

INTERNATIONAL JOURNAL OF ARCHITECTURE (IJA)

Volume 1, Issue 1,
January – December (2013), pp. 70-76
© IAEME: www.iaeme.com/IJA.asp



.....

OPTIMIZATION OF DESIGN PARAMETERS OF BIOLOGICAL TREATMENT PROCESS FOR TEXTILE DYE WASTE WATER TREATMENT

Umme Zakira¹, Synthia Tagar², Dr. Faroque Ahmed³

¹Department of Civil Engineering,
Bangladesh University of Engineering and Technology, Dhaka-1000, Bangladesh,

²Department of Civil Engineering,
Bangladesh University of Engineering and Technology, Dhaka-1000,

³Department of Civil Engineering,
Bangladesh University of Engineering and Technology, Dhaka-1000, Bangladesh,

ABSTRACT

Textile Industries are huge sector where a large amount of effluents are produced that, if left untreated or poorly treated, cause detriment to the environment threatening both human health and aquatic life. So it is necessary to purify the effluents before discharging them to water bodies. Biological wastewater treatment processes harness the ability of microorganisms to break down and assimilate organic compounds. Although this process occurs naturally, optimization of design parameters of biological treatment accelerate the process by optimizing bioreactor conditions to promote higher-than-typical biomass concentrations. Hereby, the aim of this study was to optimize the design parameters (aeration period, Sludge volume Index, F/M ratio) to increase the rate of removal of biodegradable substances resulting in enhancing the efficiency of Biological treatment process.

Keywords: BOD, COD, optimum aeration period, optimum F/M ratio, Sludge Volume Index

1. INTRODUCTION

The textile and apparel industry in developing countries like Bangladesh play vital role in economy and employment, accounting for 80% of exports and employing 3 million workers. The growth in this sector, and other small and medium scale enterprises, undoubtedly has a positive effect on national economic development but there are also negative implications.

A large number of these mills generate and discharge waste waters. Most of the industries that are based in and around Dhaka city usually appear in Savar, Gazipur, and Narayanganj and most of them are situated near rivers and canals. It was reported by the various organization and monitoring authority that the pollution of the rivers and canals in and around Dhaka is well above their acceptable level. The reason is simple; being located so close to a water body most of these industries did not bother with what they perceived as the sunk cost of a treatment plant, instead choosing to dispose their wastewater and other contaminants into the nearby rivers, canals, ponds and even open grounds or farming land.

Various agencies are trying to safeguard the clean environment. Bangladesh Government has already issued various forms of warning and red alerts to the concerned industries. A lot of textile wet processing industries have already installed effluent treatment plants (ETP) and many of them are at various stages of installing ETP's. For an integrated cost based design, optimizations of various design parameters are emphasized.

Previously Afia Sharmin and Manashi Paul have studied on wastewater treatment of Textile Industries. In their study they did not optimize the design parameters for treatment process rather measuring the parameters. Moreover, they did not study on wastewater having variation in quality. So, wide model study on optimization of different parameters of Biological treatment process needed to be done. So, the present work was conducted on wide laboratory model study to optimize the important design parameters of Biological treatment process. This will facilitate to make the process cost effective for the treatment of Textile wastewater and discharging them into surface water body with compliance to Bangladesh Environmental Quality Standard, 1997.

2. METHODOLOGY

2.1 Sample Collection

Wastewater sample was collected from the EOS Textile Industry, located on Dhaka Export Processing Zone (DEPZ). About 40 litre composite samples were collected of several dyeing batches at the inlet of the equalization tank. Sludge has been collected at the outlet point of settling tank.

2.2 Biological Treatment Process

Biological processes are used extensively in wastewater treatment process to convert biodegradable organics and other nutrients into a more manageable form. Conditions which must be fulfilled to carry out biological process are following-

- **pH:** The allowable pH in the biological process ranges between 6-9.
- **Temperature :** temperature must be within 25-30°C .
- **Nutrients :** Nitrogen, phosphorus, calcium, magnesium are needed for increasing microorganism activities and better performance of the process.
- **Toxicity :** Toxic substances hinders rate of biodegradation of wastewater.
- **Volumetric (BOD) Loading :** With activated sludge treatment, the removal performance depends on initial BOD loading. Generally for sequential batch reactor process BOD loading limit is 0.1-0.3 kg/m³/day [1].

2.2.1 Biological Treatment Setup

At first, pH, EC, Color and COD of raw sample has been measured. Raw sample has been adjusted to pH 7 with sulphuric acid solution. Adjusted sample has been added to 1 liter sludge in such amount so that 4 liter wastewater sample is prepared. Then aeration has been done by diffuser. After certain period of time, diffuser was turned off and sample was collected after 30 min settling time. EC, pH, Color, COD of collected sample has been measured. Rest of water has been removed by water pressure from the raw sample. The entire process has been repeated for different concentration of organism. In such way, due to the acclimatization of bacterial population with environment of the aeration basin, efficiency of COD and BOD removal has been increased gradually.

F/M is one of the most important parameters of an activated sludge system. The F/M ratio is controlled by the amount of wasted sludge; an increase in wasted sludge mass decreases the F/M ratio, when vice versa. The best performance of activated sludge is only achieved when F/M is maintained at an optimum, constant value.

$$F/M \text{ Ratio} = \left[\frac{\{\text{COD concentration in the wastewater (mg/l)} * \text{Volume of Wastewater (l)}\}}{\{\text{Mixed Liquor Suspended Solid (mg/l)} * \text{Volume of Sludge Added (l)}\}} \right]$$

The sludge volume index is long-established measure of activated sludge settling ability. This is obtained by allowing a sludge sample to settle under standardized conditions. The SVI has been measured by filling a 1 liter graduated cylinder with mixed liquor from the activated sludge aeration basin and allowing it to stand undisturbed for 30 minutes. Thus the volume of settled sludge has been read in milliliters. The suspended solids concentration has been determined using a sample of mixed liquor from the aerating basin which is known as MLSS and the SVI is expressed as volume in milliliters occupied by 1 gm of settled suspended solids.

$$\text{Sludge Volume Index (SVI)} = \left(\frac{\text{Volume of 1000 ml Sludge after settling} * 1000}{\text{Mixed Liquor Suspended Solid}} \right) \text{ mg/l}$$

3. EXPERIMENTAL FINDINGS

The untreated raw wastewater samples, collected from the EOS Textile Ltd, were investigated in the laboratory in order to find out the different water qualities, i.e. physical, chemical and bio-chemical qualities of the wastewater. The obtained results have been presented in Table 3.1.

Table 1: Variation of Wastewater Characteristics

Type of qualities	Wastewater quality parameters	Average concentration	ECR, 1997
Physical	Color (Pt-Co)	1675	–
	Grease and Oil	Not found	10
Chemical	EC (mS/cm)	3.17	1.2
	pH	8.55	6–9
Bio-Chemical	COD (mg/L)	828	200
	BOD (mg/L)	686	50
	BOD Loading (kg/m3.d)	0.138	-

According to the Effluent Quality Standard at Discharge Point for Industries, COD and BOD₅ must be within 200 mg/l and 50 mg/l respectively. Since the average COD value of raw wastewater is 1472 mg/l and average BOD₅ value is 1024 mg/l. So, treatment is required to limit these values within the standard values. The Table 1 reveals that in the existing effluent there is high concentration of biodegradable organic matter (causing high BOD values) as indicated by high COD: BOD ratio in raw samples. So, biological treatment process was followed in the laboratory as model study.

3.1. Optimum Design Parameter for Effective Biological Treatment

Wastewater treatment covers different artificial processes to remove or alter its objectionable constituents so as to render it less dangerous. By controlling the system variables, the rate at which these processes occur is maximized and the time required for treatment is minimized. There are many design parameters which should be optimized to enhance the treatment performance. These include the following:

- Aeration Period
- Sludge Volume Index (SVI)
- F/M ratio

3.1.1. Optimum Aeration Period

Optimum aeration period is the shortest possible time of aeration within which maximum permissible limit of COD and BOD can be achieved. From experiment it has been found that only 16 hours aeration period is needed to reach the standard value of COD and BOD which are 200 mg/l and 50 mg/l respectively. Fig 1 shows variation of COD and BOD value with aeration period.

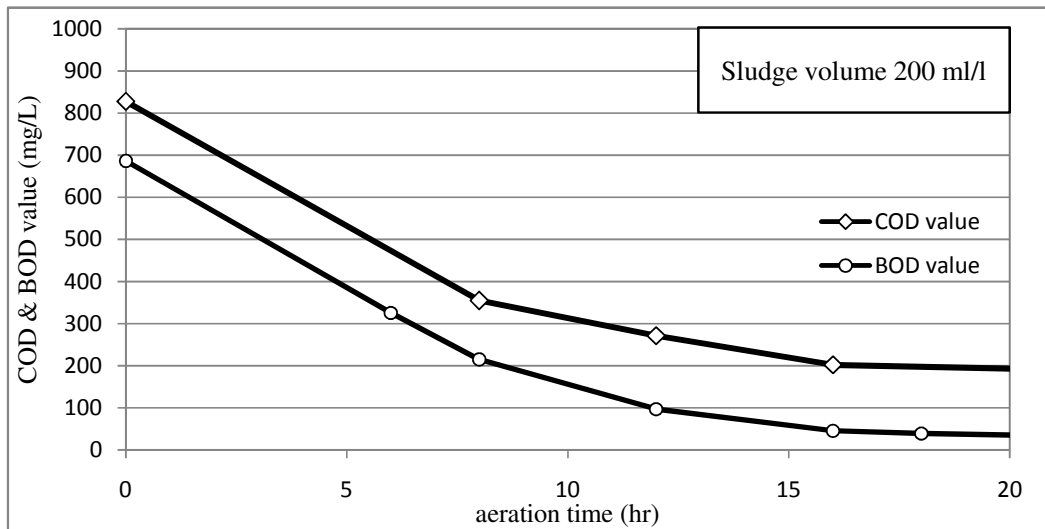


Figure 1: average variation of COD and BOD with aeration period

From the Fig 1, it is clear that within 16 hours aeration COD and BOD have been reduced below 200 mg/l and 50 mg/l respectively which signify that the optimum aeration period of the sample is 16 hours. That means 16 hours aeration is enough to reduce COD and BOD value to allowable limit.

3.1.2. Optimum range of Sludge Volume Index (SVI)

The efficiency of secondary sedimentation tank is linked to the efficiency of the biological unit and depends on the settle ability of microbial biomass formed and this is particularly critical in the separation of activated sludge from the treated wastewater. The variation of remaining BOD₅ value with different sludge volume index (SVI) has been depicted graphically in Fig 2.

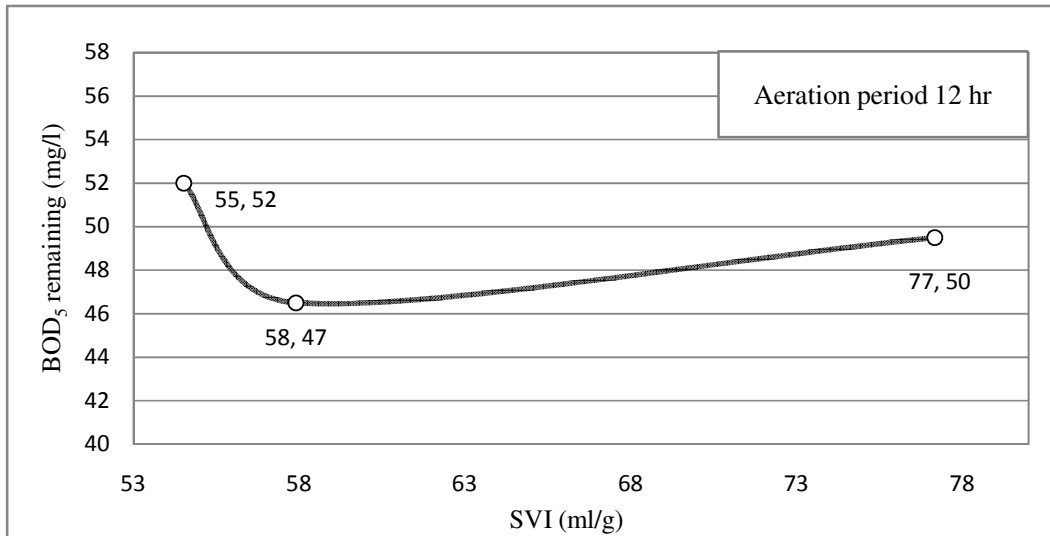


Figure 2: variation of BOD₅ remaining with SVI

Here at maximum BOD removal efficiency, the SVI is found to be 58 which mean that the settle ability of sludge is maximum at close to this value. Normally a high SVI indicates a poor settle ability and in general sludge with an SVI>120 have poor settling properties, possibly bulking. A good sludge would have an SVI<80 and a very good one around 50 [2]. These indices are easily and rapidly performed on site and are routinely used by operators to check the condition of activated sludge.

3.1.3. Optimum range of Food to Micro-organism (F/M) Ratio

The important aspect in the operation of biological treatment process specially activated sludge process is to control the optimum F/M ratio so that desired endogenous respiration phase of growth can be achieved within the shortest possible time of aeration. The optimum F/m ratio for extended aeration system is mentioned as 0.2-0.1 (Steve Grimme, 2001) and 0.25-0.5 (Gray Lee, 1997). The F/M ratio is controlled by the amount of sludge recycled. The best performance of biological treatment process is only achieved when F/M is maintained at an optimum level. In the laboratory, arrangements were made to observe the effect of F/M ratio on the efficiency of the biological treatment process. Three different set of sample were tested in which only variable parameter was the F/M ratio, maintaining all other parameters (pH, EC, initial COD, BOD and aeration period) in same condition.

Fig 3 illustrates the variation of COD remaining after 16 hour aeration with initial F/M of raw sample. Here COD value has decreased gradually up to F/M 0.375 and then increased beyond standard value of COD.

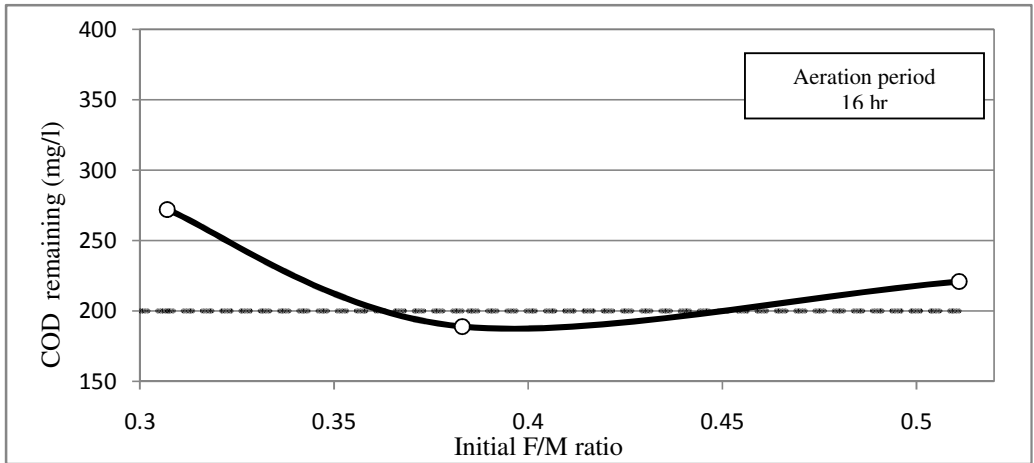


Figure 3: variation of COD remaining with initial F/M

The curve shows a decreasing trend due to biodegradation of organic matter. But after certain range of F/M ratio, COD value again started to increase with increasing F/M ratio. Therefore operation at high F/M ratio results in poor COD removal efficiency. So for our wastewater sample optimum F/M ratio is about 0.36-0.45 considering COD removal performance (Fig 3).

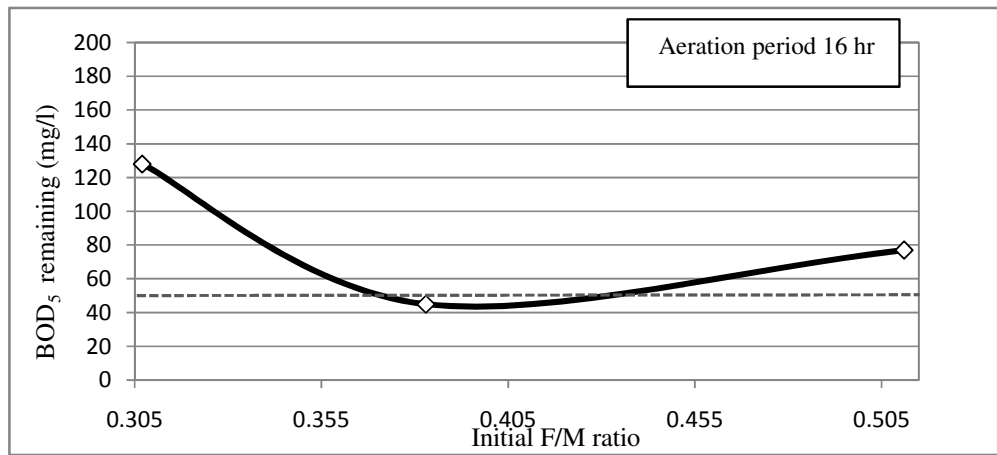


Figure 4: variation of BOD remaining with initial F/M

Variation of BOD₅ value with initial F/M has been depicted in Fig 4. It shows that BOD₅ value has decreased gradually up to F/M 0.375 due to biodegradation of organic matter and then again started to increase. So it is clear that for our wastewater sample considering BOD₅ remaining only, the optimum F/M is between 0.36-0.43 (Fig 4).

At high F/M ratio, microorganisms are in exponential growth phase, characterized by excess food. The microorganisms are in dispersed growth such that they do not settle out of solution by gravity. Therefore operation at high F/M ratio results in poor BOD removal efficiency.

4. CONCLUSION

The number of textile industries has increased significantly during the past 10 to 15 years in Bangladesh. Discharge of untreated or poorly treated wastewater lead to serious water pollution causing severe environmental hazards on both aquatic and human life. Most of the Textile industries adopt chemical process without assessing the characteristics of the effluent. For EOS Textile Mills Ltd (Dhaka EPZ,Savar) biological treatment process has been found effective. To ensure maximum efficiency of this treatment process optimization of its design parameters is essential. From the laboratory experiments the optimum aeration period has been found 16 hours. Also optimum SVI and F/M ratio have been found 50 and 0.36-0.43 respectively.

5. ACKNOWLEDGEMENT

The authors are really privileged to have their project work done under the reverend supervision of honorable teacher Dr. Farooque Ahmed, Professor, Department of Civil Engineering, Bangladesh University of Engineering & Technology (BUET), whose valuable advice, apt mentoring and guidance as well as support throughout the project kept them on the right track and to act according to their potential.

The authors also wish to express obligations to Mr. Giuseppe Berto, Managing Director and Mr. AungKyawChing, Chemical Analyst of EOS Textile Mills Ltd., Dhaka Export Processing Zone (DEPZ) for their help and cooperation to collect wastewater sample and other related information needed for this study.

Thanks to the Environmental Engineering laboratory assistants, without whose help authors could never have finished the project in this stipulated time period. Last but not the least, the authors express the gratitude to their parents for their support and blessings throughout the period of the study.

REFERENCES

- [1] Metcalf & Eddy, wastewater engineering treatment and reuse (4th edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003), 747
- [2] N. F. Gray, biology of wastewater treatment (Oxford University Press, USA, 1989) 128, 346-347
- [3] Peavy, Rown, Tchobanoglous, environmental engineering (McGraw-Hill-International Edition, 1985)
- [4] P.S.Davies, the Biological Basis of Wastewater Treatment
[\[http://bartec-benke.nl/media/1000154/thebiologicalbasisofwastewatertreatment.pdf\]](http://bartec-benke.nl/media/1000154/thebiologicalbasisofwastewatertreatment.pdf)
- [5] P. A. Whalen, P. J. Whalen, D. R. Tracey, Improving Biological Wastewater Treatment Process Control through ATP-Based Parameters
[\[http://www.environmental-expert.com/Files/5306/articles/13834/468.pdf\]](http://www.environmental-expert.com/Files/5306/articles/13834/468.pdf)
- [6] S. Afia and M. Paul, Wastewater Treatment of Textile Industries, MS Thesis, Department of Civil Engineering, Bangladesh University of Engineering and Technology, March, 2012