10. Research agenda for Wastewater In Japan

Presenter

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Infrastructure And Transport

RESEARCH AGENDA FOR WASTEWATER IN JAPAN

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ABSTRACT

The researches on wastewater system have been conducted many public and private sectors. National budget is allocated mainly to four institutions. Municipalities and universities also act important role. Current research topics are: risk, global climate change, practical nutrient removal, resource recovery, and the ecosystem. The first two topics are addressed elsewhere; this paper reviews the three remaining topics.

KEYWORDS

wastewater, nutrient removal, resource recovery, ecosystem

INTRODUCTION

Japan has been developing modern wastewater systems over the last few decades. Since Japan is a highly urbanized society, sewerage systems are considered to be the main wastewater systems. These systems receive large quantities of wastewater from both domestic and industrial activities. Consequently, sewage has a large impact on the water environment, material cycle and greenhouse gas exhausts in Japan. Many current research projects focus on these issues.

ORGANIZATION AND INSTITUTION FOR TECHNOLOGY DEVELOPMENT

Figure 1 illustrates the institutional structure. The four research institutions shown in the center of the figure are those to which national research budgets have been allocated. In recent years, the annual national research budget for wastewater systems has been approximately 900 million yen. Among the municipalities, which have implemented wastewater works, some large designated cities have their own technology development division. The MLIT organizes the Technology Development Council, which involves public institutions that promote joint research and information exchange. The private sector and universities are also active in this field. They carry out many joint research programs with the public sector.
The characteristics of those institutions that have been allocated funds from the national research budget are described as follows.

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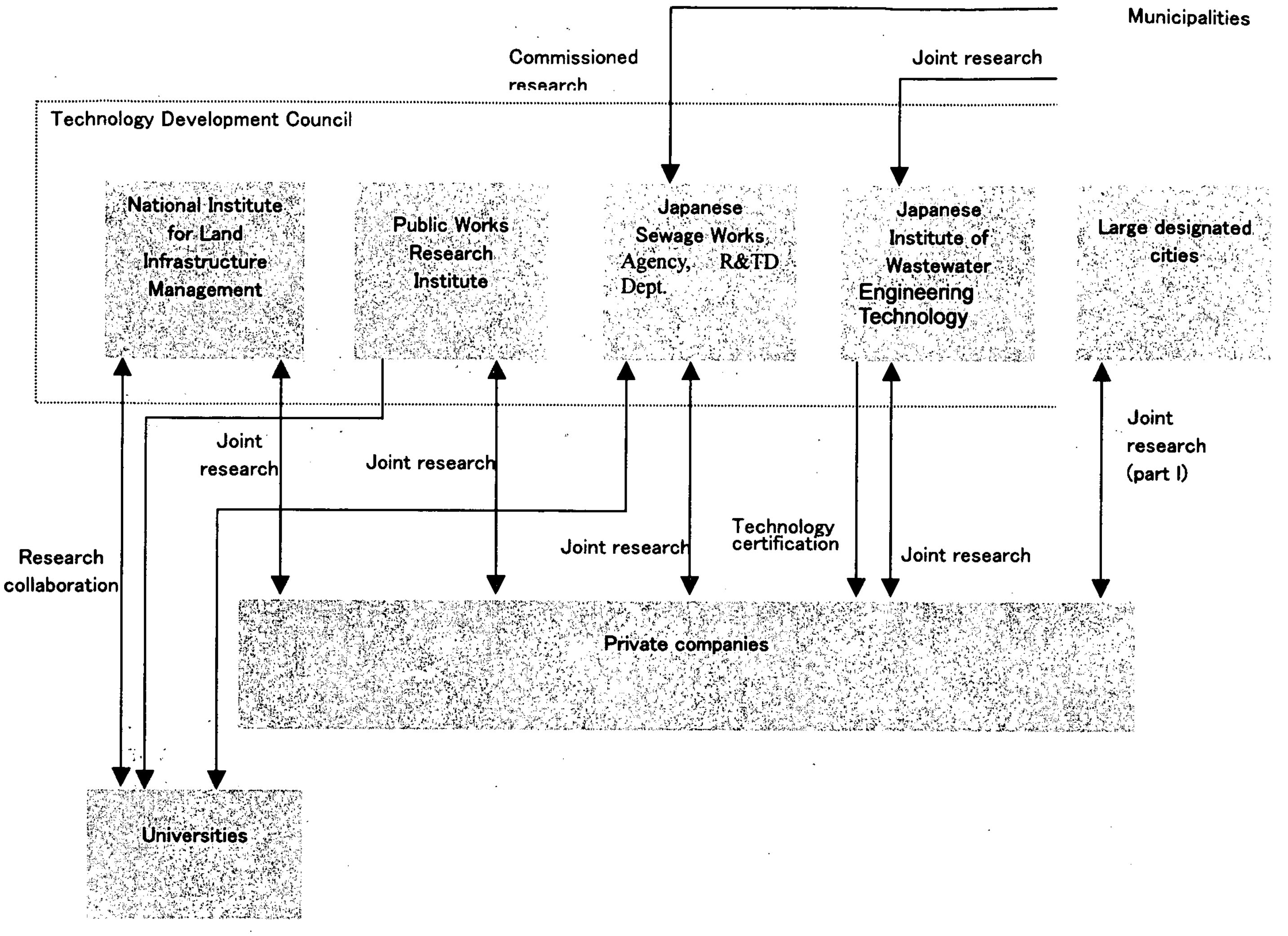


Figure 1. Institutional structure of sewerage in Japan [1)]

National Institute for Land and Infrastructure Management
The National Institute for Land and Infrastructure Management (NILIM) was established in 2001. It has a Water Quality Control Department, which mainly deals with wastewater systems. This institute has three main goals: to present a firm technological base for the national agenda which includes the establishment of laws or ordinances, establishing national standards and providing advice on ways of conducting national projects. For example, NILIM is supporting the establishment of the Ordinance for Structural Sewerage System Standards.

Public Works Research Institute
The Public Works Research Institute (PWRI) is an independent administrative institution that emerged from the national institution in 2001. It has a long history of more than 80 years. This institute conducts essential public research. These research studies include the development of new technology, basic research and multi media research of the kind that the national government itself need not conduct. For example, recent topics considered by PWRI include: endocrine disruptors in sewage, energy

recovery from municipal sludge, etc.

Japanese Sewerage Works Agency, R&TD Department

The Japanese Sewerage Works Agency (JSWA) was established in 1972 mainly by providing professional skills to municipalities constructing wastewater systems. The agency's R&TD Department supports the application and evaluation of wastewater technology, develops new technologies that meet the requirement of municipalities and basic research that will be the core technology of the future. For example, JSWA promotes the application of the original biological nutrient removal process, Multi Stage Step Feed Process throughout Japan.

Japanese Institute for Wastewater Engineering and Technology

The Japanese Institute for Wastewater Engineering and Technology (JIWET) is a non-profit foundation, established in 1992. Its aim is to promote the development of wastewater engineering and the application of this technology to sewage treatment works. They have helped the New Technology Promotion System that improves the municipalities' application of new technologies. The institute also conducts the Technology Evaluation System that examines and certifies private sector technology.

CONSTRUCTION AND OPERATION OF A NEW BIOLOGICAL NUTRIENT REMOVAL PROCESS

Nitrogen and phosphorous regulation is introduced into the main closed water bodies in Japan. Figure 2 shows special areas related to closed sea and designated lakes and reservoirs where nutrient control has been introduced. Water usage in these areas is significantly limited by eutrophication. Many existing wastewater treatment plants (WTP) in this area employ conventional secondary treatment processing. However, the regulation requires them to convert to an advanced wastewater treatment process. Nitrification and denitrification are the major processes involved in removing nitrogen and require a large reactor in order to maintain nitrifier. These plants are located in urbanized areas so there is little room available to expand the facilities for advanced treatment.

In the 1980s, a new technology was developed that overcame the limitations of space. Instead of expanding the reactor, immobilized microorganisms were placed into the reactor in order to enhance the biological treatment especially nitrification. Photo 1 shows the kinds of immobilized pellets used in Japan. Pellets are made from polyethylene glycol, polypropylene, sponge cubes, etc. The major advantage of this technology is that it can be applied to existing WTP with only minor modifications. As shown in Figure 3, screen sieves are necessary at the end of the reactor in order to retain the pellets within the reactor. Other sieves are required at the front-end of the reactor to prevent clogging of downstream sieves. Pellets are returned from the back-end of the reactor to the inlet by some device such as an airlift pump.

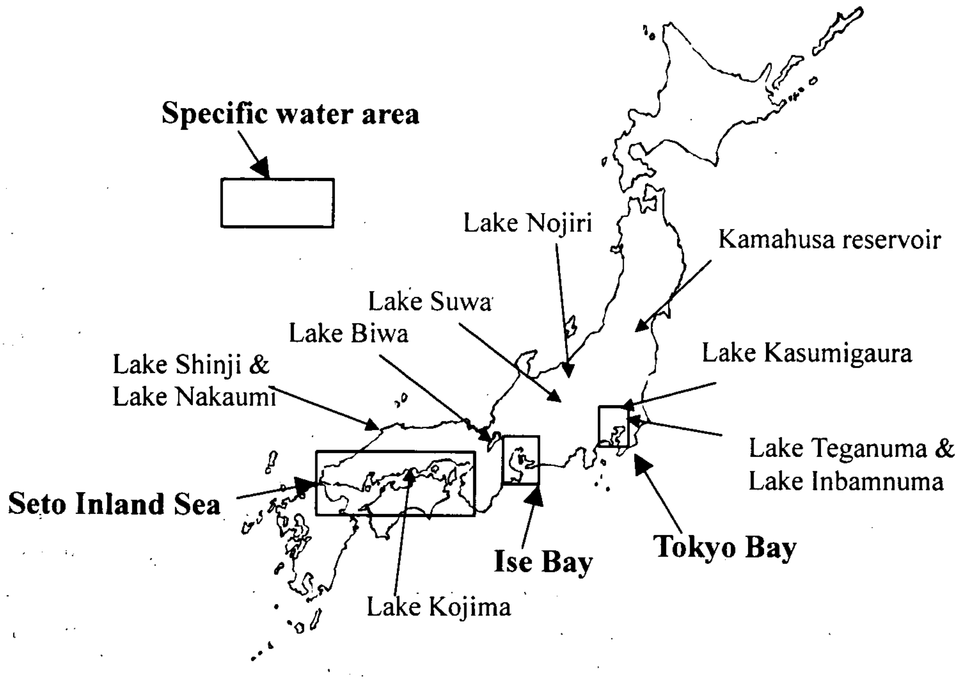
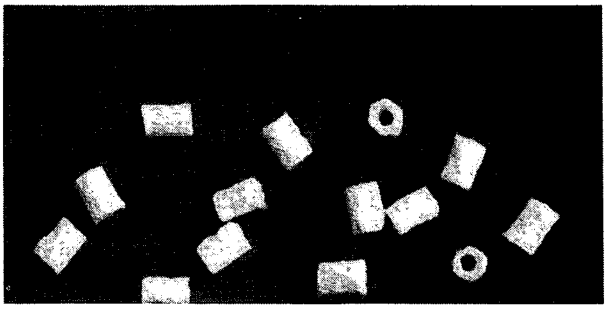
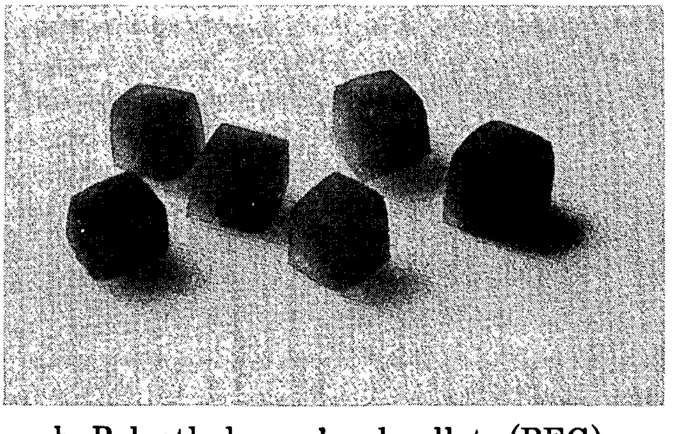


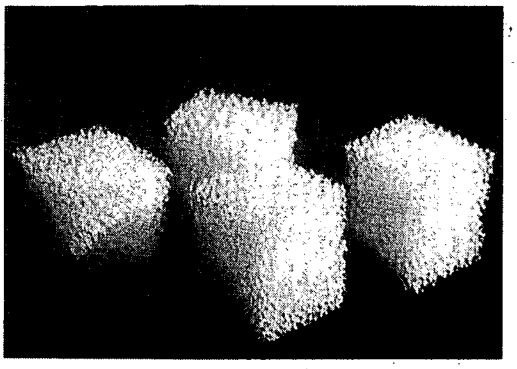
Figure 2. Specific water areas and designated lakes and reservoirs



a. Polypropylene pellets (PP)



b. Polyethylene glycol pellets (PEG)



c. Sponge cubes (S)

Photo 1. Pellets used in Japan [2)]

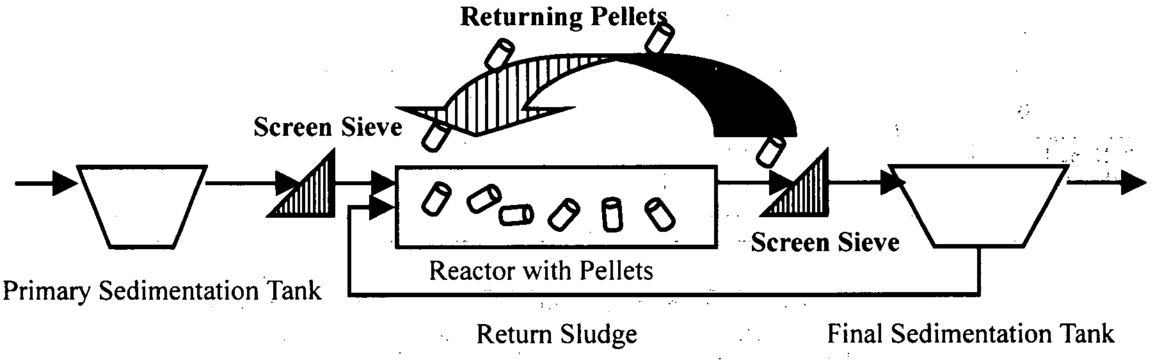


Figure 3. Using immobilized microorganisms in existing wastewater treatment plants

Fourteen WTPs used the immobilized microorganism process in Japan. The descriptions of these plants are listed in Table 1; their locations in Figure 4. The oldest WTP is in north Kyushu. It has a nine-year history. There are two WTPs in Osaka Konohana, and Takayama Miyagawa. They will be equipped with the immobilized microorganism process in the near future.

At the development stage it is expected that there will be problems with abrasion of pellets, leakage of pellets from the sieve, clogging of the sieve and over-concentration of pellets in the reactor. Improvement of pellets and sieves almost eliminates these problems. This process has become indispensable in terms of enhancing nutrient removal.

Table 1. Descriptions of those wastewater treatment plants using the immobilized microorganism process

No. from Figure 4	1	2	3	4	5	6	7
City	Takanezawa	Munakata	Ootsu	Miyakonojou	Okayama	Rikuzen-takada	kawasaki
WTP	Housyakuzi	Munakata	Ootsu	Seiryukan	Haga-sayama	Rikuzen-takada	asou
Year of opening	1993	1994	1995	1996	1997	1998	2000
Treatment process *	F+F	BNR +C	BNR	F+F	BNR +C	BNR	BNPR
Treatment capacity m^3/day	2,100	11,300	11,800	7,200	2,680	2,800	13,000
Pellet type**	PP	PEG	PP	PP	PEG	PEG	PEG
Designed retention time in hours	4.5	7.3	5.2	3.8	7.4	13	8.2
Designed effluent quality							
BOD mg/l	5	14.2	10	20	12	10	14
T-N mg/l	-	6.3	10	-	18	10	10
T-P mg/l	-	0.2	-	-	1.2-	-	0.5

No. from Figure 4	8	9	10	11	12	13	14
City	Akasi	Ichihara	Funabashi	Ginowan	Seki	Kawasaki.	kurasiki
WTP	Ookubo	Matsuga-shima	Nishiura	Ginowan	Sekishi	Iriezaki	mizusima
Year of opening	2001	2001	2001	1995	2000	2001	2002
Treatment process	BNR	BNR +C	BNR +C	AS With S	AS With S	BNPR	BNR
Treatment capacity m^3/day	23,750	21,000	7,500	45,000	14,500	19,910	20,500
Pellet type	PP	PEG	PEG	S	S	PP	PEG
Designed retention time in hours	8	7.5	7.49	4.4	4.5	9.1	7.9
Designed effluent quality							
BOD mg/l	20	10	13	20	16	10	7
T-N mg/l	10	10	10	-	-	10	10
T-P mg/l	-	0.5	0.5	-	-	0.5	1.0

* F+F:Fluidized bed+filtration BNR+C:Biological nitrogen removal with coagulant
BNR:Biological nitrogen removal AS with S:Activated sludge process with sponge cube
BNPR:Biological nitrogen and phosphorous removal
**: see photo 1

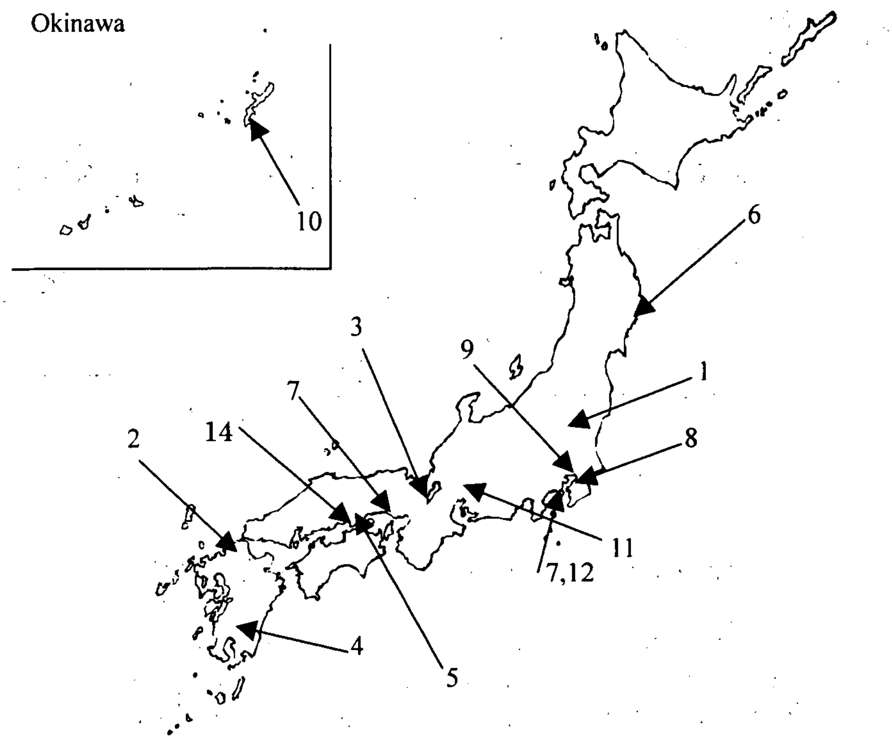


Figure 4. Location of immobilized microorganism process

RESOURCE RECOVERY FROM MUNICIPAL SLUDGE

Municipal sludge consists of water, organic and inorganic materials. Biogas and compost are common products from the organic material resulting from municipal sludge. Oil and char recovery has been tested for a long time.

There are promising resources in the inorganic material found in sludge; one of these is phosphorous. One European institute estimated that the world's phosphate rock supply would be consumed within 60 to 150 years. The USA increased the export price of phosphate rock six times in 1999 in order to maintain the national phosphorous resource.[3)]

Figure 5 illustrates the phosphate balance in Japan in 1993. 60,000 tons of phosphorous was released to the environment through the country's sewerage system. This amount will increase as the size of the population on reticulated sewerage systems increases.

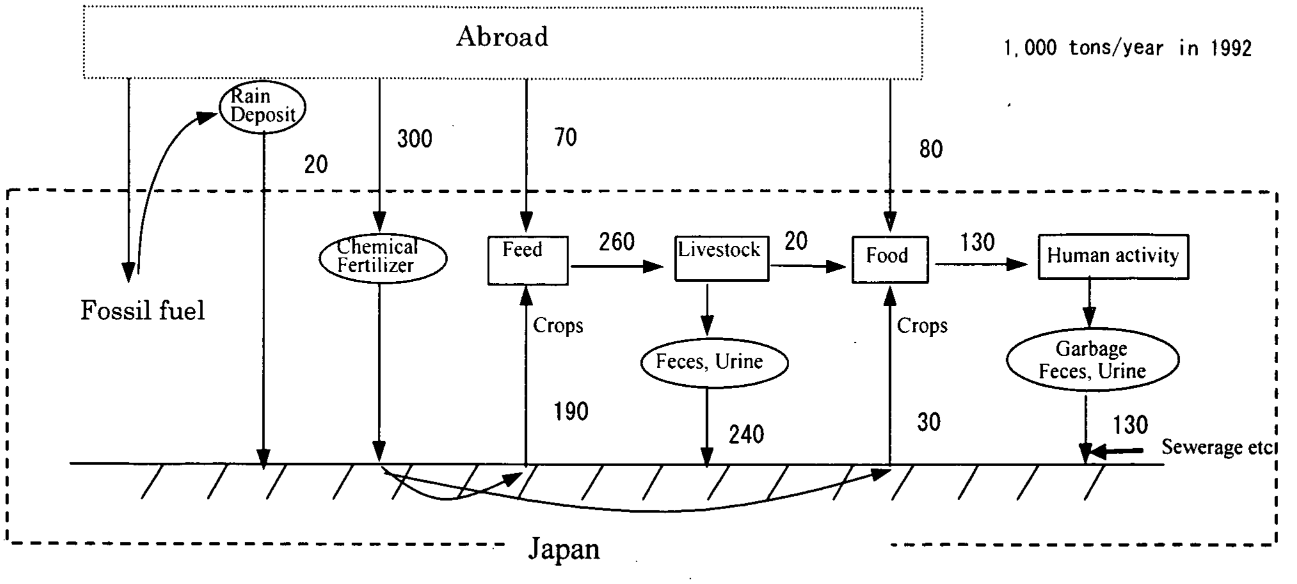


Figure 5. Phosphorous in Japan in 1993 [4)]

The biological phosphorous removal process in mainstream wastewater treatment becomes common where regulation of phosphorous levels in effluent is introduced. Phosphorous release through the sludge treatment process generally causes low removal efficiency. On the other hand, the supernatant of the sludge treatment process contains large quantities of phosphorous, so it is worth recovering the phosphorous from it. The magnesium ammonium phosphate (MAP) and crystallization processes are being investigated and applied in Japan.

Most municipal sludge is incinerated in Japan. 1,432,000 DS-tons of incinerated ash was produced in 1999. The ash contains phosphorous (as shown in Figure 6) and is considered the same as phosphate rock.

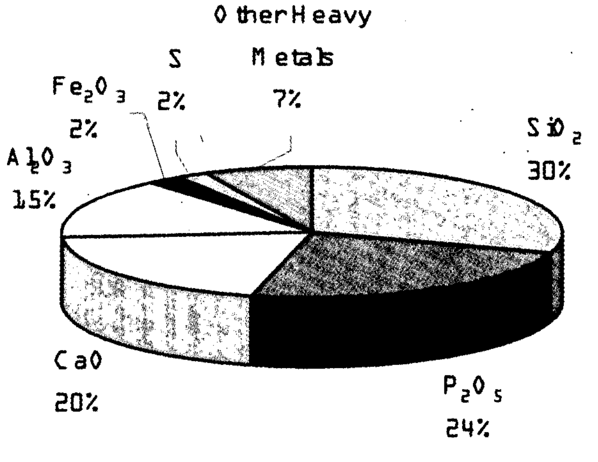
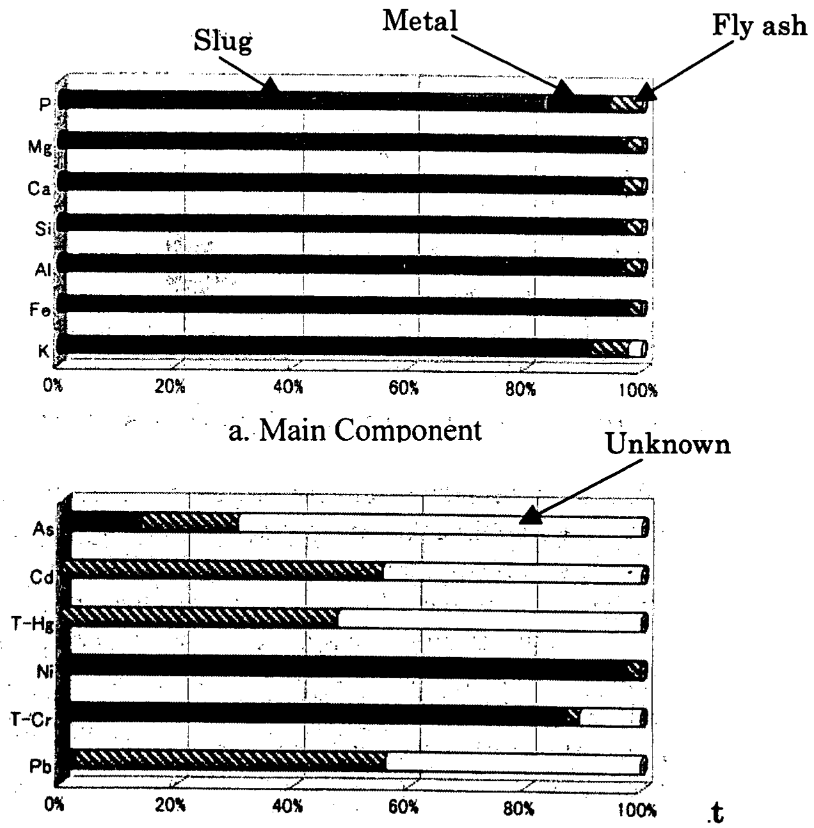


Figure 6. Composition of municipal sludge ash [5)]

An investigation to recover pure white phosphorous from ash was conducted. The

recovery method, using a melting furnace in the reducing condition, is almost the same as that used for white phosphorous production from phosphate rock.
Another promising method is the production of slow-acting phosphate fertilizer. The ash is mixed with magnesium and calcium and melted in a reducing furnace. The mixture becomes light slug, heavy metal and gas in the furnace. The slug contains most of the phosphorous, magnesium and calcium. Heavy metals in the ash such as iron turn to metal. The gas contains volatile components such as Hg, Pb and Cd. This method is the same as fertilizer production from phosphate rock. The mass balance of each component is shown in Figure 7.



a. Main Component

b. Hazardous Component

Figure 7. Mass balance of each component [5)]

ECOLOGICAL EFFECTS OF EFFLUENT

Water resources are highly utilized around mega cities such as Tokyo, Osaka and Fukuoka. Cascade utilization of water is commonly observed. Effluent from the paddy fields goes back to the rivers. Effluent from WTPs is a major water resource in urban rivers. Figure 8 shows the percentage of effluent from WTPs in urban rivers in the Tokyo metropolitan area during dry weather. For example, the dry weather flow of Kanda River consists of 96% effluent. Ayu, a particular kind of migratory fish found in Japan, returned when WTPs applied nitrification and filtration processes to their water. Since the river structure is not suitable for these fish to spawn in, reproduction of ayu has not yet been observed.

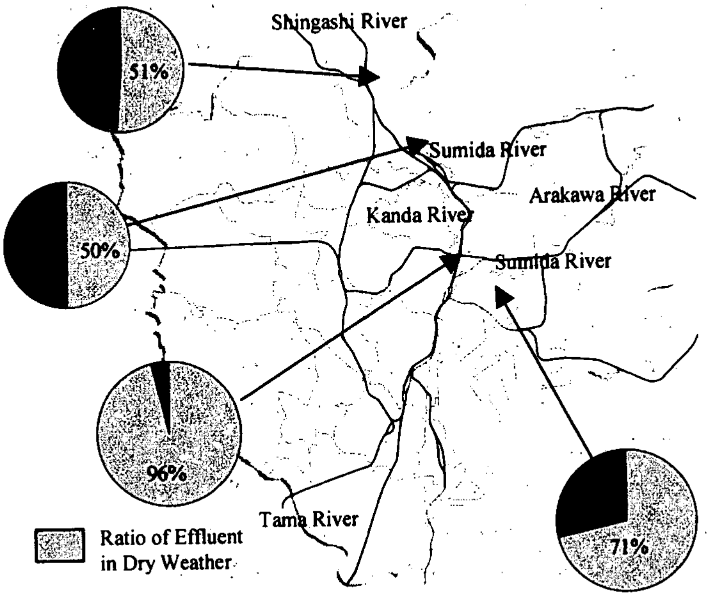


Figure 8. Percentage of effluent in urban Tokyo rivers in dry weather [4)]

Many engineers and ecologists have intensively investigated the ecological effects of effluent. The MLIT published a guideline for enhancing eco-friendly sewerage systems. In this guideline, several examples of eco-friendly sewerage facilities are presented.

In 2000, 53 ultraviolet ray facilities instead of chlorination plants were used to disinfect effluent, and the protection of ayu, dragonfly larvae, etc. was expected. Several WTP constructed *Biotops* using their effluent from the WTP sites to enhance their environmental education. Figure 9 shows a diagram of an eco-friendly sewerage system. However, as the ecological effects of these plans are not yet clear, it is important to obtain scientific evidence.

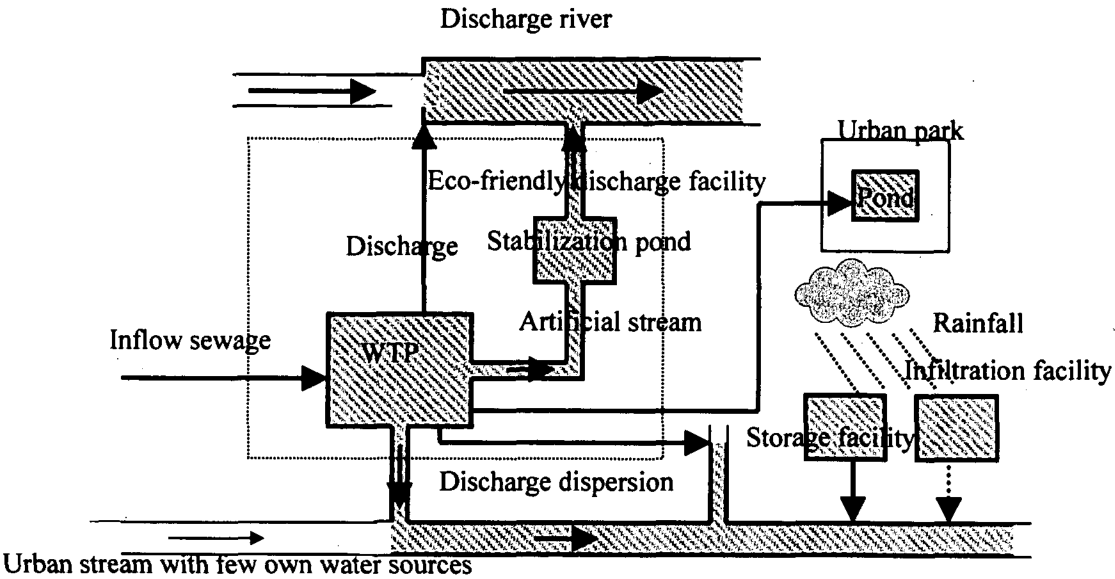


Figure 9. Eco-friendly sewerage system [6)]

CONCLUSION

The Japanese economy and society have changed drastically over the last 10 years. Central and local governments have invested large quantities of money and manpower into constructing wastewater systems, and as a result the country's wastewater system has improved. It is now important to consider wider national and global concerns such as ecosystem protection.

Japan's population will decrease all over the country with the ratio of the elderly in rural areas likely to increase in the future. Consequently, the stock management of wastewater system will be a key issue in maintaining the wastewater and sludge systems. The next study will focus on the maintenance and rehabilitation of existing systems.

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