The Trend of Odor Control Techniques in Japan

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Abstract

In Japan, malodor has been considered as one of the most serious public nuisances for many years, and various kinds of techniques are developed to control odor. Government and some organizations have tried to make related industries install appropriate odor control systems by detailed instructions, occasionally by presenting handbooks and manuals. However, some of traditional methods may become economically unreasonable because some new methods are now gaining popularity. In future, Japanese manufacturers will have to supply some low-energy technologies to achieve more effective odor control and to have them accepted worldwide.

In this report, the market of industrial odor control systems in Japan is introduced. A rough estimation suggested that the scale of this market is around 13-22 billion yen/year in the present, but it will increase up to 30 billion yen/year after five years. Then, outlook for several major odor control methods are explained. Regenerative thermal oxidizer (RTO) and plasma oxidizer are the typical examples of state-or-the-art odor control methods, but biofiltration will play an important role of the environmental-friendly method for odor and VOCs (Volatile Organic Compounds) control.

1) Background

Japan has a strict policy on odor nuisance, and it is defined by *The Offensive Odor Control Law* (1972). This law regulates emission of odor against all industries located in designated area, and the measurement of odor is conducted by ether instrument or human nose. Especially, sensory odor measurement, which uses human nose and measures detection threshold, detects all kinds of odor compounds. Therefore it is necessary for industry to control all kinds of odorous compounds, if their area is regulated by a certain value of Odor Index which is calculated by the value of dilution-to-threshold.

On the other hand, Japan has been outdistanced on the policy for control of VOCs until now, and several national measures were enforced quite recently: for instance, PRTR (Pollutant Release and Transfer Register) and *Air Pollution Control Law* amendments 2004 (not in effect). Consequently, emission of some kinds of VOCs is being restricted by several national laws, including *The Offensive Odor Control Law*. Hence the requirement of high-performance and cost-effective systems for VOCs control will be getting increase in Japan.

2) Economical impacts of odor control techniques

The market of odor control systems, installed at industries and at public facilities in Japan, is evaluated as **Table 1**. There are two estimations of total sales values in the fiscal year 2000. One is

Table 1. Estimation of market scale on odor control systems

Method	Num. of annual installation	Treated air volume (m^3 min^{-1})	Normal single installation cost (millon yen)	[Num.]*[Single Inst.Cost] (millon yen)	Installation Cost (million yen)*
Water scrubber	60	30.2	9.2	549	
Chemical scrubber	52	35.0	9.3	481	1100
Adsorption	492	16.8	4.4	2165	9300
Incineration	110	40.3	24.5	2695	4800
Biofiltration	201	13.9	3.9	774	6200
Ozonation	287	11.8	1.3	366	
Deodorant sprinkling	560	6.8	2.5	1400	
Others	1172	17.5	4.3	5027	200
			Total cost (millon yen)	13457	21600

*from literature: Market trend survey of Deodorization systems 2000, Sogo-kikaku Center Osaka, Japan (2001)

derived from the number of installation, average volume of treated air and normal installation cost at that air volume, based on the questionnaire result.(1) Another one is quoted from an market survey report.(2) The values are considerably different, but it can be concluded that the market scale on odor control systems is ranging between these values, 13-22 billion yen/year.

In the past, United States carried out stricter VOCs regulation by *Clean Air Act* Amendments 1990, and it brought about 50% expansion of the market in VOCs treatment in five years.(3) Some Asian countries, such as Korea and Taiwan, also have the policies for VOCs control. In Japan, *Air Pollution Control Law* Amendment 2004 has just announced and VOCs regulation was defined for the first time (but not yet enacted the detailed enforcement). This situation is quite similar what was caused in United States about 15 years ago, hence 20-30 billion yen/year, the result from the same expansion ratio, are expected as the market after five years.

In the process of establishing the amendment, *The Committee for VOCs Emission Control* suggested that the emission standards should be determined considering realistic availability of emission control techniques such as RACT (Reasonable Available Control Technology), and they also proposed that the control should be promoted by both legislations and voluntary actions of VOC-emitting industries.(4) The regulation is primarily applied only to limited kinds of industries and to those which have large amount of emission, but the voluntary actions will be spread in the future, because VOCs emission is also regulated by PRTR and *The Offensive Odor Control Law*.

In Japan, compliance with both VOCs control and countermeasures for odor emission in small businesses will be the major factors that stimulate the market of odor control systems. Current increase of odor nuisance is remarkable especially in restaurant or some other urban small facilities. Considering realistic emission control in such situations, biofiltration and plasma deodorization will have the possibility to increase their installation in near future.

3) Variety of odor control techniques

Generally, Japanese legislations and policies for environment emphasize to meet the standards or instructions, so that sometimes too much detailed instructions causes less flexibility for choosing pollution control techniques. However, mentioning particularly on odor control, many kinds of techniques have the opportunity to be utilized as the most appropriate method, because there are wide variety of emission sources that have to be controlled.

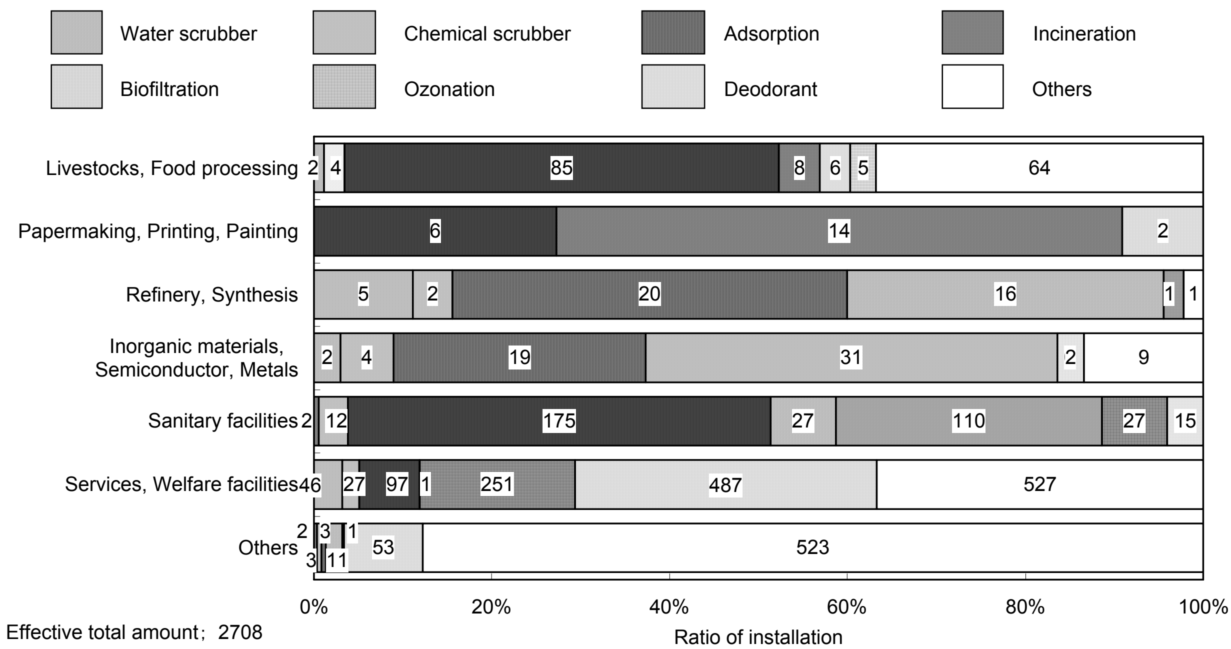

Figure 1. The amount of installed odor control systems for each category of odor-emitting industries in Japan in the fiscal year 2000

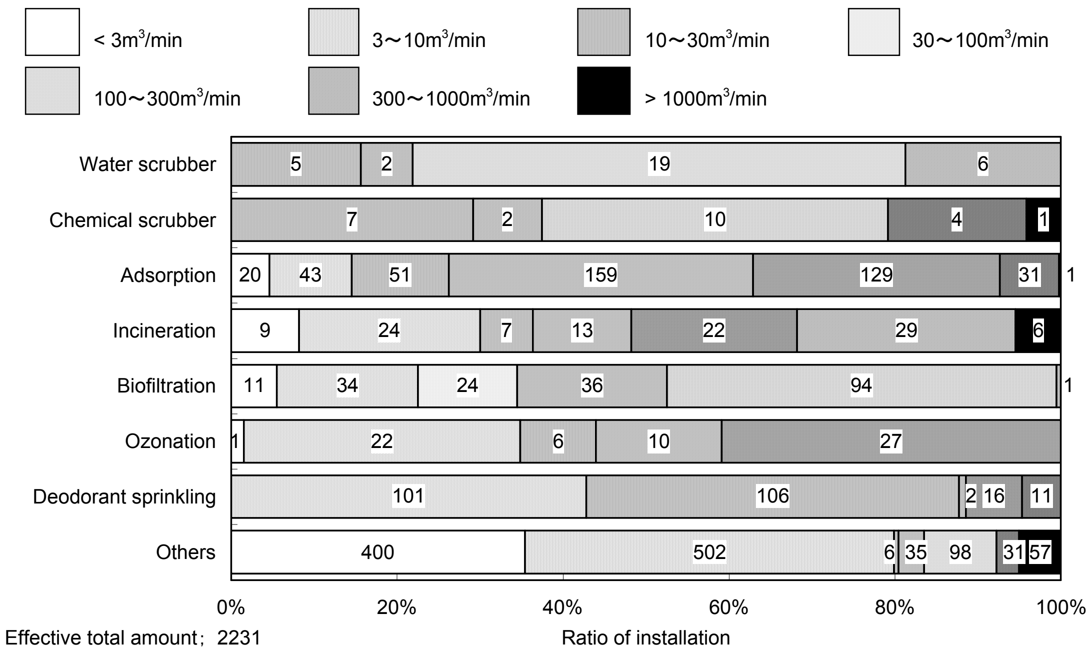

Figure 2. The amount of installed odor control systems for each scale of ventilation velocity in Japan in the fiscal year 2000

In fact, there are many kinds of equipments for odor control, and their applications in Japan are thought to be well-balanced and be dependent on the characteristics of emission sources. **Figure 1** is the number of installation for each kind of odor control system and each category of odor emission source, summed up in Japan in the fiscal year 2000.(1) It shows that dominant equipments are unique to each category of emission sources. **Figure 2** shows the distribution of treated gas volume in each kind of odor control system in the same statistics. Chemical scrubber and incinerator are used for the treatment of huge gas volume, despite high operation cost and the possibility of secondary pollution. At least in Japan, these two equipments have a long history of successful applications, and the users can gain more economical advantage if they require larger size of systems.

Japanese ministry of the Environment (Kankyousyou) has issued various kinds of odor control manuals for many kinds of emission sources.(5) In the past, these manuals described detailed characteristics of odor emission and applicable techniques in the viewpoint of engineers, while the recent one (see **Figure 3**) contains only simpler explanations.(6) This change reflects the trend, the needs for odor control are now being moved from large industries to small businesses which do not employ engineers.

Figure 3. The latest handbook for selecting odor control systems (6)

4) Advantages and disadvantages of major odor control techniques

As mentioned above, each kind of odor control system is likely to be

Table 2. Characteristics of major odor control systems

System	Summary	Advantages	Disadvantages
Direct incinerator	Pollutants are converted into carbon dioxide and water with around 750ūC of heat.	Various kinds of VOCs are degradable. Efficiency is stable.	Operation cost is very high without heat recovery. NOx generates.
Catalytic incinerator	Pollutants are degraded in the presence of catalyst with around 250-350ūC of heat.	Operation cost is lower than that by direct incinerator. NOx generation is less.	Care should be taken in the deterioration of the catalyst.
Regenerative themal oxidizer	Heat-exhange efficiency is enlarged up to around 95% by heat regenerating materials. 800-1000ūC of heat is used.	Operation cost is much lower than that by other types of incinerator. NOx generation is less.	Large space is needed. System has much weight. Installation cost is high.
Chemical scrubber	Pollutants are absorbed or degraded by the contact with sprayed chemicals. Acids, alkalis, or oxidants are selected according to the species of pollutants.	Installation cost is low. Mist and dust can be treated simultaneously. Cooling of gas stream is expected.	Waste water treatment and strict operation management are needed. Care should be taken in chemical hazard and in corrosion.
Packed bed adsorber	Pollutants are adsorbed by adsorbents such as activated carbon. The adsorbent is regenerated or exchanged when it is saturated by the pollutants.	Operation is easy. System is compact.	Pollutants must be low concentration if the adsorbent is not regenerated. Waste water treatment are needed if the adsorbent is regenerated by chemicals. Care should be taken in explosion for some pollutants.
Honeycomb-rotor condenser	Pollutants are collected by honeycomb-shape adsorbents and condenced into a small volume of air.	High-volume gas can be easily treated. Operation is easy. System is compact.	Application is not possible if the gas contains corrosive substances against honeycomb. Care should be taken in explosion for some pollutants.
Biofilter	Pollutants are treated by the packed bed containing microorganisms, such as soil, humus, or compost.	System is low price. Operation is easy. Waste water is not generated.	System is vast. Only limited kinds of pollutants and those of low concentration can be treated. Pressure drop is not stable.
Biotrickling filter	Pollutants are treated by synthesized packed materials holding microorganisms. Water is sprayed and trickling into the packe bed.	System is smaller than biofilter. Operation is easy and low cost.	Only limited kinds of pollutants and those of low concentration can be treated. Acclimation period is needed. Acid waste water is often generated.
Bioscrubber	Pollutants are degraded by the contact with sprayed sludge.	System is smaller than biofilter. Operation is very easy and low cost.	Aeration tank is additionally needed.

applied to a certain kinds of emission sources, because it has both advantages and disadvantages. The summary of the characteristics on major kinds of odor control systems is shown in **Table 2**.(5) In Japan, it is more important for odor control systems to be small-scale or to be easy of maintenance than to save energy, because the cost for land and labors is the matter of utmost concern for most industries. And that is why RTO (regenerative thermal oxidizer) and biofiltration, which need relatively large size but less energy, did not get apparent popularity until now. However, to save energy will be important for odor and VOCs control in near future, mainly due to the needs for reduction of CO_2 emission. And energy-saving type odor control systems will be spread with the increase of such needs.

Actually, innovative types of equipments are gradually getting popular. Plasma or photocatalyst deodorization is the typical example of newly spreading equipments. All of these equipments, including biofiltration, have some advantages and disadvantages: for example, Plasma system achieves relatively high efficiency for various kinds of compounds, whereas it has the possibility of generating by-products and of poisoning catalyst. Biofiltration also has the potential of the application for the removal of various kinds of gaseous pollutants. However it has relatively low efficiency and the uncertainty of long-term stability in some cases. It must be important for us to use new kinds of equipments appropriately, after understanding the fundamental mechanisms and surveying the compatibility of the system with the emission source for each combination.

5) Potential of biofiltration

Biofiltration is now considered as one of the major odor control methods, and its effectiveness has already proven for biogenic malodor, such as hydrogen sulfide, some other reducing sulfur compounds, and ammonia. And this method will be most attracted because of saving energy and of less concern of secondary pollution. Moreover, there are many researches that biofiltration has enough potential to be applied to VOCs control, and latest researches showed that extremely high removal capacity has already acquired in some conditions. The summary of academic reports on VOCs biofiltration is shown in **Table 3**.(7)

However, biological treatment for environmental pollution control has some "unknown" factors, and

Table 3. Elimination of gaseous VOCs by biofiltration (Biofilter and Biotrickling filter)

compound	EC_{max} ($g\ m^{-3}\ h^{-1}$)	critical load ($g\ m^{-3}\ h^{-1}$)*1	EC_{max} ($g\ m^{-3}\ h^{-1}$) reported by others*2	critical load ($g\ m^{-3}\ h^{-1}$) reported by others*2
hexane	3-8	1	1.5-21	<0.5-21
isopentane	7-8	1-2	2-28	<1.5-15
MEK	30-35	20-22	22-120	2-100
MIBK	40-50	13-15	25-30	<15-18
acetone	65-70	21-23	40-150	120
ethyl acetate	140-240	175-180	79-350	40-200
butyl acetate	32-34	28-32	40	8-10
isobutyl acetate	74-76	44-48		
methanol	135-150	32-34	30-120	25-80
ethanol	148-150	78-80	20-130	40
1-propanol	150	115-120		
2-propanol	120	78-80	50-78	
sec-butanol	140	80-85	24-76 (for butanol)	20-60 (for butanol)
benzene	7-8	1	2-47	<5
toluene	8-20	6-8	5-55	5-40
xylene	15-20	2	25-42	10-15
ethylbenzene	30-32	2		
methyl tert-butyl eter (MTBE)	0	0	8-57	15-20

*1; Critical load means the maximum loading at which the removal efficiency starts to deviate significantly from the 100% removal line.
*2; The type of biofiltration for each data is mentioned by reference No.5. (Deshusses,M.A., et al.)

especially for gaseous pollution control, gas-biomass contact efficiency and sorption capacity of gaseous pollutants have to be understood, in addition to biological activity of pollutants decomposition. These conditions are very sensitive to the outer conditions and are easy to change. Furthermore, universal structure and typical operation conditions are not established in biofiltration, so it is very difficult to transfer the fundamental studies to application uses. That is, through many trials of application, a sort of standardization in the structure and operation conditions is required for biofiltration, and the fundamental studies should be carried out in expectation of real use.
For example, elimination capacity (EC), which is expressed as the unit of g m^{-3} hr^{-1}, is usually shown as an indicator for the capacity of biofiltration, but this value is applicable to a certain combination of the pollutant and packing material which immobilize microorganisms (strictly speaking, temperature, nutrition supply, and some other conditions also affect it). There are various kinds of pollutants to which biofiltration is applied, and there are many kinds of packing materials which is used by biofiltration. Therefore, in future works, the effect of the characteristics of pollutants and that of the structure and surface properties of packing materials on the removal capacity should be investigated systematically for biofiltration.

6) Conclusion

As the whole, the trend of odor control in Japan is plainly represented that both the kinds of target sources and the types of control methods are expanding. Moreover, low-energy techniques will be required for the compliance with national and international policies. As the result, about 50% increase of the market on odor control will be expected in next five years. Some kinds of new methods have already being popularized, and at the same time, appropriate selection and usage on odor control systems have also been introduced to some extent. However, in some methods, for example, biofiltration for VOCs control, more fundamental and applied studies are needed for them to be accepted widely by the market.

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