Biological Aerated Filter: An Advanced Approach Towards Wastewater Treatment

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Abstract- *Biological Aerated Filter (BAF) is an emerging wastewater treatment technology designed for a wide range of municipal and industrial applications. Biological Aerated Filter (BAF) serves as an efficient fixed biofilm reactor with advantages of high polluants removal rate, low reactor volume required and unique capability of removing solids and nutrients together. The performance of BAF is mainly based upon the factors such as filter media and its size, media height, aeration system, biofilm growth and flow configuration. The BAF can be operated in upflow or downflow mode depending upon the level of treatment to be achieved. BAF offeres many advantages over conventional treatment process despite of limitations. The present paper provides a brief summary of BAF and its effectiveness over various factors to get higher level of efficiency.*

Keywords- Biofilm, Biological Aerated Filters, flow configuration, media and Wastewater.

I. INTRODUCTION

Increase in the urbanization and industrialized with a rapidly expanding world population are responsible for generating large amount of wastewater. The wastewater that is being generated is discharged into the surface sources causing pollution in the downstream areas. Therefore, all of the pollution sources i.e. municipal, industrial and agricultural must be managed in order to reduce the concentrations of the pollutants to improve the quality of the environment. The most adverse environmental impacts associated with improper discharge of municipal wastewater having significant amounts of organic matter (COD), nitrogen (N) and phosphorus (P) include promotion of eutrophication, toxicity to aquatic organisms and depletion of dissolved oxygen to receiving streams. Due to the adverse impacts, there is a need for complete treatment of municipal wastewater before discharge.

Today many options are available for the treatment of wastewater. Although conventional biological treatment processes are mostly reliable, well designed and tested, they present a number of drawbacks in terms of treatment capacity, efficiencies, stability and space requirements. With the continuing need to increase wastewater effluent quality with respect to the removal of organic matter and nutrients, one of the advanced biological treatment systems, the biological aerated filters (BAFs), proves to be more reliable.

The Biological aerated filters (BAFs) process is a technology that provides secondary treatment to the municipal and industrial wastewater. BAFs are relatively compact, easy to operate and may be more efficient in carbonaceous and ammonia removal than activated sludge system.

II. BIO-AERATED FILTER (BAF)

Biological aerated filter (BAF) is one of the advanced secondary treatment methods. The term BAF is basically originated from the combination of air and the filtering action of the bacteria. A BAF typically consists of medium that treats carbonaceous and nitrogenous matter using biomass fixed to the media and capturing the suspended solids in the media. [1] Basic operating principle of BAF is based on a conventional biofilter operating in a submerged mode. It consists of three phases; a solid phase that acts as a support media for microbial growth, a liquid phase in which the solid material is submerged and gas phase created by the input of air into the reactor. The granular media is submerged in the reactor and fed wastewater after removal of some solids by primary settling (clarifying), enters the BAF at the top or the bottom depending upon the design of the plant Conventionally, BAF is a submerged media wastewater treatment reactor that combines oxic biological treatment and biomass separation by depth filtration. The BAF has undergone rapid development in the last decade and has become a promising alternative to conventional biochemical wastewater treatment process. Various factors associated with performance of BAF are discussed below.

2.1 Biofilm growth

BAF is an attached growth process, where the biofilm grows on the surface of the BAF and reduces the organic load on the filter by metabolizing the organic matter present in wastewater.[6] The optimal condition for the relevant microorganisms within BAF system can be maintained independently of hydraulic retention time in order to achieve high level of treatment. The main factors that influence the biofilm growth within BAF are flow rate and nutrient concentrations. Surface characteristics, such as surface area, porosity and surface roughness are another importance factors that influence the biofilm formation and concentration.[2] Hence, the biofilm growth and its desirable thickness plays an important role in removing the undesirable organics from wastewater through aerobic process. [9]

2.2 Flow configuration

The BAF system can be designed with two configurations either upflow or downflow mode. For the upflow BAF, the influent is introduced at the bottom of BAF and flows co-current with air while for the downflow BAF, the influent is fed at top of BAF and flows counter current to air.[2] The upflow BAF has the ability to cope with higher influent flow rates, has longer operational cycle system, and can decrease odour problem occurring since the atmospheric air only contacts with treated effluent at the top of the BAF. Despite, the downflow BAF also offers an advantage of better mixing and longer contact time of the air and water or wastewater which is conducive to oxygen transfer and biodegradation in the lower portion of the filter.[1]

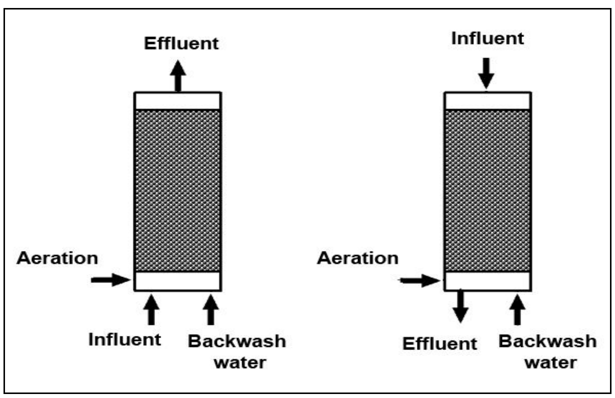

Fig.1 Schematic Diagram of Upflow and Downflow BAF

2.3 Aeration System

Aeration system is an important part in the BAF system to supply oxygen which can be at the bottom or bottom half of the BAF system. The removal of carbon and ammonia are predominant in the BAF systems with aeration system at the bottom with suspended solids are also filtered well. However, only the upper section of BAF system can perform well for carbon and ammonia removal if the aeration is supplied at the bottom half of BAF system.[2] A BAF system with sufficient oxygen supply will be a good condition for biofilm growth and good removal of ammonia. If the aeration volume is higher than required, the biofilm growth would be abraded and carried out of the BAF system with the effluent. It has found that, low aeration volume or dissolved oxygen in the BAF can affect the biofilm specific growth rate.[5]

2.4 Filter Media

A filter media is one of the main components in the BAF system to achieve effluent quality requirements. The filter media has a noticeable influence on the hydraulic characteristics on oxygen-substrate transfer rate. Therefore, the selection of a suitable BAF media is critical part in BAF process, to enable the effluent quality reached the regulated standard. In any BAF system, there are two types of filter media; floating media such as plastic media and polystrene pellets and sunken media such as ceramics, zeolite and sand.[3] The filter media provide a large surface area per unit volume to maintain a high amount of active biofilms and variety of microbial population. The media also allows the reactor to act as a deep, submerged filter and incorporate suspended solids removal. The selection of filter media to enable the required effluent standard quality for ammonia removal is depending on some factors which is media type and sizes. It has been found that the characterization of filter media is required to determine their suitability for biofilm growth and attachment.

Fig.2 Polystyrene Pellets and Plastic Media

2.4 Media Size

Media size affects the efficiency of BAF performances in treatment process as well as the removal of suspended solid, organic contaminants, and inorganic contaminants. The smaller size media offers a greater surface area per unit volume for biofilm development and minimizes the required BAF volume, but high backwash frequent is required. A larger media basically greater than 6 mm effectuates reduction in nutrient removal due to the less surface area for biofilm growth and attachment because of the high void age in the BAF. However, low backwash rate is required for larger size media and decreases the operation and maintenance cost. Consequently, different sized media have been recommended for different applications. It has been found that the BAF system using the smallest size media (2-4 mm) gives maximum efficiency as compared to the media of larger size (4-8 mm and 5.6-11.2 mm).

2.5 Media Height

The media packing in the BAF system can be operated either partially or fully packed. The partially packed BAF had a comparable performance with the fully packed BAF in the removal of nutrients from wastewater. Generally the greatest increment of removal efficiency occurs at the top 100 *cm* of media height and within the first 100 *cm*. The roughness and the shape of media also influence the performance of BAF. [4]

III. WORKING OF BIO-AERATED FILTER (BAF)

The Biological Aerated Filter (BAF) is a upflow or downflow, high rate, fixed film, biological wastewater treatment system. The process is capable of removing both soluble and suspended organic material from the wastewater. Primary effluent is introduced to the BAF and flows downward through a packed bed of granular media. The media within the filter cells is tightly packed and provides a surface for the growth of microorganisms which assimilate the organic matter in the wastewater. The micro-organisms which grow on the surface of the media consumes the organic matter and other pollutants from the effective treatment can be achieved. Air is introduced directly into the packed bed, countercurrent to the wastewater flow, which provides oxygen for biological growth. The BAF system typically employs multiple filter cells that are rotated in and out of service as needed to accommodate varying wastewater flow rates and concentrations of organic materials in the flow. [4] BOD removal and solids filtration are accomplished in the upper portion of the bed. The bed volume below the level of air injection is undisturbed and serves as a polishing zone for the removal of suspended solids. This may eliminate the need for a separate secondary clarifier.

Excess biological growth and trapped suspended solids are removed from the bed by periodic backwashing of the entire media with treated effluent. Air is introduced to the bottom of the bed during the backwash cycle to scour excess solids from the media. The dirty backwash water is removed from the BAF system by siphon and returned to the primary clarifier. The backwashing should be conducted efficiently to avoid the supporting media from being damaged and interference on the biofilm growth. [6]The under washing can bring out short operating cycle and possible solid breakthrough. Meanwhile, over washing can cause reduction of biomass which eventually leads to poor performance.

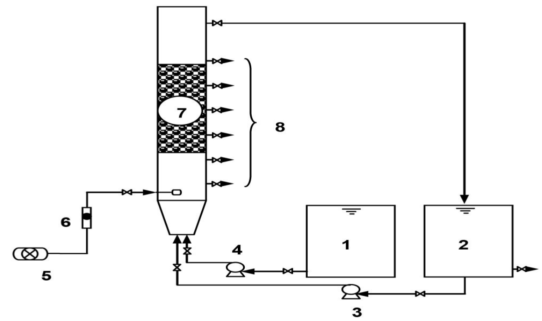

Fig.3 Schematic diagram of the biological aerated filter (BAF) process system; (1) Influent tank, (2) Effluent tank, (3) Backwash pump, (4) Peristaltic pump, (5) Compressor, (6) Flow meter, (7) Filter media, (8) Sampling port

3.1 Merits of Bio-Aerated Filter

Elimination of secondary clarifiers reduces the associated costs and operational problems that can accompany traditional treatment processes.BAF requires less space due to its small footprint.It is fully automated in operation with minimum operator attention.BAF is effective for treatment of cold and dilute wastewaters.BAF is capable of handling wide flow and temperature variations.

3.2 Limitations of Bio-Aerated Filter

The cost of energy consumption and chemical is higher than the conventional clarifier.BAF typically performs best at constant flows, concern about varying performance with daily flow variation.BAF is a mechanically intensive process requiring increased operator attention. Plant operator should have very good knowledge and skill on the use of the automatic control system and the biological sewage treatment technology.Choice of filter media is specific to the level of treatment and pollutants to be removed.Frequent backwashing or cleaning to avoid clogging is vital for operation in warm climatic areas.

IV. CONCLUSION

The BAF system is relatively new advancement in biological wastewater treatment which shows potential for producing a high quality treated effluent than those of conventional treatment alternatives. BAF is biological treatment process, stable in operation, while at the same time it minimizes the noise, odour and space requirements with high degree performance. BAF may be used as a treatment process for the removal of SS, COD, BOD and ammonia from wastewater. BAF systems can be operated at a low HRT and can be used as a compact system for small communities in treatment of the wastewater for carbon and nitrogen removal.

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