REVIEW AND INVESTIGATION WORK ON CLOSED SYSTEM DISPOSAL FACILITIES IN SERVICE FOR AN IMPROVEMENT OF DISPOSAL TECHNOLOGY

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ABSTRACT

The number of closed system disposal facilities (CS) is soon going to reach 30 as of today in Japan. Some systems have already been put into service and a few of them have been operating for several years. Others are under construction. Our research group aims to investigate existing CS to collect useful information on design conditions, operating methods and even complaints about systems in service so that we can consider and realize how to improve the closed type landfill system technology. We made inquiries into design conditions, thoughts and opinions for an improvement of the system for consultants, general contractors and clients who designed, constructed and are operating CS. From those data, we collected and examined problems and opinions to improve the technology for the system. The paper is an interim report of investigations on issues of CS from the answers to our inquiries etc. and considerations and research for an improvement of the system technologies.

INTRODUCTION

To comply with the purpose of the RIWCS, for the first step, we sent inquiries to 16 closed system landfill sites to pick up themes to take into consideration at their planning and designing stages and to discover problems taking place in service. We also visited some of the systems to listen directly to users of the facilities and to collect technical data and information. Items included in the inquiries are as follows;

(1) Covering work (roofing materials)
(2) Liner facilities
(3) Water sprinkling on waste
(4) Deposit planning, environmental conditions of indoor, control of depositing
(5) Leachate treatment systems
(6) Enhancement of stabilization of waste deposits
(7) Method of proper finishing of dumping, closure and ultimate land use of landfill sites
(8) Other facilities and maintenance methods

We discovered problems and tasks that closed system landfill sites have, from the answers to our inquiries, and selected themes of investigation.

These are indoor environment control, a non-discharge system of leachate from CS and a water sprinkling system for the conditioning of indoor works and waste stabilization. This is how our research work started and the investigative work was carried out by members of RIWCS.

DISCOVERY OF PROBLEMS AND STATISTICS ON CS

Discovery of problems on CS

From the information provided by the answers to our inquiries, we found problems and tasks regarding CS technologies. Major items are described as follows;

Structure of CS:

(1) Possibility of corrosion caused by dew.
(2) Method of setting liners on the sharply inclined wall.

Indoor environment:

(1) Adjustment of inside temperature, humidity, condition of gases and dust etc.
(2) Water sprinkling method for dust control.
(3) Tendency of outdoor environmental condition to discharge contaminants in inside atmosphere by ventilation.
(4) Emergency measures and exit.

Water sprinkling and waste stabilization:

(1) Identification and clarification of stabilization process.
(2) Proper water sprinkling rate and method of waste stabilization.
(3) Selection of waste and method of dumping for the promotion of waste stabilization.
(4) Research on aerobic landfill system for enhancement of waste stabilization.
(5) Method for uniform and balanced water sprinkling.
(6) Short passing of sprinkled water in waste.
(7) Adjustment of water sprinkling condition in accordance with seasonal climate condition.
(8) Anti-icing measures for sprinkling system.
(9) Measures to prevent surface of waste from mudding to keep fair condition for work of tractors or power shovels.
(10) Sprinkling method at dumping.

Leachate treatment and non-discharge system:

(1) Design condition of leachate volume from site.
(2) Design condition of leachate quality.
(3) High salinity leachate treatment technology together with concentrate treatment from desalination process.
(4) Designing of down sized leachate treatment system.

Closure and ultimate land use of CS:

(1) Designing on final cover soil and a measure for leachate treatment.
(2) Plan of roof structure disposal.
(3) Way of ultimate land use of CS.

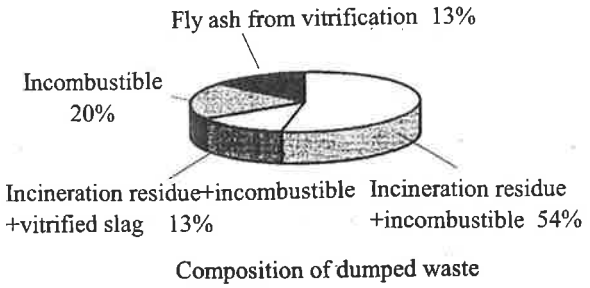
Statistics on CS

We analyzed the answers to our inquiries and got some statistical data on CS. Figures 1 and 2 show several samples of statistics on CS in Japan classified by various parameters.

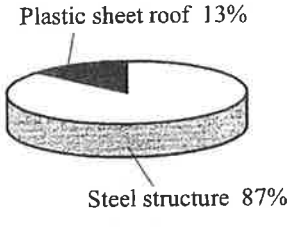
The figures show the composition of waste dumped in CS is mainly incinerated residue, incombustible, but there are CS of only incombustible or fly ash deposited from the vitrification process. The roof structure is mostly steel and some of the CS use plastic sheet. A major type of sprinkling is a sprinkler and spray valve system attached under the roof. Some CS do not install a water sprinkling system.

The types of leachate discharge are the discharge of leachate after treatment (47%) and the non-discharge of leachate at CS sites (53%). Some non-discharge CS take leachate to other facilities to treat it, others treat leachate by recycling it as sprinkling water for the CS. Types of the leachate treatment system are with and without a desalination system.

To enhance the stabilization of waste, most CS plans to apply water sprinkling. After the closure of CS, they intend to use the CS for a facility such as a gymnasium or warehouse etc. by leaving roofs (40%), to use the green field or forest by removing roofs (27%) and the rest are undecided how to use the place yet.



Composition of dumped waste



Structure of roof

Figure 1 Statistics on CS (1)

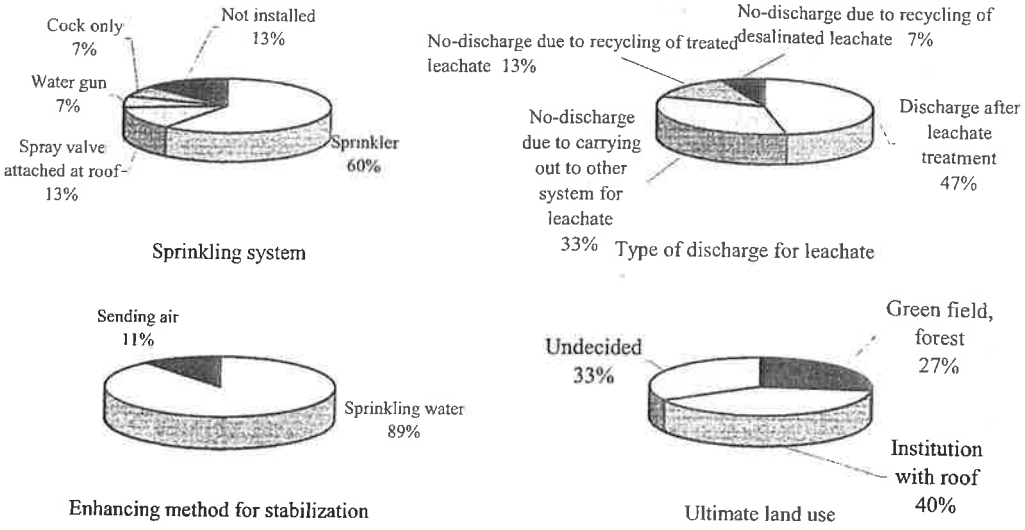


Figure 2 Statistics on CS(2)

INDOOR ENVIRONMENT OF CS

When we investigate on the indoor environmental condition of CS, we were requested to consider both manned and unmanned sites. The paper covers mainly manned sites.

Data from inquiries

Answers to inquiries show that the measures applied for indoor environmental control of existing CS are natural ventilation by opening of the buildings, mechanical ventilation by fans, to carry out dust and gases generated in indoor landfill sites, water sprinkling at dumping spots when waste is dumped, the controlled running route of working power shovels and devising better methods of dumping. Several CS control their indoor environment by installation of gas monitors for gases which can possibly be generated.

Establishment of indoor environmental standards

At first, prior to considering indoor environmental conditions, we collected and arranged standards on environmental conditions for manned working places to investigate proper working conditions of CS.

Work in CS should be done in accordance with "Guidelines for Controlling Safety and Health in Public Cleaning Services" stipulated in the notification of "Measures to Prevent Job-related Accidents in Public Cleaning Services (Labor Standards Bureau Notification No.123 of March 2,1993, by the Director of Labor Standards Bureau of the Ministry of Labor)" as is done in other refuse treatment facilities. A summary of the Notification related CS is shown below.

--Summary of Guidelines for Controlling Safety and Health in Public Cleaning Services---

○Selection of a promoter of safety and health (for having 10～50 workers)

○Adjusting protective equipment for dust etc.

○Installing sanitation facilities such as resting room, dining room and lavatory etc.

Table 1 Hazardous Substances in manned working environments

Hazards in manned working environments	
Environment for human body and surroundings	-Dust -Hazardous substances -Carbon dioxide gas -Concentration of oxygen and hydrogen sulfide -Flue gas -Temperature, humidity -Illumination -Malodorous substances
Flashing	-Combustible gases

Table 2 Items and criterion values for environmental control

Items	Criterion values	Note
Dust	E=2.9/(0.22Q+1) E:Concentration for control(mg/m^3) Q:Concentration of free silica	Industrial Safety and Health Law (Working Environment Evaluation Standards) (for dust 10μm or less)
	Dust inhalable:0.5mg/m^3 or less Total dust:2mg/m^3 or less	Japan Society for Occupational Health (for dust inhalable 7.07μm or less at concentration of free silica less than 20%)
Asbestos	2 pcs/cm^3 or less as fiber of 5μm or larger	Industrial Safety and Health Law (Working Environment Evaluation Standards)
Mercury and its compounds	0.05mg/m^3 as mercury	Industrial Safety and Health Law (Working Environment Evaluation Standards)
Hydrogen gas	1.2% or less	Industrial Safety and Health Law (Ordinance on Industrial Safety and Health)
Methane gas	1.5% or less	Industrial Safety and Health Law (Ordinance on Industrial Safety and Health)
Carbonic acid gas	1.5% or less	Industrial Safety and Health Law (Ordinance on Industrial Safety and Health)
Oxygen	18% or more	Industrial Safety and Health Law (Ordinance on Prevention of Anoxia, etc.)
Hydrogen sulfide	10ppm or less	Industrial Safety and Health Law (Ordinance on Prevention of Anoxia, etc.)
Carbon monoxide	50ppm or less	Japan Society for Occupational Health
Nitrogen dioxide	3ppm or less	ACGIH Notification by US government
Temperature	37℃ or less	Industrial Safety and Health Law (Ordinance on Industrial Safety and Health)
Illumination	70 lux or more	Industrial Safety and Health Law (Ordinance on Industrial Safety and Health)

○Carrying out medical examinations.
○Implementing safety and health education.
○Assigning qualified persons for crane work and oxygen deficiency prevention.
○Periodic checking of apparatuses for work
○Warning of dangers such as generation of dust and gases, oxygen deficiency.

Table 1,2 shows items to be cautious about in manned working environments and criterion values for environmental control.

Consideration of environmental standards for unmanned working places

In the unmanned working place, cranes and other equipment are necessary. So in this kind of place working efficiency is important. Other items to take into consideration are the influence on the surrounding environment by generated gas and the effects of dust or humidity on equipment used in the indoors of CS.

In case it is expected to enter a house where waste is deposited for an operator, the same control as manned conditions is requested.

Table 3 shows items to be cautious about in unmanned working environments.

Frequency of monitoring

Regarding measurement and monitoring of working places, Article 21 of the Enforcement Order of the Industrial Safety and Health Law is applied.

Table 4 depicts workshops having to carry out measurements of the working environment. However, in the Industrial Safety and Health Law, there is no article that states the necessity of continuous monitoring, so it is recommended to establish items for continuous monitoring for the safe operation and health of operators of the facilities.

Consideration of standards for the indoor working environment

Table 3 Hazardous substancea in unmanned working environments

Hazards in unmanned working environments	
Environment for human body and surroundings	-Dust -Flue gas -Temperature, humidity -Illumination -Malodorous substances
Flashing	-Combustible gases

Table 4 Workshops carrying out measurements of the working environment

No.	Classification of working place	Item of monitoring	Frequency of monitoring
1	Indoor workshops significantly emitting dust of earth and stones, rocks, ores(minerals), metalic materials or	Concentration of dust in atmosphere, concentration of free silica	Daily before starting work.
2	Indoor workshops having hot, cool or humid working conditions.	Temperature, humidity, radiant heat	Twice a month
3	Indoor workshops suffering from market noise.	Equivalent noise level	Once every 6 months
4	Workshops in pits. (1)Place of retentive carbon dioxide (2)Place of 28℃ or more in temperature (3)Pit with ventilator.	 Air flow volume Temperature Air flow volume	 Once a month Twice a month Twice a month
5	Indoor workshops to manufacture or handle the specified chemical substances, etc., listed in item 1 or 2.	Concentration of chemical substances, etc., listed in item 1 or 2.	Once every 6 months
6	Indoor workshops wherein carry out lead work.	Concentration of lead in atmosphere	Once a year
7	Workshops in which work is carried out in places involving danger of oxygen deficiency.	Concentration of oxygen in atmosphere (plus hydrogen sulfite if its danger is	Daily before starting work.
8	Indoor workshops wherein to carry out operations to manufacture or handle organic solvents.	Concentration of organic solvents in atmosphere	Once every 6 months

Note : Cited and extracted from Article 21 of Enforcement Order of the Industrial Safety and Health Law

Concentration levels for the control of hazardous substances are established by "Working Environment Evaluation Standards" in the Industrial Safety and Health Law. The items for CS from the Law are considered to be mercury and its compounds and dioxins. As for dioxins, it is noted in the Law that, when considering the relationship of concentrations of total dust and dioxins, the control level of dioxins by the concentration of total dust is acceptable. It is recommended to take notice of the explosion limits of typical combustible gases related to CS such as methane, hydrogen gas, ammonium gas, methyl mercaptan and methyl sulfide etc. other than the gases listed in Table 1, considering conditions of waste composition to dump, methods of depositing and the ways of sprinkling for CS.

NON-DISCHARGE SYSTEM OF LEACHATE FROM CS

Stabilization of waste in landfill proceeds by biological and physicochemical functions. In these functions a proper level of moisture or water is desirable. In almost all cases where water is supplied, a sprinkling system is installed for CS. The capacity and quality of leachate has been designed referring to data of open type landfills so far, so we tried to collect data of leachate from existing CS in service. On the other hand, CS which do not discharge leachate are sometimes desired by inhabitants living near the place where the installation of a CS is planned. Taking advantage of CS that can control leachate volume by controlling the water flow rate of sprinkling, it may be possible to design a CS, which does not discharge leachate by recycling leachate after water treatment to reuse for sprinkling.

Table 5 shows analytical values of leachate of several CS. CS A in which only incombustible is deposited, shows that BOD, COD and T-N are 17, 167 and 22.4mg/L respectively. As for inorganic salts, EC, TS, Cl^- and Ca are 511mS/m, 3,340, 1,230 and 20.2mg/L. As for CS B to D, where the deposits are incinerated residue, analytical values relating to organic matter of BOD, COD and T-N are 2.7-57, 11-156 and 6.4-23.1mg/L. The maximum values between CS A and others seem not to vary so much. But regarding inorganic salts of CS B to D, the analytical values of EC, TS, Cl^- and Ca are 1,880-5,260mS/m, 12,300-56,000, 6,350-22,000 and

Table 5 Analytical results of leachate from CS

Items		Units	CS					
			A	B(1)	C(1)	C(2)	D	B(2)
Composition of waste	Incinerated residue	%	0	(bottom ash)60	70	70	75	(fly ash)100
	Incombustible	%	100	40	30	30	25	0
pH		–	8.6	9.4	6.5	6.4	7.6	7.4
BOD		mg/L	17	8.1	12	2.7	26.5	57
COD_{Mn}		mg/L	167	156	18	11	52.2	71
SS		mg/L	13	36	6	6	4	46
T-N(total nitrogen)		mg/L	22.4	19.6	8.1	15	23.1	6.4
EC (electric conductivity)		mS/m	511	1,880	–	5,260	2,950	2,730
TS (total solid)		mg/L	3,340	12,300	25,000	56,000	–	17,900
Cl^-		mg/L	1,230	6,350	11,000	22,000	17,900	11,300
Ca		mg/L	20.2	7.5	1,800	4,400	–	1,800
Temperature		℃	20	20	25	17.5	–	20

Note : B(1) is 1st section CS B (bottom ash + incombustible), B(2) is 2nd section of CS B(fly ash).
C(1) is a sample taken in Sept. 2003 and C(2) is taken in Nov. 2003.

7.5-4,400mg/L. Except for Ca of CS B(1), these analytical values of inorganic salts are very high compared to those of CS A. These phenomena can be attributed to the leaching out of salts from incinerated residue.

Figure 3 shows analytical data of leachate for CS A. CS A has a leachate treatment system composed of biological treatment followed by a settling tank, a sand filter and an activated carbon column. Treated water is recycled to use for sprinkling on deposited waste. The figure depicts that BOD in leachate is removed thoroughly by treatment, but the COD removal rate is not so high. EC and COD seem to very slightly increase for the term from August '99 to July '03. This means that CS deposits incombustible (without incinerated residue), can recycle leachate by water treatment without the desalination process or at least can lower the load of the desalination system.

Figure 4 shows analytical data of leachate for CS D. The figure shows that organic matter expressed as BOD or COD in leachate is not much different from that of CS A, but the inorganic salts level is very high due to the damping of incinerated residue. Leachate from CS D is treated by a water treatment system with biological treatment, a settling tank, a sand filter, an activated carbon column and a chelating resin column, and treated water is discarded in a river. These data suggest that if we want to plan a non-discharge type CS, recycling treated leachate for sprinkling, a desalination system should be installed

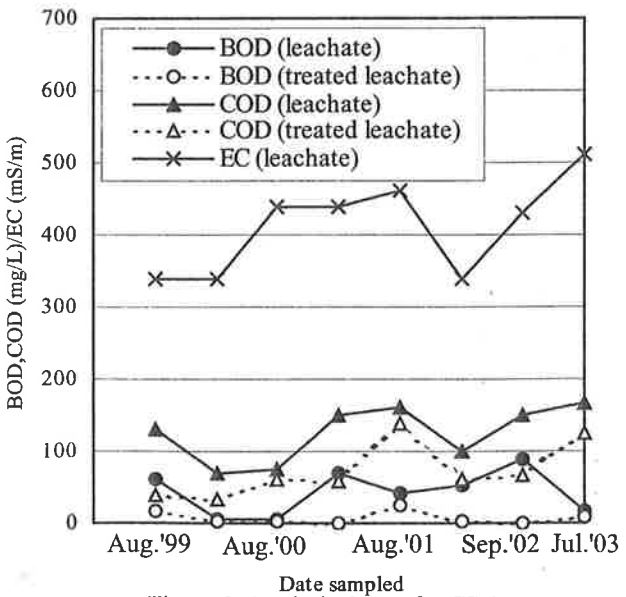


Figure 3 Analytical data for CS A

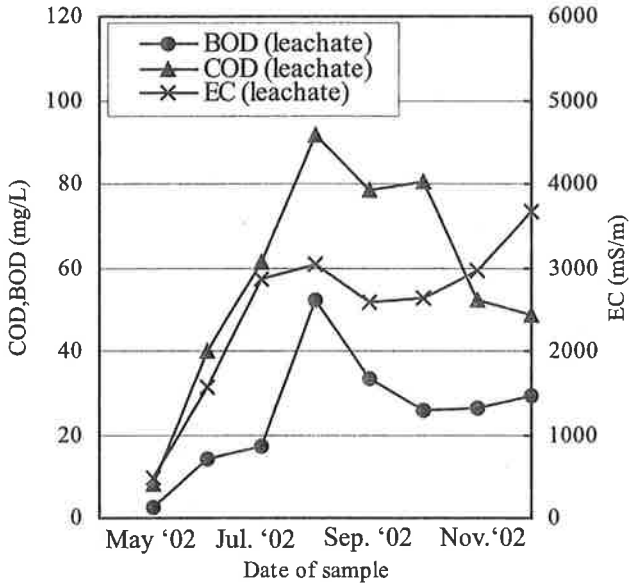


Figure 4 Analytical data for CS D

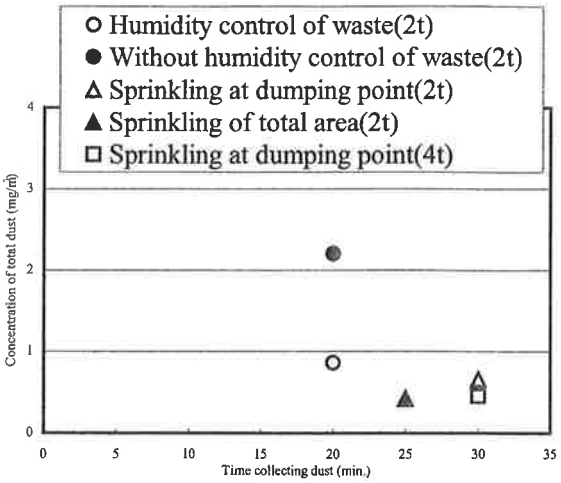


Figure 5 Restraining effect on dust generation by sprinkling at dumping place (measured at dumping point)

to prevent an increase of inorganic salts in sprinkling water, which will obstruct stabilization of waste hindering biological activities.

SPRINKLING SYSTEM

CS install a sprinkling system for restraining dust generation at dumping, for enhancing the stabilization of waste and to control malodors. We hereby describe our investigation to control dust generation and malodors by sprinkling. We obtained our information from inquiries and by reviewing data reported on CS so far.

Installation of sprinkling system

From the data of our inquiries, many sprinkler systems are used for CS aiming to spread water uniformly on deposited waste. But actually, if the water volume or method of sprinkling is not arranged properly, the expected washing effect is not achieved due to the low permeability of waste, power shovels can not work well due to the mudding of waste attributed to excess water sprinkling, the formation of dew in house takes place and in some districts, icing of the sprinkling system or on deposited waste occurs.

For sprinkling water, ground water, well water, river water and treated leachate were mainly used. Also, rain water and in some cases where incinerated residue and fly ash are deposited, leachate treated by the desalination system is used.

Methods to control sprinkling systems by auto-manual change over type or applied timer type are commonly adopted. The frequency of sprinkling is not clear from our inquiries; considering that it would be done before or after dumping, sprinkling could be made once to several times a day.

As a sprinkling system should be installed at places where it will not hinder dumping, most CS install sprinkling systems at roofs or on top of side walls. In some cases, mobile type sprinklers are used to spray water from above.

Effect of sprinkling on indoor environment control

Effect of dust control: In a CS, they are trying tests to sprinkle or add humidity to smashed waste when dumping at a dumping place to confirm the effects of restraining dust by supplying water. Figure 5 and 6 show the effects of restraining dust generation by sprinkling just after dumping at the dumping place and above the surface of the waste. The highest effect was gained by using sprinklers and the experiment suggests the effective methods for restraining dust are sprinkling at the place of dumping and sprinkling indoor areas before dumping as well (Hanashima et al., 2002).

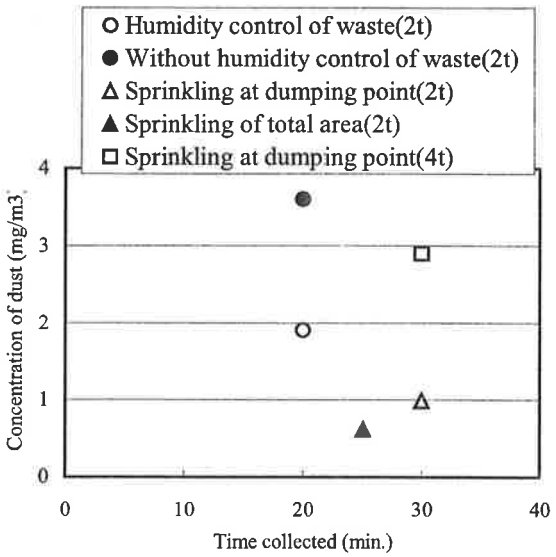


Figure 6 Restraining effect of dust generation by sprinkling at dumping place (measured just above surface of waste)

Table 6 Amount of dust collected by Andersen's sampler and amount of dust smaller than 1.1μm

Condition of experiment	Amount of dust collected (mg/m^3)	Amount of dust collected smaller than 1.1μm (mg/m^3)
Humidity control of waste	1	0.39
Without humidity control of waste	0.95	0.17
Sprinkling at dumping point	0.4	0.18
Normal work	0.3	0.17

Table 6 depicts a result of the dust measuring test using Andersen's sampler at the same CS (Hanashima et al.,2002). The amount of collected dust was reduced by sprinkling at dumping. However, the ratio of the amount of dust 1.1 μ m or less which could reach the lungs was higher when sprinkling than without humidity control. And the amount of dust collected under 1.1 μ m from the calculation by the distribution curve collected had a larger value when sprinkling or controlling for humidity than without humidity control. This result seems to mean that dust of larger size cannot follow streams of drops of water or mist, a difference of velocity takes place and the dust is caught to filter for collection. But dust of smaller size continues to spread without being caught by the filter. In order to catch smaller size dust it would be effective to change the nozzle of the sprinkler to a nozzle that can make mist with smaller size particles. Furthermore, when working on waste in CS, it could be recommended to put on masks as well as to sprinkle prior to work, taking into consideration the generation of dust caused by working.

Restraining effect of malodor by sprinkling: Most malodors from landfills are caused by anaerobic digestion of organics sticking to residual organics in incinerated residue and smashed incombustible waste. A proper sprinkling enhances the digestion of organics but the sprinkling of too much water causes an anaerobic condition that hinders the reduction of malodors from deposited waste.

CONCLUSIONS

(1) Our investigative work sending inquiries and visiting CS in service gave us much important information and provided suggestions to improve the technology of CS.

(2) Investigative work on indoor environment showed many CS equip natural and/or mechanical ventilation systems. Indoor environmental condition should comply with relating laws and ordinances. In order to improve indoor environment, to install a proper environment control equipment such as sprinkling system, to design effective house, to equip gas monitors and to consider dumping method are necessary.

(3) Leachate treatment system are installed in almost CS, and in case to design a non-discharge type CS, technology of recycling including desalination for leachate should be developed and promoted.

(4) Almost CS install sprinkling system and further investigative work how to sprinkle in proper condition and way is requested.

(5) We made an interim report of our works hereby and hopefully, it will contain some solutions or suggestions for all.

ACKNOLEDGEMENTS

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