Evaluation of the efficiency of ozonation in wastewater treatment systems containing hazardous pollutants

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The purpose of this research is to use ozone in different wastewater treatment systems and to present a brief comparison of treatment with and without ozonation. Two different systems are considered and a comparison on the results of both shows a very high efficiency to consume ozone in reaching more COD (Chemical Oxygen Demand), BOD (Biochemical Oxygen Demand), TOC (Total Oxygen Concentration) removals and less sludge sedimentations. This leads to less costs in order to remove hazardous materials which are harmful pollutants in the environment. The important parameters which should be considered well are time and dose of ozonation.

Key words:.ozonation, COD, BOD, TOC, AOX (Alternative Oxidase), wastewater treatment, ozone, environment.

INTRODUICTION

Advanced Oxidation Technologies (AOTs) are efficient choices for underground water treatment and wastewaters containing recalcitrant materials. Such processes are based on the formation of highly reactive OH radicals with a standard electrode potential of 1.5 V which is twice higher than that for chlorine (the standard electrode potential is 0.75 V). These radicals react with most organic compounds with constants of K□106-109 $m^{-1}s^{-1}$ and start a large number of reactions, which ultimately lead to formation of organic pollutants. AOTs comprise H_2O_2/UV, phantom reaction, ozone, O_3/UV, photo catalysis with TiO_2, sonorous action, electron throwing process, and radiolysis. However, AOTs, as well as any physical, chemical or biological treatment process, often provide the formation of by-product which are more toxic than the main pollutants.

The increase of priority pollutants in wastewaters has caused an attention to oxidative processes to decompose and to remove the pollutants. Every of physical, chemical and/or biological processes for water treatment should be functional, effective and should have an expense limits. For instance, in physical processes of adsorption or volatility into air the pollutants, being not destructed, are transferred from the liquid phase to the volatile one. Since final removing of biological solid materials containing hazardous pollutants is one of the most important problems in wastewater treatment, which has a lot of costs, ozonation process as AOT is used for treating both industrial and household sewages.

A comparison of treatment with ozone and without ozone in the two different wastewater treatment systems shows a great benefit in biological treatment with ozonation. These wastewaters are those from the pulp factory and from dyeing industries [1-14].

MATERIALS AND METHODS

One of the wastewater samples came from sulfide pumps of the dyeing factories. It contained alkaline substances originated from processing of wood industry. According to the ratio of products in this sample, two third part of substances was formed via chlorination stage and one third part was raised via alkaline extraction stage. These substances contained large concentrations of the following mineral substances: 135 mg lit^{-1} NH_4Cl, 35 mg lit^{1} HK_2PO_4, 33 mg lit^{1} $MgSO_4$ and 7 mg lit^{1} $CaCl_2$. The buffer substances, i.e. 0.5 mg lit^{1} $NaHCO_3$ and 0.3 mg lit^{1} $CaCO_3$ (pH value 6.5 to 7.0 Ca^{+2}) were also used because they play a very important role to make anaerobic bacterium unmovable. The characteristics of the wastewater combinations are shown in Table 1.

Biological treatment for wastewater used in dyeing industries wastewater applied the anaerobic

Table 1. Characteristics of the wastewater combinations from a dyeing factory

Parameters	Chlorination stage	Extraction stage
PH	1.9	11.8
COD, g L^{-1}	1.7	3
AOX, mg of C L^{-1}	106	163
VSS, %	0.09	0.24

reactors at the first stage and the aerobic reactors in the second part of cycle. In this method ozone was added to the biological treatment reactors when mineral substances have been added to the wastewater.

The second sample of the wastewater came from pulp factories. It entered first the BFB (Biological Filtration Base) system, which has been formed by biological dissolvable substances, with a water vapor. Then it entered reservoir tank which included ozone gas and extra air. Ozone has been dissolved by UV. The environment's pH was kept about 7 in the reaction time. The concentration of ozone in the BFB system cycle was measured and controlled with an amperometric electrode, which was used to measure the ozone concentration limited to about 20 mg l^{-1}. This system hasn't been performed but it had the potential to be used for 2 years. The treatment process began by removing salts and other harmful combinations, and it increased the concentration of dissolvable substances. It was continued by extracting 200 ml of diethyl from the acidified sample. The standard temperature started at 70°C and was kept 2 min, then raised finally to 240°C and was kept 3 min. The concentration of the liquid phase was also measured. The brown color of wastewater which was removed during ozonation indicated a medium. Since ozone is a highly oxidant agent, the pilots were made of the materials resistant to ozone.

RESULTS AND DISCUSSION

The experiments showed that ozone could be effective to solvie the most organic materials in activated sludge or to transform them to mineral ones. It was shown that biodissolubility increased related to the solved materials. In fact, ozone usage for sludge caused a remarkable increase in existing of biota related to organic materials which were being bioanalyzed smoothly. Both solubility effects and facilities provided transformation of organic matters to mineral ones, and it might explain the effect of the ozonation treatment on the reduction of sludge production in the biological treatment.

Table 2. Consumed wastewater combination in the closed ozonation reactor

Measured variables	Wastewater without aerification (A)				Aerobic output (B)	
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
V_i, L	0.4	0.35	0.35	0.6	0.35	0.6
O_3 g m^{-3}	14.1	16.5	10.1	18.3	17.7	8.46
pH i	12.0	7.38	7.84	7.5	8.52	7.5
pH e	8.5	3.67	7.53	7.5	6.86	7.5
COD_0, g m^{-3}	1464.0	1482.0	1831.0	1528.0	1511.0	1046.0
TOC_0, g m^{-3}	526.0	607.0	620.0	537.0	535.0	370.0
AOX_0, g m^{-3}	103.0	91.0	102.0	118.0	98.0	62.0
Symbols for Figs. 1 and 2	○	▲	□	+	■	●

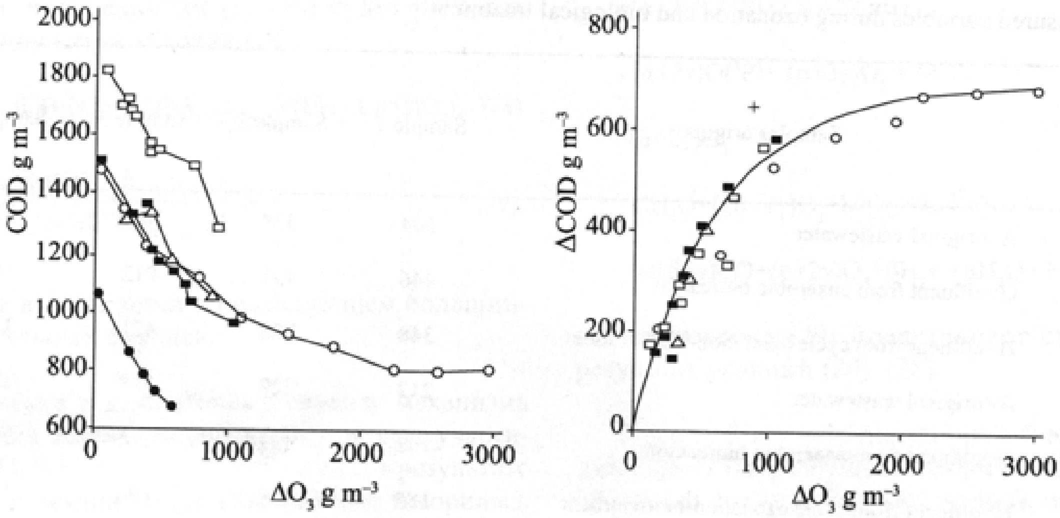

Figure 1. COD concentration at different stages

Table 2 consumed wastewater combination in the closed ozonation reactor in dyeing factories showed the measured variables in 6 stage samples with aerobic output and without aerification. The results showed the benefits to use the applied system.

Usually the output ozone concentration from the system should be less than 0.5 g m^{-3}. In the primary steps the ozone was completely consumed. Therefore, the output became zero (CO_3, out =0). In this study both wastewater treatment methods were used and made it clear that during biological treatment the chlorinated monomer combinations were well separated from phenolic combinations. It is seen from Fig. 1 that COD was removed from the system in a very high value at the beginning of the process. TOC concentration during ozone consumption is shown in Fig. 2.

Table 3 shows the measured variables (COD, TOC, AOX) in original wastewater, effluent from anaerobic bioreactor, and effluent from cycle ozonation-biotreatment during bio-ozone–biotreatment of pulp factories which was a good result of the comparison.

In this reactor liquids passed sequentially and according to bio-ozone–biotreatment method. This showed that when ozone was consumed very fast, no ozone could enter the reactor actually. Experiments showed that the ozone value never reached the ozone value in the new portion of entering wastewater

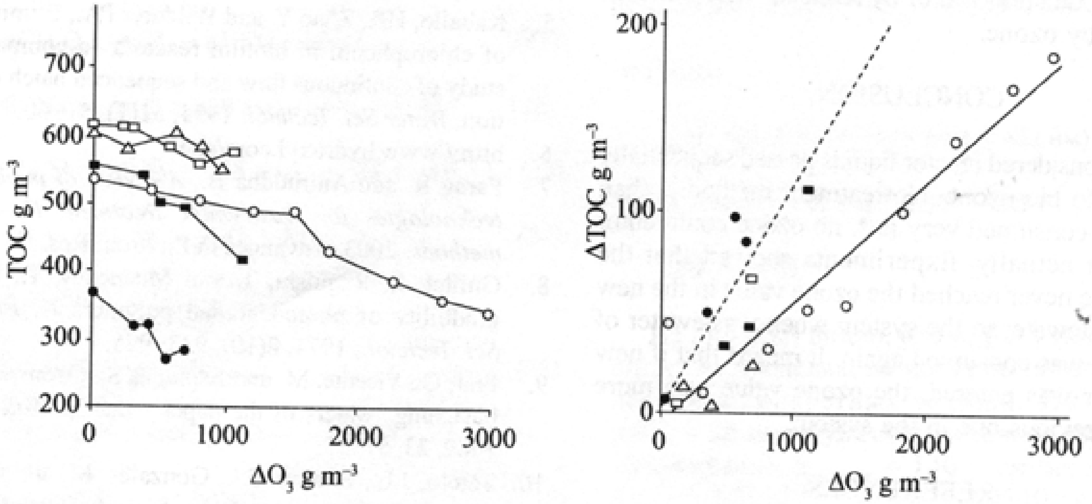

Figure 2. TOC concentration during ozone consumption

Table 3. Measured variables during ozonation and biological treatment

Measured variables	Samples origins	Sample 1	Sample 2	Sample 3	Sample 4
COD	A=original wastewater	504	528	1073	926
	G=effluent from anaerobic bioreactor	446	491	912	749
	H=effluent from cycle ozonation-biotreatment	348	308	421	336
TOC	A=original wastewater	212	229	388	370
	G=effluent from anaerobic bioreactor	192	192	298	287
	H=effluent from cycle ozonation-biotreatment	185	139	198	153
AOX	A=original wastewater	40	36.5	64.4	64.2
	G=effluent from anaerobic bioreactor	37.7	30.7	38.8	55.2
	H=effluent from cycle ozonation-biotreatment	27.8	14.2	18.9	15.3

to the system when wastewater of the system was consumed again. It means that if new wastewater was entered, the ozone value was more than the previous one in the system.

COD removal value in the anaerobic system (30 to 180 g m^{-3}) was very remarkable. However, in the similar reactor TOC removal value for samples 3 and 4 with a high value of TOC (85 g m^{-3} and 90 g m^{-3}) was not high. AOX removal value in anaerobic reactors was usually high (about 25 g m^{-3}) which is rarely seen. It should be mentioned that reducing the ΔAOX/ΔCOD ratio could be caused by improved biological COD removal or by reduced AOX removal efficiency by ozone.

CONCLUSION

In the considered reactor liquids passed sequentially according to bio-ozone–biotreatment method. When ozone was consumed very fast, no ozone could enter the reactor actually. Experiments showed that the ozone value never reached the ozone value in the new inflow wastewater to the system when wastewater of the system was consumed again. It means that if new wastewater was entered, the ozone value was more than the previous one in the system.

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Оценка эффективности озонирования при очистки сточных вод, содержающих опасные загрязнители

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Рассматриваются две различные системы очистки сточных вод, и сравнение результатов показало более высокую эффективность потребления озона в достижении нужных значений ХПК (химическое потребление кислорода), БПК (биохимическое потребление кислврода), ОКК (общая концентрация кислорода) абсорбции и уменьшению отложений в иле, что приводит к меньшему расходу с целью удаления опасных материалов для окружающей среды. В работе приводятся данные развития исследований своими методами с применением известных методов, учитывающих особенности сточных вод с предприятий Ирана.

Ключевые слова: озонирование, ХПК, БПК, ОКК, АО (альтернативная оксидаза), очистка сточных вод, озон, охрана окружающей среды.

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