Design and Construction of a Conceptual Single Unit Filtration System for Water and Wastewater Treatment

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Abstract

Shortage of drinking water is the big challenge for urban as well as rural areas. The water treatment involves a huge cost, which is the main reason for using untreated water for drinking purposes in many urban areas in India. The use of contaminated water for drinking purpose of causing water born-diseases like Diarrhoea, Typhoid, etc and seriously affect the human health. The disposal of generated wastewater from residential as well as industrial/commercial sources also an important concern now a day. Filtration is a process for separating the contaminants from water as well as wastewater by passing through the porous media. Filter media refers to a layer of filter materials which helps to achieve the filtration process. In this work, a single unit filtration system is developed which is going to treat the water as well as wastewater which generated onsite. Various materials like activated carbon, activated zeolite and activated alumina going used to construct the multimedia filtration system. The advantage of this project will help to convert the acidic water into alkali, and to increase the total dissolved solids concentration in drinking water source, remove excess total dissolved solids from wastewater, removal of the organic matter from wastewater. One of the important mechanisms, adsorption which helps to remove the contaminants from wastewater.

Keywords: Water treatment, Contaminants, Filtration, Single unit, Multimedia

I. Introduction

Water is one of the important natural resources available on the surface of earth. Out of the total availability of water on earth, 97% found on saline sources and rest 3% fresh water which available on river, stream and glaciers. Water sources like subsurface water or water within aquifers are known as ground water resources. Ground water resource recharge from the precipitation mostly in the monsoon season in India. Canal irrigation and other form of irrigation systems also contribute to the recharging of the ground water. The annual potential of natural groundwater recharge from rainfall in India is about 342.43 km^3, which is 8.56% of total annual rainfall of the country. The annual potential groundwater recharge augmentation from canal irrigation system is about 89.46 km^3 (Rakesh Kumar, R. D. Singh and K. D. Sharma).

Water is available only for a few hours in most Indian cities and the quality is also not up to the mark. Water woes are also because of insufficient or low pressure and erratic supplies. The rural population suffers from low water quality but the urban and semi- urban areas are most prone to water shortage. The water quality should be safe and sound at the microbiological level and mere continuous supply is not enough. Another aspect is the water wastage in terms of leakages and illegal connections. “The water quality monitoring results obtained during 1995 to 2006 indicate that the organic and bacterial contamination are continued to be critical in water bodies. This is mainly due to discharge of domestic wastewater mostly in untreated form from the urban centres of the country. The municipal corporations at large are not able to treat increasing the load of municipal sewage flowing into water bodies without treatment. Secondly the receiving water bodies also do not have adequate water for dilution.

Therefore, the oxygen demand and bacterial pollution is increasing day by day. This is mainly responsible for water borne diseases." (CPCB- http://cpcb.nic.in/water.php).

A water filter removes impurities from water by means of a fine physical barrier, a chemical process or a biological process. Filters cleanse water to different extents for purposes such as providing agricultural irrigation, accessible drinking water, public and private aquaria, and the safe use of ponds and swimming pools. Filters use sieving, adsorption, ion exchanges, biological metabolite transfer, and other processes to remove unwanted substances from a quantity of water. And unlike a sieve or screen, a filter can potentially remove particles much smaller than the holes through which its water passes.

Wastewater filtration is often part of the tertiary treatment process that involves the final removal of suspended particles from water that has passed through both the primary and secondary treatment phases and immediately precedes disinfection. As the water passes through the filter, residual suspended material and bacteria is trapped in the filter and are removed from the filtered water. Passage can be blocked by physical obstruction, biological action, adsorption, absorption or a combination of ways. Wastewater filtration is usually the final step in the solids removal process.

II. OBJECTIVES

The primary focus of this research is to design and construct a single unit filtration system for both water and wastewater which generally generated at onsite. The materials used for the design of multimedia filtration system zeolite, activated carbon and activated alumina.

- The other objectives of this research are:
- To reduce the cost of whole treatment system.
- To increase the efficiency of the treatment system.
- To increase the quality of raw water.
- To perform onsite treatment of generated wastewater.
- Recycling wastewater and reusing it.

III. MATERIALS AND METHODS

A. *Collection of Sample:*

For the experimentation purpose 10 samples were collected (5 water samples and 5 wastewater samples). The water samples were collected from Sabarmati River from each 2 days interval. The wastewater sample which collected for experimentation purpose was sullage water. The source of generation of sullage water is mostly from kitchen, bathroom, sink etc. Total 5 wastewater samples were collected at an interval of 2 days. The collected samples were immediately transferred to the laboratory to carry out different experiments.

B. *Experimentation:*

Various experiments were performed for water i.e., pH, TDS and Turbidity and for wastewater i.e., pH, COD, TDS and Turbidity. pH of the sample helps to determine the acidic or basic characteristics. Generally the pH scale varies from 0 to 14. 0 to 7 is acidic, 7 are neutral and 7-14 is alkali in nature.

The chemical oxygen demand (COD), determines the amount of oxygen required for chemical oxidation of organic matter using strong chemical oxidant, such as potassium dichromate under reflux condition. The refluxing generally done at 150 º C for 2 hrs. Sample is titrated with ferrous ammonium sulphate. The disposal limit for COD is 250 mg/L.

Total dissolved solids (TDS) are a measurement of the total amount of dissolved inorganic compounds in water. It is determined by an instrument that measures the ability of water to conduct electricity. As the concentration of inorganic compounds increases, water becomes a better conductor of electricity.

Turbidity of the sample is defined as the cloudiness and haziness due to presence of suspended or dissolved solids. The unit of measurement is NTU (Nephelometer Turbidity Unit). For drinking purpose the value should not exceed 10 NTU.

For experimentation A.P.H.A. Standards Methods for the Examination of Water and Waste Water, American, Public Health Association, Washington, D.C. 1985, 19th Edition was followed.

C. *Fabrication of Model:*

A single unit filtration model was fabricated, one compartment for water and one compartment for wastewater filtration. For both the filter material arrangement is common.

Table – 1
Material arrangement for filtration

Layer-1	*Base material*	*Gravel*	*5 cm thickness*
Layer-2	*Filter material*	*Activated alumina*	*5 cm thickness*
Layer-3	*Filter material*	*Zeolite*	*5 cm thickness*
Layer-4	*Filter material*	*Activated carbon*	*5 cm thickness*

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Fig. 1: Fabricated model of a single filtration system

IV. RESULTS AND DISCUSSION

pH is one of the important chemical characteristics in terms of drinking water as well as discharge of wastewater point of view. Here the result shows an increase tendency. For all the water and wastewater samples which were analysed, pH is increasing around 2 points (Figure 2 and 3). This is one of the new concepts of our research work. Due to 2 points increase in the pH value acidic water will become alkali. This is suitable for drinking as well as disposal. The increase in pH is due to the materials used for the filtration mechanism. Three materials used i.e. activated carbon, zeolite and activated alumina. All the materials used are alkaline in nature, the pH range of zeolite generally varies from 7.35 to 7.45, for activated carbon it is 9 to 11.

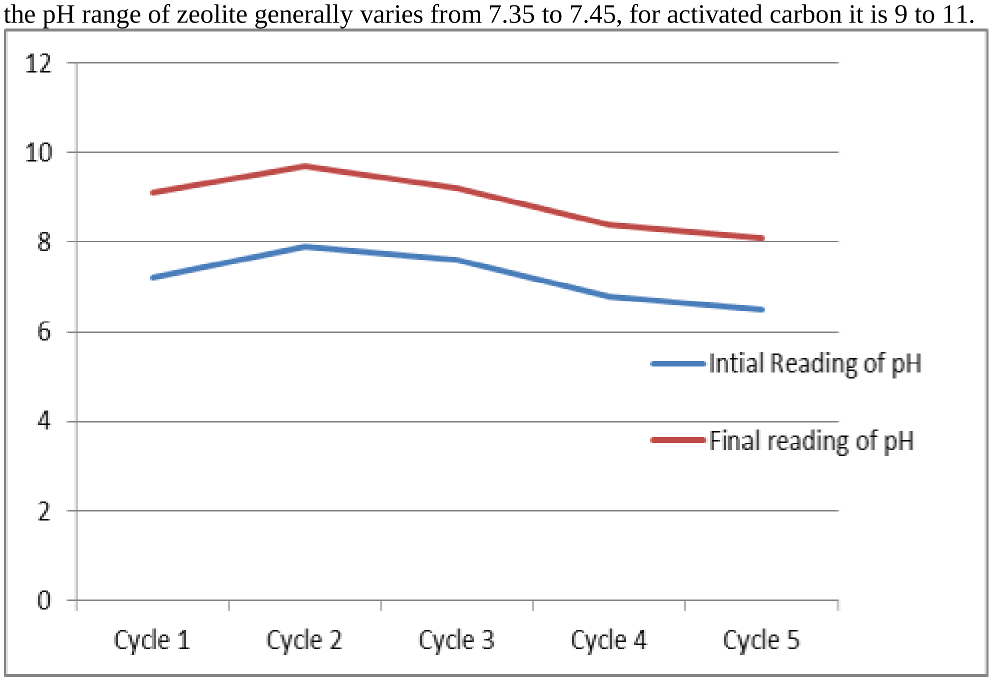

Fig. 2: pH result analysis for water sample

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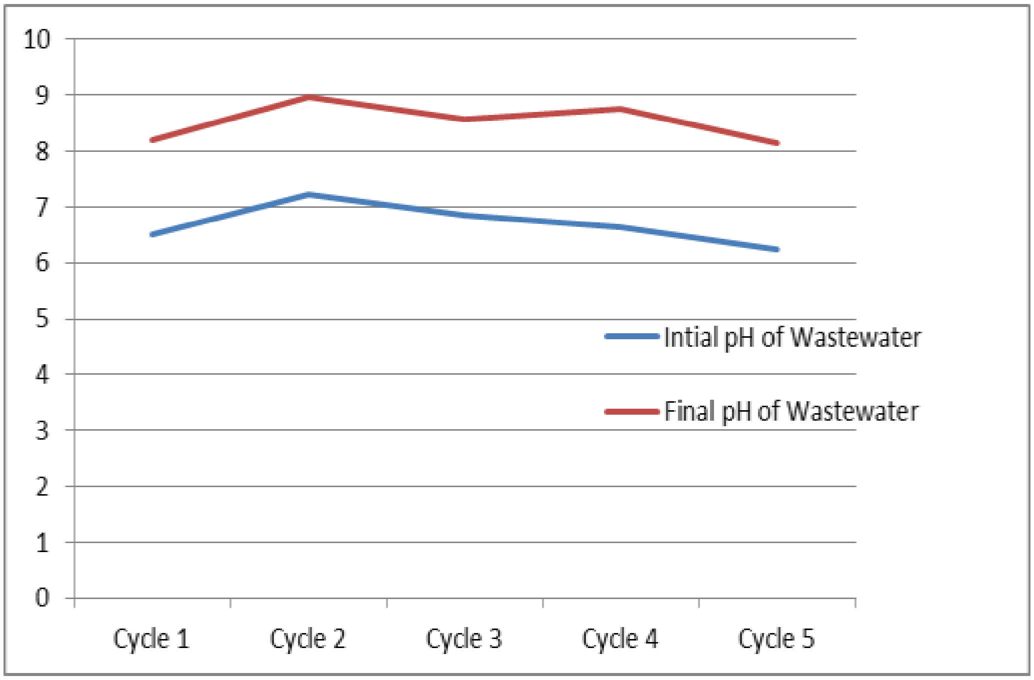

Fig. 3: pH result analysis for wastewater sample

According to turbidity removal point of view our designed filter is efficient to remove the excess turbidity from water as well as from wastewater. According to Bureau of Indian Standard (BIS) the turbidity limit is 10 NTU for drinking purpose but there is no prescribed limit for wastewater disposal point of view. In the raw water after filtration the turbidity decrease from 14.8 NTU to 8.44 which are under the prescribed limit (Figure 4). Sullage sample is collected and the initial turbidity was measured. The turbidity varies from 103 NTU, after filtration it reduces up to 49 NTU (Figure 5). There is almost 50 % reduction in turbidity. The mechanism behind the removal turbidity in water and wastewater is the adsorption mechanism. The suspended particles adsorbed to the filter media and reduction in concentration.

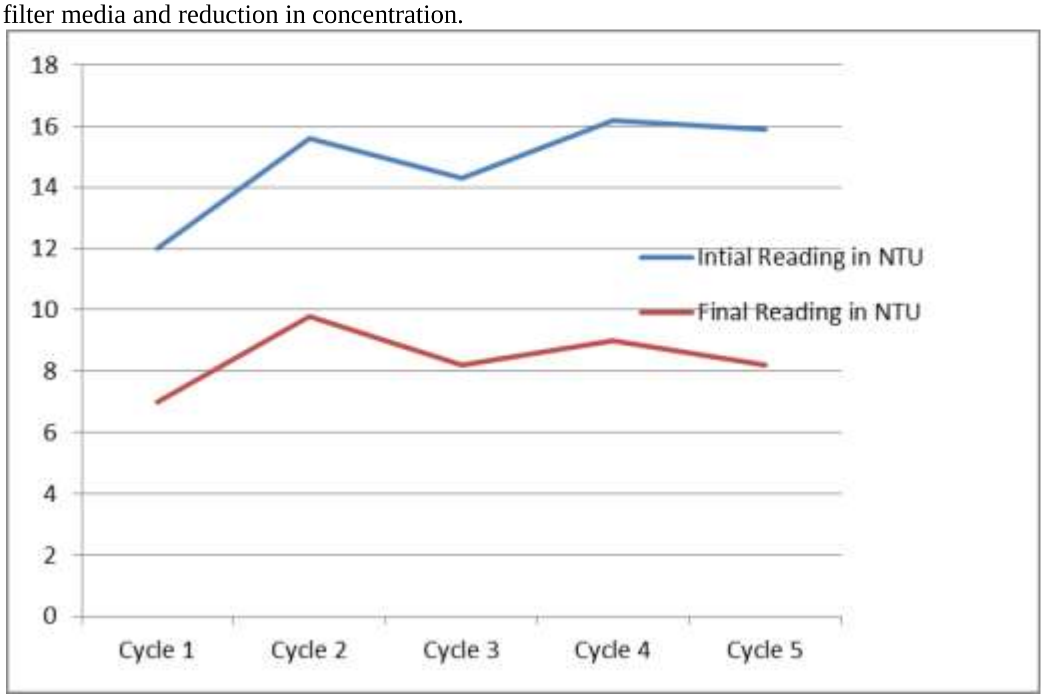

Fig. 4: Turbidity result analysis for water sample

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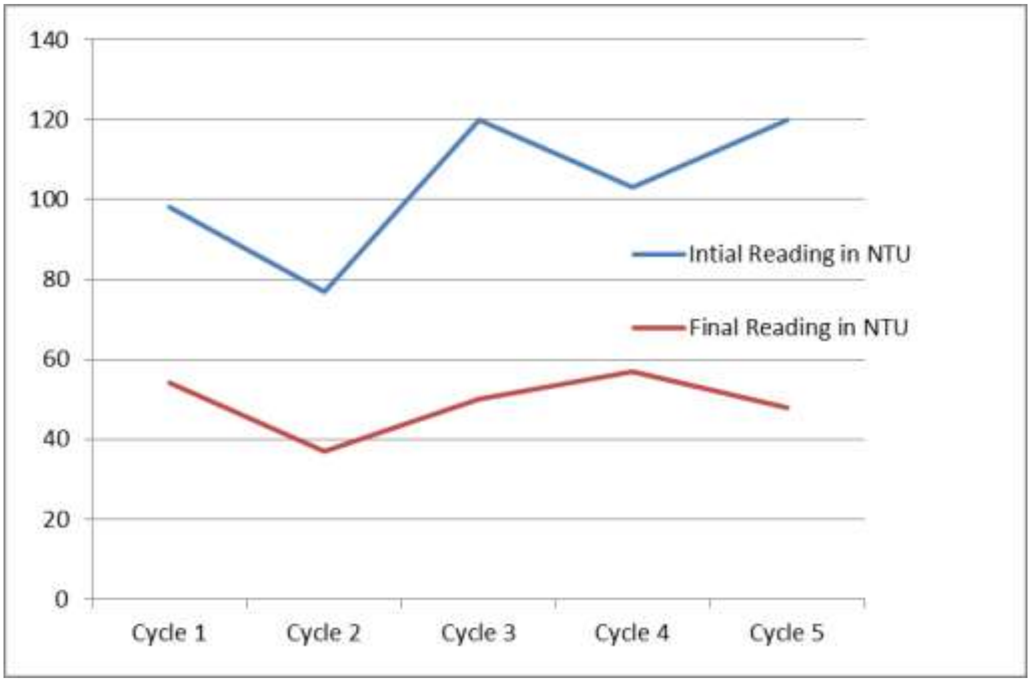

Fig. 5: Turbidity result analysis for wastewater sample

In the wastewater samples a common tendency of decreased TDS concentration was observed. The average initial TDS for wastewater is 1028 PPM, and after filtration it is 662 PPM. The TDS removal for wastewater is around 35 % (Figure 7). Our filter is efficient for removal of excess TDS from sullage wastewater. But in case of water there is one interesting trend was observed. Instead of decrease in the concentration the value of TDS is increasing. For the 5 collected water sample of Sabarmati River the average TDS concentration is 78.52 but it increase to 510 PPM (Figure 6). The main reason behind this is the filter material used for the filtration. At the top of filter activated carbon is used. According to Meilani and Santoso, The large sized activated carbon resulted the highest water TDS compared to the other sizes. The small sized activated carbon resulted the lowest water TDS compared to the other sizes. TDS using activated carbon varied from 0.01 to 0.64 gm/L. When the weight of medium sized activated carbon were 0.5 g, 1 g, 3 g, 5 g, 7 g, 10 g, 15 g and 20 g, the value of water TDS gradually increased. But when the weight of medium sized activated carbon was 25 g, the value of water TDS decreased. Another material used as a filter material is zeolite which is a microporous, aluminosilicate minerals commonly used as commercial adsorbents and catalysts also contributes towards the increase concentration of TDS. Zeolite resin exchanges sodium for calcium and magnesium. For each ppm of calcium removed and replaced by sodium, total dissolved solids increase by 0.15 ppm. For each ppm of magnesium removed and replaced by sodium, total dissolved solids increase by 0.88 ppm.

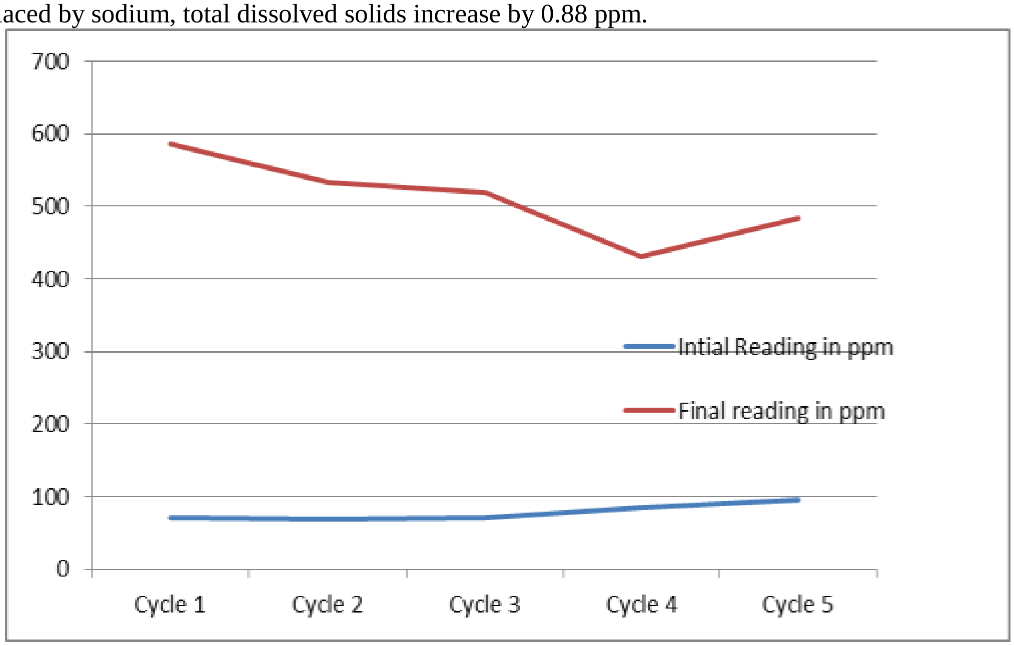

Fig. 6: TDS result analysis for water sample

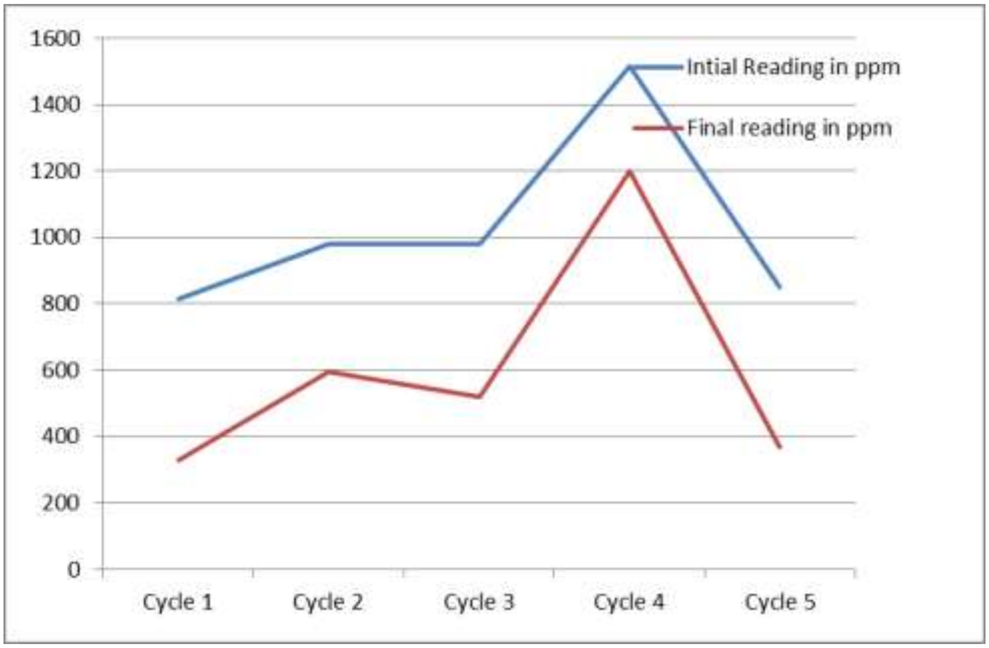

Fig. 7: TDS result analysis for wastewater sample

For the collected 5 sullage sample the average COD is 1296 mg/L. After that the wastewater is filtered through the designed filter and there is some drastically change in the COD concentration in filtered wastewater. The average COD concentration is around 538 mg/L. There is around 58 % of decrease in the COD concentration (Figure 8). This can be achieved due to the filter media which used for filtration activity. The filter media adsorbed the non-biodegradable organic matter from the wastewater. Hence the amount of total organic matter in the wastewater is decreased.

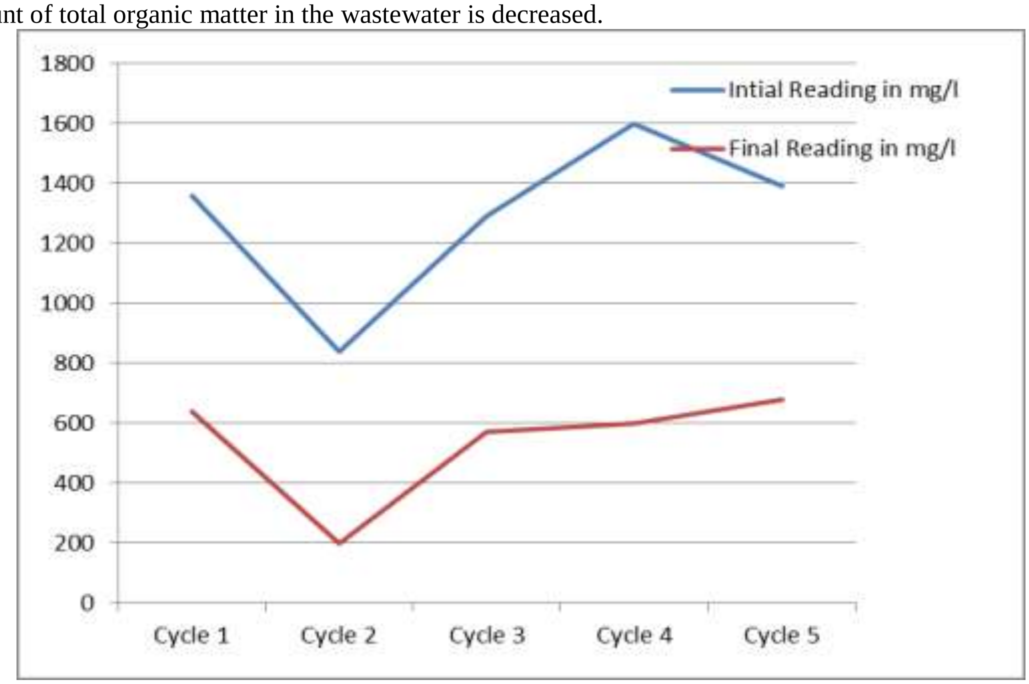

Fig. 8: COD result analysis for wastewater sample

V. CONCLUSION

The whole conclusion of this study can be drawn as the efficiency of the filter for filtration of water as well as wastewater. This is a new concept to treat both water and wastewater in a single filter. The total filtration area is equally separated into two filtration compartments, one for water and other one for wastewater. Our designed system is much efficient for

- Increases the pH concentration in water by (23.6%) and wastewater sample by (27.5%).
- Removes the TDS from wastewater by (35%) and increase the TDS in water sample by (550.8%)
- Removes the turbidity from water by (42.97%) as well as from wastewater by (52.5%).

- Decreases in the concentration of non-biodegradable organic matter, hence COD is reduced from the wastewater sample by (58.48%).

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