PT-1-44.

# COMBINING NATURAL AND ADVANCED OXIDATION TECHNOLOGIES FOR COMPLETE WASTEWATER TREATMENT

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## Abstract

Lagoons are considered to be one of the most convenient methods for treating wastewater from small communities. The combination of lagoons and constructed wetlands has resulted to be a very effective method, not only for retaining algae from pond effluents without important clogging problems, but also to achieve further reduction of sewage parameters (Steinmann, 2003).

Ponds and wetlands can be designed to remove more than 90 % of BOD, COD, suspended solids and bacteriological pollution from the through-flowing wastewater (Verhoeven and Meuleman, 1999). However, quite often such high levels of disinfection are not enough to meet WHO guidelines (WHO, 1989) for agricultural wastewater reuse, by which unrestricted irrigation requires almost no intestinal nematodes (< 1 egg/L) and less than 1000 CFU/100 ml of Phaecal Coliforms. To meet the required standards, chlorination has been the selected option, given its disinfection efficiency, low economic cost and long-term disinfection effect. However, it is well known that wastewater chlorination can yield the formation of undesirable by-products.

Advanced Oxidation Technologies (AOTs) such as $O_3$+UV, $TiO_2$-photocatalyis and others, in combination with ponds and/or wetlands can provide a convenient simple, useful solution to achieve the most stringent water quality standards.

Total and phaecal coliforms and phaecal enterococci concentrations have been determined in the influent (raw wastewater) and effluent of a natural wastewater treatment pilot plant. The system is composed of a pond and different wetlands. The disinfection results obtained by the natural system are summarised in Table 1.

| | Influent | Effluent | Removal, % |
|---|---|---|---|
| Total coliforms | 5.2 ± 7.8 (x $10^7$), 15 | 4.1 ± 5.1 (x $10^5$), 15 | 99 |
| Phaecal coliforms | 1.1 ± 0.9 (x $10^7$), 10 | 1.42 ± 2.92 (x $10^5$), 10 | 98 |
| Phaecal enterococci | 1.0 ± 1.78 (x $10^5$), 12 | 3.6 ± 7.3 (x $10^4$), 12 | 94 |

**Table 1.** Disinfection results (mean ± standard deviation, number of data) from the natural system.

As can be observed from Table 1, though high removals are obtained, effluent Phaecal coliforms are still two orders of magnitude higher than the WHO standard for unrestricted irrigation. Thus, it is necessary to implement additional disinfection methods to achieve the adequate levels. Different AOTs have been applied to the effluent of the natural system. Phaecal enterococci disinfection results for ozonation ($O_3$), $O_3$ + UV and $O_3$ + AC-$TiO_2$ + UV are presented. Figures 1 and 2 show mean Phaecal enterococci concentrations (CFU/100 mL) after different treatment times with $O_3$ and $O_3$ + UV, respectively. Mean concentrations are

calculated from 4 and 3 different experiments, respectively, with samples taken from the natural system effluent at different dates. The typical error is calculated as standard deviation/square of the number of data. A first-order kinetic model (the Chick's model) is applied to obtain a disinfection constant for comparison purposes.

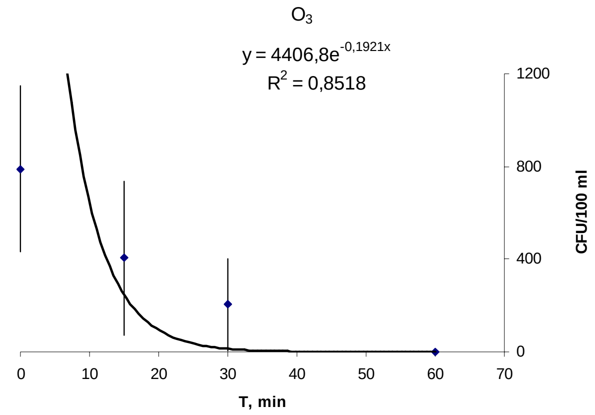


Figure 1. Mean (± typical error) Phaecal enterococci concentrations *versus* ozonation time.

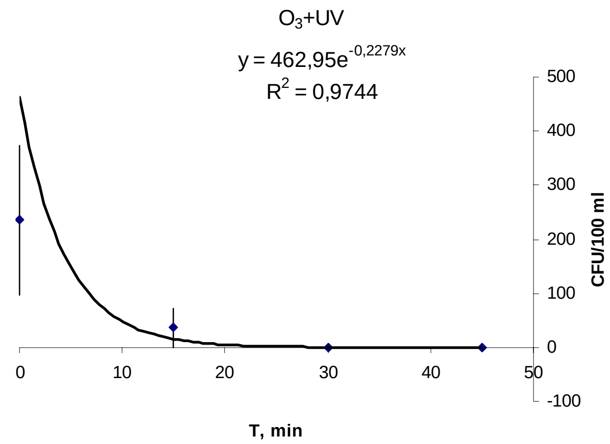


Figure 2. Mean (± typical error) Phaecal enterococci concentrations *versus* treatment time.

A one-way ANOVA was done to determine significant differences among experimental conditions. Results indicate that the system $O_3$+UV shows the highest efficiency (k= -0.228 $min^{-1}$) but slightly higher than ozone alone (k= -0.192 $min^{-1}$). The system with $O_3$ + AC-$TiO_2$ + UV gave a notably lower disinfection rate constant (k= - 0.018 $min^{-1}$) (ANOVA, $P < 0.05$; d.f.= 2; F-value= 15.9). Also, mineralization (as NPOC reduction) analyses were carried out yielding quite different results. $O_3$ and $O_3$+UV did not provide any NPOC reduction, but the system $O_3$ + AC-$TiO_2$ + UV yielded a mean mineralization of 45 %.

References


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2. WHO. Health guidelines for the use of wastewater in agriculture and aquaculture. Technical Report Series 778, World Health Organization, Geneva, Switzerland, 1989.