BASIC STUDY ON METHODOLOGY OF SELECTION OF A SITE SUITABLE FOR LANDFILL TAKING ENVIRONMENTAL RISKS INTO CONSIDERATION

K. Nakaishi[1], F. Igari[2], K. Hayashi[3], Y. Hamada[4], S. Yokota[5], T. Furuichi[6], and M.Hanashima[6]

1 Environmental Excellent Engineering Co., Ltd.

2-17-22 Takada, Toshima-Ku, Tokyo 171-0033, Japan

2 Oyo Corporation

2-61-5 Kita-ku, Toro-cho, Saitama-shi, Saitama 331-8688, Japan

3 Maeda Corporation

J.CITY14F, 5-8 Takamatsu, Nerima-ku, Tokyo 179-8903, Japan

4 TOWA Technology Corp.

10-2, Nihonbashihakozakicyo, Cyuoh-ku, Tokyo 103-0015, Japan

5 JDC Corporation

4036-1,Nakatsu,Aikawa-machi,Aikoh-gun,Kanagawa-pref,243-0303,Japan

6 The landfill systems & technologies research association of Japan (LSA, NPO)

401 Chateau Takanawa, 3-23-14 Takanawa, Minato-ku, Tokyo 108-0074, Japan

ABSTRACT

This study examined the methodology of selection of a site suitable for landfill taking environmental risks into consideration as a method for construction of landfills that can be accepted by the local residents, aiming to realize suitable and smooth construction of landfills. Then, we presented the methodology of selection and assessment of a suitable site for landfill, which is the result of this study, through a questionnaire for surveying consciousness of residents for landfills to investigate the level of the residents interest on this matter. As for the environmental risks which includes various risks with regard to landfills, we selected the risk of leak of leachate from landfills (hereafter called "the environmental risk") as a subject of the study. As an index of the environmental risk, we proposed the use of "leak outflow time (time t_0)" that expresses the leak retaining capability of a specific ground (site), and reviewed a system that performs the management of the environmental risk (minimization of the risk) of any candidate site by using the index. This study demonstrated by using the simulation that the abovementioned system is effective to some extent, and from the result of the questionnaire sent out to the residents, that the system can be a means effective for building consensus of the local residents.

Keywords: Environmental Risk, Risk Management, Selection (Evaluation) of a Site Suitable for Landfill

INTRODUCTION

Making a selection of a landfill site is a big challenge because, in many cases, the neighboring residents oppose the plan due to the deep-seated distrust of the leakage of polluted liquid from the site. To deal with this difficult problem, we considered to examine an introduction of the idea of the environmental risk management in the phase of selection of a site suitable for landfill to provide answers to their question "Why this site is selected for landfill?" by improving their understanding of the safety of the landfill and selecting a site that can minimize the environmental risk efficiently. Based on the above matter, this study examined the methodology of selection of a suitable site for landfills that considers to minimize the environmental risks of the landfills so that the project is accepted by the residents, aiming to realize fair and smooth construction of landfills. We also sent out questionnaires to the residents, in which we described the methodology of selection of a suitable landfill site that is the achievement of this study, to investigate their level of interest on this matter, and the results are presented here.

DETAILS OF STUDY

This study was made on the risk of leak of leachate from landfills, which is one of the environmental risks that are included in various risks involved in the landfills. This subject was selected for our study because the risk is assumed to cause the biggest anxiety related to the safety of the landfills in all the environmental risks of landfills (hereafter, the risk of leak of leachate from landfills is referred to as "the environmental risk". The environmental risk covers the probability of leak of leachate from a landfill and the magnitude of effects (damages) produced by the leak of leachate. This study especially placed emphasis on minimizing the effects (damages) (bringing the damages to zero as near as possible) in case of accidental leak of leachate.

Methodologies of environmental risk management in selecting suitable landfill site (methodology for minimizing environmental risk, and methodology for selecting suitable landfill site)

As for minimizing the environmental risk of a proposed landfill site, we proposed the use of "leak outflow time (time t_0)" as shown below as an index for estimating the leak retaining capability of a specific ground (site), and thus, examined to perform the risk management by using this index.

"Leak outflow time (time t_0)"＝Period of time from the geomembrane is damaged to the moment the hazardous substance contained in the leak of leachate reaches the environmental limit at the border line of the landfill (Refer to Figure 1.) …… (1)

Based on the above index, a landfill is estimated to have low "environmental risk" as the leak outflow time from the damage of geomembrane to the border of the site is longer, meaning that the leak can be retained, or it is estimated to have high "environmental risk" if the time is shorter, meaning that the leak cannot be retained. Therefore, the environmental risk is given conceptually by the following formula.

Environmental Risks＝$1/t_0$ …… (2)

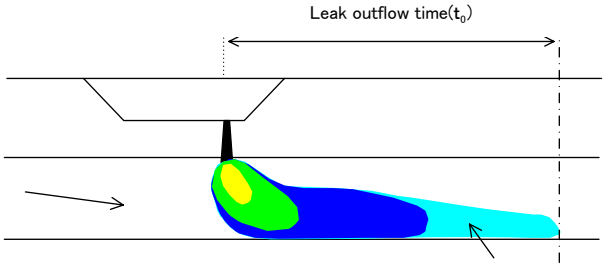
By setting the definition of the step-by-step minimization standard of the time t_0 (time T_0c) as "a time needed to take measures for prevention of diffusion of a leak of leachate to peripheral area in case of leak", it is possible to conduct the management

of leak as a preventive measure by using the step-by-step standard as a bench mark. As a result, a landfill system that is capable of achieving an ultimate standard value ($t_0=\infty$) is planned out. This means that selection of a site suitable for a landfill is made by implementing measure for prevention of an accidental leak (environmental risk nearly equal to zero) assuming that it can ensure prevention of effects (damages) on the peripheral environment with infinite time t_0.

Figures 2 to 5 show concrete risk management process with detailed description of t_0 and T_0c .

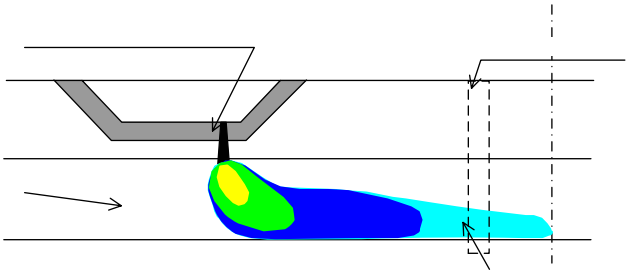
For a candidate landfill site, t_0 that is defined as a time the concentration of pollutant measured at the border line of the site reaches the environmental standard of the locality is T_0 in the state before a particular preventive measure is taken in that site (Step 0 in Figure 1). T_0c is the minimum standard time of T_0, and it changes as T_0c1, T_0c2, and T_0c3 as the step advances.

The meanings of T_0c and T_0 in individual steps are as described in the Figures1 to 4 respectively.



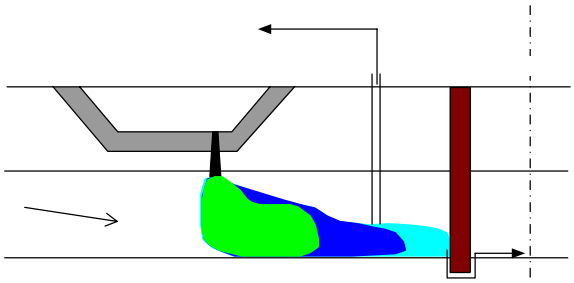
Time T_0;Time the concentration of hazardous substances contained in the groundwater and soil from leak of leachate reaches the environmental standard at the border line of a site when no particular preventive work is done (T_0).

Figure 1　Meaning of time T_0 in step 0



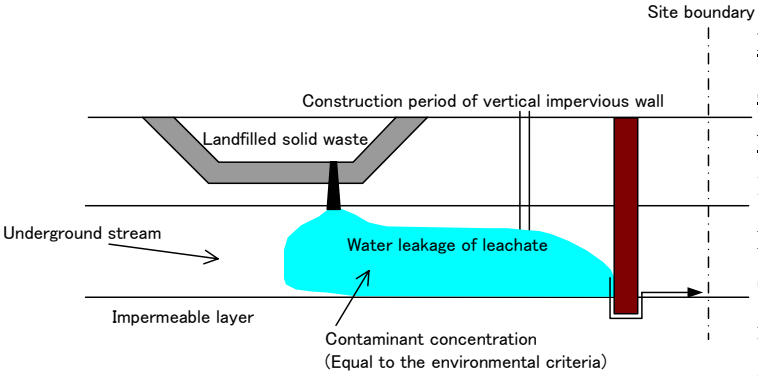
T_0c1 is a time needed for preparation of a full-scale work in step 2 in case of accidental leak of leachate. Therefore, if it is decided that the time of step 0 is $T_0<T_0c1$, an improvement of the system assuming that a corrective work for making $T_0 \geqq T_0c1$ (constructing a third seepage control system) is to be made to secure the period needed for the work to prevent the effect of the leak from reaching outside of the border.

Figure 2　Meaning of time T_0 in step 1



T_0c2 is a time needed for repairing the seepage control system on the surface and then cleaning up the ground water contained in the side after containing the leachate in the site. Therefore, it is necessary to allocate the cost of accidental leak prevention work (vertical seepage control system) for achieving $T_0 \geqq T_0c2$ to make the leachate containing time longer than the period for repairing the damage and cleaning up the liquid.

Figure 3　Meaning of time T_0 in step 2



T_0c3 is the time the concentration of hazardous substance at the border needs to exceed the environmental standard after the action of step 2 is taken. Therefore, the time is infinite ($T_0=T_0c3=\infty$), meaning that the system is designed so that the concentration of hazardous substance at the border will not exceed the environmental standard.

Figure 4　Meaning of time T_0 in step 3

Discussion about method of calculation of time t_0 and verification of the validity (analysis of ground water pollution in landfills)

Examination of the method of calculation of the time parameter (t_0) that is proposed in the formula (1) and (2) as a methodology for environmental risk management and verification of the validity of this idea were implemented based on the existing methodology for simulation of soil and ground water pollution, "GETFLOWS".

Figure 5 and Table 1 show the schematic drawing of the simulated landfill model and set conditions respectively.

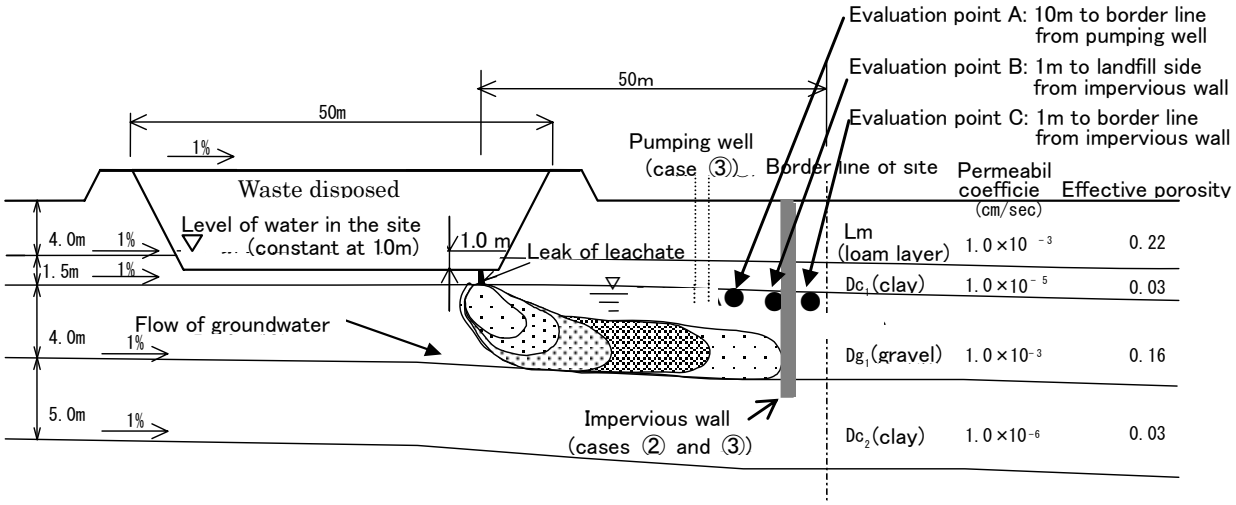


Figure 5　Setting of simulated landfill model

Table 1　Simulation conditions

Item	Simulation conditions
Size of leaking damage	10cm×20cm
Assumed pollutants and their concentration	Chlorine ion, concentration at pollutant source; 10,000mg/L, background concentration; 10mg/L
Permeability coefficient, horizontal to vertical ratio	$K_h/K_v=2.0$

Moreover, to verify the environmental risk minimization effect (effect of extension of time t_0) of the leachate leak prevention work, the simulation was made for the following two cases. An impervious wall is installed when the concentration of the chlorine ion at the border 50m downstream of the leaking point reaches 200ppm that is the standard value for drinking water.

a) No preventive work (Evaluation T_0 with respect to T_{c1})

b) Preventive work by using impervious wall and repairing leak (Evaluation T_0 with respect to T_{c2})

c) Preventive work by using impervious wall, pumping water and repairing leak (Evaluation T_0 with respect to T_{c3})

As a result of the simulation of the elapsed time from occurrence of leak of leachate to the moment the concentration of pollution reaches 200ppm, the measurements shown in Figures 6 and 7 were obtained.

Concentration of pollution (ppm)

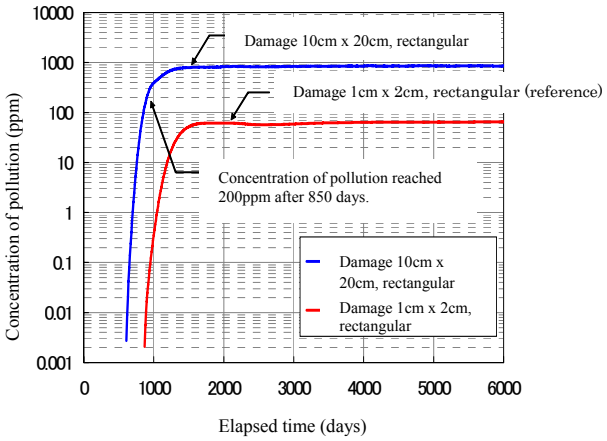


Figure 6 Change of Chlorine ion concentration at the border of the site
(Top of gravel layer, case with no protective work)

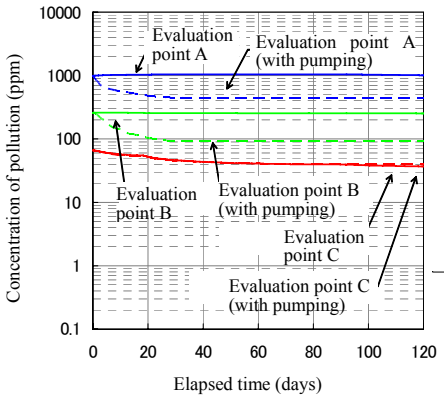


Figure7 Change of Chlorine ion concentration in and out of impervious wall
(Evaluation points A to C, cases of b) and c) with protective work)

The following knowledge was obtained based on the above results.

a) As shown in Figure 6, it was at about 850th day ($T_0 \fallingdotseq 850$ days) from the day the leak began when the chlorine ion concentration exceeded 200ppm at the border of the site that is 50m from the damaged point. This number of days is long enough for completing the construction of the impervious wall after a leak of leachate actually occurred (the construction period T_{0c} = approx. 300 days). Thus, it is confirmed that the primary action of the environmental risk management with the construction of the impervious wall under the ground layer conditions that were set for this site is effective.

b) As shown in Figure 7, the concentration reduced up to 50% of the maximum after approximately 2 weeks from the beginning of the pumping at the upstream side. When the cleaning of underground water within the site is performed, it can be realized by continuing the pumping. With this preventive action, the parameter time T_0 becomes infinitive, meaning that the action is effective for minimizing the environmental risk.

Results of the questionnaire

We had a questionnaire to the residents around a landfill through internet for the purpose of investigating what is the perception they have in terms of the landfill and what is their understanding of the facility. The outline of the questionnaire is described in the Figure 8 and Table 2.

3-2 Level of interest on methodology of environmental risk management in selecting site suitable for landfill

As one of the questions of the abovementioned questionnaire, we presented "methodologies of environmental risk management in selecting site suitable for landfill" that are shown in Figures 1 to 4 to investigate the level of interest of the residents on this matter.

Figures 9 and 10 show the results. These graphs show that approximately 90% of the residents who responded to the questionnaire made a response with the answer "I would like to hear detailed explanations about the matter", and approximately 75% of them made a response that they wish to hear especially about "how the operator take actions in case of leak of leachate". This result shows that "the methodologies of environmental risk management in selecting site suitable for landfill" that are described in this paper can be one of the systems that are effective for obtaining agreement on the landfill project from the local residents.

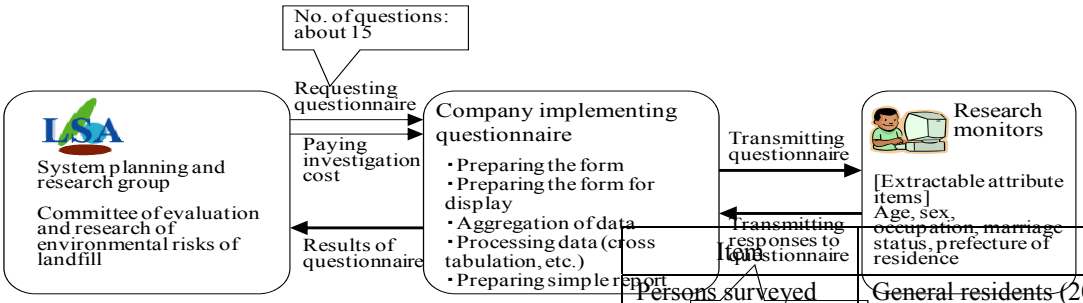


Figure 8 Outline of the questionnaire

Table 2 Outline of implementation of internet questionnaire

Item	Description
Persons surveyed	General residents (20 years old and older)
No. of valid responses	1,183 (This is the number of samples that is required for obtaining information reliable to some extent from population across the country who are 20 years old and older)
Sampling method	Random sampling from research monitors who are registered in the internet portal site
Term of implementation	from February 15 to 17, 2006 (three days)
Method of investigation	Web questionnaire through internet
District covered	Across the country (research monitors)
Principal questions	①Necessity of landfills, ②Anxieties over landfill ③Time of participation in the landfill project, ④ Environmental actions to be stressed ⑤Information about landfill that are required, ⑥Image of landfill that the resident wishes to have.

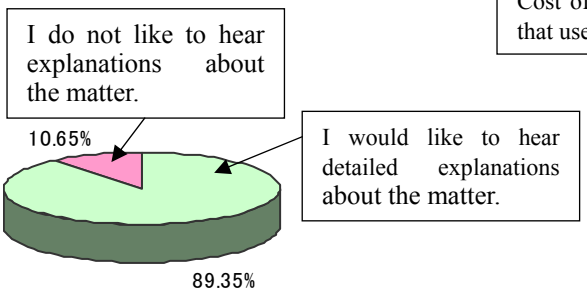


Figure 9 Level of interest on the methodologies of environmental risk management

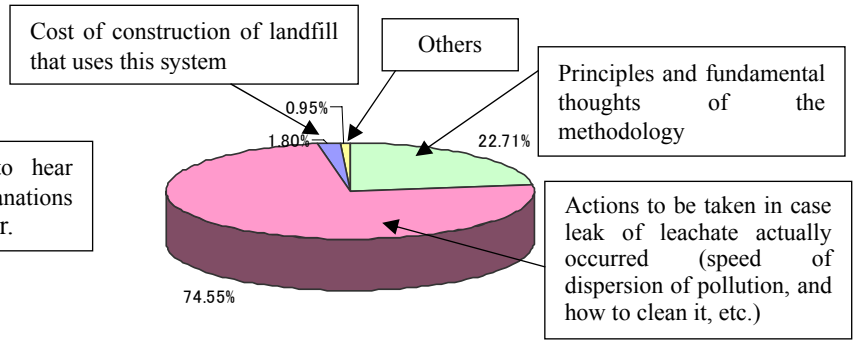


Figure 10 Matters the residents wish to hear the details when a risk management methodology is adopte

CONCLUSIONS

The effectivenesses of the parameter time t_0 that is proposed as a methodology of environmental risk management are expected as follows.

Parameter time t_0 can be obtained through calculation.

a) The results of the calculation are valid unless it is performed without deviating generally accepted theories.

b) From the effectivenesses described in a) and b), it can be said that the parameter can be used for management of risks caused by the leak of leachate.

c) From the results of the questionnaire to the residents, the methodologies of the environmental risk management that are proposed in this paper can be an effective means for obtaining agreement on the construction of landfills from the local residents.

On the other hand, since the above conclusions depend only on the analytical model, it is necessary to demonstrate and repeatability of the matter. Therefore, as a future issues, it is necessary to improve the appropriateness of the setting conditions and accuracy of the results while carrying out technical validations of the matter.

ACKNOWLEDGMENT

This study is an achievement of the study on the methodology of selection of site suitable for landfill taking environmental risks into consideration conducted by the System planning and research group in its “voluntary research project” that is a part of activities of the NPO “Landfill Systems & Technologies Research Association of Japan (LSA)”.