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STUDY ON POLLUTANT REMOVAL IN CONVENTIONAL AND MBR SYSTEM FROM TANNERY WASTEWATER AT TIED

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ABSTRACT

This study is based on the performance of pollutants removal in the conventional and Membrane Bioreactor (MBR) system in tannery wastewater at CETP of Tannery Industrial Estate Dhaka (TIED). Tannery wastewater is characterized by Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solids (SS), Total Dissolved Solids (TDS), chromium, sulfides etc. The presence of pollutants create irritation and suffocating odor in the treatment plant. Membrane process is a combination of activated sludge treatment and membrane filtration for biomass retention, and are considered as key elements of advanced wastewater treatment. In recent years the use of MBRs for medium to large-scale wastewater applications is beginning to show some of the initial promises. The main factors that contributed to their development were the experience gained with pilot/smallscale projects, the drastic decrease in the cost of membranes, the availability of subsidies and the improvements in membrane performance. Currently, it has been observed that the effluent quality at CETP exceeds the ECR'97 standards. The treated water in the conventional system contains a high amount of pollutants and is very harmful to the environment and living things. It is necessary to introduce tertiary treatment at CETP. The performance of Membrane Bioreactor (MBR) for treating tannery wastewater at a laboratory scale has been evaluated in this study. The color, turbidity, EC, TDS, TSS, COD, BOD, NH_3-N and S^{2-} removal for MBR were found to be 72.19, 99.38, 26.37, 26.41, 61.85, 61.9, 77.78, 41.7, 56.5 and 96.06 % respectively. The pH, Total Suspended Solids (TSS), Biological Oxygen Demand (BOD_5), Sulfide, and Chromium concentration from MBR outlet satisfy the allowable limits of ECR'97. These percentages indicate that MBR can successfully reduce the impurities of tannery wastewater at TIED and ensure proper effluent water characteristics for discharging in the Dhaleshwari river.

Keywords : *Tannery wastewater, Membrane Bioreactor (MBR), Treatment, Pollutant removal.*

1. INTRODUCTION

The tannery industry is recognized as one of the major polluters in Bangladesh due to the high organic loading in tannery effluents. Wastewater from the tanneries contains high Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), sulfide and suspended solids (Iqbal et al., 1998). Tannery Effluent is highly colored due to the presence of various impurities in the colloidal and suspended forms. Color caused by a colloidal form of impurities is called true color and that caused by suspended matter is called apparent color. Color is also caused by vegetable matters and coloring pigments used by tanneries (Hammer & Hammer, 2007). These impurities especially color and suspended solids can be easily removed by the Membrane bioreactor (MBR). It is a technology that has gained a considerable number of applications in the wastewater treatment process in recent years. It is a type of modification to the conventional activated sludge process under which solid/liquid separation is undertaken. Conventionally removal of large solids that may damage equipment or result in operational problems is done by physical process (preliminary treatment). The tannery effluent is treated for the removal of suspended solids (primary treatment) and followed by biological treatment (secondary treatment) for the removal of colloidal organic matter, COD and color (Hayder & Aziz, 2009). Coagulation/flocculation has been studied for leather effluent treatment to reduce COD and suspended solids (Zhi et al., 2009). A combination of both physical and chemical treatments can remove organic pollutants and nitrogenous compounds in tannery wastewater (Parag & Aniruddha, 2004). Though the physicochemical methods are effective, they are expensive, consume chemicals and produce secondary solid sludge.

Due to the complexity of the leather effluents, most of the traditional methods are inadequate for effective treatment. Thus it is necessary to develop a more economical and technically feasible compact process that effectively removes organics while reducing sludge production rate and chemical consumption. Besides, according to the monthly progress report from the Bureau of Research, Testing and Consultation (BRTC), BUET, it can be clearly observed that the present conventional system does not fulfill the requirement of treated tannery effluent quality and standards for inland surface water. Therefore, it is necessary to introduce tertiary treatment in the Common Effluent Treatment Plant (CETP). Membrane bioreactor (MBR) would be such an alternative, which can provide longer Sludge Retention Time (SRT) and requires much less reactor volume for BOD and nitrogen removal (Chiemchaisri &Yamamoto, 2005). MBR shows a higher removal rate in the tannery wastewater when compared to conventional activated sludge process (Munz et al., 2008). MBR systems offer the option of independent selection of hydraulic retention time (HRT) and sludge retention time (SRT), which permits more flexible control of operational parameters. High sludge concentrations in the bioreactor allow efficient treatment of high-strength wastewater. The retention of activated sludge containing solids and macromolecules in combination with long sludge age extends the contact time of sludge and critical classes of substrates. This allows the development of specialized, slow-growing microorganisms able to remove low-biodegradable pollutants contained in wastewater, resulting in improved removal of recalcitrant compounds (Melin et al., 2006).

The present conventional system for the treatment of tannery wastewater does not fulfill the ECR'1997 standards. Therefore, this present study was undertaken to investigate the efficiency of pollutant removal from the tannery wastewater using a Membrane Bioreactor (MBR) as a tertiary treatment with the existing conventional system.

2. METHODOLOGY

2.1 Method Of Sampling

The tannery wastewater used in this study was collected from the outlet of the Common Effluent Treatment Plant (CETP), located at Savar, Bangladesh. The primary treatment is done by chemical coagulation and the supernatant is subjected to secondary treatment by activated sludge process. The effluent was collected in plastic bottles, sealed and kept in a cool dry place before analysis. Some of

the data were collected from the monthly progress report from the Bureau of Research, Testing and Consultation (BRTC) by BUET.

2.2 Frequency of Sampling

For the proper characterization, the frequency of the sampling collection process was varied. The samples were collected from January 2019 to September 2019.

2.3 Membrane Bioreactor (MBR)

The pore size of the membranes used in the MBR process was 0.04 μm. The water systems are based on the MBR MCXL2 filter, which has a membrane surface area of 8 m^2. The high packing density of the filters (185 m^2/m^3) minimizes the space requirements. It works at low aeration demand, energy cost, backflush capability and minimum maintenance requirements. Membranes are activated with NaOCl for 48 hours at a temperature between 20-30 ℃. After that, discharging NaOCl solution and filling the tank with clean water is needed. Prior to the operation and to determine permeability, a clean water test should be conducted to check whether the system is properly installed. In continuous operation, filters are operated with transmembrane pressures (TMP) between .05 to .2 (max .25) bar. It is recommended to run the system by setting the TMP and achieving an associated flow from the filtration system. Fine screening is essential to prevent debris and fibrous material from entering the membrane tank. Treated water will be filtrated by the MBR system to separate water and suspended solids.

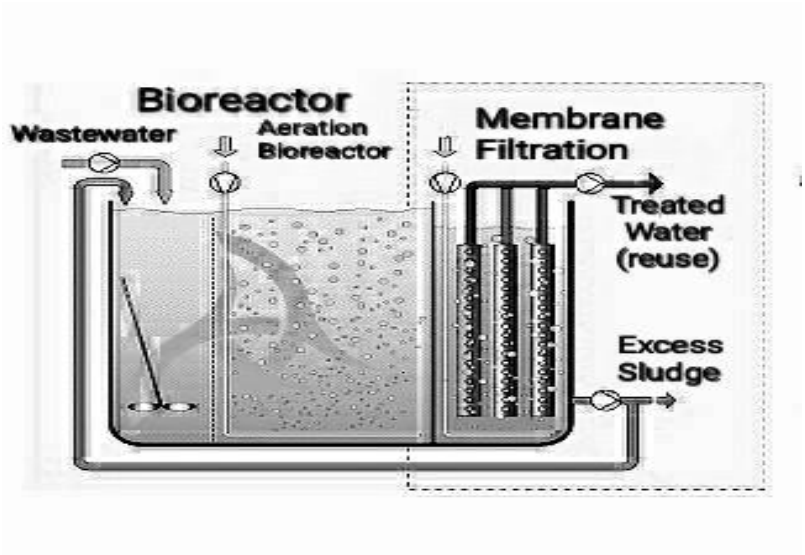


Figure 1 : Working Process of MBR.

3. ILLUSTRATIONS

3.1 Condition Of Treated Effluent in Present System

The design limit of the CETP for effluent discharge is COD < 200mg/L and BOD_5 < 30 mg/L. The parameter COD was not included in the disposal of tannery effluent in ECR'97. However, it is observed that the COD value of treated effluent doesn't satisfy the allowable limit (200 mg/L) for wastewater disposal in an inland water body as per ECR'97. Though, the design value of the treated effluent of the CETP should be < 250 mg/L. Chemicals (PAC and PAM) must be introduced to fulfill the requirements. It is to be mentioned that the Bangladesh standard for BOD_5 should be < 100 mg/L for tannery effluent. The BOD_5 of treated disposal tannery waste does not satisfy in the months of July, August and September 2019. The chromium concentration and the ammonia concentration in treated disposal don't satisfy the disposal standards. The allowable limit for S^{2-} as per ECR'97 is 1

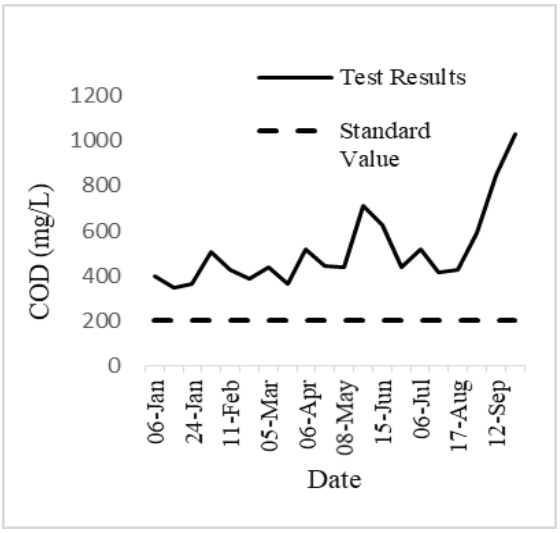
mg/L. It is observed that the present treatment system doesn't satisfie the allowable limits of all the parameters.

Table 1 : Characteristics of Treated Effluent (mg/L) in the CETP of Tannery Estate, Savar, Dhaka (January 2019 –September 2019)

Date	COD	BOD_5	Sulfide	Cr	pH	NH_3-N
06-Jan	400	56	0.062	4.52	7.22	70
14-Jan	345	24	0.2	5.094	7.75	67.5
24-Jan	365	60	0.425	5.3	7.65	75
03-Feb	505	40	0.05	2.52	7.7	90
11-Feb	425	16	1	2.6	7.75	120
27-Feb	385	32	0.125	1.49	7.45	62.5
05-Mar	435	48	0.025	3.77	7.6	72.5
20-Mar	365	25	0.08	3.32	7.47	62.5
06-Apr	520	72	0.02	4.98	8.23	152.5
20-Apr	445	64	0.03	2.16	7.71	62.5
08-May	440	40	0.035	7.62	7.23	30.75
20-May	710	50	0.03	17.33	7.49	30.5
15-Jun	625	128	0.035	3.48	6.67	55
24-Jun	440	155	0.04	4	7.48	125
06-Jul	515	80	0.035	1.35	7.33	130
23-Jul	415	24	0.05	4.54	7.79	105
17-Aug	425	128	0.018	8.07	7.16	3.5
29-Aug	590	56	0.025	2.9	8.08	157.5
12-Sep	845	230	0.1	16.75	8.61	285
25-Sep	1030	310	0.125	11.42	8.4	277.5

a)

b)



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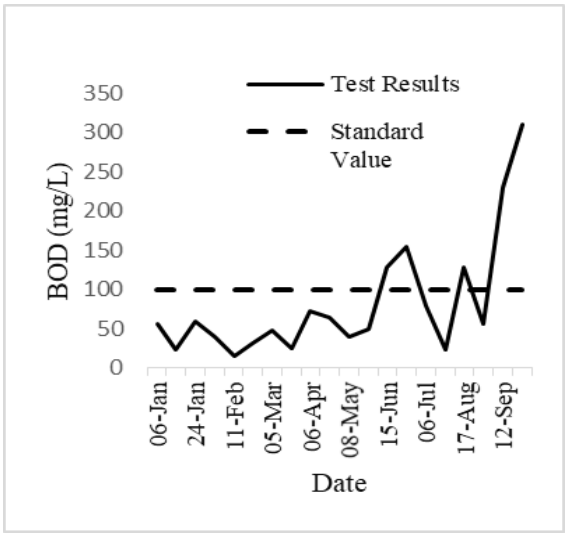

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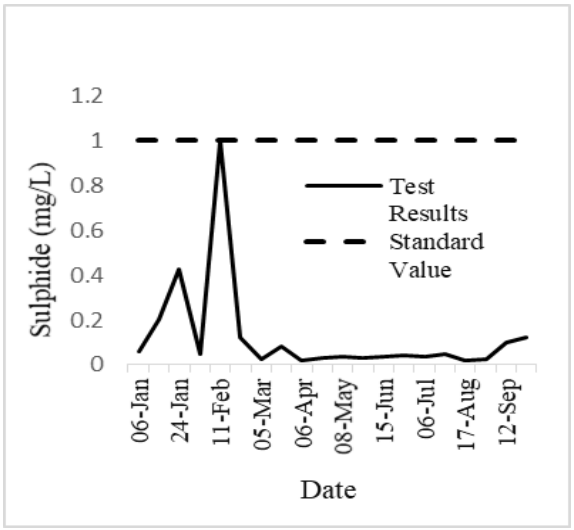

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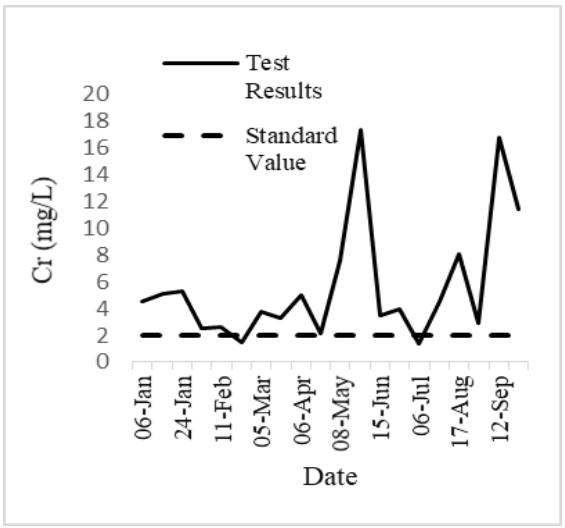

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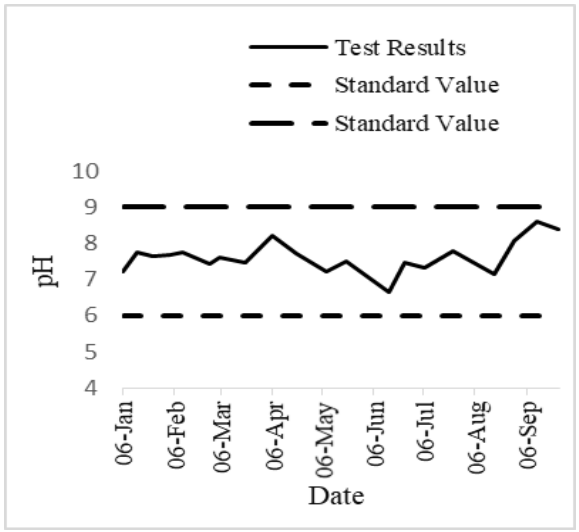

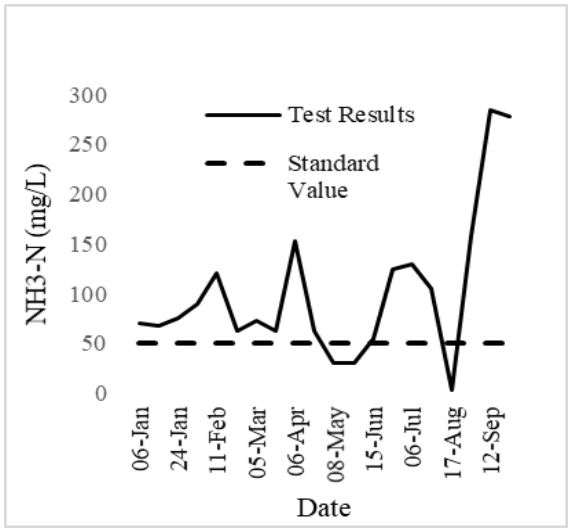

Figure 2 : Condition of treated effluent at the CETP of Tannery Industrial Estate Dhaka (TIED) in Present System a) COD, b) BOD, c) S^{2-},d) Cr, e) pH and f) NH_3-N

3.2 Performance of MBR as Tertiary Treatment

The main advantages of MBR technology compared to conventional activated sludge systems are smaller footprint and smaller reactor volume as a consequence of higher MLSS concentration and loading rate (option for low to moderate sludge age), decreased sludge production (option for high sludge age), higher and more consistent effluent quality as a result of membrane filtration, lower sensitivity to contaminant peaks.

The main disadvantages of MBRs are: relatively expensive to install, limitations imposed by pressure, temperature and pH requirements to meet membrane tolerances, membranes may be sensitive to some chemicals, less efficient oxygen transfer caused by high MLSS concentrations, the filtration pressure & flow, the backwash pressure & flow and membrane air scour flow must be recorded frequently for ensuring proper functioning.

Table 2 : Test Results of Inlet and Outlet of MBR

Parameter	Unit	Inlet of MBR (Outlet of CETP)	Outlet of MBR (Disposed into the river)	Allowable limit ECR'97 (mg/L)
pH		8.24	8.49	6-9
Color	(Pt-Co)	820	228	-
Turbidity	(mg/L)	185	1.13	-
Electrical Conductivity (EC)	(mS/cm)	12.17	8.96	-
Total Dissolved Solids (TDS)	(mg/L)	6928	5098	< 2100*
Total Suspended Solids (TSS)	(mg/L)	270	103	< 150
Chemical Oxygen Demand (COD)	(mg/L)	525	200	-
Biological Oxygen Demand (BOD_5)	(mg/L)	72	16	< 100
Ammonia Nitrogen (NH_3–N)	(mg/L)	317.5	185	-
Sulfide (S^{2-})	(mg/L)	0.115	0.05	< 1
Chromium	(mg/L)	5.75	0.226	< 2

*****There is no consideration for TDS by DoE in the present proposed allowable limits.

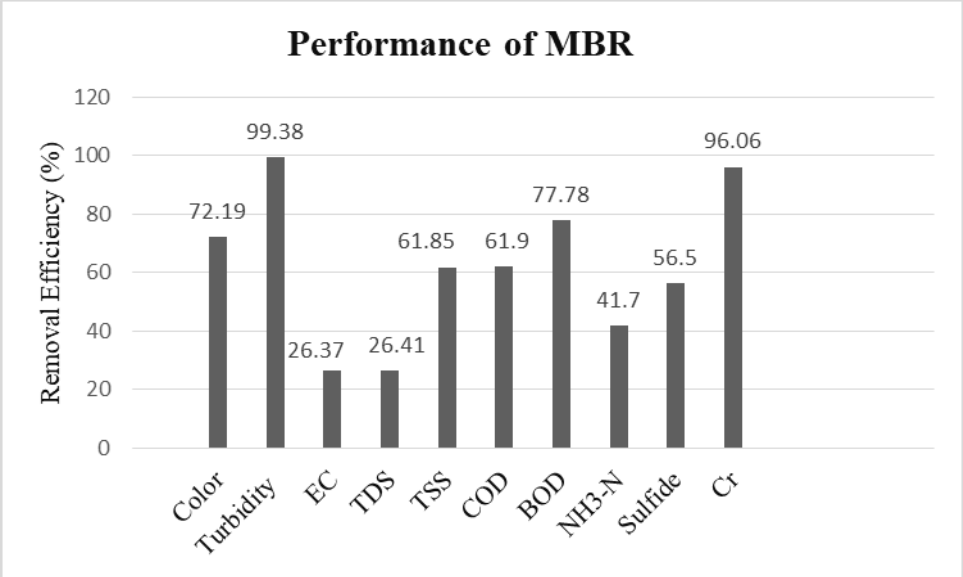

Figure 3 : Performance of MBR

The color, turbidity, EC, TDS, TSS, COD, BOD, NH_3-N and S^{2-} removal for MBR were 72.19, 99.38, 26.37, 26.41, 61.85, 61.9, 77.78, 41.7, 56.5, and 96.06 % respectively. MBR showed well performance on turbidity and Cr removal. The aerated membrane bioreactor is capable of removing organic contaminants of wastewater (Alighardashi et al., 2017). The removal efficiency of Total Dissolved Solids (TDS) is very less for MBR as the membrane cannot significantly separate dissolved particles. The pH, Total Suspended Solids (TSS), Biological Oxygen Demand (BOD_5), Sulfide, and Chromium concentration from MBR outlet satisfy the allowable limits of ECR'97.

3.3 Inland Water Quality Standard for Effluent Disposal

Tannery industry produces leather goods by inducing a huge mass of liquid waste which should be treated before the final disposal in any surface water body. The liquid waste should maintain a minimum quality so that the treatment process can be effective enough within an affordable expense. At present, in the conventional system, the treated effluent of CETP does not satisfy all the parameters

of the 'Standards For Inland Surface Water' (ECR Schedule-3, Page-205) while discharging directly in the Dhaleshwari river. So the installation of MBR as a tertiary treatment process is necessary to fulfill the standards.

Table 3 : Water Quality in the Dhaleshwari River

Parameter	Water Quality in the Dhaleshwari River (25.09.2019)	
	10m North from Outlet of CETP (Upstream)	10m South from Outlet of CETP (Downstream)
pH	7.14	6.95
BOD_5 (mg/L at 20°C)	2.2	1.6
Electrical Conductivity(μmhoms/cm)	147	237
COD (mg/L)	8.0	7.0
TDS (mg/L)	107	160
TSS (mg/L)	71	77
S^{2-} (mg/L)	0.035	0.022
Chromium (mg/L)	0.051	0.131
Chloride (mg/L)	10	28
NH_3 –N (mg/L)	0.27	0.34
Color (Pt-Co)	132	100

Table 4 : Standards for Inland Surface Water (ECR Schedule-3, Page-205)

Most bacterial cells range in size from 0.2 to 10 micrometers. In this study, the pore size of membranes used in the MBR process was 0.04 μm. So most of the bacteria cells are removed from outlet effluent by using MBR and the sludge can be recycled and reused for the biological treatment process. From the monthly progress report by Bureau of Research, Testing and Consultation (BRTC), BUET in Table-2 it can be clearly observed that the present system does not fulfill the requirement of treated tannery effluent quality and standards for inland surface water. MBR at the outlet point

Parameters	Sources of Drinking Water 0nly after Disinfection	Water Usable for Recreational Activity	Water Usable by Fisheries	Water Usable for Irrigation
pH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
BOD_5 (mg/L at 20°C)	≤ 2.0	≤ 3.0	≤ 10 (proposed)	≤ 10.0
Electrical Conductivity (μmhoms/cm)	1200.0	-	-	2250.0 at 20°C
COD (mg/L)	6.0	-	≤ 25 (proposed)	-
TDS (mg/L)	1000.0	-	-	-
H_2S (mg/L)	0	-	-	-
Chromium (mg/L)	0.05	-	< .1 (proposed)	-
Chloride (mg/L)	600.0	-	-	-

satisfies the dischargeable limit of tannery water. Maintaining a standard discharge quality is necessary as the magnitude of pollution from the effluent is degrading the water quality of the Dhaleshwari river as well as threating the public health and the environment.

4. CONCLUSIONS

Using Membrane Bioreactor (MBR) as a tertiary treatment with the existing conventional system for the treatment of tannery wastewater increases the treatment efficiently. The BOD removal efficiency was found to be 77.78% using MBR. For COD, the removal efficiency was 61.9%, for Cr it was 96.06%, for TSS it was 61.85%, for NH_3-N it was 41.7% and for color the removal efficiency was

found to be 72.19%. It is observed that the existing conventional treatment is not adequate to treat the tannery wastewater. In this study, the results showed that a tertiary treatment, using Membrane Bioreactor with the present conventional system, satisfies the ECR'1997 standards, except TDS. It can be concluded that introducing tertiary treatment is necessary for pollutant removal at the CETP of TIED. This leads to better effluent quality, more capacity for organic loading, reduced footprint and sludge production, and process flexibility towards influent variations.

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