State of the Art of the Deodorizing Technology in Korea

Sang Jin PARK
Dept. of Civil & Environmental Engineering, Woosong University
17-2 Jayang-dong Dong-gu, Daejeon, Korea 300-718

Key words : Odor removal technique, odor regulation, Korea

Abstract

The Odor Prevention Law will take effect on and after Feb. 10th 2005 in Korea. 23 malodorous compounds including the existing 8 compounds are designated as odor compounds by the legislation and the strict emission standards are also enforced. To enforce the Odor Prevention Law, government agencies as like Ministry of Environments have carried out various projects related with odor works. This paper reviews the status of odor works and the state of the art of deodorizing technique developed by Koreans.

1. Status of Odor Works in Korea

1.1 Regulation for odor works and analysis of odor

Until 2003, odor works have been included and controlled by the Preservation Law of Air Environment. But it is expected that odor works will be enlarged, because the Odor Prevention Law was passed in national assembly in 2004 and the regulation and guidelines are almost prepared. The main contents of the Law are shown in brief at the proceedings of the international workshop on odor at Beppu, Japan, 2003(1).

Table 1 shows the status of emission standard and chemical compounds designated by the legislation as odor compounds. Until now, legal control had been adopted for stack and off-site, considering the characteristics of the area. And legal odor compounds will be expanded step by step and finally 23 compounds will be designated in 2010.

The methods such as air dilution sensory test and instrumental analysis have been used to measure odor quantitatively in Korea. In addition, a direct sensory test which measure on-site odor intensity at field has been used.

1.2 Status of Deodorizing Technique in Korea

Although activated carbon tower and chemical scrubber were installed at night-soil treatment plants, deodorizing facilities such as soil bed at sewage treatment plants have become wide-spread from 1988, at which time the Seoul Olympics were held3). Increasing odor annoyance in early 1990, the concern with odor problems has been growing and many studies were carried out with the support of MOE(Ministry of Environment). Until now, about 16 projects with 4.6 million US dollars of project funds were performed actively for the past four years(4).

Various biological deodorizing techniques including plasma, electron beam, photo-catalysis were studied. As the results of these studies shows, eight techniques which are mainly a biofiltration technique, were designated as the new odor removal techniques protected by legislation. Market share of odor and VOCs removal technology in Korea were represented in Figure 1.

Table 1. Emission standard of Odor in Korea

odor (O.U./m³)	residental area		industrial area	
	general standard	strict standard	general standard	strict standard
stack	less than 500	300~500	less than 1000	500~1000
off-site	less than 15	-	less than 20	-

malodorous compounds (ppm_v)	general standard		strict standard (industrial area only)
	residental area	industrial area	
ammonia	1	2	1~2
methyl mercaptane	0.002	0.004	0.002~0.004
hydrogen sulfide	0.02	0.06	0.02~0.06
dimethyl sulfide	0.01	0.05	0.01~0.05
dimethyl disulfide	0.009	0.03	0.009~0.03
trimethyl amine	0.005	0.02	0.005~0.02
acetaldehyde	0.05	0.1	0.05~0.1
styrene	0.4	0.8	0.4~0.8
propion aldehyde[1)]	0.05	0.1	0.05~0.1
n -butyl aldehyde[1)]	0.009	0.03	0.009~0.03
i-butyl aldehyde[1)]	0.02	0.07	0.02~0.07
n -valeric aldehyde[1)]	0.009	0.02	0.009~0.02
i -valeric aldehyde[1)]	0.003	0.006	0.003~0.006

(remark) 1) is going to designate from 2005

Table 2. Odor compounds to be designated by legislation in the future

The number of compounds	Malodorous chemical compounds controlled by regulation in Korea		Remark
8	Ammonia Acetaldehyde Hydrogen sulfide Dimethyl sulfide	Dimethyl disulfide Trimethyl amine Methyl mercaptane Stylene	at present
4	Propionaldehyde Butylaldehyde	n-Valeric aldehyde i-Valeric aldehyde	from 2005
5	Toluene Xylene Butyl acetate	Methyl isobuthyl ketone Methyl ethyl ketone	from 2008
5	Propionic acid n-Butyric acid n-Valeric acid	i-valeric acid i-Butanol	from 2010

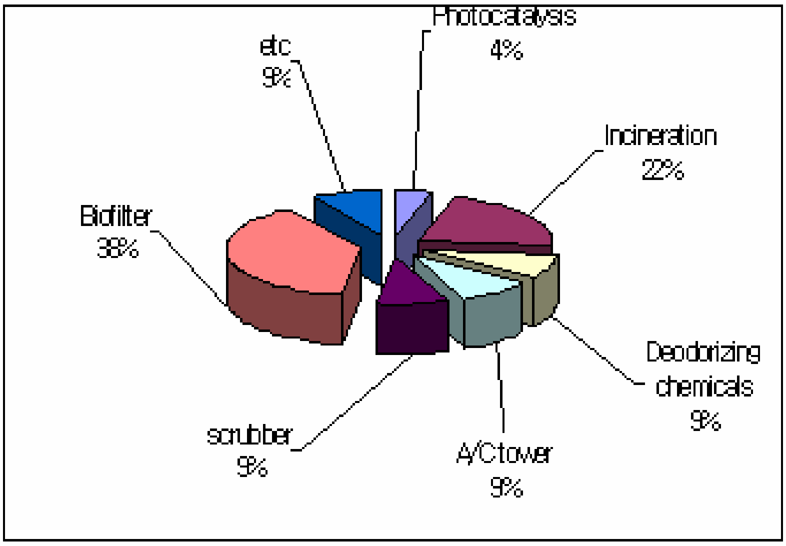

Figure 1. Marketing of odor removal technology in Korea

2. State of the art of biofiltration technique developed by Korea.

Although soil bed was used widely in early 1990, a closed-type biofilter, similar to the biotrickling filter, have been used in these days. In this paragraph, elementary techniques of wide-spread biofilters designed by Korean engineers are reviewed in brief.

2.1 Microbial carriers of biofilter

Although mixtures with inert sphere and organic materials such as compost, peat moss have been used in Europe, in-organics including ceramic are used as the microbial carriers of biofilter in Korea. Especially, as the ceramic medium has not condensed but having a pH buffer capacity and adsorption ability, it was reported that the biofilter using a ceramic medium reduced odor from a composting facility effectively(6). Figure 2 shows the three mediums made from ceramic(a), polyurethane(b), and cork(c). The unit price of these mediums is estimated to range from 600 to 800 U.S dollars.

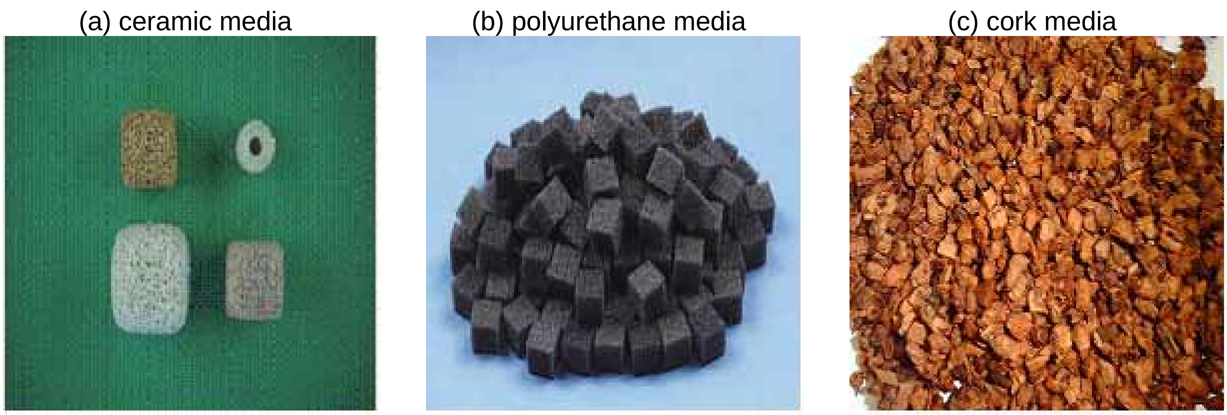

Figure 2. Microbial carriers manufactured by Korean

2.2 Control of biofilter clogging by excess microbial mass

As shown in Figure 3, clogging due to excess microbial mass is caused to reduce removal efficiency of biofilter. It has been reported that chemicals such as hypo-choline was added to inhibit microbial growth but the effectiveness was not proven(7)(8)(9)(10).

Mechanical stirring shown in Figure 4 and backwashing with air/water shown in Figure 6 are used to prevent microbial clogging in Korea. Figure 5 shows that stirring one time per month could keep the pressure drop at less than 50 mmH_2O/m during operation period at kitchen-wastes composting facility.

It was displayed that (a) is to reduce the excess mass using water only and (b) dissolved air flotation and (c) water with fine air bubbles. As observed in Figure 6, it was estimated that back washing of water with 0.2cm air bubbles is very effective.

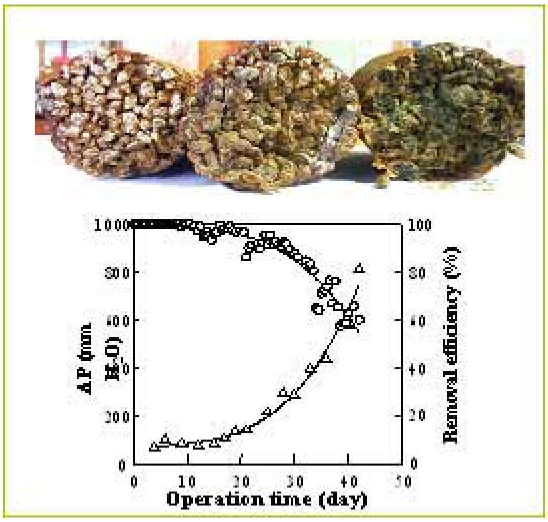

Figure 3. Time-course increase of pressure drop during operation periods

Figure 4. Mechanical stirring device to prevent a clogging in a biofilter

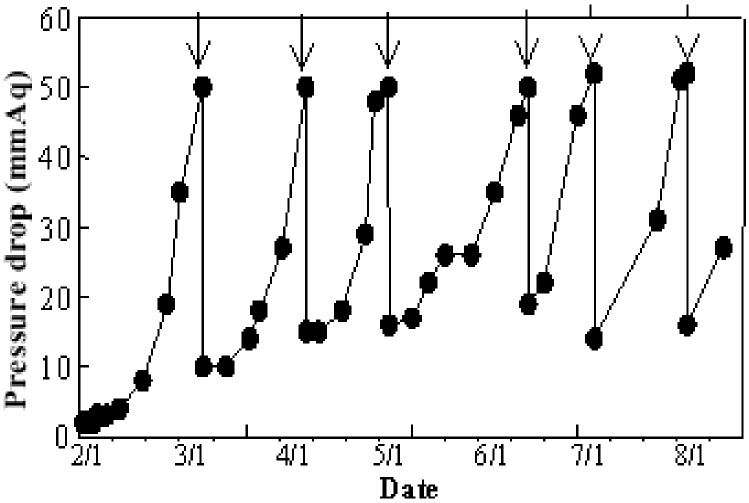

Figure 5. Variation of pressure drop during operation

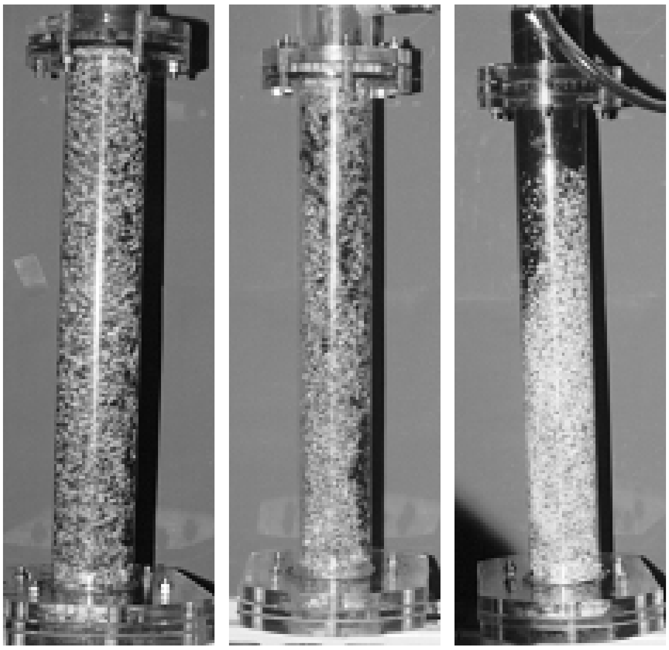
Figure 6. slough off effect of excess microbial mass by injecting with air and water
(a) water only, (b) dissolved air flotation, (c) water with air

2.3 Biofilter system design using CFD program and operation by PLC

In general, as compared in Figure 7, short-circuiting due to dead space in the reactor also caused to reduce removal capacity of the biofilter. In the case that the biofilter is located a long distance away, a productive operation would be difficult. As the alternative to solve these problems, CFD(Computational Fluid Dynamics) in Figure 7 and PLC(programmable logic controller) in Figure 8 were applied to design the useful biofilter. These design techniques were applied to the biofilter shown in Figure 9. It was estimated through the full-scale studies that this new-designed biofilter had higher efficiency than a conventional biofilter

3. Field application of biofiltration technique developed by Korean

3.1 The KAVOTEC biotrickling filter : odor and VOCs mixtures treatment from vitamin manufacturing of BASF(Ltd).

The biotrickling filter, having a design capacity of 550 m^3/min, was installed to treat odor from BASF vitamin manufacturing, and glass forming ceramic inoculated with thickened activated sludge was filled. Figure 9 displays a long view of the biofilter prepared by KAVOTEC(Ltd). Although removal efficiency was decreased temporarily because of very hot incoming gas, the whole operating result represents that this biofilter has removal efficiency more than 90% shown in Figure 10.

3.2 The BIOSAINT biofilter : odor and VOCs mixtures treatment from POTWs of Busan Janglim.

The biofilter, having a design capacity of 1,000 m^3/min, was installed to treat odor from Busan Janglim sewage treatment plants(See Figure 11). This biofilter filled with a poly-urethane medium had mechanical stirring to prevent microbial clogging. As observed in Figure 12, odor concentration of treated gas was maintained consistently below the legal emission standard, 15 O.U m^{-3}.

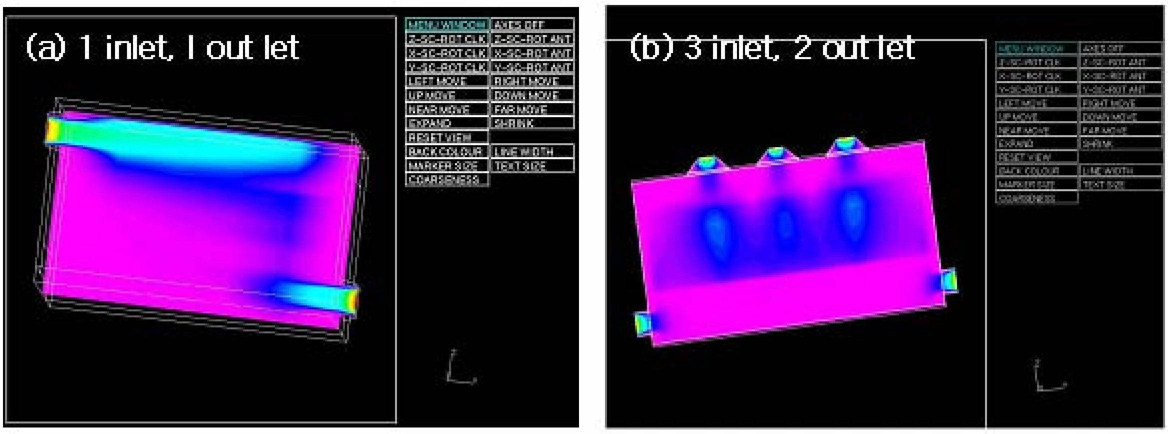

Figure 7. Analysis of air flux flow in a down-flow biofilter using CFD
(a) conventional type, (b) modified type

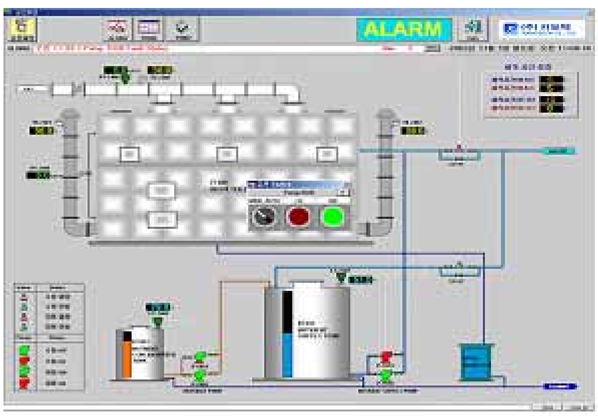

Figure 8. Schematic diagram of instrumentation panel using PLC

Figure 9. Long view of KAVOTEC biotrickling filter installed at BASF vitamin manufacturing factory

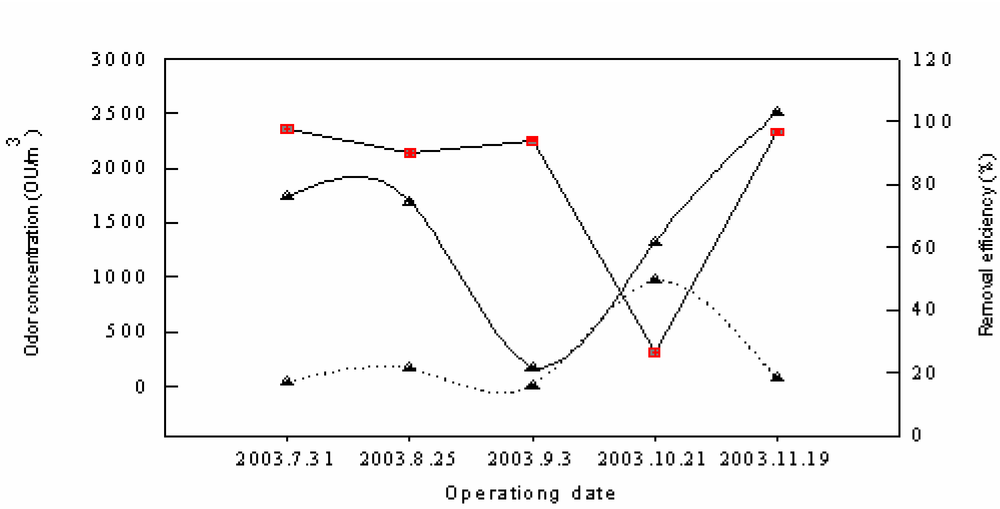

Figure 10. Time-course removal and KAVOTEC biofilter inlet and outlet concentration

Figure 11. Long view of BIOSAINT biofilter installed at Busan Janglim POTWs

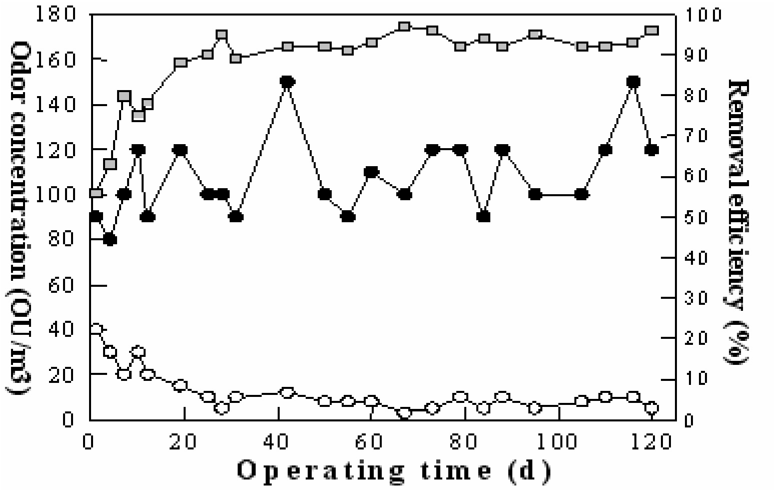

Figure 12. Time-course removal and KAVOTEC biofilter inlet and outlet concentration

Reference

(1) MOE of Japan, Odor Measurement Review, 2003, pp. 73-74

(2) MOE of Korea, Odor Prevention Law, 2004

(3) Sangjin Park, A study on the cost-effective deodorizing technique to reduce odor from POTWs in Korea, 1989, Annual Report of Korea Institute Construction Technology

(4) Sangjin Park, Development of biofiltration technique to treat odor and VOCs mixtures, 2002, Ministry of Environment Eco-project Report

(5) Joseph S. Deviny, Marc S. Deshusses, Todd S. Webster, Biofiltration for air pollution control, 1999, Lewis publishers, pp. 211-250

(6) Sangjin Park, et. al., Removal of odor emitted from composting facilities using ceramic biofilter, 2001, Journal of Water Science and Technology, Vol. 44, No. 9, pp. 301-308

(7) Weber F.J. and Hartmans, S., Prevention of clogging in a biological tricle-bed reactor removing toluene from contaminated air, 1996, Biotechnol. Bioeng., 50(1), p. 91

(8) Holubar, P., Andorfer, C., and Braun, R., Prevention of clogging in trickling filters for purifiction of hydrocarbon-contaminated waste air., 1995, Proc., 1995 conf. on Biofiltration, Univ of Southern California and Reynolds Group, Tustin, Calif., pp.115~121

(9) Kinney, K. A., Chang, D. P. Y., Schroeder, E. D., and Scow, K. M., Performance of a directionally-switching biofilter treating toluene contaminated air, 1996, in Proceedings of the 89th Annual Meeting and Exhibition of the Air and Waste Management Association, Air and Waste Management Association, Pittsburgh, PA.

(10) Sorial, G.A., Smith, F.L., Suidan, M.T., Pnadit, A., Biswas, P., Brenner, R.C., Evaluation of trickle bed air biofilter performance for BTEX removal, 1997, J. Environmental Engineering, 6, pp.530~537