Available online at **www.joac.info**

ISSN: 2278-1862

Journal of Applicable Chemistry

2018, 7 (5): 1126-1131

(International Peer Reviewed Journal)

Assessment of Industrial Wastewater Treatment Using Advanced Ozonation Systems for Removing Toxic Contaminants

Amir Hajiali[1]* and Gevorg P. Pirumyan[2]

1. Postdoctoral Fellow at Yerevan State University (Center for Ecological Safety), Yerevan, **ARMENIA**
2. Center for Ecological Safety; Head, Yerevan State University, Yerevan, **ARMENIA**

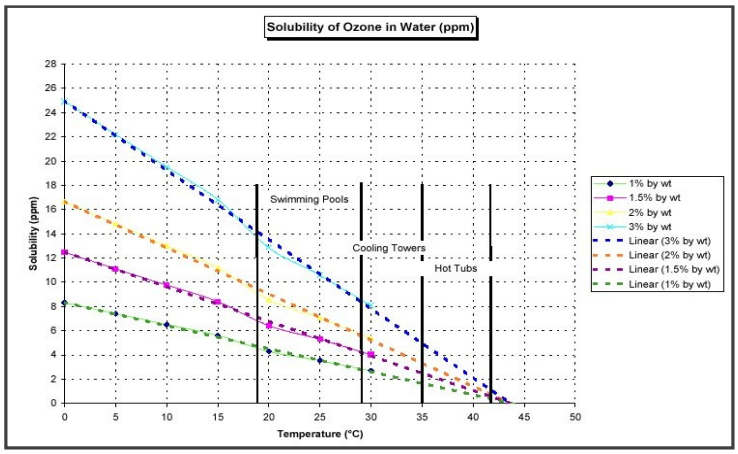
Email: a.hajiali.env@gmail.com, gevorg_pirumyan@mail.ru

Accepted 10th August, 2018

ABSTRACT

Treatment of an industrial wastewater was experimented in order to remove the value of hazardous contaminants through advanced ozonation methods. Ozonation is one of ecologically clean perspective methods for the treatment of industrial wastewaters, as in this case chemical reagents, such as potassium permanganate, chlorine and so forth which cause the secondary pollution of water, aren't applied. Ozonation can be applied in the different stages of water treatment process. The aim of the work is the application of more efficient methods in wastewater treatment system by which organic matters, suspended solids and other contaminants will be removed from wastewaters produced by industries as well as combination of ozonation and filtration methods in the cleaning process of wastewaters from industries. By this way, the concentration of the contaminants was reduced to the permissible level in water. Furthermore, maximum solubility by the use of minimum ozone dose and determination of the optimal duration and dosage of ozonation is achieved.

Graphical Abstract



Solubility of ozone in water (mg L^{-1})

Keywords: Industrial Wastewater, Ozone Injection, Toxic Contaminants, Treatment.

INTRODUCTION

In recent years, the issues of wastewater treatment have become one of the most important environmental problem [**1**]. Taking into consideration the increased demand of water use for different purposes (drinking, households, agricultural, industrial, hydro energy and so forth) related to the current world population growth rate and the fact that, according to the different assessments, the world will be threatened by the lack of water resources in a few decades, the improvement of wastewater treatment system is considered very vital, important and actual **[2, 3**].

For the creation of efficient wastewater treatment system, the development of such methods of wastewater cleaning, the application of which will be cost-effective and more efficient, is very important [**4, 5**].Nowadays ozone, as a strong oxidant, has a wide application in oxidation processes. It is used for the removal of organic pollutants from wastewaters [**6**].

The application of ozonation in the treatment process of highly polluted wastewaters is more efficient [**7**]. Ozone can be used in the treatment processes of such wastewater that are treated for the use of drinking and other purposes. Taking into consideration the strong oxidizing property of ozone and the fact that ozone is converted to molecular oxygen after oxidation, the application of ozone in oxidation processes looks more efficient.

MATERIALS AND METHODS

In this study the details of ozonation process are evaluated by using some vast studies and it is supposed that ozonation process can lead to the maximum amount of solubilization with the minimum dose of consumed ozone. The complete purpose is to determine the most effective and practical ozonation time and ozonation dose. The efficiency of solubilization is evaluated based on the solution`s necessary chemical oxygen and the concentration of excess sludge samples before and after ozonation. Furthermore, with the consideration of this fact that vast scale ozone generators can generate air flows filled with high concentrated ozone, designing a process which needs high concentration gas form ozone is acceptable. Primary studies for deliberation of ozonation process, determination of the approximate time needed for sludge ozonation and making the situation ready for detailed analyses of ozonation process were done [**8**]. Different studies for evaluating the effect of ozone dose and plentifulness of consumed ozone on solubilization rate and linear corrosion were also accomplished.

Ozonation is done in a reactor that ozonated air is regularly injected from wastewater in to it in order to perform the treatment [**9**]. This reactor model is completely a combined model, therefore the reactor`s concentration is fixed in the liquid phase. For availability to a rate of impurity which is necessary for the ozone generator, the air which was used as the source of oxygen is treated and processed before anything else in order to be cleaned out of any fat, moisture, hydro carbons, and dust, although ozone`s productions are changeable by the much electrical current and regulating the air. In this study these two parameters are arranged 0.8 A and 100 L h^{-1} respectively.

Ozonated air is blown in to the reactor that here the magnetic mixer plate provides effective mixing conditions for the complete solubilization of gas in the liquid phase. At the end of ozonation phase the remaining ozone in the liquid phase is cleaned by about 5 h air blowing.

Separator parts of ozonation system are like a reversible cycle. The whole reactor system is filled with 250 to 500 mL reactor`s liquid. Gas flow among the columns of the system is 140 mL min^{-1}, and the rotation stream velocity of the liquid in the system is 50 to 80 mL min^{-1}. Pure oxygen is flowing through an ozone generator and the concentration value of the flowing ozone in the system is regulated by an electrical connection, and it is being controlled.

The mentioned liquid is flowing through an absorber column sequentially with a specific velocity, and enters the liquid reservoir container which has 1 L volume. The absorber column has a height of 0.4 m and a diameter of 4×4 mm. pH was calculated and regulated by a regulator. Furthermore, there is an ozone demolisher in the final part of the reactor`s system.

A cylinder reactor with a rising flow at the fixed temperature of 20°C with an external ring for the wastewater flow with the help of a pump is used. The flow causes that micro-organisms and the under layer becomes mixed in the reactor`s depth and increases the ability of the process for overcoming the over load in comparison with the continuous flow during bio-filtration.

During filling, the slope of concentration increases along the reactor that this slope becomes fixed when the flow continues again, and the contents are mixed. Because of the high flow (100 L h^{-1}), and the linear velocity, the increase of concentration`s slope is limited to the filling time and the beginning of the reactor`s phase. At the beginning of each cycle the certain primary volume of wastewater is pumped in to the system, and then it flows along the whole reactor and finally leaves [**10, 11**]. For removing the excess biological mass, the bottom of the reactor should be repeatedly cleaned by an air compressor and cleaners [**12**]. Parameters such as insoluble DO (dissolved Oxygen), temperature and pH are successively regulated.

The other factor that was taken into consideration for using ozone in waste water treatment was the solubility of ozone [**13**], that depends on the water temperature and the ozone concentration in the gas phase, in the following table solubility of ozone in mg L^{-1} is presented (Table 1).

Table 1. Ozone solubility (mg L^{-1})

O_3 GAS	5° C	10° C	15° C	20° C
1.5%	11.09	9.75	8.40	6.43
2%	14.79	13.00	11.19	8.57
3%	22.18	19.50	16.79	12.86

Furthermore, solubility of ozone in water according to temperature is shown in figure (1).

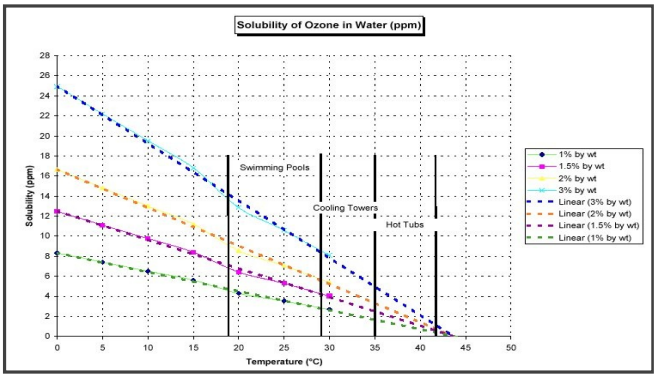


Figure 1. Solubility of ozone in water (mg L^{-1}).

RESULTS AND DISCUSSION

Ozonated wastewater provides necessary substances for bio-treatment in both aerobic and anaerobic stages. For providing the essential substances for final biological treatment, sufficient solution which is ozonated wastewater is produced in some groups.

The concentration reduction of nitrite, nitrate, ammonium, phosphate ions and phenol by the bio-ozonation method in industrial wastewaters, the opportunity of the significant reduction of the mean values of BOD, COD and total dissolved carbon content during wastewater treatment with ozonation due to the velocity change of suspended solids, and making wastewater clear by the reduction of high color and turbidity values with ozonation were the remarkable achievement of such a wastewater treatment method. After ozonation is done from the fifth step as it is seen in table 2 and measurements were recorded, the effect of using ozone on biological treatment showed itself very efficiently that can be seen in toxic resistant and poisonous pollutants` removal in the following table [14].

Table 2. The effect of ozonation on biological treatment in order to remove resistant and poisonous toxic pollutants

Steps	Ozone Value		Treated Effluent by Biological Treatment System				Treated Effluent by Bio-Ozone-Bio Treatment System			
	Added (gm^{3-1})	Consumed (gm^{3-1})	BOD (gm^{3-1})	COD (gm^{3-1})	NO_3^- (gm^{3-1})	NO_2^- (gm^{3-1})	BOD (gm^{3-1})	COD (gm^{3-1})	NO_3^- (gm^{3-1})	NO_2^- (gm^{3-1})
1	-	-	62	150	20	-	-	-	-	-
2	-	-	65	235	18	-	-	-	-	-
3	-	-	214	570	14	-	-	-	-	-
4	-	-	62	88	16	-	-	-	-	-
5	39.1	15.2	98	109	13	-	60	103	-	-
6	39.1	16.3	60	189	12	-	60	102	-	-
7	48.3	17	41	76	10	-	25	48	5	-
8	48.3	18	100	180	5	0.48	60	80	4	0.41
9	48.3	17.8	75	101	4.5	0.70	40	78	2	0.62
10	48.3	18.4	40	52	14	0.3	24	33	7	2.1
11	48.3	17.9	50	200	13.5	0.6	25	60	9	0.54
12	57.1	23	40	190	13.5	0.4	26	25	7.3	0.38
13	57.1	20.1	38	200	11.5	0.62	25	30	6.9	0.6

Biological Oxidation Conditions: pH= 7.05-8.9 Temperature=21-25.6°C
Bio-Ozone-Bio Oxidation Conditions: pH= 8.09-8.91 Temperature=20.5-25.3°C

The scientific innovations of this treatment method can be counted as followings:

The treatment of the waste water was done by the combination of ozonation and filtration methods. By this way, the concentration of hazardous contaminants, such as phenol, total solids, suspended solids, ammonium, nitrite and nitrate ions, the cleaning of which had not been possible to implement by the standard methods before, was removed or reduced to the permissible level in the waste water, having the opportunity of the significant reduction of the mean values of BOD, COD and total dissolved carbon content during waste water treatment with ozonation due to the velocity change of suspended solids. The decontamination of viruses and microbes in the wastewater was done by the bio-ozonation method. Making waste water clear by the reduction of high color and turbidity values with ozonation, the maximum solubility of contaminants was achieved by the use of minimum ozone dos. The optimal duration and dosage of ozonation were determined.

Nature protection agencies, which treat industrial and household wastewaters, according to the issues and the aims of wastewater treatment, can choose:

1. To implement the treatment of industrial wastewaters containing the high concentrations of total and suspended solids by the bio-ozonation cleaning system as a result of which cleaned wastewaters can be used again for agricultural, industrial and other purposes.
2. To perform the treatment of waste water is having the high color and turbidity values by the bio-ozonation cleaning system.
3. To implement the cleaning of wastewaters containing the high concentration of phenol, this is considered as one of the most toxic contaminants in wastewaters, by the bio-ozonation cleaning system.

4. To perform the cleaning of wastewaters containing the various types of viruses and bacteria by the advanced method.

APPLICATION

With this method industrial wastewaters which content toxic and mineral substances can be treated with a significant efficiency. Based on what presented in this research it can be concluded that using Ozone in industrial wastewater treatment has several remarkable advantages over the many various chemical alternatives that have been used for treating wastewater from resistant and poisonous pollutants.

CONCLUSION

Results achieved from both of the treatment systems showed that the content of the stable and toxic contaminants, and the efficient cleaning of which wasn't possible to implement before ozonation, can be removed or reduced to the permissible level in wastewaters by the developed method presented here. Moreover, the decontamination of different viruses and bacteria in the wastewater was done by the developed method presented in this method. According to this research, ozonation is one of ecologically clean perspective methods for the treatment of industrial wastewaters, as in this case chemical reagents, such as potassium permanganate, chlorine and some others which cause the secondary pollution of water aren't applied.

REFERENCES

[1]. Metcalf and Eddy, *Wastewater Engineering, Treatment and Reuse, fourth edition*, **2004**, 12, 1287-1290.
[2]. George T., Frakin L., David S., Wastewater engineering: treatment and reuse, *fourth Edition, Metcalf and Eddy, McGraw Hill*, **2003**, 1288-1290.
[3]. Kaza Somasekhara Rao, Kaza Kalyani Sekhar, Kaza Naga Krishna Vani, Kaza`s Carbons-Tools of Decolourization of Aqueous Waste Effluent Water, *J. Applicable Chem.*, **2016**, 5(4), 708-713.
[4]. Amir Hajiali and Gevorg P. Pirumyan, Efficiency of Ozonation Disinfection in a Domestic Wastewater Treatment for Removing Existing Infectious Bacteria and Viruses and a Comparison with Chlorine Disinfection, *International Research Journal of Advanced Engineering and Science*, **2018**, 3(2), 341-344.
[5]. Amir Hajiali, Assessment of Total Organic Carbon (Soluble and Suspended) Removal in a Bio-Ozone-Treatment of an Industrial Wastewater with and without Sediments, *International Research Journal of Advanced Engineering and Science*, **2018**, 3(1), 220-223.
[6]. Amir Hajiali, Evaluation of $NH_4^+$and PO_4^{3-} Removal in Treatment of an Industrial Wastewater Containing Chlorophenolic Contaminants with Ozonation, *J. Applicable Chem.*, **2017**, 6 (5): 934-940.
[7]. Prat C., Vicente M., Esplugas S., Ozonization of bleaching waters of the paper industry, *Water Res*., **1989**, 23, 51-55.
[8]. C. Di Iaconi, A. Lopez, R. Ramadori, G. Ricco, M.C. Tomei, Ozonation of secondary effluents of tannery industry: kinetics and effect on biodegradability and toxicity, *Proceedings of the International Conference on Wastewater Treatment, Standards and Technologies to Meet the Challenges of the 21st Century, No.2, Leeds, UK* ,**2000** ,625-639.
[9]. A. Hajiali, Principles of Wastewater Treatment with Ozonation, *Yerevan, Armenia*, **2012**, 224-226.
[10]. Shun Dar Lin, Water and Wastewater calculations manual, 2nd edition, **2007**, 6,752-755.
[11]. M. Borghei, Principles of swage and industrial wastewater treatment, *Sanati Sharif University, Tehran*, **2000**.

[12]. LidaSalimi, Amir Hajiali, Determination of Poly Aromatic Hydrocarbons (PAHs) Amounts in Anzali Lagoon (Iran) and Assessment of their origin, *Journal of Applicable Chemistry*,**2017**, 6 (3), 363-373.
[13]. H.Beffadhel, A. Ratel, Removal of color and Organic Matters in Industrial Phosphoric Acid by Ozone: Effect on Activated carbon Treatment Ozone, *Science Engineering*, **1995**, 17(6), 637-645.
[14]. Snehal D. Kale, N. N. Bandela, Study of physico-chemical Parameters of Wastewater Effluents from Waluj Industrial Area, Aurangabad, *J.ApplicableChem*,**2016**, 5(6),1307-1314.