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CONTENTS

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THE CONTROL OF THE USE PATTERN AND THE LIFE OF METALS FOR ENVIRONMENTAL RISK MANAGEMENT; THE CASE OF LEAD

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I Introduction

This paper is to propose a new paradigm of socio-academic study for achieving a balance between the utility of metals and the hazards of their waste. One of the major dilemmas of our time is how to make decisions about dealing with the unknowable and yet conceivable environmental risks. Uncertainty about risks of pollution and uncertainty about costs of reducing pollution allow enormous scope for distortion in representing what can or should be done. Risk assessment based on currently available information can lead to over-confidence about knowledge of ways in which accidents can occur. Most of the data on the risks of metal waste are not connected with those on the benefits of metal products. It may well be that people, in assessing the risks, are also analyzing the social worth of the technology using metals, the credibility of the science behind that technology, and the promoting and governing institutions that foster and create it. An assessment, therefore, must be made of the total metal cycle and not just an isolated part of it. Environmental risks are involved at all stages-mining, the manufacture of metal and also metal waste management processes.

It is very difficult to estimate the risk of metal wastes when they have gradually accumulated in the environment, because it is not yet resolved in the field of dose-response relationship study what effect is caused by the long-term accumulation of heavy metals in the environment. Taking into account the interactions among many substances in the environment, it is not easy to make clear the cause-effect relationship between heavy metals and the ecological system. It must be, therefore, more important for reducing risks to make clear the decision-making and the using process of metals than to adhere to the development of new cause-effect relationship models. The main factors that influence the frequency and the magnitude of risk caused by heavy metals are:

1) The time between the utilization of heavy metals by human society and the disposal or discarding of those materials,
2) The use pattern of heavy metals,

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3) The spatial distribution of heavy metal products and their waste, and
4) The organization of and the institutions concerning the metal recycling system.

In spite of the fact that it is presupposed that the recycling of heavy metal waste reduces the metal pollution and environmental risks, the organization of an adequate recycling system cannot be achieved simply by increasing the price of primary metals and the cost of pollution control without a social assessment of metal use. A recycling plan should not only accelerate the improvement of recycling technology but also establish an evaluation and policy-making system for using and disusing metals. An attempt has been made to establish the planning theory of a totalized social-environmental metal recycling system in the following study will be referred to as a "socio-metallic study" conducted under the following headings (Sueishi and Ueta, 1981).

1) A study of the socio-economic assessment of metal use.
2) A study of the social cost of discarded metals.
3) A study on the optimal design of a metal recycling system.

In order to develop such a theory, using lead as an indicative metal, the effects of structural changes in the use pattern and the life of lead upon environmental risks were analyzed as a part of the above study and are presented in the following sections.

II The Structural Change of the Use Pattern of Lead and Its Effect upon the Problem of Waste

The average consumption growth rate of non-ferrous metals during the 10 years from 1963 to 1973 in Japan was as follows: lead, 6.8%; zinc, 9.8%; copper, 12.8%; and aluminum, 20.8%. Consider the historical change in the value of the substantial GNP (the price of 1970 fiscal year) and the amount of the domestic demand for copper, lead and zinc given in Figure 1. Supposing that the values of these indices in 1955 are normalized to 100, the values of the amounts of domestic demands of copper, lead and zinc are 1078, 558, and 748 respectively in 1973 when the first oil shock occurred. These figures are higher than those for the United States, West Germany and other industrialized countries and also the growth rate is higher than that of the GNP in Japan during the same period. The industrial structure of Japan during this period of high economic growth became increasingly resource-consumption oriented. The increased amounts of used metals have, in turn, led to various types of social cost concerning the environment.

The demand structure for lead has been drastically changed together with the rapid increase of the amount of lead consumption through the process of high economic growth.

The main uses of lead, the lead content of products and the estimated life of these products, are shown in Table 1. Figure 2 illustrates the annual change in lead supply for the main use categories and the Recovery Effort Index (REI) (Pearce, 1976), where,

$$REI_a = \frac{SC + RSC + X_s - M_s}{PC + SC + RSC} \qquad (1)$$

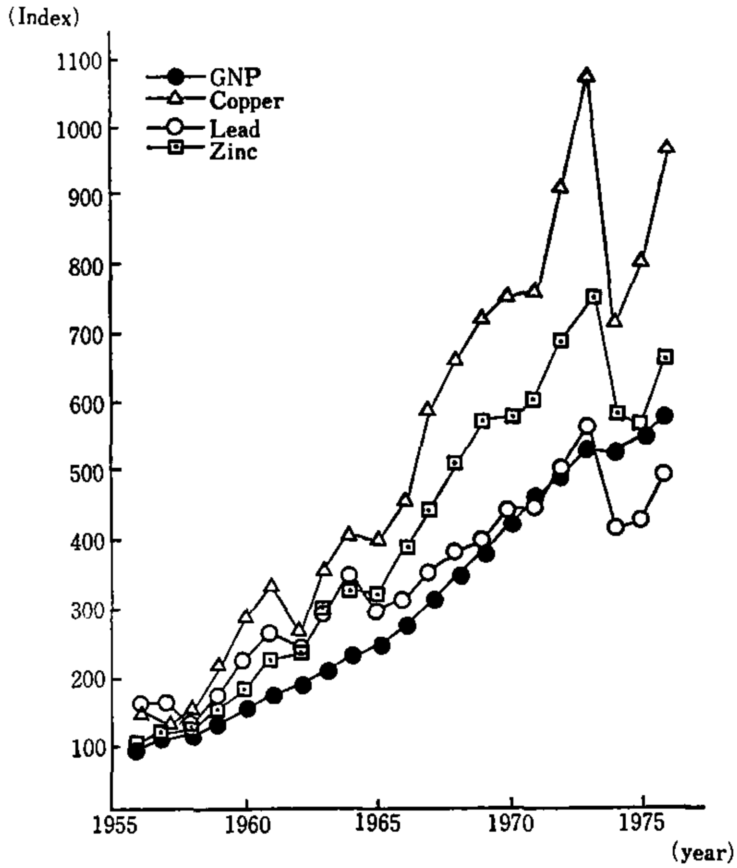

Figure 1. The Annual Change of Substantial GNP and Domestic Demand for Copper, Lead, and Zinc.

Table 1. Main Uses and Average Life of Lead in Japan

Category		Lead Content (%)	Main Uses	Estimated Life (years)
I Batteries		70	Automobile, Traction, Fixed	2~3
II Inorganic Chemicals	Litharge	93	Stabilizer for Vinyl Chloride, Drier	1~6
	Chrome Yellow	90	Yellow Pigment	1~6
	Red Lead	90	Enamel, Dye for Rubber	1~6
III Lead Pipes and Sheets		90~	Water Pipe, for Chemical Industry	5~35
IV Antifriction Metals and Solders		40~80	Cans, for Machinery Industry	3~10
V Type Metals		60~80	Sheet for Printing	2
VI Cables		90~	Cable Sheathing	5~20

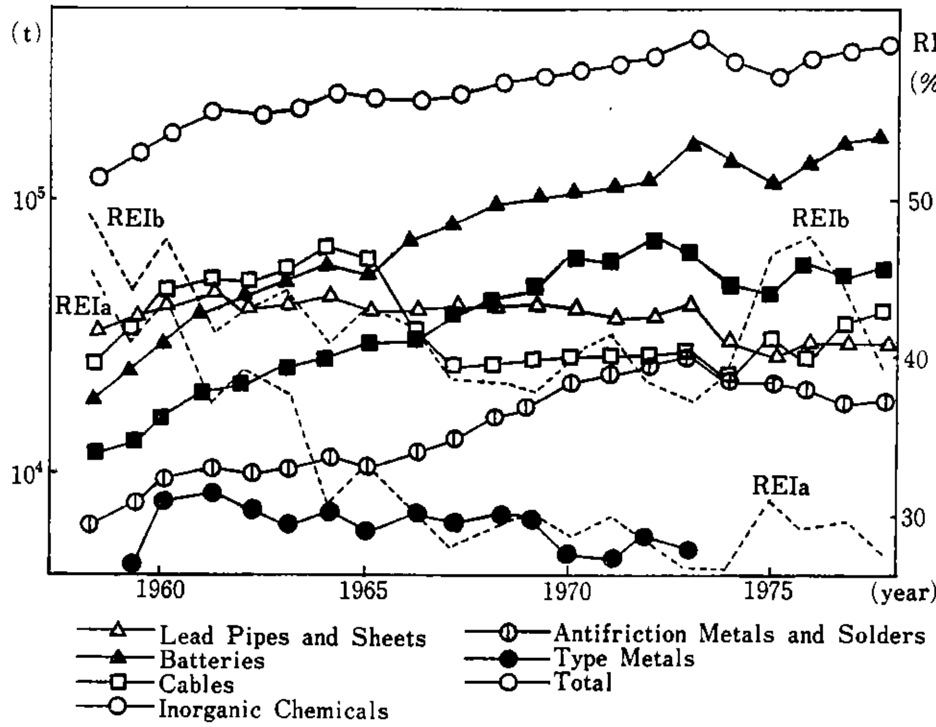

Figure 2. The Annual Change of Lead Supply for the Main Use Categories and Recovery Effort Indices.

$$REI_b = \frac{SC + RSC + SI + X_s - M_s}{PC + SC + RSC} \tag{2}$$

where,

PC = primary lead consumption,
SC = secondary lead consumption,
RSC = remelted secondary lead consumption,
X_s = exports of scrap,
M_s = imports of scrap, and
SI = scrap input to primary lead refining.

REI_a does not include the Recovery Effort Index with lead scrap input for primary lead refining, while REI_b does. By comparison of REI_a and REI_b, the annual variation shows not only the recovery ratio of scrap but also the distribution of scrap utilization between primary and secondary refining. The total amount of the demand for lead has been increasing except in 1973 when Japan experienced the first oil shock and consequently the demand for lead was less than during the previous year. The increase in the total demand for lead was caused by the increase in the demand for lead for batteries and inorganic chemicals. As can be seen in Figure 2, during the latter half of the 1950's, the demand for lead increased mainly for use in cables and batteries, inorganic chemicals, and lead pipes and sheets. In the 1960's, there was no increase in the amount of lead consumed for lead pipes and sheets because PVC began to replace lead in water pipes. Therefore, the main uses of lead were for batteries and cables. During the latter half of the 1960's, the amount of lead consumed for cables was reduced by almost 50% because lead cable sheathing was rapidly substituted with aluminum. On the other hand, the amount of lead consumed for batteries increased with the growth of the automobile industry, and the amount of lead consumed in inorganic chemicals, whose use reflects the increasing sophistication of human life, also rose. Therefore, the amount of lead consumed for both batteries and inorganic chemicals has accounted for 60 to 70% of the total demand for lead. One characteristic of the demand structure of lead in the 1970's was the fact that the amount of lead consumed in inorganic chemicals decreased and did not return to the peak of 1972. This phenomenon was caused not only by the slow recovery of the demand for lead after the sharp decrease caused by the first oil shock as a result of low economic growth after 1973 but also by the decrease in the amount of lead for paint owing to environmental pollution problems. In effect, the main uses of lead changed from goods used by industry in prewar days and directly after the end of the war to consumer goods afterwards.

The effects of this structural change of the use pattern of lead described above upon the obsolescent process of lead were as follows:

First, there has been a shortening in the useful life of lead. The average disuse function of lead is:

$$f(\tau) = \frac{\sum_{i=1}^{u} I_i f_i(\tau)}{\sum_{i=1}^{n} I_i} \tag{3}$$

where $f(\tau)$ = average disuse function,
$f_i(\tau)$ = the disuse function in the use i of lead,
τ = the time elapsed from the input of lead,
I_i = lead consumption for use i, and
$i = 1, \ldots, n$.

The disuse function shows the relationship between input and output of material shown in Figure 3. The disuse function of each use of lead is shown in Figure 4. Supposing that

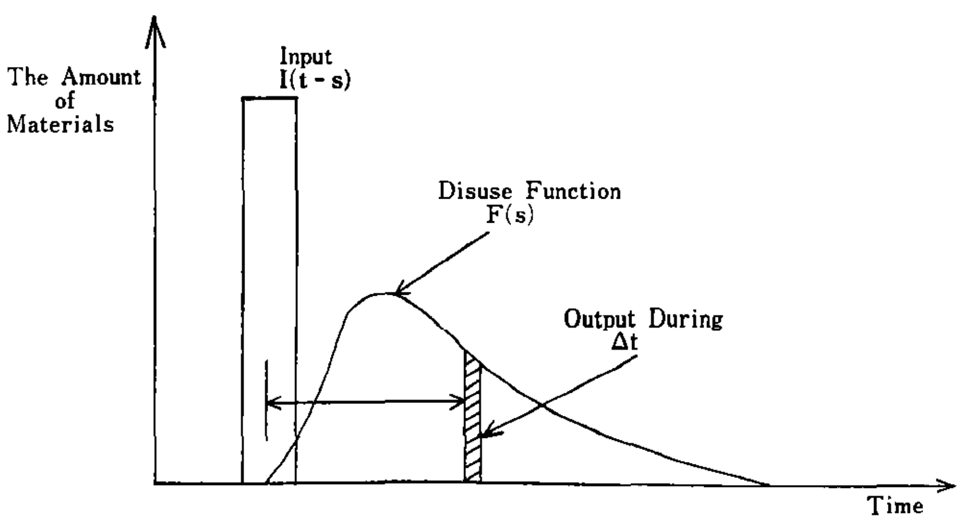

Figure 3. Relationship between Input and Output of Materials.

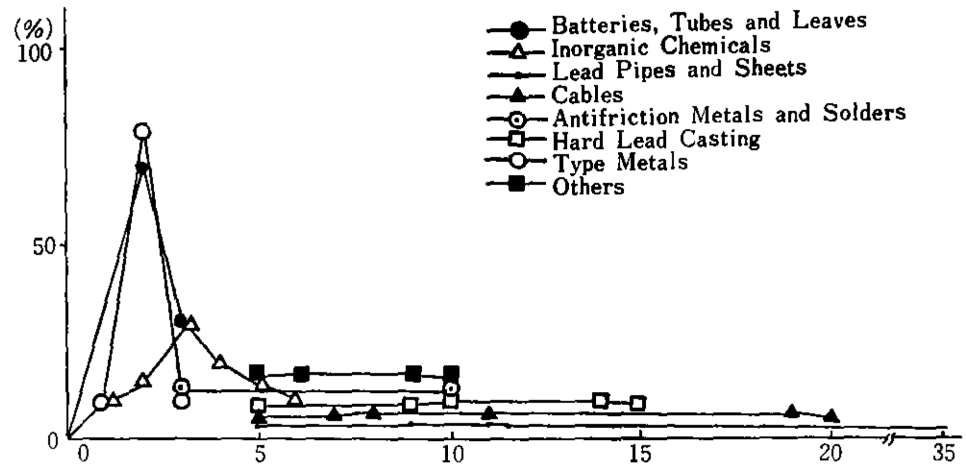

Figure 4. The Disuse Function of Lead in Each Use.

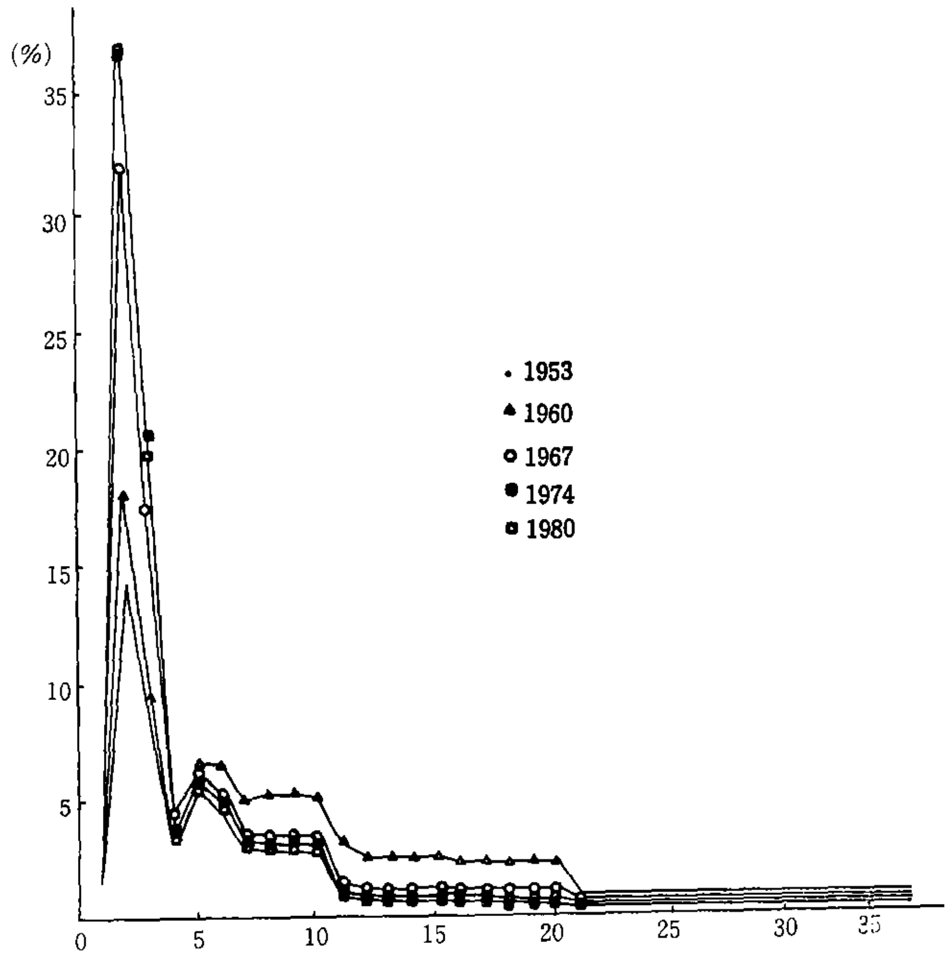

Figure 5. The Change in the Disuse Function of Lead

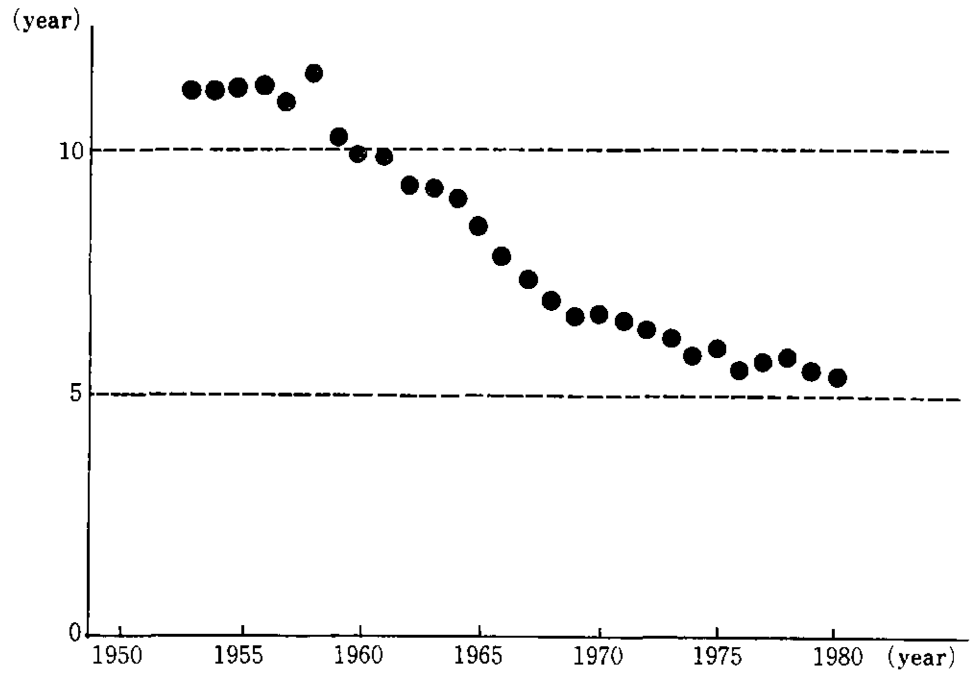

Figure 6. The Annual Change in the Average Useful Life of Lead.

the from of the disuse function $f_i(\tau)$ had not changed from the postwar days to 1980, the form of the average disuse function $f(\tau)$ would have changed as shown in Figure 5 according to the change in the use pattern of lead. The peak year in the average disuse function has not changed, but the peak value has increased remarkably. The average life of lead has changed as shown in Figure 6, according to the following definition of the average life of lead:

$$\tau_m = \int_0^{\infty} \tau f(\tau)\, d\tau \qquad (4)$$

where, τ_m = average life.

The average life of lead decreased remarkably during the period of high economic growth. This change corresponds to the change in the use pattern of lead as shown in Figure 2.

The second point to notice is an expansion of the spatial distribution of lead with variety in the use phase of lead. It has become difficult to recognize and control the spatial distribution of lead. The increase in the total amount of lead consumption is due not only to the increase in the amount of lead consumed in traditional ways but also to the expansion of new uses of lead. For example, the increase in the total amount of metals consumed for inorganic chemicals caused the increase in the number and the kinds of chemical products that contain metals. The number of kinds of chemical product that contain more than one of the 41 main metal elements increased from about 320 in 1968 to about 720 in 1982 as shown in Figure 7. The safety management of chemical materials as a part of environmental policy has been conducted recently with reference to this.

The third point with regard to the effects of the shortening of the useful life of lead is that the demand for lead for various unrecyclable uses such as inorganic chemicals

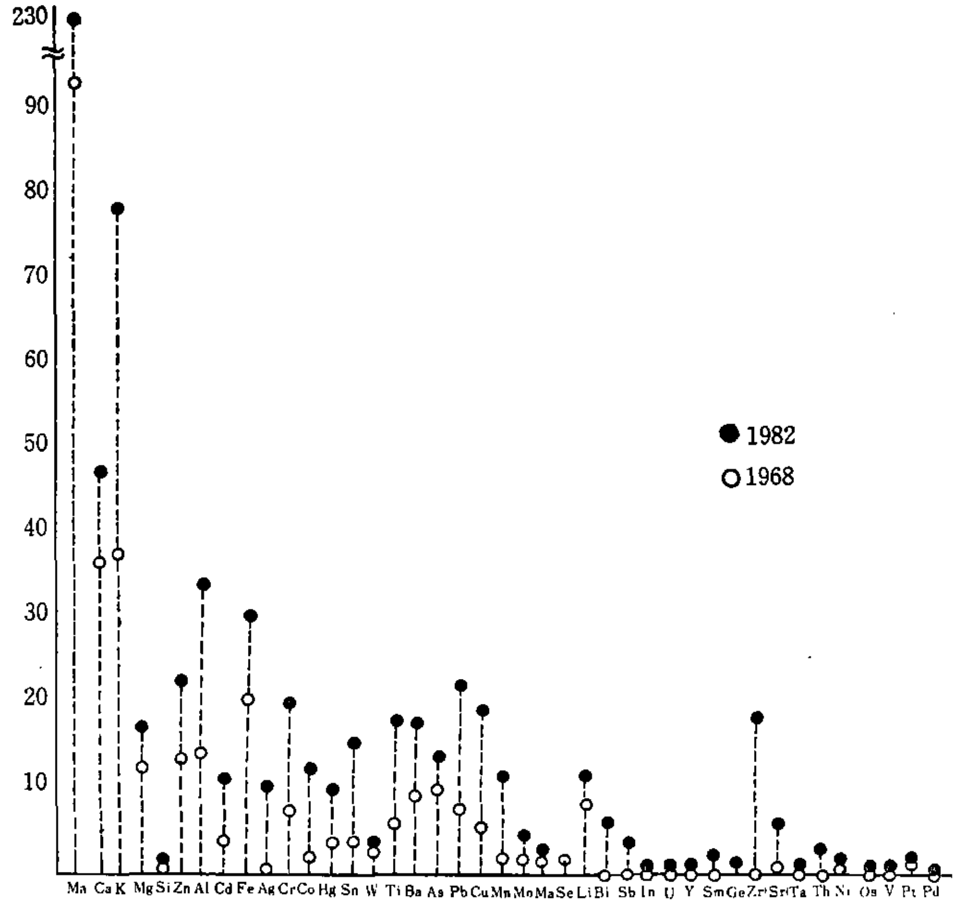

Figure 7. The Change in the Number of Chemical Products Including Metals, by Metal.

amounted to 35 percent of the total demand for lead. The economic conditions of realizing a waste recycle system are as follows:

1) A large quantity of waste generation,
2) Useful property of waste,
3) Recycling technology, and
4) Demand for the recycled product.

Morever, it is necessary to meet these four conditions simultaneously. Strictly speaking, the possibility of recycling cannot be decided only with reference to what the metals are used for. However, the state of lead wastes can be classified by usage because lead products are used in similar places and similar forms according to each use. We classify the pattern of lead waste disposal into the following four types.

1) Recyclable disposal type.
2) Non-disposal type.
3) Dispersive disposal type.
4) Dissipative disposal type.

The main uses relating to each waste disposal type are as follows:

The typical example of a recyclable disposal type is lead used for car batteries and for the greater part of lead pipes and sheets. A typical example of a non-disposal type is the lead consumed for radioactive screening sheets over which our society has to have control for extremely long periods of time. Another example of a non-disposal type is the lead used for art objects and cultural artifacts. In these two uses, lead wastes are stored in a particular space and are recycled. Typical examples of a dispersive disposal type are the lead used for inorganic chemicals in paint and lead sound screening sheets and solder in household electrical appliances. In these cases, in spite of the fact that the place where the lead product is used is apparent and the lead product falls into disuse after a certain period of time, it is not easy to recycle the lead because the amounts in each place are small, and it is very difficult technically and uneconomical to collect and concentrate the available lead in one place. Typical examples of the dissipative disposal type are tetraethyl lead consumed as an antiknock compound in automobile gasoline, and lead arsenate used in pesticides. In these cases, it is impossible to recycle the wastes because lead is discharged and dispersed into the environment simultaneously with the consumption of the lead product. Lead wastes are not recycled now in the cases of lead consumed in non-disposal type uses, dispersive disposal type uses and dissipative disposal type uses. The distribution ratio of the demand for lead for these various unrecyclable uses in the total demand for lead has increased gradually in the postwar period as shown in Figure 8 (Ueta, 1981). This is one of the effects caused by the structural change in the demand for lead.

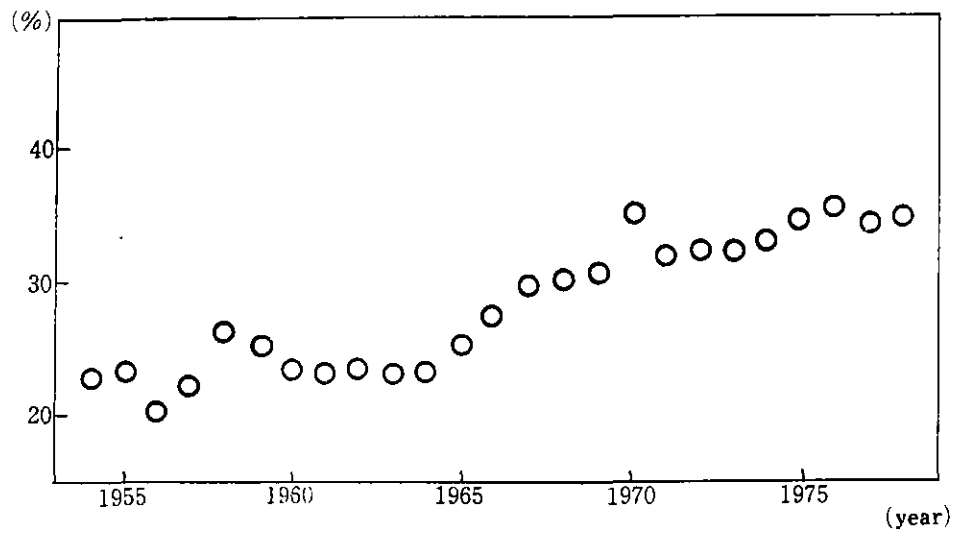

Figure 8. The Annual Change of the Ratio of the Demand for Lead in Unrecyclable Use.

III The Environmental Impact of Lead Use and the Conservation Effects of Product Life Extension

The total amount of lead in the use phase having a potential environmental impact is evaluated in the following way (Sueishi, Morioka and Ueta, 1981), on condition that the annual change in lead supply in each use category is given. The waste amount in each use category is expressed by the convolutional integral

$$O_i(t) = \int_0^\infty I_i(t-s) f_i(s)\, ds \qquad (5)$$

where,

O_i = the waste amount in use i

I_i = the total consumption of lead in use i, and

$f_i(s)$ = the disuse function in use i.

This equation shows the relationship between input of lead product and output of its waste as shown in Figure 3.

The output to a unit input and the indicial admittance can be used to obtain the output to a force that is an arbitrary function of time by application of the principle of superposition. The principle of superposition can be applied to any linear system. However, the application of the method mentioned above is subject to another restricting condition. Let us assume that a unit input is applied at the time s, and that we observe the output at the instant t; then we also assume that this output is only a function of the elapsed time $t-s$ and does not depend either on t or on s separately. This will be the case if the coefficients of the differential equations of the system are constants; it will not be the case, in general, if the coefficients are functions of the time. These two conditions are known as Duhamel's integral (Karman and Biot, 1940). Strictly speaking, it is not easy to check whether these conditions are satisfied in input-output system of lead use, because the disuse function of each commodity has not been investigated enough and the planned obsolescence of products. There are, however, two abvantages in this method. One is that the state of future waste generation can be predicted with reference to the estimated value of the annual lead supply in each use category corresponding to the estimated period based on past records. The other advantage is that we can compare the obsolescence process in each use category.

I_i is calculated by the following equation

$$I_i = PC_i + SC_i + RSC_i \qquad (6)$$

where,

PC_i = primary lead consumption in use i,

SC_i = secondary lead consumption in use i, and

RSC_i = remelted secondary lead consumption in use i.

The amount of recovered lead in use i is calculated by

$$RA_i = SC_i + RSC_i + X_{si} - M_{si} + SI_i \qquad (7)$$

where,

RA_i = amount of recovered lead in use i,

X_{si} = exports of scrap in use i,

M_{si} = imports of scrap in use i, and

SI_i = scrap input to primary lead refining.

The value of X_{si}, M_{si} and SI_i are not reported in governmental statistical reports in each use category, and so, we can estimate only the total amount of exports of scrap, imports of scrap, scrap input to primary lead refining, and also the amount of recovered lead.

The total amount of lead having a potential environmental impact EI can be calculated by

$$EI = O - RA \tag{8}$$

where,

$$O = \sum_{i=1}^{n} O_i \tag{9}$$

$$RA = \sum_{i=1}^{n} RA_i = SC + RSC + X_s - M_s + SI \tag{10}$$

$$SC = \sum_{i=1}^{n} SC_i \tag{11}$$

$$RSC = \sum_{i=1}^{n} RSC_i \tag{12}$$

$$X_s = \sum_{i=1}^{n} X_{si} \tag{13}$$

$$M_s = \sum_{i=1}^{n} M_{si} \tag{14}$$

$$SI = \sum_{i=1}^{n} SI_i \tag{15}$$

Substituting the values of Figure 2 and Table 1 in Eqs. (1), (2), (8), the annual change in the total amount of demand for lead, the amount of lead wastes and the lead discharged into the environment is estimated as shown in Figure 9. The annual change in the value of Recycling Ratio a (RRa) and Recycling Ratio b (RRb) as shown in the following equation is also shown in Figure 9.

$$RRa = \frac{RA(t) - SI(t)}{O(t)} \tag{16}$$

$$RRb = \frac{RA(t)}{O(t)} \tag{17}$$

Both the amount of cumulative lead waste and the amount of cumulative lead discharged into the environment have been increasing annually, but the rate of increase is slowing down. The amount of lead waste in 1978 was 8.32% of the amount of cumulative lead wastes for the period from 1960 to 1978. The amount of lead discharged into the environment was 9.38% of the amount of cumulative lead discharged into the environment for the period from 1960 to 1978. The amount of lead discharged into the environment in 1978 can be broken down as follows: inorganic chemicals, 38.6%; cable, 18.1%; batteries, 14.1%; lead pipes and sheets, 13.8%, antifriction alloy and solder, 11.5%. As lead wastes generated from inorganic chemicals cannot be recycled, the amount of inorganic chemical waste accounts for more than 30% of lead wastes discharged into the environment. The amount of lead cable waste is more than that of battery waste in 1978 because the life of a cable is longer than that of a battery and the cumulative effect upon the environment of waste generation of cables used in the 1960's cannot be ignored. The amount of lead

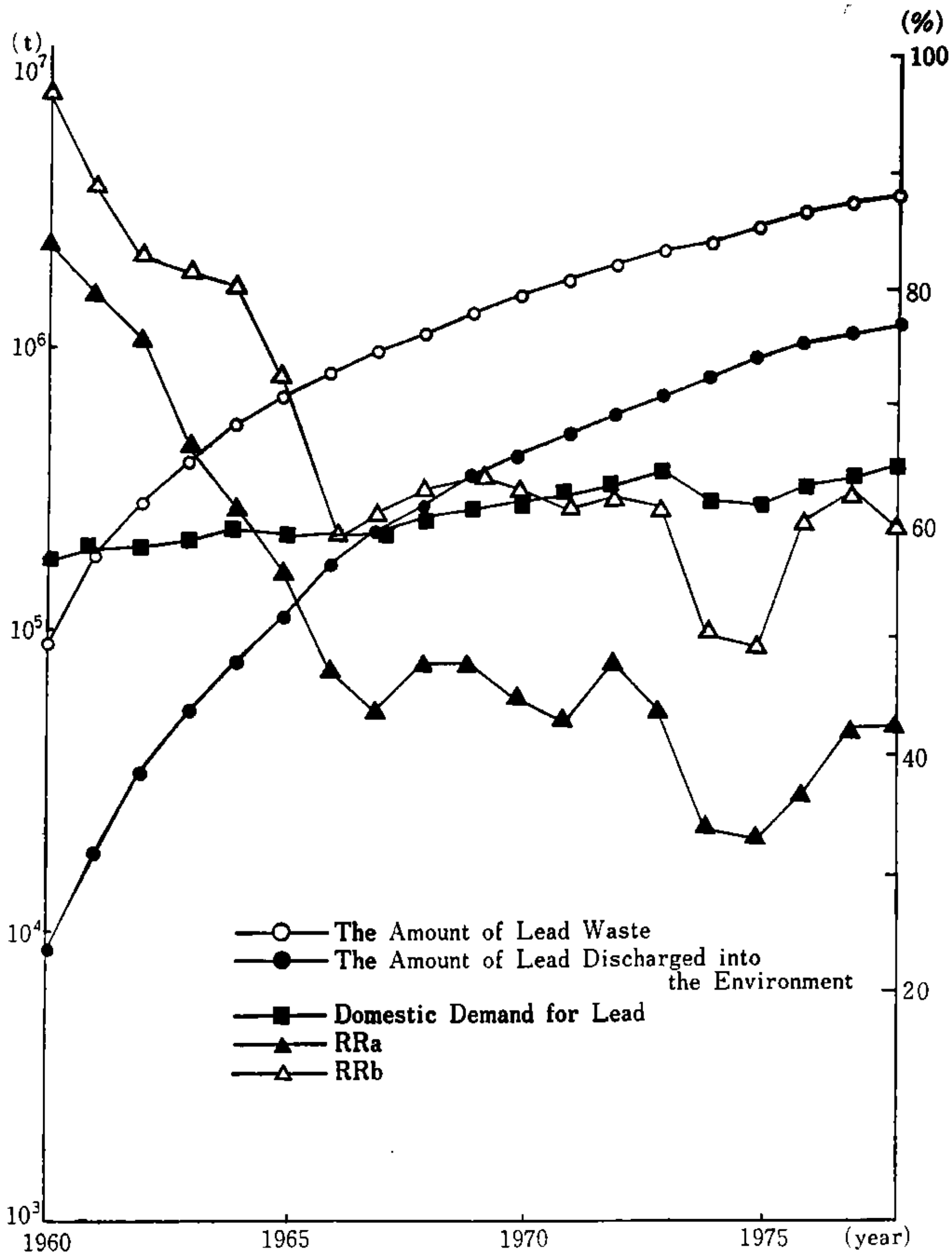

Figure 9. The Annual Change in the Demand for Lead, the Amount of Lead Waste, the Amount of Lead Discharged into the Environment, and the Recycling Ratio

discharged into the environment had been increasing annually until 1975 but dropped after that. In contrast, the amount of lead waste has been increasing annually. The incresing rate of the amount of lead discharged into the environment is less than that of lead waste because the Recycling Ratio has been rising since 1975. Both RRa and RRb have changed in a similar way to REIa and REIb respectively, but the tendency since 1973 has been considerably different.

The estimated total amount of lead discharged into the environment for the period from 1960 to 1978 is 1, 194, 000 tons. If the lead discharged into the environment of Japan accumulated evenly in the outer layer of the soil 10 cm in depth, the lead content in the soil would have risen 32. 3 ppm, which is about three times the normal lead content of 10 ppm. The additional amount of 59, 000 tons of tetraethyl lead from 1969 to 1978 having a potential environmental impact should also be considered in the above estimate. Statistics for lead production and consumption do not include tetraethyl lead because it is not manufactured in Japan.

We regard product life extension as a useful policy instrument to solve resource, energy and environmental problems, not only when seen from the point of view of the acceptability of product life extension for society in the moral sense, but also because of the value of the recognition that the useful life of a product is not physically fixed but is a socio-economic operational variable of the society. The effect of lead product life extension upon resource conservation and waste generation can be investigated through a comparison of resource consumption between the case of extending the lead product life by 20 percent and the case of retaining the existing product life. This comparison is implemented under the assumption that the stock of products in actual use phase is constant. If the utility contributed by the product to society is independent of the life and the use years, the constant stock of the products means that the utility contributed by the stock of products and the stock of lead in the products to society is also constant.

The disuse function of lead products in the case of extending the product life 20 percent is shown in Figure 10. The decreasing rate of the demand for lead for the period from 1960 to 1978 by extending the product life 20 percent is shown in Fiqure 11.

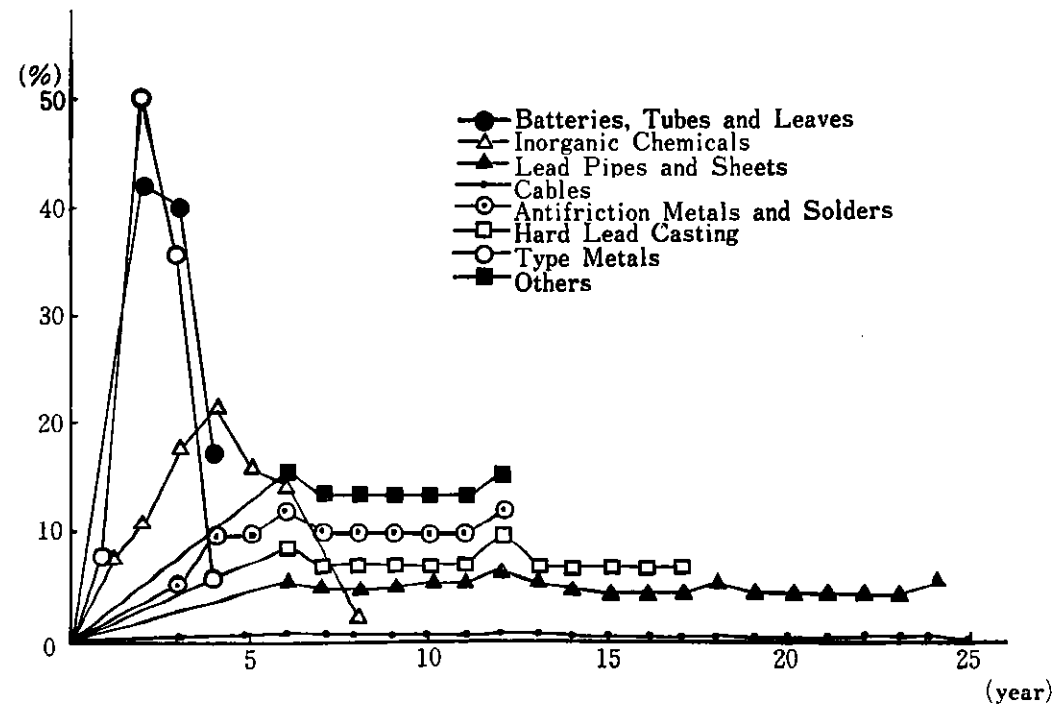

Figure 10. The Disuse Function of Lead in Each Use

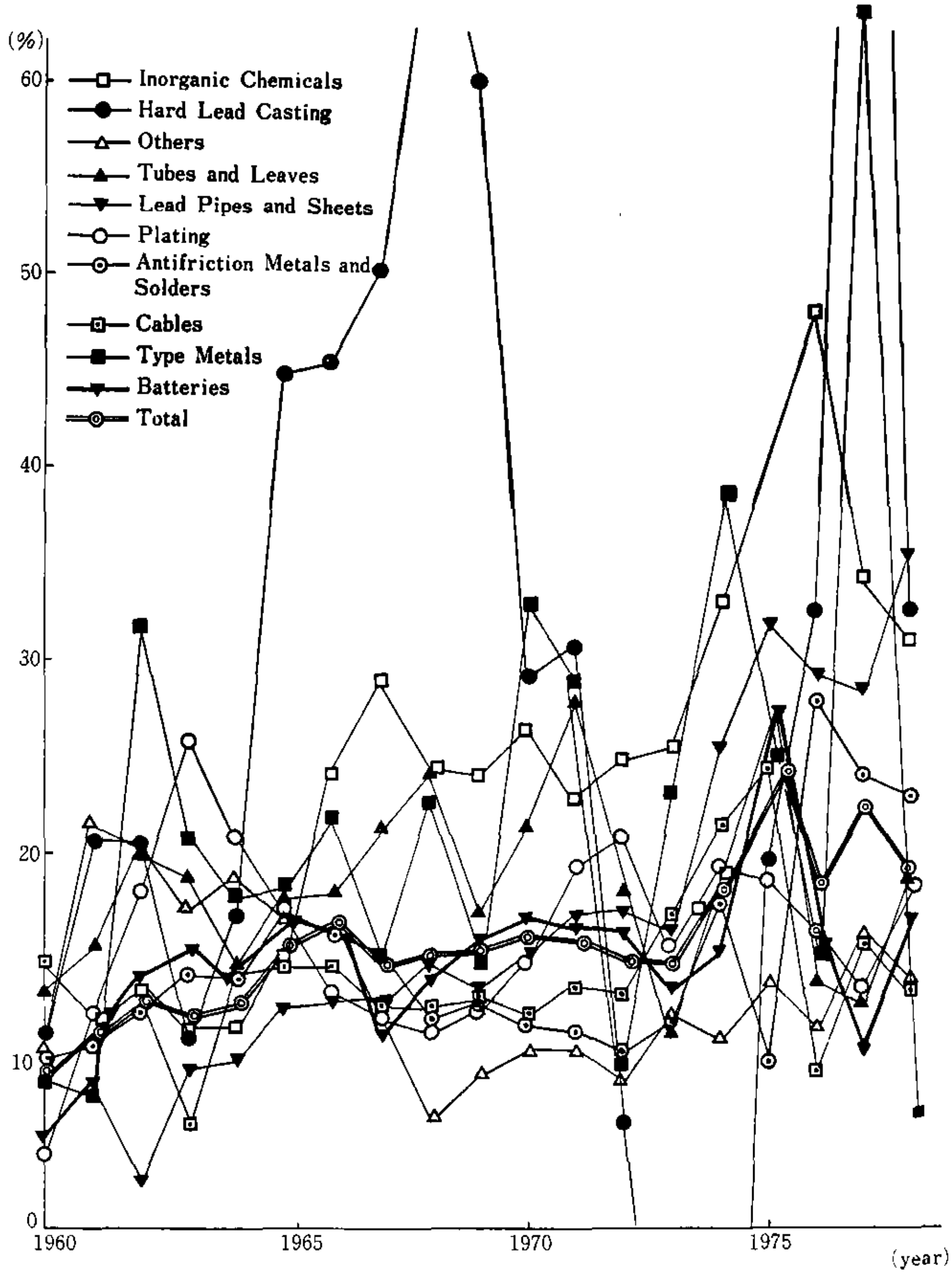

Figure 11. The Dacreasing Rate of the Demand for Lead by Product Life Extension

The effects on the demand for lead have been increasing annually. The decreasing rate of the demand for lead in lead pipes and sheets is higher than that of the total demand after 1971. In constrast, the decreasing rate is higher for lead batteries than it is for the total from 1960 to 1965, but as in the 13 years from 1966 to 1978, there are only four years in which the decreasing rate is higher than that of the total figure. The range of the decreasing rate in the demand for lead varies widely, and it is difficult to recognize a consistent change that relates to all uses. It is considered that the decreasing rate in the

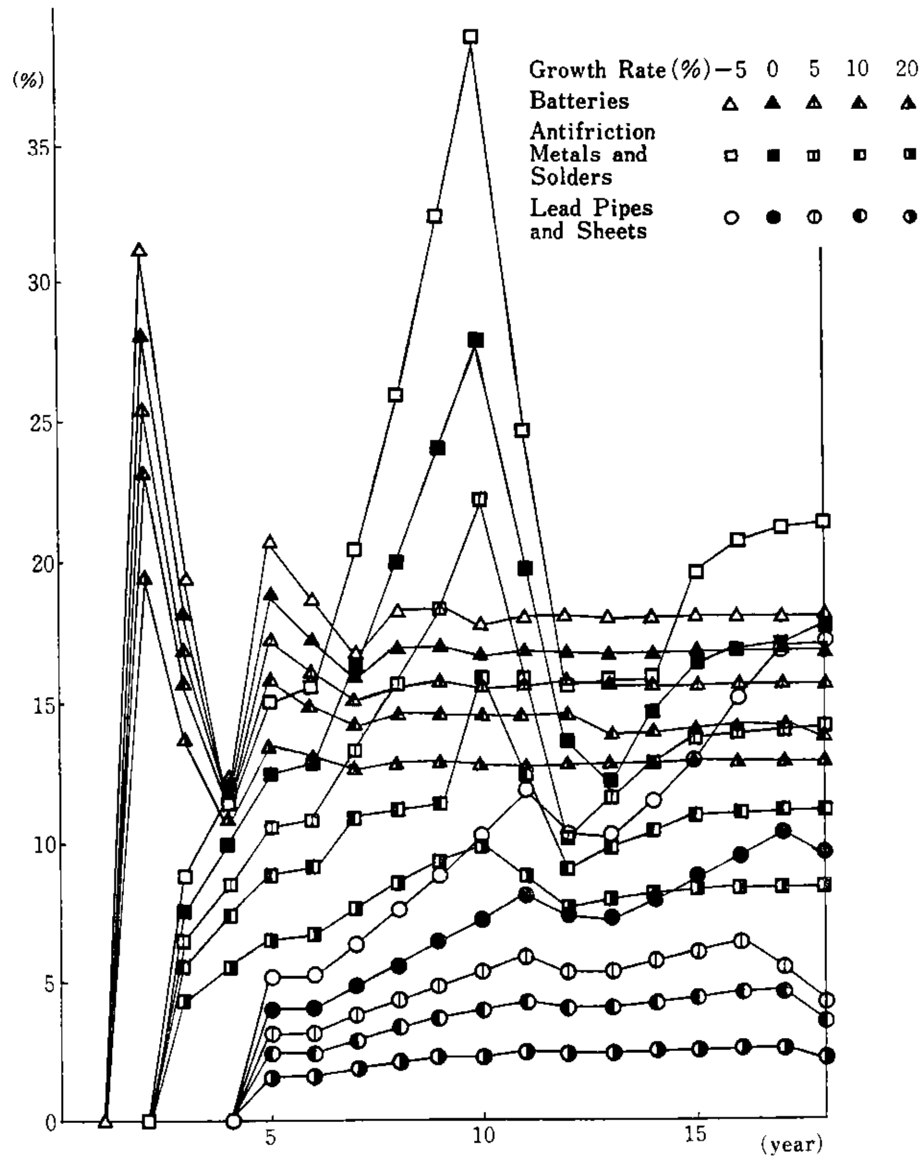

Figure 12. The Annual Change of the Reduction Rate of the Demand for Lead by Product Life Extension in the Three Main Uses

demand for lead is affected by some factors other than product life extension. Considering the three main uses having a different useful life —— batteries, antifriction metals and solders, and lead pipes and sheets —— and the five cases of demand growth rates —— 20 %, 10%, 5%, 0% and −5% ——, the decreasing ratc in the demand for lead is compared in each case. The different factors affecting the demand for lead in the various uses are only the growth rate of the demand for lead and the disuse function for each use. On the relation between the demand for lead and the stock of lead, it is found that the annual growth rate of the demand for lead is equal to the annual growth rate of the stock of lead.

The decreasing rate of the demand for lead is calculated under the following conditions. The stock of lead in the three main use categories at the starting point is supposed to be 0. The demand for lead in the three uses at year 1 is assumed to be 10, 000 tons. The stock of lead after that is estimated on the assumption that the stock of lead changes based on the growth rate of the demand for lead and the disuse function in each use. Subsequently, if the product life is extended by 20 percent, the demand for lead will change in order to maintain the stock of lead at the same level had it not been extended. The decreasing rate of demand for lead from when the product life is not extended is calculated as shown in Figure 12.

Consider the relation between the annual growth rate of the stock of lead and the decreasing rate in the demand for lead, the value of the latter becomes lower as the value of the former goes up. The amount of lead saved by product life extension is very small compared with the stock of lead because the higher the growth rate of the demand for lead, the higher the growth rate of the stock of lead. The rate of difference between the decrease in the demand for lead when the growth rate of the stock of lead is 0% and that when the growth rate of the stock of lead is 20% becomes larger as the product life shortens. With lead pipes and sheets, the decreasing rate in the demand for lead goes down to 42. 64% as the growth rate of the stock of lead goes up from 0% to 20%. For batteries, the decreasing rate in the demand for lead goes down to 81. 85%. It is considered that this is due to the difference in the stock of lead. The stock of lead in lead pipes and sheets is 2. 64 times higher than that in batteries. Moreover, in contrast to batteries, where the effect of product life extension is realized during 2 or 4 years, it takes 42 years for lead pipes and sheets. Therefore, in order to accomplish a decrease in the demand for lead for a short period, it is more effective to extend the life of the product having a shorter life than the product having a longer life, in spite of the fact that the stock of lead in the former is less than in the latter.

With lead manufactured goods, it is necessary to take into account the growth rate of demand for lead, the recycling ratio of lead waste, and the stock of lead of lead products in order to make lead product life extension effective for resource, energy and environmental conservation. It is clear that lead product life extension without taking into consideration those factors mentioned above may require more energy than before (Ueta, 1983).

IV The Philosophy of Lead pollution Control for Environmental Risk Management

With the hazards of metals that are poisonous in the environment, the time delay between the benefits gained by their use and the risks from their waste vary according to use. The benefits and the risks may fall on different groups of people so that the areas on which risks are concentrated may be different from those of the benefits. Therefore, the control of the use pattern and the life and the spatial distribution of metals for balance between the utility of metals and the hazards of their waste is indispensable in metal risk management.

The estimation of the benefits of hazardous waste management is in its infancy.

Because the benefits of pollution control —— savings in health costs, damage to property and the environment generally —— cannot be quantified accurately, society has to set the level of acceptable risk in relation to the likely costs involved in reducing the hazard. Controlling the risks of toxic substances is especially difficult both because the exact nature of the hazard has yet to be fully recognized by regulatory authorities and because of certain characteristics displayed by these pollutants which make control by traditional policy instruments fairly ineffective. Risk management basically involves four phases, that is, risk identification, risk estimation, risk evaluation, and risk control, which by necessity are closely related. Risk evaluation is really the central task of risk management for it involves not only the social judgement of risks as identified and estimated, but the balancing of such risks as against perceived or estimated social gains. Lead pollution discharged from automobile exhaust has been shown to be dangerous and toxic. It should be noted, however, that potential pollution from lead scrap and waste metabolism is even greater as shown in the previous section. It is not easy and not necessarily needed to identify the degree of risk caused by the potential pollution, since exaggerating the scale and magnitude of risks beyond reasonable compass for investigation is not worthwhile for the society. It is not useful to attempt to ascertain the risks too precisely, because the full risk assessment of all toxic products is much more complicated and time consuming. For example, it will take at least ten years and cost millions of dollars to do the full risk assessment of all toxic products required to be examined under the U. S. Toxic Substances Control Act (1976).

Although it is not clear if the lead discharged into the environment causes health damage, we should recognize that an environmental policy should be determined with foresight and err on the side of safety. The value in use of lead in consumer goods should be reconsidered. We have already found that the order of preference in lead use changes when the recovery factor is added to the production and consumption scheme (Sueishi, Morioka, Ueta and Migita, 1979).

In the context of environmental risk problems, policy-makers must decide what degree of risk is acceptable. Since, however, there is a general lack of data on pollution generation, transfer functions and dose-response relationships, the potential for catastrophic costs relatively modest benefits in terms of environmental risk, the very great uncertainty surrounding the potential costs and benefits, and the severe institutional problems created by the extended delay between the hazard occurrence and the manifestation of its damage effects and the irreversibility of the effect cannot be clearly determined. Because of the fair distribution of costs and risk over time and the latency and irreversibility charactristics of risk, the redesign of lead pollution control strategies is necessary in order to be able to anticipate adverse effects rather than merely react to existing, known effects. The redesign of pollution-management programmes should be focused on the control of the use pattern and the life of lead. An adequate recycling plan, therefore, for resource, energy, and environmental conservation cannot be realized without the redesign of the use structure of lead.

V Summary and Conclusion

In this paper, characteristics of the change of lead use structure in Japan relating to waste problems after the Second World War were summarized as follows:

1) The useful life of lead has been shortened from more than 11 years in 1955 to about 5.5 years in 1980.
2) The use of lead has been expanded from goods used in production to consumer goods, therefore, we have not only to control enterprises but also to warn households —— the subjects of the use of lead for environmental risk management.
3) The demand for lead for various unrecyclable uses amounts to 35% of the total demand for lead in 1980, increasing from about 20% in 1955.

The estimated total amount of lead having a potential environmental impact for the period from 1960 to 1978 is 1, 194, 000 tons. It is considered that the environmental risk derived from lead has increased because of the sudden catastrophic change of the demand structure of lead without adequate management of the use pattern and the life of lead.

The early warning of potential pollution hazards is a major concern of the public and governments. The methods for assessing the chronic effects of pollutants are also in need of improvement so as to provide workable techniques for pollution control. Since such assessments, however, would impose impossible organizational and financial burdens on government authorities and the public —— in the framework of existing control structures —— the control of the use structure of lead for environmental risk management should be realized without waiting for the development of such assessment techniques. An adequate recycling system could be established through the redesign of the use pattern and the life of lead in the direction of a closed system without increasing social cost such as an extravagant consumption of energy.

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