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Short Note

Operating Strategies for Activated Sludge Process to Enhanced Coliform Removal

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Abstract: This paper deals with the effectiveness of activated sludge process in removing coliforms with respect to operating parameters like MLSS, F/M and SVI. It was observed that operation of biological treatment with high MLSS (3000-3500), low F/M ratio (0.2-0.35) and SVI in the range of 80-150 ml/g tended to result in increased removal of microbial indicators and pathogens. Therefore, it can be taken as a controlling range for higher coliform removal efficiency. Monitoring of these parameters at regular intervals will reveal the total spectrum of plants working efficiency so that operations and maintenance troubles in treatment system can be corrected in time.

Key words: Activated sludge process, coliforms, MLSS, MCRT, F/M.

Introduction

Wastewater treatment plants are usually designed to remove the organic pollutants and nutrients efficiently, but seldom have they been planned specifically to remove pathogenic microorganisms from wastewaters. Conventional wastewater treatment reduces the number of enteric microbes, but reductions in treatment processes can vary extensively and wastewater effluents still contain high numbers of fecal microorganisms.

Typically, an optimally working biological treatment process with respect to conventional activated sludge process may achieve 90-99% reductions. An extensive review of published data indicates that activated sludge process is an effective treatment system for microbiological removal from wastewater. The overall efficiency of coliform removal has been reported to be 90-95% and 90-98% in complete mix and extended aeration activated sludge process respectively (Arceivala, 2004). James (1985) reported 97% removal of coliform by conventional activated sludge system. Earlier studies in activated sludge plants have usually shown similar 90-99% enteric bacterial reductions (Koivunen et al., 2003).

The removal efficiency of pathogenic and indicator microorganisms in wastewater treatment plants vary according to the treatment process type, retention time (HRT), biological flora present in activated sludge, O_2 concentration, pH, temperature and the efficiency in removing suspended solids (Koivunen et al., 2003). The microbial removal efficiency can also be controlled by process parameters like MLSS, F/M and SVI. A comparison of coliform concentrations in secondary effluent as a function of MCRT and MLSS has been studied by WERF (2004). Further, microbial concentration can be decreased with increasing MCRT and MLSS. It is the fact that interactions of microorganisms with process parameters in activated sludge process are not well understood and little work has previously been carried out in this sector.

Thus, the aim of this study was to provide comparative and quantitative information about the fate of coliform populations in full-scale conventional activated sludge

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process w.r.t. operational parameters like MLSS, F/M and SVI.

Material and Methods

Plant under Study

Sewage treatment plant operating under conventional activated sludge process, installed at Kankhal, Hardwar (18 MLD) was selected for regular monitoring, over a period of one year and results were obtained.

Sampling

Wastewater collected from the inlet, aeration tank and outlet of the plants was conveyed to the laboratory within six hours and stored at 4°C for microbiological as well as chemical analysis (APHA, 1998).

Sample Analysis

TC, FC and FS were selected as indicator organisms of pathogens for monitoring removal efficiency. The methods used for their enumeration were in accordance with Standard Method (APHA, 1998). Three tube fermentation tests (Most Probable Number, MPN) gave results for Total Coliform (TC), Fecal Coliform (FC) and Fecal Streptococci (FS). The MPN of coliforms in each test was determined using MPN tables. Determination of MLSS and SVI was carried out using procedures outlined in standard methods (APHA, 1998).

Results and Discussion

The wastewater samples collected from inlet, aeration tank and outlet of ASP, Haridwar, were analyzed for various microbiological as well as process parameters (Tables 1 and 2).

The mean concentration of TC, FC and FS (as Most Probable Number per 100 ml) in raw sewage was 3.6×10^8, 6.5×10^7 and 5.7×10^6, respectively. In the treated effluent, the mean TC, FC and FS values were significantly lower than the raw sewage i.e. 3.8×10^5, 1.8×10^5 and 1.3×10^4 MPN/100ml, respectively. The overall mean removal of TC, FC and FS was found to be 99.2, 99.47 and 98.52%, respectively. As per Metcalf and Eddy (2003), reduction of bacteria in ASP is 90-98%. Earlier studies in activated sludge plants have usually shown similar 90-99% enteric bacteria reduction (J. Koivunen et al., 2003). Gohary et al. (1998) reported that a removal of more than 99% in indicators of fecal pollution in terms of fecal coliform and fecal streptococci was achieved through the biological treatment process i.e. activated sludge process.

Table 1: Descriptive data on physico-chemical and microbiological parameters

Parameters	*Influent*	*Effluent*
TSS		
Range	280-373	8-30
Mean	333.80	17.35
% Removal (Mean)	94.07	
BOD		
Range	95-160	9.6-24
Mean	136.87	15.84
% Removal (Mean)	88.06	
TC (MPN/100 ml)		
Range	2.3×10^6-7.5×10^8	9.3×10^3-2.3×10^6
Mean	3.64×10^8	3.75×10^5
% Removal (Range)	93.48-99.98	
% Removal (Mean)	99.15	
FC (MPN/100 ml)		
Range	2.1×10^5-4.3×10^8	1.5×10^3-2.3×10^6
Mean	3.64×10^8	3.75×10^5
% Removal (Range)	99.00-99.99	
% Removal (Mean)	99.47	
FS (MPN/100 ml)		
Range	2.3×10^4-4.3×10^7	1.5×10^2-9.3×10^4
Mean	5.73×10^6	1.25×10^4
% Removal (Range)	94.65-99.95	
% Removal (Mean)	98.52	

Table 2: Summarized Data on operational parameters

Process parameters	*Ranges*	*Mean*
MLSS	2780-3600 mg/l	3500 mg/l
SVI	73-299 ml/g	125 ml/g
HRT	2-4 hrs	-
SRT	8-10 days	-
F/M	0.16-0.46	0.3

Microbial Indicator Removal Efficiency of Activated Sludge Process as a Function of MLSS Concentration in Aeration Tank

The relative influences of operating parameters i.e. Mixed Liquor Suspended Solids (MLSS) upon the removal of fecal biomarkers were assessed. A comparison of the secondary effluent concentrations of TC, FC and FS as a function of MLSS are shown in Figure 1. Correlation coefficients were derived in between microbial variables in treated effluent and MLSS concentration in aeration tank at the same time. The correlation coefficient was

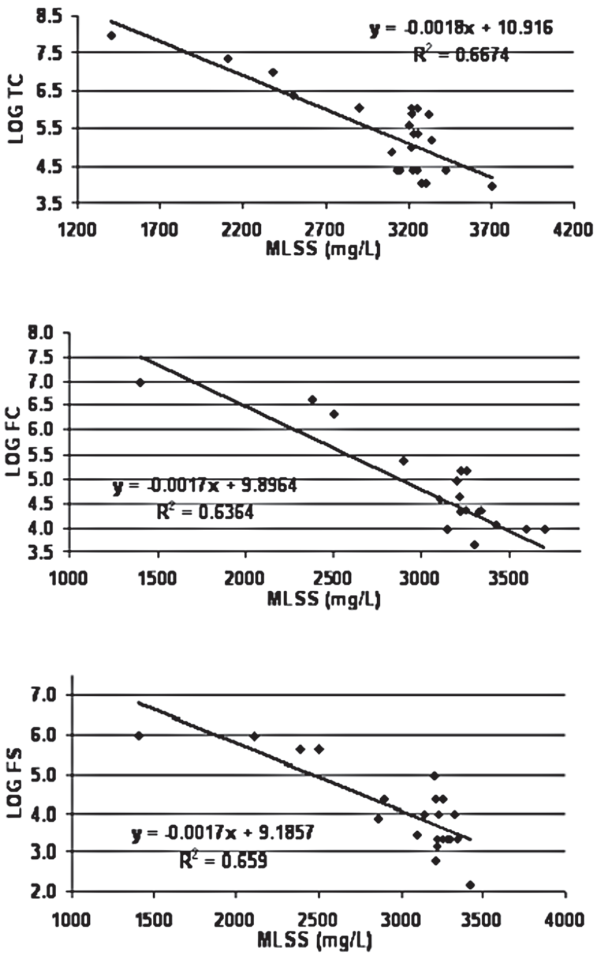

Figure 1: Correlation between MLSS and effluent concentrations of TC, FC and FS.

0.67, 0.64 and 0.66 for TC, FC and FS respectively. In general, concentration of these indicators decreased with increasing MLSS, perhaps due to the increased potential for entrapment in biological flocs. We found our observations are consistent with those obtained by WERF (2004). They found almost similar correlation coefficient (r^2 = 0.6) for fecal coliforms as a function of MLSS concentration in aeration tank. They further suggest that higher levels of MLSS concentration and longer MCRT may play a significant role in increased removal of microbial indicators and pathogens. The less concentration of microbial indicators were noted in treated effluent within a MLSS range of 3000-3500 mg/l. An optimum MLSS range of 2000-5000 mg/l has been suggested by various researchers worldwide (Metcalf-Eddy, 2005; Rittmann & McCarty, 2005; Arcievala, 2005) for complete mix activated sludge process.

Microbial Indicator Removal Efficiency of Activated Sludge Process as a Function of Food to Microorganisms (F/M) ratio in Aeration Tank

The optimum operating range of F/M helps to get the desired effluent concentration. It provides a means for maintaining the best effluent quality (Melissa Durbin, 2006). With this intent, we tried to find out the optimum F/M range for better coliforms removal. A significant correlation coefficient (r^2) was obtained i.e. 0.68 for TC, 0.63 for FC and 0.68 for FS as a function of F/M ratio applied to the system (Figure 2). The higher microbial indicators removal was obtained at an optimum F/M range of 0.2- 0.35. A low F/M ratio will facilitate constant endogenous phase to the system. During this stage, bacteria begin to die-off or bacterial cell lyses will occur (McKinney, 1962). For a conventional design for the activated sludge treatment of domestic sewage, the F/M ratio has been suggested within a range of 0.25-0.5, a range that generally results in reliable operation with BOD removal efficiency of about 90-95% (Metcalf-Eddy, 2005; Rittmann & McCarty, 2005; Arcievala, 2005). If the F/M ratio is maintained at very high levels, the microorganisms will not floc but will be completely dispersed and the energy level of the system will be quite high at this non-flocculent stage (Rittmann and McCarty, 2005).

Microbial Indicator Removal Efficiency of Activated Sludge Process as a Function of Sludge Settling Property

Sludge Volume Index (SVI) was also examined as a controlling parameter for higher coliform removal. A significant correlation coefficient (r^2) was obtained i.e.

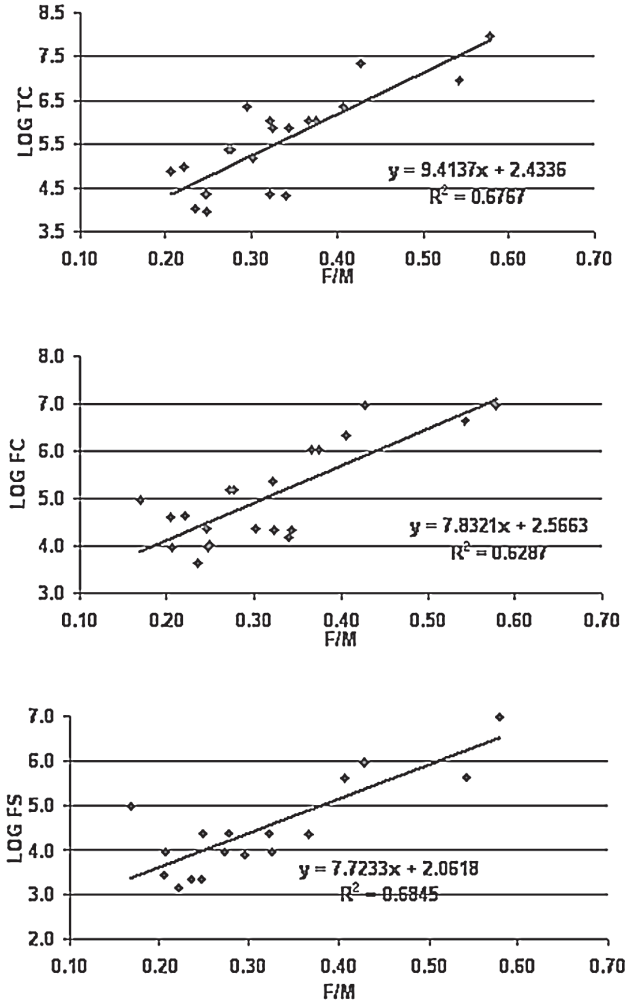

Figure 2: Correlation between F/M ratio and effluent concentrations of TC, FC and FS.

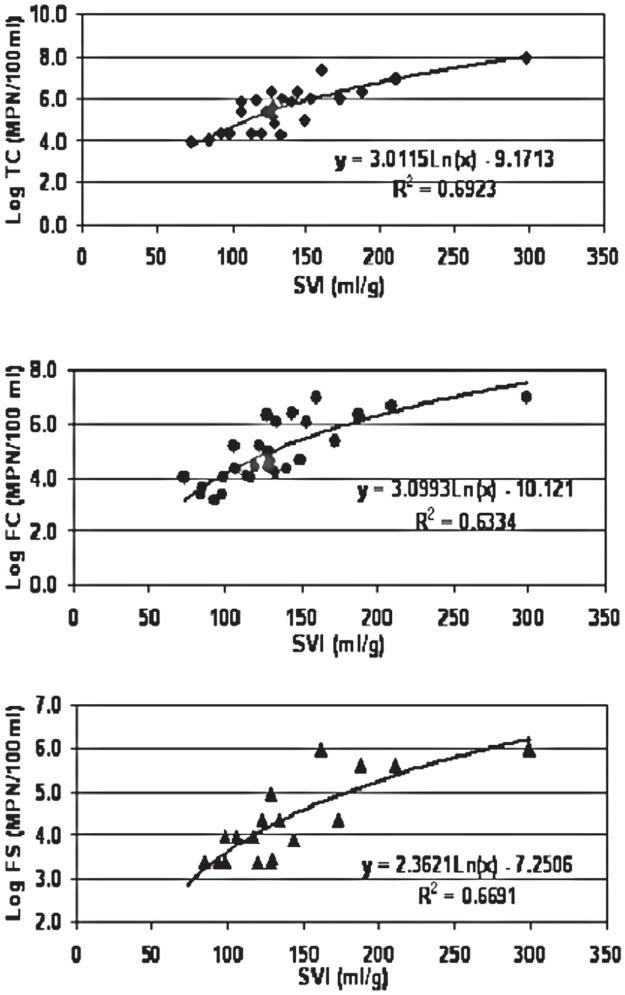

Figure 3: Correlation between SVI and effluent concentrations of TC, FC and FS.

0.69, 0.63 and 0.67 for TC, FC and FS, respectively (Figure 3). The most probable reason may be that higher sludge settling capacity achieves the increased potential for entrapment of suspended particles in the biological flocs, resulting in the reduction of escaping of particles associated microorganisms in the effluent. The observation revealed that an optimum SVI range of 80-150 ml/g were associated with low effluent microbial concentration. The usual adopted range of SVI is 50-150 ml/g and such a value indicates good sludge settling. SVI values above 150 are typically associated with filamentous growth (Metcalf & Eddy, 2005; Rittmann & McCarty, 2005).

Conclusion

In the light of observations, we can conclude that the effectiveness of full-scale biological treatment in an activated sludge process in removing fecal bio-indicators significantly depends upon operating parameters like MLSS, F/M and SVI. Operation of biological treatment with higher level of MLSS (3000-3500), lower F/M ratio (0.2-0.35) and SVI within a range of 80-150 ml/g tended to result in increased removal of microbial indicators and pathogens. Finally, this paper concludes that activated sludge process system should be monitored for its performance evaluation through usual physico-chemical and microbiological parameters as well as process parameters i.e. MLSS, SVI and F/M in aeration tank. Monitoring of these parameters at regular intervals will reveal the total spectrum of plants working efficiency and operating and maintenance trouble in treatment system can be corrected in time.

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