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Comparison between conventional activated sludge and bio-augmentation media application process for domestic sewage

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Abstract

Due to growing urbanization and industrialization causing severe water pollution, because of partially or untreated waste deposit into the water sources. Immediate intervention is required to reduce the magnitude of water pollution through proper treatment of biological waste before disposal. Out of other biological methods, Activated Sludge process has been employed as a remediation technology for centuries where naturally growing bacterial cultural used for bio-degradation of organic matters. Under a control environment, bacterial culture has been grown which was used in a different batch reactor process. An alternate method, bio-augmentation media has been added (specifically formulated microorganism, coated with enzymes that are available in form of solid cake or powder and can be preserved for some time) instead of naturally grown biomass. The experiment was continued for the period of one year varying environmental condition. This research deals with the comparative study of different operational parameters in a specific volume of sewage, maintaining an optimum range of F:M ratio and dosing of bio-augmentation media into the waste environment. Separate aeration tanks of same sizes, pH range 6 - 9 has been maintained during the experiment period. Operational parameters have been varies to determine the advantage and disadvantage of these processes. The effluent produced from both processes includes BOD removal 80% -95% however, problems like; sludge handling and high occupancy area etc. have given growth to newly proposed method i.e.: bio-augmentation media process. The results reveals that the recommended ECR limit has obtained within 2.6 hours and 4 hours achieving around 87% and 70% of COD reduction using these two process respectively. Similarly, performance wise COD removal rate after 3hours of aeration bio-augmentation media (24%) showed lower compared to activated sludge (56%). However, in the case of EC and TDS an increasing trend of complete reverse situation has observed. Around 24% and 60% of increase EC and around 26% and 65 % of increase.

Keywords: Activated sludge, bio-augmentation, sewage, optimum, explore.

1. Introduction

Domestic wastewater treatment in developing countries is a major concern and solution has become challenging for various unfavorable conditions. With it, humans have come forward in treating domestic wastewater by far with new technology. The use of Activates Sludge in biological treatment is mostly common where greater flexibility of treatment, permitting a control over the quality of effluent desired. The effluent produced is clear, sparking and non-putrescible. BOD removal 80% - 95% and bacterial removal 90% - 95% (Metcalf *et al.* 1995). It includes seeding of bacterial culture in naturally however, bio-augmentation media is a new scientific approach that includes specific formulated microorganism coated with enzyme. Due to the limitation of activated sludge like; disposing problem, large treatment space, odor etc., this newly proposed bio-augmentation media have been used as method access to treatment. No sludge recirculation, no sludge production and nutrient added enzymes have make this process wiser. The development of selected and adapted bacteria provides single species cultures which can degrade specific target substrates. The cultures are harvested and preserved by freeze drying. It Increases the concentration of desirable bacteria and thus reducing their response time (lag phase) to specific substrates (N. C. A. Stevens 1989). Treatment of wastes with bacteria involves the stabilization of waste by decomposing into harmless inorganic solids either by aerobic or anaerobic process. In aerobic process, the decomposition rate is more rapid than to that of anaerobic process and it is not accompanied by unpleasant odor, whereas in anaerobic process, longer detention period is required and gives unpleasant odor. Microorganisms can degrade numerous organic pollutants owing to their metabolic machinery and to their capacity to adapt to inhospitable environments. Thus, microorganisms are major players in site remediation. However, their efficiency depends on many factors, including the chemical nature and the concentration of pollutants, their availability to microorganisms, and the physicochemical characteristics of the environment (Saı¨d El Fantroussi *et al.* 2005).

2. Methodology

2.1 Collection of wastewater

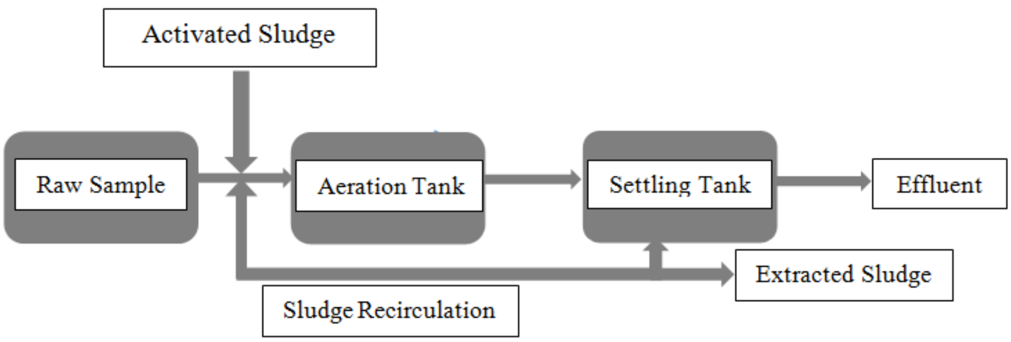
The Sample was collected from nearby domestic backyard manhole. The obtained raw sample has vary COD values. The sample was collected during peak flow time around 8-10 am.

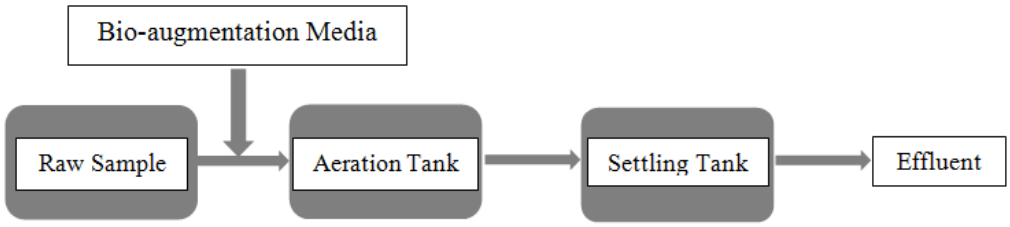
2.2 Test procedure for wastewater characterization

In this study, BOD, COD, DO, pH, turbidity, EC, MLSS, MLVSS, and F:MO were determined following the standard methods (AWWA 1998) for raw sample.

2.3 Experimental Setup

The setup of conventional batch process for the treatment of domestic wastewater using activated sludge and bio-augmentation media is shown below.





2.4 Procedures

Seeding of Sludge was done separately for more than 2 weeks. Nutrients and extra diffusers were added at the initial phase to increase the process of seeding. Sampling of Raw water was done using 10L of gallons each. We found the COD and EC of raw sample above 500mg/L and 1200 micro simen/cm each time. The experiment was done with a continue aeration for 8hours at a constant room temperature. No sludge recirculation in the case of bio-augmentation.

3. Result and discussion

3.1 Activated sludge

3.1.1 Effect of volume of sewage on COD reduction

In the experiment, different volume of waste water has been used to obtained best reduction rate of COD. The size of the aeration tanks used for both methods were kept same.

Using small volume of sewage, maintaining the ratio (diameter:depth) of around 1:1. Various problem like, poor floc formation, dispersed growth problem and filamentous bulking of sludge under natural environmental conditions etc. have been encountered (Michael Richard *et al.* 2003). Using large volume of sewage by maintaining the ratio of around 2:1 have shown better performance.

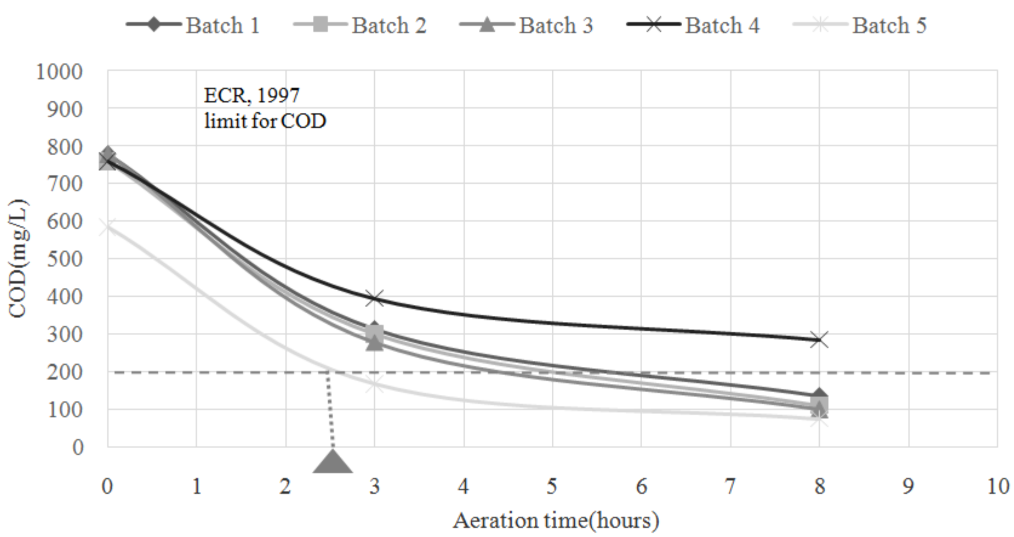


Fig. 1. Variation of COD with aeration time (Activated Sludge).

Based on the graph plotted above, ECR limit 1997 has been achieved within 2.6 hours. We can say, by maintaining the ratio 2:1, the distance between the wall of tank and aerator was sufficient to avoid the hydraulic effect. This decreases the chances of collision between reactor wall and flocs, obtains the better performance and reduce the settle ability of flocs.

3.1.2 Effect of F:M ratio on COD reduction

Reduction of COD has been observed with varying F:M ratios in sequential batch process using activated sludge. For a conventional plug flow the F:M ratio should be 0.2–0.4. (Source: Typical design parameter for Activated Sludge). As due to sludge thickening, the F:M ratio was found to be low that cause removal rate of COD a bit low to some extent.

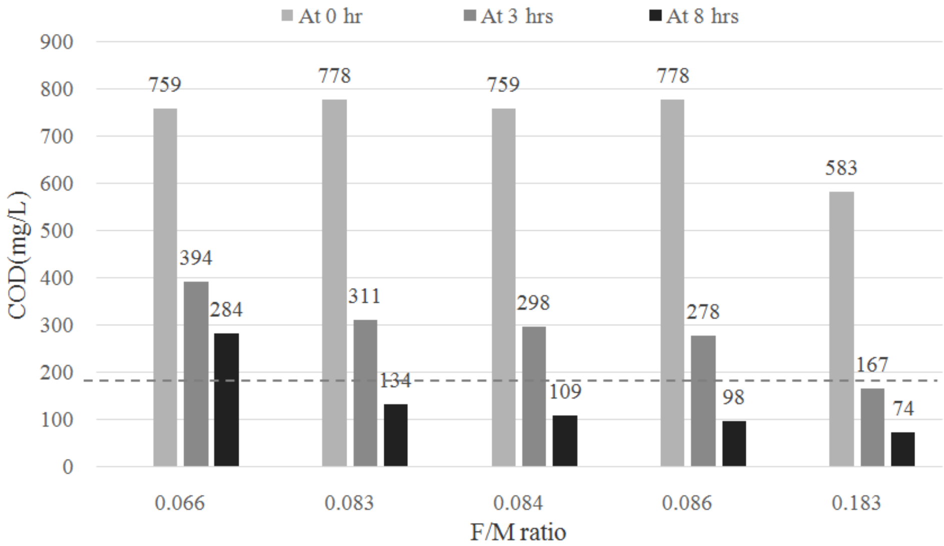


Fig. 2. COD variation with F:M ratio.

The bar graph shows, batch 5 (F:M = 0.183) has achieved the recommended ECR limit within short time i.e. least COD value.

3.1.3 Effect of sludge aged

By diverting a certain portion of settled sludge or recirculation, increase the opportunity of growing new bacteria. The variation of pH, increase alkalinity and concentration of NH_3 in the experiment shows the existence of nitrifying bacteria. Since, significant nitrifying bacteria have observed that cause a reduction of COD removal performance. Due to increase of pH, it might affect the bio-oxidation process of bacteria and might function slowly. However, the study needs further investigation.

3.2 Bio-augmentation media

3.2.1 Effect of volume on COD reduction

Using the larger volume of sewage by maintaining the ratio (diameter:depth) of 2:1 have shown better results. The problem of failing of selected strains often to show under the natural environmental condition have encountered during using of smaller volume of sewage (ratio 1:1). As the distance between the wall of tank and aerator was sufficient to avoid the hydraulic effect, the recommended ECR limit 1997 has been achieved within 4 hours of aeration period.

3.2.2 Effect of dosing of bio-augmentation media on COD reduction

Varying the dosing of bio-augmentation media, reduction of COD value has been observed in the sequential batch process. From the graph, at 5 gm per 16 L of sewage, COD removal rate was observed to be good. Least COD value within 4 hours of aeration time have been obtained. It reveals that, 5 gm is an optimum dosing for 16 L of sewage.

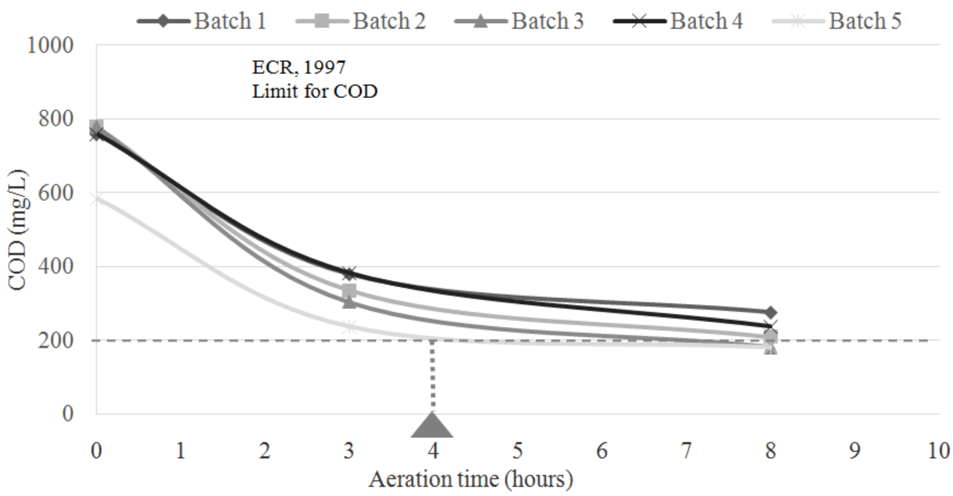


Fig. 3. Variation of COD with aeration time (bio-augmentation media).

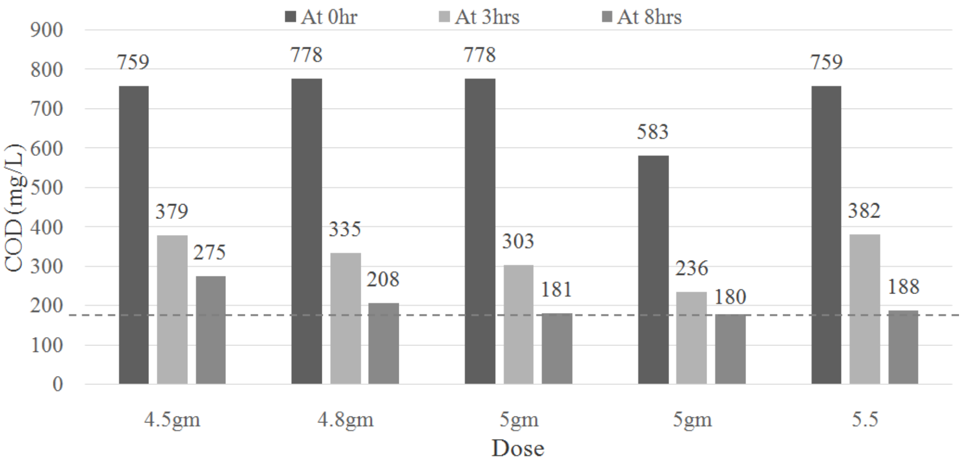


Fig. 4. COD variation with dosing of bio-powder.

3.3 Comparison between activated sludge and bio-augmentation media process

3.3.1 Variation of COD reduction trend with aeration time

The trend of COD reduction rate has been observed that reveals that obtained COD reduction rate in activate sludge process was quiet good compared to that of bio-augmentation media application process.

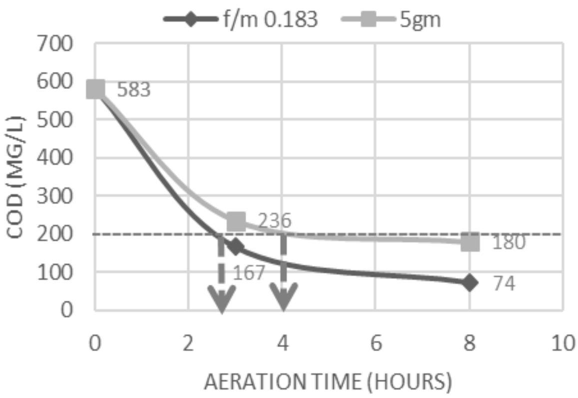


Fig. 5. COD reduction trend with aeration time.

From the graph, the recommended ECR limit has been achieved within 2.6 hours and 4 hours in activated sludge and bio-augmentation media process respectively.

3.3.2 Variation of COD reduction with pH

Reduction of COD has been observed with pH changes in sequential batch process. 87.3% of COD reduction has been achieved in activated sludge process where pH varies from 7.43 to 7.58 however, 78% of COD reduction has been achieved in bio-augmentation media process where pH increased from 7.43 to 8.22. The increment of pH using bio-augmentation media is due to dissociation of enzyme that cause a reduction of COD removal performance as enzymes itself increase COD.

3.3.3 Variation of EC and TDS with aeration time

Increasing trend of EC has been observed with the aeration time using diffuser aeration process. An increasing trend of complete reverse situation has been observed.

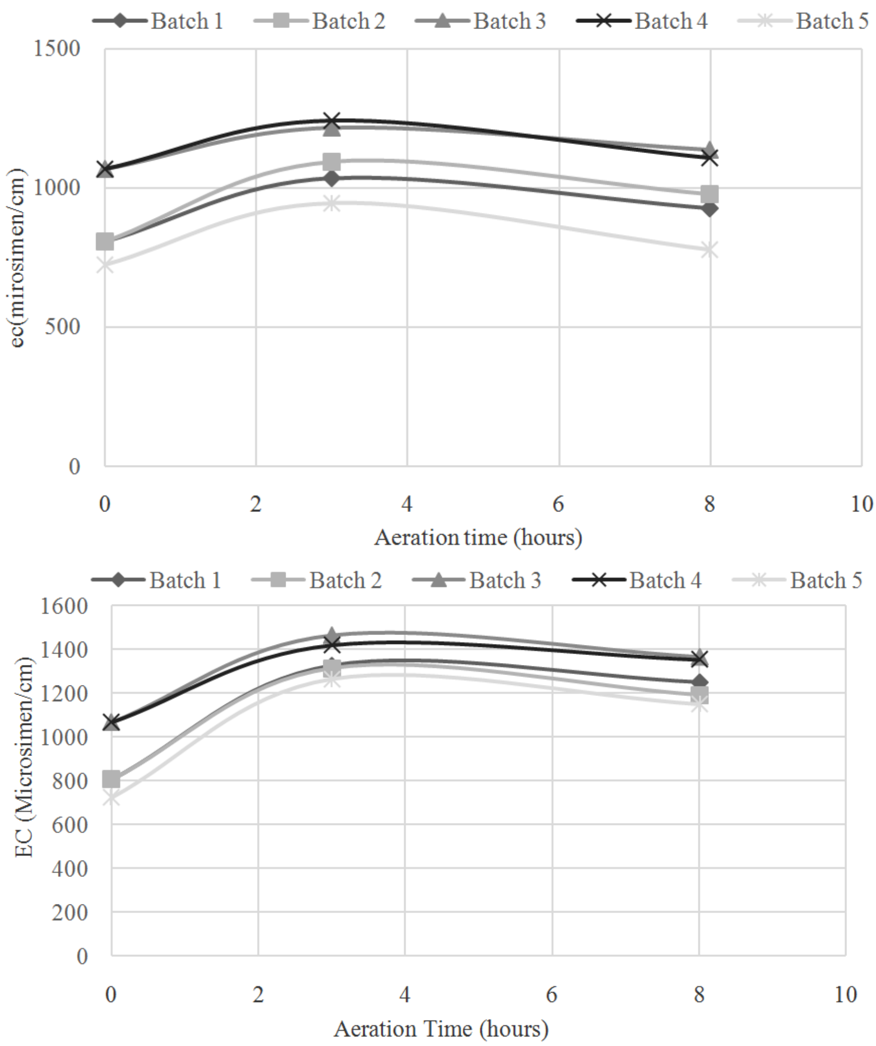


Fig. 6. (a) Activated sludge (b) Bio-augmentation media.

Results reveals that around 24% and 60% of increase in EC has been observed after the addition of activated sludge and bio-augmentation media. The tremendous increased of EC in bio-augmentation is due to ion dispersion as there might be some inorganic ions that release from the coated enzymes. When EC increases, TDS (26% and 65% respectively) and ion concentration of water also increase, which might not favorable for local redox reaction and also effect the solubility of water.

3.3.4 Environmental aspect

As disposal of sludge with poor drying creates odor and unpleasant smell around the surrounding. Sludge of a very good quality can be turned into compost, mainly used in agriculture and green spaces. The spreading of raw sludge in agriculture is the sector itself as the most economical and most environmentally friendly. Microorganism after drying can be source of food for the decomposer that enhance the fertility of the soil. The sludge disposal is the last link in the waste water treatment. The solids that result from wastewater treatment may contain concentrated levels of contaminants that were originally contained in the wastewater. A great deal of concern must be directed to the proper disposal of these solids to protect especially aquatic environmental considerations. Failure to do this may result in a mere shifting of the original pollutants in the waste stream to the final disposal site where they may again become free to contaminate the environment. Burial, filling, dedicated incineration, forced dehydration can be the solution. (Source: https://www.researchgate.net/ post). In the case of bio-augmentation media, benefits are minimal when the indigenous population is well established and already capable of treating the waste. In other words, bio-augmentation has no marginal value. In some cases, the wrong bio-augmentation product is applied, and the bacteria neither survive nor accomplish treatment goals. Some bio-augmentation products are cultured using rich media and high temperatures, but are poorly adapted to treatment environments with low levels of substrates or low temperatures. Thus, the added bacteria do not survive or function well. The dose of a proper bio-augmentation product is frequently too low to show detectable benefits. Addition of foreign bacteria increase the mass and SRT (sludge retention time) of microorganism. Bacteria are enclosed with coated enzymes which ultimately increase cod by itself.

4. Cost analysis

The most significant difference between the two processes of secondary treatment is in their cost. The cost variation to maintain the entire system according to the different processes is very high. The process cost is very high in bio-augmentation process. A primary cost regarding the main substance needed for bio-augmentation process is for bio-augmentation powder. A simplified calculation of cost needed to buy bio-augmentation powder in order to maintain an ETP with a capacity of 100 m^3 is presented below.

Capacity of the ETP = 100 m^3
From the experimental data we have obtained the optimum dosing to be 5g/16L.
So, Total quantity of bio-augmentation powder needed = (100*1000)*5/16 = 31.25 kg.
Price of 1 kg of bio-augmentation powder = 4500 Tk.
So, total price needed for 1 batch of wastewater = 31.25* 4500 = 1, 40,625 Tk.

If we consider 8 hours/ batch and 2 batches of wastewater every day, the cost would be (140625*2) = 2, 81,250 Tk. So it would require 2, 81,250 taka every day to treat 200 m^3 of wastewater additional to the other cost that are common in both cases. Where activated sludge process can be done almost with no cost required to the production of sludge.

5. Conclusions and recommendations

Bio-augmentation is using added microorganism to “reinforce” biological waste treatment population so that they can effectively reduce the contaminant load by transforming it into less dangerous compound. The efficiency of the bio-augmentation depends on many factors, which include the chemical property and concentration of the pollutants, and the activity of the bio- augmented bacteria. Therefore, process performances were unpredictable and the full-scale applications of bio-augmentation to the existing wastewater treatment facilities were rarely reported. (Fang Ma *et al.* 2008). Moreover on balance, the experimental analysis cited in this review are discouraging. The use of bio-augmentation media for treatment waste water includes unpredictable performance. The COD reduction rate for first 3 hours was very effective compared to last hours but as a whole performance was not good than that of activated sludge. Compared to bio-augmentation media injection process, the activated sludge process would be more efficient for COD reduction. In addition, the sludge utilization processes have advantages of easy control, stable performance, and high operation flexibility. The relatively low operation cost and environmental safe of this systems increases application in treatment practice. Different attempt has been done to accelerate the process. Seeding procedures should be done with careful. Balanced Nutrients like urea, TSP (maintaining BOD:N:K = 100:5:1) should be used in cyclic period. This will increase the optimize growth of bacteria. The aeration tank for both processes must be provided sufficient gap between diffuser and wall of the tank (ratio of diameter to depth of tank) to avoid the hydraulic force of water so, as to prevent microorganism getting hit into the wall and break themselves down at the initial stage. Certain portion of initially bio-powder treated water must be added to the existing water, as they were familiar to the environment, it increases their capacity. Sludge recirculation should be provided to optimize the growth of new cells. Submergence depth of the tank must be minimum (4-5) m so, as to obtain standard Oxygen Transfer Efficiency (SOTE) i.e. (20-30) %. Special attention should be provided while using diffuser. Bubble size must be (1-2) mm. As, SOTE increases with the Lower of Bubble size. However, due to the lack of data for quantitative assessment, the study needs further inception.

References

El Fantroussi, S., Agathos, S.N., (2005), Is bio-augmentation a feasible strategy for pollutant removal and site remediation? Curr. Opin. Microbiol. 8, 268–275

Fang Ma, Jing-bo Guo, Li-jun Zhao, Chein-chi Chang, Di Cui, (2008), Application of bio-augmentation to improve the activated sludge system into the contact oxidation system treating petrochemical wastewater.

Metcalf & Eddy, Inc., (1995), Wastewater Engineering: Treatment, Disposal and Reuse, P-360, 3rd edition, Revised by G. Tchobanoglous and F. L. Burton, Tata McGraw Hill Publishing Company Limited, New Delhi.

Michael Richard, Ph.D., Sear-Brown, Fort Collins CO, (2003), Activated Sludge Microbiology Problems and their control.

N. C. A. Stevens, (1989), The Application of Bio-augmentation to Waste Water Treatment, International Bio deterioration 25 (1989) 87-95

www.researchgate.net, Bachir Achour, Rafik Karaman, What is the most eco-friendly and safest choice for municipal sewage sludge treatment? (in case of no previous wastewater treatment), https://www.researchgate.net/post/What_is_the_most_ecofriendly_and_safest_choice_for_municipal_sewage_sludge_treatment_in_case_of_no_previous_wastewater_treatment.