Practical problems of odor measurements and odor controls

YOSHIHARU IWASAKI
Tokyo Metropolitan Research Institute for Environmental Protection

Key words : odor measurement, odor control, Triangle Odor Bag Method

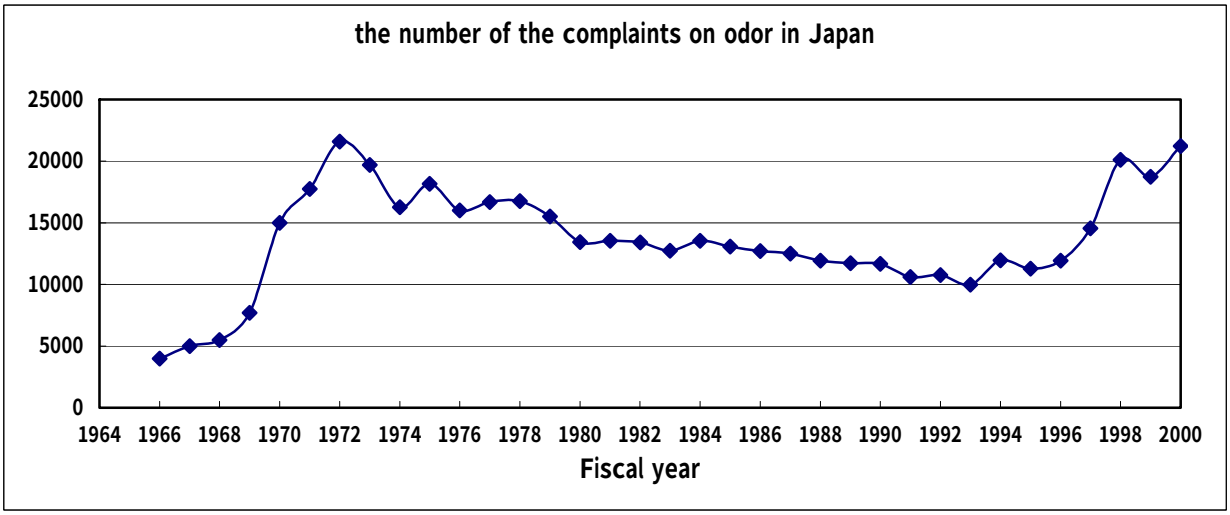
Abst.

Dynamic olfactometer has been widely used in European countries and some other countries. On the other hand, in Japan, Triangle Odor Bag Method was developed in 1973, and have been used in Japan for regulation method of the law and byelaw of local governments. It is very important to investigate the reliability of both methods.

The deodorant devices on the markets are almost for the big factories. And the costs are very expensive for the medium and small factories. It is a matter of great urgency to develop the odor controls for the medium and small factories.

1. Introduction

The odor problem is the common problem in the world. Today, global environment problems and dioxin problems have been very important environmental problem. And, odor problems are seemed to be minor. But, practically I think that odor problems are very important for our daily life. Because, almost people desire to take comfortable environment. The number of the complaints for offensive odor had been increasing rapidly from the late 1960's, as following Fig. 1. Thereafter, the number decreased, but increased again in recent years. The cause of the increasing may be seemed to be the increasing of the number of the complaints for burning off dead grass.



2. History of odor measurement methods in Japan

The A.S.T.M. syringe method had widely been used as a means of measuring odor concentration till 1975 in Japan. The syringe method was very easy for measurements at the sources of offensive odor, and there were a lot of measured results about many kinds of emitted sources till 1975 in Japan.

However, because of the unreliability of obtaining reproducible concentration values, it has been considered that the syringe method is useful only for a rough estimation of odor and not suitable for precise administrative regulation.

In order to eliminate the disadvantages of A.S.T.M. syringe method, a 3 liter plastic bag is used instead of the 100 ml syringe. The diluted sample is prepared in the bag by filling it with odor free air and injecting a certain amount of odor sample（primary odor）into it. We adopted the triangle method, that is , each panel chooses one bag containing odor out of 3 bags in order to obtain more objective results.

From the late 1970s, we imported the Scentometer from The Barnebey-Cheney Company located in the United States of America and investigated the credibility of this method such as dilution accuracy, repeatability. As a result, the Scentometer was scarcely fit for use.

In the early 1970s, some institutes in Japan made a respective Olfactometer similar to that used in European countries.

Well, in 1973, a certain Japanese company placed the Olfactometer on the market. However, adsorption loss of odors on the inner surface of the gas line of the olfactometer in those days could not be disregarded.

For this reason, the production of the olfactometer was stopped after the several years.

3. Comparison dynamic olfactometer in EU with Triangle Odor Bag Method in Japan

Dynamic olfactometer has been widely used in European countries and some other countries. This method was standardized in 2002 after the energetic examination during several years (CEN standard).

. On the other hand, Triangle Odor Bag Method had been developed in 1973, and have been used in Japan for regulation method of the law and bylaw of local governments.

We have been investigating the credibility of both method, concretely, the accuracy of the dilution and the repeatability of the measured results of same sample and so on.,

The results were that the accuracy of dynamic olfactometer was not good for hydrogen sulfide and alcohol compounds. On the other hand, the accuracy of Triangle Odor Bag Method was good for many kinds of odorants.

Measured results of odor concentration of the same samples by both measurement methods were almost similar.

4. Triangle Odor Bag Method

(1) Outline of Japanese method (Triangle Odor Bag Method)

One bag is the odor bag into which a certain amount of the primary odor is injected and the two other bags are filled with only odor-free air.

Panel tests to determine the odor concentration are carried out by means of dilution, that is, the test is started with a concentration that the panel can easily recognize the odor, and the dilution ratio is successively diluted approximately 3 times in any step of dilution when the answer of the panelist is correct. It is continued until an incorrect answer occurs.

In this way, panels can easily distinguish the odor sample and avoid the risk of coincidence with the concentration ascending method. The dilution of approximately 3 times is adopted.

(2) Panel member

A panel consists of over 6 panelists. It is necessary for each panelist to be over 18 years old. All panelist need to pass the panel screening test.

(3) Panel screening test

The panel screening test is done using standard 5 odorants of the T&T olfactometer. The concentrations of the odorants are as follows (dilution liquid is odor-free liquid paraffin).

β—phenyl ethyl archole	$10^{-4.0}$	w/w
methyl cyclo pentenorone	$10^{-4.5}$	w/w
isovaleric acid	$10^{-5.0}$	w/w
γ—undecaractone	$10^{-4.5}$	w/w
Skatole	$10^{-5.0}$	w/w

① The 5-2 method is adopted as the procedure for the panel screening test.

② 5 odor-free papers (size: 14cm×7mm) are prepared. We soak the top 1 cm of 2 papers in a standard odorant liquid. The remaining 3 papers are soaked in the odor-free liquid paraffin using the same method.

The subjects sniff the 5 papers, and answer the nimog the 2 papers that contains the odor

③ Each subject is tested for the 5 standard odorants using the same above mentioned method.

④ The subject whose answers are all correct for the 5 standard odorants is passed in the panel screening test.

(4) Procedure of sensory test

① Fill 2 odor bags with odor-free air until the bags are almost full and closed with silicone rubber stoppers. Beforehand, completely exchange the remaining air in the bag with odor-free air.

②Inject primary odor taken from a sampling bag into one of the odor bags through its label. Its injection volume should meet the required concentration.

③The other 2 bags are filled only with odor free air, holes are marked on the labels of the bags by the syringe needle, and the bags are delivered together with an odor-filled bag to a panelist.

④The panel sniffs the air in the bags with their nose which is connected to glass pipes and lists the number of the bag from which he or her senses an odor.(refer to Fig.2)

⑤When his or her answer is correct, the same procedure is carried out at the next stage in which the odor is diluted approximately 3 times. This procedure is continued until the panel gives an incorrect answer and then test by the panel is finished

Fig. 2 Triangle Odor Bag Method

5) Calculation

① Threshold values are calculated for each panelist using the following formula（For example, Panelist A）.

Xa＝（log al＋log a2）／2

Xa：threshold value for panelist A

al：correct maximum dilution ratio

a2：incorrect minimum dilution ratio

② Mean of the threshold values calculated for each panelist in excluding minimum and maximum values is taken as the threshold value for a group of all the panelists.

③ The odor concentration is calculated by converting the threshold value obtained in as follows:

$Y=10^X$

$Z=10 \log Y=10X$

X: threshold value for a group of all panels

Y: odor concentration

Z: odor index

8) The yardstick of odor concentration is widely used in the world. I think, odor concentration scale is very useful scale. At present time , we use mainly odor level scale in Japan. Odor level scale is the scale transformed odor concentration into

logarithm as follows .

Odor level = 10 x log (odor concentration)

In Japan, this odor level scale is called “odor index” . We proposed this odor index scale about 30 years ago. I think this odor level scale is better than odor concentration, considering Weber-Fechner’s law. The odor index is good scale corresponding to human olfactory sense ,such as phon or decibel in noise pollution.

5 Odor control problems

1) Odor emission sources

Generally, every factories that hold the production process, have necessarily odor problems. Practically, all kinds of factories are the subjects of offensive odor complaints. Human waste treatment center, sewage disposal center, fishmeal plants, paint factories, print factories are typical offensive odor emission plants. But, even the factories that emit good smell are sometimes the subjects of odor complaints. Concretely, these factories are coffee bens roast factories, cake factories, and chewing gum factories.

2) 400,000 chemicals have original smells

It is said that the chemicals their molecular weight are from several tens to 4 hundreds almost have smells. The number of chemicals that have smells may be about 400,000. There are the exceptional chemicals, such as ammonia (molecular weight 17).

Almost chemicals their molecular weight are over 400 are solid. Therefore, they have no smell.

3) The relationship between the harmful gas controls and offensive odor controls

Comparing the controls of the harmful gases that influence the physical damage on human bodies with the controls of the offensive odors, the both controls different from each other.

Concretely, in case of odor controls, it is good methods to make the stuck higher and to dilute the odors till the olfactory threshold levels, But, in case of the controls of the harmful gas, the dilution by the high stuck is equal to spread the damage areas.

4）Importance of odor controls for the medium and small factories.

The factories, such as printing, painting, plating, food companies, are almost small type in Japan. the number of the big factories are very few. And, the big factories measured already the odor controls in 1970 to 1990. The offensive odor problems with the big factories were solved already.

5）the direction for the resolutions of odor problems

What is necessary for the resolution of the odor problems. It is the big target to clear the regulation values. We must work hard to clear the regulation values. At the same time, it is very important to try to decrease the number of odor complaints.

It is a good measure to dilute the exhaust odors and to make the odor level the thresholds or below, for the purpose of the decreasing the odor complaints,

The most essential measure for the odor controls is the reduction of odor emissions as mentioned lately.

6) Selection of the odor control devices

After the investigation of above mentioned odor control, in the case of the difficult problems, we must introduced of the odor control devices. There are 7 methods in the odor control devices.

(1) Thermal incineration method

The odorous gas are heated till 700 ~ 800 C (duration time 0.3- 0.5 sec) by using the city gas or kerosene, and are decomposed finally. The running cost is very important for the reason of using the fuel. This method is very suitable for the odors of small exhaust gas volume, and of high concentration, almost thermal incineration plants have the heat recovery devises. The recovery efficiency influence considerably to the running costs.

This method is very useful for the VOC control.. And, the factories that emit very strong odors, such as fishmeal plants, introduced the incineration systems. If, the factories have the boilers, the thermal incineration method can be replaced by the boiler.

(2) Catalytic combustion method

Catalytic combustion method is the method to make the odorous gas oxidize by using the catalysts and decompose. The oxidization temperature of the thermal incineration method is very high, but the temperature of the catalytic combustion system comparably low(300～400℃). For the reason, the running cost of this method is not expensive comparing with the thermal incineration system. The catalysts are almost made with platinum compounds.

This control method are almost used at the painting factories and the printing factories, as same as the thermal incineration methods.

It is necessary to pay attention to the catalyst poisons (sulfur compounds, organic silicon). The means of the solving the problem are to attach the test piece or prefilter in front of the catalyst. The change of the filter in front of the catalyst is necessary for the maintenance of high efficiency for .the longtime.

(3) Adsorption method

Adsorption method is the method to remove the odorants using the adsorption reagents. This method is suitable for the exhaust gas of large volume or low concentration gas. The method is applicable to all odorants.

Chemical impregnated carbon and activated carbon have been widely used for the adsorption reagents. When the adsorption volume are over the capacity, the ability of

the adsorption decrease rapidly.

Therefore, the recovery by heating is necessary for the operation. Generally the recovery operations of the activated carbons ask to the maker. But, almost big factories have a recovery plants.

(4)Cold trap adsorption method

Cold trap adsorption method is the method to make the odorants condense by decreasing the gas temperature. It is possible to recover the odorous compounds.

The removal efficiency of the cold trap adsorption method is not high comparing with the other deodorant methods, but this method is suitable for very high concentration odorants. We can see these devices in VOC (mainly chloric compounds) emitted factories.

(5) Wet scrubber method

Wet scrubber method is the devices to remove the odorants by absorption to the liquids. There are two absorption mechanisms that are physical action and chemical action such as oxidation reaction.

In case of using chemical action, this method is sometimes named “chemical absorption method”.

This method is suitable for aqueous odorants, but can not be expected the every high efficiency, but is effective for preliminary treatment.

(6) Biological deodorization method

Biological deodorization method is the method to decrease the odor by biological action. Deodorizations by soil filter and by activated sludge are typical biological deodorization method. Kuroboku soil is widely used for the biological soil, but in recent years peatmoss is popular for the soil.

By attaching the microbe on the surface of the solid, such as ceramics, the odor controls for large volume exhaust gas were capable.

This method is very useful for sulfur compounds, such as hydrogen sulfide and methyl mercaptane. We can see these biological deodorization devices in sewage treatment centers.

(7) Deodorant reagent method

it is very difficult to explain simply the deodorant reagent method, for the reason of a lot of deodorant mechanisms in this deodorant reagent method.

It is not few cases that some adsorption deodorant method and some biological deodorant method are sometimes called “deodorant reagent method”.

7) The subjects of the odor controls

The deodorant devices on the markets are almost for the big factories. And the costs are very expensive for the medium and small factories. The initial costs of the deodorant

devices are almost over 10 million yen　And the running costs are over 0.1 to 0.2 million yen per month.

The olfactory sensory method was adopted in Offensive Odor Control Law in 1995. the regulation subjects of the Law are all factories, therefore the deodorant control for the medium and small factories had been very important. The targets of the deodorant efficiency in almost deodorant devices are 99% levels till now, but I think that even 70% efficiency is satisfactory to these factories. The costs (initial cost, running cost) are a priority matter for the medium and small factories.

These factories desire the simple maintenance of the deodorant devices. It is impossible to place the maintenance specialists in these factories.

For the reason, maintenance free devices are required. I wish that the deodorant maker tries to product the cheap deodorant devices for medium and small factories.

Table 1　measured results of deodorant efficiencies of each deodorant devices

Deodorant methods	Deodorant efficiency (%)						Ave of deodorant efficiency
	<20	20～50	50～80	80～90	90～99	99	
Thermal incinerater	4	2	3	1	3	8	68%
Cataltst combustion	2		7	4	17	1	82%
Adsorption method	2		1		4	2	72%
Wet absrption	13	5	10	1	1		33%

8) Measurement results of the deodorant efficiencies by each deodorant devices.

Table 1 shows the measurement results of practical deodorant efficiencies.

We can realize easily from this Table, which ranges the 91 measured results entered in.

At the time when the deodorant devices were attached at first, the deodorant efficiencies might be very high levels. But I think that the efficiencies have been decreasing gradually year by year.

The causes of the deceasing are mainly the difficulty of the maintenances.

In case of the thermal incineration method, the number of the devices that the efficiencies are over 99% is 8 devices, near the half.

But sadly, the number of the devices that the efficiencies are under 50% is 6 devices.

In case of the catalyst combustion system, the very high efficiencies can not be expected, almost are over 90% levels.

In case of wet absorption method, it is impossible to expect the high efficiencies that are over 80%. We can see easily the low efficiencies that are under 20 %.

I wish that the deodorant makers try to product the cheap deodorant devices for medium and small factories.