control. The initial DO in the wastewater was found to be 2.25mg/l. After treatment, the DO value increased to a 5.6 mg/l.

Fig 5. Digital DO meter used for testing DO in wastewater

9.3 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 waste water. Before treatment the level of BOD is 178 mg/l after treatment through the filter bed in the experimentation unit after a contact period of two days, the BOD was reduced to 96 mg/l. The effluent obtained after the treatment is again recirculated from the 1st stage reactor till completion of sequence of 2nd stage, 3rd stage and 4th stage of treatment. The final effluent obtained was found to have BOD of 68 mg/l. However; it is expected to have BOD of 30mg/l for agricultural purpose. Hence experimentation should be carried out for obtaining further reduction of BOD. Henceforth this technology seems to be promising low cost wastewater treatment. Further reduction in BOD can be achieved by using multistage filtration with increased contact period and multiple beds.

10. CONCLUSION

Fly ash which is available in abundance at the coal field electric power plants can be efficiently used for the treatment of domestic waste water. When Fly ash is used as filter bed of 40mm thick the parameter value can be reduced down. Coal fly ash bed is an inexpensive and effective for removal of harmful agents from waste water. When fly ash is used as filter bed the parameter value is likely to get reduced to great extent from initial value.

It is concluded that the fly ash is better option as a low cost waste water treatment material. The obtained results of the experiment are on the lower side but not within the permissible limit for agricultural purpose. However environmental pollution issues can be minimized to certain extent by using thermal power plant fly ash in this technology of waste water treatment.

11. ACKNOWLEDGMENT

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