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Application of Medium Pressure UV Lamp for Wastewater Disinfection of Milk Production Industry

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Abstract: UV disinfect ion has gained widespread use for municipal wastewater and more recently, interest in using UV for water reuse applications has increased too. Medium pressure lamp has emerged as a viable alternative and is beginning to gain more popularity than the conventional low-pressure lamps. This study has been performed with the objective of utilizing MP lamp for the disinfection stage of wastewater from a milk industry. The lab-scale UV submerged system used in the experiments was a single-lamp reactor with 3 L volume, which was operated at two contact times. Two MP lamps of 300 and 400 W had been used separately. Results indicated that for disinfection of all the samples with different %T, meeting the goal of 1000 MPN /100 mL or less was always possible. Besides, for 95% of these samples, the MPN of irradiated effluents had reached to less than 240/100 mL. Another conclusion is that by use of 400 W lamp, all the samples are well disinfected to 100 total coli forms or less per 100 mL and so are become ready for most applications of water reuse programs.

Key words: Disinfection, UV, MP lamp, wastewater treatment, milk industry

INTRODUCTION

As it becomes recognized that water resources protection will require integrated regulations for wastewater effluents discharges, accomplishing the disinfect ion process by use of an appropriate disinfectant has been considered to be an essential task for preventing health risks of direct or indirect wastewater reuse applications, particularly in water-limited regions (Emerick *et al.*, 2003; Goosen and Shayya, 2000). But by use of conventional process of chlorination problems such as producing toxic by-products and questionable efficiency on high turbid and ammonia-rich effluents are often reported. On the other hand, high free chlorine concentration (beyond the breakpoint) is required to inactivate cysts and viruses of concern (Emerick *et al.*, 2003; Metcalf and Eddy, 2003). Thus, a number of facilities in advanced countries are in the stage of substituting chlorine by other disinfection operations. Ultraviolet (UV) as a completely chemical-free process is a proven technology that enables wastewater to be disinfected and reused economically and safety (Masschelein, 2002). While technologies using Low-pressure (LP) lamps are still more common, the new guidelines also address new types of UV systems and now technologies using Medium-pressure (MP) lamps are considered to be a solution for better disinfecting wastewaters of poor quality and for flow rates greater than 140 mgd, so trend globally is more towards MP system (Cairns and Wright, 2000; Swift *et al.*, 2002). Of course, MP systems are more energy consumptive but have fewer components to replace, thus in terms of objective choice comparing the higher power cost for the MP system with the higher component cost (Sleeves, ballasts and lamps) for the LP option is essential. Indeed, each has merit and the total cost of the project is being used to determine the successful vendor (Cairns and Wright, 2000; Stedman, 2004). The purpose of this study was to determine the feasibility of MPUV lamp in disinfect ion of a highly polluted industrial wastewater and the extent to which this lamp type can be used in these applications. This study has been performed in 2004 and all the wastewater analyses had been accomplished in the laboratory of Environmental Health Department of TUMS.

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MATERIALS AND METHODS

UV equipment: The UV system source was a medium pressure mercury lamp. The lamp's characteristics are presented in Table 1. In contrast to the low-pressure lamps, which can be precisely monitored with a calibrated photo detector, the irradiance of the MP lamps cannot easily determined by similar available apparatus. This being the case, the data was confined to the determination made by the lamp manufacturer, which was reported to be 90 μW cm^{-1} UV irradiance in 1 M from the new lamp. For running the experiments by this lamp, a lab scale UV submerged system was arranged with 3 L effective volume and 10 cm ID. This single-lamp reactor was adjusted to operate at the flows of 18 and 6 L min^{-1} in the equivalent contact times of 10 and 30 sec. Figure 1 shows the used UV reactor. The MP lamp was enclosed within a quartz jacket in order to prevent the direct contact of lamp with wastewater.

Wastewater samples: The samples were collected from Pegah Milk Factory in Tehran. It should be noted that food processing in Iran produces the highest volume of industrial wastewater. Sampling of the secondary effluent of this factory was performed (totally 13) on grab basis in the spring and summer of 2004. The characteristics of these samples are presented in Table 2.

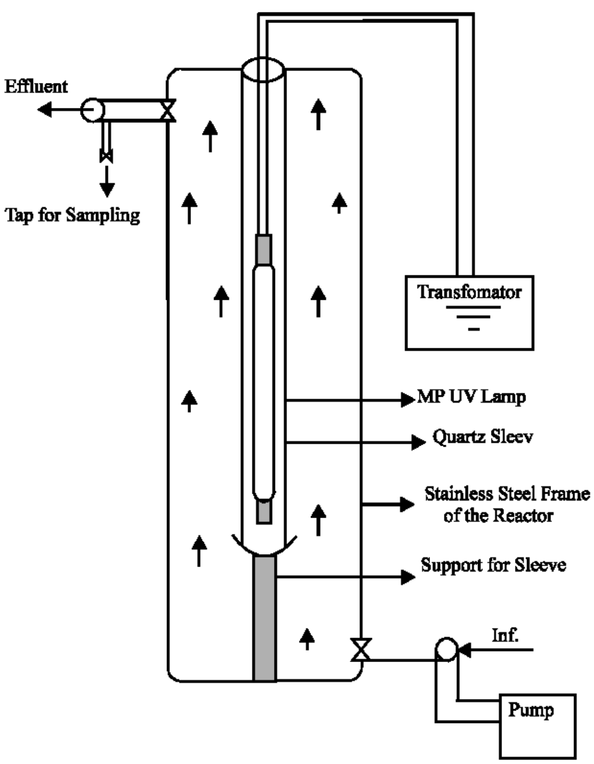

Fig. 1: Medium presure UV reactor for wastewater disinfection

Table 1: The UV lamp specifications*

Lamp type	L (mm)	D (mm)	Arc Length (mm)	Voltage (V)	Current (Amp)	Life time (h)
MP MV 400	125.5	20	72	130±15	3.25	10000

*Technical information report from the lamp manufacturer (Arda Inc. France-1995)

Table 2: Characteristics of Pegah Secondary Effluent Samples in the period of the study

Parameter	Total coliforms MPN/100 mL	COD (mg L^{-1})	UV trans-mittance (%)	Turbidity (NTU)	TSS (mgL^{-1})
Range	14000-1100000	60-180	37-69	10-50	15-54

All the analyses have been performed according to the procedures described in Standard Methods (APHA, 1998). Comparison of disinfect ion results of various samples has been accomplished by determination of coliform group (using 15 tube test) (APHA, 1998).

RESULTS AND DISCUSSION

For this study, results obtained from irradiation of 13 wastewater samples of Pegah Milk Factory by 300 W lamp in two contact times of 10 and 30 sec are reflected in Fig. 2 and 3 and the same results for 400 W lamp in Fig. 4 and 5. As these 13 samples had different UV transmittances (Table 2), the effect of this parameter on disinfection efficiency had been determined and can be seen in Fig. 6 and 7. Finally, Fig. 8 shows a comparison of results obtained by two lamps in two contact times.

At this time, wastewater disinfection levels are determined by standards or recommendations, which are specific to each reuse application. For example, regarding Total Coliforms (TC), 1000 TC/100 mL are required for agricultural use of effluents, while more stringent standards are needed for reuse of effluents in non-potable urban applications (the values vary between 240 to less than 2). Figure 2 suggests that meeting the requirement of 1000 TC/100 mL or less is easily possible even by 10 secirradiation with 300 W lamp. Moreover, in 95% of these cases, the resulted effluents had the MPN/100 mL of 270 or less and by tripling the contact time the value had increased to 90% less than the standard of 240 (Fig. 3). This efficiency had increased even much more in the stage of utilizing 400 W lamp for which disinfection results can be seen in Fig. 4 and 5 and meeting the requirement of 100 TC/100 mL less had become possible at this stage (two cases above this level had been considered for 10 sec contact time). Thus, it can be concluded that the irradiated effluent may be regarded very useful for many applications of water reuse programs provided that the concentrations of other pollutants are not more than the required MCL_s, too.

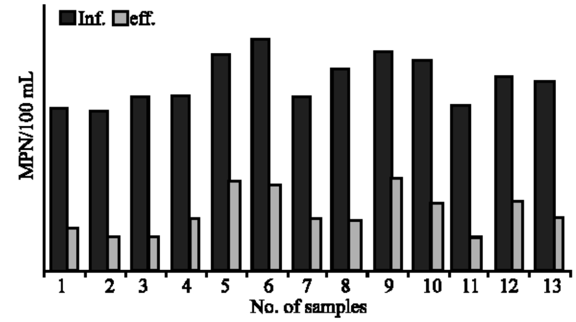

Fig. 2: MPN/100 mL of total coliforms in the industrial effluent samples before and after UV irradiation (300 W Lamp, 10 sec - t_d)

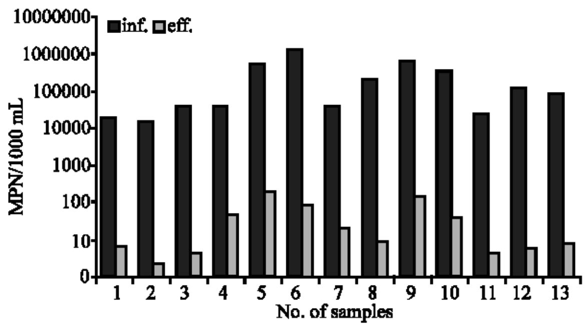

Fig. 3: MPN/100 mL of total coliforms in the industrial effluent samples before and after UV irradiation (300 W Lamp, 30 sec - t_d)

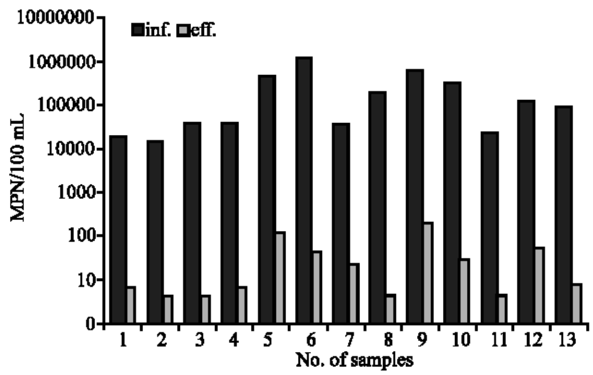

Fig. 4: MPN/100 mL of total coliforms in the industrial effluen samples before and after UV irradiation (400 W Lamp, 10 sec - t_d)

One of the most important parameters for UV disinfection is UV transmittance (in 254 nm) of effluent samples, or fraction of light passing through a given length (1cm) of that sample. Percent transmittance (%T) that can also be expressed in terms of UV demand of a sample is affected by TSS and certain dissolved solids.

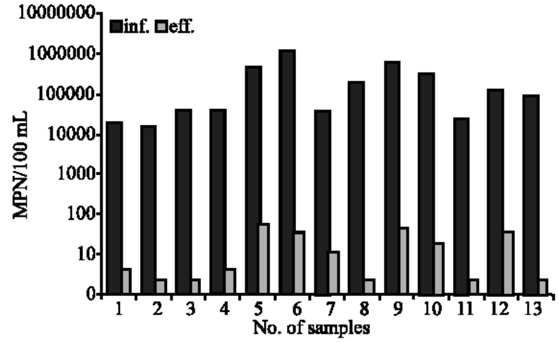

Fig. 5: MPN/100 mL of total coliforms in the industrial effluent samples before and after UV irradiation (400 W Lamp, 30 sec - t_d)

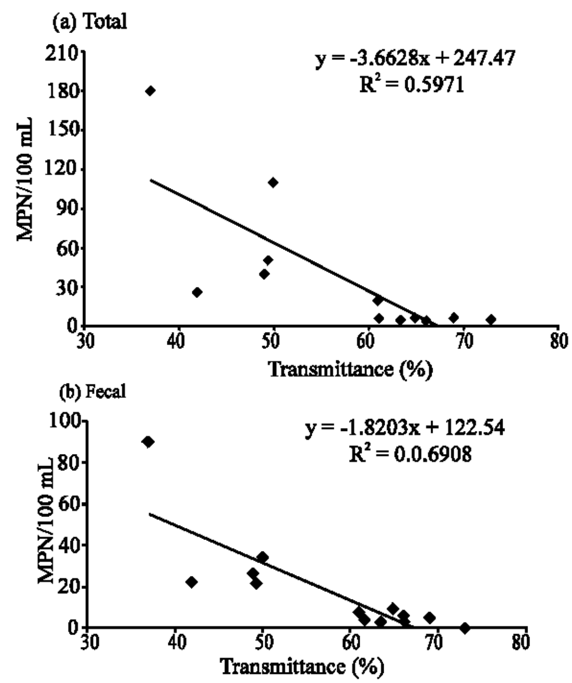

Fig. 6: MPN/100 mL of coliforms in the disinfected effluents vs. UV transmittance (400 W Lamp, 10 sec - t_d)

UV doses required for a given pathogen removal rate are significantly influenced by this parameter and to minimize the phenomenon for LP lamps, effluent %T must be above 50% (Goosen *et al*., 2000). For MP lamps recent research suggests that good pathogen inactivation can be expected even for bad quality secondary effluents (with %T less than about 50%), but to date no definite value has been specified. According to our study, coliform group disinfection results have been affected by %T and as it can be seen in Fig. 6 and 7, tripling the contact time has not a significant effect. In other words,

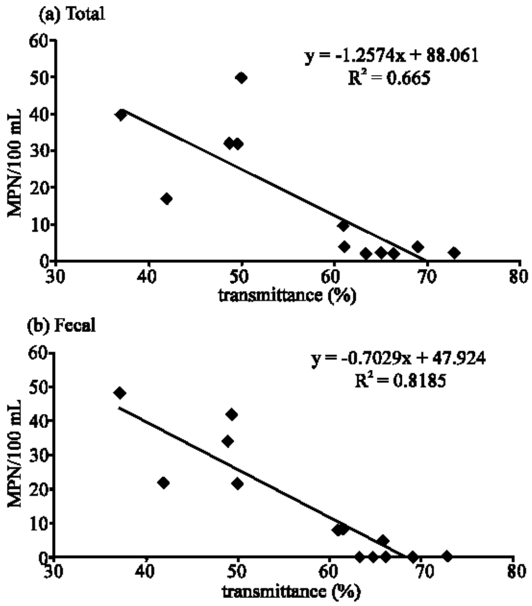

Fig. 7: MPN/100 mL of coliforms in the disinfected effluents vs. UV transmittance (400 W Lamp, 30 sec - t_d)

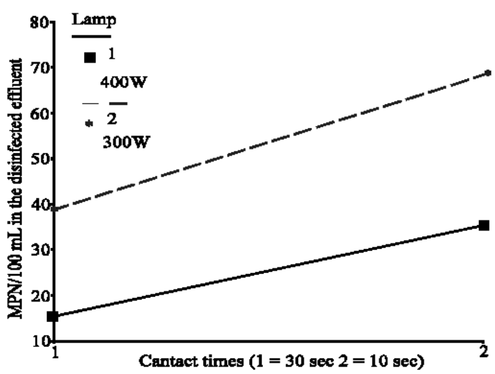

Fig. 8: Comparison of total coliform disinfection results by two lamps (400 W and 300 W) in two contact times (10 and 30 sec)

by increasing the contact time in the stage of treating bad quality effluents (with %T less than about 40%), no important improvement in disinfection results should be expected. However, this means that excellent disinfection even in 10 sec is always possible unless the %T has not decreased to less than about 40%. Reducing the contact time is not recommended.

Finally, Fig. 8 indicates that although some improvement in disinfection results can be expected by using more powerful lamp (and /or higher contact time) and statistical analysis has revealed a p-value of 0.05 or less in this regard but the extent of this improvement is not so much to have enough justification for resorting to higher contact times or UV irradiances. To assess treatment efficiency and potential risks additional research is needed to extend these findings to other pathogens, which are more resistant than coliform group.

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