Technical Manual on Industrial Pollution Control

(Textile dyeing / finishing industry & Meat processig industry)

— Based on project cases and investigation research reports of Japan Environment Corporation (JEC) —

MARCH 1997

JAPAN ENVIRONMENT CORPORATION

FOREWORD

Although serious industrial pollution and deterioration of the living environment had occurred in Japan in the period of high economic growth beginning in the latter half of the 1950s, these critical situations were overcome by taking various measures throughout the country. Information on such experiences and pollution control techniques accumulated in Japan would greatly contribute to countries that need pollution control measures at present.

The Japan Environment Corporation (abbreviated as "JEC" , hereafter) has striven to prevent industrial pollution by operating construction and transfer programs and financing business as a national specific assistance organization for preventing pollution throughout the 30 years since its foundation in 1965. Particularly, although small-and-medium scale corporations were strongly urged to prevent pollution, it was difficult for them to enforce the necessary measures from the aspects of funds and technique.

JEC has assisted to enable them to establish pollution control. Along with economic and social changes in Japan, JEC has expanded its business to cover, in addition to industrial pollution control, such fields as management of industrial wastes, improvement of urban environment and conservation of nature. It also covers environmental problems in a global scale, by disseminating Japan's environmental information to foreign countries, and operating "Global Environment Fund" program.

Within the framework of its information dissemination activities, JEC provides the concerned organizations abroad with "Outline and Cases of Japan Environment Corporation" which summarizes JEC's function and experience, cases of construction & transfer business (Case file) and cases of finance business (Data sheet).

This " Technical Manual on Industrial Pollution Control (Textile dyeing/finishing industry & Meat processing industry) " continues on the previously issued " Technical Manual on Industrial Pollution Control (Metal plating industry & Marine product processing industry)" Based on the project cases of Japan Environment Corporation, the present manual focuses on the small- and medium-scale corporations, whose pollution control measures, need to be improved urgently in particular as pollution control measures in developing countries, having summarized the essential elements of pollution control technique in Textile dyeing/finishing industry and Meat processing industry.

We will be extremely pleased if the experience accumulated during implementation of pollution measures in Japan can provide useful reference in countries striving for pollution control and can contribute to protecting the global environment.

Japan Environment Corporation

Osamu Watanabe

President

Contents

1. Pollution Control Measures in Japan, and JEC

Japan achieved rapid economic growth from the latter half of 1950s through the 1960s. Rapid expansion of industrial production simultaneously caused environmental pollution and the concentration of population in urban areas worsened the living environment there, so it was time to tackle these problems and look for urgent countermeasures.

To cope with the serious industrial pollution problem, the Japanese government began to consolidate various kinds of legal systems in the former half of the 1960s, enforcing emission regulations on pollutants and promoting the construction of pollution control facilities.

The government also tries to systematically rearrange the urban areas and develop infrastructures in accordance with the firmly established industrial location policy. However, since these measures did not work efficiently, air pollution, water pollution etc. brought serious physical hazards to residents in some regions resulting in serious social problems.

Being exposed to severe criticism by society, corporations regarded as pollution sources urgently needed to improve their production facilities and install new pollution control facilities. However, the investment to be made in these facilities was not only a heavy burden for the industrial field, but also technically difficult especially for the small- and medium-scale corporations which were incompetent to develop and introduce pollution control techniques by themselves, since Japan at that time had relatively little experience with pollution control measures.

In order to break through such difficulties, the government, which provided exemption from taxes for pollution control investments and which was doing research and development work on pollution control techniques, organized a new system for loaning the official funds for pollution control expenses, at lower interest than that charged by commercial financial corporations, with the objective of promoting industrial pollution control and furthering the development of infrastructure. Thus, for this reason, JEC was established in October 1965 using governmental funds, as a nonprofit corporation to undertake the task of pollution control, in compliance with the "Environmental Pollution Control Service Corporation Law" promulgated in June 1965.

Such government policy and the support of people throughout the country made it possible for Japan to break free from its critical stalemate concerning the pollution problems at that time. The successful outcome is entirely thanks to appropriate combination of "regulation" with "assistance" done by the government. As a specific organization to enforce government policy for rendering assistance, JEC has played the following roles.

Firstly, using a methodology in which JEC directly constructs facilities and transfers them to each applicant, JEC has corrected inappropriate land utilization, contributing greatly to conservation and improvement of the urban environment. The urban environment was improved by transferring factories and business offices, which had been randomly scattered in urban areas, to other areas suitable for their location or by constructing buffer green belts and park facilities to separate the factory area from the residential area.

It should not be forgotten that such transfer projects of JEC not only contributed to improving of the on-site environment but also played a leading role in the pollution control measures taken by private corporations. Going through trials and errors repeatedly, these pioneering project cases implemented by JEC provide excellent examples of techniques and methods when pollution control measure work is being done by a private corporation,

Secondly, JEC has played a leading role in supplying pollution control funds for industry. These funds supplied to date are said to correspond to about 10% of the total amount invested by Japanese industries for industrial pollution control.

When JEC started, private financial corporations were reluctant to loan installation funds for pollution control equipment, because the equipment did not directly contribute to promoting the productivity of manufacturers and was still immature. Consequently, JEC's financing system played a pioneering role in this field. Thereafter, accompanying the recognized importance of pollution control measures, these private financial corporations gradually expanded their loan frames toward this field, learning from JEC's actual results.

JEC's mandate has been revised and its organization has been reshuffled so as to cope with problems newly arisen along with environmental situation in Japan, for example, by the addition of new business and elimination of existing business of reduced significance. At present, JEC is engaged in new tasks such as appropriate treatment and disposal of industrial waste substances, protection of natural environment and conservation of global environment.

Shown in the table below are the conditions for implementing construction transfer program and financing program which JEC is now undertaking.

Table 1 - 1 Table of conditions for programs by JEC (Construction & transfer program)

(as of Jan. 1, 1996)

Name of facility for construction		Target	Down payment rate	Repayment period (incl. deferment period)	Deferment period	Interest rate (Annual interest %)
Group installation building		Small and medium scale industry or local government	5% or more	within 20 years	within 2 years	3.15
		Body other than above	10 % or more	within 20 years	within 2 years	3.15
Common welfare facility		Small and medium scale industry	5 % or more	within 20 years	within 2 years	3.15
		Local government	10 % or more	within 20 years	within 2 years	3.15
		Body other than above	15 % or more	within 20 years	within 2 years	3.15
Greenery area as air pollution measures		Local government	10 % or more	within 20 years	within 2 years	3.15
Industrial waste treatment facility provided with greenery area	Facility for treating waste from specific industry	Local government, Local public entities, or Public-private entities	10 % or more	Machinery : within 15 years Others : within 20 years	within 2 years	3.15
	Final disposal site provided with greenery area	Local government	10 % or more	within 20 years	within 2 years	3.15
Composite facility in National Park and Quasi-National park		Local government, or Public -private entities	10 % or more	within 20 years	within 2 years	3.15

Table 1 - 2 Table of conditions for programs by JEC (Loan program)

Facility or enterprise for loan	Target	Portion of loan	Repayment period (incl. deferment period)		Deferment period		Interest rate (Annual interest %)	
			Machinery	Others	Machinery	Others	3 years after loaning	4 years and onwards
Industrial pollution control facility (relating to common-use facility)	Small and medium scale industry or Local government (incl. air conditioning & heating in the community)	within 80%	within 15 years	within 20 years	within 2 years	within 3 years	3.15	
	Body other than above	within 70%					3.15	3.15
Industrial pollution control facility (relating to individual's facility)	Small and medium scale industry or Local government	within 80%	within 15 years		within 2 years		3.15	
	Body other than above	within 50%			1		3.15	
Industrial pollution control facility (Industrial waste treatment facility)	Local government	within 80%	within 15 years	within 20 years	within 2 years	within 3 years	3.15	
	Center or Local public entities	within 80%	within 15 years		within 2 years		3.15	
	Pubic-private entities						3.15	
	Small and medium scale industry						3.15	
	Body other than above	within 50%					3.15	
Business for soil pollution control in urban district	Small and medium scale industry	within 80%	within 20 years		within 3 years		3.15	
	Body other than above	within 70%					3.15	
Loaning business for installation of combined-type private sewage treatment tank	Local public entities, Public-private entities or Body set up under Article 34 of Civil Law	within 100 %	within 5 years		within 6 months		3.10	

2. Environmental Problem in Developing Countries, and JEC

Among developing countries, some countries and districts in the rapid economic growth are confronted with industrial pollution and urban environmental problems accompanying unprecedentedly violent changes of the existing structure of society. They appear to be in a common situation, the same one we experienced involving pollution and environmental problems in Japan.

To assist solving such problems, it seems useful to inform developing countries of Japan's experiences on pollution problem. In particular, the data accumulated by JEC are doubly significant, i.e., (1) Technical information on pollution control measures enforced in business, and (2) Management and business know-how as a financial organization specialized in pollution control.

As a part of its new mandate of "providing environmental information to overseas areas", JEC implements a new program of providing information on projects carried out to date and project operation know-how.

This program started in the 1992 fiscal year with investigation and research work to examine basic strategies for information transfer. Based upon the approved strategies, a report " Overview of Japan Environment Corporation (JEC) and Case Studies " (in Japanese and English) concerning JEC's functions and experiences, and cases of construction and transfer projects (Case files), was edited and sent to international organizations and governments of developing countries in the 1993 fiscal year. Financing project cases were summarized in data sheets and compiled in the electronic form in the data base. As from the 1994 fiscal year, these existing data sheets have been distributed in the printed form as well as in the diskette. In future, providing these data sheets through Internet is expected.

Since the 1995 fiscal year, as a part of this project, by extracting technical information about pollution control measures involved in the past financing and construction/transfer projects by industrial category, JEC has started to prepare a document summarizing technical guidelines. This document, translated into English, is expected to be widely used as a training text book, oriented toward administrative officials and environmental pollution managing engineers in developing countries. In the 1996 fiscal year, the first year of this program, the metal plating industry and the marine products processing industry, which produce significantly great amounts of pollutants especially from small- and medium-scale enterprises in the Asian region, have been selected for the target sector. The then-document entitled "Technical Manual on Industrial Pollution Control (Metal plating industry & Marine products-processing industry) ---- Based on project cases and investigation and research reports of Japan Environment Corporation (JEC) " is the product.

In May 1993, a "Global environmental fund" was established by contributions from the government and private bodies, and management of the fund was entrusted to JEC. Since then, using the management profits of the fund, JEC has been providing fund assistance and other support for environmental protection activities in developing countries conducted by domestic and overseas non-governmental organization (NGO). Although various kinds of projects such as nature conservation and environmental education and training are also eligible for JEC assistance, projects related to industrial pollution control include "International workshop on pollution control measures of small- and medium-scale corporations in Asian region" by the Overseas Environmental Corporation Center (Japan) (abbreviated as OECC, hereafter) and TechnoNet (Headquarter : Singapore), "Activities to provide Vietnam with information about experiences of environmental pollution and civilian activity in Japan" (Indochinese Civilian Corporation Center) and "Seminar on environmental problems, focusing on air pollution in India" (Association for Overseas Technical Scholarship, Japan).

The "Technical Manual on Industrial Pollution Control" was actually used as textbook in the training for leaders of small- and medium-scale industry in Asia concerning the plating waste management (Bangkok, Thailand, November 1996), sponsored by OECC and TechnoNet Asia. Moreover, some cases of small- and medium-scale industries devoting themselves to a high level environmental management were also introduced and it was reported that Japan needs to introduce to those people not only its experiences on pollution control but also the way as to how to tackle and solve the upcoming problems.

In order for Japan to further contribute to promoting the environment conservation in developing countries, it is considered necessary to render the technical support more positively in the form of proposition. However, the technical support should be reviewed by exchanging opinions with the readers so as to reflect their requests and suggestions. Then, the technical support may not be regarded only as transmission of information from Japan.

In implementing Japan's role in promoting the environmental conservation in developing countries, JEC would like to fulfill its function as an interface for the technical cooperation on the pollution control.

For further detailed information regarding the general JEC activities or publications, please do not hesitate to contact the following JEC Division.

International Corporation Division
Japan Environment Corporation
1-4-1 Kasumigaseki, Chiyoda-ku ,Tokyo 100
Tel : (033) 5251-1075, Fax : (033)3592-5056

3. General Approach to Industrial Pollution Control

When it was revealed that health hazards having occurred in a region in the past were attributed by the industrial pollution, an urgent need to take measures for the pollutant source was emphasized and the pollution control measures consequently started by arranging or strengthening emission regulations of substances which caused health hazards. This concept is now considered the starting point of "PPP" (Polluter-Pays-Principle). In the meantime, laws and regulations have been arranged for each media of emission source of pollutant such as effluent, exhaust air and solid waste, and measures for each media have been developed individually to meet such requirements. However, such methodology, in some cases, merely encourages the transfer of pollutants among media, and lacks efficient performance in reducing the total amounts of hazardous substances discharged into the environment. Furthermore, by examining the costs incurred by the installation and operation of facilities introduced as environmental measures for each individual media, it has also been disclosed that transfer of pollutants among media caused extra expenses.

Having undergone these experiences in various ways, industry managers have come to recognize the importance in the concept of management ; "Not only to control the discharge of pollutants in the final production process but also to reduce the generation of pollutants in the production process and to recycle it as secondary resources " or "Develop and adopt the production process which uses raw material containing less pollutants" .

This is the approach under the concept of "Cleaner Production" , in which comprehensive emission reduction program for the contaminants is to be studied, including the improvement in production process and change in operation method. Its superiority was gradually recognized in the history of pollution control in Japan as well as in other countries and it is now internationally recognized. In addition, attempts are ongoing so that the concept of environment management system (EMS) should be standardized internationally and that the environment-friendly factories should be accredited according to the international standard (ISO standards).

Following the regulatory system had been developed in Japan, approaches to the cleaner production were also implemented in addition to the emission regulations and consequently pollution in Japan has now been placed under control. Furthermore, recent effort is to keep pace with international coordination as regards the promotion of management concept based on above EMS.

Described in this section are organization and education for pollution control as well as emission regulations in Japan and its transition, and further descriptions are given as to how industry should deal with the pollution problem and how their operation and management should be recorded and controlled.

3. 1 Organization and Education for Pollution Control

Pollution control is an indispensable task for corporate management, and it is evident from the "polluter-pays-principle" (PPP) that the pollution problem should be primarily solved as the responsibility of the corporation itself. Furthermore, pollution control should be handled as part of the overall facility arrangement and operation plan in the factory including modification of the production process, not just as the matter of treatment facility. If pollution control is entirely entrusted to the personnel in charge of the job site, it is not effectively performed. It is important that the top manager of the corporation bears the highest responsibility for pollution control organization, which is to promote systematic pollution control through the corporation.

Of course, the top manager must plan not only adjustment of the production amount and product items with variations of the market, but also pollution control at source level; as well as planning the arrangement and the performance in maintenance of the treatment facility according to the production amount and product items. Moreover, taking into account the various available options, including the expansion of existing equipment and the installation of additional facilities as well as development of low pollution products and cleaner production processes and the renovation of facilities involving factory relocation to an industrial park of other site (possibly, in group), the top manager must make rational judgments about pollution control in the future.

Also, education of organization members, or all employees, is needed, to enlighten them about pollution control awareness. Of course, personnel in the pollution control division must be convinced of the importance of their operation. On the other hand, personnel in the production division must also be educated, considering the fact that proper management in the production process is indispensable for product quality control and good operation of the pollution control facilities. It may be particularly effective to let all personnel know the environmental implication of their operation, such as properties of chemicals used, appropriate use and storage of raw materials, contents of air emission and wastewater, and their influence on treatment facility and external environment, etc.

Business and industry, including transnational corporations, should recognize environment management as among the highest corporate priorities and as a key determinant to sustainable development. Some enlightened leaders of enterprises are already implementing "responsible care" and product stewardship policies and programs, fostering openness and dialogue with employees and the public and carrying out environmental audits and assessments of compliance. These leaders in business and industry, including transnational corporations, are increasingly taking voluntary initiatives, promoting and implementing self-regulations and greater responsibilities in ensuring their activities have minimal impacts on human health and the environment. (The portions of the original omitted.) The improvement of production systems through technologies and processes that utilize resources more efficiently and at the same time produce less wastes achieving more with less is an important pathway towards sustainability for business and industry. (Remainder omitted)

-----Excerpt from Agenda 21, Chapter 30, "STRENGTHENING THE ROLE OF BUSINESS AND INDUSTRY" , adopted at the United Nations Conference on Environment & Development (UNCED) (June 1992, Rio de Janeiro)

3.2 Need for Investigation at the Project Design Phase

It is desirable to conduct environmental impact assessment when new siting, relocating or expanding a factory, as well as renovating a factory, is planned and designed. By doing so, the present situation surrounding the factory can be understood and the sources and amounts of contaminants to be generated by the planned production processes can be estimated, and the technique for measures to be taken against these and the environmental influence, can be evaluated and, accordingly, and optimal measures can be selected to minimize adverse environmental influence under given conditions.

In this process, it is important not only to evaluate the external influence for the proposed plan but also to examine most suitable industrial locations and environmental control programs by combining various optional factors including comparison of multiple programs and change of the program itself.

Precisely conducted investigation at the design phase makes a remarkable contribution to successful environment control as well as to future business management. Accurate design can be achieved by correctly understanding the necessary information, such as up-to-date availability of technical options, estimated amounts of contaminants and allowable emission levels (including regulation trends in future). A facility designed by such a process will be able to exhibit its full functions in good condition, and even if a malfunction does occur, the cause will be so easily identified and analyzed that measures can be taken immediately. On the other hand, in a case where the necessary information is inaccurate and the installed facility is unsuitable, these deficiencies can occasionally cause critical condition in functions in the facility. In principle, such investigation should be done by the industry itself, but it can be done by entrusting to specialists such as consultant firms. Even though some expenses are unavoidable, they are generally a very small portion of the overall expenditures of the factory development and may be beneficial from the long-term point of view, taking into account the reduced expense for emission measures and the smooth proceeding of production in the future.

In the evaluation of production process and emission control techniques, it is also efficient to look for available data from the study of similar precedent cases. However, direct transfer of experiences in other regions is sometimes problematic due to the difference of geographical properties (district, climate), national conditions (infrastructure, labor market), and legal regulations and data analysis methods, Fact-finding investigation is indispensable for accurately understanding whether or no the target area to which the technique is transferred satisfies the basic design requirement for correct function of each technique.

Fig. 3-2-1 Typical Flow of Environmental Impact Assessment

Step 1 Identify Problems and Specify Alternatives
- State problems and requirements
- Nature and extent of each alternative

↓

Step 2 Assemble Available Data
- Collect data relevant to each site and process/operation alternative
- Reference to national/international lists of priority chemicals

↓

Step 3 Assess Staff Competence
- In-house sufficiency or external assistance required ?

↓

Step 4 Initial Impact Identification
- Review of site and construction/process alternativeness in relation to the available data on the existing environment
- Identification of impacts via an "interaction" matrix

↓

Step 5 Preliminary Assessment
- Application of Screening Test-are there any potential adverse impacts generated by the proposed developments ?

No. → No Further Assessment Required

↓

Step 6 Preparation & Execution of Detailed Baseline & Process Studies
- Define terms of reference for further environmental assessment tasks: appoint appropriate specialists
- Execution of detailed studies-data collection &analysis

↓

Step 7 Identification/confirmation of Potential Adverse Impacts
- On existing environment
- Initial consideration of appropriate constraints during construction and operational phases of the development

↓

Step 8 Impact Assessment
- Assessment of impacts of the project activities in terms of their exposure, nature, reversibility, directness and cumulative and synergistic effects

↓

Step 9 Summarize and Present Findings
- Summary sheet
- Provisions for follow-up surveillance and monitoring

Table 3-2-1 Typical Cause-Effect Matrix of Environmental Impact Assessment

CHARACTERISTICS OF THE EXISTING ENVIRONMENT	NATURE AND CHARACTERISTICS OF THE PROPOSED DEVELOPMENT A SITE PREPARATION AND CONSTRUCTION Industrial buildings and process structures Highways, roads and tracks Bridges Railways and sidings Transmission lines, pipelines and corridors Barriers, including fences Channel dredging and straightening Canals Dams and impoundments Deepwater ports and marine terminals Blasting and drilling Underground works Surface excavation, incl. cut and fill Land clearing, incl. burning Surfacing or paving Erosion control and terracing Landscaping Noise and vibration	B PROCESS OPERATIONS Cooling water discharge Liquid effluent - industrial and domestic Water demand Septic tanks - domestic and industrial Stack and exhaust emissions Spent lubricants Noise and vibration Odour	C RAW MATERIAL HANDLING Dust Stockpiling Noise and vibration	D ENERGY PRODUCING OPERATIONS Atmospheric emissions Cooling water discharge Liquid effluent Water demand Stockpiling of materials Noise and vibration	E TRANSPORTATION REQUIREMENTS Highways, roads and tracks Bridges Railways and sidings Shipping	F ACCIDENTS/HAZARDS Explosions Spills and leaks Operational failures	G WASTE DISPOSAL AND CONTROL Landfill, spoil and overburden Solid waste disposal
1 CLIMATE AND AIR QUALITY Wind directions and speeds Precipitation/humidity Air quality							
2 WATER Hydrological balance Groundwater regime Drainage/channel pattern Sedimentation Flooding Water quality Surface waters							
3 GEOLOGY Unique/special features Tectonic/seismic activity and volcanic activity Mineral resources Physical/chemical weathering Landslide Subsidence							
4 SOILS Erosion (wind and water) Slope stability Liquefaction Bearing capacity Settlement/heave Earthworks Soil structure							
5 ECOLOGY Species checklists Plant communities Diversity (species and spatial) Productivity Biogeochemical/nutrient cycling							
6 ENVIRONMENTALLY SENSITIVE AREAS Prime agricultural land Forestry land (silviculture) Wetlands/estuarine and coastal zones Landfills (solid/toxic waste disposal sites)							
7 LAND USE AND LAND CAPABILITY Land use Land capability							
8 NOISE AND VIBRATION Noise Vibration							
9 VISUAL QUALITY							
10 ARCHAEOLOGICAL, HISTORIC AND CULTURAL ELEMENTS Archaeological structures and sites Historic/cultural structures, sites and areas							

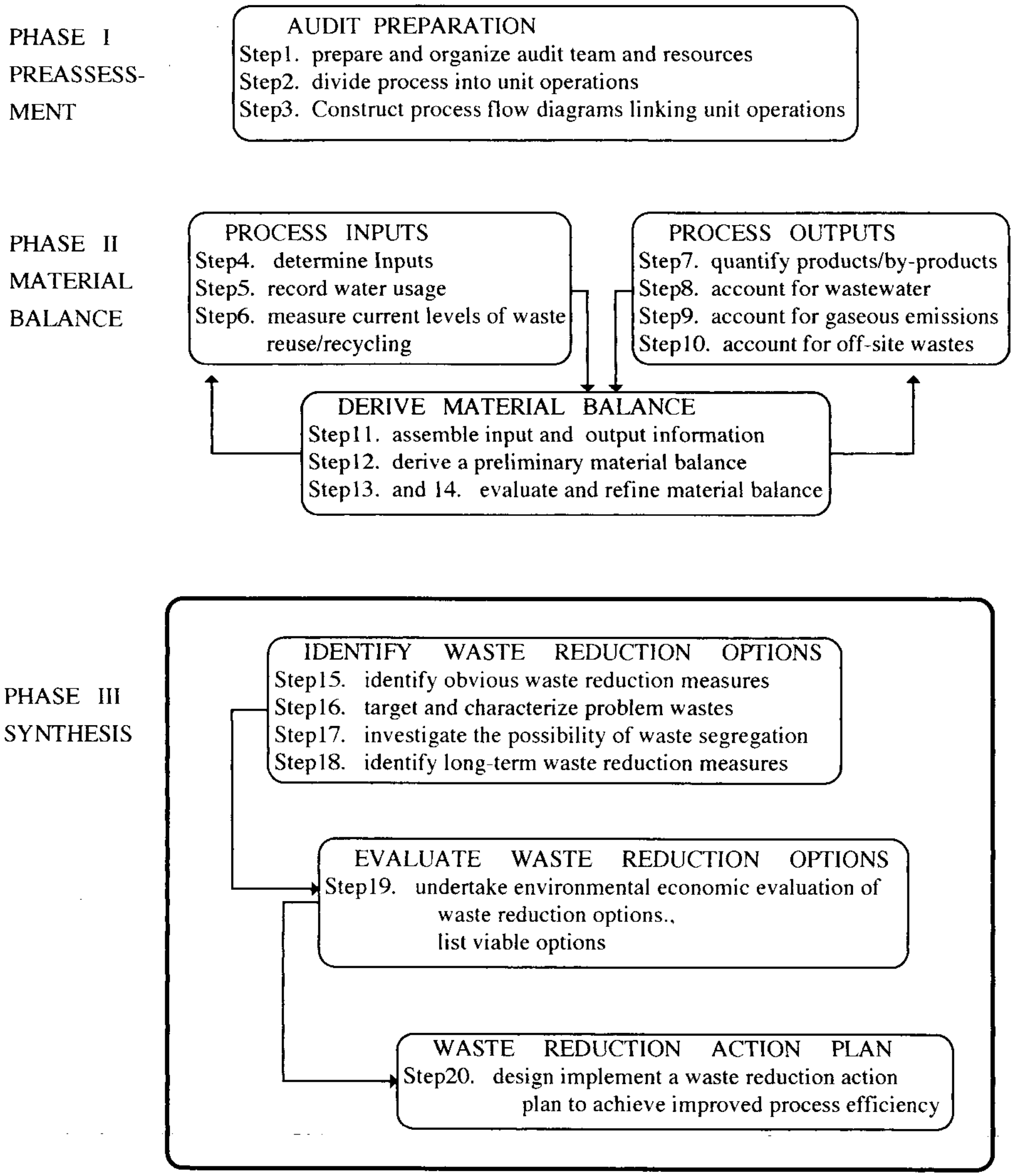
3. 3 Monitoring and Management

The discharge of pollutants from a factory must be regularly measured and recorded and then reported to an authority. Such procedures are legal requirements in many countries. Inspection of fulfillment of legal requirement such as emission standards is a minimum task, but the most important is to examine the present state of the ongoing environmental control program and the outcome thereof in the light of the objectives initially set up. Such a procedure has further significance: it reveals whether or not the environmental impact assessment in the preliminary investigation was correctly carried out. If the objectives are inadequately attained, revision of environmental control program and procedures is required.

Even if legal requirements are not involved, voluntarily conducted monitoring and recordings are very useful for the factory itself. Namely, if discharge data is abnormal, abnormality of the treatment facility as well as abnormality of production process operated in the factory can be readily detected. By doing so, not only unfavorable influence on the external environment can be immediately avoided, but stable product quality can be maintained. Moreover, basic data can be collected so that uneconomical segments of the factory operation and resources can be identified and the facilities would be modified in the future for improving product quality and saving on production cost.

An environmental audit is composed of systematized procedures described above. As a management tool, an example of the audit process, advocated by UNEP/UNIDO, is shown on the following pages.

Fig. 3-3-1 Audit of pollution and waste discharge and processes for their reduction according to UNEP/UNIDO



3. 4 Technical Options for Industrial Pollution Control

3. 4. 1 End-of-Pipe Technology and In-Process Technology

Since environmental regulations in Japan are oriented toward each medium (water, atmosphere, solid waste) which contains pollutants, industrial pollution control measures have progressed individually to cope with these separate regulations. These measures which apply so-called "end-of-pipe technology" were effective to the extent that the necessity of taking control measures against sources of pollutants was first recognized, that discharge treatment technologies were developed and at the same time, emergent avoidance of the further progress of the serious environmental pollution was secured. However, application of the end-of-pipe technology always require additional investment to the production facility, and continuous costs for operation and maintenance. Another disadvantage of "end-of-pipe technology" is transfer of contaminants among environmental media, or generation of secondary pollution; for example, wastewater treatment may produce another pollution as regards solid waste disposal associated with sludge management.

On the contrary, pollution control through the application of in-process technologies (that is, through the review of raw material and processing technology, the production process itself is improved, rationalized or replaced.) enable simultaneously resource and energy conservation and also contributes to the production cost saving. The fact that such an approach called "Cleaner Production (CP)" is far more effective has already been proved in the experiences of industrial pollution control in most developed countries.

Also, In Japan where serious industrial pollution was experienced, it was the Cleaner Production technology that solved such pollution problems, and consequently the CP technology could simultaneously achieve improvement in product quality and reduction of production cost as well as reduction of discharges. Decisive factor having contributed to terminate the pollution incidents such as organomercury contamination in Minamata(Kumamoto Pref.) and pulp and paper effluent contamination in Tagonoura (Shizuoka pref.) was not the installation of treatment facility applying the end-of-pipe technology but the implementation of comprehensive measures for improvement of the facilities including the replacement of production process. These can be taken up as the most obvious examples. In Japan, moreover, Cleaner Production has substantially been implemented in association with the severe competition among enterprises which aim at reduction of production cost and enhancement of product quality.

Cleaner Production concept have also helped promote group location and joint treatment system in the transfer program of JEC.

In the financing project of JEC, "effectiveness from management viewpoint" have been considered as important criteria in screening the funding target since its early days. Not only removal of hazardous substances, but also general rationalization of management and effective utilization of resources by improving the process, are considered to be essential factors for pollution control measures. It is conceivable that the coexistence of pollution control measures with economic development in Japan has been realized by consistently maintaining such a philosophy.

Regulations themselves are changing as an international trend. Instead of controlling the emissions in each medium (such as water, atmosphere, solid waste emissions) by different laws or specific emission standards, the methodology called the integrated approach is becoming the mainstream. In this approach, each factory is evaluated for its environmental management system, production process and pollution control facilities, according to the technical and economic constraints and environmental requirement, and operational permission is considered. Such an approach is particularly important in the developing countries that should promote development and achieve sustainable growth.

3. 4. 2 Group Location and Transfer

It is often difficult to install additional treatment facilities for the existing process in the restricted space and available solutions may be limited for enforcement of pollution control on corporations randomly scattered in a residential-commercial region. In some cases, it may be more efficient to transfer these corporation, as a group, to an industrial park where individual treatment facility sites are secured or a joint treatment facility is prepared. Characteristically, this simultaneously solves problems of air emission and waste water as well as noise and vibration problems.

In many cases, these transferred corporations can improve their production efficiency by introducing new processes, rationalizing facility lay-out and expanding work space, so that this transfer project contributes greatly not only to pollution control but to the modernization and rationalization of these corporations. Moreover, improvements of the urban environment are expected to be much more effective when the acquisition of transfer sites and the utilization of sites remaining after transfer are implemented in relation to city planning programs.

On the other hand, the projects for grouping and joint installation of factories have the following problems.

1) Increase in project-fund scale
2) Land acquisition difficulties
3) Raw materials and products must be transported for long distance
4) Commuting of employees

JEC's industrial park construction and transfer projects are as follows: A cooperative association is organized by small-scale factories which are having difficulty in taking pollution control measures immediately. After JEC secures a new site for the industrial park and constructs factory buildings and pollution control facilities at site, these are transferred to the cooperative association. Each corporation constituting the cooperative association repays the expenses of constructing these facilities in long terms and is under obligation to use the site remaining after the factory transfer for housing and offices which cause no pollution problems. At the new site, not only are the environmental protection promoted by securing a site for the pollution control facility or by installing a joint pollution control facility there, as described in the next paragraph, but also the creation of new production circumstances such as the ensuring of greenery and amenities in the factory park, is planned. The local government plays important roles in such areas as selection/acquisition of the new business site and guidance/co-ordination for utilizing the former sites.

3.4.3 Individual Treatment System versus Joint Treatment System

As measures for treating discharges such as air emission containing smoke/soot and toxic gas, wastewater, and solid waste associated with the operations at factories and work sites, installation of a pollution control facility jointly by a group of corporations may be more advantageous than installing individual facilities by each corporation. The following advantages are possible merits of joint facilities.

1) Joint facility saves space.
2) Construction of a large facility is economical due to the advantage of scale. Joint-enterprise enhances reliability so that its fund raising ability is improved.
3) Joint work saves on operation costs. Expert operators and technicians are easily secured.
4) The treatment techniques and facility are easily upgraded.
5) By mixture and interaction of discharge from different sources (cf. improving quantitative and qualitative steadiness, dilution, neutralization, complementation of nutrients, etc.), treatability is improved.

On the other hand, some disadvantages are observed, as follows:

1) Since the discharge is concentrated at a specific site, its environmental influence is intensely localized. Sometimes, an advanced treatment facility is needed, and consequently its construction cost is rather more than expected.
2) Since the cost of laying the waste water collector conduits is rather high, this offsets the advantage of saving construction cost.
3) It is not easy to formulate a fee system that satisfies every participant corporation as well as providing incentive for motivating corporate efforts to reduce the pollution load. Consequently, a joint treatment facility does not always result in saving of running cost.
4) Mishandling by one corporation among participants can interrupt operation of the joint treatment facility. During the recovery time, operation of all participant corporations may have to be at standstill. Sometimes, it is difficult to identify the source of trouble and to take measures for preventing recurrence.
5) Freedom of production operation is restricted. (Changes of operation time and product inventory/processes in an individual corporation may be restricted by the operation time and performance of the joint treatment facility.)
6) The individual corporation's awareness of responsibility for pollution control may be decreased.

The joint pollution control facility construction and transfer projects by JEC focused on the advantages of joint treatment. Including the pioneering project first implemented, remarkable achievements have been made since 1965. However, as pollution control activities have spread, the technical ability of private corporations has been improved and a number of consultants and manufacturers with relevant experts have been established. Accordingly, as far as conventional pollution control measures are concerned, this trend has enabled even small-and-medium scale corporations to independently implement pollution control measures either by themselves or by hiring specialist contractors . The disadvantages of the joint treatment system are being emphasized later and the system has not often been applied since 1985.

3.5 Benefits from Pollution Control Activities

Environmental measures with focus on Cleaner Production, if they are implemented, will enable to enhance productivity, convert waste into valuables, rationalize water and it will further make it possible to lessen technical and economic burden which has been required in the wastewater and waste treatment. Consequently, environmental measures, in addition to pollution control, will result in an improvement in terms of economy and can attain a variety of benefits listed below:

1) Benefits from Cleaner Production

- Stabilization and improvement of quality under technical management
- Improvement of yield

  Yield is raised by reducing losses of raw materials and products.
- Production of valuables as by-product

  Raw materials and products which has conventionally been discarded as waste are converted into valuables and the cost required for treatment and disposal is minimized.
- Rationalization for use of water

  Expenses required for use of water and wastewater disposal are reduced.
- Energy conservation

  Energy is recovered from waste gas, thermal discharge and high calorific waste.
- Reduction of pollution load on wastewater treatment, etc.

  Not only pollutants are reduced in quantity but also pollutants persistent in the subsequent treatment process are reduced.
- Saving on waste treatment and disposal

  Excess sludge from wastewater treatment and other waste are reduced.
- Improvement in terms of economy

  Improvement in terms of economy is substantially attained even by deducting the installation cost and labor needed for Cleaner Production..
- Energy conservation

  Less utilization or effective utilization of the limited resources is achieved.

2) Benefits of wastewater treatment

- Protection of water quality in public water area receiving effluent discharge
- Enhancement in reliability towards corporations
- Extermination of sanitary insects

3) Benefits by measures for offensive odor

- Protection of working environment
- Avoidance of offensive odor in the near-by area of the factory

4. Industrial Pollution Control and Technology

4.1 Emission Control Regulations and Trend in Japan

Pollution problems in Japan stems from an old era approximately a century ago when the government started to promote national industrialization, and during this period, major pollution problems were with the mining industry. Since the pollution problems with the industry developed a grave serious public concern, measures started being taken under enforcement of the "Mining Industry Law" and the "Mine Safety Law".

In the meantime, in the general industrial pollutions other than that in the mining industry, noise, soot & smoke, sewage gradually became a target of complaint along with rapid industrial development. However, due to that citizen's consciousness of human rights was still low and besides, Japan soon rushed into the military governance with the World War II, pollution problems hence did not come out to the primary concern of the Japanese people until the World War II came to an end. Ten years after the war were the days to restore Japanese industries, and the scale and contents of environmental pollution were regarded as merely continuation from the prewar days although some local governments attempted to establish pollution control ordinance.

As Japanese economy made great strides, problems such as air pollution, water contamination and noise became coincidentally recognized. In particular, the conversion of energy from coal to petroleum and subsequent formation of petrochemical complexes as well as densely developed heavy chemical industry brought forth air pollution and water contamination caused by sulfur oxides in a wide range. Moreover, rapid concentration of population into cities and advancement in people's consumption standard created, so-called, urban pollution.

In order to cope with such situation, pollution control laws and regulations started to be developed. Environmental infrastructures started to get deployed by enactment of "Cleaning Service Law" in 1954 and "Sewerage Law" in 1957. From the pollution control aspect, "Law relating to Preservation of Water Quality in Public Water Area" and "Law relating to Restriction on Factory Effluent, etc." were established in 1958, with wastewater accident by a paper mill as the turning point. Later in 1962 "Law relating to Restriction on Emission of Soot & Smoke" was established.

During the period from 1955 to 1965, as described above, laws were enacted to restrict air pollution, water pollution, ground subsidence, etc. and administrative measures were taken against pollution. However, these administrative measures were to independently cope with individual case of pollution and besides, they were only emergency and temporary means, being incapable of fully dealing with violently growing pollution problems. With these circumstances as background, JEC was established in 1965 as a financial institution to promote pollution control efforts and in 1967 furthermore, the "Basic Law for Environmental Pollution Control" was enacted in order to promote the planned and comprehensive pollution control administration. Together with these laws, the administrative system for promoting the comprehensive pollution control activities was developed and various laws and regulations were either enacted or revised under this system. That is, "Air Pollution Control Law" and "Noise Control Law" were established.

In the end of 1960s general framework on the jurisdictional system for pollution in Japan was constructed as stated above. Nevertheless, as the Japanese economy marked further rapid expansion, pollution problems increased in their varieties and new pollution problem which are not covered by the existing laws, emerged one after another. Also, geographical coverage of pollution problems expanded to cover almost everywhere in Japan. In 1970, pollution problems relating to air pollution and water contamination occurred even more frequently, the situation was regarded so serious that it could no longer be left unattended. In the so-called "Pollution National Diet" held in November 1970, the "Basic Law for Environmental Pollution Control" was revised. Later in 1971 the Environment Agency was created in an attempt to centralize the pollution control administration which had been handled by different administrative organizations. Meantime, in 1970 an institute regulating absolute liability for compensation for damages was introduced for the case which involves air pollution and water contamination.

After above-mentioned history, Japan has now overcome intense industrial pollution which has long been regarded as a national concern. Subsequently as environmental problems changed its style from industrial pollution to life style-originated problems and global environmental issues, it became obvious that the "Basic Law for Environmental Pollution Control" had its limitation in dealing with such problems and in 1993, therefore, the "Basic Law for Environmental Pollution Control" was drastically revised to be given a birth as the "Basic Environment Law".

4.1.1 Water Pollution Control

(1) Control target

As was referred to in the section 3.1, it was December 1958 when Japan first set up a law and started the control over factory effluents and the conservation of quality in public water area. The laws enacted at that time were "Law relating to Restriction on Factory Effluent, etc."

(Factory effluent law) and the "Law relating to Preservation of Water Quality in Public Water Area " (Water Quality Preservation Law). Since the present "Water Pollution Control Law " was enacted in 1970, above two are called the "Former two laws on water quality" .

These former two laws on water quality designated the water areas and types of industry to be controlled and thus, emission standards were established for each target. However, the water area and types of industry to be controlled were not always designated smoothly and some opine hat that the former two laws on water quality did not contribute to successful prevention of the water pollution in the public water area.

By incorporating above opinion, the present "Water Pollution Control Law" enacted in December 1970 basically covers emission control almost uniformly over the whole country, being provided with the following characteristics.

1) Designation of target water areas under the former two law on water quality was abolished and instead, whole public water area is designated as target area of control.
2) Direct punishment system is introduced in order to enforce the parties concerned to intensively and forcibly comply with the emission standards.
3) Authorities are transferred to each prefectural government and at the same time, its governor is entitled to specify the stricter standards than the one specified by the nation (More stringent standard).
4) Monitoring and measuring organization for water quality in public water area are to be arranged.
5) Authority for on-site inspection to monitor and measure the wastewater quality is to be arranged.
6) Establishment of wastewater standards and step to strictly and forcibly comply with its standard are basically incorporated into the present "Water Pollution Control Law" .

As Table 4-1-1 shows, the "Water Pollution Control Law" has five categories for the effluent standards. Applicable target is determined according to the type of industry, area, scale of facility and item to be regulated. The aim of the law by setting forth regulations in detail is that the concerned parties more readily correspond to the regulations specified under the law.

The " Specified facility" stipulated under the "Water Pollution Control Law " shall be the facility which discharges sewage or wastewater having either one of following condition 1) or 2) and further be designated under the government ordinance. These conditions are specifically described in the separate Table -1 (item 4 among those from 1 to 71) in enforcement ordinance for the " Water Pollution Control Law" .

1) To include the substances designated by the government ordinance, such as cadmiüm, etc. which may possibly cause hazards to human health.

2) To include the pollutants designated under government ordinance, as indexed by the chemical oxygen demand etc.(including that due to heat, but excluding substances specified under the preceding item) to the extent that may possibly cause hazards to living environment.

Table 4-1-1 Water pollution control standers for industrial effluents

	Type of industry	Object area	Scale of facility	Parameters
Uniform standards	All types of industry	Nation-wide public water area	Specified under the law	· Items related to living environment · Hazardous substances
Provisional standards	Industry recognized incapable of meeting uniform standards at enactment of law		Specified under the law	· Items related to living environment · Hazardous substances
Standards for area-wide pollutant load control		Area specified under the law (Within Tokyo Bay, Ise Bay, Seto Inland Sea area)	Specified under the law	· Designated substance (COD)
More stringent prefectural standards		Area specified under Prefectural Ordinance, requiring stringent control to achieve environmental standard	Specified under the law	· Items related to living environment · Hazardous substances
Additional controlling standards		Area specified under Prefectural Ordinance, requiring stringent control to achieve environmental standard applied by prefectural government	Specified under the law	Items not specified under the present environmental standards

(Note) Among the items related to living environment, control of nitrogen and phosphorus is limited to the wastewater being discharged into public water area (lakes and ponds or sea area) specified by the Director of Environment Agency

(2) Effluent standards

(a) Uniform standards

The effluent standards by the Water Pollution Control Law are set under the two categories; standard for hazardous substance and items relating to living environment. This standard is uniformly specified nation-wide under the ordinance of Prime Minister's Office against the effluent (to be discharged from the specified facility to the public water area), and is called uniform standards. Please refer to the next Table 4-1-2 and Table 4-1-3 for the uniform effluent standard values for the hazardous substances and the uniform effluent standard for the living environment -related items. Uniform effluent standards for the items related to living environment are not applied to the effluent from the specified factory where daily average effluent volume is less than 50 m^3. It should be noted that COD specified under the Japanese law means COD_{Mn} and unless specifically remarked, COD always means COD_{Mn} in this report.

The standard values for both hazardous substances and living environment items shall be the permissible value specified for each item. The level of standard values shall, in principle, be at a level 10 times the environmental standards relating to ambient water quality. This derives from an assumption that effluents, if they are discharged into the public water area, would normally be diluted to approx. 10 times or so at least by the river water, etc. streaming in the area concerned.

With regard to the level of uniform effluent standard values for the living environment-related items, the contents of BOD, COD, SS, nitrogen and phosphorus are specified to be equal to the numeric values which are obtained by treating general household sewage under simple settling process.

This is based on the concept that household sewage was not taken up as a pollution source although it has continuously been discharged into rivers and streams ever since old times.

Table 4-1-2 Uniform effluent standards relating to hazardous substance

Hazardous substances	Standard values	Remark
Cadmium and its compounds	0.1(mg/l) for Cd	Established in 1971
Cyanide	1 (mg/l) for cyanide	" in 1971
Organic phosphorus (limited to parathion, methyl parathion and EPN)	1 (mg/l)	" in 1971
Lead and its compounds	0.1 (mg/l) for Pb	" in 1971
Chromium (VI) compounds	0.5 (mg/l) for Cr(VI)	" in 1971
Arsenic and its compounds	0.1 (mg/l) for As	" in 1971
Mercury, alkyl mercury and other mercury compounds	0.005 (mg/l) for Hg	" in 1971
Alkyl mercury compounds	Not detectable	" in 1971
PCB	0.003 (mg/l)	" in 1975
Trichloroethylene	0.3 (mg/l)	" in 1989
Tetrachloroethylene	0.1 (mg/l)	" in 1989
Dichloromethane	0.2 (mg/l)	" in 1994
Carbon tetrachloride	0.02 (mg/l)	" in 1994
1, 2-Dichloroethane	0.04 (mg/l)	" in 1994
1, 1-Dichloroethylene	0.2 (mg/l)	" in 1994
cis-1, 2-Dichloroethylene	0.4 (mg/l)	" in 1994
1, 1, 1-Trichloroethane	3 (mg/)	" in 1994
1, 1, 2-Trichloroethane	0.06 (mg/l)	" in 1994
1, 3-Dichloropropane	0.02 (mg/l)	" in 1994
Thiuram	0.06 (mg/l)	" in 1994
Simazine	0.03 (mg/l)	" in 1994
Thioben	0.2 (mg/l)	" in 1994
Benzene	0.1 (mg/l)	" in 1994
Selenium and its compounds	0.1 (mg/l) for Se	" in 1994

Table 4-1-3 Uniform effluent standards relating to living environment items

	Standard values	Remark
Hydrogen ion concentration (pH) Discharge into water area other than sea Discharge into sea	 5.8～8.6 5.0～9.0	Established in 1971
Biochemical oxygen demand (BOD)	160 (mg/l) (Daily average 120 mg/l)	" in 1971
Chemical oxygen demand (COD_{Mn})	160 (mg/l) (Daily average 120 mg/l)	" in 1971
Suspended solids volume (SS)	200 (mg/l) (Daily average 150 mg/l)	" in 1971
n-Hexane extracts Mineral oil content Animal and plant oil/fat content	 5 (mg/l) 30 (mg/l)	" in 1971
Phenol content	5 (mg/l)	" in 1971
Copper content	3 (mg/l)	" in 1971
Zinc content	5 (mg/l)	" in 1971
Soluble iron content	10 (mg/l)	" in 1971
Soluble Manganese content	10 (mg/l)	" in 1971
Chromium content	2 (mg/l)	" in 1971
Fluorine content	15 (mg/l)	" in 1971
Coliform group number	Daily average 3,000/cm^3	" in 1971
Nitrogen content	120 (mg/l) (Daily average 60 mg/l)	Applied in 1985 (Rivers & streams) Applied in 1993 (Sea)
Phosphorus content	16 (mg/l) (Daily average 8 mg/l)	" in 1985 (Rivers & streams) " in 1993 (Sea)

(Note) Because nitrogen and phosphorus are feared to cause extensive proliferation of phytoplankton, effluent standards for these substances were applied only to the areas designated by the Director General of Environment Agency, namely, lakes, ponds and, sea and other public water area which flows into lakes, ponds or sea. Consequently, applicable lakes and ponds were designated in 1985 and the designated sea was set in 1993.

(b) Provisional standards

Provisional standards are applied to the industries which, at enactment of the relevant law, are recognized having difficulties to properly observe the uniform standards. For such industries, standard values are provisionally set for each water quality parameter for a limited duration. Table 4-1-4 shows the provisional standards (except nitrogen and phosphorus) relating to the living environment items such as BOD and COD. Only for 5 years starting on June 24, 1971 when uniform standards were enforced under the Water Pollution Control Law, less stringent standards than the uniform standards were applied to the provisional standards relating to the living environment items. Years have passed since 1971 to the present and thus, the provisional standards have now been switched over to the uniform standards. For all types of industries, the provisional standards relating to the living environment items such as BOD and COD have now been switched over to the uniform standards.

However, the standards for nitrogen and phosphorus were applied in a different way; Uniform standards were later applied to lakes, ponds and the sea, thereafter, provisional standards were set. In 1985, the provisional standards were applied to the lakes and ponds designated by the Director General of Environment Agency as those which are feared to most easily cause proliferation of phytoplankton, as well as to the effluents which are discharged into public water areas flowing into above mentioned lakes and ponds. Provisional standards established at that time was shown in the Table 4-1-5 as transition to the present, but they have now been switched over to the uniform standards. Furthermore, in 1993 the uniform standards for nitrogen and phosphorus were applied to the designated sea area as well and as Table 4-1-6 shows, the provisional standards were set toward certain types of industries for the limited duration.

Table 4-1-4 Provisional standards (1)
(applied for 5 years as from June 24, 1971, abbreviation: daily average= d.a.)

Parameters	Category and Classification of Industry	Emission standard(mg/l)
BOD	Marine foods mfg. ind.	390(d.a.300)
	Marine foods mfg.ind.&Frozen marine product mfg. ind.	780(d.a.600) up to 6/23,1973 260(d.a.200) up to 6/24,1973
	Fish meal feed mfg.ind.	780(d.a.600)
	Frozen minced fish meat mfg.ind. & Fresh minced fish mfg.ind.	1,800(d.a.1,400) up to 6/23,1973 780(d.a.600) as from 6/23,1973
	Distilled liquor and compound liquor mfg.ind.	1,000(d.a.800) up to 6/23,1973 780(d.a.600) as from 6/23,1973
	Dissolved sulfite pulp mfg.ind.	1,000(d.a.1,200) up to 6/23.1974 780(d.a.600) as from 6/23,1973
	Core chemi-ground wood pulp mfg.ind.,Core semi-chemical wood pulp mfg.ind. & bleached straw wood pulp mfg.ind.	1,300(d.a.1,000) up to 6/23,1973 780(d.a.600) as from 6/23.1973
	White potato starch mfg.ind.	20,000(d.a.16,000) from Jan.to Mar. 780(d.a.600) from Apr.to Dec.
	Gelatin, adhesive mfg.ind., Tanned skin mfg.ind. & leather mfg.ind.	2,300 (d.a.)
	Sweet potato starch mfg.ind.	3,100(d.a.2,400) up to 6/23,1973 2,300(d.a.1,800) as from 6/23,1973
COD_{Mn}	Natural gas mining ind.,Marine foods mfg.ind.., Canned fruits mfg.ind.,Tomato processing & mfg. ind.,Miso mfg.ind., Sodium glutamate mfg.ind., Yeast mfg.ind., Spinning &weaving ind., Scoring ind. Dyeing finishing ind., Craft pulp mfg.ind.& Laundry	260 (d.a. 200)
	Marine canned foods mfg.ind.and Frozen marine product mfg.ind.	650(d.a.500) up to 6/23,1973 260(d.a.200) as from 6/23,1873
	Beet sugar mfg.ind.	520(d.a.400) from Jan. to Mar. 260(d.a.200) from Apr. to Dec.
	Fish meal feed mfg. ind., Lime straw pulp mfg.ind. and Ethyl alcohol mfg.ind.	780 (d.a. 600)
	Frozen minced fish meat & fresh minced fish meat mfg.ind.	1,600(d.a.1,200)up to 6/23,1973 780(d.a.600) as from 6/23,1973
	Distilled liquor & compound liquor mfg.ind. Sulfite pulp mfg.ind.	1,000(d.a.800) up to 6/23,1973 780(d.a.600) as from 6/23,1873
COD_{Mn}	White potato starch mfg.ind.	20,000(d.a.16,000)from Jan.to Mar. 780(d.a.600) from Apr. to Dec.
	Coal mining ind & Coal washing ind	1,000 (d.a. 800)
	Dissolved sulfite pulp mfg.ind.	1,800(d.a.1,400) up to 6/23,1973 1,000(d.a.800) as from 6/23,1973
	Gelatin, adhesives mfg.ind., Tanned skin mfg. and leather mfg.ind.	2,300(d.a.1800)

	Sweet potato starch mfg.ind.	3,100(d.a.2,400) up to 6/23.1973 2,300(d.a.1,800) as from 6/23,1973
SS	Coal mining ind., Lignite mining ind., Coal washing ind., Crude oil mining ind., Non-metallic mining. ing. Agar mfg.ind., Frozen marine product mfg. ind.,Distilled liquor &Compound liquor mfg. ind., Fish meal mfg. ind., Soybean curd mfg. ind., Bread & cake mfg. ind., Bean paste mfg. ind., Silkworm cocoon and silk mfg. ind., Bleached straw pulp mfg.ind., Ethyl alcohol mfg. ind., Gelatin & adhesives mfg. ind., Ceramic-use earth mfg. ind., Minerals , muddy stone crushing & processing ind., Dead animals processing plant &Slaughter house, Sweet potato starch mfg. ind. Coal straw pulp mfg. ind., Waste oil disposal ind	330 (d.a. 250) 650 (d.a. 500)
	White potato starch mfg. ind.	5,500(d.a.6,500) from Jan. to Mar. 330(d. a.250) from Apr. to Dec.
	Coal mining ind., Coal washing ind. and non-metallic ind.	26,000(d.a.20,000) up to 6/23, 1973 10,400(d.a.8,000) as from 6/23, 1973
n-Hexane extracts (Mineral oil content)	Gas ind	10 up to 6/23, 1973
	Non-metallic, non-metallic alloy rolling ind., Electric cable mfg. ind., Metal product mfg. ind. ,General machines & tools mfg. ind. ,Electric machines & tools mfg. ind., Transport machines & tools mfg. ind., Precision machines & tools mfg. ind. and Waste oil disposal business.	10
	Crude oil mining ind., Natural gas mining ind., Automobile fuel oil retail business, Railway ind. Road passenger transport ind. and Automobile repair ind.	20
n-Hexane extracts (animal and vegetable oil & fat content)	Marine foods mfg. ind and Fishmeal mfg. ind.	
	Meat product mfg. ind., Dairy product mfg.ind. Spinning & weaving ind.	50
	Scoring ind., Pulp mfg. ind., Gelatin, adhesives mfg. ind., Tanned skin mfg. ind., Leather , mfg. ind. and Laundry	50
Phenol content	Gas ind.	10 up to 6/23, 1973
Zinc content	Artificial silk mfg. ind., Electric plating ind. and Galvanized iron plate mfg. ind.	10
Soluble iron content	Metal mining ind. and Non-metallic primary refining & finishing ind.	50
Soluble manganese content	Metal mining ind. and Non-metallic primary refining & finishing ind.	50

Chromium content	Gelatin, adhesives mfg. ind., Tanned skin mfg. ind. and Leather mfg. ind	60
Fluorine content	Hydrogen fluoride mfg. ind. and Aluminum primary refining and finishing ind.	25
Coliform group number	Dead animals processing ind. and Slaughter-house	d. a. 30,000 (piece/cm^3)

Table 4-1-5 Provisional standards (2)
(applied for 5 years as from July 15, 1985. abbreviation : daily average= d.a.)

Parameters	Category and Classification of Industry	Emission standards (mg/l)
Nitrogen	Raw medical powder mfg. ind., Raw medical solution mfg.ind,Semi-conductor element mfg. ind. and Integrated circuit (IC) mfg. ind.	140 (d. a. 70)
	Livestock foods mfg. ind.(excl. meat product mfg. ind. and dairy product mfg. ind.), Seaweeds processing ind., Pasted marine product mfg. ind., Frozen marine foods mfg. in., Sugar mfg. ind.(excl. Sugar refinery ind.), Baking powder, yeast and other yeast agent mfg. ind., Grain starch mfg.ind, Uncompound feed mfg. ind., Organic feed mfg. ind., Ammonium alum mfg. ind. and Sewage service (to be applied only to the facility equipped with night soil charging equipment)	180 (d. a. 90)
	Electric machines & tools mfg. ind. for power generation, power distribution and industrial use Private-use electric machines & tools mfg. ind., Bulb mfg. ind., Industrial waste treatment ind. (For detail, refer to stipulations in laws and regulations.)	240 (d. a. 120)
	Marine foods mfg. ind. (excl. Seaweeds processing ind., Fish meat ham & sausage mfg. ind., Pasted marine product mfg. ind. , Frozen marine product mfg. ind.), Dyeing finishing ind, Phosphorus & phosphorus compound mfg. ind., Dead animals processing and slaughter house	300 (d. a. 150)
	Highly pure aluminum mfg. ind., Hot dipping galvanized plating ind.	400 (d. a. 200)
	Natural gas mining ind., Potato starch mfg. ind., Glue mfg. ind., Gelatin mfg. ind., Anodized aluminum processing ind. and Night soil purifying tank (For detail, refer to stipulations in law and regulations.)	500 (d.a. 250)
	Parts mfg.ind. for electronic and communication apparatus (excl. electronic tube mfg. ind., semi-conductor element mfg. ind. and IC mfg. ind.)	600 (d. a. 300)

Nitrogen	Livestock agricultural ind., Tanned leather mfg. ind. and Fur mfg. ind.	700 (d. a. 350)
	Electric plating ind. (excl. steel plating ind.) and Battery mfg. ind.	800 (d. a. 400)
Phosphorus	Industrial waste treatment ind. (For detail, refer to stipulations in laws and regulations.)	20 (d.a. 10)
	Dairy product mfg. ind., Frozen marine product mfg. ind., Vegetable pickles mfg. ind. (excl. vegetable pickles in cans, bottles and pots), Miso mfg. ind., Sugar mfg. ind., Biscuit & dried confection mfg. ind., Rice confection mfg. ind., Bean curd & dried bean curd mfg. ind.Uncompound feed mfg. ind., Organic fertilizer mfg. ind., Industrial waste treatment ind. (to be applied only to the industry equipped with neutralizing facility), Dead animals handling business, Slaughter-house, Central whole sale market and Local wholesale market	30 (d.a. 15)
	Dyeing finishing ind.	40 (d. a. 20)
	Meat product mfg. ind., Baking powder, yeast and other yeast agent mfg. ind., Frozen & cooked foods mfg. ind., Bark tanning ind., Fur mfg. ind. and Night soil purifying tank (For detail, refer to stipulations in laws and regulation)	50 (d. a. 25)
	Livestock foods mfg. ind. (excl. Meat product mfg.ind. & Dairy product mfg. ind.), Seaweeds processing ind., Pasted marine product mfg. ind., Frozen marine foods mfg. ind., Canned vegetable food, Canned fruit and Agricultural food preservatives mfg. ind. (excl. vegetable pickles), Bread mfg. ind., Unbaked cake mfg. ind., Bean paste mfg. ind., Electric machines & tools mfg. ind. for power generation, power feeding, power distribution and industrial-use, Private-use electric machines and tools mfg. ind. and Bulb mfg. ind.	60 (d. a. 30)
	Semi-conductor element mfg. ind. and IC mfg. ind.	70 (d. a. 12)
	Glue mfg. ind., Gelatin mfg. ind. and Parts mfg. ind. for electronic and communication apparatus (excl. Electronic tube mfg. ind., Semi-conductor element mfg. ind. and IC mfg. ind.)	80 (d. a. 40)
	Livestock agricultural & marine foods in cans and bottles mfg. ind., Animal oil & fat mfg. ind. and Grain & starch mfg. ind.	100 (d. a. 50)
	Agar mfg. ind., Potato starch mfg. ind. and Electric plating ind. (excl. Steel plating ind.)	140 (d. a. 70)
	Marine foods mfg. ind. (excl. Marine foods in cans & bottles mfg. ind., Seaweeds processing ind., Agar mfg. ind. Fish meat ham & sausage mfg. ind.,Pasted marine product mfg. ind., Frozen marine product mfg. ind. and Frozen marine foods mfg. ind.)	200 (d. a. 100)
	Anodized aluminum processing ind.	1,000 (d. a. 500)
	Phosphorus & phosphorus compound mfg. ind.	1,800 (d. a. 900)

Table 4-1-6 Provisional standards (3)

(applied for 5 years as from Oct. 1, 1993. abbreviation : daily average= d. a.)

Parameters	Category and Classification of Industry	Emission standards (mg/l)
Nitrogen	Seaweeds processing ind. and Animal oil & fat mfg. ind.	180 (d. a. 70)
	Fish meat ham & sausage mfg. ind.	260 (d. a. 130)
	Uncompound feed mfg. ind.	320 (d. a. 160)
	Frozen marine product mfg. ind.	360 (d. a. 180)
	Marine foods mfg. ind. (excl. Marine foods in cans & bottles mfg. ind., Seaweeds processing ind., Agar mfg. ind., Fish meat ham & sausage mfg. ind., Pasted marine product mfg. ind., Frozen marine product mfg. ind. and Frozen marine foods mfg. ind.)	380 (d. a. 190)
	Marine foods in cans & bottles mfg. ind.	440 (d. a. 220)
	Pasted marine product mfg. ind. and Frozen marine foods mfg. ind.	460 (d. a. 230)
Phosphorus	Seaweeds processing ind.	60 (d. a. 30)
	Marine foods in cans & bottles mfg. ind. and Animal oil & fat mfg. ind.	100 (d. a. 50)
	Frozen marine product mfg. ind.	140 (d. a. 70)
	Fish meat ham & sausage mfg. ind.	160 (d. a. 80)
	Pasted marine product mfg. ind. and Frozen marine foods mfg. ind.	320 (d. a. 160)
	Marine foods mfg. ind. (excl. Marine foods in cans & bottles mfg. ind., Seaweeds processing ind., Agar mfg. ind., Fish meat ham & sausage mfg. ind. , Pasted marine product mfg. ind.,Frozen marine product mfg. ind. and Frozen marine foods mfg. ind.)	340 (d. a. 170)

(c) Area-wide total pollution load control

The system for enforcement of area-wide total pollutant control was established in the 1979 fiscal year. Effluent discharges from the specified factories within the Tokyo Bay, the Ise Bay and the Seto Inland Sea basins are strictly controlled, for water quality conservation in these enclosed water areas.

The pollutant loads allowable for discharges are set according to the volume of effluent specified, corresponding to the type of industry, and the specific COD_{Mn} concentration decided on by prefectural governors. Each specified factory must measure the load amount for itself and report it, to ensure this remains within the allowable limit.

The area-wide total pollutant load control system has been strengthened three times up to date, and the fourth intensification is forthcoming.

The allowable effluent load amount is set as follows;

$$L = (C_j \times Q_j + C_i \times Q_i + C_o \times Q_o) \times 10^{-3}$$

where,

L : Allowable pollutant discharge load amount (kg/day)

C_j, C_i, C_o : Definite COD (mg./l) decided by prefectural governors is called the value of C (j, i, o depend upon the setup date.)

Q_j, Q_i, Q_o : Effluent volume notified corresponding to C_j, C_i, C_o, respectively

In the third revision, the following C values were applied, depending upon the setup date, from April 1, 1994:

1) Set up before June 30, 1980: C_o
2) Set up July 1, 1980 through March 31, 1989: C_i
3) Set up after April 1, 1989: C_j

Values such as C, etc. were set up for each industry category and other classifications relating to the area-wide total pollutant load control and in March 1996 these values were specifically notified to all the prefectures in the form of notification by the Director General of Environment Agency. In accordance with these values, prefectural governors decide on their own values for individual corporation.

(d) More stringent prefectural control

Nationwide uniform effluent standards stipulate that where pollution control over in public water quality is deemed insufficient, prefectural governors are entitled to designate such water area under the prefectural ordinance and to set up the stricter standard than the uniform standard. This stricter standard is called as "More stringent standard by prefecture" .

Table 4-1-7 shows the ordinance which sets up the stringent standards of Shiga Prefecture where the Lake Biwa lies as one of the Japan's most important water supply sources.

In some prefectural standards, the effluent standards are also set up for the factory which discharges the effluent less than 50 m^3/day to which uniform standards for the living environment items are not applied (so called, "Foot down "). Or, the stricter effluent standards is, in some cases, set up to the newly installed factories than to the existing ones. Table 4-1-8 shows an example where the more stringent standard is set up in Osaka.

(e) Extending standards

In specifying the stricter standards than the uniform standards set up by the ordinance of Prime Minister's Office, one method is to apply the stricter limit for the content of the same water quality parameters and another method is to increase the number of parameters to which effluent.regulation is applied. The former method is, as described previously, called as the more stringent standards. The latter method in which controlling parameters are increased is, sometimes, called as the extending standards.

The stringent standards specifying the stricter standards than the uniform standards must be implemented in accordance with the procedure designated under the government ordinance (Cl. 4 in Enactment of the Water Pollution Control Law). Such procedure sets that the prefectural standards should be on a level required for and sufficient to maintain environmental standards for the parameters whose environmental standards are specified.

For the parameters whose environmental standards are not specified, either Prefectural governments or Prefectural governors are entitled to specify the stringent effluent standards by setting up the environment standard in terms of administrative target as and when necessary. In the meantime, for the environmental standards relating to the living environment items, so called "Fitting" technique is needed. Environmental standards in this connection are set up only when "fitting" work is completed.

Table 4-1-7 Stringent effluent standards of Shiga prefecture

(Lakes and ponds area under Shiga Prefecture's Pollution Control Ordinance)
(abbreviation : daily average= d. a.)

Living environment-related item	Uniform effluent standards (under Water Pollution Control Law)	Example of stringent effluent standards (under Shiga Prefectures Pollution Control Ordinance)
Hydrogen ion concentration (pH) Discharge into water area other than sea area Discharge into sea area	 5.8～8.6 5.0～9.0	6 or more but 8.5 or less
Biochemical oxygen demand (BOD)	160 (d. a. 120)(mg/l)	(Depending on category and scale of corporation, BOD is set between 20 and 120)
Chemical oxygen demand (COD)	160 (d. a. 120)(mg/l)	(Depending on category and scale of corporation, COD is set between 20 and 120)
Suspended solids (SS)	200 (d. a. 150)(mg/l)	(Depending on category and scale of corporation, SS is set between 70 and 150
n-Hexane extracts content Mineral oil content Animals & vegetable oil and fat content	 5(mg/l) 30(mg/l)	 5 20
Phenol content	5(mg/)	1
Copper content	3(mg/l)	1
Zinc content	5(mg/l)	1
Soluble iron content	10(mg/l)	10
Soluble manganese content	10(mg/l)	10
Chromium content	2(mg/l)	0.1
Fluorine content	15(mg/l)	8
Coliform group number	D. a. 3,000 pieces/cm^3	3,000 pieces/cm^3
Nitrogen content	120 (d. a. 60)(mg/l)	(Depending on category and scale of corporation, this value is set between 10 and 80)
Phosphorus content	16 (d. a. 8)(mg/l)	(Depending on category and scale of corporation, this value is set between 0.5 and 5.)

Table 4-1-8 Stringent effluent standards of Osaka

(Upper stream of River Ina, River Ai and River Yamato in Osaka)

(abbreviation : daily average= d, a,)

Classification	Scale of effluent volume (m^3/d.)	BOD, COD (mg/l)	SS (mg/l)
Existing facilities	30~50	150 (d. a. 80)	200 (d. a. 150)
	50~200	100 (d. a. 120)	100 (d. a. 80)
	200~1,000	65 (d. a. 50)	90 (d. a. 70)
	1,000~5,000	45 (d. a. 35)	80 (d. a. 60)
	5,000 or more	35 (d. a. 35)	65 (d. a. 50)
Newly installed facilities	30~200	20 (d. a. 15)	65 (d. a. 50)
	200~5,000	15 (d. a. 10)	40 (d. a. 30)
	5,000 or more	10 (d. a. 5)	25 (d. a. 20)

4. 1. 2 Air Pollution Control

(1) Target to be controlled under the law

Atmospheric hazardous substances which are controlled under the Air Pollution Control Law and whose emission standards are specified are as shown in the Table 4-1-9. This specifies soot & smoke generating facilities and their scale (boiler with 10 m^2 or more of heat transfer area and 32 other facilities) ordinary dust generating facilities (coke oven and 5 other facilities) and also the specific dust generating facilities (cotton loosening machine and 9 other facilities).

(a) Soot and smoke

Applicable soot and smoke are as below:

- Sulfur oxides generated as result of combustion of fuel and other substances
- Soot and dust generated as result of combustion of fuel and other substances or use of electricity as heat source
- Among substances generated as result of combustion, composition, decomposition and other treatment of raw materials, the substances potentially imposing damages to human health

or living environment as specified under the Air Pollution Control Law enacting ordinance (Hazardous substances).

(b) Coarse particulate

When the law was revised in 1970, some substances were newly added as target substances for control, i.e., the substances generated from the process other than combustion process in coke oven, coal storage yard, raw material yard, crusher, etc.

Table 4-1-9 Substances to be controlled under Air Pollution Control Law

Target substances for control	Example of substances	Source process of generation	Source facility of generation	Regulative measures	Enforcement measures
Soot and smoke	Sulfur oxides · SO_2 · SO_3	Combustion of fuel and other substances	Facility generating soot and smoke	Emission standard · Regulation of volume · Regulation of k-value in each region · Area-wide total pollutant load control	Order for improvement, direct punishment
	Soot and dust · Soot, etc.	Same as above	Same as above	Same as above · Concentration control · Industry type/scale specific standards	Same as above
	Hazardous substance · NO_x,Cd,Pb, HF, Cl_2, HCl, etc.	Combustion, composition, decomposition, pressing, etc.	Same as above	Same as above · Concentration control · Industry type/scale specific standards · Area-wide total pollution load control for NOx	Same as above
	Specified toxic substance · Not yet designated	Combustion of substance	Same as above	Same as above · Regulation of volume · Regulation of k-value	Same as above
Coarse particulate	Specified coarse particulate · Asbestos	Opening, Cutting, Grinding, etc.	Facility generating specific coarse particulate	Control standard · Standard for concentration · Monitoring at Site boundary	Order for improvement

	Ordinary coarse particulate · Cement powder, coal powder, iron powder, etc.	Crushing, separation, pilling, etc. of substance	Facility generating coarse particulate	Standard for structure, application and management	Order for complying with standard
Automobile exhaust gas	CO_2,HC, Pb, etc.	Automotive traffic	Specified automobile	Allowable limit · To be considered by safety standards	Traffic regulation, order for maintenance, etc. (by other laws)
Specified substance	C_6H_5OH (phenol) C_5H_3N (Pyridine)	Accident during chemical treatment such as synthesis of substance, etc.	Specified facility (not specified under governmental ordinance, etc)	Not applicable	Order for taking measures at occurrence of accident

(Note) In 1989 "Coarse particulate" was classified into "Specific coarse particulate" and "General coarse particulate ", while in December 1989 asbestos was designated as the specific coarse particulate.

(c) Automobile exhaust gas

Substances presently designated as automobile exhaust gas are carbon monoxide, hydrocarbon, lead compound, nitrogen oxides and particulate matter. Except lead compound, respective allowable limits are set up.

(2) Emission standards

(a) Types of control standards

· General emission standards

These standards are unifiedly set by the national government for specific facilities and scales respectively. It is stipulated that sulfur oxides are regulated by each regional categorization, while soot & dust and hazardous substances are regulated uniformly throughout the nation.

· Special emission standards

Special emission standards are applied in the areas where a number of facilities emitting soot and smoke are collectively installed and the pollution is observed above a certain level as to the substances by which combined contamination may occur. For the newly installing facilities which may generate soot and smoke in the above-mentioned areas, the more stringent standards than ordinary ones are applied. This special emission standards are set up at present for sulfur oxides and soot & dust. (not applied to nitrogen oxides)

· More stringent prefectural standard

The more stringent prefectural standards are specified for such a case where general nation-wide emission standard is judged to be insufficient to protect human health or preserve living environment from natural and social conditions. The stricter standards as mentioned above are specified under the prefectural ordinance. The substances for which prefectures can set the stringent standards are soot & dust and hazardous substances, but sulfur oxides are not included. This is because the standard for sulfur oxides are set on area-specific basis and also, as the national policy, the primary approach to sulfur emission control is to decrease sulfur content in fuel oil. In this situation, the supply and demand of fuel oil are broadly controlled by the government, making it difficult for the prefectural government to take measures.

· Area-wide total pollutant load control standard

At the time when laws were revised in 1974, in the areas where compliance with environmental standards only by the conventional standards is difficult, the plan for reducing total volume of the designated soot & smoke should be prepared for the specified factories (of certain scale) and accordingly, the area-wide total pollutant load control standards were specified under the enforcement regulation of the Air Pollution Control Law .

· Standards for utilization of fuel

Two standards as mentioned below are set as the standards for utilizing fuel.

① Measures relating to seasonal use of fuel

In order to correspond the pollution by sulfur oxides on the streets under high-rise buildings in urban central areas, standards for using fuel are specified for each area and recommendations and orders may be given so as to use low sulfur fuel for decreasing soot & smoke or to reduce amount of fuel used. As emission standards for sulfur oxides are specified for each area, in densely high-rised areas, pollution by sulfur oxides may sometimes become significant in winter, although annual average pollution is not so high. Such measures are introduced to cope with the increase in the use of fuel for heating systems installed in the buildings.

② Measures relating to use of fuel in designated areas

Designation of area is in accord with the notification in 1970 (pertaining to control of air pollution due to heating systems in buildings in city centers);(i)Pollutant concentration as to sulfur oxides discharged into air already exceeds 0.005 ppm as average value in the same period for the latest 2 years, or the number of pollutant exceeding this average value is 1 or more, becoming an area where air has extensively been polluted or will be polluted, and (ii) the consumption of fuel in the facility generating soot & smoke such as buildings within the applicable area exceeds approx. 10,000kl or installation of such facility is anticipated. These areas presently count 14 all over the nation.

4. 1. 3 Offensive Odor Control

(1) Control standards at site boundaries

Shown below are the control standards for air pollutants on the ground level at the site boundaries. Prefectural ordinance, etc. may set the concrete standard values within the range shown in the table below.

Table 4-1-10 Control standards at site boundaries

	Offensive odor substance	Concentration in air (ppm)
1	Ammonia	1 or more but 5 or less
2	Methylmercaptan	0.002 or more but 0.01 or less
3	Hydrogen sulfide	0.02 or more but 0.2 or less
4	Methyl sulfide	0.01 or more but 0.2 or .less
5	Methyl disulfide	0.009 or more but 0.1 or less
6	Trimethylamine	0.005 or more but 0.07 or less
7	Acetaldehyde	0.05 or more but 0.5 or less
8	Propionaldehyde	0.05 or more but 0.5 or less
9	n-buthylaldehyde	0.009 or more but 0.08 or less
10	Isobuthylaldehyde	0.02 or more but 0.2 or less
11	n-valeraldehyde	0.009 or more but 0.05 or less
12	Isovaleraldehyde	0.003 or more but 0.01 or less
13	Isobutanol	0.9 or more but 20 or less
14	Ethyl acetate	3 or more but 20 or less
15	Methylisobuthylketone	1 or more but 6 or less
16	toluene	10 or more but 60 or less

17	Styrene	0.4 or more but 2 or less
18	Xylene	1 or more but 5 or less
19	Propionic acid	0.03 or more but 0.2 or less
20	n-Butyric acid	0.001 or more but 0.006 or less
21	n-Valeric acid	0.0009 or more but 0.004 or less
22	iso-Valeric acid	0.001 or more but 0.01 or less

(2) Control standards at emission outlet

In the control standards for the offensive odor at emission outlet, the following equation is used for calculating flow of odorous substances excluding methylmercaptan, methyl sulfide, methyl disulfide, acetaldehyde, styrene, propionic acid, n-butyric acid, n-valeric acid and iso-valeric acid. However, it is not applicable when the correction height at emission outlet is less than 5 m.

$$q = 0.108 \times He^2 \cdot C_m$$

provided ;

q : Flow rate (Unit : m^3/sec being converted into condition of 0 ℃ temperature, 1 atmospheric pressure)

He : Corrected height of emission outlet (Unit : m)

C_m : Control standard value of offensive odor substance (To be same with that on premises boundary)

$$He = Ho + 0.65(H_m + H_t)$$

$$H_m = \frac{0.975\sqrt{Q \cdot V}}{1 + \frac{2.58}{V}}$$

$$= 2.01 \times 10^{-3} \cdot Q \cdot (T - 288) \cdot (2.30 \log J + \frac{1}{J} - 1)$$

$$J = \frac{1}{\sqrt{Q \cdot V}} \cdot (1460 - 296 \times \frac{V}{T - 288}) + 1$$

provided ;

He : Corrected height of emission outlet (Unit : m)

Ho : height of emission outlet (Unit : m)

Q : Flow rate of exhaust gas at temperature of 15 ℃ (Unit : m^3/sec)

V : Emission velocity of exhaust gas (Unit : m/sec)

T : Temperature of exhaust gas (Unit: Absolute temperature)

(3) Control standards based on allowable limit for odor index

Odor index is obtained by the method in which composition of odor is not identified but intensity of odor collected on site is measured by the sense of smell.

This measurement method is also called as "Triangle bag method for odor sensory measurement" by which odor-containing specimen and odorless specimen are scent and the olfactory expert makes his judgment at what dilution proportion the specimen no longer smells. For above-mentioned classification of (a) to (c), specimen sampling method and calculation method of odor index are specified respectively

(4) Control standards for effluents water

Control standards for effluents apply following calculation equation for methyl-mercaptan, hydrogen sulfide, methyl sulfide and methyl disulfide.

$$C_{Lm} = kC_m$$

provided,

C_{Lm} : Allowable limit for odor substance in effluent water (Unit:mg/L)

k : Constant

C_m : Control standard value on boundary of factory premise

Constant (k) is as shown in the table below.

Table 4-1-11 Values of constant (k)

	k		
Substance name	$Q \leqq 10^{-3}$	$10^{-3} < Q \leqq 10^{-1}$	$10^{-1} < Q$
Methylmercaptan	16	3.4	0.71
Hydrogen sulfide	5.6	1.2	0.26
Methyl sulfide	32	6.9	1.4
Methyl disulfide	63	14	2.9

Note: Q (m^3 /sec)

4.1.4 Treatment and Disposal of Wastes

(1) Purpose of jurisdictional control

Treatment and disposal of wastes are controlled under the "Waste Disposal and Public Cleansing Law" (No.137 enacted in 1970).

Purpose of this law is to restrict the discharge of wastes, to ensure appropriate treatment of wastes, such as sorting, storage, collection, transport, recycling, disposal and also to conserve the living environment and enhance public health by keeping the living environment clean.

(2) Target for control under the law

Following factories are subjected to the application of this law.

1) Factories which discharges wastes
2) Factories which treats wastes (such as sorting, storage, collection, transport, recycling, disposal)

(3) Types of wastes

Wastes are classified into following categories.

<table>
<tr><td rowspan="4">A. Waste</td><td rowspan="2">B. Industrial wastes</td><td>Among the wastes generated by industrial activities, combustion ash, sludge, waste oil, waste acid, waste alkali, waste plastic, and other 19 types of wastes specified under the governmental ordinance
Imported waste</td><td>D. Industrial wastes to be specially managed</td><td>Explosive, toxic, infectious or with other properties to possibly cause damages to human health or living environment specified under the government ordinance</td></tr>
<tr><td>E. Other industrial wastes
E = B - D</td><td colspan="2">The industrial wastes subtracting ones to be specially managed</td></tr>
<tr><td rowspan="2">C. Ordinary wastes</td><td>Waste other than industrial wastes
C = A - B</td><td>F. Ordinary waste to be specially managed</td><td>Explosive, toxic, infectious or with other properties to possibly cause damages to human health or living environment specified under governmental ordinance</td></tr>
<tr><td>G. Other ordinary wastes</td><td colspan="2">The ordinary wastes subtracting ones to be specially managed</td></tr>
</table>

(4) Framework for treatment disposal of industrial wastes

Industrial wastes are treated mainly by source industries or specialized contractors commissioned by source industries for treatment and disposal . Fig. 4-1-1 below shows the role of administrative organization and the concerned parties on this matter.

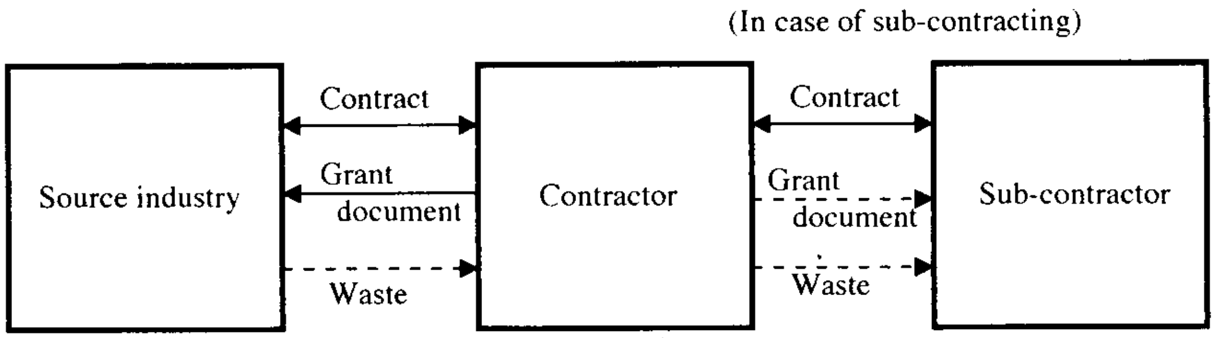


Fig. 4-1-1 Role of parties concerned relating to industrial waste

- Clauses to be included in the contract
  1) Type and volume of the waste
  2) (If transport work is consigned) Address of final destination of transport
  3) Scope of business of the contractor granted
  4) (If the contractor subcontracts the work to others) Matters relating to authorization of contractor
  5) Matters relating to provision of information on disposal of waste sub-contracted (from contractor to sub-contractor)
  6) Matters relating to report to contractor when work finishes by sub-contractor
  7) Matters relating to handling of untreated waste in case of cancellation of sub-contract
- Clauses to be included in the document to be issued from contractor to sub-contractor

  Personal name or company name to whom disposal is entrusted (To the person who undertakes the waste transportation)

  Personal name or company name who transports waste to the disposal site (To the person who undertakes the waste disposal)

  <In case of sub-contract (To be issued when handing waste over to sub-contractor)>

  1) Document which describes contract matters relating to the work, commissioned to the contractor
  2) Personal name or company name to whom disposal work is commissioned (To the person who accepts subcontract work for transport)

     Personal name or company name who transports waste to the disposal site (To the person who undertaks the subcontract on the waste disposal)

4. 2 Fundamental End - of - Pipe Technoloies

Since Japan experienced unprecedented industrial pollution, the Basic Law for Environmental Pollution Control was first established in 1967 to avoid catastrophic situation by the pollution and systematic restriction on the pollution control was started. Here, the elements specified as pollution were ①Air pollution, ②Water contamination, ③Soil pollution, ④Noise, ⑤Vibration, ⑥Offensive odor and ⑦ Ground subsidence (later underground water pollution was added to item ②). Jurisdictional institution was accordingly arranged and at the same time, target standard values were set and technical measures for achieving those values were implemented by both governmental bodies and civil organizations. This concept started with a recognition to the effect that the most imminent task is firstly to decrease emission load from outlet of factory, etc. to the surrounding environment so as to protect the public health from industrial pollution . By going through this type of process, Japan's pollution control is said to have been started with the end-of-pipe technologies. Afterwards, emergent control measures accomplished their objects and helped to lessen adoption of emergent measures after situations became stable. Then, the end-of-pipe technology has been developed and enacted as a part of comprehensive pollution prevention measures together with the in-process technologies.

This section outlines the basic technologies for controlling air pollution, water contamination and odor prevention, that are regarded to be most closely connected with the environment as conservation at direct surroundings of the factory among industry management.

4. 2. 1 Wastewater Treatment Techniques

Wastewater treatment is the technique to separate suspended or dissolved contaminants in wastewater to obtain target water quality or even cleaner water and also to make the separated sludge or condensate harmless. Wastewater treatment technologies presently adopted are classified into two; physical & chemical treatment processes and biochemical treatment processes.

Contaminants contained in wastewater include suspended particles (including solids) and dissolved substances (possibly, colloidal substance) and these are further classified into organics and inorganics broadly.

The unit operation forming treatment process is separation of solids from liquid (classified in physical and chemical treatment), while dissolved substances are treated by either physical/chemical or biochemical processes to make them into solid matter which can be separated from liquid, or treated by chemical process to make them harmless by oxidative decomposition or ready to remove.

Outline explanation is given below for the treatment characteristics and the target contaminant for physical/chemical treatment processes and biochemical treatment processes. In the even that either processes are applied, it is indispensable to properly treat and dispose the sludge, etc. generated after the event. The detailed explanation on sludge handing will be given in the later part of this chapter since these matters correlate each other in many aspects.

(1) Physical/chemical treatment process

Typical processes of physical/chemical treatment are such as solid-liquid separation (screen, precipitation separation or floatation separation, coagulation separation, filtering, etc), neutralization (acid/alkali treatment, etc.), oxidation/reduction treatment (ozone treatment, etc.), adsorption (activated carbon treatment, ion exchange, etc). Lately, membrane separation technologies have widely been adopted.

(a) Solid-liquid separation techniques

① Screen

Screen is a device which physically removes impurities with different sizes having mixed in wastewater. Uses of the screen differs depending on its direct or indirect purpose referred to in the latter section such as prevention of mechanical equipment trouble, improvement of treatment function and environmental conservation.

Impurities may take many different shapes and properties, various sizes such as dust, garbage, tree leaves, branches, vinyl fabrics, oil and grease, etc.

The hand-scraping screen, mechanical screen, etc. are used according to the scraping method of impurities, but the bar screen is most popular. Other types of screen include rotary screen, drum screen, traveling screen, wire screen, etc. These screens are used for separation of impurities from wastewater discharged from utility facilities, industrial facilities, pulp mills, fruit juice factories, livestock processing facilities and domestic (kitchen) facilities.

Screens are intended to separate large impurities in water, while strainer is used to separate fine suspended particles such as muddy sand, dust, plankton, etc. Strainer is often used in wastewater treatment.

② Precipitation separation

This is the method in which particles floating or suspending in wastewater whose specific gravity is larger than water are precipitated and separated and then, precipitated particles are separated and removed by using scraper.

③ Floatation separation

This is the method in which specific gravity of particles floating or suspending in wastewater are made smaller than that of water, then, such particles are floated on water surface and separated and removed by using scraper, skimmer, etc. This is classified into following types in terms of its function ;

- Floatation separation
  - Natural floatation separation (Atmospheric pressure floatation separation)
  - Pressure floatation separation
    - Nonchemicals injection type
    - Chemicals injection type (Coagulation type)

(i) Natural floatation separation

Natural floatation separation process is applied when difference of apparent specific gravity between the target particle and water is large, and floating potential is high. Oil separator falls under this category.

(ii) Pressure floatation separation

Pressure floatation separation process is applied when difference of apparent specific gravity between particle and water is small, and floating potential is low. In this process, pressurized water is mixed with wastewater and diffused into atmospheric pressure so as to precipitate the dissolved air as bubble and then, by attaching this bubble on to particles, floatation potential is made higher and separation efficiency is enhanced. This process is widely adopted in the treatment of oil-containing wastewater, the treatment of white water recovery in paper mills, the treatment of petrochemical effluents, etc. Further, it is utilized for thickening of surplus sludge generated from activated sludge treatment facilities.

As is shown in Fig. 4-2-1, the pressure floatation system feeds circulation water into stagnation tank and dissolves air through pressurized air separately from compressor . Pressurized water after fully dissolving air is mixed in wastewater and fed into separation tank. Then, precipitated bubble attaches to particles in wastewater and suspended particles are floated and separated. Floated particles are removed by scraper. The treated water is partially used as circulation water and the remainder is used for other application or discharged.

In case of bonding of bubbles and particles in wastewater and bubble is difficult, a coagulant should be added to improve characteristics of particles. For further details on coagulation processes, refer to the next section.

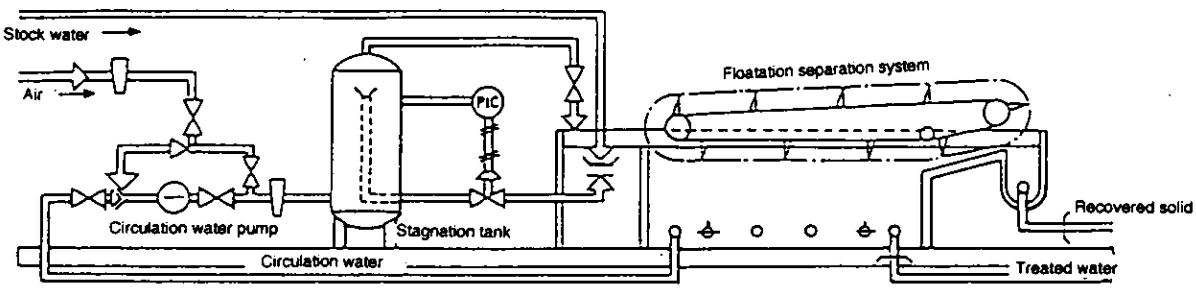


Fig. 4-2-1 Outline of pressure floatation separation system

(iii) Coagulation treatment

As suspended particles becomes smaller, precipitation speed gets slower, and when the particles become like colloidal particle, separation by precipitation becomes no longer possible. Coagulation process is the technology which converts the hard-to-precipitate particles into the easy-separable particles.

Fact that colloidal particles are stably kept in water is generally because of the phenomenon in that particle surface has same electric charge of plus or minus, react each other and deny bonding. By adding, ion having electric charge opposite to that of particle surface, electric charge is neutralized to make colloidal particles easily bonded each other (i.e., coagulated), resultantly forming flocculated particles. These flocculated particles possess property of suspended substance and therefore, they can be treated by means of the aforementioned solid-liquid separation technology.

This coagulation promoter is called coagulant. It is coagulant such as inorganic salt (aluminum sulfate, ferric chloride, polyaluminum chloride), acid, alkali and high molecular coagulant, being selectively used according to the target particles. In the course of selection, jar test is conducted so as to determine optimum addition ratio, pH conditions, etc. Moreover, it is possible to simultaneously separate phosphorus by using aluminum salt and iron salt as coagulant.

Coagulation treatment is basically configured of chemical injection equipment, rapid agitation tank (mixing tank, reaction tank), slow agitation (coagulation tank) and separation tank (precipitation or floatation) and is done as shown in the figure below.

Rapid agitation process is the chemical mixing process in which chemical agent and original wastewater are quickly mixed as as to neutralize electric charge on the surface of particles . In this process acid or alkaline agent is added in order to make adjustment for obtaining optimum pH for coagulation.

Slow agitation tank is also called as flocculation tank in which particles whose electric charge was neutralized collide each other, bond together and grow to be the large flock.

Solid-liquid separation tank is the process in which flock is separated by precipitation or floatation separation. Refer to the aforementioned precipitation treatment or floatation separation.

Effectiveness of coagulation treatment is dependent on selection and combination of coagulant, amount of injection and adjustment of optimum pH. It is the ordinary practice to use the device(coagulation test system), so-called, jar tester, and determine above factors by conducting preliminary test for every object wastewater. Jar tester is either 4-series or 6-series agitation system. In approx. 500 ml beaker, chemical injection ratio, pH condition, etc. are set in several steps and a series of operations from chemical injection to rapid agitation, slow agitation and still-standing precipitation. Thereafter, turbidity of supernatant is compared and optimum conditions are estimated.

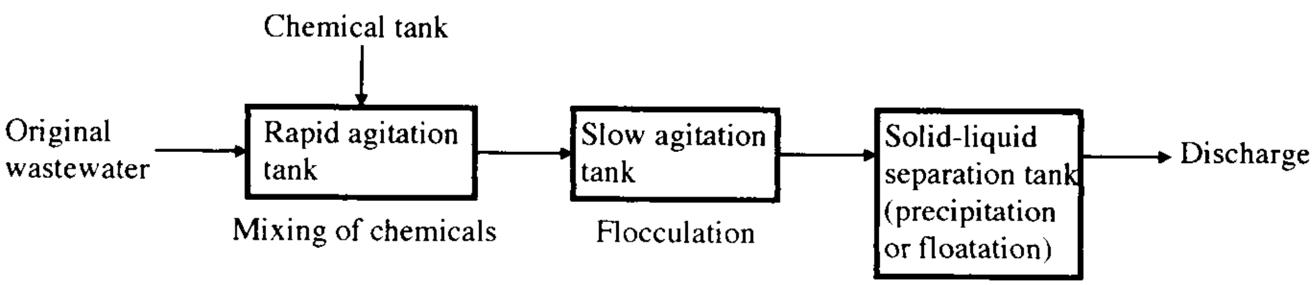


Fig.4-2-2 Basic process flow of coagulation treatment system

(b) Treatment (Neutralization) of acid and alkali

Water containing strong acid and alkali corrodes concretes and metallic materials and also gives harmful effect to the biotics. It is, therefore, necessary to neutralize waste-water before discharging. Effluent standard for acid and alkali wastewater is ordinarily set to be approx. pH 5.6 ~ 8.6 and neutralization treatment by chemical agents is generally applied. For the effective functioning of various unit-wise treatment processes such as coagulation process and separation of heavy metallic ion, wastewater must also be controlled in a way to restrict pH to the appropriate value. As mentioned above, neutralization or pH control is a very important process in the water treatment.

① Neutralizer

Chemical agents to be used for neutralization or pH control are acid neutralizer (caustic soda, soda ash, slaked lime, limestone) and alkali neutralizer (sulfuric acid, hydrochloric acid, carbon dioxide). Another process often used is the method to mix and neutralize acid wastewater and alkali wastewater which are discharged from the production processes. Furthermore, waste gas containing acid gas such as SOx (sulfur oxides) is used for neutralization of alkali wastewater.

② Neutralization system

Neutralization system is divided into some different types according to its application; case where neutralizer is injected in soluble or slurry condition, case where granular neutralizer is used and case where gas is used as neutralizer.

(i) Case where neutralizer is used in soluble or slurry condition

This system consists of chemical solution injection equipment, reaction tank and pH control unit. Generally the target pH value is controlled by monitoring pH in treatment water and switching ON-OFF injection of neutralizer or by regulating injection volume.

Another control method is to install neutralizers for several stages in series in order to stabilize pH of treated water in response to fluctuation width and buffer capability of pH in original wastewater.

(ii) Case where granular neutralizer is used

In case a large amount of acid waste solution is neutralized, preliminary neutralization up to pH4 by use of limestone is done in some instances for reducing chemical agent cost. In this case, reaction is slow if CO_2 gas or insoluble salt adhere on the surface of limestone and therefore, pipe with hole is installed at the bottom of the reaction tank to agitate by blowing air.

(iii) Case where gas is used as neutralizer

Neutralization system by gas uses neutralizing tank in some cases and neutralizing tower in other cases. Method adopted in the former system is such as agitation by blowing gas, combined use of mechanical agitation and surface agitation in closed tank for gas-liquid reaction. Method adopted in the latter system is to spray waste solution from the top and blow gas for neutralization from the bottom. Improvement in efficiency can be obtained by using the packed tower for the material forming no scale.

(c) Membrane separation technique

Membrane separation technology has finished its stage as research and development and has now entered the stage of commercialization. It is applied as water treatment technology as well as concentration technology. Either of these technologies can be expected as in-process technology for the cleaner production. There are 3 methods for the membrane separation treatment, i.e.; ultrafiltration, reverse osmosis and precision filtration. Further, ion-exchange membrane treatment added with special nature falls under this category. Various kinds of module for utilizing membrane are being developed.

① Types of membrane

Membranes to be used for the treatment are generally classified into ultrafiltration membrane (or reverse osmosis) and precision filtration membrane. Ultrafiltration membrane has fine membrane layer which passes only water molecule, while precision filtration membrane is porous membrane with uniform hole diameter and can be referred to as a very fine screen. Materials used for membrane are largely classified into cellulose acetate-series and synthetic high polymer-series. Material developed for the porous membrane is the nuclear pore membrane with extremely accurate and uniform hole diameter. (to be manufactured by irradiating radioactive rays on plastic membrane)

② Types of module

Types of module developed include flat disc type, spiral type, tubular type (tubular membrane type), hollow string type, etc. Modules of tubular type and hollow string type are used under internal pressure system (apply pressure inside tube and permeate outside) and external pressure system (suck from tube inside and permeate from outside to inside). For the tubular type, internal pressure system is mainly adopted owing to convenience of backwashing, while hollow type adopts both systems corresponding to its application object.

③ Application of membrane separation technique

Membrane separation technologies have been utilized in the process to treat water such as desalination, manufacture of highly pure water and treatment of wastewater. A number of practical results on this technology has already been reported and it is important for not only utilization of treated solution but also utilization as concentration technology.

(i) Treatment for pure water generation

· Desalination

Reverse osmosis process started with desalination of boiler water. Since desalination of seawater requires desalination ratio of 99 % or higher and it is reported that, after the multistage process (2-stage process) was introduced, it became possible to obtain treated water with TDS 195 mg / l or less.

· Polishing of precision water

As an application example for manufacture of super-high pure water, a reverse osmosis plant of 1,200 m^3/d in a semi-conductor industry in U.S.A. has reduced from TDS 200 mg / l to 5 mg/l after treatment. As water for boiler, the plant-S in Ibaraki Pref. owns 13,000 m^3/d plant.

(ii) Wastewater treatment

· Advanced sewage treatment

Desalination ratio of 90 % or higher and COD separation ratio of 95 % or higher are reported.

· Treatment of wastewater from pulp manufacture

In the plant capable of treating 3.8 ~ 18.9 m^3/ d, the membrane treatment is provided for the waste solution generating from various kinds of chemical pulp manufacture and desalination ratio of 90 % or higher is attained.

· Treatment of wastewater from dyeing

Membrane treatment is provided for the wastewater generating from various kinds of dyeing process and favorable results in color and COD are attained. It is reported that the removal ratio was 90 ~ 98 % for the raw waste water of COD 70 ~ 900 mg / l. Another noticeable achievement is that the removal ratio of 90 % or higher has been attained for the surfactant as far as COD as index is concerned.

(iii) Concentration technique (use of concentrate)

· Concentration treatment of whey

While making 1 kg cheese in its manufacture process, whey in amount of 8 ~ 10 kg is produced. This whey, if it is discharged into rivers, will cause an extensive contamination. Therefore, whey is utilized after concentrated through membrane treatment of wastewater whilst the BOD for final discharge is reduced. Solid content is 6.3 % in whey, 30 % in concentrate and approx. 0.63 % in separated solution for final discharge.

· Valuable resource recovery from marine foods processing effluent

After separating impurities, such as oil content, etc. from marine foods processing effluent, supernatant having precipitated and separated shows approx. BOD 600 ~ 1.000 mg/ l but it contains high quality protein. By concentrating this protein through ultrafiltration and reverse osmosis treatment, high purity protein and grade 2 protein are recovered for reuse. Its concentrate show BOD 15,000 mg / l and salinity 5,000 mg / l or so. While, separated solution shows BOD 14 ~ 80 mg / l and can be recycled for cleaning water.

· Recovery of valuables from wastewater in surface treatment processes

In some examples, washing wastewater generated from plating and coating processes for metallic surface is rendered for the membrane treatment and resultantly, concentrated paint is recycled after adjustment, while treated water is utilized for preliminary washing. API in U.S.A upgraded this method and succeeded in realizing the " closed system " for the wastewater generated in plating and washing processes. Ni concentration was 650 mg /l in original wastewater, 13,000 mg / l in concentrated water and 53 mg /l in treated water. But, it was reported that membrane treatment for plating wastewater was not necessarily easy.

(iv) Examples for utilization of ion exchange membranes

In Japan ion exchange membrane was developed mainly for the purpose of manufacturing salt by concentrating sea water. Salt in amount of 1 million ton as annual domestic demand is manufactured under the ion exchange membrane process. Moreover, a water manufacture plant capable of 1.2 million daily production is being constructed in the world to produce drinking water from underground water.

(2) Biochemical treatment method (Treatment of organic wastewater)

From large scale sewage treatment plants to small scale plants, biochemical treatment processes are applied to almost all organic wastewater. As shown in Fig. 4-2-3, their basic treatment flow consists of the primary treatment process in which sand and coarse dust (incl. solid organic substance) are removed prior to biological treatment, and subsequently the secondary treatment process being configured of biological reaction tank and solid-liquid separation tank. Hence, main purpose of biological reaction tank is to separate the soluble organic substance.

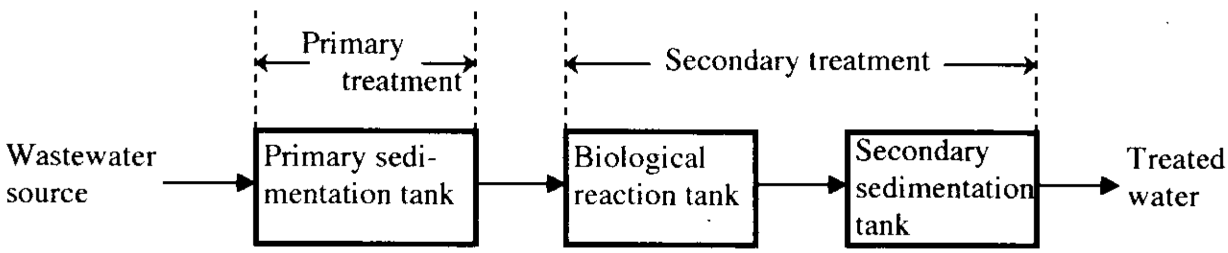


Fig. 4-2-3 Basic flow for treatment of organic wastewater

Biological treatment methods available are suspension biological method and biological membrane method. The former is generally called as activated sludge process, consisting of various methods such as standard activated sludge process, tep injection method, extended aeration method, oxidation-ditch process, sequencing batch reactor process, contact stabilization process, anaerobic-aerobic activated sludge process, oxygen aeration process, etc. The latter consists of the methods such as sprinkling filtration process, contact aeration process, rotating biological contactor, suspension biological membrane process, etc. Above-mentioned processes are all classified as the aerobic treatment. While, anaerobic digestion process is an anaerobic process. This process is applied to the treatment of dense sludge or sludge generated in wastewater treatment, in which by-product methane is used for heat generation. In addition to these processes, lagoon process and aerated lagoon process are also classified into biological treatment process.

The most suitable treatment system is selected in a case-by-case basis according to concentration and property of organic composition. In the small scale stations, it is in many cases that organic wastewater is discharged only after primary treatment. In other instances, coagulation sedimentation process is adopted as the primary treatment without applying the subsequent biological treatment. In other instances, moreover, very dense organic wastewater is incinerated after being concentrated.

(a) Suspension biological method (Activated sludge process)

As shown in Fig. 4-2-4, the common characteristics of the activated sludge treatment facilities are the installation of aeration system and return of sludge. The most important element in the activated sludge process is that microorganism grown under aerobic condition is separated in the sedimentation tank and returned to the biological reaction tank (aeration tank) so that, good activated sludge microorganisms are maintained.

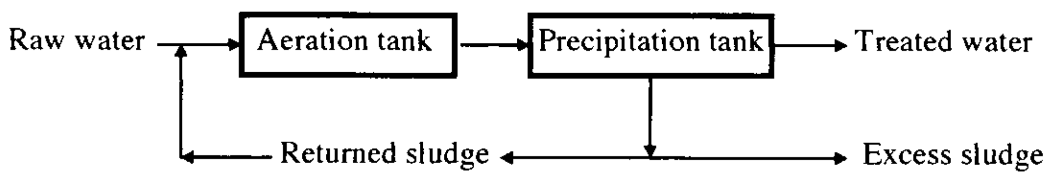


Fig. 4-2-4 Basic flow for treatment in activated sludge treatment facility

Aeration is made either by air blower or mechanical aerators. As the air blowers, porous air blow plates and air blow pipes are often used. As the mechanical aerators, simplex units and surface agitation units are used. There are two aeration systems for the aeration tank, the general aeration system and the single side aeration system. The former is applied to the aeration tank of complete mixing type and the latter to that of plug flow type.

① Standard activated sludge process

This is a conventional activated sludge process which produces the treated water with good quality when operated properly. Properties of activated sludge often fluctuate according to the quality of raw water and sometimes, solid-liquid separation becomes difficult due to bulking and the quality of treated water is resultantly deteriorated. If the quality is once deteriorated, it takes time to restore the normal condition of the activated sludge. The causes for failure in solid-liquid separation includes bulking, demolition of the sludge and generation of activated sludge scum. How to avoid bulking is technically the most important question in the management of activated sludge process. As is shown below, the quality of treated water may be deteriorated due to different causes and therefore the operation of activated sludge process is considered as technically difficult;

(i) Bulking occurs when the flock of activated sludge connects each other in weak bonding and become difficult to concentrate. This phenomenon occurs mainly for the treatment of dense organic wastewater in which case actinomycetes (or ray fungi filament-like bacteria) often grow in activated sludge.

(ii) Activated sludge breaks up when aeration agitation in the aeration tank is too strong (excessive aeration) although the in-flow load and nutrition are insufficient. When pH lowers due to extensive nitrification, bacteria no longer forms flock . This is a phenomenon in which activated sludge flock break up and flows out without sedimentation.

(iii) Generation of activated sludge scum is a phenomenon in which filament-like microorganisms, such as actinomycetes, that are very buoyant grow in large volume and float up (scumming) with activated sludge to flow out of the sedimentation tank and flow the said tank.

② Step injection method

Step injection method is a process in which the raw wastewater is separately injected into front, center and rear part of the plug flow type biological reaction tank. This method is applied in the case that the organic concentration of raw water is excessively high. Parts of the raw water is injected into center and rear parts of the tank where the organics has been decomposed in an attempt to stabilize BOD load in different segments of the tank by lessening BOD load at flow-in part. Other cases include; due to the low nutrition concentration of the raw water, excess aeration may possibly occur in center and rear part of the tank. As the BOD becomes even in different segments of the tank, the operation and maintenance of the activated sludge process becomes easy.

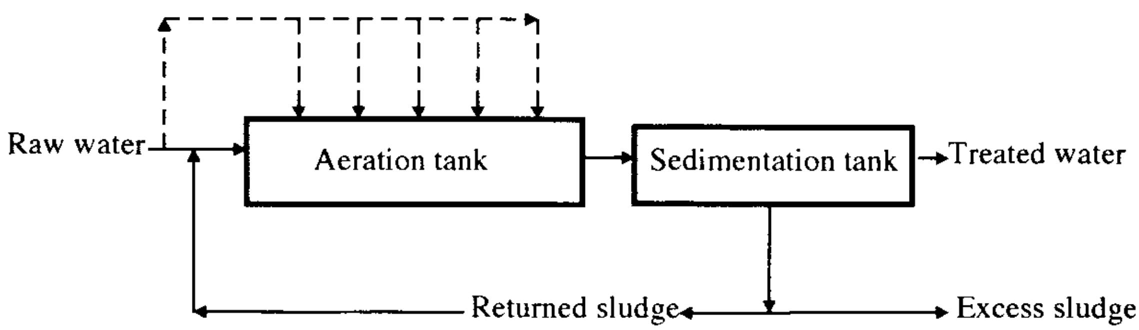


Fig. 4-2-5 Conceptual figure of treatment flow under step injection method

③ Long - time aeration process

Long time aeration process is adopted for small-scale facilities where time fluctuation of inflow load is comparatively large. By applying a large biological reaction tank so as to ease the occasional shock load and by making aeration time longer, activated sludge is digested in the

aerobic condition and consequently the amount of generated sludge is reduced.
Since the SRT (Sludge Retention Time) is long and nitrifying bacteria is likely to grow, excess aeration should be carefully avoided, then, denitrificaition may be attained. Since such operation needs large volume of air, power cost per volume of treated water increases relatively.

④ Oxidation-ditch process

The principle of this process is same as that of the long time aeration process. A circular water channel (approx. 1 m deep and 3 m wide) is installed as the biological reaction tank, where the stream is generated by rotor, etc. so that aeration and agitation are made. The stream velocity is set to be approx. 3 m / sec to prevent sludge from sedimentation. As anaerobic-aerobic conditions can partially be achieved, the removal of nitrogen and phosphorus is then expected by the principle described in the subsequent section.

⑤ Batch reactor process

In the batch reactor process, biological reaction and sedimentation are conducted in a single tank in which operation such as injection, aeration sedimentation and discharge are repeated at a certain cycle. This process is fit for small-scale facilities because bulking can be controlled by proper operation. Since anaerobic-aerobic cycle operation is possible, nitrogen and phosphorus may also be removed by the principle described in the subsequent section.

⑥ Contact stabilization process

Contact stabilization process is slightly different from the above processes in a way that activated sludge and sewage contact each other and contaminants are adsorbed into activated sludge in the biological reaction tank. This sludge, after being sedimentated and separated, is fed to re-aeration tank where the adsorbed contaminants are oxidized and decomposed and thereafter, the activated sludge is again returned to the biological reaction tank. Since the retention time in the aeration tank is approx. 30 minutes, the scale of the treatment facility can rather be small. The conceptual flow chart of this process is shown in Fig. 4-2-6.

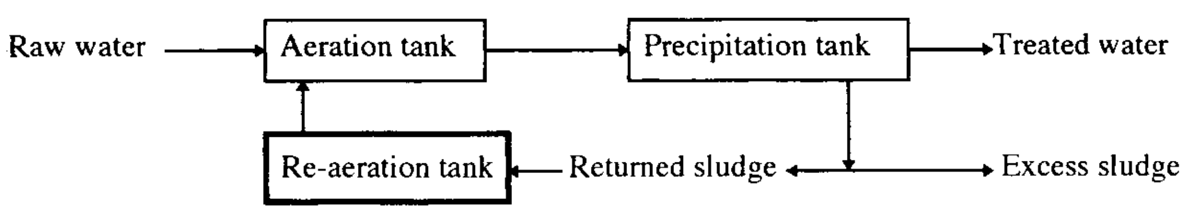


Fig. 4-2-6 Conceptual flow chart of contact stabilization process

⑦ Anaerobic - aerobic activated sludge process

Anaerobic-aerobic activated sludge process is adopted as a technology for simultaneous removal of nitrogen and phosphorus as is mentioned in the subsequent section. Historically, this process has been developed as a measure for bulking control in the activated sludge treatment. Actinomycetes, a microorganism causing bulking, is obligate aerobe (which can not be grown in anaerobic condition) and therefore, it is possible to restrict the proliferation of actinomycetes by installing an anaerobic tank before the aeration tank.

⑧ Oxygen activated sludge process

While aeration by air is made in the aeration tank in processes so far described, in the oxygen activated sludge process, aeration is made by pure oxygen or oxygen-concentrated air. By doing so, it becomes possible to increase dissolved oxygen several times higher compared with aeration method and to maintain the concentration of MLSS in the aeration tank at the level several times higher. That is, even the the raw water with high organic concentration can be received under the condition where BOD volumetric load is high. The primary advantage of this process is the reduction of the volume of aeration tank and installation space in the factory. Other advantages are as follows;

- Resistive to fluctuation of raw water concentration and superior in sedimentation of activated sludge.
- Amount of excess sludge is relatively small and its composition is advantageous for the subsequent sludge treatment. The sludge substance is hard to decay.
- Amount of generated gas is small so that, odor control is easily achieved.

On the other hand, the disadvantages are as follows;

- The aeration tank should be sealed for effective utilization of oxygen and consequently, construction cost increases.
- Transparency of the treated water is low.
- The concentration of carbon dioxide in the mixed liquor in the aeration tank becomes high and consequently, corrosion-preventive measures for the tank wall made of concrete must be taken.

(b) Biological membrane treatment process

Different from the activated sludge process, the biological membrane treatment process features, as shown in Fig.4-2-7, with the characteristic in that no sludge return system is installed. In this sense, as the suspended biological membrane process installs sludge return system, it falls under the category of activated sludge process. Biological membrane treatment facilities, in addition to installing no sludge return system mentioned above, has the advantage that biological reaction tank can be easily operated compared with activated sludge process.

Compared with activated sludge, microorganisms forming biological membrane are rich in species and stable. The organisms grow on the surface of the filter media (without being pushed away), and therefore; species with small proliferation rate can also be grown. Thus, the ecological system of microorganism is significantly stable so that it can accept wider ranges of variation of types and concentration of organic substances. Moreover, the sludge generated by the biological membrane treatment process quickly sediments and concentrates.

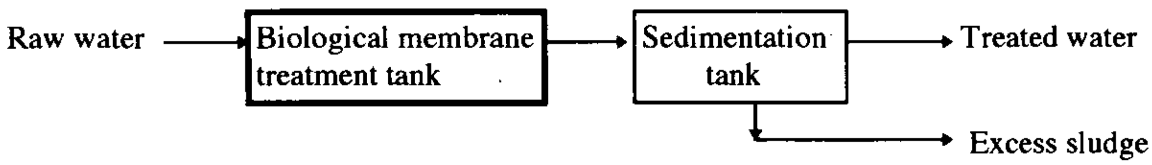


Fig. 4-2-7 Basic treatment flow in biological membrane treatment facility

① Sprinkling filtration process

From the historical viewpoint, sprinkling filtration process is older than activated sludge process and has been utilized since early 1990's. Crushed stones have been used as the filter media, but along with the development of plastic filter media, this system is now reevaluated for its large void space and light weight. Because aeration and sludge return equipments are not needed, the operation cost is cheap, and the range of applicable water quality is wide. And this process can be applied for both pretreatment and post-treatment in water treatment facilities. Owing to these features, the quality of the treated water can further be improved by installing this sprinkling filtration system in 2-rows, 3-rows, etc.

With regard to the relationship between BOD load and separation rate, BOD separation rate is 80 ~ 60 % or so when sprinkling intensity is 35 m^3/ m^2/d and 1 ~ 3 kg-BOD/ m^3/d. The defect of this process is that the treatment facility may possibly be the source of unsanitary insects such as fly, etc. Therefore, facilities of this process should be carefully operated and maintained.

② Rotating biological contactor

In the rotating biological contactor process, the biological contactor is installed and rotated in a way that the contactor is immersed in the raw water by about 40 % of its area. This makes alternate contact with the air and raw water to develop 1 ~ 3 mm thick biological membrane on the surface of the contactor and resultantly organic contaminants are oxidized biologically. As the sprinkling filtration process, the operation cost is cheap because the installation of aeration and sludge return equipments are not needed. Besides, the range of applicable water quality is wide and thus, it can be applied to both pretreatment and post-treatment in water treatment facilities.

Biological composition is relatively rich and therefore the process is applicable wide variety of raw water quality, just like the trickling filtration process. ' The rotating disc can also support nitrifying bacteria with slow proliferation speed and thus, nitrification may develop. However, this process may pose a problem with low transparency of the treated water due to peeling off etc. of the nitrifying bacteria.

③ Suspension biological membrane process

In the suspension biological membrane process, sludge return system is different from that in activated sludge process. But, the microorganism carrier is returned to biological reaction tank by preventing such carrier from being washed away. In this concept, this process can be considered as the modified type of the activated sludge process . This has improved the process performance by increasing stability of activated sludge and resultantly, the operational manageability has been substantially improved.

Methods to fix microorganism on carrier include the carrier binding method (adhesion method) and the wrapping method. The carrier binding method is to adhere microorganism on activated carbon or sand. The wrapping method is to wrap microorganism in gel-like grids or wrap it with polymer membrane.

(3) Sludge treatment technique

Sludge generated by wastewater treatment is specified, together with solid waste such as waste unable to recycle, as industrial waste by the "Waste Disposal and Public Cleansing Law" . Industrial wastes shall, in principle, be disposed in the proper manner under the source enterprise's own responsibility .

Sludge coming out of effluent treatment facilities contains much water content and thus, if it is dealt with under such condition, its handling is difficult and besides, cost for disposition is high. In view of this, it is the general practice to apply dewatering treatment to such an extent that no water leaks off after sludge is carried onto a carrier vehicle. There are several dewatering methods for sludge and technical development has been made individually. Among them, the belt-press dehydrator is widely used for the facts that automatic operation is possible, it is fit for excess sludge generated from biological treatment processes and it can readily be introduced to the small-scale enterprise. Also, in many instances in small-scale treatment station sludge may be transported by vacuum truck etc. instead of applying on-site sludge treatment.

As far as the sludge storage tank with the appropriate capacity is installed, sludge treatment can be operated without suffering from various fluctuation as experienced in the wastewater treatment.

(a) Dehydrator

There are some kinds of dewatering system such as pressure dehydrator, vacuum dehydrator and centrifugal dehydrator. Further, pressure dehydrator is broadly classified into filter press dehydrator and belt press dehydrator. Vacuum dehydrator is classified into belt-type vacuum dehydrator and drum-type vacuum dehydrator.

① Pressure dehydrator

(i) Filter press dehydrator

Filter press dehydrator is installed laterally or vertically. Sludge is fed into the filtration chamber severally divided (between filter cloth) and mechanically compressed to squeeze out the water content. The number of filtration chamber should be set according to the volume of sludge to be treated. From the operational point of view, it is necessary to add slaked lime and ferric oxide before dehydration for adjusting sludge quality. In the case of sewage sludge, the water content of the dehydrated cake is approx. 60 ~ 70 %.

(ii) Belt press dehydrator

Belt press dehydrator is an equipment whose principle is that two endless filter clothes at top and bottom are put between a number of rolls, sludge is fed in between filter cloth and the water content is squeezed out as the sludge passes between compression rolls. For adjusting the quality of sludge, it is sufficient to add only slight amount of high molecular coagulant and thus, the volume of sludge does not increase by adding the chemical agent. In case of sewage sludge, the water content in dehydrated cake is approx. 75 ~ 80 %.

② Vacuum dehydrator

(i) Belt type vacuum dehydrator

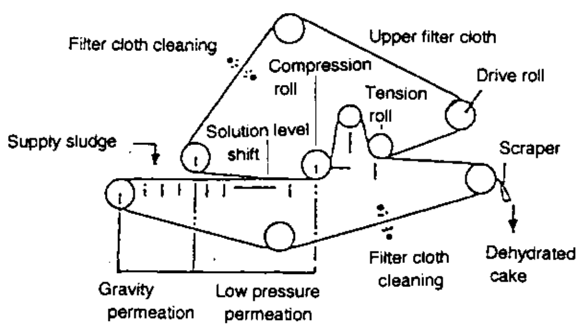
In case of belt type vacuum dehydrator, dehydrated cake layer is peeled off when the cake leaves drum main body together with filter cloth and is released from vacuum pressure. Materials to be used for the filter cloth are such as polypropylene, tetron, vinylon, saran which are hard to cause clogging but durable. These materials should be selected by observing peeling performance to suit to property of sludge and cleanliness of filtrated solution, etc.

Sludge needs to be adjusted before dehydration and coagulant such as slaked lime and ferric oxide is added in a large amount. In case of sewage sludge, the water content in dehydrated cake is approx. 75 ~ 80 %. The filter cloth needs to be carefully cleaned to avoid clogging with coagulant. Also, the operation should be conducted in an open atmosphere and it does not look like hygienic and recently the adoption of this type of machine has been decreasing.

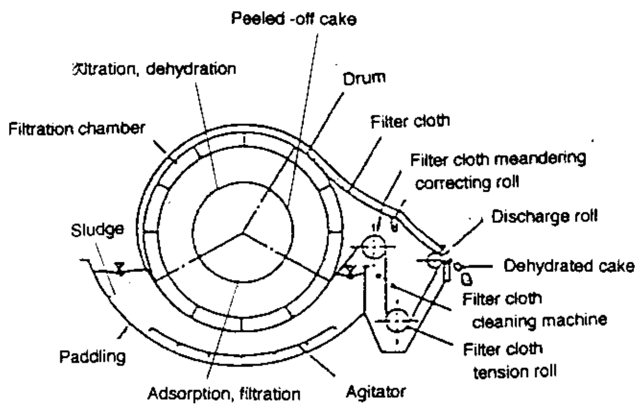
(ii) Drum type vacuum dehydrator

In case of drum type vacuum dehydrator, filter cloth is closely fitted to the rotary drum into radially divided chamber. This chamber is made vacuum for dehydration and pressurized air for peeling off the dehydrated cake, which is then raked off. The material for the filter cloth is selected in the similar manner to the belt type vacuum dehydrator. But, the replacement work is troublesome because filter cloth is fixed on the drum.

Sludge needs to be adjusted before dehydration and coagulant such as slaked lime and ferric oxide is added in a large amount. In case of sewage sludge, the water content in dehydrated cake is spprox. 75 ~ 80 %. The filter needs to be carefully cleaned to avoid clogging with coagulant. Also, the operation is conducted in an open atmosphere and it does not look like hygienic and the adoption of this type machine has been decreasing.



· Example of belt press dehydrator



· Belt-type vacuum dehydrator

Fig. 4-2-8 Examples of dehydrator

4. 2. 2 Air Pollution Control Techniques

From the historical point of view, air pollution problems started with soot and dust or smog as regional environment problems. Along with the conversion of main fuel from coal to petroleum, the problems of SOx and NOx newly arose and further developed to coincide photochemical oxidant problems. Furthermore, the air pollution problems at the present encompass two important issues;

one is the acid deposition problems as secondary phenomenon and the other is the global environmental problems of global warming and depletion of ozone layer, caused by carbon dioxide, CFCs, etc. In this paper, dust and soot, SOx and NOx are mainly discussed.

(1) Dedusting and dust collecting techniques

Air pollutants such as dust, soot and smoke, aerosol and mist are suspended in the air in the various grain sizes and also in the forms of solid and liquid . Dedusting and dust collecting technology is the technique to separate these grain size substances.

Dedusting and dust collecting processes are classified into dry dust collector and wet dust collector. Also, based on their structural function, the processes are also classified into gravity dust collector, inertia dust collector, centrifugal dust collector (cyclone, etc), dust scrubber, filtrating dust collector (bag filter, etc) and electrostatic precipitator. A variety of dedusting processes have been developed and put into commercial operation corresponding to the different application, such as removal of soot and smoke from stack gas, dust from crushing mill and sulfuric acid mist, the production of ultra pure air for precision manufacturing processes, etc. In actual operations, such unit processes are combined to achieve effective treatment, the combination with desulfurization and denitrification. Cyclone is, in many instances, used as a provisional dust collecting unit prior to dust scrubber, bag filter and electrostatic precipitator. Inertia dust collector is, in some instances, used as a unit installed downstream (finishing section) of demister and wash dust scrubber. Basic principle and concept on each dust collection system are shown in Fig.4-2-9 to Fig.4-2-14.

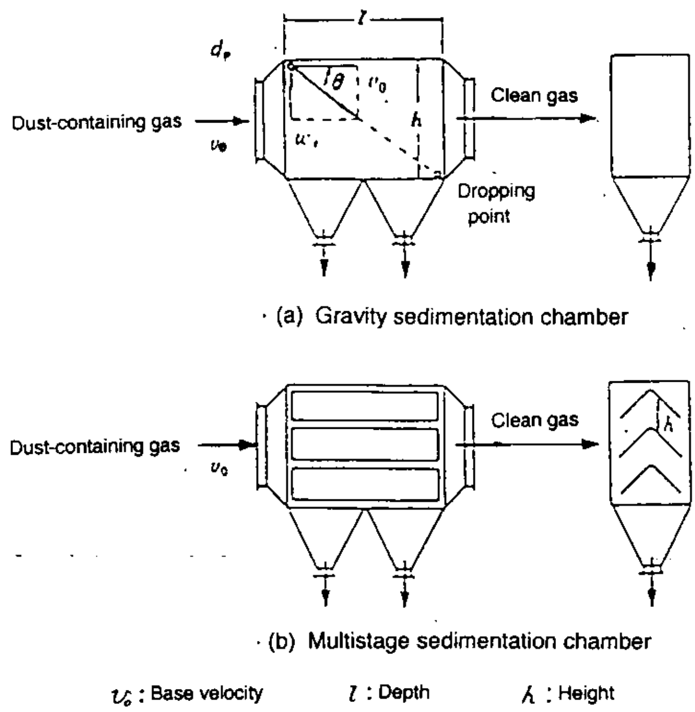
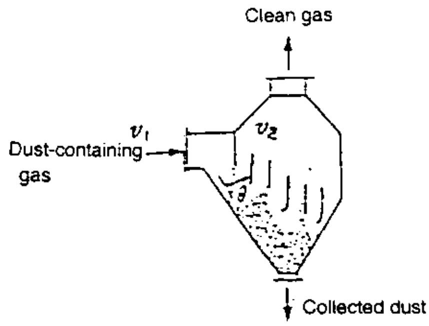
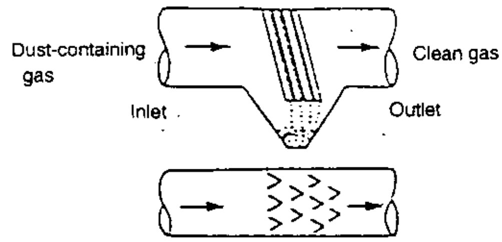


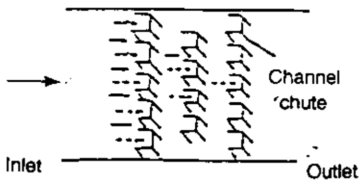
Fig. 4-2-9 Gravity dust collector



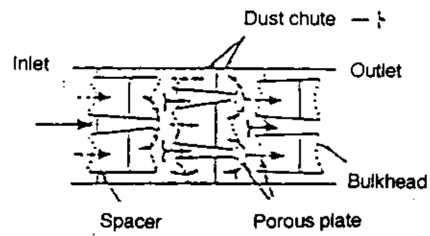
(a) Single stage type



(b) Multistage type

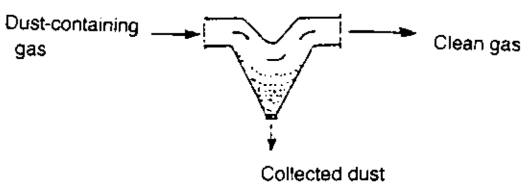


(c) Staggered type (channel type)

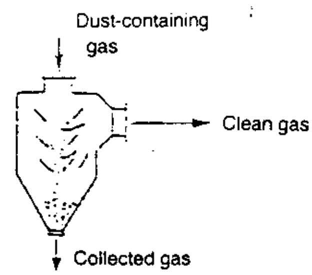


(d) Staggered type (nozzle type)

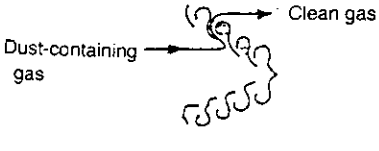
Impingement inertia dust collector



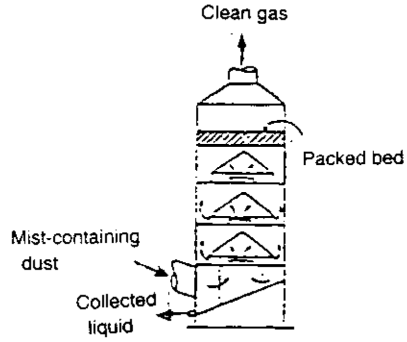
(a) Bend pipe type



(b) Louver type



(c) Pocket type



(d) Multi-buffle type

Reverse rotating inertia dust collector

Fig. 4-2-10 Inertia dust collector

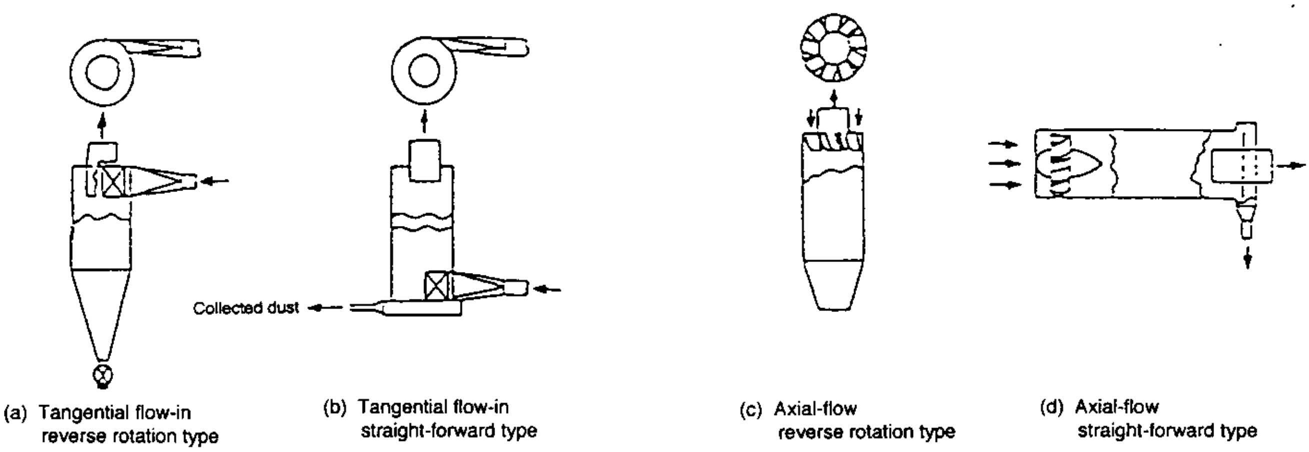


Fig. 4-2-11 Centrifugal dust collector (cyclone, etc.)

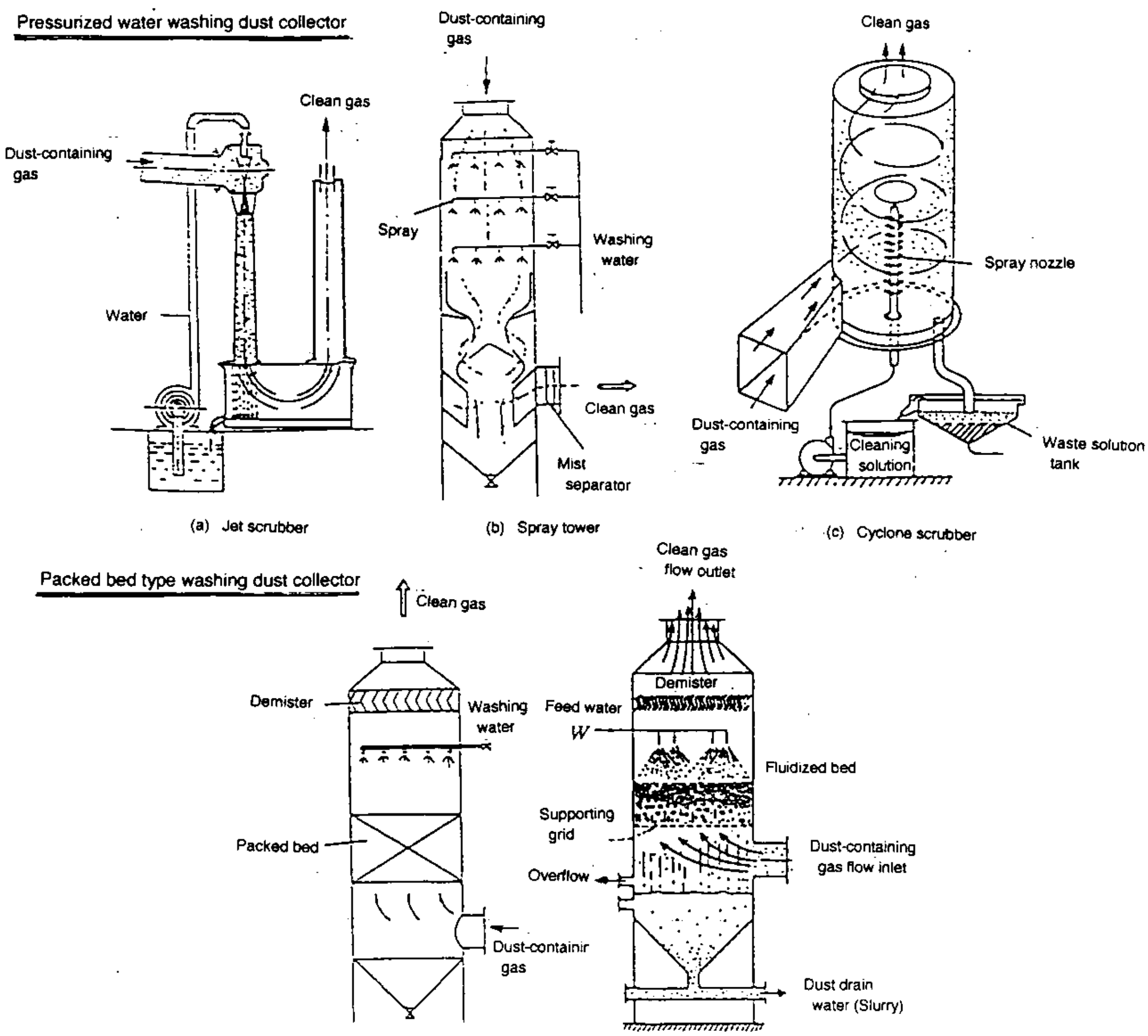
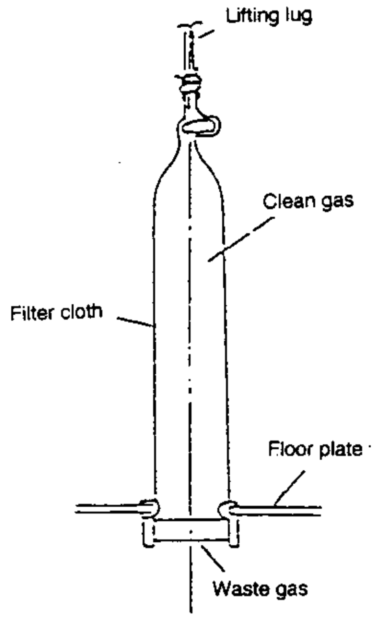
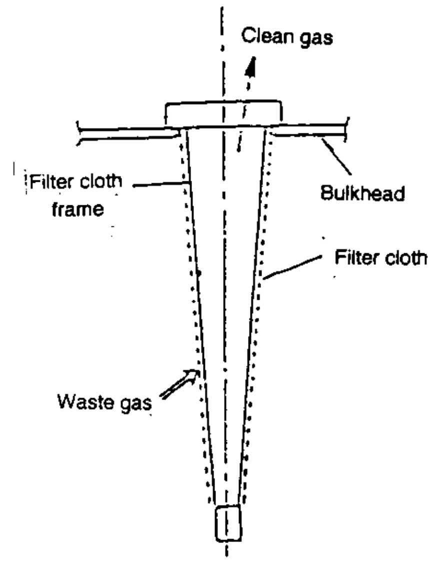


Fig. 4-2-12 Washing type dust collector

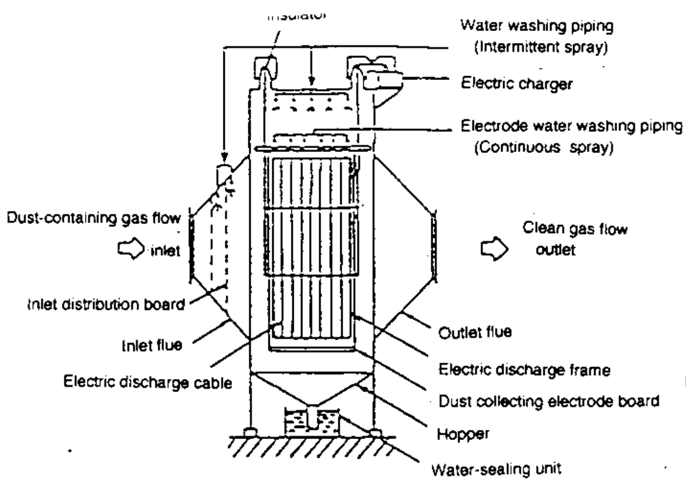


(a) Cylindrical type

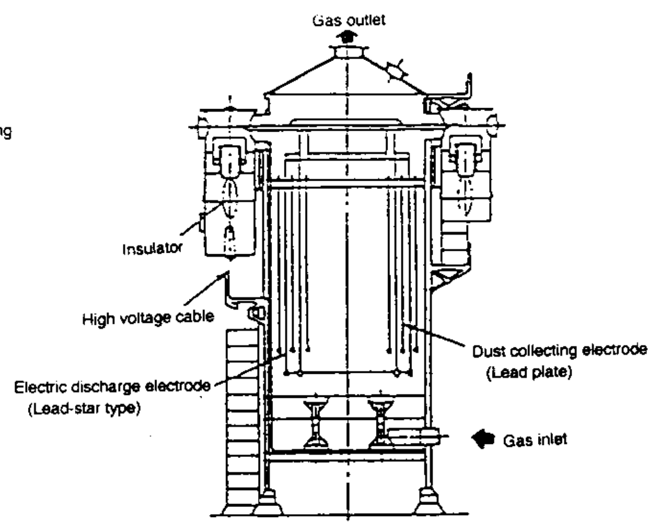


(b) Flat plate type

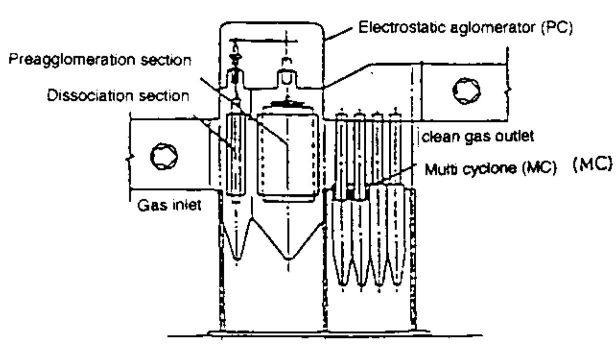
Fig. 4-2-13 Filtration dust collector (such as bag filter)



Wet flat-type electrostatic precipitator



Electrostatic precipitator for sulfuric acid mist



PC-MC type dust collector

Fig. 4-2-14 Electrostatic precipitator

Presented below are some thoughts on the selection of dust collection system among the different type mentioned above taking the example of dust removal from boiler exhausts ;

(a) Pulverized coal fired boiler

PCF boiler dust consists of the melted ash formed by the complete combustion of pulverized coal as well as pulverized coal particles emitted after the incomplete combustion. For the flue gas consisting of dust, mainly coal particles emitted after the incomplete combustion, which is comparatively large in grain size and small in its electric resistance ratio, the electrostatic precipitator with a cyclone upstream is considered to be effective. While, it is said to be effective to independently use the electrostatic precipitator for the flue gas consisting of dust, mainly melted ash formed by the complete combustion, which is small in its grain size and large in electric resistance ratio.

(b) Heavy oil fired boiler

Since the grain size of dust from the heavy oil boiler is small, electrostatic precipitator should be adopted. As Table 4-2-1 shows, dust from heavy oil boiler contains much of moisture and sulfuric acid. In the thermal power station, etc., dust collection is accelerated by injecting ammonia into flue at boiler outlet to make ammonium sulfate and at the same time, then to avoid metal corrosion at lower temperature and to prevent the secondary pollution due to acid dust.

Table 4-2-1 Example of chemical composition (%) of dust from heavy oil fired boiler

	Fixed carbon	Ash content	Volatile matter	Moisture content	SO_3
Cyclone	63.7	12.6	18.8	3.9	14.4
Electrostatic precipitator	34.6 ~ 28.7	24.1 ~ 20.6	24.1 ~ 20.6	14.5 ~ 9.5	26.8 ~ 32.3

Note) Multi-cyclone type was used.

Table 4-2-2 Separated particle size of main dust collector

Dust collector	Separated particle size	Remark - 1	Remark - 2
Gravity type	50 ~ 60 μm	Limit particle size for separation	
Inertial type	20 μm or so	〃	Impediment type, reverse rotation type, etc.
Centrifugal type	Several μm	〃	Cyclone, etc.
Washing type	1 μm or so	50 % Separation	Reservoir water type
	0.1 μm or so	〃	Pressurized water type
	1 μm or so	〃	Packed bed
Filtration type	0.1 μm or so	95 % Separation	Bag filter, etc.
Electrostatic precipitator	Effectively working with 0.1 μm or so		

(2) Sulfur oxide (SOx) removal technique

Flue gas desulfurization methods widely adopted in Japan are wet process and dry process. The former process is utilized in most of commercial application. Approx. 85 % of the total flue gas desulfurization equipment (in unit number) uses alkali slurry and potassium solution as absorbent.

The major portion of sulfur oxides in combustion gas is SO_2 and becomes acidic when it is dissolved in water. This means SOx can effectively be absorbed by alkaline absorbent. Absorbent chemicals are lime slurry, caustic soda, sodium sulfite, ammonia water, magnesium slurry, basic aluminum sulfate, etc. In general, among the current desulfurization processes, lime slurry absorption system is least expensive.

In many of the large-scale facilities, by-products such as gypsum, sodium sulfite, ammonium sulfate are collected and recycled. In small- and-medium scale facilities, by-products are consumed in own facilities or sold in rare instance. However the facility to collect by-products is very expensive to operate and thus, by-products are not recycled usually. Desulfurization efficiency is attained over 90 %.

(3) Nitrogen oxides (NOx) removal technique

Nitrogen oxides generated in the course of combustion of fuel are nitrogen monoxide (NO) and nitrogen dioxide (NO_2), both of them are jointly called as NOx. In ordinary combustion systems like boiler, volumetric ratio of NO/NOx is approx. 90 ~ 95 % and thus, the major part of NOx in exhaust gas is NO.

Nitrogen oxides removal technology has shown its improvement; 20 ~ 70 % by low NOx combustion technology, 40 ~ 60 % by non-contact method and 90 % by catalyst method in flue gas denitration. Methods adopted as flue gas denitration include dry selective catalyst reduction process, which is prevailing, and non-catalytic reduction process, wet direct absorption process and wet oxidation absorption process.

(a) Dry selective catalytic reduction process

The dry selective catalytic reduction process, most widely used as flue gas denitration technology, uses ammonia gas as reducing agent. At the temperature of 200 ~ 400℃ under atmosphere with oxygen, NO is removed by reduction into nitrogen as is shown in equation below;

$$4\,NO + 4\,NH_3 + O_2 \rightarrow 4\,N_2 + 6\,H_2O$$

The catalyst most often used is the composition catalyst with titanium dioxide as carrier and vanadium pentaoxide as activator. Coexistent SO_2 in exhaust gas is oxidized into SO_3 by catalyst and it reacts with unreacted ammonia gas at the temperature below 250 ℃ to form ammonium hydrogen sulfate. This not only attaches and deposits on heat exchanger to cause corrosion, but also increases draft resistance. Therefore, the equipment is properly maintained. In actual plant fired by coal, heavy oil or LNG, the denitration efficiency over 80% is attained at the temperature of 300 ~ 400℃ with the NH_3/NO ratio being 0.8 ~ 1.

(b) Non-catalytic reduction process

In this process ammonia gas is added in high temperature and NO is reduced into N_2 without using catalyst. According to the fundamental experiments, the reaction develops at temperature of 900 ℃ and maximum denitration efficiency is attained at the temperature of 1000℃.
In the case of boiler, etc., denitration efficiency is approx. 30 ~ 50 % because exhaust gas reaches the optimum temperature range only for a short period of time.

(c) Wet oxidation absorption process

Solubility of NO into water is 0.04 m^3/m^3 at 30 ℃, which is only 1/500 that of SO_2. Process used here is the liquid phase oxidation absorption process in which exhaust gas is fed into solution of strong alkaline potassium permanganate so as to oxidize and absorb NO. NO_2 is absorbed at the same time to form KNO_3, KNO_2, and MnO_2. MnO_2 precipitated in the absorbent solution is filtrated and KNO_3, etc. of liquid phase are recycled after condensation so as to reproduce $KMnO_4$. The commercialization of large scale denitration equipment with this process is difficult due to the high cost of oxidation absorbent and complexity of recycling and reproduction process, etc.

(d) Electron beam irradiation process

By irradiating electron beam in exhaust gas, radical OH and atomic O are formed to react with NO and SO_2 in exhaust gas and consequently produce nitric acid (HNO_3) and sulfuric acid (H_2SO_4). When ammonia gas (NH_3) equivalent to concentration of NOx and SOx is added in exhaust gas and electron is irradiated, solid powder of ammonium nitrate and ammonium sulfate are produced. Such powder particles are collected by an electrostatic precipitator.

Prerequisite for this method is to establish the electron beam technology as regard the reduction of electron beam dose and the development of large scale accelerator.

4. 2. 3. Offensive Odor Control Techniques

Troubles due to offensive odor frequently occur in the food processing and related factories. Offensive odors in those cases are not only the offensive odor substances which are stipulated under the offensive odor control law but also all odors which people living in the nearby region feel with sense of smell. However, offensive odor pollution is seldom complained in wide-spread areas, but by its characteristics the pollution is limited in the local area. People also complain when offensive odor of high concentration is emitted at different hours of a day.

Basis of the offensive odor control is to ascertain cause of offensive odor, condition of its source, characteristic of diffusion route, etc. and then to take different steps such as 1) measures for offensive odor control at the site boundaries, 2) application of deodorization technology, 3) control offensive odor which is transmitted through effluent. Fig. 4-2-15 shows the matters to be studied and investigated in the course of implementing offensive odor control measures.

	Emission source	Deodorization facility	Target and effect	At ground level
Matters to be studied	1) Study on method for restricting generation of offensive odor 2) Study on measures for reducing treatment gas volume by concentration separation , etc. 3) Methods for collecting offensive odor	1) Selection of treatment system 2) Design of treatment facility 3) Effluent water, waste,etc. generated by deodorization treatment 4) Study on treatment facility management and its economy	1) Target value of offensive odor at discharge outlet 2) Calculation of diffusion for odor-wise component 3) Change of offensive odor component in air	1) Tolerance for offensive odor by resident living leeward 2) Monitoring of offensive odor 3) Regional characteristics in applying offensive odor control law
Matters to be investigated	1) Configuration of offensive odor component 2) Effluent volume unit consumption for odor-wise component 3) Exhaust gas volume	1) Concentration of gas and odor at outlet of facility 2) Facility's removal capacity 3) Nature and volume of secondary product	1) Stack height and delivery pressure 2) Annual and hourly fluctuation of wind direction, velocity, and weather 3) Surrounding topography and building	1) Offensive odor background value 2) Offensive odor concentration at the site boundary 3) Max. ground level odor out of the boundary

Fig. 4-2-15 Matters to be investigated and studied for offensive odor measures

(1) Management of the odor level at the site boundary

In the factories including food processing plants, many places can be the source of offensive odor; such as product processing line, storage of raw material, thawing process, garbage and disposed waste. The odor may spread over the site boundary to the surrounding area and consequently cause noxious to the nearby resident. Once a complaint is placed, source industry is most likely to consult the deodorizer manufactures to study if a deodorizer is to be installed. It is, however, effective to start by considering following actions which may partially belong to the in-process measures.

1) To keep raw materials frozen is largely effective in preventing offensive odor.
2) It is also effective to build enclosure around the source processes such as thawing process and boiling process to prevent diffusion of offensive odor.
3) Moreover, indoor exhaust air is collected and diffused from a elevated place such as the stack.
4) To install a dust to collect severe offensive odor, to lead it to the boiler and to deodorize it by combustion and dilute it by exhausting through the stack.
5) It is also effective to tightly seal batch-type boiling pot, but, on the contrary it is also effective to discharge odor by diluting it by installing the continuous boiling process to avoid the concentrated emission by the bath-type process.
6) Measures are to be taken for the improvement of waste storage and disposal, etc.
7) Recycling the air containing offensive odor after cooling (water washing) and reducing the volume.

In case that above measures do not work in controlling the offensive odor, further measures such as installation of deodorizer on stack, are to be studied.

(2) Deodorization technique

In the event deodorization facility needs to be installed by any means after studying preceding actions, deodorization method must be studied; 1) At what exhaust volume, 2) For what intensity of odor, 3) To what levels the deodorization should be conducted, 4) What method for deodorization should be adopted.

The classification and features of deodorization technology are shown in the Table 4-2-3 and Table 4-2-16.

Table 4-2-3 Characteristics of deodorization method

Deodorization method		Characteristics of method and its outline
Deodorant	Masking	To govern offensive odor by strong fragrance
	Neutralization	To take smell off by opposing smell
Condensation	Subzero fractionation	To cool offensive odor by liquid nitrogen and condensate offensive odor for separating as solid
Dissolution	Water washing	To wash away offensive odor with shower
	Acid alkali washing	To wash offensive odor with acid alkali shower
	Solvent washing	To wash offensive odor by solvent shower and to separate and recover solvent
Adsorption	Activated carbon adsorption	To pass offensive odor through activated carbon bed
	Zeolite adsorption	To pass offensive odor through zeolite bed

Ion exchange	Cation exchange		To pass offensive odor through wet cation exchange resin bed
	Anion exchange		To pass offensive odor through wet anion exchange resin bed
	Adsorptive resin		To pass offensive odor through wet resin bed
Oxidation	Chemical oxidation		To clean offensive odor by oxidizing chemicals
	Thermal cracking	Direct combustion	To mix offensive odor with feed air in combustion furnace for firing it at 800℃ or higher
		Catalytic combustion	To fire offensive odor at about 300℃ similarly under atmosphere of platinum catalyst
	Biological oxidation	Soil treatment	To pass offensive odor through infiltrated Ando soil (volcanic ash soil) bed, etc.
		Compost treatmen	To pass offensive odor through compost,peat moss bed
		Activated sludge	To blow offensive air into activated sludge treatment tank

(a) Incineration of offensive odor

Offensive odor substances such as ammonia, methylmercaptan, hydrogen sulfide, methyl sulfide, methyl disulfide, trimethylamine, low grade fatty acid and alcohol, becomes odorless when oxidized. Since combustion means the state of intensive oxidizing reaction, it is effective for the factory using the boiler, etc. to connect offensive odor to boiler feed air by means of duct for combustion. Incomplete combustion of organic substance containing nitrogen will possibly generate cyanogen and therefore, it is necessary to heat such substance up to high temperature in the air for complete combustion. Although most of offensive odor substance are combustible at approx. 500 ~ 600℃ in the air, the temperature of 85 ℃ or higher is said to be necessary for prevention of cyanogen. A boiler may have the high enough temperature of 1000℃, but the contacting time is not enough to prevent the cyanogen formation.

- **Physical method**
  - Water washing method — To have offensive odor water-washed, dissolved and removed
  - Adsorption method — To adsorb and remove offensive odor by substance high in gas adsorption such as activated carbon, zeolite, etc.
  - Cooling and condensation method — To cool offensive odor substance for condensation and removal
  - Dilution method — To diffuse offensive odor into atmosphere for dilution

- **Chemical method**
  - Chemical dose absorption method
    - Oxidation absorption method
      - Gas phase oxidation method : To dissolve odor by ozone, chlorine gas, etc.
      - Liquid phase oxidation method :To dissolve odor by chemical dose of sodium hypochlorite
    - Acid, alkali absorption method — To dissolve odor into chemical solution such as acid and alkali for chemical change and removal
  - Chemical adsorption method — To adsorb odor by ion exchange resin, gas adsorbent, etc. for removal
  - Combustion method
    - Direct combustion method — To burn odor at high temperature of 800℃ or higher for thermal cracking
    - Indirect combustion method — To burn odor at low temperature for thermal cracking by platinum vanadium, etc. as catalyst in case flammable component content is low
  - Neutralization method — Masking method — To hide and confine odor by masking agent, etc.

- **Biological method**
  - Soil adsorption method — To degrade and remove odor component by biological and chemical action of soil bacteria
  - Biological deodorization method — To degrade and remove odor component by biological and chemical action in reaction tank which is filled with carrier fixed with bacteria
  - Enzymatic method — To degrade and remove odor component by enzymatic agent

Fig. 4-2-16 System of deodorization technology

(b) Activated carbon adsorption

Activated carbon is utilized for its purifying power by adsorption, but its effect differs according to the type of offensive odor. Easy-to-adsorb odors are those of acetic acid, butyric acid, alcohol, mercaptan, hydrogen sulfide, cresol, refined oil. Hard-to-adsorb odors are those of amine, ammonia, aldehyde. Hard-to-adsorb odor is removed by scrubber and thus, it can almost completely be deodorized if scrubber and activated carbon adsorption are provided in combination.

In activated carbon adsorption, offensive odor collected in dust is passed through column which is filled with granular activated carbon at space velocity of under 0.5m/min. Also, holding capacity (adsorption capacity) of activated carbon is generally constant for each odor substance and thus, deodorization is no longer possible if its capacity has exceeded. That is, activated carbon column needs periodical replacement and the activated carbon, after it is used, can be recycled and used by applying steam activation. New activated carbon needs to be replenished because volume reduces by 10 % or so in each recycling treatment.

(c) Activated sludge treatment

Activated sludge is symbiosis body of many micro-organism, and it, in some cases, can degrade offensive odor substances. Bacteria which degrade offensive odor substances is hidden while ordinary water treatment is done, but its deodorizing capacity comes to the surfaces as offensive odor is blown in it for a given period. The period till deodorization capacity appears is called the acclimatization period. Sulfur and nitrogen odor requires 2 to 3 days for acclimatization, while some of hydrocarbon odor need 1 to 7 days for acclimatization.

In the factory installed the effluent treatment facility with activated sludge process, it is possible to remove offensive odor by injecting the odorous air into 1m deep in the aeration tank by blower.

Following Fig.4-2-17 shows concept as an example of installation.

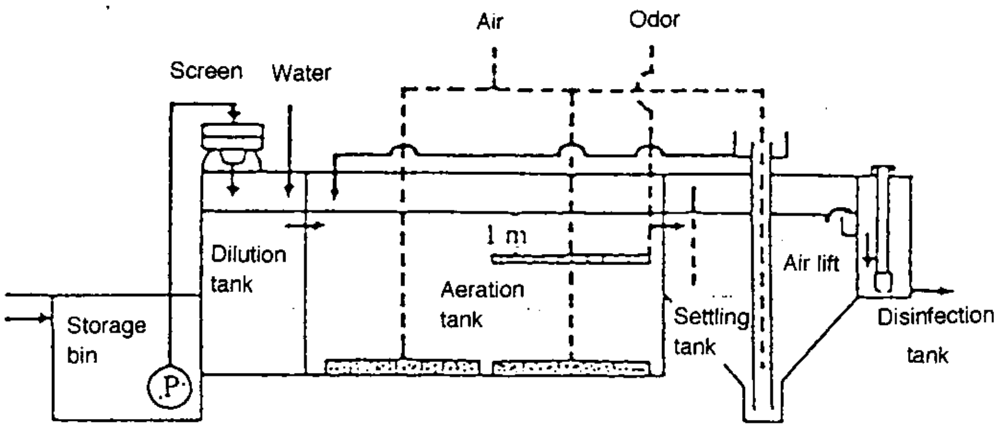


Fig.4-2-17 Deodorization method by activated sludge (Conceptual drawing)

(d) Soil deodorization

It is generally said that innumerable number of aerobic bacteria called soil microorganism grow and are capable of capturing and degrading a variety of contaminant and absorbs even offensive odor substances. Therefore, deodorization effect can be obtained by blowing offensive odor into the soil. Deodorization is attained in a way that piping is laid in gravel layer so as to diffuse and blow out offensive odor at the rate of $1m^3$/min offensive odor for 10 m^2 ground area packed by sand and soil to the depth of 30~50cm. However, it may happen that deodorization effect decreases if offensive odor contains organic substances favored by bacteria such as alcohol and low grade fatty acid because such substances like to be intaken better than offensive odor substances. In such case, it is possible to enhance deodorization effect by devising water washing prior to the soil deodorization.

4. 2. 4 Treatment and Disposal of Wastes

The "Waste Disposal and Public Cleansing Law " stipulates that solids wastes which can not effectively be recycled and sludge generated by the effluent treatment is regarded as industrial wastes. The main aim is often set at the strict observation of the effluent standards in the effluent treatment, but another noticeable factor is how to reduce the amount of the waste generated by such treatment.

It stipulates that industrial wastes must be disposed properly under the business enterprises' own responsibilities.

It is further obligatory that in case business enterprises treat and dispose of industrial wastes by themselves, they must comply with technical standards specified under the law and indicate it in order to prevent harmful substances from leaking into the environment.

Generally, however, it is difficult in many instances to treat and dispose industrial wastes by business enterprises themselves, and it becomes necessary to commission such work to a contractor.

It is obligatory in such a case for the business enterprises to confirm beforehand that the contractor possesses the legal permission on the business of industrial waste collection and transportation as well as industrial waste disposal.

Moreover, it is needed that the manifest which certifies proper implementation of treatment and disposal is managed in an appropriate manner. The manifest shall be kept by the 3 parties: business enterprises as emission source, company who collects and transports waste and contractor who takes charge of final disposal. Business enterprises as emission source are to keep 2 kinds of manifest: Manifest of dispatch and manifest certifying final disposal. Therefore, 4 sheets of manifest are needed for industrial waste disposal.

There are two kinds of final disposal; Landfill disposal and Dumping into ocean. However, along with revision of the London Convention, it is practically impossible to dump industrial waste into ocean in the future.

Landfill disposal site is divided into 3 types; Stabilized type, Managed type and Shutoff type. The disposal sites were designated was sorted out according to the kind of industrial waste. On the other hand, environmental protection has not been effectively implemented against naughty disposal of industrial waste, it was hard to restore reliability and consequently it is difficult to find out and maintain the disposal site. Under this circumstance, JEC has newly launched construction and transfer project for the final disposal yard sites.

4. 3 Advanced Wastewater Treatment Technology (Technology for Removal of Nutrient Salt)

Pollution control technology so far described was for so-called, primary pollutants, which is harmful by itself or causes pollution. This section describes advanced treatment technology for removal of nutrients (nitrogen and phosphorous) from wastewater; Such nutrients do not cause the pollution directly but causes eutrophication (extensive proliferation of plankton and rampant growth of waterweed) in the public water area, where anaerobic water lump develops to such an extent that the aquatic ecosystem is completely destroyed. Another problem is that they cause the proliferation of certain plankton emitting abnormal odor (musty odor) in reservoir as source of drinking water supply, and consequently deprives the reservoir of value as water source.

4. 3. 1 Nitrogen Removal Techniques

Nitrogen forms main components in biotics body like nucleic acid, amino acid and protein and furthermore, it plays a role in gaining energy for nitrifying bacteria and denitrifying bacteria. It is, thus, an important element for the biotics. As shown in Fig.-4-3-1, nitrogen circulates by changing its form from nitrogen gas (N_2), ammonia, nitrous acid, nitric acid to organic component.

Its form is changed in a way that plant changes nitrogen from inorganic to organic compounds and the animal having eaten the plant transforms organic nitrogen and excretes it in the form of uric acid and ammonia. In the nitrogen cycle, microorganism, in addition to plant and animal, is involved. Some microorganisms decompose organic nitrogen in excrement and withered body into ammonia. Some change ammonia into nitrous acid and nitric acid (nitrifying bacteria). Some also change nitric acid into nitrogen gas under presence of organic substances (denitrifying bacteria) and other fix nitrogen gas and changes it into organic body (nitrogen fixation bacteria). Another source of nitrogen is the chemical industry, and fertilizer industry. Electric discharge of thunder changes the nitrogen in air into ammonia and nitrogen oxide.

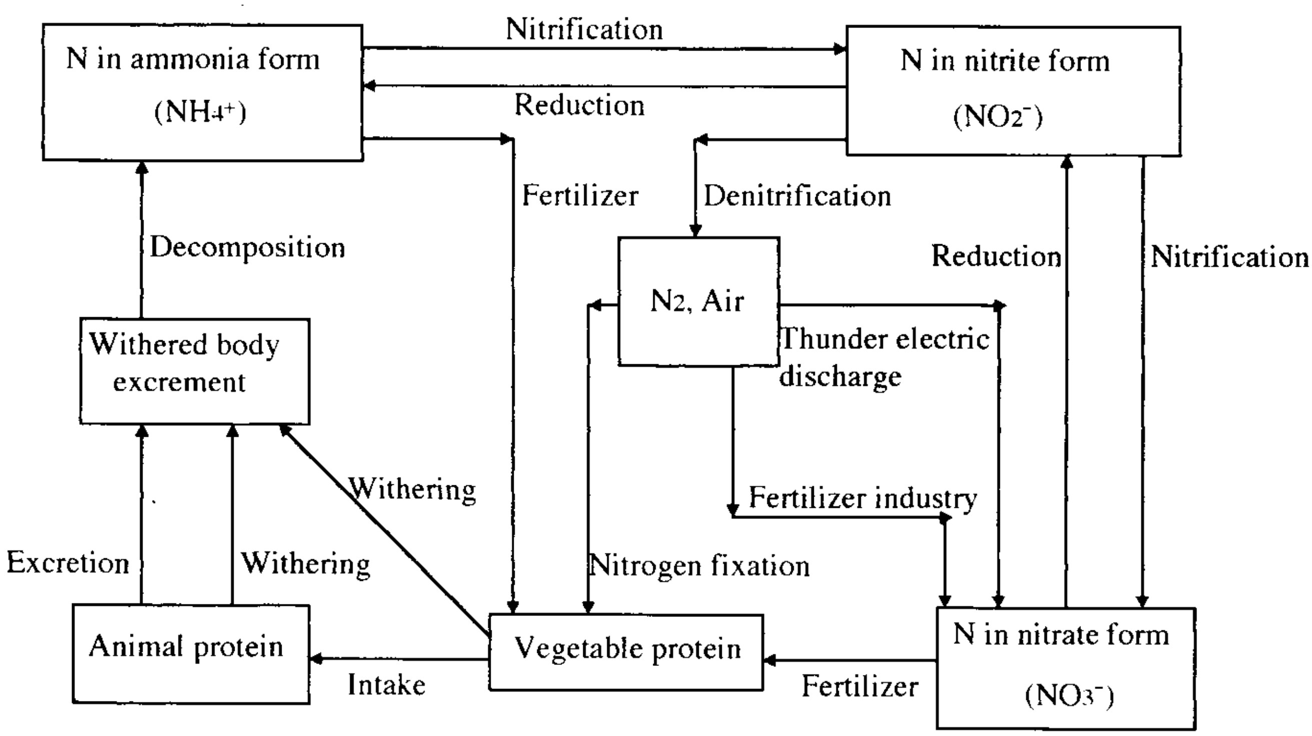


Fig.4-3-1 Nitrogen circulation cycle

Technologies for removal of nitrogen in the effluent is divided into two sorts, a method which utilizes function of the biotics and the other method which removes nitrogen physically and chemically. A variety of studies have been conducted and this section describes outline of typical nitrogen removal technologies.

(1) Biological nitrification and denitrification techniques

As shown in Table 4-3-1, biological nitrification and denitrification technology consists of 3 processes; 1) Deamination process (formation of ammonia) 2) Nitrification process (formation of nitric acid and nitrous acid) and 3) Denitrification process (formation of nitrogen gas).

Deamination process and nitrification process are aerobic processes. In deamination process, ammonia is formed through deamination reaction in the course where organic substance is decomposed in a conventional secondary treatment process. Nitrification process is the process in which ammonia is oxidized to the form of nitric acid, requiring large volume of oxygen. This reaction starts in the latter half of secondary treatment process and requires sufficient nitrification for effectively removing biological nitrogen. It is, therefore, necessary to spend longer time for aeration in secondary treatment or to add yet another aeration step for the nitrification process. In the operational point of view, furthermore, Sludge Retention Time (SRT) is set to be longer in order to keep a large volume of nitrifying bacteria in the system.

Denitrification process is anaerobic treatment process and organic carbon is required for reduction of nitric acid. To realize this reaction, one additional unit of anaerobic tank is installed where organic substance such as methane is injected. Or, organic substance in raw wastewater is utilized by bypassing and a part of raw wastewater is fed to the anaerobic tank. Another method is to circulate nitrifying solution by installing anaerobic tank prior to secondary treatment process line so as to utilize organic substance in the raw wastewater.

Table 4-3-1 Outline of biological nitrogen removal process

Process	Condition	Change of nitrogen	Outline of reaction
Deamination process	Aerobic	Org-N → NH_4 ~ N (Activated sludge)	1) Removal of BOD 2) Formation of ammonia
Nitrification process	Aerobic	NH_4~N→NO_2~N (Nitrosomonas) NO_2-N →NO_3~N (Nitrobacter)	1) Alkalinity is consumed (Note) due to nitrification and thus, alkaline agent needs to be added in some cases. 2) Optimum pH is 7.0~9.0 3) Target N/SS load (nitrogen concentration over activated sludge concentration) shall be 40g-N/kg-SS/d . 4) SRT (sludge retention time) shall be set to be longer for proliferating nitrifying bacteria.
Denitrification process	Anaerobic	NO_2-N → N_2 ↑ (Pseudomonas,etc.)	1)DO shall be kept to be 1mg/l or less. 2) Denitrifying bacteria is heterotrophic bacteria and thus, organic substance needs to be replenished. (BOD/N=3 or so is the reference value.) 3) Alkalinity can be recovered(Note) through reduction of nitric acid.(Optimum pH=7.~7.5)

(Note) All processes of nitrification and denitrification proceed under the following equation and alkalinity of 3.57 times the removed nitrogen is consumed. In case alkalinity in raw wastewater is low, it needs to be replenished. Alkalinity balance in nitrification and denitrification process is as follows:

・Nitrification; $2NH_4^+ + 3O_2 \rightarrow 2NO_2^- + 4H^+ + 2H_2O$

$2NO_2^- + O_2 \rightarrow 2NO_3^-$

By combining 2 equations, ammonia of 2 mol and oxygen of 4 mol react each other to resultantly generate nitric acid of 2 mol and hydrogen ion of 4 mol.(Alkalinity equivalent to 2 mol is consumed.) That is ; alkalinity of 7.14 times of nitrified N_2 is consumed.

・Denitrification : $2NO_3^- + 4(H) \rightarrow 2NO_2^- + 2H_2O$

$2NO_2^- + 6(H) \rightarrow N_2 \uparrow + 2OH^- + 2H_2O$

By combining 2 equations, nitric acid of 2 mol is reduced to resultantly generate nitrogen gas 1 mol and hydroxide ion of 2 mol. (alkalinity equivalent to 1 mol is recovered.) That is, alkalinity of 3.57 times denitrified N_2 is recovered. (H) in equation shows that organic carbon works as hydrogen donor.

Fig.4-3-2 below shows the typical treatment flow in biological nitrification and denitrification process.

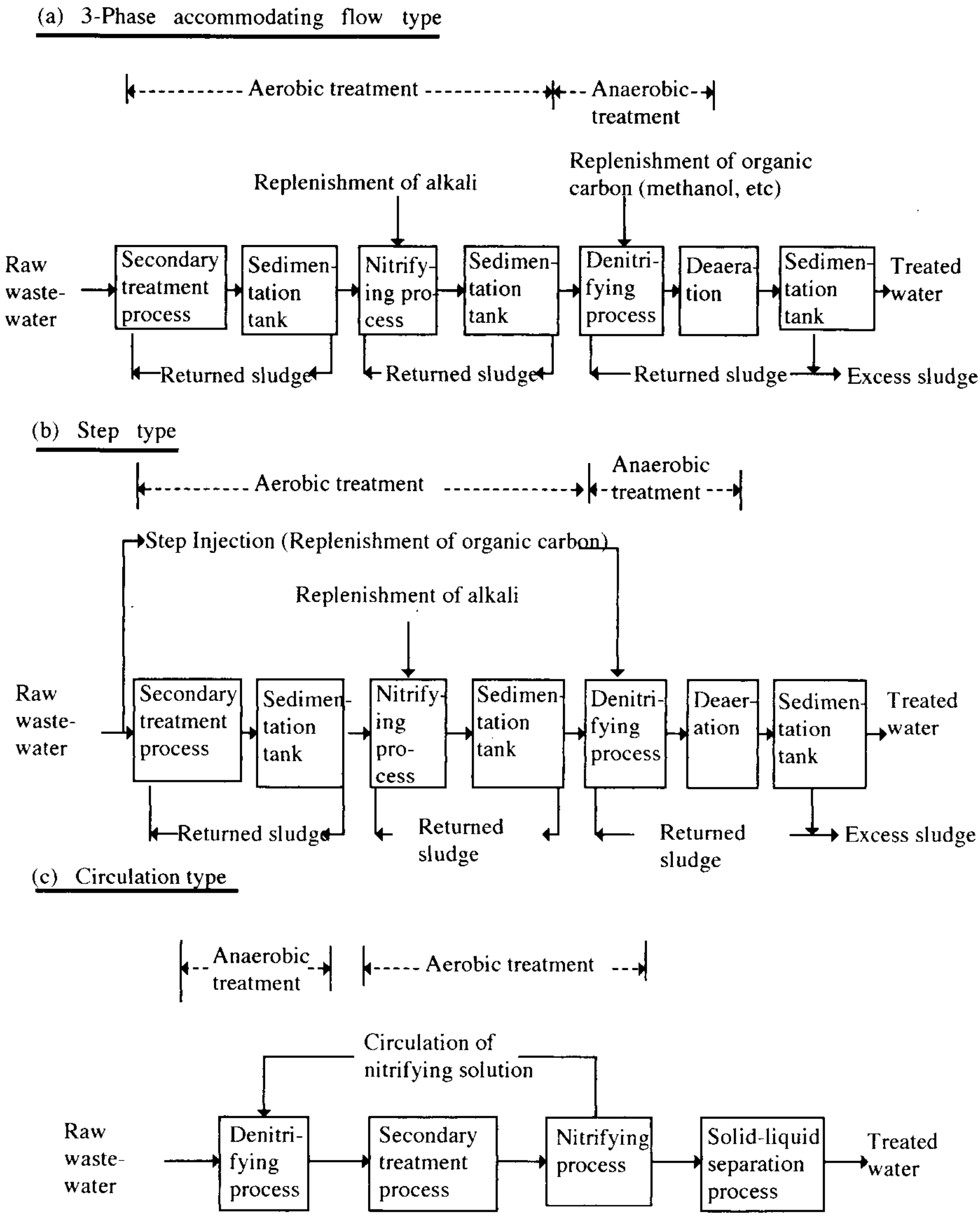


Fig.4-3-2 Treatment flow of biological nitrification and denitrification process

If bubble of nitrogen gas is held by activated sludge in the denitrification process, the sludge floats up in sedimentation tank during solid-liquid separation process and it finally overflows the said tank. In order to prevent above phenomenon, deaeration process is provided in the above Fig. 4-3-2 as a process in which bubble is removed by means of aeration.

The (a) 3-phase accommodating flow type shown in Fig.4-3-2 is called 3-phase sludge type in which activated sludge in secondary treatment process, nitrification process and denitrification process is circulated in separate sludge returning lines. Other systems actually used are 2-phase sludge system which consolidates secondary treatment process and nitrification process into one sludge return line, or consolidates nitrification process and denitrification process into one sludge return line, and single phase sludge system in which above 3 processes are treated in 1 tank. In some case of single phase system, including intermittent aeration type and batch type, nitrogen treatment is given by using a device which was initially installed as secondary treatment facility, because it is possible to reduce nitrogen in treatment water by regulating aeration and setting the raw water injection cycle.

(b) Step type uses organic substances in the raw water for replenishing organic carbon under accommodating flow system and thus, a part of the raw water is bypassed and fed into denitrification process. Therefore, flow where denitrification process take place in the in-flow section is devised (recirculation type).

(c) Circulation system can reduce the volume of alkali to be replenished because nitrifying solution is circulated into the anaerobic tank installed upstream of aerobic tank in secondary treatment process so that the alkalinity is recovered. Through these, oxygen which is bonded with nitric acid formed in nitrification process is utilized for treatment of raw water BOD. This will further lead to the effective utilization of the aerated oxygen and also deaeration process can be eliminated. However, as it is shown in the treatment process diagram, nitrifying solution is partly circulated and thus, 100 % removal of nitric acid is not possible. Nitrogen removal rate is given under the equation below.

$$\eta = R \cdot \eta_n \cdot \eta_d / (1 + R \cdot \eta_n \cdot \eta_d)$$

Here, η : removal rate, R : Circulation ratio, η_n : Nitrification ratio, η_d : Denitrification ratio

As mentioned in the previous paragraphs, there are two methods of biological treatment. Suspended biological method and Biological membrane method. In biological nitrification and denitrification process as well, two methods are adopted. In one case, the same method is used for both aerobic process and anaerobic process. In another case, suspended biological method and biological membrane method are used separately. In actuality, the most suitable method is selected according to respective raw water condition, history of facility expansion and modification, land availability.

(2) Physical and chemical nitrogen removal techniques

Typical methods of physical and chemical nitrogen removal are such as ammonia stripping method, breakpoint chlorination method and ion exchange method. These methods can effectively remove nitrogen but are not good from economic point of view, due to the cost of chemicals, etc. Thus, these methods have not been widely adopted in ordinary wastewater treatment . The principles of respective methods are briefly described.

(a) Ammonia stripping method

Ammonia in wastewater almost stays in the form of ammonium ion around pH 7, but it almost becomes free ammonia (gas state) around pH 11. By pouring alkaline by shower and aerating with blower, ammonia is stripped into the atmosphere. The treated water is neutralized by acid and discharged. Cost for chemicals such as alkaline agent and acid is high and enormous amount of energy for feeding air is required.

(b) Breakpoint chlorine treatment

When chlorine (chlorine gas or hypochlorite) is fed into wastewater containing ammonia, chloramine is formed. By further feeding chlorine, chloramine is decomposed into nitrogen gas and hydrochloric acid. The volume of chlorine poured for converting chloramine into nitrogen gas is called breakpoint and its volume is approx. 10 times the ammonia nitrogen.

This technology has spread for water supply station. This technology is applied only when ammonia concentration is low from its economical point of view. This technology is not adopted for the wastewater treatment because cost for chemicals is high when ammonia concentration is high.

(c) Ion exchange method

Ion exchange method includes ion exchange resin method, ion exchange membrane method, zeorite adsorption method, etc. In the case of ion exchange resin and ion exchange membrane, it is possible to remove both ammonia nitrogen, nitric acid and nitrous acid nitrogen by alternately using cation exchange resin and anion exchange resin, but it is not effective for organic nitrogen. In order to change organic nitrogen into inorganic nitrogen for enhancing ion exchange effect, pretreatment for removing organic substances and SS is required. Also, resin is expensive and thus, it needs to be recycled and treatment of waste solution after recycle becomes necessary. Considering these points, above methods are largely disadvantageous in terms of economy for applying to the wastewater treatment.

Meantime, zeorite method is effective in adsorbing ammonia nitrogen, but it is not effective for nitric acid, nitrous acid nitrogen or organic nitrogen. Besides, adsorption volume is small and recycling interval becomes more often.

4.3.2 Phosphorus Removal Techniques

Phosphorus removal methods are largely classified into physical/chemical method and biochemical method.

(1) Physical/chemical treatment method

There are two methods as physical and chemical treatment: One is chemicals coagulation sedimentation in which chemicals forming insoluble metal salt in combining with phosphorus are added and the salt is sedimented and removed. The other method is crystallization method in which phosphorus is crystallized on the surface of the crystal nucleus composing of phosphorous compounds.

(a) Coagulation treatment method

Chemicals which have been studied as coagulant since 1960s were aluminum sulfate, aluminum chlorine, iron chloride, lime, rare earth elements, tin dioxide and activated aluminum. Because of the problems such as cost of chemicals and complexity of operation, generally used coagulant in wastewater treatment as end-of-pipe technology are aluminum salt, ferric salt and lime.

Phosphorus in wastewater mostly becomes orthophosphoric acid and the reaction equation for phosphorus removal in using aluminum sulfate is presented below.

Phosphorus forms slightly soluble aluminum phosphate, while excess aluminum salt reacts with bicarbonate ion (alkalinity) and form aluminum hydroxide. Aluminum hydroxide becomes flock in the water and the slightly soluble particle (colloid particle) such as aluminum phosphate are adsorbed into flock, sedimented and removed.

$$2PO_4^{3-} + Al_2(SO_4)_3 \rightarrow 2AlPO_4 + 3SO_4^{2-}$$

$$Al_2(SO_4)_3 + 6HCO_3^- \rightarrow 2Al(OH)_3 \downarrow + 6CO_2 + 3SO_4^{2-}$$

Minimum solubility is obtained based on the relationship between solubility of aluminum phosphate and pH : i.e. approx. 0.01mg/l at pH6, approx. 0.3mg/l at pH7 , and approx. 0.03mg/l at pH5. Aluminum salt that can be used for removing phosphorus are poly-aluminum chloride (PAC) and sodium aluminate.

(b) Crystallization method

Crystallization method has been studied for its commercialization in Japan since latter half of 1970s. Phosphate ore, bone coal and converter slag are used as crystal nucleus. This method is mainly adopted in phosphorus removal technology as the tertiary treatment.

Basic chemical reaction in crystallizing phosphorus removal method is as shown below and is same with reaction in forming hydroxyapatite under lime coagulation method.

$$10Ca^{2+} + 6PO_4^{3+} + 2OH^- \rightarrow Ca_{10}(OH)_2(PO_4)_6$$

Factors influencing above reaction are the concentrations of Ca^{2+}, PO_4^{3+}, OH^- i.e., slaked lime is added into secondary-treated water to establish pH condition of appropriate range and over-satulation condition of apatite. On the other hand, substances which compete to hinder reaction are bicarbonate ion, magnesium ion, sulfuric ion, etc. In particular, a large amount of bicarbonate is contained in the secondary-treated water and therefore, pretreatment such as decarbonizing treatment and pH adjustment are required.

(2) Biochemical phosphorus removal method

In case aerobic atmosphere is created in the first half of the aeration tank under activated sludge process, orthophosphoric acid is released from MLSS (phosphorus discharge) in the anaerobic tank, while in the aerobic tank, intake of phosphoric acid take place and phosphorus is absorbed up to the level that phosphoric concentration becomes below that of the raw water. In this way, once phosphorus is released in the anaerobic tank, phosphorus can be absorbed in the aerobic tank (excess intake) more than phosphorus which activated sludge released. The content of phosphorus in MLSS in ordinary operation is approx. 2 to 2.5 %, but the content of phosphorus under aerobic anaerobic operation reaches 5 to 6 %. In one example of bench-scale experiment it is reported the content of phosphorus reached as high as 12.8 %.

Biochemical phosphorus removal process is, in principle, utilize the phenomenon of excess intake of phosphorus by activated sludge under anaerobic aerobic operation. There are several directions for development, but this process is broadly classified into A/O method and phostorip method.

(a) Anaerobic aerobic activated sludge process

In anaerobic aerobic activated sludge process the basic flow is shown in Fig.4-3-4. It is based on the phosphorus removal method (A/O method) which was developed through the research on the restriction of bulking in secondary treatment activated sludge process (anaerobic aerobic operation). In this method, sludge high in its phosphorus content obtained as result of anaerobic aerobic operation is drawn out as excess sludge and then, removal of phosphorus can be achieved. It is necessary that phosphorus is not released during the sludge treatment process. Characteristics of this method are as follow;

1) Chemicals specially for phosphorus removal are not needed.
2) Thus, amount of excess sludge does not increase due to use of chemicals.
3) Sludge is good in its precipitation and concentration performance because of anaerobic aerobic operation.
4) Removal of phosphorus becomes feasible only by partially modifying existing activated sludge treatment facility.
5) Fertilizer effect is enhanced because phosphorus concentration in generated sludge is high.
6) Simultaneous removal of nitrogen and phosphorus is also possible as stated in the subsequent sections.

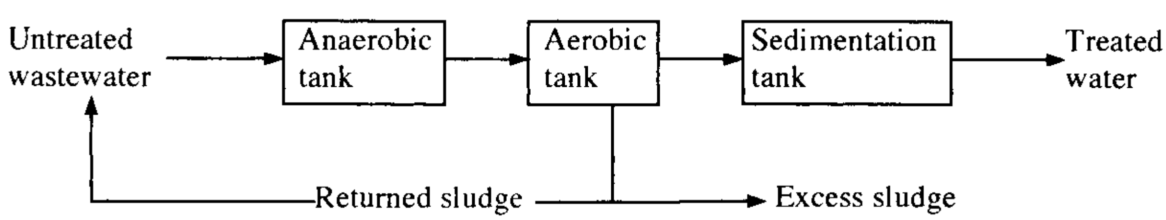


Fig. 4-3-4 Basic flow of biochemical phosphorus removal method (A/O method)

(b) Phostorip method

Phostorip method is the method which was developed prior to above mentioned A/O method. The principal difference is that an anaerobic tank is installed in the sludge return line and the discharged phosphorus in separated solution in phosphorus removal tank is fixed by lime. Its treatment flow is shown in Fig.4-3-5. Characteristics of this method are as follows:

1) Phosphorus is released in the return sludge line and is removed by lime. It is operated, therefore, in the condition that content of phosphorus in MLSS is low.
2) Facility becomes complicated and chemicals such as lime cost significantly, but it is stabe in the capacity of removing phosphorus.
3) Lime treatment in sludge line is provided and thus, cost of chemicals is lower by approx. 10 % than the lime treatment of whole amount of raw water. Besides, the content of phosphorus in the lime sludge is high and it is highly valuable as fertilizer.
4) Simultaneous removal of nitrogen and phosphorus is feasible as mentioned in subsequent sections.

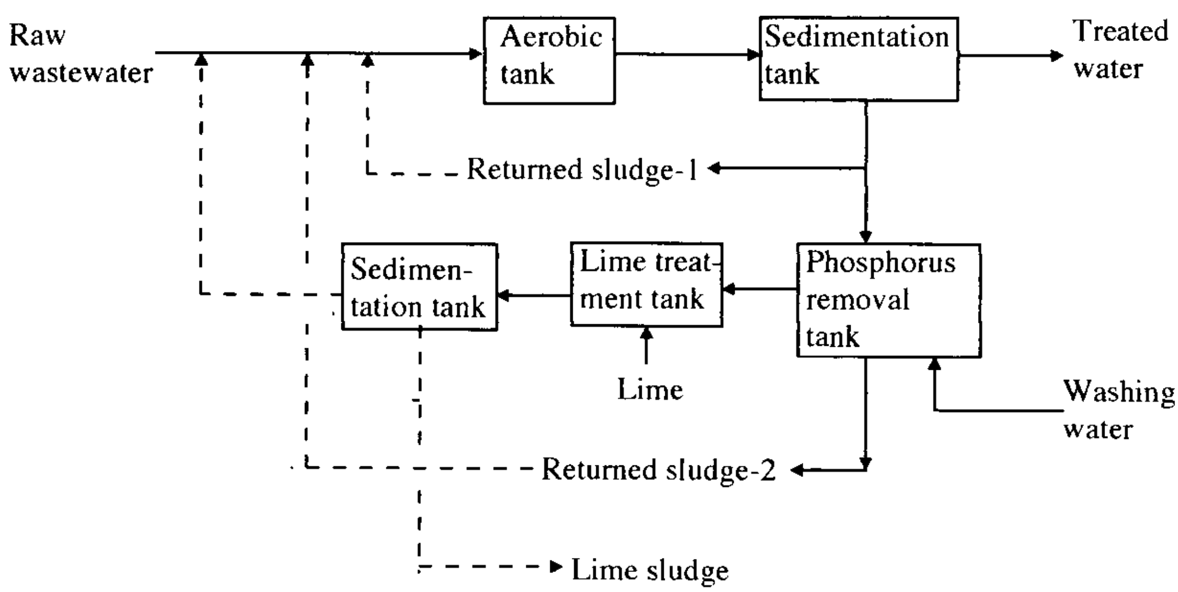


Fig.4-3-5 Conceptual flow diagram of phostorip method

4. 3. 3 Simultaneous Removal Technology of Nitrogen and Phosphorus

Simultaneous removal of nitrogen and phosphorus presently in the commercial operation level is achieved in the treatment facility which combines and integrates both of above-mentioned denitrification technology and phosphorus removal technology. Shown below is the outline of such system.

(1) Biological denitrification process + Coagulation sedimentation process

In this process, coagulation sedimentation phosphorus removal line is installed at downstream of biological denitrification system. In the biological denitrification system, several systems are applied ranging from 3-phase accommodating flow system, which is most common, circulation system, limited aeration system and to batch system.

(2) Coagulant addition biological denitrification and phosphorus removal process

Biological denitrification and phosphorus removal process with addition of coagulant is the simplest method in combination of biological denitrification method and coagulant method. In this process, phosphorus is fixed by feeding coagulant in the aeration tank of biological denitrification method and moreover, it helps to improve the sedimentation of sludge. Basic biological denitrificaton system is based on the circulation type anaerobic aerobic denitrification method, but this process can also be applied in both limited aeration denitrification method and batch type denitrification method. This process can be provided by minor improvement of existing facilities and switching of operation method.

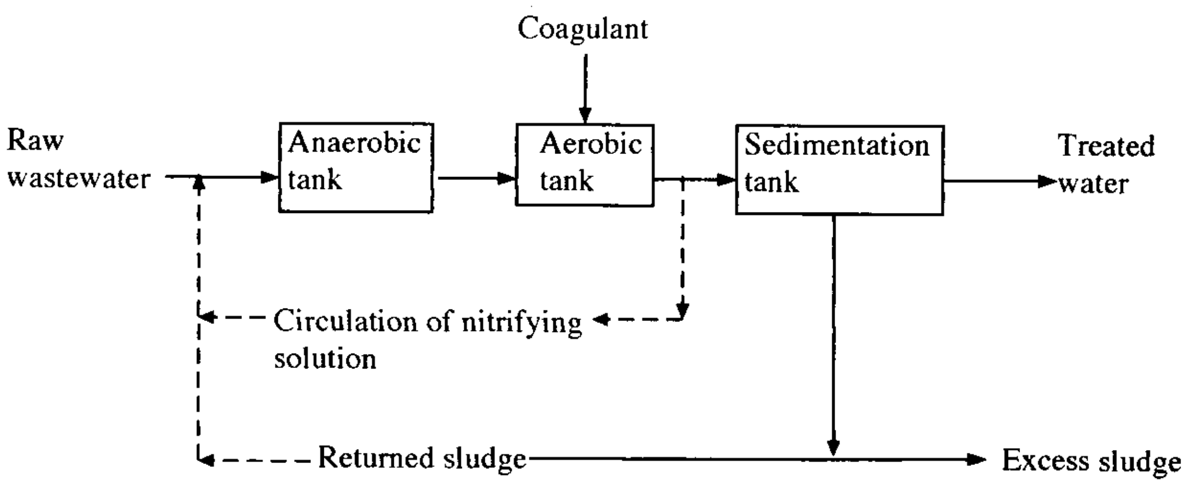
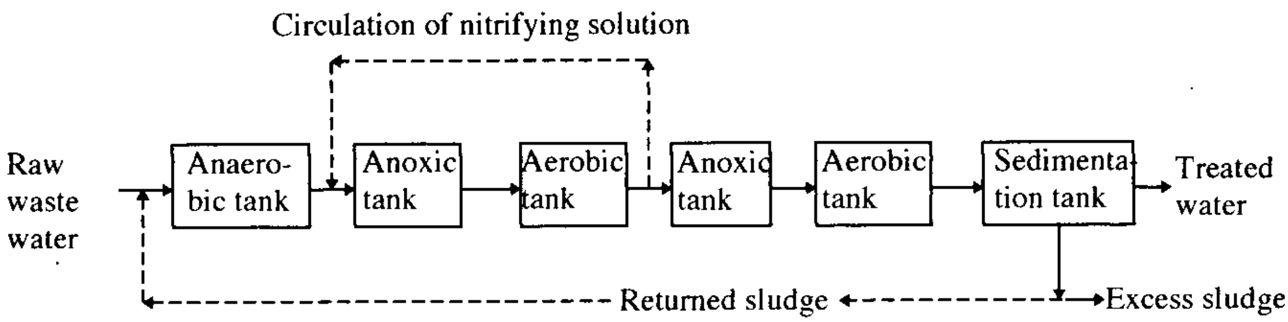


Fig.4-3-6 Basic flow of coagulant addition biological denitrification and phosphorus removal process

(3) Biological denitrification process + Anaerobic aerobic phosphorus removal process

The method which combines biological denitrification process and anaerobic aerobic phosphorus removal process is found in the two systems ; Modified bardenpho method which was developed into simultaneous removal method of nitrogen and phosphorus by installing the anaerobic tank for phosphorus release at upstream of the bardenpho process, and A2 O method which combines anaerobic aerobic phosphorus removal method (A/O method) and circulation type biological denitrification method. Both methods are same in the system configuration as is shown in the basic flow of Fig. 4-3-7.

(a) Modified bardenpho method



(b) A2 O method

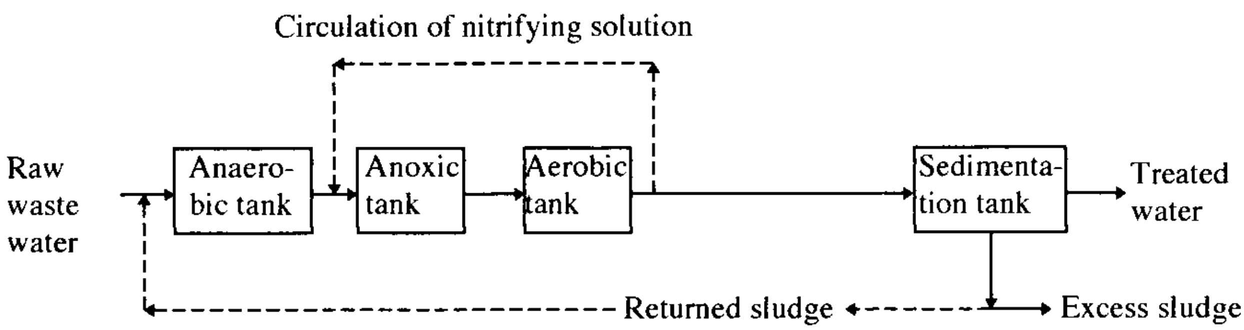


Fig. 4-3-7 Basic flow of biological denitrification and phosphorus removal method

(4) Biological denitrification method + Phostorip method

In this method, an anaerobic tank is installed in the upstream of the aerobic tank in phostorip method and nitrifying solution is circulated and phosphorus removal process is added.

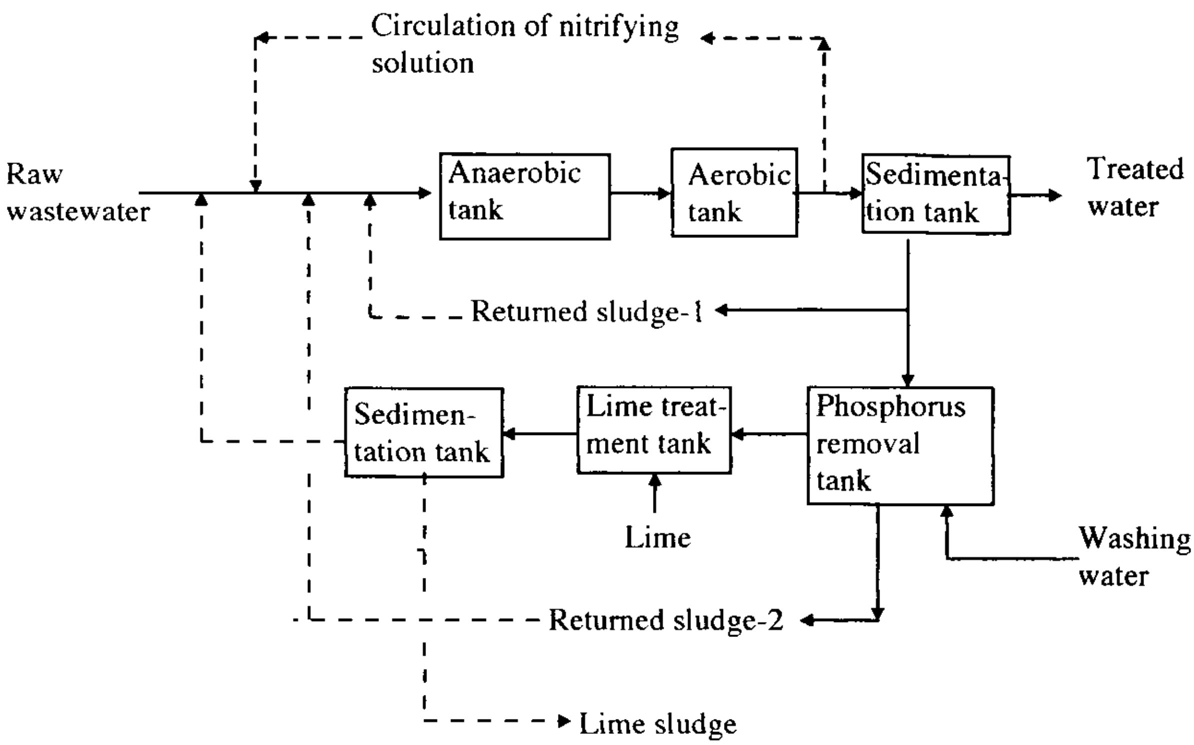


Fig. 4-3-8 Conceptual treatment flow diagram of phostorip method

4. 4 Management of Wastewater Treatment Facility, Major Troubles and Countermeasures

4. 4. 1 Management of Wastewater Treatment Facility

(1) Treatment capacity and actual amount of wastewater

Process content, its scale and chemicals used may change as time elapses since the time when the wastewater treatment equipment was designed and installed according to changes of products, demands for product quality, etc. Consequently, wastewater volume, water quality and compositions may exceed the treatment capacity and technical compatibility of the facility.

When the wastewater volume increases and the wastewater treatment capacity becomes insufficient due to growth of the business, expansion and renovation of the treatment equipment are needed.

At regular interval or whenever seasonal operation and manufacturing items as well as manufacturing method are changed, the compatibility of treatment capacity of the facility must be reviewed. In this case, to understand the changes of components in the wastewater, analysis of wastewater quality must be done concerning the conditions of soluble composition, nitrogen and phosphorus in different forms, etc.

(2) Layout and maintenance inspection of treatment facility

Maintenance and inspection of the wastewater treatment equipment, focusing on its regular functions or malfunction must always be done. If it is possible to inspect the series of facilities along its treatment flow, maintenance and inspection can be attained even easier.

Although the wastewater treatment equipment may usually be located in limited space, since inspection and maintenance are important in addition to checking the data of the installed automatic control equipment and wastewater quality monitoring equipment, the wastewater treatment equipment must also be carefully laid out.

(3) Unit operation function of each wastewater treatment equipment

In some instances the wastewater treatment equipment includes the combined unit operation such as pretreatment by screen, oil separator and coagulation sedimentation and biological treatment. If the functions of these unit operations are inadequate, the quality of treated water meeting the effluent standards cannot be achieved. Such a situation may occur in case when the quantity or quality of the wastewater has exceeded the treatment capacity range as described before. Accordingly, operation control, including the content of each operation in the manufacturing process, must be examined immediately.

This type of situation can also occur in other cases where a defect is inherent in the structure or specifications of the equipment itself, so that perfect operation is impossible even when the applied technique is adequate.

For example, the performance of the reaction tank for coagulation reaction, is affected by the shape of tank, agitation method, agitation capacity, flow of wastewater, injection position of chemical solution, etc.

To evaluate the effects of wastewater treatment, not only the operation control but also the function of devices in unit treatment equipment must be checked. If some trouble with the equipment is found, the necessary measures should be taken immediately. If this is done, the trouble can sometimes be solved by comparatively minor repair or improvement.

(4) Maintenance and control of sensors for wastewater treatment facility

Sensors such as pH meters, ORP meters and level meters used for monitoring and automatic control of wastewater treatment facility may likely indicate erroneous values when oil and scum in wastewater adhere to them.

Periodical cleaning, calibration and functional checking of these meters for the indicated values are required. It is also important to record the resultant data from these processes in the operation control and continuously utilize them for operation control.

(5) Control of COD_{Mn}, BOD, phosphorus and nitrogen

For the enterprises that usually discharge treated water to enclosed water area such as lake, pond and inner bay, control of phosphorus and nitrogen in addition to COD_{Mn}, BOD might be required as result of the strengthened restrictions.

Such enterprises are demanded to adopt a method to combine coagulation treatment and an upgrading of biological treatment provided with the advanced treatment function. In this case, biological treatment facility comes to have more capability through rationalization of service water and effect by in-process load reduction measures, it also becomes possible to improve removal effect of nitrogen and phosphorus depending on the operation method.

To make sure that wastewater treatment is effective, the water quality must be monitored for raw wastewater, treated water and water discharged from each manufacturing process and in some cases also, the treated water from each treatment unit. The current effectiveness of the treatment must be understood. In case the data to be officially reported are taken, wastewater quality must be analyzed in the company's own laboratory in compliance with the method specified by the law or it must be commissioned to an authorized analysis institution.

However, the water quality monitoring for the operation management of wastewater treatment should preferably be carried out by a simple analytical method that is characterized by rapid and frequent measurements, though the accuracy is relatively low. In this case, correlation with regular analytical methods should be checked beforehand.
(e. g., BOD measurement to be substituted by COD measurement).

(7) Management of wastewater treatment equipment control records

The principal aim of wastewater treatment, etc. is to implement the treatment work in conformity with the legally required effluent standards. It is also defined to be one of the activities such as cleaner production and environmental management. In this regard, wastewater treatment cost must be clarified and at the same time, energy conservation, resource conservation and rationalization of manufacture cost, etc. must be analyzed. As the basic data, efforts exerted, treatment effect, electricity, cost, etc. must systematically be recorded in terms of daily and monthly reports of operation management of wastewater treatment facility, maintenance & inspection, chemicals used, consumption of electric power, etc. Furthermore, these records must be analyzed in correlation with the state of production process, including the types and numbers of processed products, chemicals used, etc.

(8) Reserved spare parts for wastewater treatment equipment

Basic spare parts and consumables to be used for the wastewater treatment equipment must always be kept on hand and stored. In particular, sensors for the automatic control such as pH meter are precision parts and are susceptible to breakage.

They may be damaged by mistake while workers are committed in the maintenance and inspection or cleaning. On the other hand, fuses and thermal switches are the parts designed to break down to protect the main unit.

As described in operation manual for wastewater treatment equipment or the like, it is important to check daily operation reports, and then for the items requiring frequent replacement and consumables used in large amounts, to keep the necessary parts and consumables on hand.

Furthermore, their durability and storage method must be noted.

4.4.2 Main Troubles in Wastewater Treatment and Troubleshooting

In many instances following points are considered to be the causes of insufficient treatment function by the wastewater treatment facility in which person in charge of its operation management goes through hardship in spite of big amount invested by the company executive.

1) Wastewater property does not suit treatment technology.
2) Treatment capacity does not catch up with the increased production output.
3) Management and operation methods of devices and apparatuses constituting treatment facility are not adequate.
4) Manager of treatment facility is lack of knowledge relating to treatment technology.

1) Wastewater property does not suit treatment technology

Explanation on the wastewater treatment technology is given in the beginning of this section and in chapter 4 " Wastewater treatment measures " on the industry-specific pollution control measures. Wastewater treatment means the treatment and disposal in which the aimed water quality or even the cleaner water are attained by removing pollutant suspended or dissolved in the wastewater and further, the removed and separated sludge or condensed solution are made harmless. Present water treatment technology generally adopted is broadly classified into physical /chemical treatment method and biochemical treatment method. Pollutants contained in wastewater include suspended particles (incl. solids) and dissolved substances (even colloidal) and are further classified into organic and inorganic properties largely. Unit operations constituting treatment process include a solid liquid separation (classified as the physical/chemical treatment), in which dissolved pollutant is solidified by the physical/chemical or biochemical method, and solidified pollutant is separated from liquid. Or, pollutant is made harmless or removed and separated by oxidation decomposition.

Important thing, therefore, is to select unit operation and wastewater treatment system as combination of unit operations in accordance with the factors such as property of wastewater, its fluctuation, characteristics of treatment technology and target of treatment. Under any circumstance, cheap installation cost and operation cost shall not be the reasons for the selection. An example of ordinary unit treatment process is shown in the Table 4-4-1. In case pollutant is organic, the biochemical treatment is generally introduced.

As is described in the section 3.2, it is important to conduct the careful investigation at the design-phase in order to adequately select the wastewater treatment technology.

2) Treatment capacity does not catch up with the increased production output

It is the general trend that the more active the operation becomes, the larger the wastewater volume becomes and the higher the pollutant load goes up. This leads to the higher concentration of wastewater and resultantly, the load on wastewater treatment facility goes up higher, while the treatment performance decreases. The basic guidance is to study the production expansion plan in the design-phase investigation.

Factors of fluctuation of wastewater as result of increased production output are mainly the hourly fluctuation in a daily operation due to restriction in incoming raw materials and in products for shipment, the seasonal fluctuation in operation due to similar influence as well as social fluctuation factors influenced by the tendency of businesses and consumers.

It is important to study in advance as to how hourly and seasonal fluctuation can be coped with by the selection of adequate wastewater treatment technology and the operational technology. In the field of dyeing processing industry strongly influenced by the social factors like tendency of consumer's liking, it is necessary to ensure the production managers that they should always recognize the capacity of wastewater treatment facility, revise the plan for wastewater measures of their wastewater treatment facility in the course of equipment investment for production increase and modify or renew the wastewater treatment facility as necessary.

3) Management and operation methods of devices and apparatuses constituting treatment facility are not adequate

Biological treatment is generally introduced for the treatment of organic wastewater. The biological treatment processes comparatively widely adopted are those shown in the Table 4-4-1. Each process requires the appropriate management and operation methods, respectively. Otherwise, troubles take place. Main troubles in this respect are described in the Table 4-4-3.

Table 4-4-1 Comparison among biological treatment processes and features in management of facility

		Activated sludge process	Sprinkling filtration process (high efficiency)	Rotating biological contactor process	Oxidation lagoon process
Facility and feature	Main facility	Aeration tank, sedimentation tank, aeration unit, pump	Filter, sedimentation tank, aeration unit, pump	Contactor tank, sedimentation tank	Oxidation lagoon (aeration unit)
	Size of facility	Normally $0.5m^2$/BODkg or more, Poly-layer aeration, Deep aeration $0.3m^2$/BODkg or more	Normally $0.5m^2$/BODkg or more, Deep filtration $0.3m^2$/BODkg or more	Normally $1.2m^2$/BODkg or more, This can be reduced if poly-layer is introduced	Standard: $170m^2$/BODkg, High efficiency: $50m^2$/BODkg,
	Condition of micro-organism	Added and suspended when wastewater is returned from sedimentation tank	Attaching on filtrating material as biological membrane	Same as left	Suspended in natural condition
	Oxygen feed method	Air blow system (by blower) Mechanical agitation method	Natural draft, Forced draft	Natural draft	Natural draft and high efficiency by mechanical force
	Role of sedimentation tank	Solid-liquid separation, Sludge return, Sludge drawing out	Solid-liquid separation, Sludge drawing out	Same as left	None

Management and function	Main trouble	Bulking, Disorganization, Formation of scum, Breakdown	Proliferation of filter fly, Turbidity, Scum, Breakdown	Turbidity, Breakdown	Coloring, High breakdown rate is trouble
	Main control item	Examine SV_{30}, MLSS, biota, DO and regulate, return volume, drawing out volume, aeration volume. Water quality inspection	Examine peel-off of biological membrane, clogging of filter and spraying condition. Eliminate filter fly and inspect water quality	Draw out sludge according to peel-off of biological membrane. water quality inspection	Normally not required (For feeding fish, measure DO and regulate aeration.)
	Treatment efficiency · BOD removal ratio · SS removal ratio	 90~98 % 85~95 %	 85~93 % 70~85 %	 90~95 % 80~95 %	 90~95 % 80~90 %
	Influence of temperature	Small in air blow system, Large in mechanical agitation	Easily affected	Easily affected (Covering may have to be installed)	Slightly susceptible
	Influence by fluctuated load	Easily affected	Slightly hard to be affected	Slightly hard to be affected	Hard to be affected
	Influence of SS flow in	Hard to be affected (Excess sludge increases if SS is much)	Easily affected	Hard to be affected (Sludge increases)	Slightly hard to be affected
	Influence of toxicant	Easily affected	Slightly hard to be affected	Slightly hard to be affected	Hard to be affected
	Formation of excess sludge	0.4 ~ 0.6 kg/ removed BOD kg	0.1 ~ 0.3 kg/ removed BOD kg	Same as left	Very slight

Table 4-4-2 shows an example of main troubleshooting in the activated sludge process. It is generally said that biological treatment, in particular, activated sludge treatment process requires advanced technology. On the other hand, however, the treatment effect at higher level than planned can sometimes be obtained by the activated sludge process if methods of aeration and raw water feeding are properly adopted. Presence of a number of operating factors in this process, in turn, indicates its wide range of applicability and flexibility.

It is deemed difficult for the operator/manager in charge of factory's wastewater treatment to personally be trained for necessary engineering elements and thus, it is considered essential that factory's supervisory organization and administrative organization provide training opportunity, such as jointly holding seminars.

Table 4-4-2 Example of troubleshooting in activated sludge process

Kind of trouble	Actual phenomenon	Cause of trouble
Insufficient purification	In ordinary activated sludge process 90 % or more the flowing in BOD and COD is removed.but it sometimes happen that the removal ratio substantially lowers	(1) Overload (2) Flow in of harmful substance which is an obstacle for activated sludge creatures (3) Flow in of persistent substance (particularly insufficient removal of COD) (4) Unbalanced nutrition (BOD:N:P = 200 : 10 : 1) (5) Low temperature of 10 ℃ or below, High temperature of 40 ℃ or higher
Increase of excess sludge	Amount of excess sludge to be drawn out increases and its disposal becomes difficult	(1) Overload (2) Bulking (3) Flow-in water contains much salts such as ferrous and SS
Bulking	In case mixed solution in aeration tank is left still, sludge does not sediment as expected even after a long time (30 min or so) showing as appearance the flock of sludge has bulked	(1) Inadequate load, (BOD, SS load 30 ~ 200 kg/MLSS 100kg · day) (2) Treatment of wastewater containing insoluble inorganic particle or inorganic substance which becomes insoluble in aeration (3) Proliferation of sphaerotilus (4) Insufficient aeration
Breaking up of sludge	Fine sludge particles mix in supernatant in sedimentation tank and are flown out. It does not look like swelled in bulking but rushed state	(1) Excess aeration (2) Low load (3) Flow in of harmful substance (4) Unbalanced nutrition (5) Violent physical impact of sludge

Formation of scum	Lump of sludge floats up to the surface of sedimentation tank and forms lamellar shape. Gas and oil attach to sludge flock. Mixed solution is oxidized.	(1) Excessive aeration (Ammonia changes to be NO_2, NO_3 in aeration tank, reduced in sedimentation and generates N_2) (2) Insufficient draw-out of sludge from sedimentation tank (3) Flow-in water contains much wood chips and oil which come up to surface. (4) Improper structure of sedimentation tank
Bubbling in aeration tank	Bubbles cover entire surface of aeration tank and are flew away with wind.	Mixing of surfactant such as ABS
Generation of offensive odor		(1) Defective function (2) Insufficient aeration (3) Flow-in of special substance

Moreover, in case physical/chemical treatment is introduced instead of biological treatment, wastewater treatment facility is equipped with mechanical equipment such as screen pumps, pipings and valves and these equipment require routine conditioning work such as inspection, cleaning, greasing, descaling and painting. In case these conditioning works are done, condition of those work record, replacement record of consumables and storage of spare parts should be checked and if any shortage is found, such parts and consumables should also be replenished. Table 4-4-3 shows an example of the works required.

Documents shall be prepared in relation to the management work required, its interval, countermeasures at occurrence of trouble, communication and notification, procurement method of consumable parts, etc. It is important that these documents are surely given from the maker of wastewater treatment facility to the factory's manager when equipment is installed and when the maker renders explanation on operation, and demonstrates the test run.

4) Manager of treatment facility is lack of knowledge relating to treatment technology

In order to prevent troubles as mentioned in above 1) to 3), it is necessary to have knowledge pertaining to not only end-of-pipe technology but also improvement and management of production process. Engineers who are involved in the management of wastewater treatment facility are demanded to master the scientific knowledge relating to the treatment technology in a broad sense.

Joint organization of seminars by supervisory organization and administrative organization could be the way to train the engineers who are involved in these works.

Table 4-4-3 Example of management work for devices and apparatuses installed for wastewater treatment facility

		Activated sludge process	Sprinkling filtration process (high efficiency)	Rotating biological contactor process	Oxidation lagoon process
Facility and feature	Main facility	Aeration tank, sedimentation tank, aeration unit, pump	Filter, sedimentation tank, aeration unit, pump	Contactor tank, sedimentation tank	Oxidation lagoon (aeration unit)
	Size of facility	Normally $0.5m^2$/BODkg or more, Poly-layer aeration, Deep aeration $0.3m^2$/BODkg or more	Normally $0.5m^2$/BODkg or more, Deep filtration $0.3m^2$/BODkg or more	Normally $1.2m^2$/BODkg or more, This can be reduced if poly-layer is introduced	Standard: $170m^2$/BODkg, High efficiency: $50m^2$/BODkg,
	Condition of micro-organism	Added and suspended when wastewater is returned from sedimentation tank	Attaching on filtrating material as biological membrane	Same as left	Suspended in natural condition
	Oxygen feed method	Air blow system (by blower) Mechanical agitation method	Natural draft, Forced draft	Natural ventilation	Natural draft and high efficiency by mechanical force
	Role of sedimentation tank	Solid-liquid separation, Sludge return, Sludge drawing out	Solid-liquid separation, Sludge drawing out	Same as left	None

Manage-ment and function	Main trouble	Bulking, Dis-organization, Formation of scum, Breakdown	Proliferation of filter fly, Turbidity, Scum, Breakdown	Turbidity, Breakdown	Coloring, High breakdown rate is trouble
	Main control item	Examine SV_{30}, MLSS, biota, DO and regulate, return volume, drawing out volume, aeration volume. Water quality inspection	Examine peel-off of biological membrane, clogging of filter and spraying condition. Eliminate filter fly and inspect water quality	Draw out sludge according to peel-off of biological membrane. water quality inspection	Normally not required (For feeding fish, measure DO and regulate aeration.)
	Treatment efficiency · BOD removal ratio · SS removal ratio	90~98 % 85~95 %	85~93 % 70~85 %	90~95 % 80~95 %	90~95 % 80~90 %
	Influence of temperature	Small in air blow system, Large in mechanical agitation	Easily affected	Easily affected (Covering may have to be installed)	Slightly susceptible
	Influence by fluctuated load	Easily affected	Slightly hard to be affected	Slightly hard to be affected	Hard to be affected
	Influence of SS flow in	Hard to be affected (Excess sludge increases if SS is much)	Easily affected	Hard to be affected (Sludge increases)	Slightly hard to be affected
	Influence of toxicant	Easily affected	Slightly hard to be affected	Slightly hard to be affected	Hard to be affected
	Formation of excess sludge	0.4 ~ 0.6 kg/ removed BOD kg	0.1 ~ 0.3 kg/ removed BOD kg	Same as left	Very slight

5. Sectoral Approach to Pollution Control

5. 1 Dyeing Finishing Industry

5. 1. 1 Outline of Dyeing Finishing Industry

Dyeing finishing industry is the general name of entire manufacture industries of fabric products in which various processes such as scouring and dyeing are given to the raw materials like thread and textile for the purpose of providing textile products with added value and also for enhancing functional quality and are shipped as fabric and clothing products. Among these, the industry which provides dyeing finishing process for dry woven materials like fabrics and manufactures textile product such as clothing is called as apparel industry. Since it uses almost no water in its manufacture process, the apparel industry is separately categorized. It is, thus, general in Japan that the dyeing finishing industry is the one which undertake only dyeing finishing work with use of process water in a large amount.

The manufacture process of dyeing finishing industry is basically as shown in Fig.5-1-1 though it is slightly different depending on the materials such as cotton, silk, wool, etc.

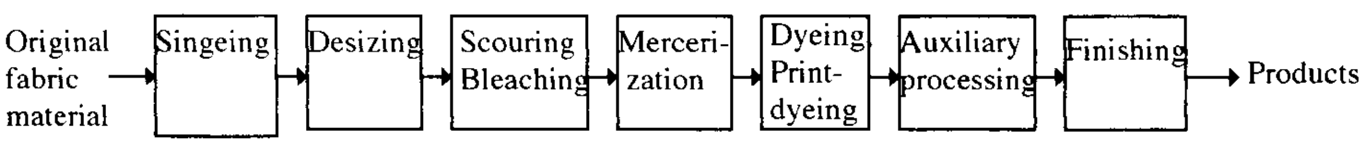


Fig. 5-1-1 Basic production process of dyeing finishing industry (Example of cotton fabric)

(1) Scouring process

Soda ash, detergent, surfactant, etc. are used in the process to remove size used for texture, impurities contained in textiles, size adhered during spinning and weaving, dust and oil.

Large volume of size is consumed in the course of weaving of raw fabric materials for cotton and hemp. Raw fabric materials with size are brought into dyeing factory. First of all, thus, desizing is done by using starch degrading enzyme called amylase and oxidizing agent, then, the oil and pigment contained in the textiles are removed by surfactant and oxidizing agent. In case of cotton, moreover, mercerization process (dipping into caustic soda solution) is provided to thereby attain silk-like glossy surface and improve dyeing performance.

There are two types of bleaching processes for removing the colored substances: bleaching by oxidation and bleaching by reduction. Bleaching by oxidation is applied to cotton, staple fiber and rayon with use of oxidizing agent such as sodium hypochlorite and hydrogen peroxide.

Bleaching by reduction is applied to cotton and wool with use of reducing agent such as sulfurous acid, sodium sulfite and hydrosulfite.

(2) Dyeing process

Dyeing is divided into dip-dyeing and print-dyeing according to its method. Dip-dyeidng is the method for dyeing the fabrics by dipping into dyeing solution and mainly applied to plain cloth. There are two sorts of print-dyeing method; one is to mix dyestuffs in sizing agent, dye by printing and fix by applying steam; the other is to decolor the plain cloth dyed previously. Chemicals used for dyeing include dyeing auxiliaries and sizing agent. Different dyestuffs and dyeing auxiliaries are applied for different textiles and dyeing methods, as the basic combination is shown in the Table 5-1-1.

Table 5-1-1 Raw textile material and dyestuffs used

	Cellulose	Silk	Fur	Acetate	Nylon	Vinylon	Polyacrillic nitril textile	Polyester textile
Direct dye	◎	○	○		○	○		
Acid dye		◎	◎		◎	◎		
Metal complex acid dye		◎	◎		◎	◎		
Reactive dye	◎	○	○					
Disperse dye				◎			○	◎
Cationic dye		○	○	○			◎	
Naphthol dye,Derivative dye	◎							
Vat dye	◎							
Pigment	○	○	○	○	○	○	○	○

◎ : Dyestuff mainly used　　○ : Dyestuff used as necessary

5. 1. 2 Characteristics of Dyeing Finishing Industry in Japan

Dyeing finishing industry constitute a part of manufacturing processes in a series of textile industry which manufactures a variety of textile products. In Japan there are few enterprises, dealing with dyeing finishing industry which integrates the processes from scouring to finishing, but in many enterprises the processes are separately dealt with.

According to the industrial statistics in 1986, the number of enterprises categorized under dyeing finishing industry is 11,000 in Japan. Small industry with 9 employees or less occupies approx. 76 % the total number. Meantime, the number of the enterprises designated in accordance with the Water Pollution Control Law is approx. 4,200, the approx. 72% of which is occupied by the enterprise whose wastewater volume is less than 50 m^3/d.

By its raw material such as cotton, silk and wool, the dyeing finishing industry is further classified as below according to the standard industrial category in Japan. In any of these industries, treatment of wastewater generated from the scouring and dyeing processes is obligatory.

① Cotton, staple fiber, hemp woven fabrics machine dyeing industry

② Silk, rayon woven fabrics machine dyeing industry

③ Fur woven fabrics machine dyeing industry

Since there are a number of different raw materials, styles at dyeing (cloth, thread, bulky fur), dyeing methods and dyeing processes, the wastewater of different properties including various contaminants are discharged from the dyeing finishing factories. In such circumstance, it is difficult to uniformly describe wastewater treatment measures, but the characteristics of wastewater from the factory where wastewater treatment is relatively difficult and mainly continuous scouring and dyeing is conducted are summarized as below;

1) Voluminous wastewater is discharged.

Wastewater volume per unit product is significantly large compared with that of other industries. Throughout the transition period from traditional craftwork to machine dyeing along with Japan's modernization, wastewater volume has increased and over paced the increase of production output.

Dyeing processing machines recently developed are of the type whose water washing section adopts counter current washing system and water and energy saving under computerized control. For this reason, wastewater volume tends to reduce at times of renewal of processing machines.

2) Seasonal and daily fluctuation in wastewater volume is large

Wastewater volume largely fluctuates throughout the year because products to be processed differ in each season and raw materials as well as processing methods applied are different. The recent trend is that the production based on small lot of various specification is adopted to meet the diversifying demand and accordingly the solution in pack is replaced more often to accelerate daily fluctuation and the pollutant load increases as well.

3) Pollutant source is organic substance

Pollutant generated is mainly the organic substance with BOD and COD being an index. Moreover, the colored wastewater, though not high in concentration in terms of organics, is discharged from the dyeing process and this color density does not change even after it is considerably diluted.

There exists some "local" dyeing industry which inherits the market demand for traditional craftworks. To keep and transit its raw materials, dyeing technique, process, etc. as traditional art craft is often the motivation to run the dyeing finishing industry in the particular local area. For such traditional industry, it is needless to say that a different approach is needed as regards the environmental management from the ordinary dyeing finishing industry.

5. 1. 3 Sources and Properties of Pollution

(1) Main generation source

Dyeing finishing processes are significantly different in the detail depending on the textile raw materials and specification for finish processing. As is shown in the Fig.5-1-2, main sources of wastewater are the processes such as desizing, scouring, bleaching, dyeing (dip-dyeing, print-dyeing) and finish processing. Among these sources, concentrated wastewater is discharged from the scouring and dyeing processes, which are considered the main source of the pollutant load in this industry.

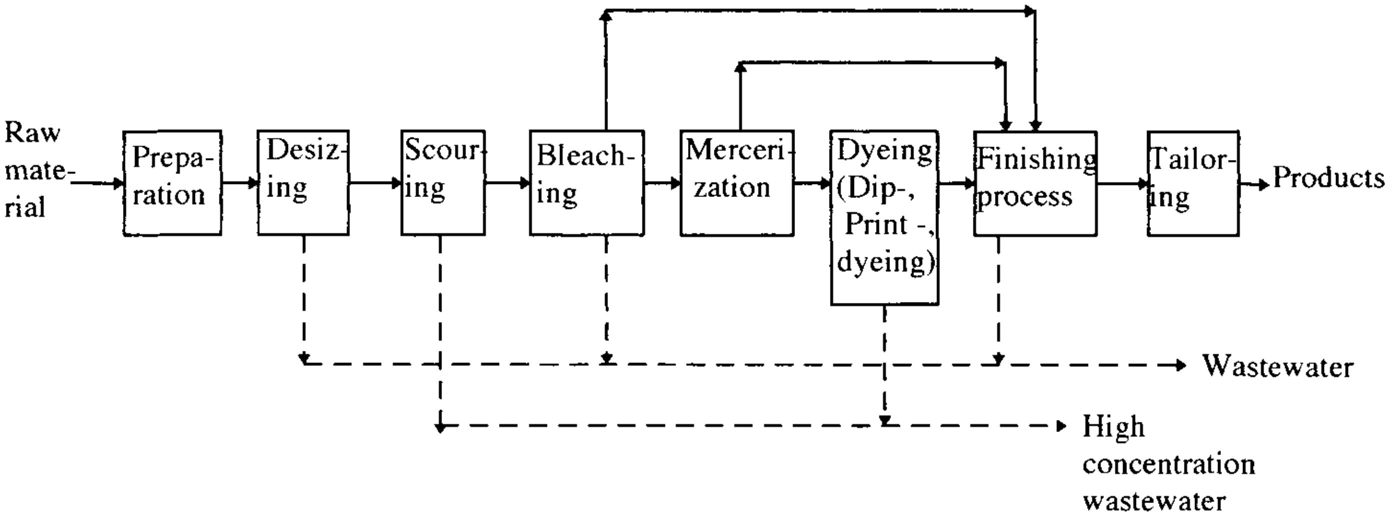


Fig.5-1-2 Main sources of wastewater from dyeing finishing processes

(2) Examples of wastewater quality

Main pollutant sources in the dyeing finishing industry are the scouring process and the dyeing process. Table 5-1-2 shows examples of quality of wastewater discharged from those processes.

Table 5-1-2 Quality of wastewater from main processes in dyeing finishing industry

	Scouring process				Dyeing process		Finishing process
	Sizing	Scouring	Bleaching	Mercerization	Dip-dyeing	Print-dyeing	Finishing
COD	13,000 ~ 500	1,200 ~ 600	500 ~ 150	110 ~ 30	600 ~ 120	2,300 ~120	300 ~ 60
	800 ~ 500				600 ~ 250		
BOD	4,000 ~ 2,200	1,100 ~ 500	450 ~ 150	60 ~ 10	300 ~ 100	250 ~100	150 ~ 40
	800 ~ 400				300 ~ 250		
Main chemicals used	Desizing agent, weak acid		Chlorine agent, Surfactant, salts	Caustic soda	Dyestuff, dyeing auxiliaries, surfactant	Dyestuff, desizing agent, surfactant	Resin agent, surfactant

5. 1. 4 Wastewater Regulations relating to Dyeing Finishing Industry

Among emission control for air pollution, water pollution, odor, soil contamination, etc. , the dyeing finishing industry attaches the most important attention to the measures for water pollution control. When water pollution in the public water area raised social problems before the enactment of the Water Pollution Control Law in 1971, many of the dyeing finishing industries were small in the scale, distributed into local area and thus, the measures against pollution were not taken firmly.

Wastewater from the dyeing finishing industry did not, impose any immediate hazard human health, but as the colored wastewater has been continuously discharged, it has long been regarded to be an environmental hazard.

(1) Water pollution control

Emission standards to be applied to the dyeing finishing industry are the uniform standards, the provisional standards and the area-wise total pollutant load control standards.

(a) Uniform standards

Table 4-1-2 and Table 4-1-3 show the uniform effluent standards based on the Water Pollution Control Law which has been implemented since 1971. Wastewater from the dyeing finishing industry does not contain hazardous substances designated by the Law, and thus, main controlling parameters are the so-called living environment items such as BOD and COD. The allowable limit under the uniform standards is 160 mg/l for both BOD and COD (daily average 120 mg/l). In addition, as from 1993, effluent standards for N, and P has newly been added for the closed water areas such as lakes, ponds, and sea .

In the effluent standards set for the dyeing finishing industry in the River-K basin, which was the water area designated under the two former water quality laws, the standard value for COD was 180 mg/l (daily average 150 mg/l) as shown in the Table 5-1-3. This was slightly more stringent than the uniform standards.

Table 5-1-3 Effluent standards under former two water quality laws (Dyeing finishing industry in water area of the River-K)

	Effluent standards in the River-K basin (Dyeing finishing industry)
Hydrogen ion concentration (pH)	5.8 ~ 8.6
Chemical oxygen demand (COD)	180 (mg/l) (daily average 150 mg/l)

Facilities of dyeing finishing industry specified under the Water Pollution Control Law are shown in the Table 5-1-4. The uniform standards relating to the living environment are applied to the factories which discharge wastewater more than 50 m^3/d with these specified facilities.

Table 5-1-4 Specified facility relating to dyeing finishing industry

19		Facilities which are rendered to the services of manufacturing industry and processing industry of spinning and textile products, as listed below
	a	Cocoon boiling facility
	b	By-product silk processing facility
	c	Raw material dipping facility
	d	Scouring machine and scouring chamber
	e	Mercerization machine
	f	Bleaching machine and bleaching chamber
	g	Dyeing facility
	h	Chemical solution dipping facility
	i	Desizing facility
20		Facilities which are rendered to the services of fur washing industry, as listed below:
	a	Fur washing facility
	b	Washing carbonizing facility
21		Facilities which are rendered to the services of synthetic textile industry, as listed below;
	a	Wet type spinning facility
	b	Chemical treatment facility of linter or unscoured textile

(b) Provisional standards

When the Water Pollution Control Law was enacted on June 24, 1971, there were some industries which were regarded to be incapable of quickly achieving uniform standards from the technical point of view. For those industries, the provisional standards less stringent than the uniform standards were adopted for the limited period of 5 years. Table 5-1-5 shows the provisional standards applied to the dyeing finishing industry. At present there are no industries to which provisional standards are applied because the provisional standards pertaining to the living environment items such as BOD and COD have been switched over to the uniform standard.

Table 5-1-5 Provisional standards (5 years from June 24, 1971)

Item	Kind of industry	Tolerable limit (mg/l)
BOD (mg/l)	Fur spinning industry (limited to industry making fur washing), Fur washing industry, Dyeing finishing industry	260 (Daily average 200)
COD_{Mn} (mg/l)	By-product silk manufacturing industry	330 (Daily average 250)
n-Hexane extracts (content of animal vegetable oil and fat) (mg/l)	Fur spinning industry (limited to fur washing industry)	50
	Fur washing industry	50

As regards the control of nitrogen, however, for the effluent from the dyeing finishing industry into the sea area specified by the Director General of Environment Agency, where ocean plankton may substantially proliferate, the provisional standards are applied for 5 years till Sept. 30, 1998, with the nitrogen standard of 420 mg/l (Daily average 320).

(3) Areawide total pollutant load control

Areawide total pollutant load control is as described in the section 3. 1. 2 (3) (c) and its target facilities in the dyeing finishing industry is shown in the Table 5-1-6.

In the Enforcement Regulation of Water Pollution Control Law, the values such as C are indicated in the range as shown in the Table 5-1-6 and within the range, the prefectural governors may specify the values for each factory.

Table 5-1-6 C values in dyeing finishing industry

Industry classification		COD					
		C_o		C_i		C_j	
		Lower limit	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit
58	Woolen cloth machine dyeing finishing p. in textile ind.	40	60	40	60	30	60
59	Textile machine dyeing finishing p. in textile ind.	80	120	80	100	80	160
60	Textile hand dyeing finishing p. in textile ind	90	120	90	120	90	110
61	Cotton fabric and thread dyeing finishing p. in textile ind.	50	100	50	50	50	70
62	Knit and lace dyeing finishing p. in textile ind	50	100	50	80	50	70
63	General textile dyeing finishing p. in textile ind.	90	120	90	120	80	110
64	Non-woven cloth manufacturing p. in textile ind.	70	90	70	90	60	90
65	Felt manufacturing p. in textile ind.	40	60	40	60	40	60
66	Manufacturing p. of top coated woven cloth and water proof woven cloth in textile ind.	40	90	40	60	40	60
67	Manufacturing p. of fabric hygienic material in textile ind.	40	70	40	60	40	60
68	Textile ind. (except those mentioned in preceding classification)	30	100	30	70	30	50

(Abbreviation : p. = process, ind. = industry)

(4) Stringent standards

Table 5-1-7 shows an example in which the more stringent standards are established for the dyeing finishing industry. For the water quality items unspecified under the stringent standard, the uniform standard is applied.

In Kawasaki City the effluent control based on chromaticity is enforced under its ordinance. Tokyo Metropolitan Government set the control standards for colored effluents so that there should be no unnatural color in effluents. Further, in Nishiwaki City the effluents are controlled by its transparency. In some other cities, effluents are controlled for the chromaticity and transparency which are not regulated by the uniform standards.

Table 5-1-7 Stringent effluent standards relating to dyeing finishing industry

(Abbreviation : D. = Daily, av.= average) (mg/l)

Item	(Water Pollution Control Law)	Aichi prefecture stringent standard	Hyogo prefecture stringent standard
	Uniform standard	Nagoya port, Shonai River, etc. water area	Seto Inland Sea Water area (effluent volume, 5,000 m^3 or more)
pH	5.0 ~ 9.0 for discharges to the sea 5.8 ~ 8.6 for other discharges		
BOD	160 (D.av. 120)	50 (D.av. 40)	55 (D.av. 40)
COD	160 (D.av. 120)	50 (D.av. 40)	35 (D.av. 25)
SS	200 (D.av. 150)		50 (D.av. 40)
n-Hexane extracts (mineral oil content)	5		
n-Hexane extracts (animal & vegetable oils & fats content)	30	10	15
Phenol content	5	1	1
Copper content	3		
Zinc content	5		
Dissolved iron content	10		
Dissolved manganese content	10		
Chromium content	2		
Fluorine content	15		
Coliform group number	D. av. 3,000 (pcs/ml)		
Nitrogen content	120 (D.av. 60)		
Phosphorus content	16 (D.av. 8)		

5.1.5 Response of Industry and Role of JEC

The dyeing finishing industry in Japan was originally characterized as small-scale processing factory and it has been developed as local industry and the nature of effluents largely fluctuated from season to season. Due to these factors, necessity for the water pollution control was not keenly recognized and resultantly implementation of the pollution control has delayed. However, as the institutional arrangement of pollution regulation administration progressed in 1970s, the dyeing finishing industry was obliged to take adequate steps by installing wastewater treatment facilities.

In the beginning, many factories tried to meet the requirement by hiring subcontractors to install the wastewater treatment facilities to which the conventional wastewater treatment technology was adopted. In such arrangement, the design of facilities was in many instances entrusted entirely to the supplier of wastewater treatment facilities, or was often spared by using the outline design prepared by the facility supplier.

This was the typical situation for the application of the end-of-pipe technology. Due to insufficient technical experience of the wastewater treatment in the industry, the facility designn did not fully reflect the effluent characteristics and factory's operation conditions and consequently the facilities could not function satisfactory in many examples. There were the cases where the mere wastewater treatment technology could not solve the problem, but it was necessary to take wide-ranged measures as in-process technology including changeover of chemicals, improvement of production management, and substantial conversion of the management policy. Case studies of the financing program by JEC (Refer to section 5.2.), also illustrate circumstances under which comprehensive pollution control have come to be adopted gradually after the transition as mentioned above.

In order to assist above activities, JEC has played a leading role in arranging funds through its financing program and construction and transfer program, while JEC performed the pollution control program to demonstrate new methods and techniques on the process management, and has furnished the industry with the model of the pollution control . JEC's program in Nishiwaki City is outstanding as an example of JEC's construction and transfer program. (Refer to the section 5.1.)

5.1.6 Establishment of Basic Policy of Pollution Control and Implementation Plan

A typical flow for industrial pollution control is shown in the following cycle of 5 processes;

① Determination of basic policy (Setting of target)

② Menu of available control options

③ Establishment of a plan for wastewater treatment measures, etc

④ Implementation of the plan

⑤ Monitoring and evaluation of effect of measures taken

If the target is considered to be achieved after the above cycle, ④ and ⑤ should be further continued and fed back for reviewing the basic policy, as necessary.

(1) Viewpoint for target setting

Viewpoints for setting the basic target to which the pollution control plan is established are ① Pollution control, ② Cleaner production and ③ Environment management.

(a) Pollution control

Along with the revision of the Basic Law for Environmental Pollution Control in 1970 in Japan, regulations and laws such as Water Pollution Control Law and Air Pollution Control Law were established or revised and further, the regulatory institutions were arranged. Such regulations and laws stipulate the types of industry to apply uniform standards, provisional standards, and stringent standards (ordinances, etc.), and scale of wastewater, with the particular attention to the regional environmental characteristics.

The pollution control in the dyeing finishing industry mainly focuses to the water pollution. Particular problems are associated with the high concentration organic effluent, the colored effluent originating from residual dyestuff and the biologically persistent COD contents originating from the chemicals used. Other measures to be taken by this industry are air pollution control and offensive odor prevention.

Observation of the essential elements of the pollution control target includes the specified effluent standards and comply with other legislative requirements.

(b) Cleaner production

As stated in the section 3.4.1, effective means for the pollution control can be taken by the approach of Cleaner Production: In-process measures including, resource saving, rationalization of service water and energy saving should be taken at the first hand mainly in the manufacturing process. The manufacturing process itself must also be improved by controlling the use of raw materials which may be toxic or persistent in the treatment process, and products should be switched over so that pollutants are not discharged in large amount.

In the dyeing finishing industry, the Cleaner Production is implemented through rationalization of water use, effective utilization of heat, selection of chemicals used, etc., or by changing over the production machinery. Through above steps, pollution load on the wastewater treatment facility can be reduced, so that pollution control as well as reduction of wastes, resource saving and reduction in production cost can be effectively achieved.

(c) Environmental management

Environmental management is the step to implement, as a cycle, the planning implementation, evaluation and review of pollution control program by combining the pollution control responding to legislative standards with the Cleaner Production (Process management is conducted when reviewing pollution control). The ultimate industrial environmental management is to realize the rationalization of productions, the reduction of production cost through the implementation of environmental management and then, to develop the environmentally-sustainable industrial management.

(2) Essential elements in the preparation of menu of available options

In setting the menu of pollution control options in dyeing finishing factories, it is essential to work out the menu which covers control measures against soot & smoke and effluent (measures for achieving the emission standards) and also the menu which facilitates the comprehensive review from technical and economical points of view taking into consideration three essential elements for target setting, as discussed above.

(a) In-process measures

Dyeing finishing industry consist of heating process and cleaning process, as well as process consuming the large amount of water. Improvement in manufacturing process by introducing the counter current system and batch system will consequently attain not only rationalization of water use, but also resource saving, energy saving (effective use of heat) and cost reduction. Moreover, since there is a clear distinction between high concentration effluents and low concentration effluents, process can be rationalized by separating the water discharge lines, the wastewater treatment is as described in the subsequent section.

Some of the products of the dyeing finishing industry are regarded as regional traditional products and thus, traditional technique for manufacturing those products is applied. It will, thus, be difficult in such a case to introduce in-process measures including the change of dyestuff, etc. In this case, however, hand work process such as hand dyeing is mostly employed and such factory is small in its scale and thus, it is assumed that such factory should take measures by wastewater treatment (separation collection treatment, etc.) rather than by in-process measures.

It is the typical approach of the application of the in-process technology that the effluent which is easily to treat is attained by developing dyeing technique, improving and selecting chemicals used.

(b) Wastewater treatment techniques

Adoption of wastewater treatment technology is determined depending on property of wastewater, target for treatment, sludge disposal method, possible treatment cost, etc. The technology may be applied independently, or in combination. According to the treatment systems applied, necessity for separating drain line may be different.

Wastewater from dyeing finishing industry is characterized in high BOD and coloring property. Coagulation sedimentation process, biological treatment process, activated sludge process and ozone treatment process, etc, are usually applied independently, or in combination. In Japan the demanded level for the wastewater quality differs according to the factory location and thus, menu for the wastewater treatment measures should be prepared in a manner to include the options by which respectively demanded level can be attained.

(c) Air pollution measures

Steam heating process is generally applied as heating process in the dyeing finishing industry and boiler is thus essential unit. In some instances sulfur compound higher than standards is contained in exhaust gas from boiler and thus, desulfurization treatment of exhaust gas may need to be taken. One of the practical options is to utilize the alkaline effluent from the process for washing the exhaust gas and to utilize sulfite component in the effluent from the gas washing (neutralization reagent for alkali effluents).

(d) Offensive odor preventive measures

Problems relating to offensive odor in the dyeing finishing industry are mainly odor of hydrogen sulfide generated from the process which uses sulfide dyestuff and wastewater treatment facility. Since the end-of-pipe measures demand considerable cost to be incurred, many factories intend to mainly adopt in-process technique by changing sulfide dye stuff to other one, etc.

(3) Monitoring

(a) Evaluation of the effect of measures taken

It is important to monitor implementation condition of environmental management plan and evaluate its effect in the light of the target.

In case the target is not fully achieved, it must be ascertained as to if its cause is due to implementation method, its organization or the plan itself.

For measuring and evaluating the effect, a variety of data ranging from ledger data analysis to automatic measurement data of water quality, etc. are required. Accordingly, comprehensive evaluation in addition to evaluation on individual options must be made. It is desirable to make use of expertise from specialist organizations since it might be difficult for a single expertise to fully implement the environmental management evaluation.

(b) Review of plan

In case the target is not fully achieved, it becomes necessary to review the implementation plan by taking into consideration the specified cause so that the target should be properly achieved. Final goal should be reached step by step by repeating this reviewing cycle.

5. 1. 7 In-Process Measures

(1) Improvement of manufacturing process

In the dyeing finishing industry involves a variety of chemical operations, but many of the workers employed in those works have not always sufficient chemical knowledge. Also, in many of the factories, the operational guidance is succeeded from parent, and grand parents. Moreover, those factories rely on the technical assistance by the suppliers of dyestuff and raw materials but its technical assistance is not always adequate and consequently, those factories are often obliged to make an excessive investment on the wastewater treatment compared with company's scale and profitability. Or, they may receive complaints by nearby residents for the pollution caused by their wastewater. In order to improve the manufacturing process, it is essential to rationally analyze each process.

(a) Improvement of pretreatment process for raw fabrics

In weaving the raw fabrics, starch type size has conventionally been used and consequently high BOD and COD effluents containing starch have been discharged in the course of desizing process. Because of this and also along with high speed weaving operation, size was changed from starch to PVA (Polyvinyl alcohol) to protect vertically woven thread. Since this PVA is persistent, it has posed new problem on the biological treatment of the effluent.

On the other hand, if the biological treatment of the effluent containing the persistent substances is continued, microorganism which degrades these substances may appear and grow of itself and treatment of such effluent may even become possible.

Dyeing finishing industry company may be in a weak position to request the supplier of raw fabrics to take environmental measures and thus, leaders responsible for the pollution control must jointly request the suppliers to adopt environmental measures in the manufacturing process of raw fabrics.

(b) Change of dyestuff and dyeing auxiliaries

Treatment of effluents from the dyeing finishing industry is difficult, because various kinds of dyestuff and dyeing auxiliaries are used. These are usually dissolved in water and used and yet, these substances are persistent to meet the purpose of dyeing and resultantly the treatment of the effluent containing such substances is difficult.

Conventional practice for selecting these dyestuff was to make judgment only on the standpoint for processing and product sales, i.e., good in dyestuff adhesion, good in apparent color, no color fading by washing and direct sun light and cheap in cost. Although pollution control measures for the effluent have been imposed only on the dyeing finishing industry companies who are relatively weak in its industrial and social status, in future, such measures should be taken by developing, the dyestuff easy to recover and treat in addition to the product quality and the processing utility.

Meanwhile, a large amount of acetic acid is actually used in the dyeing work together with dyestuff. Because, due to the buffer capacity of acetic acid, it becomes easy to keep pH in the dyeing bath to 4 ~ 4.5 for the stable dyeing work. But, the effluent containing acetic acid raises BOD and COD and thus, the load on the wastewater treatment also goes up. Under this circumstance, it is desired to take steps to convert into acetic acid alternative chemicals.

For the time being, following matters are to be studied in selecting dyestuff.

Coagulation performance

Chemicals to be used in dyeing finishing such as size, surfactant and dyestuff are used in dissolved form. The load on the wastewater treatment will be remarkably reduced if coagulant is added in the wastewater treatment, such as aluminum sulfate, ferric chloride, high molecule coagulant (polymer), slaked lime, etc.

· Adsorption performance

The biggest problem of the dyeing processing effluents is that the effluent is colored. The load on the wastewater treatment will be remarkably reduced by using the dyestuff easy to be adsorbed by activated carbon.

· Bleaching performance

Introduction of activated carbon adsorption process is hard due to economic reason. Instead, the load on the wastewater treatment will be remarkably improved by using the dyestuff which can be bleached by the oxidizing agent such as sodium hypochlorite and hydrogen peroxide.

· Biological degradation performance

Reason for replacing starch by PVA was to prevent putrefaction as previously mentioned. Many of the dyestuff are also hard to be degraded, making the biological treatment of wastewater difficult. The load on the biological treatment will be reduced if highly degradable chemicals are utilized.

At present, the index for biological degradation performance is not established. Among the items measured as index for organic substance, for example, BOD presents 60 ~90 % of degradable fraction. Ratio between BOD and TOD, COD can also be the index for the biological degradation performance.

A substance is practically regarded as biologically degradable if BOD presents 40 % or more of TOD. As organic substance is indicated by TOD or COD, which can be measured relatively easily , it is desirable to study these parameters when purchasing chemicals. Another method is to request the suppliers of chemicals to submit the water quality data of the solution which is diluted to the concentration at the time of application.

Results of biological degradation test of dye stuff is shown in Table 5-1-8. It is shown that many items are hard to be biologically degraded.

Table 5-1-8 Biological degradation performance of dyestuff

Dye stuff		TOD	TOC	COD	BOD	BOD/TOD
		(gO_2/gDS)				
Reactive dyestuff (for cotton)	Lavax Brill. Blue EFR	0.96	0.37	0.55	0.	0.
	Lavax Turquoise Blue E4G	1.00	0.34	0.43	0.	0.
Cationic dyestuff (for acrylic thread)	Acryl Brown B	0.63	0.26	0.41	0.18	28.6
	Cathilon Yellow K3R	1.08	0.32	0.44	0.25	23.1
Reactive dyestuff (for cotton)	Senkanol 12	0.56	0.18	0.17	0.31	55.3
Cationic dyestuff (for acrylic thread)	Nichirogen 550	0.25	--	0.16	0.10	40.0

(gO_2/gDS) : TOD for each drystuff 1 g

Table 5-1-9 and Table 5-1-10 further show the results of COD removal experiment in activated sludge process for dyeing wastewater containing various kinds of dye stuff and chemical agents and the results of advanced treatment for the treated water discharged by the activated sludge process.

・ Toxicity

The existing emission regulation rigidly control the effluents containing toxic substances and set the uniform standards for all emission sources in Japan. It is further desired to study the toxicity of chemicals, including carcinogenic and teratogenic properties.

Table 5-1-9 Results of COD removal experiment for effluents containing dyestuff and chemical agent under activated sludge process

Name of dyestuff and chemical agent		COD (ppm) in raw water	COD (ppm) in treated water	COD removal rate (%)
Dyestuff containing metal	Cipalan red prone RL	60.8	25.2	58.6
	Cipalan yellow 2BRL	85.0	40.0	52.9
	Cipalan brilliant blue RL	77.6	24.3	68.7
	Irgalan green RL	21.5	21.0	2.3
Acid dyestuff	Sulfon first black 8BX	90.0	51.4	42.9
Reactive dyestuff	Acid green 3BLA	98.2	43.9	55.3
	Benzo scarlet RS	79.5	75.9	4.8
	Sumifix black B	53.0	42.1	20.6
	Sumifix brilliant red G	43.0	39.0	9.3
	Sumicron turquoise blue SGL	97.0	90.0	7.2
Disperse dye, etc.	Sumicron black B	115.0	102.0	11.3
	Sumicron red E-FBL	103.0	79.5	22.8
	Sumifix turquoise blue BF	24.0	23.0	4.2
Detergent	Bisnol RK	300	198	34
	Peresoft	323	229	29.1
	Despol KP	115	254	*
Sizing agent (Finishing)	Pabfix	343	271	21.0

* (Property accumulating COD composition is assumed.)

Table 5-1-10 Results of COD removal experiment on advanced treatment for various chemical agents in treated water of dyeing wastewater after activated sludge process

Agent used for treatment and volume added		COD (ppm) in original water	COD (ppm) in treated water	COD removal rate (%)
Inorganic coagulant	Ferric chloride 10ppm	48.2	45.0	6.6
	" 100 "	"	41.0	14.9
	PAC 10 "	"	40.0	17.0
	" 65 "	"	28.5	40.9
	Iron alum 100 "	"	46.0	4.6
High molecule coagulant	Sunpoly A-305 20 "	"	57.0	"
	" K-20 20 "	"	55.0	"
Inorganic + High molecule coagulant	PAC 50 ppm + Sunpoly K-20 20 "	"	26.0	46.1
Activated carbon	Granular activated carbon (Coconut waste)	51.8	29.6	42.9
	Activated carbon powder (coal base)	"	10.0	80.7
Oxidizer	Sodium hypochlorite 100 "	"	49.0	5.4
	Ozone	55	63 ~ 50	3.6 ~ 9.1

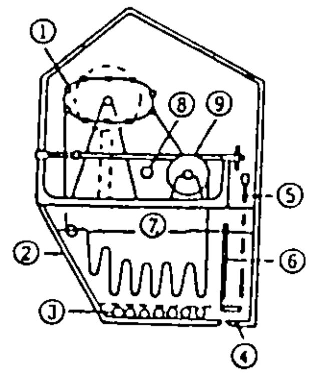
(2) Rationalization of water use

A measure to reduce the pollutant load is the reduction in the waste water volume and for this purpose, it is important to rationalize the water use.

A method for rationalization of water use is the reduction of bath ratio. Bath ratio means the proportion of the volume of dyeing solution to 1 kg original fabrics. It is usually 1: 20 ~ 1 : 30. If it is possible to introduce a machine capable of dyeing with the less bath ratio, it will reduce correspondingly the water use, wastewater and pollutant load.

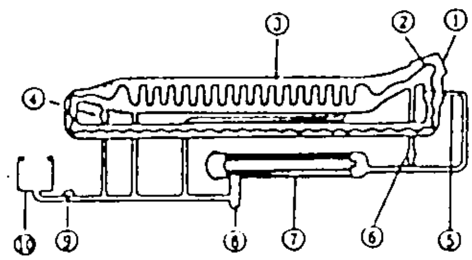
Dyeing machine manufacturers have recently developed dyeing machines capable of dyeing with the less bath ratio, and the following is an example.

In the Wince dyeing machine conventionally used, original fabrics or threads whose both edges are stitched are hanged on the Wince(reel) and the slacken part of the fabrics and threads is dipped in the bottom of tank, heated with steam and then dyed by rotating the reel. The following drawing shows an example of the modified machine in which dyeing solution fully contacts fabrics in a small bath and thereby the bath ratio is made smaller. It might be an idea to introduce this kind of machine when facilities in a factory are renewed.



① Wince (reel)
② Stainless bath
③ Steam pipe
④ Drain valve
⑤ Steam pipe with holes
⑥ Porous gate plate
⑦ Dyeing solution level
⑧ Steam pipe
⑨ Guide roll

(1) Conventional Wince dyeing machine



① Entry for fabrics ② Fabric drying reel ③ Dyeing tube ④ Control valve ⑤ Level control valve
⑥ Control valve ⑦ Heat exchanger ⑧ Solution circulation main pump ⑨ Dye feed pump
⑩ Dye, chemical preparation tank

(2) Example of small bath ratio type dyeing machine

Fig. 5-1-3 Example of Cleaner Production by converting to small bath ratio type dyeing machine

(3) Compounding of dye stuff by using computer

As in any other industry, the basis of the In-process measures in the dyeing finishing industry is also how to reduce the volume of wastewater.

While dyeing the fabrics, it happens that, although dye chemicals are compound for tentative dyeing, the target color dose not appear and thus, such dye compound is discarded as wastewater. This pollutant load, wasted labor and energy should not be neglected. According to the survey by the Environment Agency of Japan, an increasing number of enterprises recently adopt the method in which the simulation by personal computer is adopted in mixing the chemicals, instead of actual dyeing for the purpose of reduction of pollutant and conservation of energy. (Refer to the Fig. 5-1-4.)

These measures must be studied in co-operation with the suppliers of chemicals.

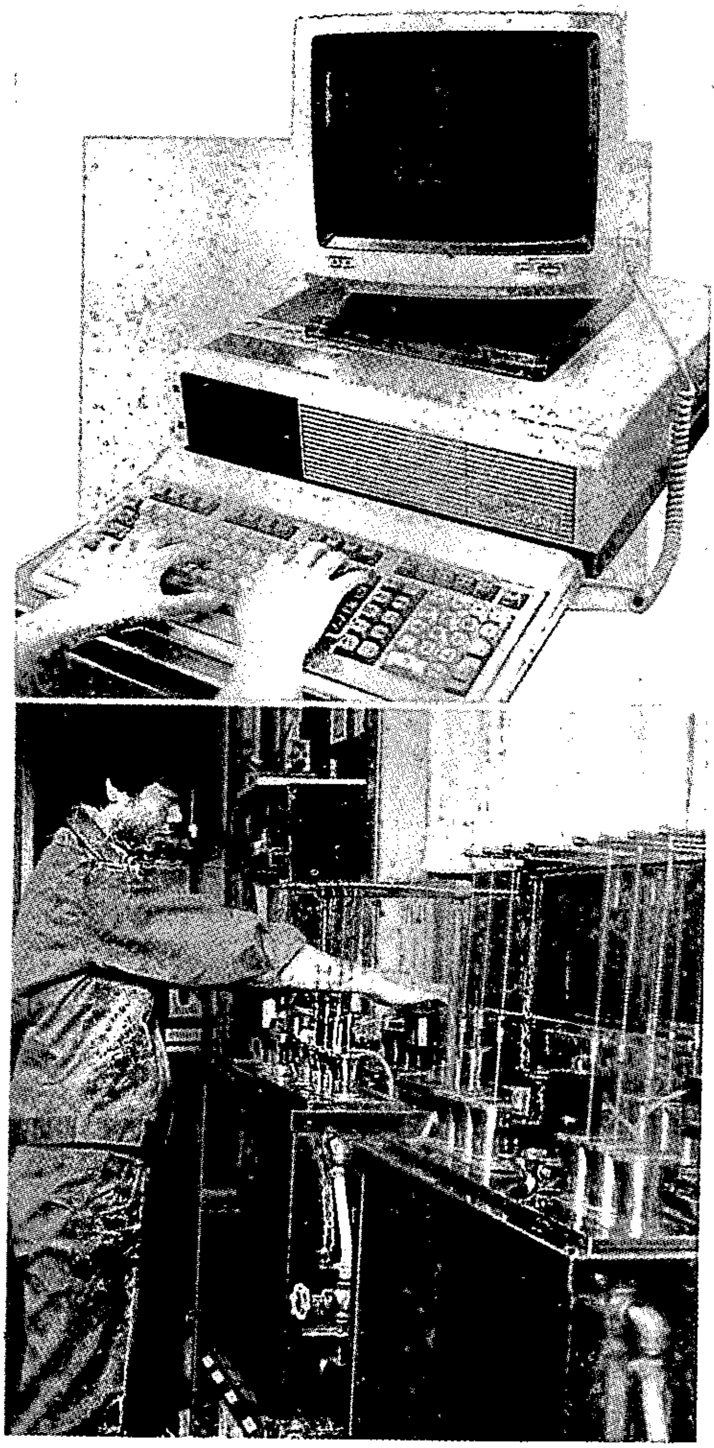


Fig. 5-1-4 Automatic compounding of dyestuff by computer and beaker dyeing (tentative dyeing)

(4) Separation of wastewater line and reduction of wastewater

Wastewater of different property is drained from each dyeing and finishing process and therefore, separated drain channel should be provided for each wastewater drain line. If these are mixed and drained together, the load on the treatment facility and the economic load will substantially increase.

Arrangement of drain channel for each wastewater line is to be further improved. That is, indirect cooling wastewater from cooling tower contains almost no contaminants and thus, such water should be collected into separate channel and stored in a separate tank and used for cleaning purpose. Volume of wastewater can thus be reduced and in addition, the load on the wastewater treatment can consequently be reduced.

Moreover, the dyestuff drams brought into factory should not be cleaned each time, but returned to the dye supplier to utilize them again for transport of the same dyestuff. This will enable to eliminate the cleaning process, rationalize water use and reduce wastewater. Counter current type multi-stage cleaning can be conducted in the cleaning process, through which wastewater is treated, recycled and utilized again in some examples.

5. 1. 8. Wastewater Treatment Measures, etc.

(1) Background

As it was described in the section 5.1.4, the national uniform standards under the Water Pollution Control Law is applied to the dyeing finishing industries whose wastewater volume is 50 m^3/d or more, and equipped with the specified facilities such as scouring machine, scouring tank, mercerization machine, bleaching machine, bleaching tank, dyeing facility, chemical solution dipping facility and desizing facility. The uniform standards for BOD, etc., are presented in the section 3.1.2.

Meantime, if application of the uniform standards is judged to be insufficient due to the feature of the receiving water areas, the stricter standards (stringent standards) may be set by the prefectural government and even the enterprises whose effluent volume is less 50 m^3/d may be put under the regulatory control. Their wastewater treatment must fully satisfy these control standards.

(2) Problem of dyeing finishing wastewater treatment

The factors causing difficulty in the dyeing finishing wastewater treatment are divided into economic and technical factors. Economic factors include;

1) Management scale of industry is small.

2) Basis of dyeing finishing work is on sub-contraction .

3) It may be difficult to secure the land for the treatment facility for existing enterprise and enterprises of small-and-medium scale.

4) Due to the small number of the employees, it is difficult to assign the expert engineer and staff for wastewater treatment.

Technical factors include;

1) Quality and volume of wastewater are not consistent.

2) There are too many types of pollutants.

3) In many aspects, one treatment process may impedes the treatment effect of other sequence.

These are the typical problems in the dyeing finishing industry.

(3) Guidelines on wastewater treatment

As a variety of dyestuff, surfactant and variety of chemicals such as dyeing auxiliaries are used in the dyeing finishing industry and therefore, its wastewater is complicate in its composition and besides, many raw materials now are persistent to the biological degradation. Wastewater from the dyeing finishing industry is thus difficult to treat. Wastewater treatment methods presently applied are coagulation sedimentation, pressure floatation, activated sludge process and activated carbon adsorption. These are used either individually or in combination.

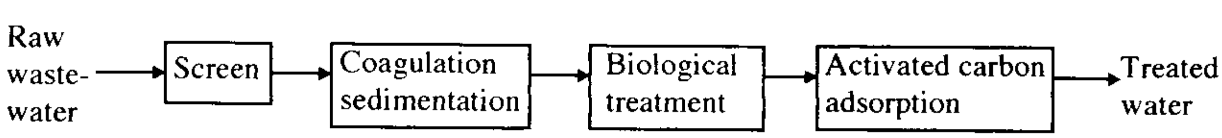


Fig. 5-1-5 Typical combination of unit treatment method of dyeing finishing wastewater

In many instances, the coagulation treatment was preferred to biological treatment because of simplicity in operation. However, concept of separate drain has become common and small scale biological treatment equipment with relatively easy operation has been developed.

Presently in Japan, biological treatment is provided only for the wastewater separated for the purpose.

Shown in the next paragraphs are the concept of the ordinary treatment technique and the most advanced treatment technique which are presently adopted for dyeing finishing wastewater in Japan as well as an example of treatment flow.

(a) Ordinary treatment technique

Wastewater from scouring and dyeing processes contains coloring and organic pollutants including oil & fats derived from raw materials as well as unreacted waste dye. If these are treated only by screen and sedimentation treatment, emission standard values specified under the Water Pollution Control Law and the ordinances would not be met. In order to achieve the effluent standards, therefore, the coagulation sedimentation treatment is introduced in many examples. (Refer to the example of section 6.2.1.)

(b) Advanced treatment technique

Although it is widely considered that the dyeing process uses a large amount of persistent substances, a large amount of acetic acid as dyeing auxiliaries, etc. are also used along with dyestuff. They are used in the processes such as sulfuric dyeing & bleaching of cotton, acid dyeing & acid mordant dyeing of wool, acid dyeing of nylon and cationic dyeing of acrylic resin, which discharge a large volume of organic wastewater subject to biological degradation (high in BOD). Since Japanese laws and regulations attach the top priority for the measures to control BOD, the wastewater treatment method combining the biological treatment with the coagulation treatment is widely used for the dyeing wastewater.

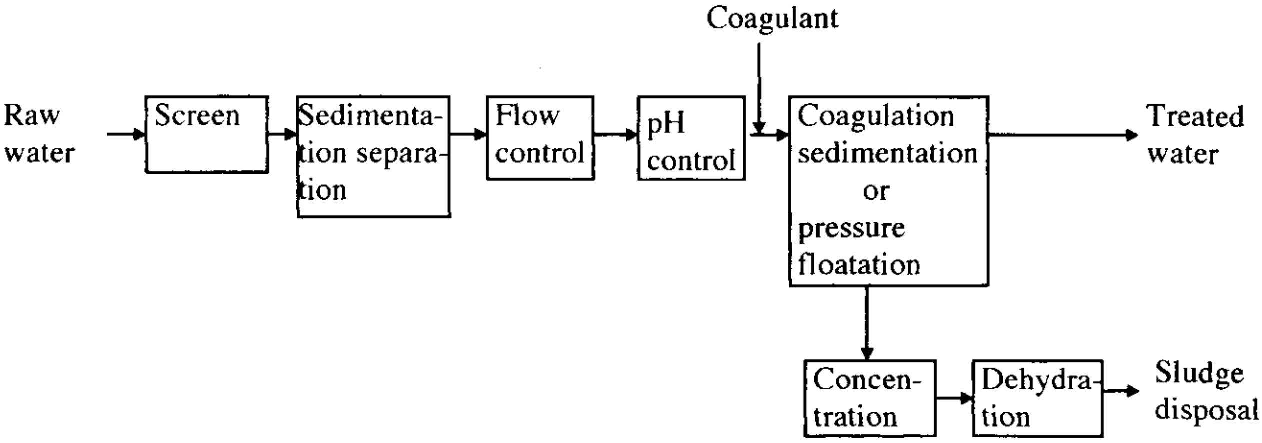
Most appropriate biological treatment method should be selected based on the conditions such as the effluent volume, economy, availability of operation engineer, as well as the features of each treatment method described in the section 3.6.2.

(c) Examples of treatment process

(i) Wastewater from machine dyeing finishing of woolen fabrics

① Treatment technique,

● Ordinary treatment technique



● Advanced treatment technique

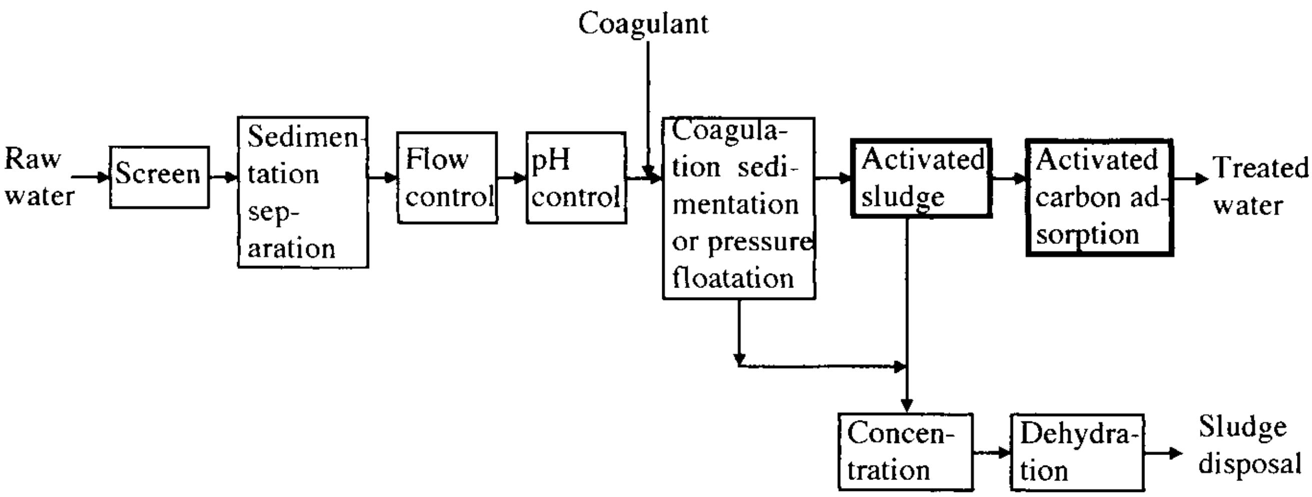


Fig. 5-1-6 Wastewater treatment flow

② Quality of treated water

Unit : mg/l

Parameters	Quality of raw water		Quality of treated water			
			Ordinary treatment technique		Most advanced treatment technique	
	Range	Average	Water quality	Removal rate	Water quality	Removal rate
BOD	13~336	69	35	45 %	8	87 %
COD	24~244	110	60	45 %	25	78 %

③ Economy

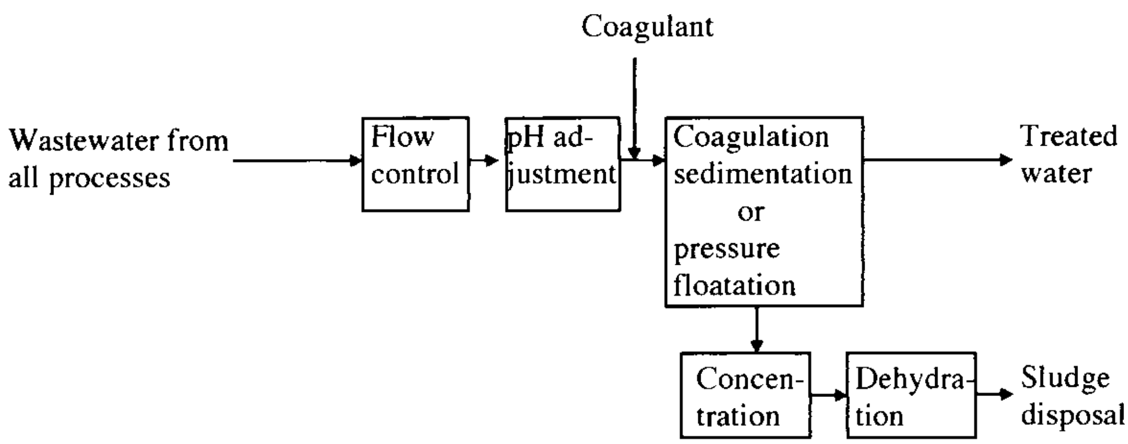
	Wastewater volume (m³/d)	Unit installation cost (¥10³/m³)	Unit operation cost (10³/m³)	Unit sludge disposal cost (10³/m³)
Ordinary treatment technique	200	260	70	2
	2000	64	52	2
Most advanced treatment technique	200	510	89	3
	2000	170	71	3

Normal value in 1977, not including cost for land and labor.

(ii) Wastewater from machine dyeing and finishing of long textile woven fabrics

① Treatment technique

●Ordinary treatment technique
(In case of small-and-medium industry)



(In case of large industry)

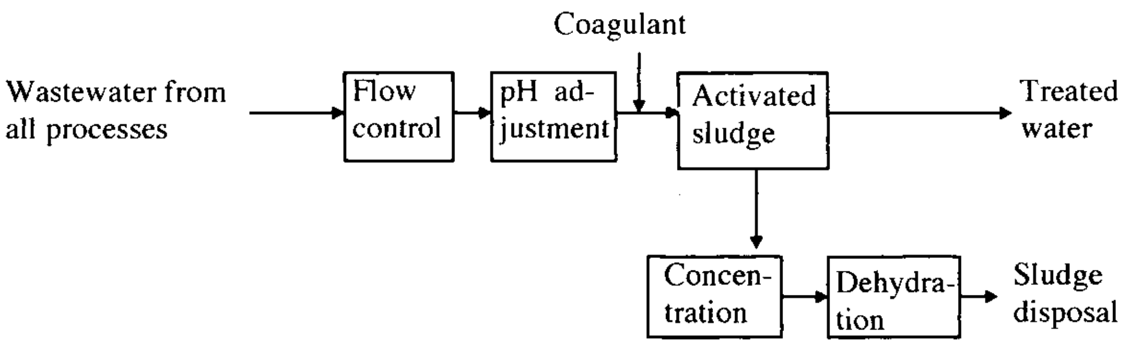


Fig. 5-1-7 (1) Wastewater treatment flow (Ordinary treatment technique)

● Advanced treatment technique

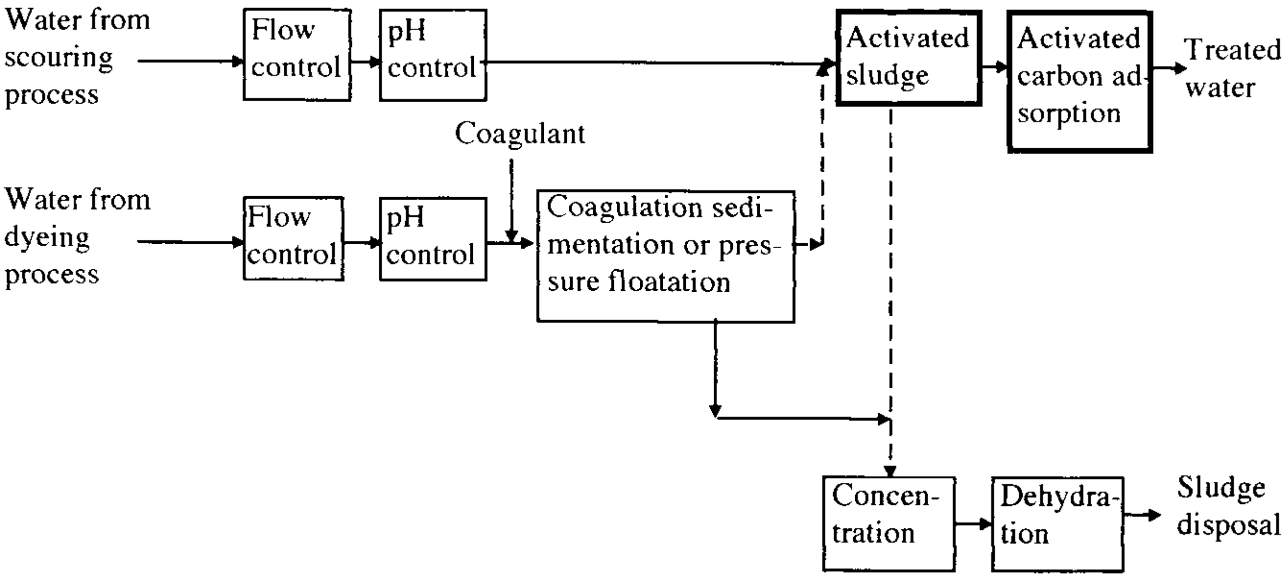


Fig. 5-1-7 (2) Wastewater treatment flow (Advanced treatment technique)

② Quality of treated water

Unit : mg/l

Parameters	Quality of raw water		Quality of treated water			
			Ordinary treatment technique		Most advanced treatment technique	
	Range	Average	Water quality	Removal rate	Water quality	Removal rate
BOD	74~600	240	90	65 %	50	80 %
COD	72~257	160	50	69 %	30	80 %

③ Economy

	Wastewater volume (m³/d)	Unit install-ation cost (¥10³/m³)	Unit oper-ation cost (10³/m³)	Unit sludge disposal cost (10³/m³)
Ordinary treatment technique	1,000	70	60	20
	5,000	64	52	15
Most advanced treatment technique	1,000	-	-	-
	5,000	50	75	15

* Value in 1977, not including cost for land and labor.

(4) Implementation example of wastewater management in dyeing factory

Presented hereafter is an example of wastewater management in a dyeing finishing factory of Firm-K, which implemented the in-process pollution control measures, such as separate collection of wastewater by different concentration and application of the wastewater for the desulfrization of exhaust gas. (For group installation of a joint treatment facility for dyeing finishing industries, an example is presented in the section 5.1.)

Firstly, process management and water use were rationalized and secondly, wastewater collection lines were separated in order to rationalize the wastewater treatment. Attempt was also made to reduce the size of the wastewater treatment facility through management of production process by averaging the volume of wastewater and reducing the volume of wastewater at peak operation.

As shown in the Fig. 5-1-8, wastewater separation and collection lines was arranged in a way that concentrated wastewater line and non-concentrated wastewater line from different processes were separated and besides, concentrated wastewater can be separated from non-concentrated wastewater from the same process with regard to the scouring process, dyeing process, and resin process. Furthermore, for the specially concentrated wastewater among the concentrated wastewater, the concentrated wastewater from dyeing process and resin process, which were most concentrated among the concentrated wastewater, were separated from the wastewater treatment line and sent into directly the sludge treatment process.

As shown in the treatment flow of Fig. 5-1-9, raw wastewater No.1and No. 2 were utilized for desulfurization of boiler exhaust, making use of its high pH property. For the biological treatment, 2-staged activated sludge treatment equipment is installed. In the 1st stage the raw wastewater No. 1 of high concentration is treated and in the 2nd stage the treated water from the 1st stage and raw wastewater of low concentration are jointly treated. This treated water is further finished by coagulation sedimentation treatment so as to meet the effluent standards in the area concerned.

Table 5-1-9 shows design water volume and quality and result of actual operation.

Table 5-1-9 Design water volume, and quality and results of actual operation of wastewater treatment facility in Firm-K's dyeing finishing factory

	Design value			Actual operation results					
				No. 1 aeration tank			No. 2 aeration tank		
	raw waste-water No.1	raw waste-water No.2	Treated water	Original water	Treated water	Removal rate	Original water	Treated water	Removal rate
Waste-water volume	1,560	7,440	9,000	-	-	-	-	-	-
COD_{Mn}	1,500	150	25(30)	1,500	140	91	120	23	81

* Water volume: m^3/d, Water quality: mg/l, Removal rate: %

【 Outline of wastewater treatment facility in Firm-K's dyeing finishing factory】

① Production content : Bleaching and dyeing processing of both spun and woven textiles and cotton cloth

② Aimed water quality : Stringent standard of Osaka Pref. was applied. (Refer to section 5.1.4)

③ Wastewater collection line : Refer to Fig. 5-1-8.

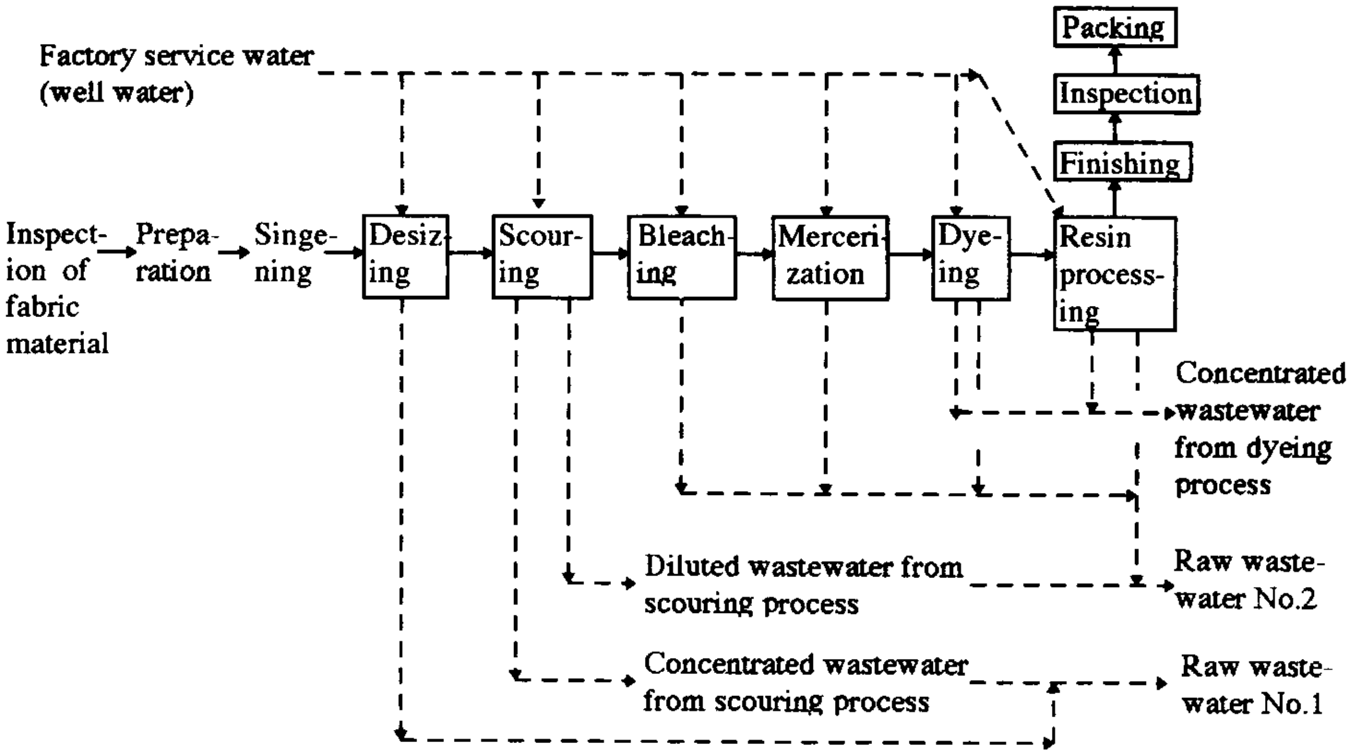


Fig. 5-1-8 Wastewater collection flow

④ Water treatment flow : Refer to Fig. 5-1-9.

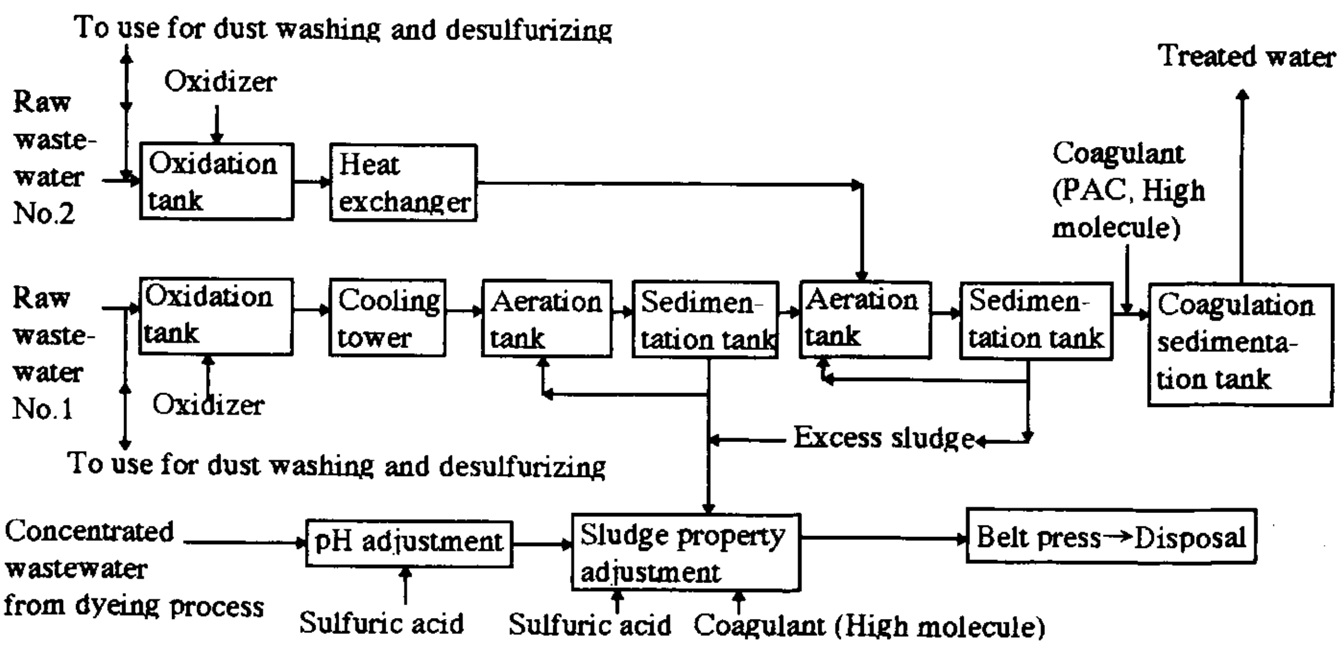


Fig. 5-1-9 Wastewater treatment flow

(5) Separate collection and incineration of concentrated wastewater

When concentrated wastewater from dyeing finishing industry is separated, the wastewater contains 2,000 ~ 5,000 mg/l of COD and BOD. In the chemical plant etc., it is considered advantageous to treat by biological method if BOD is less than 3,600 mg/L. But, concentrated wastewater from dyeing finishing industry is often discharged at relatively high temperature and thus, it can easily be concentrated by heating slightly and applying to vacuum concentration unit.

In many cases factories of dyeing finishing industry install a boiler and its residual steam is utilized as heating energy and concentrated wastewater is incinerated in the burner for boiler, so the wastewater can be disposed of with comparatively less energy.

As Fig. 5-1-10 shows, the concentrated wastewater, after it is heated by boiler steam and concentrated in vacuum, can be incinerated in the boiler combustion furnace equipped with the blowing nozzle, by blowing the wastewater on top of oil burner.

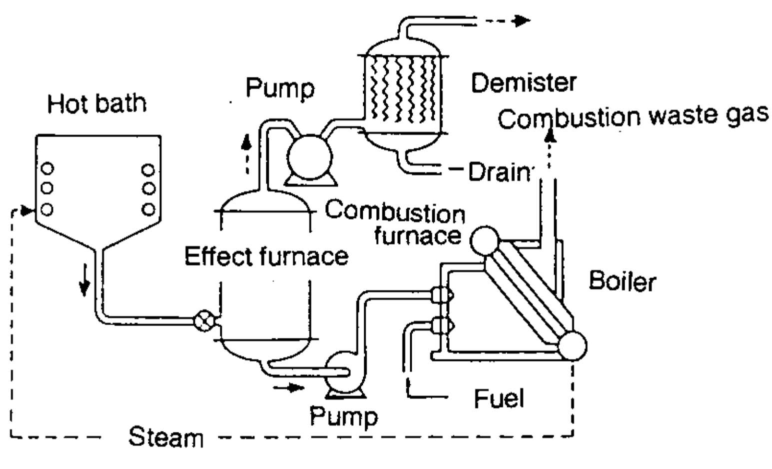


Fig. 5-1-10 Incineration disposal of concentrated wastewater

(6) Hazardous substances

The Water Pollution Control Law specifies the effluent standards for the designated substances such as heavy metals, etc., but it is probable that the hazardous substances not controlled by the law might be contained in the dyeing wastewater due to the use of various chemicals. It is necessary in this respect to check toxicity of the chemicals in terms of carcinogen and teratogen, and to avoid the use of hazardous substances.

5. 2 Meat Processing Industry

5. 2. 1 Outline of Meat Processing Industry

(1) Outline of manufacturing process

Meat processing industry is a part of foodstuff industry which processes meat for providing a variety to home cooking and for enhancing preservativity of meat for shipping out as products.

According to the raw material, Japan standard industrial classification subdivides the industry into its sub-division as below;

① Meat products manufacturing industry

This industry mainly manufactures the meat products such as sausage, ham and bacon (incl. canned/bottled/bowled meat products).

Basic manufacturing process of ham and sausage, typical meat products, is shown below

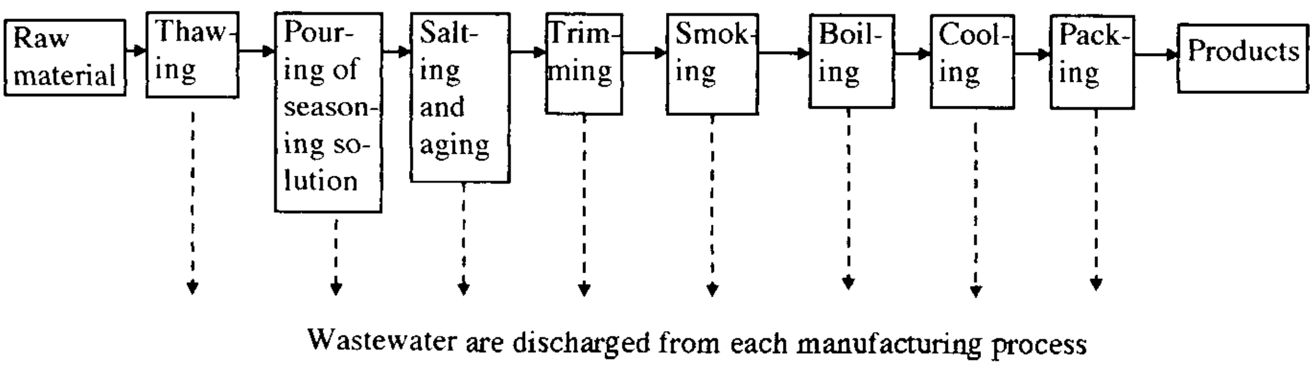


Fig. 5-2-1 Basic production process of meat product manufacturing industry

② Other livestock foodstuff manufacturing industry

Foodstuffs mainly manufactured in this industry are processed eggs, dried eggs, liquid eggs, honey products, broiler meat products, etc. Shown below is the basic manufacturing process of broiler meat products whose pollutant load is particularly high.

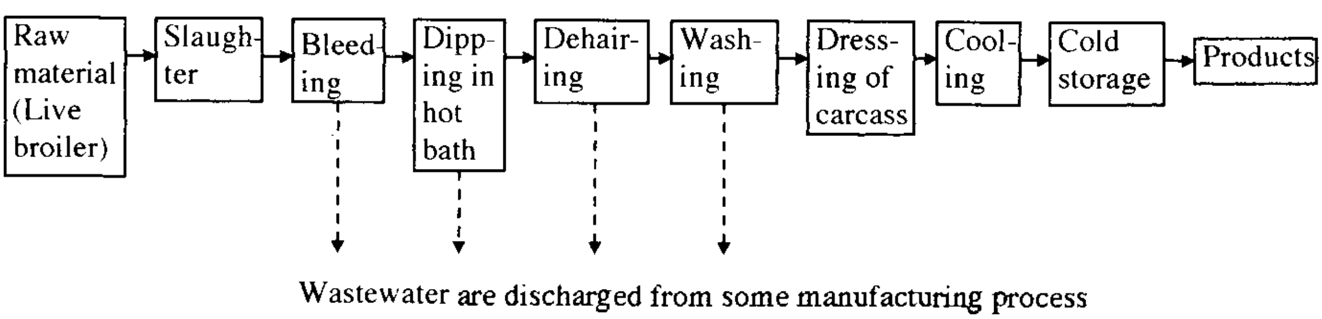


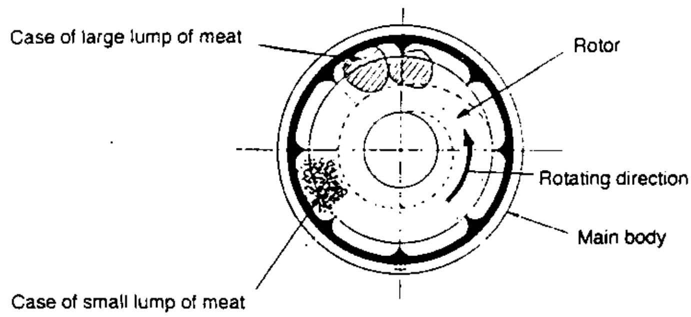
Fig.5-2-2 Basic production process of other livestock foodstuffs manufacturing industry

(2) Outline of meat processing machine and equipment

(a) Chopper

Chopper is a device which finely chops lump of meat, consisting of spiral rod to feed meat, a set of cross-shaped knife to cut meat and plate with fine holes. In order to prevent damage to meat quality during chopping, meat in chopped in 3 steps instead of chopped to fine pieces at one time.

The chopper is standardized according to the size of drilling plate diameter.

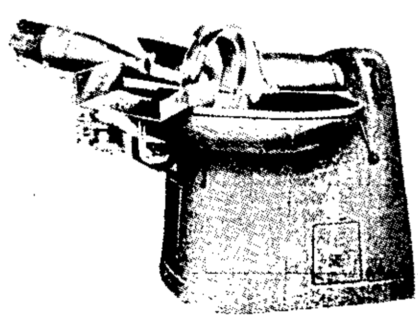


Actuation of chopper according to size of meat lump
(viewing from the front part)

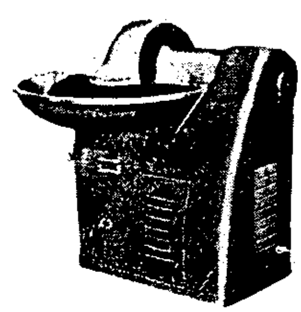
Fig. 5-2-3 Example of chopper

(b) Silent cutter

This silent cutter is a device which cuts sausage meat into fine lump. Its main component is the plate which is filled with raw material meat and rotates horizontally and slowly and the several sheets of cutter knife mounted on the shaft which rotates at high speed in tangential direct- tion, centering around cutting face of plate. Knife portion is covered with the cover together with half portion of plate for ensuring safety and preventing meat from splashing from the plate.



Silent cutter with capacity 120 kg
(with unloader)

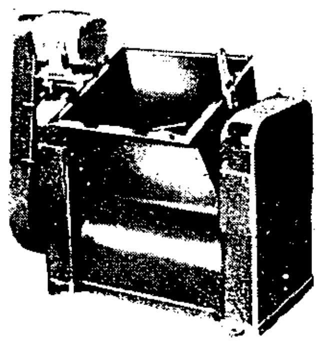


Silent cutter with capacity 60 kg

Fig. 5-2-4 Example of silent cutter

(c) Mixer

This mixer is indispensable for evenly mixing additives, spices, seasonings, etc. with sausage meat pasted by the cutter. This mixer exhibits its function satisfactorily in manufacturing the pressed ham and in pasting small lump meat with minced meat. Structure of the mixer is such that several sheets of paddle (agitating vane) are installed on two shafts passing parallel through stainless rectangular inside and these paddles uniformly mix slice of meat or pasted sausage meat by the rotation of shaft. The mixer designed for the purpose that lump of meat is salted by being mixed with saltpeter and salt by using 2 sheets of conical vane installed on the opposite side wall rotating inversely each other. In the case of pickle solution described later, if salting is done mechanically by using this type of mixer, it becomes possible to pickle whole amount of meat without emitting waste solution.



Mixer for salting

Mixer

Fig. 5-2-5 Example of mixer

(d) Stuffer (Filling machine)

After minced meat, pressed ham, etc. are seasoned and mixed with additives properly, they are stuffed into casing of suitable size by the stuffer.

Stuffers are the hand turning type with small capacity, air compression type and hydraulic type.

Main stuffer used presently in Japan in the manufacture of hams and sausages is the air stuffer, which is mainly configured of the vertical cylinder sealed at its bottom part, the cover to be sealed after meat is filled and the piston pushed up by the compressed air. Compressed air is fed from the compressor and enters at the bottom of piston and pushes the piston up. By opening the cock at filling outlet on the upper part of cylinder, minced meat flows out of nozzle and are stuffed into the casing.

(e) Smoking chamber

Smoking is the work in which filled or formed semifinished products are smoked with sawdust of lumber and the smoke generated thereby is impregnated into the products for drying. This smoking process not only enhances preservativity of products but also improves the quality in terms of flavor. Animal oil and fat contained in the livestock meat products improves its preservativity due to influence of formaldehyde generated by the smoking. In this light, smoking has more advantages than cooling in preservation storage temperature.

5. 2. 2 Characteristics of Meat Processing Industry in Japan

In accordance with the Buddhist precept against killing, people in Japan have been greatly dependent on grains like rice and the marine foods such as fishes to supplement animal protein. As modernization started in the latter half of 19th century, eating meat has come to be recommended to strengthen people's bodily structure and besides, the living standard of the nation went up and the meat-eating ratio in the nation's daily life has increased.

It is obligatory under the law in the Japanese meat product manufacturing industries that the raw material meat must be processed at the slaughter house approved by the prefectural government. Slaughter houses are mostly independent as official organization.

Accordingly, meat processing factory in Japan characteristically handles, as raw materials, partial meat such as dressed carcass, shoulder, loin, boned rib which were the dressing of carcass after slaughter and accepted by veterinary inspection as well as imported frozen meat. In view of this, volume and property of wastewater are different from that being discharged from factory in foreign countries.

Unlikely the fish, meat right after slaughter is not tasty because lactic acid generated in muscular colloid builds up to harden. Thus, aging for a certain period of time is needed.

Except special occasion, we eat meat after cooking. Various kinds of processed food is manufactured and traded for increasing a variety of cooking at home and enhancing preservativity. In the meat processing industry, raw meat such as beef and pork is processed to various kinds of meat foodstuff for the purpose of keeping and seasoning. This processed meat is favorable as offhand foodstuff and is expected to increase its consumption.

Processed meat available in the market presently in Japan are broadly classified into pressed ham, sausage, bacon and mixed product, whose standards are respectively specified under the Japanese Agricultural Standard (JAS).

Furthermore, in Japan there is it a habit to send a gift to other as summer gift and year-end gift, and the quality ham are favorably selected as these gifts. It once happened that the volume of wastewater increased during such seasons as result of enhanced operation in the meat manufacturing factories. Recently, however, seasonal fluctuation in the volume of wastewater has been reduced as result of small fluctuation in the volume of imported meat as main raw materials.

5. 2. 3 Sources and Properties of Pollution and Waste

Manufacture processes of ham, sausage, etc. relatively high in pollutant load in the meat processing industry are outlined in the preceding section. Among those processes, the process and wastewater which are particularly high in pollutant load and the main sources of pollution load are summarized as follows; Table 5-2-1 and Table 5-2-2 show examples of the qualities of main process effluents.

Table 5-2-1 Effluent water quality from major processes

	pH	BOD (mg/l)	SS (mg/l)
Thawing effluent	6.8 ~ 8.0	1,500 ~ 2,000	1,500
Washing effluent	6.5 ~ 8.0	1,000 ~ 1,000	800 ~ 1,000
Boiling effluent	6.5 ~ 8.0	100 ~ 200	100 ~ 150
Cooling effluent	6.5 ~ 8.0	1 ~ 3	1.0

Table 5-2-2 Concentration of wastewater from each processing (mg/l)

Sources of wastewater / Parameters	Trim-ming	Meat wash-ing	Meat wash-ing	Salting	Sausage & other process	Dress-ing	Boiling (sausage)		Sausage stuffer	Cleaning		
							B1	B2		B	B	A
pH	7.3	6.2	7.3	5.6	7.3	6.8	6.9	6.7	9.5	6.9	6.8	6.7
Evaporation residue	2.648	7,623	9.560	14.000	11,380	571	1,118	1,716	6,770	624	1,762	5,012
SS	1,800	973	1,920	-	560	323	246	956	3,158	334	1,004	2,144
COD	2,520	2,150	950	-	460	104	79	137	371	57	133	271
BOD	2,040	5,590	1,960	18, 000	800	353	440	1,119	3,926	334	1,060	3,298
Organic nitrogen	83	-	109	2,750	136	-	-	-	-	-	-	-
Ammonia-N	12	45	18	37	4	4	646	1,238	3,730	11	102	18
Chlorine ion	19,700	456	6,200	77,800	880	12	14	-	257	37	125	806

(1) Raw material pretreatment process

Concretely these processes are the thawing of frozen meat, trimming of dressed carcass, etc. from which small meat lump, meat-fat lump, blood, meat juice, etc. are discharged in wastewater.

(2) Heating and other treatment processes

Concretely these are the pouring of seasoning solution, salting, boiling, etc. Waste salting solution and discharge from boiling process contain a large amount of organic substances. Main purpose of salting is to remove easy-to-rotten blood remaining in meat, etc. by dehydration through permeation of salt so as to prevent meat from rotting and improve flavor, color, water holding performance of meat, etc. Conventional practice adopted in this salting process was that meat was dipped in the pickle solution including chemicals such as salt and color developing agent and as the pickle solution is degraded after repeated use, it was discharged at a regular interval. In order to completely permeate and absorb pickle solution, machine salting method has conventionally been adopted, but recently as a new method, pickle solution was injected into muscle of meat (Refer to Fig. 5-2-4). More recently, this muscle injection method was almost entirely improved and replaced by the vein injection method and consequently the muscle injection method is now being outdated.

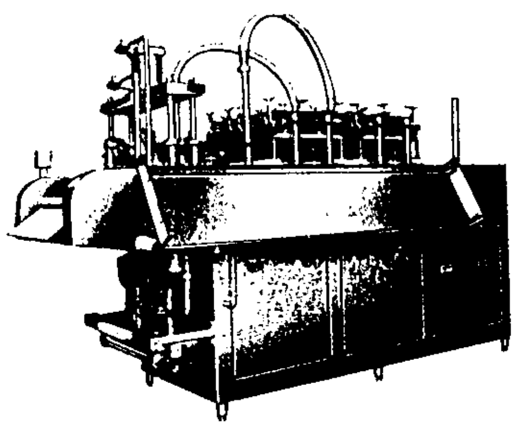


Fig. 5-2-6 Pickle injector

As the circumstance is such, discharge of pollutant load through discharging of pickle solution must have been improved. An example of pickle solution mixing is shown in Table 5-2-3. Chemicals including nitric ion are used as color developing agent because myoglobin contained in the meat bond with nitric salt and form nitrosomyoglobin. Oxydizing-type myoglobin gives meat a particular red color as an index of its freshness and tastefulness. However, if this substance is left as it is, it is changed into reducing-type hemoglobin, discolored into reddish brown showing a feeling of quality deterioration. Also, if phosphoric acid is added, tasteful flavor is said to be improved.

Since wastewater from this process contain organic substances such as saccharides and seasonings and chemicals containing nitrogen and phosphorus, water contamination load is high if such effluent is discharged. When such effluent is discharged, it means that wastewater containing a large amount of organic substances, chemicals and nutrient salt coming out of meats are discharged. It is, therefore, necessary to make an improvement not to dispose of waste solution by adopting machine salting method, vein injection method and method to replenish new chemicals, etc.

Table 5-2-3 Example of pickle solution blending

Chemicals to be blended	Example of blending ratio
Salt	10 %
Color developing agent KNO_3 $NaNO_3$	0.1 % or less
Phosphate Saccharides Oxidation inhibitor Seasoning Water	1 % 2 % 1 % or less 5 % Approx. 80 %

(3) Washing of floor and manufacturing equipment and devices

When a day's work finishes, work bench, floor and equipment and devices are washed and large volume of wastewater is discharged in a short time. This wastewater contains organic substances, nitrogen and phosphorus since blood, and meat juice originating from the raw material meat as well as chemicals used are contained.

Measures to be taken here are not only to simply wash by water but also to scrape off semi-products clinging to the manufacture equipment by rubber brush, or to freeze and store for later using by mixing with new materials so that they are not discharged in wastewater.

(4) Broiler treatment process

The process which produces the highest pollutant load among the broiler manufacture processes is the bleeding process, being done prior to dehairing. Broilers are usually slaughtered by cutting the carotid artery and, blood is squeezed out from the muscle through pulsation of muscle till muscle hardens after the slaughter.

Blood is very high in BOD, being 160,000 mg/l and susceptible to putrefaction and therefore, it must promptly be separated and removed so that it can effectively be used as fertilizer, etc. Although the amount of blood is small compared with that of large animals like cow and pig, the property is actually the same.

Moreover, feather separated is hard to be handled, but can be used effectively as animal fodder and fertilizer.

Inedible part such as bone and leg after separated from meat of dressed broiler can even be used for soup in Chinese dishes at Chinese restaurants and also such part is effectively used, together with waste from marine processing industry, as animal fodder and fertilizer.

Next table shows an example of the quality of broiler processing wastewater.

Table 5-2-4 Wastewater quality in broiler processing industry

Division	pH	BOD mg/l	COD mg/l	SS mg/l	Oil content mg/l
Range	6.2 ~ 7.2	5 ~ 2,550	7 ~ 707		1 ~ 616
Average (n=7)		614	233	177	177

Next table shows an example of the quality of the combined effluent, which is the mixture of wastewater from different processes.

Table 5-2-5 Quality of combined effluent from chicken processing factory (mg/l)

	BOD	COD	SS	T-N	T-P
Water quality	700	350	300	80	10

5. 2. 4 Wastewater Regulations relating to Meat Processing Industry

In regulatory control for air pollution, water contamination, offensive odor, soil contamination, etc., the meat processing industry attaches most importance to the measures against water pollution .

(1) Water pollution control

Effluent standards applied to the meat processing industry are the uniform standards and the areawide total pollutant load control and in some regions the stringent standards are applied.

(a) Uniform standards

Following are the specified facilities relating to the meat processing industry on which effluent control under the Water Pollution Control Law is obligated.

Table 5-2-6 Specified facility relating to meat processing industry

Index Numbers		Name of specified facility
2		Those which are served for livestock food manufacturing industry as listed below
2	a	Raw material processing industry
2	b	Washing facility (incl. bottle washing facility)
2	c	Boiling facility

As is shown in the Table 4-1-3, the uniform effluent standards relating to the living environment items under the present Water Pollution Control Law is applied to the factories equipped with above mentioned specified facilities whose wastewater volume is 50 m^3/d or more.

(b) Provisional standards

When Water Pollution Control Law was enforced on June 24, 1971, the provisional standards less stringent than the uniform standards was set for limited period of 5 years for the industry which was assessed to be technically incapable of accomplishing the uniform standards in a short period. For example, for the wastewater of the meat processing industry, provisional standard of 70 mg/l was applied to n-hexane extracts (animal & vegetable oils and fats) as shown in Table 5-2-7. But, the uniform standards are presently applied instead.

Table 5-2-7 Provisional standard (For 5 years from June 24, 1971)

Item	Type of industry	Allowable limit
n-Hexane extracts (animal & vegetable oils and fats content)	Meat product manufacturing industry, Milk product manufacturing industry	70 mg/l

(3) Areawide total pollutant load control

Areawide total pollutant load control is as described in the preceding section 4.1.1, (3), (c). According to the enactment regulations of the Water Pollution Control Law, values such as C are indicated in the range as shown below in the case of the meat processing industry and accordingly the prefectural governor may specify the values in the range shown in the Table 5-2-8 for each enterprise.

Table 5-2-8 C values in meat processing industry (Example)

Industry classification	Value such as C (mg/l)						Remark
	C_0		C_i		C_j		
5 Meat product manufacturing industry	Lower limit	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit	
	20	40	20	40	20	40	

5.2.5 Response of Industry

Meat processing industry initially did not fully recognize the necessity for the effluent pollution control and was slow in implementing the control measures since the majority of the industry enterprises were in small and medium scale. hazardous substances were usually not contained in wastewater and seasonal fluctuation of wastewater was big. In 1970s the regulatory institutions for pollution control were arranged and a number of enterprises came to install wastewater treatment facility and at the same time, they came to implement the pollution control measures and cleaner production anticipating the future development of regulations. This type of approach is becoming rather common.

JEC has actively responded, as financing organization, to provide the funds for establishing and improving these wastewater treatment facilities.

Subsequent section 6.1 shows the case in which construction and transfer program was rendered to the meat processing industry by JEC.

5.2.6 Basic Policy for Pollution Measures and Establishment of Plan

(1) Viewpoint in target setting

Viewpoints for setting the basic target to plan and establish pollution control measures are (a) pollution control, (b) cleaner production and (c) environment management.

(a) Pollution control

Since the establishment of Basic Law for Environmental Pollution Control in 1967 in Japan, 1) air pollution, 2) water pollution, 3) soil pollution, 4) noise, 5) vibration, 6)offensive odor and 7) ground sedimentation (later underground water pollution was added to 2) were specified to be the pollution and regulatory institutions have been arranged and their technical implementation have been attempted jointly by governmental and private organizations. Of above elements, the meat processing industry has the particular implication with water pollution and offensive odor. Also, for factories located in the basin of the specified lakes and ponds and the designated sea area, the measures to control water pollution are even more important as they discharge organic wastewater containing nutrient salt such as nitrogen and phosphorus.

The essential elements in the target plan for the environmental protection are to strictly observe these legal requirements, i.e. comply with the specified effluent standards, etc.

(b) Cleaner production

Oil and fats, bones, internal organs, etc. other than foodstuffs being discharged from the processes of the meat processing industry are utilized as raw materials for medicines and other industrial applications, thus it can be, in a broad sense, referred to as cleaner production beyond boundary of individual enterprise. The cleaner production is implemented mainly in slaughter house where recycling and reutilization are performed by the expert contractors so that they discard almost nothing. In the meat processing industry where dressed carcasses are brought in for processing, it is considered to be able to fully reutilize bones and oils and fats which are discharged from deboning and trimming processes and therefore, recycling of those stuff must thoroughly been conducted. Moreover, by taking the in-process measures to be described later, the effluent pollutant load is reduced and through pollution prevention and waste reduction the production cost can be reduced.

(c) Environment management

It becomes important to perform production activity compatible with environmental protection by combining pollution control measures with the measures of cleaner production.

For this purpose, each enterprise is required to design, implement, evaluate and review the manufacturing process from the viewpoint of environmental protection.

This cycle is called as the environment management.

(2) Essential elements in the preparation of menu of available options

(a) In-process measures

In the meat processing industry the following measures are developed and already spread;

1) Recycle of internal organs and sale as valuables
2) Purchase and utilization of raw material primarily processed
3) Improvement of washing method and improvement of yield
4) Separation and recycle of high concentration effluents such as boiling soup
5) Recycle and reutilization of seasoning solution

These measures are widely adopted in the slaughter house in particular. Internal organs and blood as well are used as raw materials of foodstuffs, fertilizers/fodders, medicines and other industrial products and it is no exaggeration to say almost nothing is discarded. Since meat is brought in to the meat processing factory after being processed into dressed carcass, the utilization of raw material to the maximum extent and the effort to improve the product yield will effectively work to reduce the load in the course of disposal of the waste.

It is desirable to implement the above measures one-by-one, starting with those readily feasible, taking into account individual circumstances of each enterprise such as contents of its business lines and currently installed equipment, etc.

Introduction of new manufacturing machine is normally studied in line with the renewal of existing equipment. Meantime, from the viewpoint of foodstuff hygiene management, study must be made in introducing a new machine requiring as less water as possible, bearing in mind those aspects as to if steam and rubber spatula can be used in washing process and if automated processing can integratedly be conducted with as less need as possible for touching with hands.

(b) Wastewater treatment measures

Selection of either unit treatment method or the combined method as wastewater treatment technology is determined depending on the property of wastewater, target of treatment, cost of wastewater treatment and sludge disposal method.

Since wastewater from meat processing work is organic wastewater, the biological method is basically suitable.

However, coagulation treatment had been applied when provisional standards were applied at initial stage when wastewater treatment technology was on its way of spreading. This is because biological treatment was believed to require a certain skill. By the technical development later and for switching over to the uniform standards, the treatment method was converted to the biological treatment method.

Even at present, however, some business enterprises apply the pressure floatation method or the coagulation treatment method as pretreatment of biological treatment in an attempt to reduce the load on the biological treatment. But considering the operation cost and the cost for waste treatment, it is desirable to reduce the effluent load as much as possible, at the first place by improving the manufacturing processes.

(c) Measures against offensive odor

It is reported that offensive odor in meat processing industry mostly originates in the smoking process of ham and sausage. Other attributable causes assumably stem from insufficient management of raw materials and wastes of internal organs, etc. and the resultant offensive odor in putrefaction in drainage channel and in the course of treatment in the wastewater treatment facility.

With regard to the measures against offensive odor in meat processing industry, the measures for the sources in the manufacturing process and the measures by offensive odor treatment technology are considered.

The first essential step to be taken is naturally to prevent offensive odor from generating in the manufacturing process, etc. Measures to be taken for above are to arrange inclination of floor at work place and drainage channel for the smooth water draining and to improve management of the work so that no raw materials in way of manufacture are uselessly discarded.

Furthermore, it is necessary to frequently remove residues and scums collected by the screen installed before wastewater treatment facility before their putrefaction. Also, waste from meat processing industry contain much polyvinyl chloride, rubber, polystyrene foam such as synthetic casing, etc. and often emit strong offensive odor in garbage incinerator. It is desirable to separate these plastics in advance and commission the designated contractor to treat and eventually dispose of them.

(d) Management of wastes

Important thing in managing wastes is to study if wastes can be sold as valuable item or be disposed of as industrial wastes. Particularly, semi-products attached to the mixer in the manufacture process should not be water washed purposelessly but they should be scraped off with rubber spatula, etc. and sent out for frozen storage. By doing so, such semi-products can be reused by mixing with new materials and can help improve the product yield.

It is basically essential to recycle the materials in the solid state as far as they can be solidified. Water-washing seems hygienic apparently and is an easy work, but the load on waste water treatment is high and thus, it is desirable to refrain materials from being water-washed.

In case wastes are disposed as industrial wastes, industry generally commission disposal work to the contractor specializing in the work, but it is important for the industry to assume final responsibility in compliance with the legal regulations and procedures.

(3) Essential elements in establishment of plan

(a) Assessment of present situation

Steps should be taken are to assess the present situation when establishing a plan for any action. Those steps mean the evaluation on actual conditions such as the current operation condition and impact on the environment as well as identification of points to be improved.

In initial stage, it may be effective in some instances to improve the layout of manufacturing equipment, coordination of work procedures and waste segregation at sources of wastes and wastewater and based on the observation of work flow without rendering specific supervision. While implementing the improvement of work procedure at job site, it is important for the supervisor to reflect opinions and requests of employees positively. Such care enhances employees' incentives so that the improvement has been successfully implemented in many cases in Japan. Also effective in the job site improvement is to promote activity by small group.

(b) Preparation of menu for available options

Individual options such as cleaner production, wastewater treatment technology and offensive odor measure etc. should be comprehensively picked up for subsequent consideration, with view from entire business of optimal option to achieve the target.

(c) Study on economy

Comparative study of different measures in terms of economy is also important. Such comparative study should be cover a number of aspects, i.e. measure requiring temporary expenditure to be incurred such as installation cost, and measure requiring continuous expenditure to be incurred such as cost for maintenance and management, measure which can recover the cost such as valuable item recycled, measure for improving profit through process modification, measure for mobilizing the financial assistance (grant or loan), etc.

(d) Plan for environment management

In establishing the plan for the environment management, it is desirable to concurrently set implementation organization and evaluation system to monitor its achievement condition.

(4) Monitoring on effect

In evaluating the effect of pollution control measures, it is important as was described in the section 3.4 that both implementation condition of environment management plan and its achievement are comprehensively evaluated in collation with the set target.

It is also important to incorporate the monitoring program at establishing the plan for the environmental management in order to obtain its basic data.

The following consideration must be given in evaluating the measures individually. In case achievement.of target is not sufficient, study must be begun to find out if it was attributed by the implementation method, implementation organization or the plan itself.

In order to ascertain and measure the effect, it is good if various data ranging from data analysis of ledger to automatic measurement data of water quality, etc. are utilized to the maximum extent.

In this way comprehensive evaluation in addition to individual evaluation of the measures becomes feasible. Implementation of above method may sometimes be difficult in the enterprise and therefore, it is recommended to seek assistance from external organizations such as industrial association.

5.2.7 In-Process Measures

(1) Proper layout of manufacturing equipment and arrangement of drain system

Generally the drain lines are separately arrayed for raw material receiving facility, dressing machine and cutter, steaming equipment and floor washing.

Usually drain channel is arranged so as to collectively gather wastewater from these equipment and work processes. However, if equipment is laid out for each system such as manufacturing process and the drain channel is arranged accordingly, valuable items and wastes can be recycled and reutilized according to each characteristic or separate treatment can be executed more easily.

As the result, management of manufacturing process can be strengthened and at the same time the pollutant load can be reduced.

(2) Improvement of water washing method

(a) Water washing of manufacturing equipment and devices

Reduction of pollutant load and improvement of product yield are attempted by collecting the residual processed meat as much as possible, for example by using rubber spatula, from manufacturing equipment, storing it in frozen condition and using it next day, instead of washing away. Moreover, steam washing method makes it possible to wash the equipment more cleanly with less amount of water. During this work as well, products contained in wastewater are to be recycled as much as possible, stored it in frozen condition and effectively used for different products.

(b) Water washing of floor, etc.

For water washing of floor, etc, handy hose with control plug at the handy end is used so as to feed water only during the washing work.

Consumption of hand washing water can also be minimized by attaching automatic tap.

(3) Utilization of wastes as resource

(a) Concentrated waste solution

Concentrated waste solution such as wastewater from steaming process and degraded seasoning solution contain the meat extract and it is considered possible to recycle as raw material of seasoning and produce fodder by mixing with rice bran.

These concentrated waste solutions are, even if they are generated in a small volume, high in pollutant load and besides, method for the effective utilization is readily available, it is desirable to collect in separate form as much as possible.

(b) Residue of dressed carcass

Residue of dressed carcass (bones, fats, internal organs) discharged after dressing and pressing work are the wastes high in pollutant load. But, it can be recycled as resource and its volume as waste can be reduced by making use of routine collection by the external carter.

In case such residue is put into a sealed vessel and stored in a refrigerator or it is carefully stored in a cold and dark place until it is collected, it will also work effectively to prevent offensive odor and leaking of waste solution.

Moreover, it is considered possible for fresh internal organs to be sold as food with high added value.

5. 2. 8 Wastewater Treatment Measures, etc.

(1) Wastewater treatment measures

Since the principal pollutants in meat processing wastewater are mainly organic substances, the biological treatment is basically adopted. For the proper operation and management of biological treatment facility, it becomes necessary to have the combined treatment with the pretreatment by screen to remove residues, inclusions, oils & fats. It is also essential to have adequate treatment of the generated sludge.

For accomplishing these purposes, wastewater treatment process technology has been developed and commercialized. Table 5-2-9 shows general features of unit treatment processes and the target pollutants.

Table 5-2-9 Principal unit treatment processes in wastewater treatment

Target pollutants	Treatment technology: Impurity	Treatment technology	Application range	Remarks
Coarse suspended solid	Separation	Screen	Several mm or more	
Suspended solids		Sedimentation separation Floatation separation	Several mm ~ 50 μ	
Inorganic substance		Coagulation sedimentation Coagulation sedimentation + Filtration Sedimentation floatation	50 μ ~ 1 nm 50 μ ~ 1 nm	Effective for organic substance as well
Organic substance		Biological treatment (activated sludge, sprinkling filtration)	50 μ ~ 1 nm	Biologically degradable organic substances are removed
Residual substances after biological treatment (macro molecule)		Adsorption (activated carbon) Precision filtration (Ultra filtration), pH adjustment + (Coagulation), Oxidation +, Reduction + (Coagulation)	1 nm ~ 1 Å (Same as above) (Same as above) (Same as above)	Substances to be precipitated by chemical reaction are also removed
Inorganic ion		Ion exchange, Electrodialysis, Activated carbon		
Ionic substances		Reverse osmosis membrane, Activated carbon	1 nm ~ 1 Å	

Concentrated waste solution	Separation	Concentration, Incineration, Anaerobic digestion		Recycle, Extraction of methane gas
Sludge		Concentration (Gravity, mechanical), Dehydration, Drying, Incineration, Application to greenery or farm land		Particles are made coarse by chemical reaction
Chemical substances	Detoxification	Neutralization, Oxidation, Reduction		Ultra violet ray may also be used
Microorganism		Sterilization		Chlorine, Ultraviolet , Ozone

(a) Pretreatment

Depending on the production process, a wide variety of foreign substances are contained in its wastewater. In the case of operation including primary process, some lump of meat, oil & fat discharged from dressing carcass, etc., if not recovered, flow into wastewater treatment facility. To avoid this, it is indispensable to install screen and oil separator as pretreatment equipment.

In case of biological treatment it is also required to install a flow regulation tank for the purpose of averaging the fluctuation of wastewater.

In these pretreatment equipment, screen residues and floated scums need to be removed and the operations such as agitation and aeration are to be done in a regulation tank for avoiding anaerobic atmosphere.

(b) Removal of oils & fats

Oils & fats contained in meat processing wastewater solidify at normal temperature, adhere on the wall of drain channel and wastewater treatment facility, then, cause damages, e.g. by lowering efficiency of biological treatment. Moreover, oils & fats take in pieces of meat and protein, float to the surface as scum not only hindering wastewater treatment but also easily generating offensive odor.

Although oils & fats may be removed to a certain extent by pretreatment as described above, solidification and coagulation treatment are generally recognized to be effective in removing animal oils & fats.

(c) Removal of organic substances

Main pollutant in meat processing wastewater is organic pollutant and the main purpose of wastewater treatment is to remove BOD and COD which are the indexes of organic substance and thus, biological treatment is provided.

Fig. 5-2-7 and Fig.5-2-8 show the relationship between BOD-MLSS load and BOD removal rate as well as the relationship between BOD volumetric load and BOD removal rate in activated sludge treatment of meat processing wastewater.

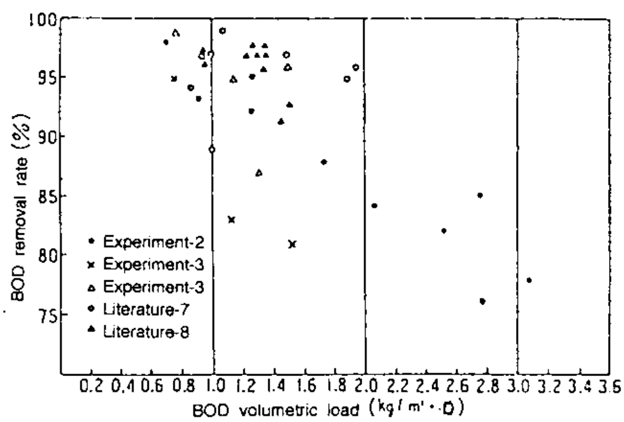


Fig. 5-2-7 Relationship between BOD-MLSS load and BOD removal rate

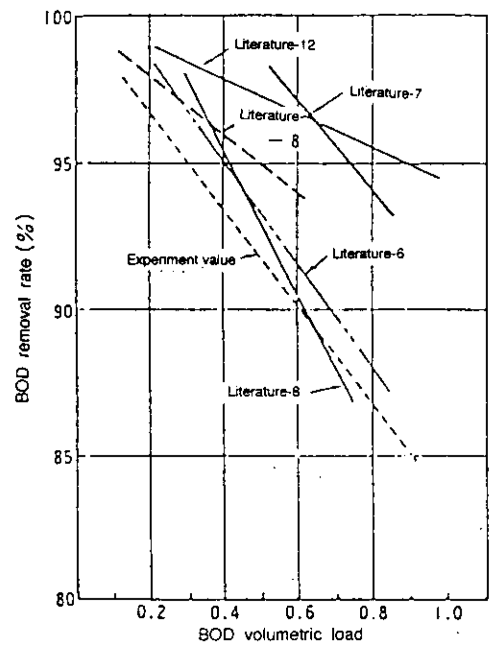


Fig. 5-2-8 Relationship between BOD volumetric load and BOD removal rate

While combined technology with coagulation and treatment technology using biological membrane are developed, wastewater concentration tends to lower owing to widely spread cleaner production. Therefore, biological treatment remains to be considered most suitable for the removal of organic substances.

In general, the removal of organic substances by biological treatment is conducted under the design conditions that the nitrification does not proceed.

Table 5-2-10 Relationship between BOD removal and indexes

BOD removal rate	BOD-MLSS load (kg.kg/day)	MLSS (mg/l)	BOD volu-metric load ($kg/m^3/day$)	Required O_2 per BOD removal (kgO_2/BOD_R)	Remark
85 % or less					Retention time in aeration tank shall be approx.4 hours
85 ~ 90 %	0.30	2,500	0.75	1.1	
90 ~ 95 %	0.25	2,500	0.63	1.2	
96 ~ 98 %	0.15	3,000	0.45	1.2	
98 % or more	0.10	3,000	0.3	1.2	

Example of biological treatment flow is shown below.

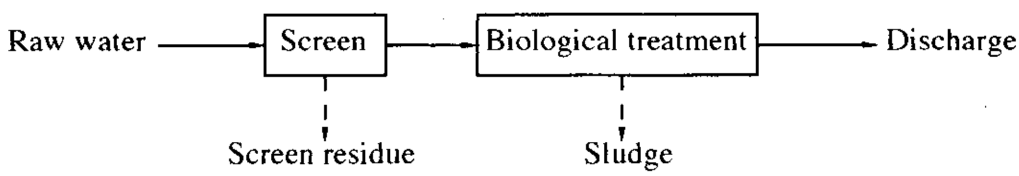


Fig. 5-2-9 Basic flow of biological treatment

(d) Advanced treatment

In order to obtain better treated water quality than uniform wastewater standards under the Water Pollution Control Law or to remove COD, nitrogen and phosphorus, advanced wastewater treatment is applied to enhance effect of biological treatment for removal of organic substance or to execute treatment with additional process.

The processes to be added to the conventional biological treatment for removing organic substances are coagulation treatment, sand filtration, activated carbon adsorption, etc. In the case of coagulation treatment, phosphorus can also be removed if metal salt coagulant is selected. Meanwhile, sand filtration is mainly used to supplement coagulation treatment, and the activated carbon adsorption is effective in removing persistent organics (COD) difficult to be decomposed by the biological treatment.

Shown below is an example of treatment flow in which coagulation treatment is added to biological treatment.

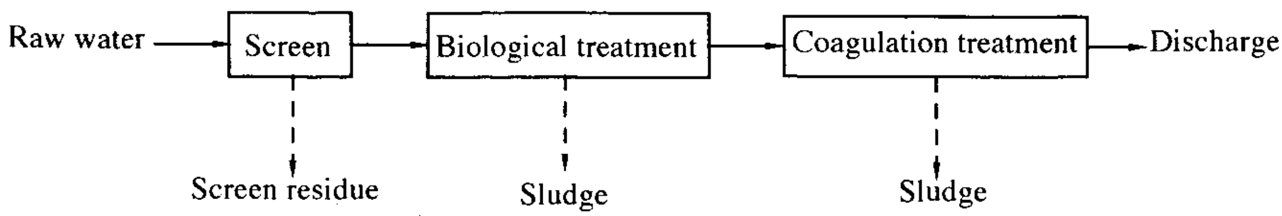


Fig. 5-2-10 Basic flow of advanced treatment

(2) Treatment and disposal of wastes

Sludge generated from wastewater treatment facility contains considerable water content. Therefore, if it is to be and disposed of in such condition, its handling is difficult and besides, costly due to the volume.

To avoid above trouble, it is general practice that sludge is provided with dehydration treatment to the extent that no water leaks when sludge is loaded on a truck.

There are several methods for dehydration of sludge and technical development has been made. Among them, the belt press dehydrator is widely applied for the reasons ; Automatic operation is possible; It is fit for excess sludge from biological treatment; Even small scale industry can afford its installation.

As far as the storage tank of adequate volume is installed, sludge can be treated without such a fluctuation as that experienced in the wastewater treatment. It is sometimes more realistic in a small scale industry that, instead of treating the sludge by the industry itself, sludge is brought out on a vacuum truck as it is for treatment/disposal by contractor.

Moreover, dehydrated sludge can be applied to farm land as fertilizers. For this application, it is necessary to use coagulant other than PAC because PAC hinders crops to grow.

(3) Measures against offensive odor

It is reported that odor generated in the meat processing industry mostly originate from the smoking process in the manufacture of hams and sausages. Offensive odors also originate from putrefaction in drain channel and from wastewater treatment facility due to insufficient management of raw materials and dressing residues.

(a) Measure against offensive odors generated from manufacturing process

The first step is to prevent offensive odor from the manufacturing process, etc. In order that offensive odor does not free from the smoking process, etc., the process should be enclosed so that the process exhaust is collected by duct with hood.

The collected offensive odor is discharged through high stack, while, in the factory equipped with biological treatment facility, deodorizing treatment can be performed in the procedures described in the section 4.2.3. It is also effective for the prevention of offensive odor to implement the measures to improve the resource management with particular attention to the storage of raw materials and dressing residues.

(b) Measure against offensive odor from drain channel

It is desirable that inclination on the job site floor and drain channel is arranged so as to transmit wastewater without sedimentation and accumulation in its course. Screen residues, and scum, etc., collected by the screen should be removed as frequently as possible before their putrefaction and discharged after dewatering and drying.

Furthermore, garbage generated from the food processing industry contains a significant amount of polyvinyl chloride like casing, rubber and polystyrene foam which often emit strong offensive odor when they are incinerated.

It is recommended to separate these plastics and contract an expert specialist for final disposal.

6. Project Cases of JEC

6.1 Cases of Construction and Transfer Programs by JEC

(1) Project case in Nishiwaki City's dyestuff joint wastewater treatment facility (1970, 1977)

(a) Outline of area

Nishiwaki City is located approx. 40 km in north west of Kobe City. This area is surrounded by the mountains and Kakogawa River rich in flow streams in the center part. Humidity fit for the textiles was maintained under such geography and its river water was soft and suitable for dyeing and consequently the fabric dyeing industry has traditionally developed in the area.

Nishiwaki City and it surroundings have been famed for one of the leading production area of top dyeing fabrics for approx. 200 years. In the old days, industries comprising Banshu Fabrics totally amounted to thousand and several hundreds including dyeing and finishing industries (22 firms) as well as trading firms, cotton processing industry and finishing /processing industries and top dyeing fabrics in amount of approx. 300 million square meters were annually exported to the countries in the world.

Processes adopted in this area are such that, after all the threads are provided with top dyeing in the dyeing factory, they are woven to the cotton cloth in the textile factory and shipped after being finished and processed. Those top dyeing fabrics is used for shirts, blouses, handkerchieves, sheets, folk costumes, etc. as final products.

Main stream in the past was a skein dyeing by top dyeing in the form of cotton, but main production recently is synthetic textile, mainly polyester, and cotton woven fabrics, being switched over to a cheese dyeing and a beam dyeing.

(b) Outbreak of pollution

Along with development of economy and dyeing machinery, production system was switched over from hand dyeing to machine dyeing in 1960s when production output remarkably increased. In the case of hand dyeing production, dyeing solution was rarely discharged into rivers.

In the machine dyeing production, however, dyeing solution was discharged into rivers without any treatment and consequently, river water came to be reddish, yellowish and blackish spots. Moreover, dyeing factories in this area used sulfide dye high polluting and accelerated deterioration of the water quality in the Kakogawa River.

In 1966 contamination expanded partly due to the effluents from pulp manufacturing industries, etc. In the downstream area trouble with drinking water occurred and was brought into court and furthermore, claim for damage caused by contamination was filed from fishery association, bringing about a grave social problem. With these situations being as a trigger, strong request was issued to the dyeing factories for early improvement in their effluent quality and control of such factory effluent became an imminent matter to be dealt with.

(c) Restriction on wastewater

During the period of rapid economic growth in Japan, air and water pollution mainly attributed by industrial activities became significant to cause serious social problem. In order to cope with these problems, the Pollution control ordinance was first enforced by Tokyo metropolitan government in 1949 and subsequently Japanese government promulgated the Law relating to restriction on factory effluent and the Law relating to preservation of water quality in public water area in 1958. Under these laws, restriction was gradually imposed on the factories in Tokyo and Osaka which had discharged highly polluted wastewater into rivers. In Kakogawa River area as well, regulatory control for the wastewater was already expected to be applied and thus, investigation on water quality in the factories was started. The dyeing factory association in Nishiwaki area also organized a committee on the factory effluent measures and conducted investigation relating to wastewater treatment technology, etc. Thereafter, effluent standards were first applied to the dyeing industry in Japan in 1967.

(d) Study on dyeing effluent treatment technology

Adequate treatment of wastewater from dyeing factory was generally recognized to be difficult due to the following reasons 1) to 3). In addition, big problems lied with 4) and 5).

1) Wastewater contained various kinds of chemicals used for dyeing.
2) Quality of wastewater substantially differed depending on the products and manufacturing process.
3) Hourly and seasonal fluctuation in quality and quantity of wastewater was big.
4) Restriction on colored effluent was scheduled to be exceptionally imposed unlike other industry.
5) Restriction for the time being was limited only to Nishiwaki area, which had to compete with enterprises in other area where this restriction was not applied. Moreover, dyeing industries in Nishiwaki area were small and medium in their scale and thus, installation and operation cost should be small enough each industry could bear the new economic burden.

In order to overcome these 5 difficulties, the following wastewater treatment method and 3 treatment technologies were studied.

1) Treatment under special public sewage

   By promptly arranging the public sewer for whole Nishiwaki City and its surrounding area, all effluents from industries located in this area were all to be discharged and treated. This is called as the Special public sewage system.

2) Carbon dioxide (boiler exhaust gas) reaction process (Researches conducted in universities).

3) Coagulation sedimentation process by waste sulfuric acid (Researches conducted in universities).

4) Activated carbon process (Technical researches conducted in prefectural industrial laboratories).

As the result, it was concluded that pretreatment by each factory was necessary for discharging wastewater into the sewer under the method 1) to comply with the Sewage Law. The method was not adopted due to the following reasons;

a) Pretreatment technology was not established.

b) High construction cost would be incurred if pretreatment facility is installed by each factory. Besides, person solely assigned for management was not found.

c) High cost will be incurred by both pretreatment work and sewage charge.

d) It was difficult to appropriately distribute expenses for construction cost of public sewage.

e) It takes time to arrange the public sewer.

With regard to the study result on wastewater treatment technology, both 2) and 3) were not adequate because removal ratio of COD and color was low. Besides, hydrogen sulfide gas generates. As for 4), removal of COD and color was effective, but deterioration of activated carbon was extensive and thus, it was judged to be economically inadequate due to its high treatment cost.

(e) Wastewater treatment experiment

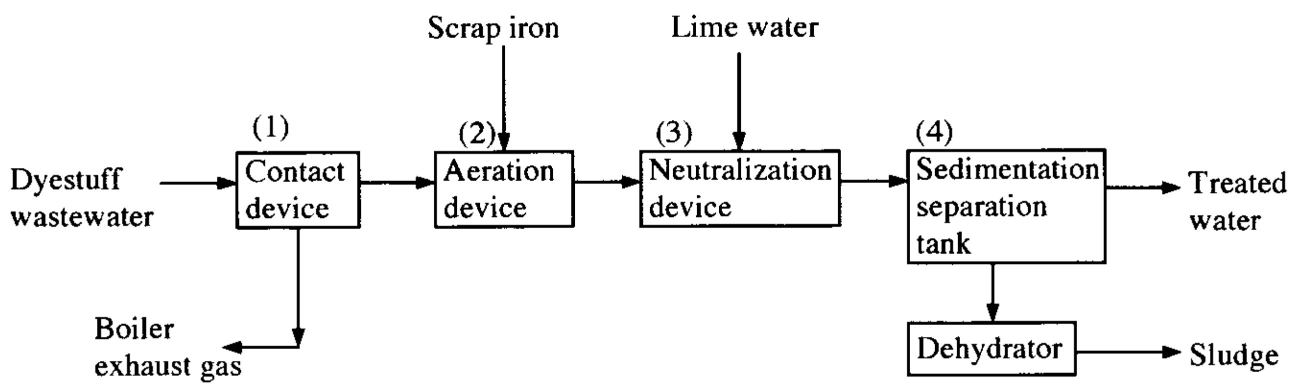
Since there were social problems due to pollution by dyeing effluent and restriction under the law, the aforementioned association, through Hyogo prefecture and Nishiwaki City, requested JEC to conduct preliminary experiment and research for establishing dyeing wastewater treatment technology to assist their project for effluent control.

JEC accordingly conducted an experiment on the Boiler exhaust gas reaction process at a dyeing factory in Nishiwaki. This process was originally developed by a boiler maker for the purpose of removing sulfur oxide gas, soot and dust contained in boiler exhaust gas. Reason why this method was studied as pretreatment method for dyeing effluents was in that boiler exhaust gas is to be contacted to the wastewater of dyeing factory where boiler was an indispensable equipment and thereafter, effect of neutralization and discoloration as well as reduction in chemicals cost were aimed at. The treatment method and flow chart are shown below.

Treatment method

1) First of all, neutralization treatment is attempted by contacting the dyeing factory effluent with boiler exhaust gas.
2) Then, air oxidation in the aeration tank is provided to prevent generation of hydrogen sulfide, and afterwards, residual sulfuric compound is converted to iron sulfide by adding scrap iron.
3) Water treated in that way is neutralized with lime and then, it is sedimented and separated, while its supernatant is discharged.
4) Sludge from the sedimentation tank is dehydrated and disposed at landfill.

Process flow chart



Consultation was held with dyeing industry association concerning the result of the experiment and it was said that the treatment technology under this method would be adopted if technical details are clarified and operation cost is estimated.

Since this project is aimed at the development of new treatment technology, financial assistance was provided by the government, prefecture and city, and in 1967, JEC installed a test plant for commercialization of the technology. As the result, it was concluded that boiler exhaust gas reaction process is not suitable for the treatment of sulfide dyeing wastewater for the following reasons;

1) It is difficult to have stable treatment because the generation of exhaust gas is not uniform.
2) Generation of hydrogen sulfide is more than anticipated.

Thereafter, for the commercialization of treatment technology 3) the Coagulation sedimentation process by waste sulfuric acid, another experiment was conducted and the treatment technology was established in 1969.

(f) Plan for facility installation

As the result of detailed study on wastewater treatment method, wastewater from dyeing industry is largely classified into

1) Wastewater whose concentration is low but volume is much and

2) Wastewater whose concentration is high but volume is not much (sulfide dyeing wastewater) and it was judged to be economical in terms of both installation and operation cost if such wastewater is separately treated. Each factory accordingly separated, for the wastewater treatment, sulfide dyeing wastewater from the wastewater other than sulfide dyeing wastewater.

Study based on economical aspect was made as regards wastewater treatment plan for all dyeing factories in Nishiwaki City and its surrounding area, and the conclusion was to adopt treatment method in both forms of joint treatment and individual treatment. That is, 1) Low concentration wastewater is treated in individual factory. 2) Sulfide dyeing wastewater high in concentration is treated in the joint treatment facility because advanced treatment is required. 3) However, for the industries located outside the urban district, two lines of wastewater treatment facility are installed in each factory. 4) These programs are common to association members and hard to be dealt with technically and economically by individual members and therefore, they should be tackled with as association's program.

Under these circumstances, 11 industries located in the city were selected and pump equipment as well as drain pipe were installed (total length of approx. 4.5 km) to collect water. The first large scale dyeing wastewater treatment facility in Japan was constructed in this way.

(g) Construction of joint wastewater treatment facility

Type of wastewater : Sulfide dyeing wastewater

Wastewater volume : 1,344 m^3/day (Total of 11 firms)

Treatment method : Coagulation discoloring sedimentation treatment

Land area : Total floor 773 m^2

Building area cost : 53 million yen

Construction cost : 200 million yen, 77 million yen (Drain pipe)

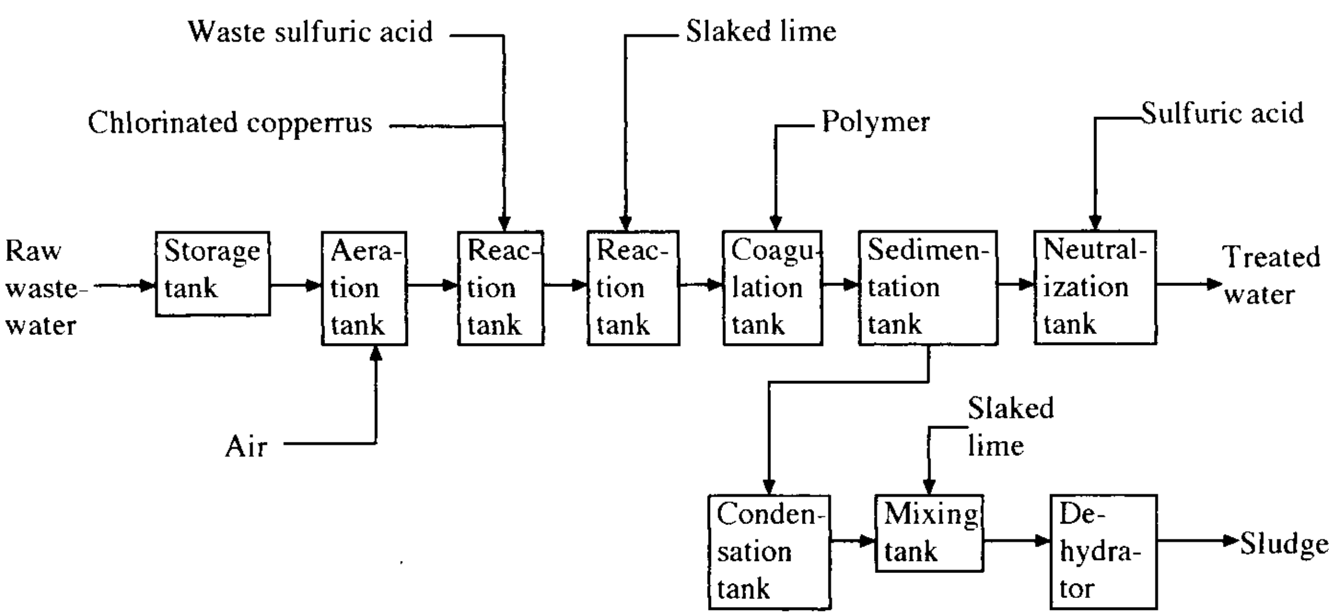
Treatment standards		
	Raw water	Treated water
pH	~ 12	5.8 ~ 8.6
COD_{Mn} (mg/l)	500	150
SS (mg/l)	70	150
Chromaticity shall have also been removed.		

Treatment process

After being fed by pump from 11 industries, wastewater is stored in the storage tank (510 m^3) so as to average the fluctuation of flow rate and water quality. Then, in order to prevent generation of hydrogen sulfide, large volume of air is blown into aeration tank (90 m^3) so as to oxidize sulfur ion.

In the primary reaction tank (22 m³), wastewater is neutralized, and in order to attain effective coagulation and discoloration, waste sulfuric acid and chlorinated copperrus (mixed solution of chlorine and ferrous sulfate) are injected. In the secondary reaction tank (22 m³), slaked lime is injected so that sulfide and COD component are treated by coagulation, adsorption and discoloration. Thereafter, in order to have successful precipitation of flock, high molecular (polymer) coagulating agent is injected into the coagulation tank (22 m^3) and it is separated into supernatant and sludge in the sedimentation tank (154 m² × 2.5 mH). Supernatant wastewater is neutralized in the neutralization tank (22 m³) and discharged as treated water. Sedimented sludge is thickened in the condensation tank (64 m² × 3 mH) and then, dehydrating agent (slaked lime) is added so as to dehydrate by the filter press (filtration area: 253 m²) to remove the water contents to 75 % or less and is disposed at the landfill. Depending on the property of wastewater and condition of treatment, ferrous sulfate alone may be used instead of chlorinated copperrus.

Treatment flow



(h) Construction of individual wastewater treatment facility (Wastewater other than that jointly treated)

Type of wastewater : Dyeing wastewater other than sulfide dyeing wastewater

Wastewater volume : 20,732 m^3/day (Total of 11 industries)

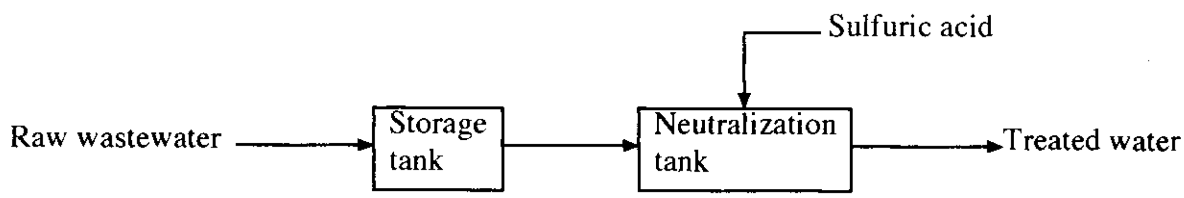
Treatment method : Neutralization treatment

Construction cost : 200 million yen (Total of 11 industries)

Treatment standard

	Raw water	Treated water
pH	~ 12	5.8 ~ 8.6
COD_{Mn} (mg/l)	145	150
SS (mg/l)		50
Chromaticity shall have also been removed.		

Treatment flow



Running cost in those days (1972) per 1 m^3 wastewater was as follow:

	Treatment cost for sulfide dyeing wastewater (yen)	Treatment cost for wastewater other than sulfide dyeing wastewater (yen)
Chemicals cost	8	2.1
Power cost	5.5	0.18
Sludge treatment cost	2	0
Labor cost	12.5	0.29
Repair cost	2	0
Others	5	0.5
Total	35	2.68

(i) Improvement to meet the revised regulation in 1976

Restriction was intensified as the result of revision of the Water Pollution Control Law in 1976. Since industries could not meet the intensified restriction only by the treatment under coagulation process, activated sludge treatment facility was additionally installed. Further, as the dyeing technique developed and the economic situation changed, distaff used also changed and the volume of wastewater changed as well. Accordingly, the segregation of wastewater is newly programed between high concentration and low concentration type instead of the conventional program between sulfide dyeing wastewater and that other than sulfide dyeing wastewater.

As activated sludge treatment facilities were additionally installed, the volume of generated sludge increased and its quality changed. Consequently conventional disposal at landfill came incompetent to meet with such change and thus, incinerator for sludge was also installed additionally. Moreover, areawide total pollutant load control on wastewater pollutant was enacted in 1981 and accordingly the automatic measuring system for quality and volume of water was added also.

Type of wastewater : High concentration dyeing wastewater

Wastewater treatment volume : 2,780 m^3/day (Total of 8 industries)

Treatment flow is shown in the subsequent section.

Treatment method : Coagulation sedimentation + Activated sludge treatment

Land area : 5,500 m^2

Cost for improvement by additional installation of activated sludge treatment facility : 324 million yen

Cost for installation of sludge incineration facility : 237 million yen

Design standards

	Raw water	(Treated water by coagulation sedimentation)	Treated water by activated sludge	Prefectural standard
pH	~ 12	7	5.8 ~ 8.6	5.8 ~ 8.6
COD_{Mn} (mg/l)	500	200	70	80 (100)
BOD (mg/l)	500	300	80	120 (160)
SS (mg/l)	70		50	70 (90)
Transparency			10 or more	10 or more

( ) shows the daily maximum value. Transparency is in accordance with Nishiwaki City 's stringent ordinance.

Treatment standards for soot and dust from sludge incineration is 0.3 g/Nm^3

Treatment process

Because the volume of wastewater increased as the result of the change in wastewater segregation, the volume of the raw water storage tank is to be increased to 1,390 m^3 for obtaining uniform water quality and the air is the blown into the aeration tank so as to oxidize sulfur ion. In the primary No. 1 reaction tank, ferrous sulfate is injected as coagulant and in No. 2 reaction tank, slaked lime is injected. (Slaked lime is not used thereafter.) In the coagulation tank, high molecular (polymer) coagulant is injected, while in the sedimentation tank, sulfide, metal compound and other COD component are sedimented for removal. Supernatant is neutralized in the neutralization tank and in the regulation tank (950 m^3) its flow rate and concentration are regulated so that biological treatment for 24 hours may be feasible. Then, since water temperature is high, it is cooled down to 40 ℃or less in the cooling tower and thereafter, nutrient suitable for biological treatment is added. (Nutrient addition was later abolished.) In the aeration tank (1,410 m^3, MLSS 2,000 ~ 3,000 mg/l, BOD and COD load 0.98 kg/m^3 d, Blower 44 m^3/min), and the sedimentation tank 290 m^2 x 2.9 mH, 9.6 m^3/ m^2 d), activated sludge process is given and finally discharged as treated water. Sedimented sludge is dehydrated in the existing condensation tank and filter press and then, it is incinerated in the sludge incineration facility (1.5 ton/H) for reducing its volume.

In the case of actually treated water, COD(Mn) is 50 mg/l and BOD is 5 mg/l, while soot and dust emitted from the sludge incineration facility is 0.05 g/N m^3 or so.

The treatment cost after improvement of facility was 105 yen per wastewater 1 m^3(1985). It will be 200 yen/ m^3 if depreciation of equipment in amount of 95 yen/ m^3 is added. (Chemicals 29 yen, electricity 33 yen, sludge treatment 7 yen, labor cost 28 yen, others 8 yen). Low concentration dyeing wastewater is neutralized in each factory and then, discharged. Its treatment cost is 5 yen per wastewater 1 m^3.

(j) Allocation of construction cost and maintenance management cost

In association, construction cost and maintenance management cost for joint wastewater treatment facility are shared at the following proportion;

a) Facility construction cost is divided into actual cost of construction and cost for feed water pump capacity equally and each industry pays those costs based on the wastewater treatment volume.

1) Division of 50 % of actual construction cost

Assuming that each industry independently constructs wastewater treatment facility, its construction cost is calculated and allocated by proportion.

2) Division of 50 % of feed water pump capacity

Each industry shares its percentage according to feed water pump capacity.

b) Allocation of cost for maintenance and management

1) Labor cost, others :	Equally divided	30 %
	Divided by feed water volume	40 %
	Divided by designed water volume	30 %
2) Chemicals, electricity, supplied water charge	Divided by feed water volume	70 %
	Divided by designed water volume	30 %
3) Sludge treatment cost	Divided by feed water volume	90 %
	Divided by designed water volume	10 %

(k) Effect of program

a) After the study on technical and economical aspects, dyeing wastewater treatment became practical that enabled the treatment of dyeing effluents to be positively implemented in other areas in Japan.

b) As a model program representing Japan, municipalities, textile enterprises, other dyeing industry association, wastewater treatment contractor, etc. from all parts of Japan as well as from foreign countries such as U.S.A, Korea, Taiwan, China, Singapore, Indonesia, etc. paid research visit to the facilities and its effect was studied in the various ways.

c) Thanks to the construction of wastewater treatment facility, the water quality in Kakogawa River was substantially improved and color transparency as well significantly exceeds the standard specified under Nishiwaki City's ordinance of 10 cm. No problems were posed in terms of drinking water, agricultural water and fishery.

d) Evaluation as cooperative association program

1) The association was recognized as social organization in the area and reliability from outside was enhanced.
2) Although a large amount of money had to be raised for construction, the association unity was strengthened because they had to reimburse and guarantee the loan together.
3) The association came to positively tackle the pollution-related problems and consequently, the dyeing finishing industry could promptly cope with the matters such as COD areawide total pollutant control (Automatic measurement of COD), reduction of nitrogen and phosphorus (Switch-over of chemicals used), trihalomethane, measures for reduction of sulfur oxides, etc.

(l) Situation at later stage

a) When facility was constructed, main textile handled was cotton and thus, sulfide dyestuff was often used. As use of synthetic resin gradually increased, dyestuff was also switched over to the reactive dyestuff. Resultantly, dye absorbance rate of thread became high and pollutant load became less. Under this condition, it was possible to provide the adequate treatment even if the product output increased.

b) Initially 11 industries used the joint wastewater treatment facility, but 6 industries now use it after the rapid appreciation of yen and competition with foreign industries. Other 5 industries discontinued their business according to the government's the Occasional special measures for textile industry. The portion of the construction cost to be borne by these industries are now borne by the remaining union members.

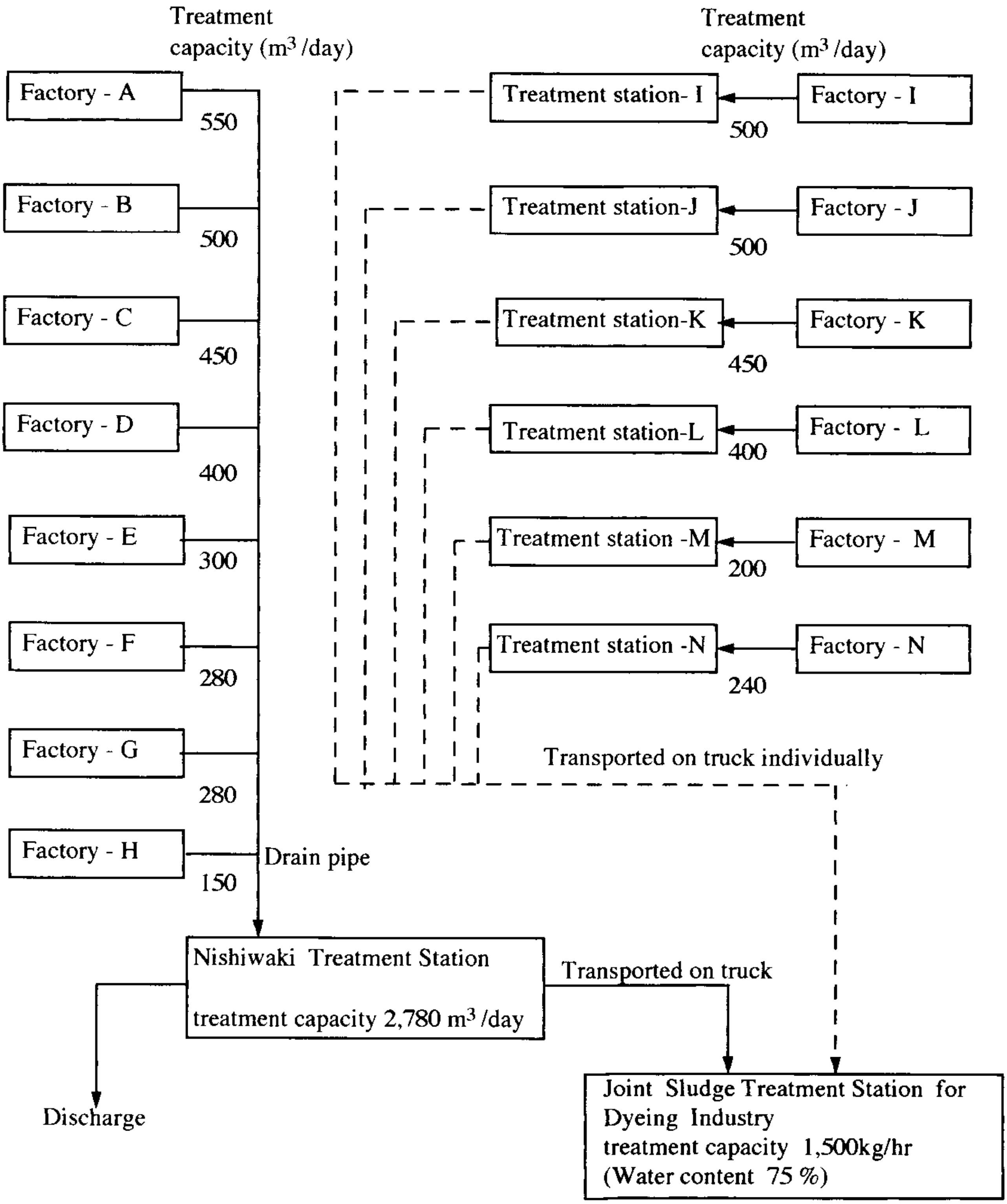
●Change in dyestuff used

Name of dyestuff	1970	1992
Sulfide dye	51 %	6 %
Reactive dye	11 %	70 %
Disperse dye	16 %	12 %
Cationic dye	0 %	2 %
Direct dye	3 %	0.4 %
Naphthol dye	15 %	0.1 %
Threne dye	4 %	0.5 %

Configuration of dyestuff joint wastewater treatment facility

8 industries in Nishiwaki City

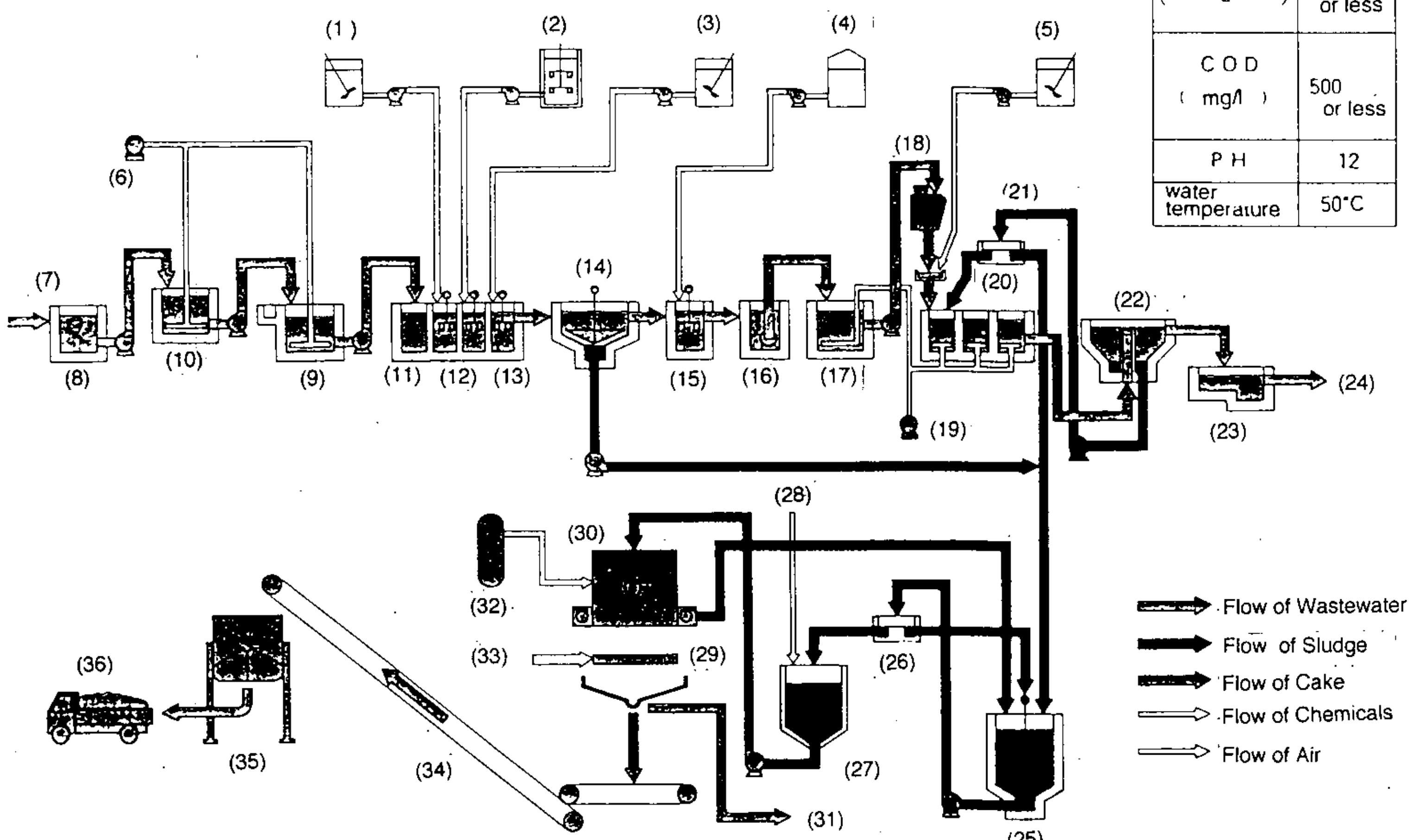
6 industries outside Nishimaki City



Outline of Nishiwaki Wastewater Treatment Facility

Hyogo pref. Nishiwaki city, wada-machi, Tel: (07952)2-6039, Capacity/ 2,780m³ /d. , 8 companies's joint enterprise in Nishiwaki

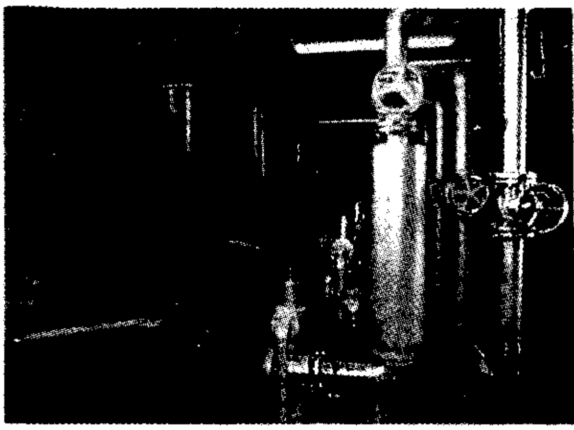
Flow Sheet

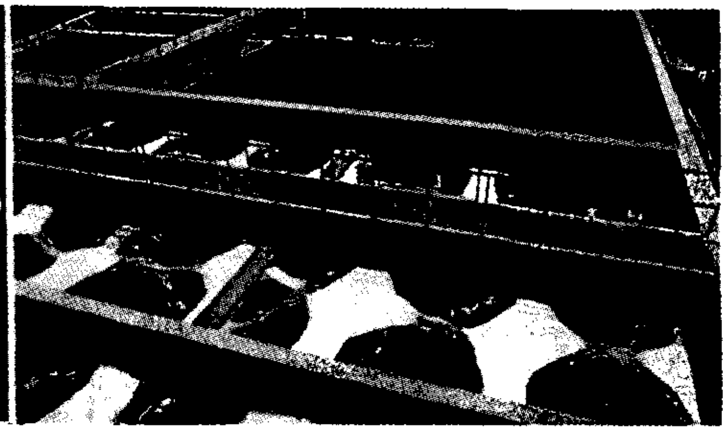


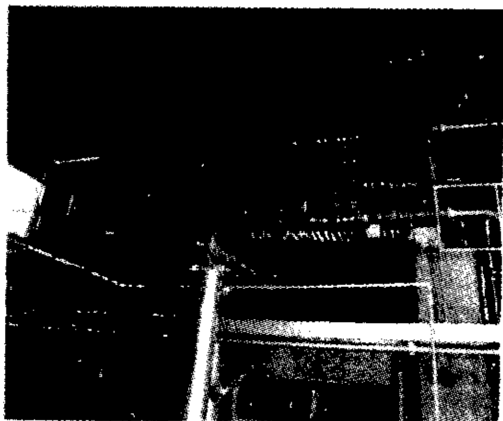
● Raw water quality

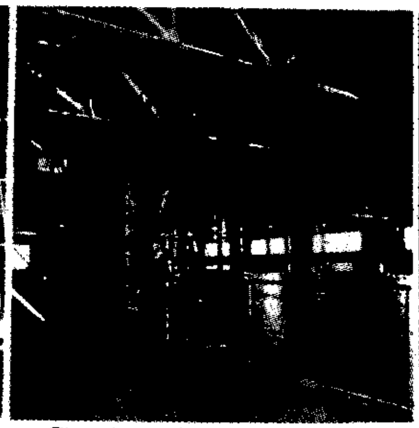
B O D (mg/l)	500 or less
C O D (mg/l)	500 or less
P H	12
water temperature	50°C

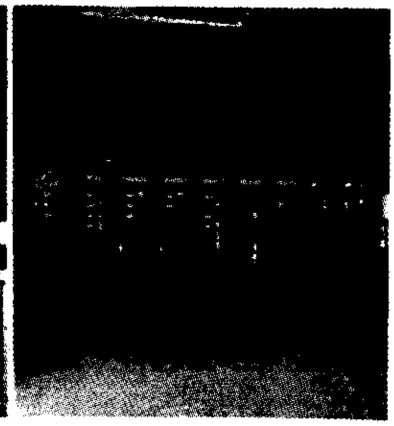
(1) Ferrous sulfate dissolving tank
(2) Lime milk storage tank
(3) Polymer dissolving tank
(4) Concentrated sulfuric acid tank
(5) Nutrient dissolving tank
(6) Blower
(7) Flown from 8 industries in city
(8) Incoming effluent well
(9) Raw water basin A
(10) Raw water basin B
(11) Aeration tank
(12) Reaction tank
(13) Flocculating tank
(14) Coagulation basin
(15) Neutralization tank
(16) Pump tank
(17) Balancing tank
(18) Cooling tower
(19) Blower
(20) Aeration tank
(21) Sludge distribution tank
(22) Final sedimentation basin
(23) Treated water measuring tank
(24) Discharge
(25) Sludge concentration tank
(26) Overflow tank
(27) Dehydrating agent mixing tank
(28) From lime milk tank
(29) Filter cleaner
(30) Dehydrator
(31) To reaction tank
(32) Air tank
(33) From water receiving tank
(34) Conveyer
(35) Cake hopper
(36) To the cooperative sludge treatment facility


Blower chamber


Aeration tank. Final sedimentation basin

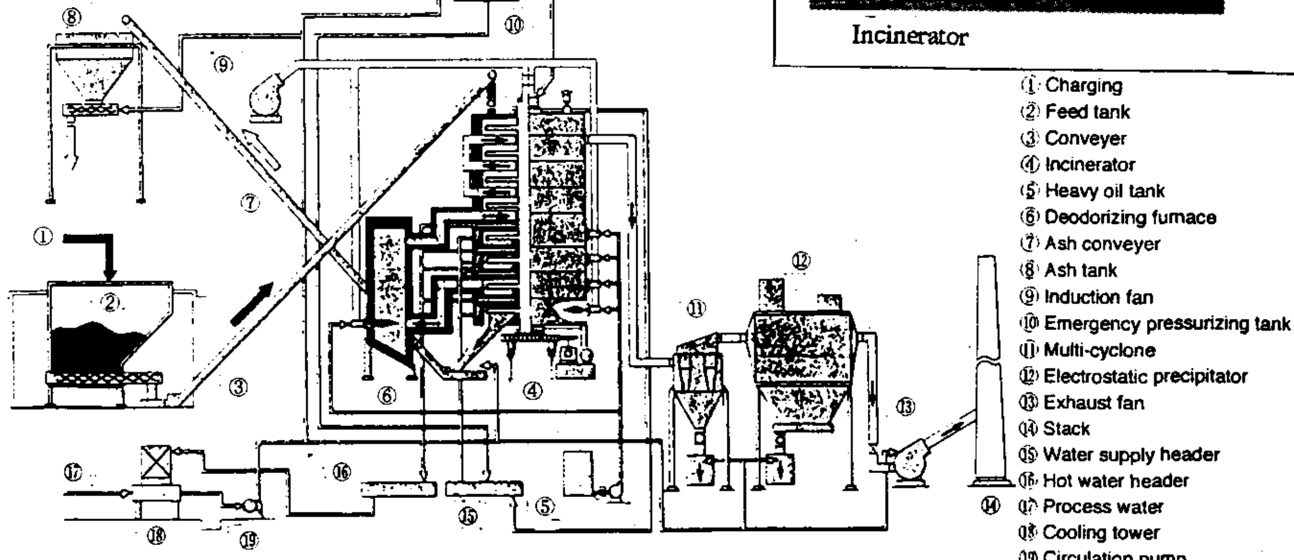

Dehydrator (Filter press)


Chemical injection chamber


Electric room


Incinerator

Flow Sheet



(2) Takasaki Food Industrial Park /Joint Wastewater Treatment Facility (1987)

Case where positive pollution control investment was rendered for regional environmental improvement.

(a) Construction of facility

Takasaki City, Gunma Pref. is located at north west inland approx. 100 km from Tokyo. As economy grew and urbanization progressed, water pollution in the rivers of Takasaki area went worse. Besides, downstream water of those rivers bad been used for water supply in Tokyo metropolitan area and thus, measures against water pollution were strongly requested.

For this facility, JEC provided its construction transfer program for both group installation building and joint pollution control facilities. Within this program, the five small-scale food related industries which were located in the area with mixture of houses and factories in Takasaki City (area where houses and factories were located together) were transferred in group and a joint wastewater treatment facility was installed for the purpose of implementing the measures against water pollution and noise.

At that time food-related industries located in Takasaki city were mostly small in their managerial scale and exempted from the effluent, standards and therefore, wastewater treatment facility was not installed. Some industries on which the effluent standards was imposed took the wastewater control measures, but not to the extent to meet the intensified new regulation.

Besides, most of the industries were in trouble with noise pollution in the neighborhood.

In order for the industry to respond to the intensified regulation as well as to expand its managerial scale and introduce modernized production equipment, land was to be newly acquired. However, these industries locating in the residential area could not afford acquiring the land to be allotted for the new facilities and were in a difficult position to take drastic measures of pollution control.

For the solution of these problems, Takasaki city government established a plan to relocate these industries to the suitable factory site and to furnish all these industries with effluent control facilities and consulted with 23 industries who had been posing the environmental problems. Finally the city government implemented the program for the selected five industries with certain conditions. Relocated industries are installed with pollution controlling facilities complying with even the future intensification of restriction, in addition to rational and yet modern production factories. Consequently, productivity and working environment was also improved. Moreover, the former factory site from where factories were relocated was renovated into quality residential area without any residual pollution.

Users of facility : Takasaki Food Industrial Park Cooperative Union,
Five Food Processing Industries

Implementation of program : March 1985 to June 1987

Scale of facility : Factory building 5 Factories 5 Buildings, Total area 4,103 m^2
Joint wastewater treatment facility : Treatment capacity 460 m^3 /day,
Building 123 m^2

Land area : 16,760 m^2 Land allotted for factory buildings 15,770 m^2

Land for joint wastewater treatment facility 990 m^2

Cost incurred by this program : 1,303 million yen, Factory buildings 632 million yen
(Production equipment were installed by industries themselves)
Joint wastewater treatment facility 168 million yen
Land purchase cost 408 million yen
Administrative expenses 96 million yen

(b) Outline of (5 industries) belonging to Takasaki Food Industrial Park Cooperative Union

Industry	Type of business	Land area	Factory area	Number of employee	Capital
A	Pork, beef and chicken meat processing	1,920 m^2	415 m^2	20 persons	20 million yen
B	Milk and milk processing	4,780	1,528	58	48
C	Meat processing	3,560	1,125	60	20
D	Dried fruit manufacturing	3,580	555	25	9
E	Bean curd manufacturing	1,930	480	16	10

(c) Outline of joint wastewater treatment facility

Wastewater volume : 460 m^3/day, Hourly maximum 84 m^3,
(Time to discharge wastewater from factory : 10 hours/day)
Wastewater treatment capacity : 460 m^3/day,
Operation time : Consecutive 24 hours a day, Operation management to be done for 8 hr/day
Person responsible for operation management : 1 person
Treatment method : Activated sludge process + Biological filtration

(d) Design of facility

Planning of factory buildings is closely related to the managerial policy of industry. Production process plan, factory layout, etc. were established and implemented by the individual industry, while JEC prepared its cost planning and design drawing and also developed the adequate infrastructures for the industrial park.

For the measures against water pollution, in the meantime, JEC conducted survey at the design phase and at the same time had discussions with Takasaki city government and Cooperative union's member industries regarding the water quality environment at the construction site, future trend of wastewater regulation, development in wastewater treatment technology and industry's capability for cost burden. Thereby factories were constructed to meet the stricter standards than the nation's discharge standards and the prefectural stringent standard.

(e) Survey for design purpose on wastewater condition and treatment method

A survey for the following items were conducted in each industry in order to determine volume of wastewater and quality of wastewater for the design of the wastewater treatment facility.

1) Type of product, production output, seasonal fluctuation and future production plan
2) Production process, volume of wastewater and method of discharging wastewater and quality of wastewater
3) Type and concentration of chemicals used (Food additives)
4) Unit load for production
5) Feasibility study on reduction of pollution load
6) Wastewater treatment system, facility installation cost and running cost

(f) Policy for wastewater treatment

1) As the main pollutant loads from wastewater are the organic substances originating from the foodstuffs, its treatment method should be biological treatment (activated sludge process). Taking these factors into consideration, joint treatment system for fully mixed wastewater is to be adopted since it is advantageous compared with individual installation in terms of construction, operation and maintenance cost. Wastewater from each factory is collected into a joint wastewater treatment facility by means of drain pipe.
2) Because of the strict treatment standards, advanced treatment is provided by applying biological filtration tank after multi-stage activated sludge process.
3) Since biological treatment is adopted, the operation should be 24 hours continuously. Operation management of facilities should be done by one person who is on duty within 8 hours a day. Spare pump is to be installed for the treatment line.
4) Excess sludge should be disposed of at landfill after adjusting its water content to 85 % or less by using dehydrator.
5) Each industry should measure the volume of wastewater by installing water level gauge. The concentration of wastewater from industry is periodically analyzed so as to calculate the cost for wastewater treatment to be shared.

(g) Description of wastewater treatment facility

Volume and quality of raw wastewater (Survey results and design standards)

Firm	Wastewater volume	BOD	COD	SS	N-H	T-N	T-P
	m^3 / D	mg/l					
A	20	500	120	270	300	20	2.7
B	180	776	415	142	141	18.2	5.7
C	110	1,091	273	900	455	39	3.1
D	35	4,000	2,933	2,533	267	23.3	5.0
E	60	1,188	650	138	31	43.8	0.9
Total	405	1,190	615	560	229	28.2	4.08
Design standards	460 460	1,230 566Kg/D	620 285Kg/D	590 271Kg/D	240 110Kg/D	30 3.7Kg/D	5 2Kg/D

COD is in accordance with Mn method. N-H means n-Hexane extract (animal & vegetable oil)
T-N means total nitrogen. T-P means total phosphorus.

Effluent standards

		Raw water	Treated water	(National uniform standards)	(Prefectural stringent standards)
Wastewater volume (m^3/D)		460			
pH			5.9 ~ 8.6	5.8 ~ 8.6	5.8 ~ 8.6
BOD	mg/l	1,230	10	160	25 ~ 80
COD	mg/l	620			
SS	mg/l	590	10	200	50 ~ 120
N-H	mg/l	240	3	30	
T-N	mg/l	30			
T-F	mg/l	5			
Coliform (pcs/cc)			3,000	3,000	3,000

Prefectural standards differ according to industrial category. Quality of treated water (design standards) is in accordance with the municipal guidelines reflecting the projection of future intensification of restriction.

(h) Wastewater treatment facility

Original wastewater discharged from each factory by gravity fall flows into the pump tank. Then the wastewater is pumped by the lift pump and foreign substances in the wastewater are removed by the screen and transferred to oil mist separator.

In the oil mist separator tank oil contained in wastewater is removed by gravity separation and is stored in the waste oil tank.

In the flow regulation tank the volume and quality of water is made uniform for the subsequent treatment process and pH adjustment is done in the neutralization tank.

Aeration tank is divided into many stages and in each tank the treatment is performed under the standard activated sludge process and organic substance contained in the original wastewater is treated and at the same time conversion to biotic body is done. In the next sedimentation tank sludge content in wastewater is sedimented and separated and thereafter, a part of sludge is returned to the aeration tank and stored in the sludge storage tank.

Supernatant in the sedimentation tank is further provided with an advanced biological treatment in the biological filtration tank and after it is sterilized via relay tank, it is discharged. In the biological filtration tank back washing by the air is periodically done so that proliferated sludge adhered to the filter medium is sedimented after separation and it is pumped back to the flow regulation tank by sludge pump. At the air back-washing in the biological tank, wastewater is fed through filtration tower where SS content in wastewater is eliminated, and then discharged after sterilization.

Excess sludge is mixed with high molecular (polymer) coagulant in the sludge reaction tank and treated to become 85 % or less in its water contents.

(i) Specifications of wastewater treatment facility (Volumetric calculation and specification)

1. Pump tank 18 m^3(4000mmW×3000mmL×5900mmH (Effective water level 1500mmH) 1 unit

Hourly maximum displacement to be stored for 10 min. Capacity 84 m^3/Hr×10/60=14 m^3

1-1 Lift pump submersible waste pump 100 mmΦ×1.4 m^3/min ×5.5W 2 units (1 unit as standby)

1-2 Screen slit 1mm sewage wire screen, High pressure cleaning device with 1.5 KW (1800mm×1200mm×85 m^3/min, stainless) 1 unit

2. Oil mist separation tank 54 m^3 (1650mmW × 7500 mmL × 4900 mmH,SRC) 1 unit

Hourly maximum displacement to be stored for 30 min. 84m^3/Hr×30/60=42m^3

2-1 Floating oil discharge pump , Air lift pump

2-2 Waste oil tank 2m^3 steel tank 1 unit

2-3 Diffuser for prevention of putrefaction 1 set

2-4 Exhaust fan for ventilation and offensive odor 1 unit

3. Flow regulation tank 278 m^3 (7500mmW ×9700 mmL × 4900mmH, SRC) 1 unit

Wastewater flowing in 10 hours a day is stored and treated within 24 hours.

460 m^3/day ×(24-10)/24 = 258.4 m^3 or more

Aeration volume for agitation and putrefaction prevention is to be 0.017 m^3/min per 1 m^3

268.4 × 0.017 m^3/ = 4.6 m^3/min , pump capacity 460 m^3/day÷24÷60 = 0.32 m^3/min

3-1 Regulation tank pump, submersible sludge pump 65mmΦ×0.4m^3/min×1.5KW 2 units (1 unit as standby)

3-2 Regulation tank blower , roots blower 100mmΦ×4.77m^3/min×45m×7.5KW 1 unit

3-3 Diffuser disk type diffuser, neoprene 1 set

3-4 Measuring tank weir system flow regulation polyvinyl chloride 1 unit

4. Neutralization tank 10.5m^3 (2500mmW × 1500mmL × 3400mmH, SRC) 1 unit
   Water for treatment is stored for 30 min. 0.32m^3/min × 30=9.6m^3
   4-1 Sulfuric acid tank 0.5 m^3 polyvinyl chloride 1 unit
   4-2 Sulfuric acid pump diaphragm pump 0 ~80CC/min × 0.1KW 1 unit
   4-3 Agitator disk type diffuser device neoprene 1 unit
   4-4 pH indicating regulator 1 set

5. Aeration tank 1135m^3 (11300mmW × 24900mmL × 4900mmH, SRC) divided into 8 sections 1 unit
   Flowing-in BOD load 460m^3/day × 1,230ppm=565.8Kg/day (566Kg/day)
   Tank volume shall be based on the condition the BOD volumetric load is 0.5KgBOD/m^3/day
   565.8KgBOD/day ÷ 0.5KgBOD/m^3 day=1131.6m^3
   Air volume for aeration shall be 80m^3 per BOD Kg
   565.8 Kg BOD/day × 80/Kg BOD =45,264m^3/day=31.5m^3/min.
   Volume of sludge to be returned shall be 100% the displacement.
   460m^3/day × 1=460m^3 m^3/day
   Aeration time 1131.6m^3 (460m^3/24Hr × (1+1))=29.5 hours
   BOD-SS load Supposing MLSS concentration in aeration tank is 3,000ppm,
   565.8KgBOD/day ÷ (1131.6m^3 × 3,000ppm) =0.17KgBOD/KgSSday
   5-1 Aeration tank blower roots blower 150mm Φ × 18.1m^3/min × 45m × 22Kw 2 units
   5-2 Diffuser disk type diffuser neoprene 1 set
   5-3 Defoaming device nozzle spray type polyvinyl chloride

6. Sedimentation tank 121m^3 (5800mm Φ × 3600mmH, SRC) 1 unit
   To be capable of storing displacement for 4 hours, 460m^3/day × 4 ÷ 24 =76.3m^3
   Water level area load is to be 18m^3/m^2 · day. 460m^3/day ÷ 18m^3/m^2 · day=25.6m^2
   Overflowing weir load is to be 50m^3/m day. 460m^3/day ÷ 50m^3/m day =9.2m
   6-1 Sludge scraping device bridge suspension type central drive rake system, steel, gear reducer
   6-2 Equalizer 1 set
   6-3 Overflowing weir device 1 set
   6-4 Sludge return air lift pump 1 set
   6-5 Floating scum separation device 1 set
   6-6 Sludge measuring tank for return sludge flow regulation polyvinyl weir system 1 set

7. Biological filtration tank 24m^3(2700mmW × 2500mmL × 4900mmH, bottom pyramid, SRC)
   To be capable of contact with displacement for filter media filling volume for 1 hour.
   460m^3/day ÷ 24 =19.2m^3 (2.7mW × 2.5m × 2.9m=19.6m^3)
   Circulation water volume Velocity inside filter media shall be 0.12m/min.
   2.7m × 2.5m × 0.12m/min =0.81m^3/min
   Volume for circulation air shall be 1.3 times the volume of circulation water.
   0.81m^3/min × 1,3 = 1.06 m^3/min
   Volume of air for back-washing shall be 0.4 m^3/min. 2.7m × 2.5m × 0.4 m^3/min = 2.7 m^3/min

7-1 Filter media 45mm × 55mm × 70mm polyethylene, 19.6m^3, specific area 140m^2/m^3
7-2 Air piping for circulation and agitation 1 set
7-3 Air piping for back-washing 1 set

8. Sludge pump tank 5m^3 (1000mmW × 1400mmL × 4900mmH, SRC)
8-1 Sludge pump 100mm Φ × 1.3m^3/min × 3.7Kw 1 set

9. Intermediate tank 33m^3 (1400mmW × 6000mmL × 4900mmH, SRC) 1 unit

To be capable of storing displacement for 1 hour and ensuring volume of general service water and water for back-washing of filtration tower.
460m^3/day × 1 ÷ 24 = 19.2m^3, back-washing water volume 12m^3
Filtration pump capacity 460m^3/day × 1 ÷ 24 = 0.32m^3/day
9-1 Filtration pump submersible pump 65mm Φ × 0.4m^3/min × 1.5Kw 2 units
(1 unit as standby)
9-2 Defoaming pump submersible pump 65mm Φ × 0.4m^3/min × 1.5Kw 1 unit

10. Filtration tower (1300 mm Φ × 3600mmH) 1unit
Filtration speed shall be 15m/Hr.
Filtration are a 460m^3/day ÷ 24Hr ÷ 15m/Hr = 1.28m^2
Filtration tower (filtration area 1.327m^2 × effective 3m), Filter media 1.33m^3
Back-washing water volume To be 3 times the volume of filtration tank.
1.3m Φ × 3m × 3 = 12 m^3/time
Back-washing air volume based on 2m^3/m^2min, 1.327m^2 × 2 = 2.66m^3/min
Collected SS volume To be 4kg per filter media 1m^3. 4kgSS/m^3 × 1.33m^3 = 5.32kgSS
Back-washing interval 460m^3/day × (10-2)ppm ÷ 5.32kgSS/time = 0.7time/day

11. Sterilizing tank 6m^3 (1400mmW × 1400mmL × 4900mmH, SRC) 1 unit
To be capable of storing displacement for 15 min. 460m^3/day ÷ 24 × 15/60 = 4.8 m^3
If volume of chlorine to be injected is 5ppm, 460 m^3 × 5ppm = 2.3/day
Effective volume of chlorine for calcium hypochlorite is 70 %
2.3kg/day ÷ 0.7=3.3kg/day
11-1 Sterilizer pellet injection system

12. Sludge storage tank 34 (2700mmW × 3000mmL × 4900mmH, SRC) 1 unit
Excess sludge generation volume 30 % the BOD load shall be converted into SS
565.8 kgBOD/day × 0.3 = 169.74kgss/day
On condition sludge concentration is 1 %, 169.74kgss/day ÷ 0.01 = 17m^3/day
Tank volume To be capable of storing sludge for 2 days 17m^3/day × 2 = 34m^3
12-1 Diffuser for prevention of putrefaction polyvinyl chloride pipe
12-2 Sludge pump roots pump with no stage gearing device
50mm Φ × 50 l/min × 1.5kw 2 units

13. Dehydrator filter cloth traveling suction system,
volume to be treated 2200L/Hr, width of filter cloth 1200mm,
Filter speed 2.17.1 m/min, volume of cleaning water 40 L/min.
Treatment capacity Operation time is to be 8 hours/day
169.74kgss/day ÷ 8 Hr/day = 21.2kg · Hr (= 2.12m^3/Hr)

Dehydrated cake generation volume　Water content is to be 85 %
169.74kgss/day × 100/(100-85) = 1,132kgss/day = 1,132m^3/day

13-1 Sludge measuring tank for regulation of sludge flow, polyvinyl chloride weir type 1 unit

13-2 Sludge reaction tank 250L (750mm × 750mm × 600mmH steel,with agitator) 1 unit
To be capable of storing treatment sludge volume for 5 min,
2.12m^2/Hr × 5/60 = 0.18m^3

13-3 Dehydration agent tank (1800mm × 1800mm × 1500mmH, steel,with agitator) 1 unit
On condition dried sludge is injected by 1 %. 169.74kgss/day × 0.01 = 1.7kg/day

13-4 Dehydration auxiliary pump　diaphragm pump 0 ~ 8 l/min × 50m × 0.4kg 1 unit

13-5 Suction blower　1 m^3/min × 450mmAq × 0.75kw 1 unit

13-6 Filter cloth cleaning pump 25mm Φ × 40 l/day × 30m × 1.5kw 2 units (1 unit as standby)

14. Cake hopper　3.4 m^3 hopper made by steel with paying-off device
To be capable of storing cake generation volume for 3 days. 1.13/day × = 3.4m^3

14-1 Cake conveyor　belt conveyor 0.75kw 1 unit

15. Power control panel 1 panel with graphic panel

16. Power receiving and transforming equipment　outdoor self-standing type 85KVA 1 unit

17. Blower chamber　30m^2 SRC

18 Management room　20m^2 SRC

19. Dehydrator chamber　70m^2 SRC

(j) Condition after completion of facility

With regard to the condition of wastewater after several year's operation is as follows: volume is 350 ~ 400m^3/day which is approx. 80 % the planned value; Concentration of BOD in wastewater is 0 ~ 4000(fluctuates daily) and on average 2,000ppm which is approx. 1.6 times the planned value, and sludge load is 1.3 times the planned value; pH is 4 ~ 12 (fluctuates daily); but it becomes neutral on average and thus, neutralization treatment is not required; Quality of treated water is less than the standards; Volume of cake generated in sludge dehydration is approx. 10 m^3 daily, which is approx. 55 % the planned value, considering the pollutant load; Since dehydrate cake does not contain heavy metal and harmful substances and thus, it can be utilized as fertilizer material.

Gold fish are raised in sedimentation tank and biological filtration tank. This fact verifies the wastewater is not harmful and treatment given is adequate.

(k) Cost for maintenance and management

Monthly cost directly incurred for the treatment amounted to 1,183,000 yen, making daily average approx. 40,000 yen. It equals to 90 ~ 115 yen for each 1 m^3 wastewater, and approx. 55 ~ 70 yen for each 1 kg of BOD pollutant load. Taking into account the depreciation cost for the waste-eater treatment facility, approx. 10,000 yen is daily added and cost needed for treatment amounted to 110 ~ 145 yen for each wastewater 1 m^3 and approx. 65 ~ 90 yen for each 1 kg BOD pollutant load.

(Treatment cost in one month = Electricity 530,000 yen + Service water 3,000 yen + Chemicals 100,000 yen + Sludge disposal 120,000 + Consumables and repair 60,000 yen + Labor cost 370,000 yen)

(1) Allocation of installation and O & M cost on wastewater treatment facility

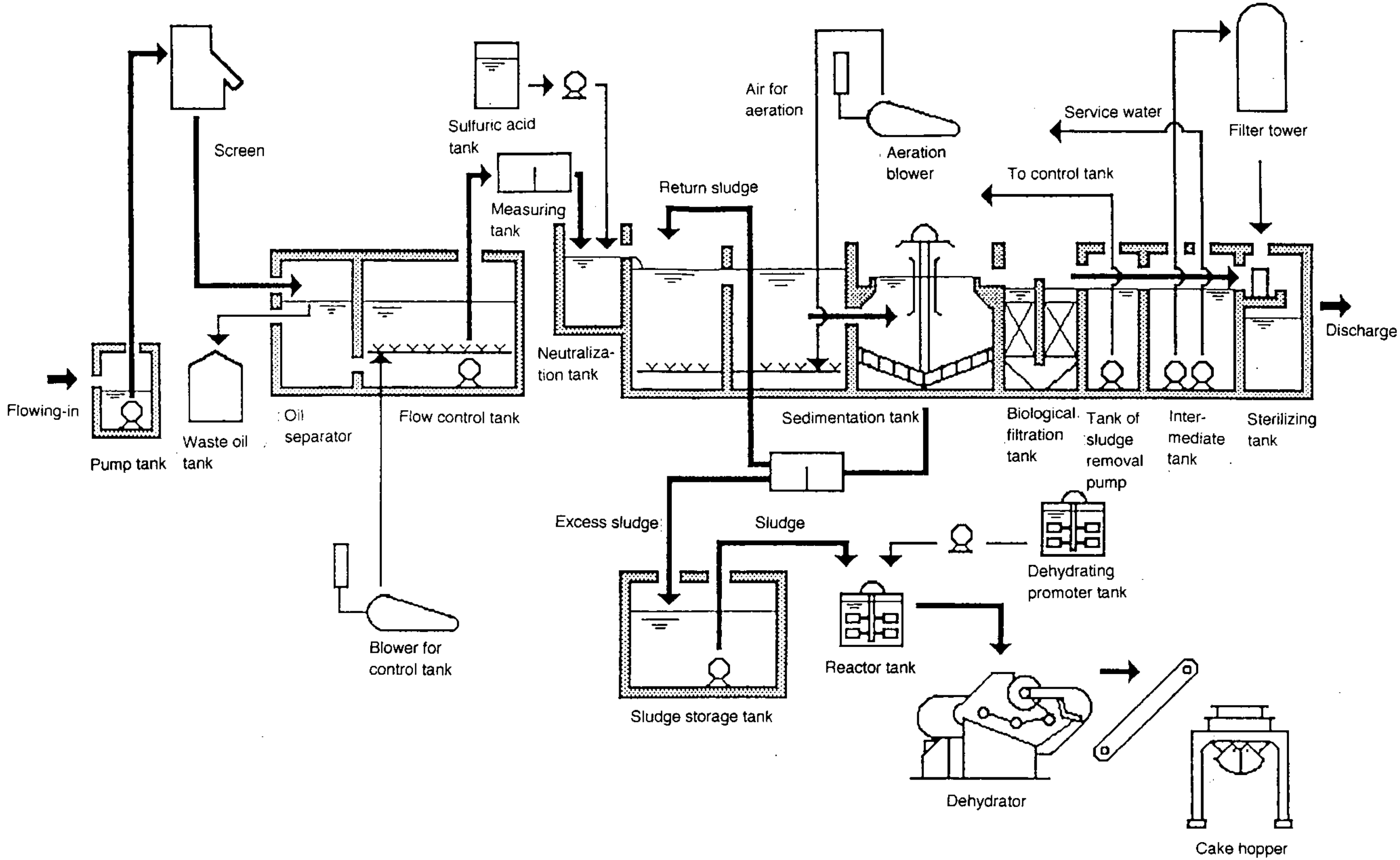
Construction cost (initial cost) was shared by union members as follows:

Land and building owned by each company ; To be borne by each company.

Road, utility land, and equipment, land for joint wastewater treatment facility ;
To be borne by each company equally.

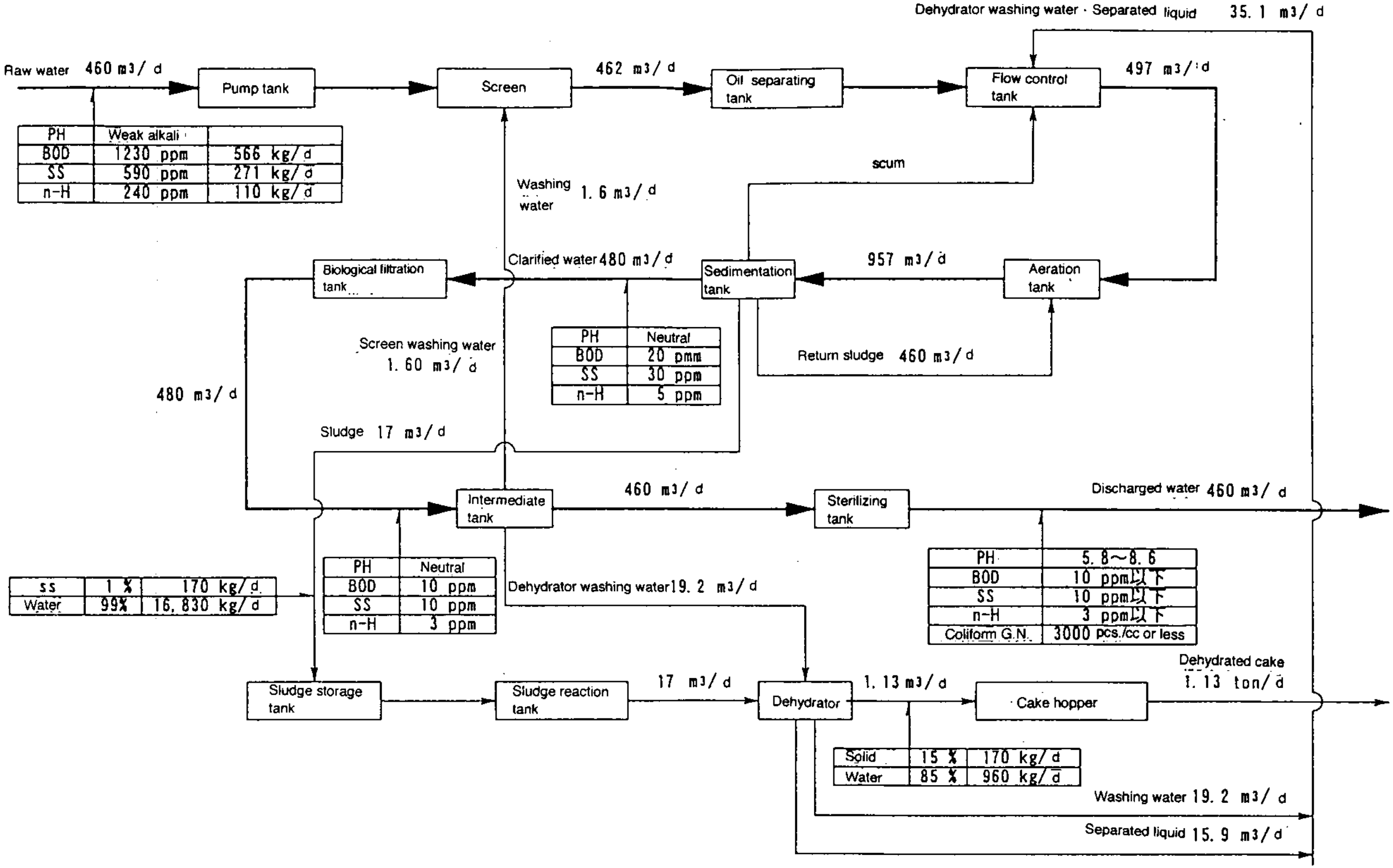
Joint wastewater treatment facility ; 1/2 cost to be shared by the proportion of wastewater volume.
1/2 cost to be shared by the proportion of BOD load.

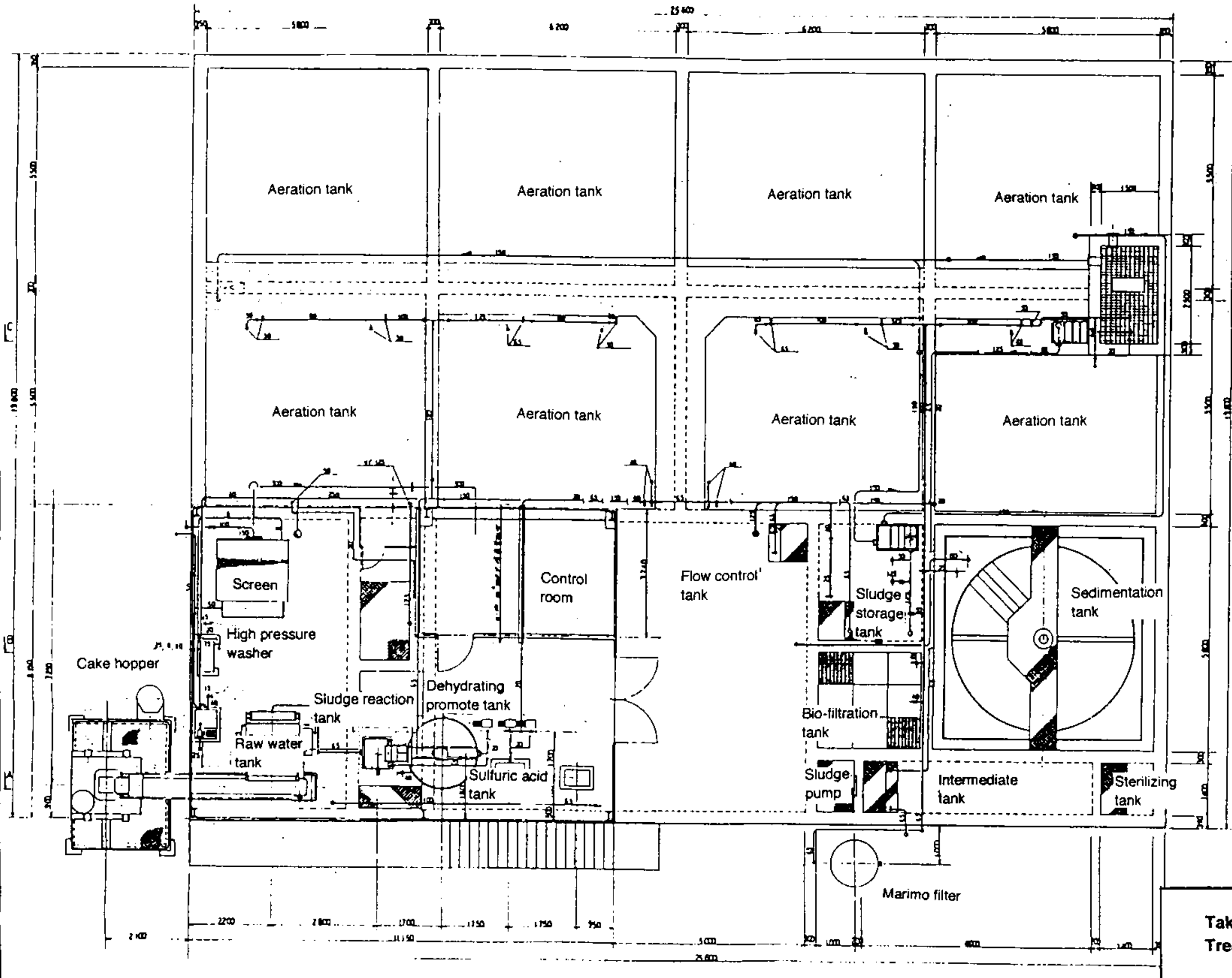
Monthly costs incurred for operation management, operation and facility maintenance (running cost) are shared as follows;
1/2 to be shared by the proportion of wastewater volume.
1/2 to be shared by the proportion of BOD load.



〈 Treating Process Flow Sheet 〉

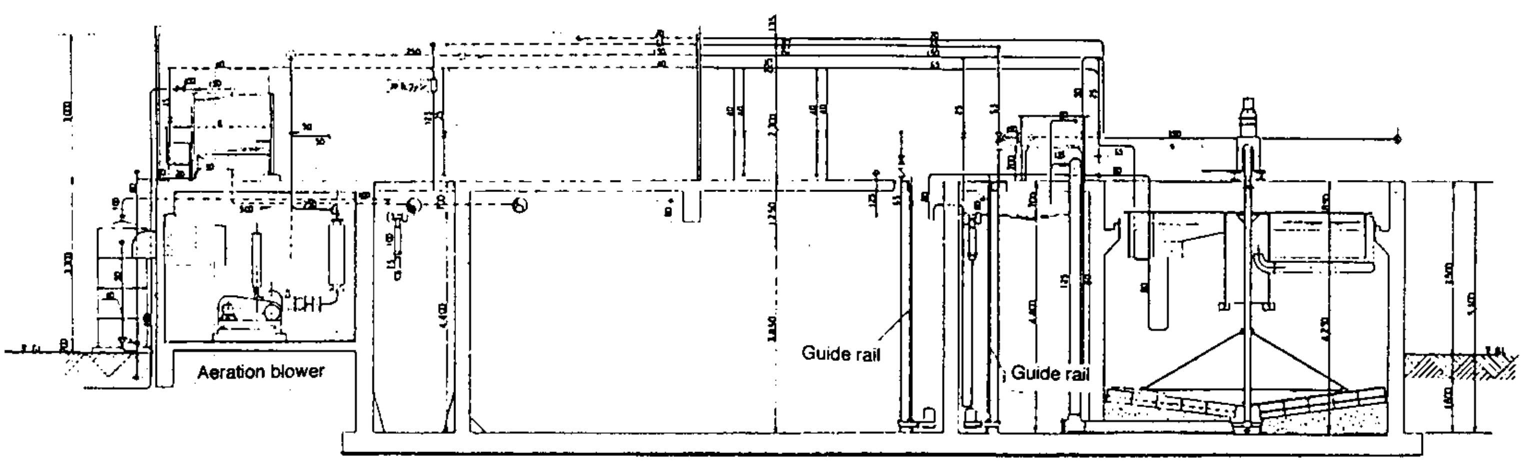
Material Balance Sheet



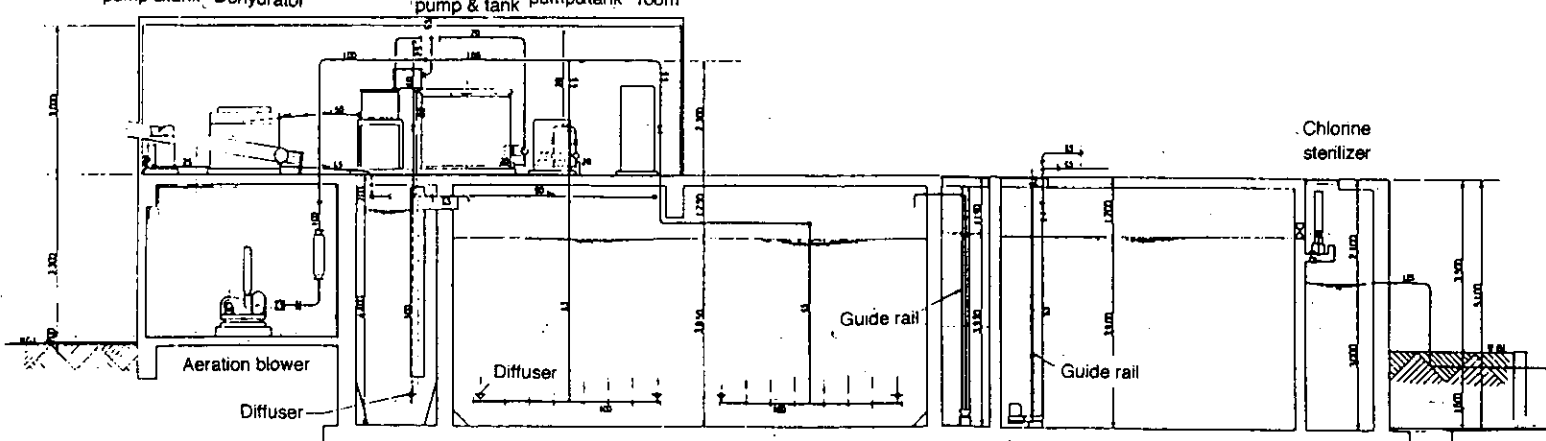


Takasaki Foods Joint Wastewater Treatment Facility

Layout



[B — B Cross Section]



[A — A Cross Section]

Takasaki Foods Joint Wastewater Treatment Facility

Cross Section

6.2 Cases of the Loan Program by JEC

6.2.1 Cases relating to the Dyeing Finishing Industry

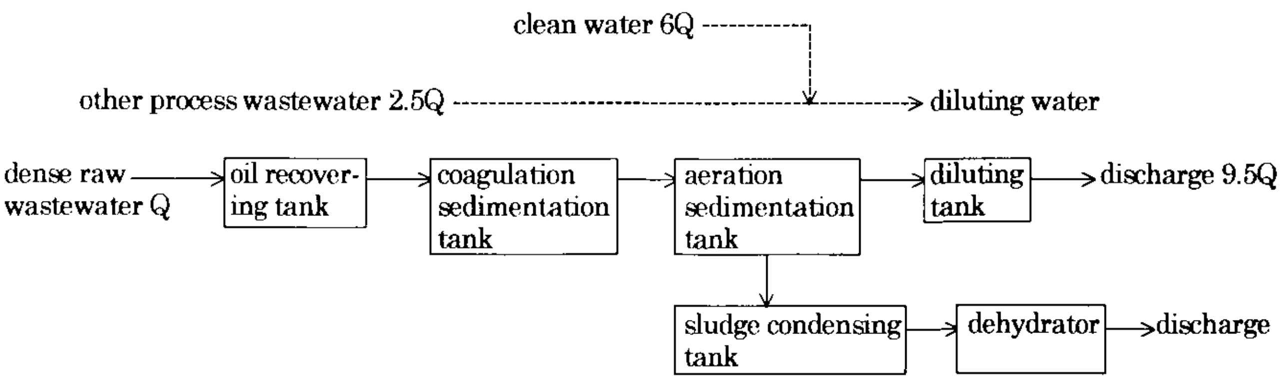
(1) Improvement of a treatment facility for oil-containing, high concentration, organic wastewater by adding coagulation and sedimentation process (1969)

Since wool scouring wastewater is highly concentrated (BOD 8,000mg/l, SS 3,000mg/l, oil 7,500mg/l), it was conventionally discharged after lime was charged and coagulation sedimentation treatment was processed. However, to meet the revised effluent standards, the treatment facility was upgraded by adding coagulation and sedimentation equipment as well as increasing the diluting water.

Main product and production scale	Wool top, synthetic fiber top, greasy wool Sales output: 1,403 million yen/year
Improved facility and reason for improvement	● Wool scouring wastewater treatment facilities Wastewater amount : 87m^3/d (treating water 20m^3/d + diluting water 67m^3/d (other process wastewater) Wastewater treatment facilities is improved to cope with the revised wastewater standards.
Content of improvement (Capacity, effect)	● Coagulation and sedimentation equipment is installed before existing lime charging and aeration equipment and the amount of diluting water is increased. ● Effluent water 20m^3/d is diluted with other process wastewater 67m^3/d and clean water 120m^3/d. Effluent water quality: BOD 115mg/l, SS 105mg/l, oil content 23mg/l
Improvement cost (Fund source)	50 million yen (JEC 77.7%, other loan 0.0%, own fund 22.3%)
Content of work (Cost ratio)	Wastewater treatment facility (34.1%) Sludge dehydrator (33.9%, other (32.0%)
Maintenance control cost	98 yen/m^3 (chemical 32 yen, power 19 yen, dehydration 47 yen)

※ Wastewater quality standards before revision : BOD 740mg/l, SS 390mg/l, oil 500 mg/l
※ Revised wastewater quality standards :BOD 120mg/l, SS 120mg/l, oil 30mg/l

◇ Treatment flow after improvement



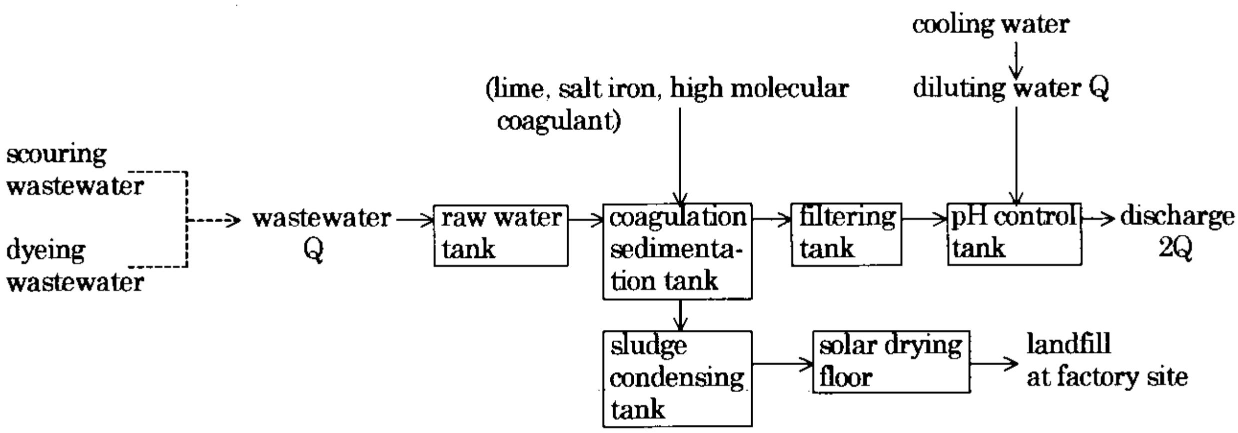
(2) Installation of coagulation and sedimentation equipment to improve treatment for oil-containing wastewater (1971)

Wastewater from scouring and dyeing process was conventionally diluted with cooling water and discharged after sedimentation. However, it became unable to meet the effluent standards regulated by the municipality. Therefore, coagulation and sedimentation equipment was provided in accordance with agreement with the municipality and Water Service Union.

Main product and production scale	Dyeing product Sales output : 72 million yen/year
Improved facility and reason for improvement	● Sedimentation treating tank for carpet dyeing wastewater Effluent amount :2,110m³/d Improvement of treatment equipment to cope with effluent standards set by the municipale Corperation Treated water quality before improvement: pH 9.6, BOD 120 mg/l, SS 30mg/l oil 50mg/l, phenol 0.15 mg/l
Content of improvement (capacity, effect)	● Installation of coagulation and sedimentation equipment (dilution with cooling water is executed unchanged) Treatment capacity 450 m³/d Treated water quality: pH 5.8 ~8.6, BOD 60mg/l, SS 10 mg/l, oil 10mg/l
Improvement cost (Fund source)	38 million yen (JEC 80.0%, other loan 18.5%, own fund 1.5%)
Work content (Cost ratio)	Coagulation and sedimentation equipment (54.7%) Foundation work (42.4%) , Electric work (2.9%)
Maintenance control cost	Unknown

※ Effluent standards set by the Municipality.:
pH 5.8~8.6, BOD 100mg/l, SS 80mg/l, oil 10 mg/l, phenol 0.5mg/l

◇ Treatment flow after improvement



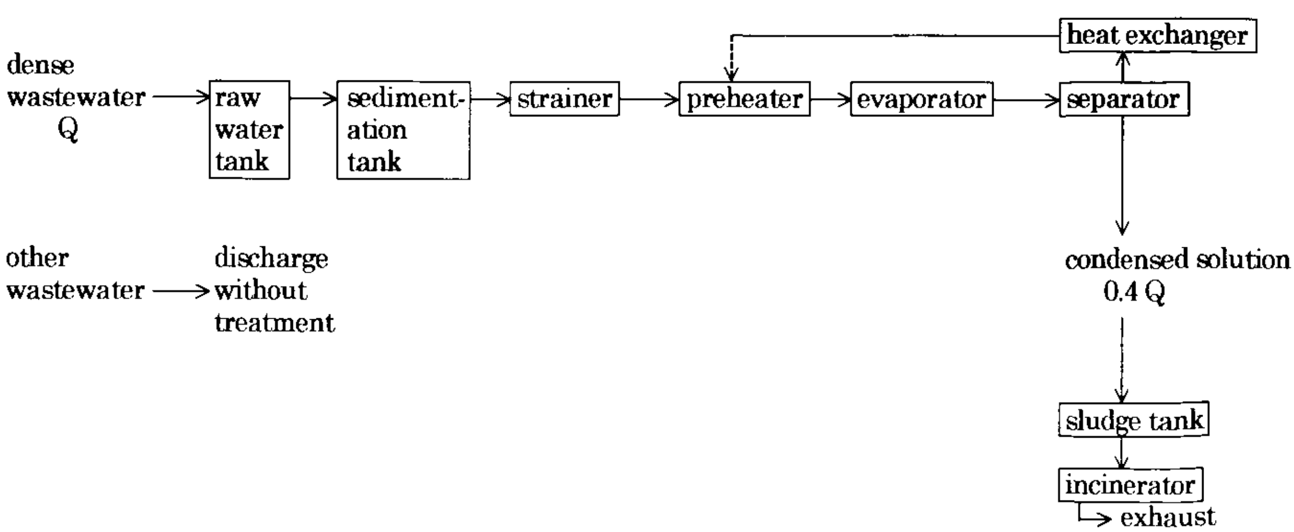
(3) Installation of the treatment equipment for oil-containing, dense organic wastewater (1972)

Wastewater from wool scouring process was conventionally discharged by merely diluting by other wastewater due to high BOD, SS, oil content. However, the company became unable to observe the wastewater standards set under the Water Pollution Control Law. Therefore, the dense wastewater was separately collected, condensed by evaporation, and finally disposed of by incineration. Separation of dense wastewater allowed other wastewater to discharge without treatment.

Main product and production scale	Woolen fabric, wool top, top processed product, weaving yarn Sales output: 1,634 million yen/year
Improved facility and reason for improvement	● Wool scouring wastewater treatment equipment (dilution) Effluent amount : 1,600m³/d (raw water 240 is diluted) ● Improvement for observing wastewater standards Effluent quality before improvement pH7.0 to 7.5, BOD 180 mg/l, SS 490 mg/l, oil 260 mg/l
Content of improvement (Capacity, effect)	● Installation of condensation incineration equipment for dense wastewater. Effluent quality after separation of dense wastewater : pH 7.0 ~ 7.2, BOD 20mg/l, SS 50mg/l, oil 25 mg/l
Improvement cost (Fund source)	33 million yen (JEC 43.0%, other loan 46.1%, own fund 10.9%)
Content of work (Cost ratio)	Evaporation condensing equipment for wool scouring, waste solution(84.6%), in-plant wastewater piping work (15.4%)
Maintenance control cost	205,000 yen/month (power cost 50 yen, fuel cost 155 yen)

※ Water quality standards under Water Pollution Control Law::
pH 5.8 to 8.6, BOD 100 mg/l, SS 150mg/l, oil 30 mg/l

◇ Treatment flow after improvement

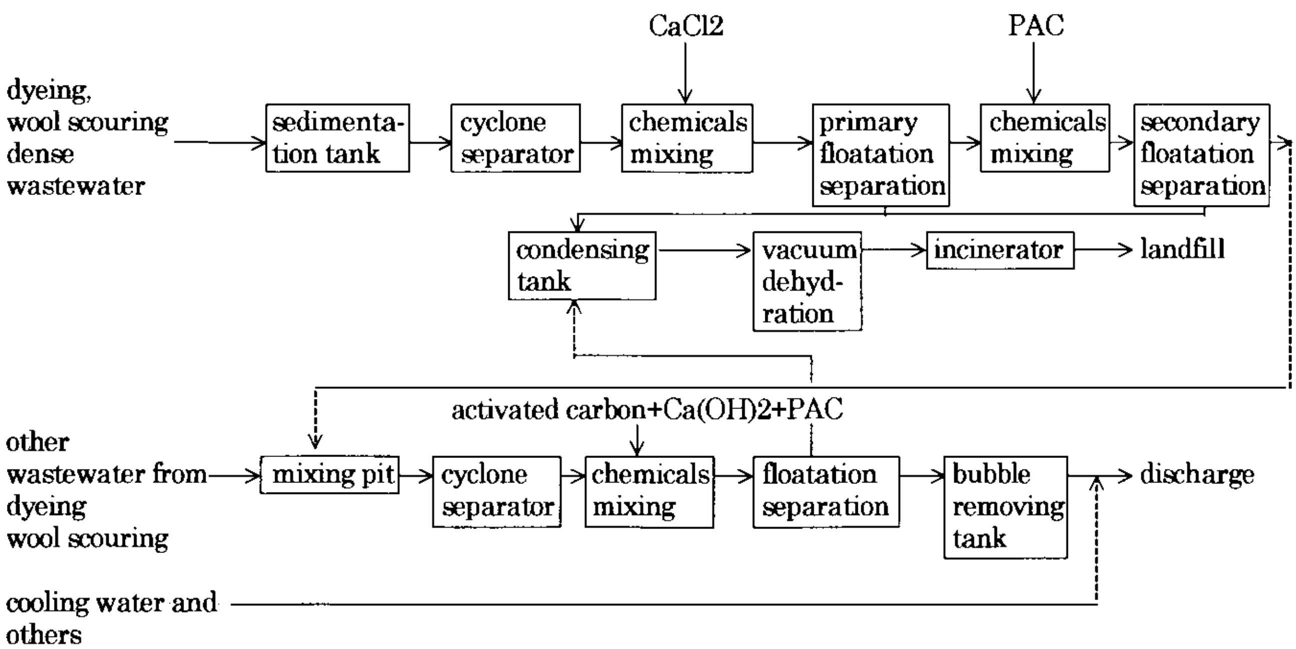


(4) Installation of pressure floatation and separation equipment to improve water quality for wool scouring and dyeing wastewater (1972)

Wastewater in wool scouring and dyeing process was conventionally diluted with cooling water.. However, to meet revised effluent standards, the dense wastewater was separately collected and the pressure floatation and separation equipment was installed.

Main product and production scale	Wool top, top processed product Sales output: 1,037 million yen/year
Improved facility and reason for improvement	● Wool scouring and dyeing process Effluent amount : 3,100m^3/d Effluent quality : pH7.1, BOD 425 mg/l, SS 476 mg/l, oil 148 mg/l ● The company failed to meet the effluent standards.
Content of improvement (Capacity, effect)	● Installation of cyclone solid liquid separation equipment and coagulation pressure separation equipment Effluent water quality: pH 7.5~8.5, BOD 93mg/l, SS 35mg/l
Improvement cost (Fund source)	88 million yen (JEC 68.4%, other loan 30.8%, own fund 0.8%)
Content of work (Cost ratio)	Effluent water treatment equipment (62.5%), civil engineering work (22.1%), piping work (2.6%), electric work (2.6%), other (8.6%)
Maintenance control cost	3.060,000 yen/month (chemical cost 920,000 yen, waste treatment cost 153,000 yen, electric power cost 210,000 yen, interest and redemption cost 1,427,000 yen, other 350,000 yen

◇ Treatment flow after improvement



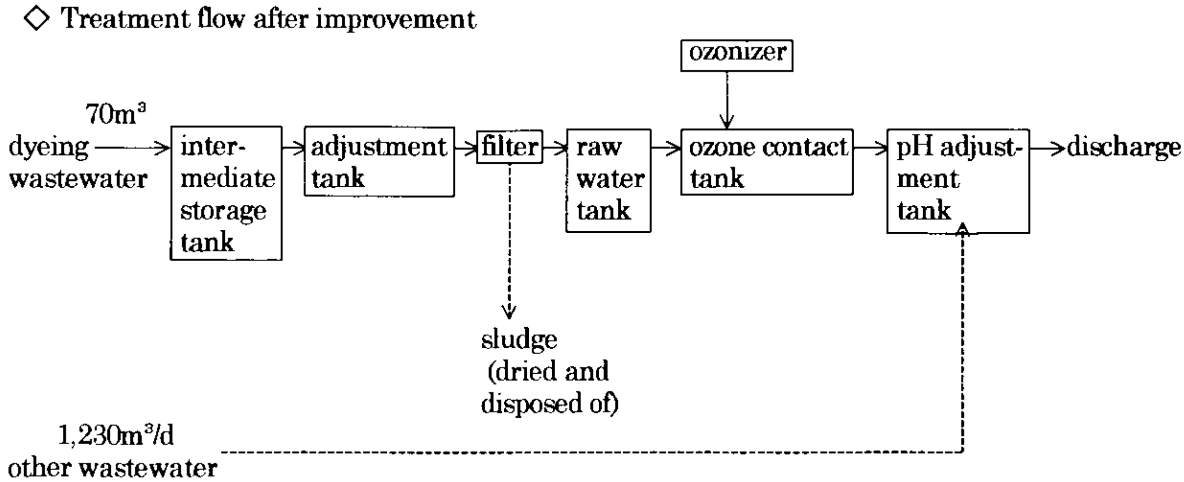
(5) Installation of ozonation equipment for the treatment of colored effluent from dyeing factory wastewater

To treat wastewater from dyeing process is colored and BOD is high, ozonation oxidization decoloring equipment was installed following the administrative guidance. Upon this occasion, separate piping for dyeing wastewater and other wastewater was provided in the plant, for the purpose of reduction of load to the ozonation treating equipment.

Main product and production scale	Coloring of cotton, Tetron cotton mix spinning, long fiber dyeing, bleachings Sales output: 520 million yen/year
Improved facility and reason for improvement	● Drain from dyeing and bleaching process Effluent amount : 1,300m³/d Effluent quality : pH8 ~10, BOD 70~200 mg/l, SS 70 ~ 200 mg/l Guidance isssued by the Muncipality for improvement of wastewater treatment. (decoloring)
Content of improvement (Capacity, effect)	● Installation of ozonation oxidization decoloring equipment to treat dyeing wastewater Effluent quality: pH 7~8, BOD 120mg/l or less, SS 150mg/l or less, light yellow
Improvement cost (fund source) (Fund source)	44 million yen (JEC 79.5%, other loan 0.0%, own fund 20.5%)
Content of work (Cost ratio)	Ozone decoloring equipment (60.0%), raw water tank (11.7%) piping work (9.5%), electric work (12.0%), affluent water conduit work (6.8%)
Maintenance control cost	20.000 yen/day

※ Effluent standards by Municipality
pH 5.8 ~ 8.6, BOD 120 mg/l or less, SS 150 mg/l or less, no abnormal coloring allowed

◇ Treatment flow after improvement



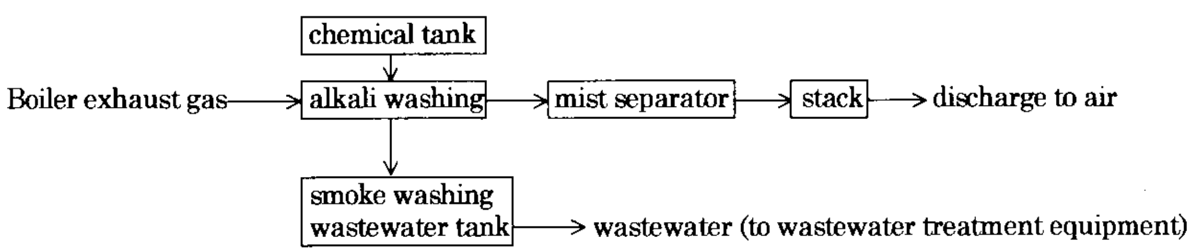
(6) Installation of flue gas desulfurization equipment to reduce sulfur oxide in exhaust gas

At the time of renewal of boiler in dyeing and finishing plant, flue gas desulfurization equipment was installed following the administrative guidance for controlling sulfuric oxide exhaust gas.

Main product and production scale	Coloring of synthetic fiber, cotton fiber, and finishing Sales output: 1,617 million yen/year
Improved facility and reason for improvement	3 boilers Exhaust gas amount: 31,040 m^3/d K value calculated from Sox exhaust gas amount : 14.685 ● Administrative guidance from Municipality for observation of SOx emission standards.
Content of improvement (Capacity, effect)	● Exhaust gas from three boilers was collected and processed at flue gas desulfurization equipment and then exhuasted through existing stack. K value calculated from SOx emission after improvement: 3.486
Improvement cost (fund source) (Fund source)	48 million yen (JEC 79.9%, other loan 0.0%, own fund 20.1%)
Content of work (Cost ratio)	Flue gas desulfurization equipment (80.4%), waste solution tank (13.9%), foundation work (2.4%) , electric work (3.3%)
Maintenance control cost	only power cost

※ SOx emission standard under the Air Pollution Control Law :
K value 14.6 (for each boiler and centralized smoke stack)

◇ Treatment flow after improvement



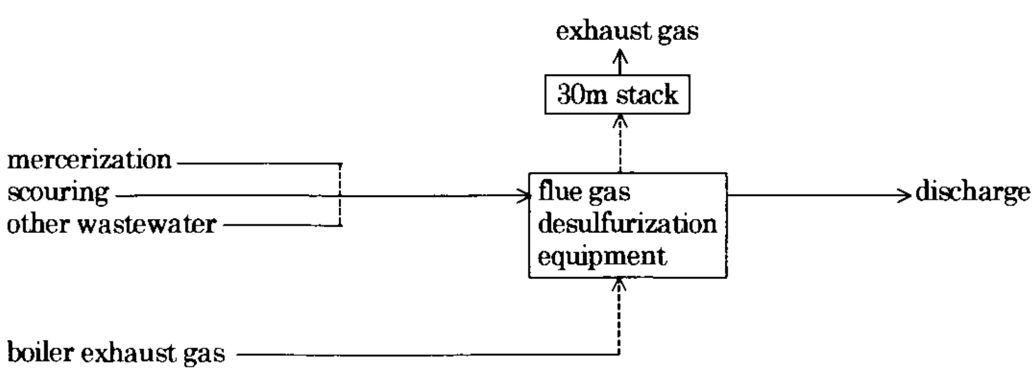
(7) Installation of flue gas desulfurization equipment and high alkali wastewater treatment equipment in order to meet the effluent standards and regulations against sulfur oxides in exhaust gas forthcoming in the near future (1971)

Since the quality of high alkali dyeing wastewater exceeds the wastewater standard values, neutralization treatment was needed. Furthermore, the regulations against sulfur oxide in exhaust gas from existing boilers was forthcoming. From such point of view, high alkali wastewater was utilized as washing agent for flue gas desulfurization, and the wastewater was neutralized.

Main product and production scale	dyeing product such as roller textile printing, automatic screen textile printing Sales output: 2,232 million yen/year
Improved facility and reason for improvement	● Wastewater and waste gas from textile printer, mercerization machine, boiler etc. Wastewater amount: 4,000m^3/d Wastewater quality: pH 10.1 to 10.5 Sulfur oxide emission :64m^3-N/h ● Observation of pH standard and regulation relating to boiler exhaust gas sulfur oxide.
Content of improvement (Capacity, effect)	● Installation of flue gas desulfurization equipment where high alkali wastewater is used as washing agent. Treating water quality: pH 7 to 8.6 Exhaust gas sulfur oxide 30m^3/h
Improvement cost (fund source)	24 million yen (JEC 50.0%, other loan 50.0%, own fund 0.0%)
Content of work (Cost ratio)	Flue gas desulfurization equipment (64.9%), waste solution tank (6.7%), piping work (11.3%), foundation work (2.3%), electric work (14.8%)
Maintenance control cost	Power cost 3,500,000 yen

※ Uniform standard under the Water Pollution Control Law : pH 5.8 ～ 8.6
Exhaust gas standard under the Air Pollution Control Law : sulfur oxides 102m^3-N/h to K value 15.8

◇ Processing flow after improvement



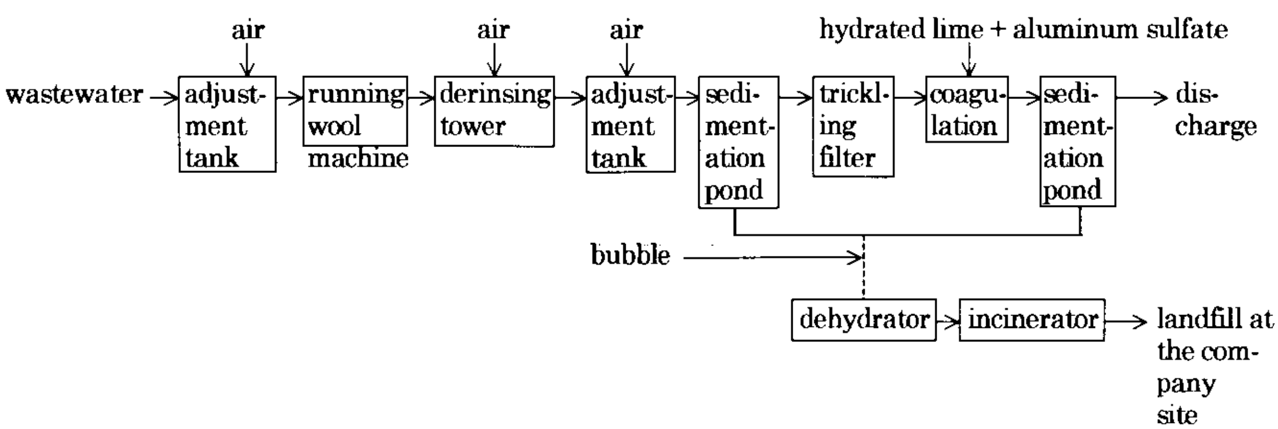
(8) Installation of trickling filter and coagulation, sedimentation equipment at the existing treatment facilities to cope with new wastewater standards for wastewater from washing machine and scouring, milling machine. (1974)

In the manufacturing process of felt for paper making, wastewater was conventionally diluted with ground water and discharged after coagulation and sedimentation treatment. However, to cope with the application of additional wastewater standards, trickling filter and coagulation sedimentation equipment were provided at the existing treatment facilities, to treat the felt manufacturing wastewater, together with wastewater from washing process in order to satisfy the new standard value. The sludge generated is dehydrated, incinerated and land-filled in the company's site.

Main product and production scale	Felt Sales output: 4,486 million yen/year
Improved facility and reason for improvement	● Drain from washing machine, scouring and milling machine Wastewater amount: 1,000m³/d (after diluted) Wastewater quality: pH 6.6 to 8.0, BOD 120mg/l, SS 150mg/l, oil 10mg/l To cope with additional wastewater standards set by Chiba Prefecture.
Content of improvement (Capacity, effect)	● To install trickling filter and coagulation sedimentation process, to treat process wastewater and utility wastewater together. ● Generated sludge is dehydrated and burnt in company.
Improvement cost (fund source)	65 million yen (JEC 49.6%, other loan 0.0%, own fund 50.4%)
Content of work (cost ratio)	Mechanical equipment (54.3%), running wool processing equipment (3.6%), incinerator (2.3%), piping work (4.7%), civil work (33.6%), other (1.5%)
Maintenance control cost	8,656 yen/d (hydrated lime 224 yen, aluminum sulfate 400 yen, iron chloride 432yen, electric power 7,600yen)

※ Use of cooling water was abolished because of regulations relating to ground water pumping. Therefore, the system to meet the standards without dilution.

◇ Treatment flow after improvement

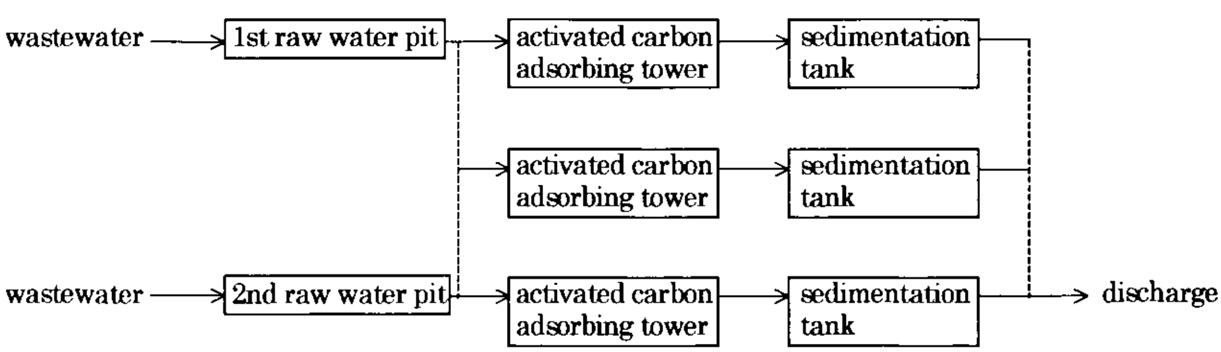


(9) Addition of activated carbon adsorption equipment for decolorization to meet the water quality standards set by the Municipality. (1970)

For observation of the water quality standards set by the Municipality, 10 units of activated carbon adsorbing equipment were installed. However, due to the expansion of the plant, another activated carbon adsorption equipment was installed.

Main product and production scale	Resisted yarn dyeing, resisted yarn bleaching Sales output: 1,712 million yen/year
Improved facility and reason for improvement	● Drain from dyeing machine Wastewater amount: 6,500m^3/d Wastewater quality: pH 6.2, BOD 38mg/l, COD 36mg/l, SS 8mg/l Effluent standards set by the Municipality pH 5.8 to 8.6, BOD 20 mg/l or less, SS 40mg/l or less
Content of improvement (Capacity, effect)	● Installation of another activated carbon adsorption equipment (80m^3/h). Water quality after improvement pH 6.8, BOD 19mg/l, COD 31mg/l, SS 8 mg/l
Improvement cost (fund source)	5 million yen (JEC 77.8%, other loan 0.0%, own fund 22.2%)
Content of work (Cost ratio)	Activated carbon adsorbing equipment (66.7%), piping and pumping work (27.7%), foundation work (5.6%)
Maintenance control cost	10 yen/m^3 for 8 treating water (activated carbon, fuel, labor cost, power cost, redemption) Activated carbon is used by recycling at activated carbon recycling furnace.

◇ Treatment flow after improvement

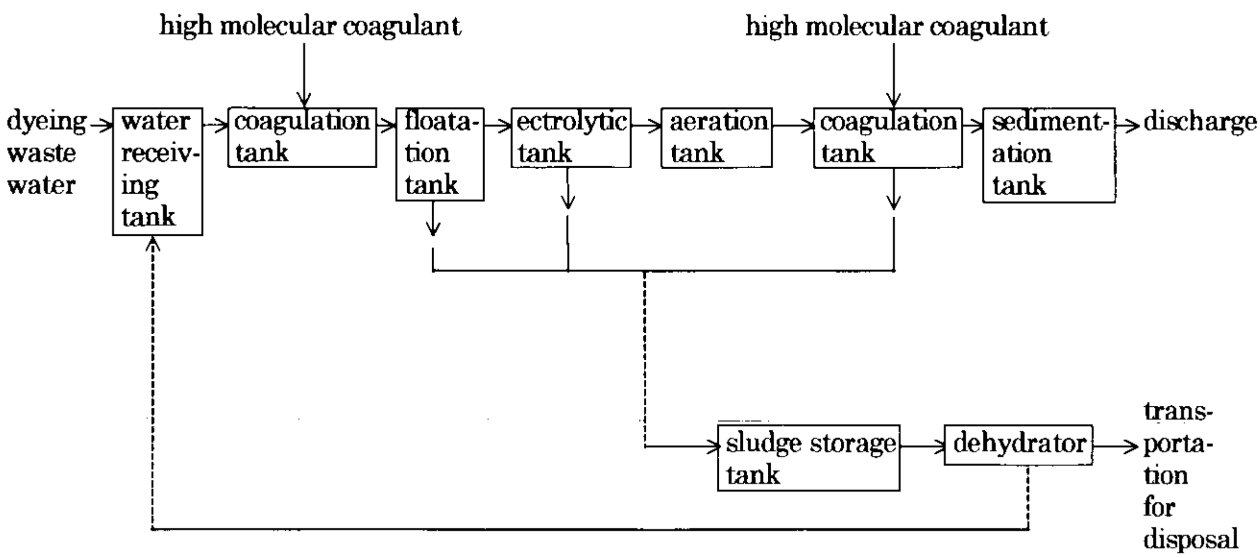


(10) Installation of electrolytic treatment equipment for chromium contained wastewater to cope with revision of effluent standards.(1973)

As the effluent standards were revised to be more stringent, electrolytic treatment equipment was installed for wastewater from dyeing process.

Main product and production scale	Dyeing of cotton, wool, synthetic fiber product Sales output: 187 million yen/year
Improved facility and reason for improvement	● Drain from dyeing process Wastewater amount: 500m³/d Wastewater quality: pH 6.8, BOD 160mg/l, SS 40mg/l, Cr 10mg/l Effluent standards set by Municipality. pH 5.8 ~ 8.6, BOD 80 mg/l, SS 50mg/l, Cr 2mg/l
Content of improvement (Capacity, effect)	● Installation of electrolytic treatment equipment. Water quality after improvement pH 5.8 ~ 8.6, BOD 70mg/l, SS 30 mg/l, Cr 0.2mg/l
Improvement cost (fund source)	27 million yen (JEC 74.08%, other loan 0.0%, own fund 26.0%)
Content of work (Cost ratio)	Electrolytic treatment equipment (93.2%), electric work (6.8%)
Maintenance control cost	15 to 22 yen per treated water 1m³

◇ Treatment flow after improvement



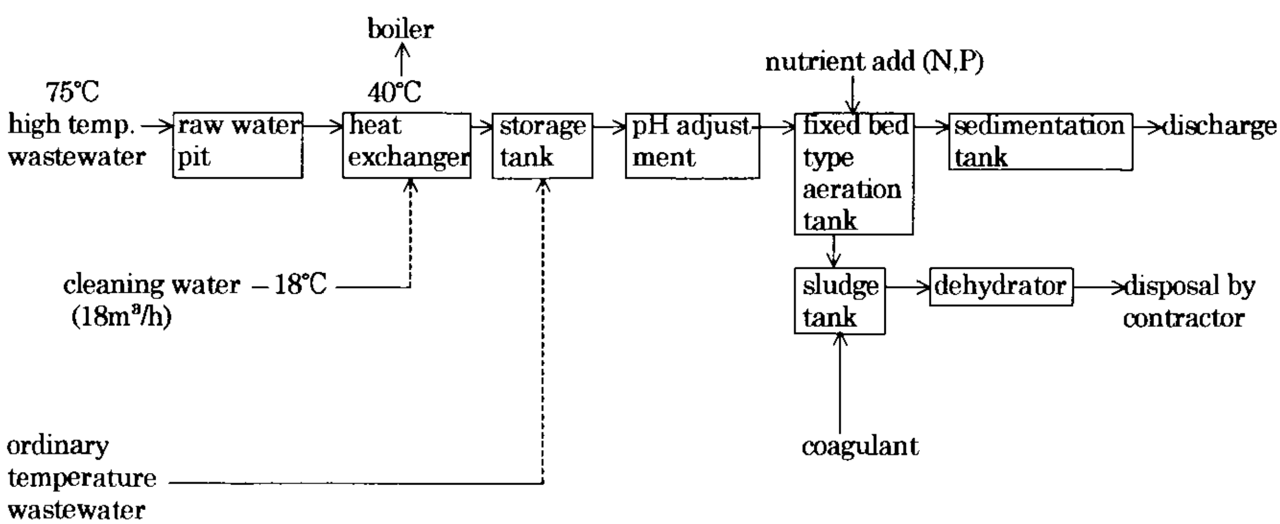
(11) Improvement of wastewater treatment equipment and installation of heat recovery system for energy saving (1979)

Since wastewater from silk and cotton scouring and finishing process had been discharged without treatment, issue was the administrative guidance for improvement. Then, fixed bed type biological treatment equipment was installed. Furthermore, heat exchanger was installed for heat recovery, because the wastewater had high temperature.

Main product and production scale	Nylon ribbon, silk ribbon, cotton ribbon, Sales output: 1,473 million yen/year
Improved facility and reason for improvement	Drain from scouring machine, bleaching machine Wastewater amount: $80m^3/d$ Wastewater quality: pH 6 to 11, BOD 520 to 550mg/l, SS 50mg/l
Content of improvement (Capacity, effect)	● Installation of fixed bed type biological treatment equipment ($240m^3/d$) and installation of heat exchanger.. Water quality after improvement pH 6 to 8, BOD 60mg/l, SS 40 mg/l, Heat recovery from raw water 70°C to 40°C
Improvement cost (fund source)	113 million yen (JEC 70.6%, other loan 17.7%, own fund 11.7%)
Content of work (Cost ratio)	Land purchase cost (21.4%).fixed bed type, biological treatment equipment (15.0%), heat exchanger (4.9%), civil work (48.6%), electric work (10.1%)
Maintenance control cost	4,876,000 yen (power, chemical 2,736 yen, others 2,140 yen)

※ Increase by bout 160m/d of wastewater from nylon scouring process is anticipated.

◇ Treatment flow after improvement



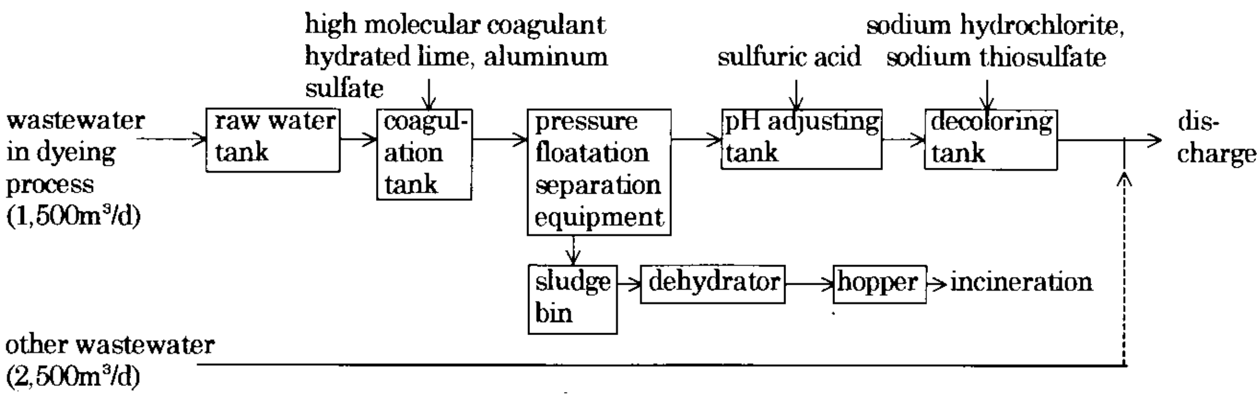
(12) Installation of chemical decoloring treatment as measures against the colored wastewater from dyeing process

Part of wastewater from dyeing process was discharged without treatment, which violated the effluent standards. In response to complaints of local residents, the wastewater treatment equipment was integrated, and as measures for colored wastewater, chemical decoloring equipment using sodium hypochlorite, sodium thiosulfate was supplemented.

Main product and production scale	Printing and dyeing product of cotton, staple fiber, synthetic fiber Sales output: 7,178 million yen/year
Improved facility and reason for improvement	● Drain from scouring, mercerization, bleaching, dyeing Wastewater amount: 4,000m³/d Wastewater quality: pH 10, BOD 250mg/l, SS 180mg/l, oil 10mg/l. transparency 5cm Failure in meeting the standards, and complaints from local residents
Content of improvement (Capacity, effect)	● Installation of coagulation, pressure floating separation equipment and decoloring equipment. Wastewater quality : pH 7.8, BOD 100mg/l, SS 25 mg/l, oil 3mg/l, transparency 15cm or more
Improvement cost (fund source)	101 million yen (JEC 49.5%, other loan 0.0%, own fund 50.5%)
Content of work (Cost ratio)	Coagulating, pressure floating equipment (32.1%), water tank work (22.5%), dehydrator (27.6%), demolition of building (12.5%). building construction (5.3%)
Maintenance control cost	15 million yen/year (chemical cost, power cost)

※ Effluent standards under the municipal regulation:
pH 5.8~8.6, BOD 120 mg/l, SS 96 mg/l, oil 40 mg/l

◇ Treatment flow after improvement



(13) Countermeasures against offensive odor by hydrogen sulfide generated in fiber forming process (1975)

Complaints by local residents were placed regarding offensive odor by hydrogen sulfide generated in the rayon staple fiber forming process. And, to cope with failure in meeting the offensive odor standards, hydrogen sulfide removal equipment was installed..

Main product and production scale	Staple fiber Sales output: 82,645 million yen/year
Improved facility and reason for improvement	Drain from finishing, mercerization, bleaching, dyeing Fiber forming machine Hydrogen sulfide 0.04ppm (at site boundaries) Failure in compliance with offensive odor standard. Complaints by nearby residents
Content of improvement (Capacity, effect)	● Hydrogen sulfide is oxidized with iron chelate and recovered as sulfur, and reduced iron chelate is oxidized in the air for reuse. Concentration of hydrogen sulfide at site boundaries: 0.02ppm or less
Improvement cost (fund source)	570 million yen (JEC 50.0%, other loan 0.0%, own fund 50.0%)
Content of work (Cost ratio)	Hydrogen sulfide absorption equipment (79.4%), raw gas supply equipment (5.2%), piping work (6.2%), electrical and instrumentation equipment (3.3%), other (5.3%)
Maintenance control cost	13 million yen/month(interest and redemption 9 million yen, other 4 million yen) Recovered sulfur is to be sold.

※ Hydrogen sulfide standard under Municipality Regulations: 0.02ppm (at site boundaries)

6.2.2 Cases relating to the Meat Processing Industry

(1) Installation of oil separator and activated sludge treatment equipment (1971)

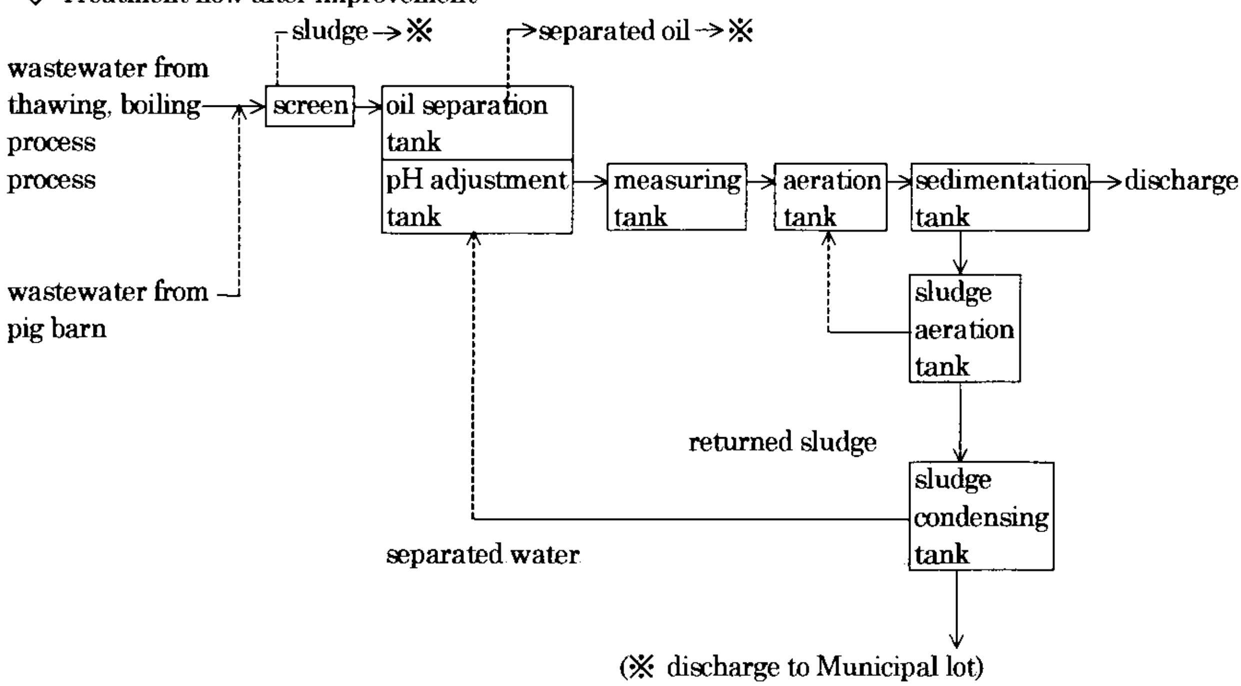
Wastewater from meat processing plant and livestock barn were conventionally discharged after filtering through the screen only. However, it was high in organic substance load.

.With increased production of meat processing industry, a treatment facility was installed following the administrative guidance for compliance with the effluent standards.

Main product and production scale	Press ham, sausage, ham, bacon Sales output: 3,881 million yen/year
Improved facility and reason for improvement	● Drain (with screen) from raw livestock processing equipment, boiling equipment, washing equipment, and dehydrating equipment. Wastewater volume: 850m³/d Wastewater quality: pH 10.1, COD 100mg/l, SS 220mg/l, oil 10mg/l.
Content of improvement (Capacity, effect)	● Installation of oil separator and activated sludge treating equipment. Quality of treated water : BOD 20mg/l, SS 40 mg/l, oil 10mg/l or less
Improvement cost (fund source)	40 million yen (JEC 80.0%, other loan 0.0%, own fund 20.0%)
Content of work (Cost ratio)	Activated sludge treatment equipment (49.9%), building (1.9%) mechanical work (19.1%), piping work (11.4%), electric work (3.6%), other (16.1%)
Maintenance control cost	57,960 yen/month (power cost 54,960 yen, chemical cost 3,000 yen)

※ Standards under Water Pollution Control Law
pH 5.8~8.6, BOD 100 mg/l, SS 80 mg/l, oil 10 mg/l or less

◇ Treatment flow after improvement

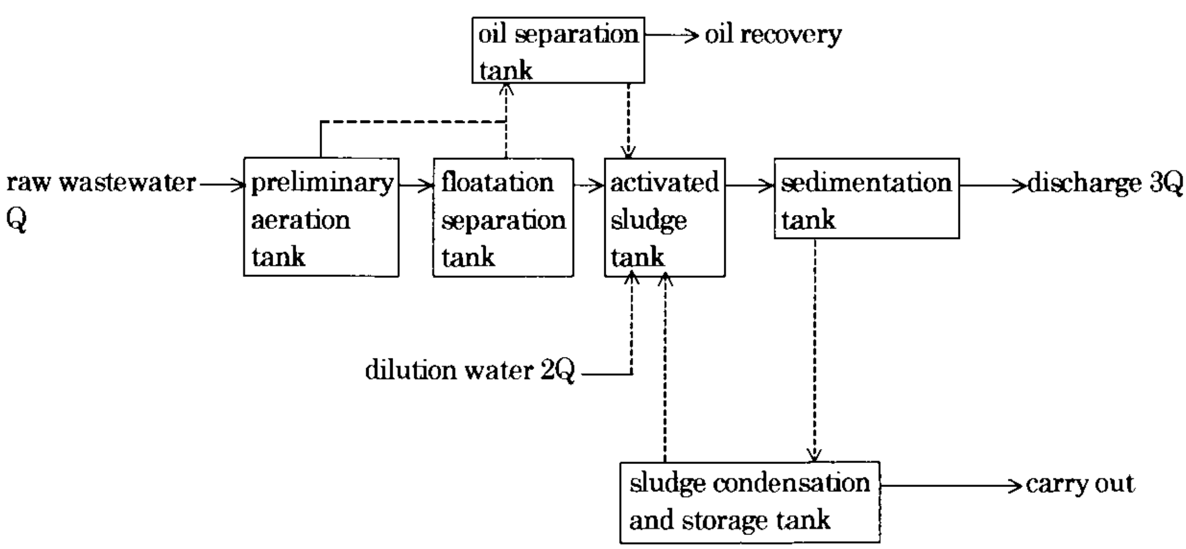


(2) Installation of organic wastewater treatment equipment (pressure floatation separation and activated sludge process) (1970)

In a bacon plant, wastewater of high BOD and SS was generated from the boiling process and colored wastewater from the coloring process. As the process wastewater was discharged after mere dilution.. Complaints were placed by fishers operating in the recipient water area. Therefore, wastewater treatment equipment was installed following administrative guidance.

Main product and production scale	Frozen cut, whale bacon Sales output: 3.518 million yen/year
Improved facility and reason for improvement	● Drain from whale bacon boiling tank Upgrading of treatment (from mere dilution). Dilution of raw wastewater BOD 3,000 → 1,000 mg/l SS 3,000 → 1,000 mg/l oil 5,010 → 1,670 mg/l
Content of improvement (Capacity, effect)	● Installation of pressure floatation separation equipment and activated sludge treatment equipment Quality of treated water : pH 6.8, BOD 65mg/l, SS 60 mg/l, oil 2.4mg/l
Improvement cost (fund source)	17 million yen (JEC 49.7%, other loan 0.0%, own fund 50.3%)
Content of work (Cost ratio)	Pressure floatation separation equipment (21.0%) Activated sludge treatment equipment (21.9%) Lot purchase (50.1%), others (0.7%)
Maintenance control cost	558,000 yen (power cost 438,000 yen, other expense 120,000 yen)

◇ Treatment flow after improvement



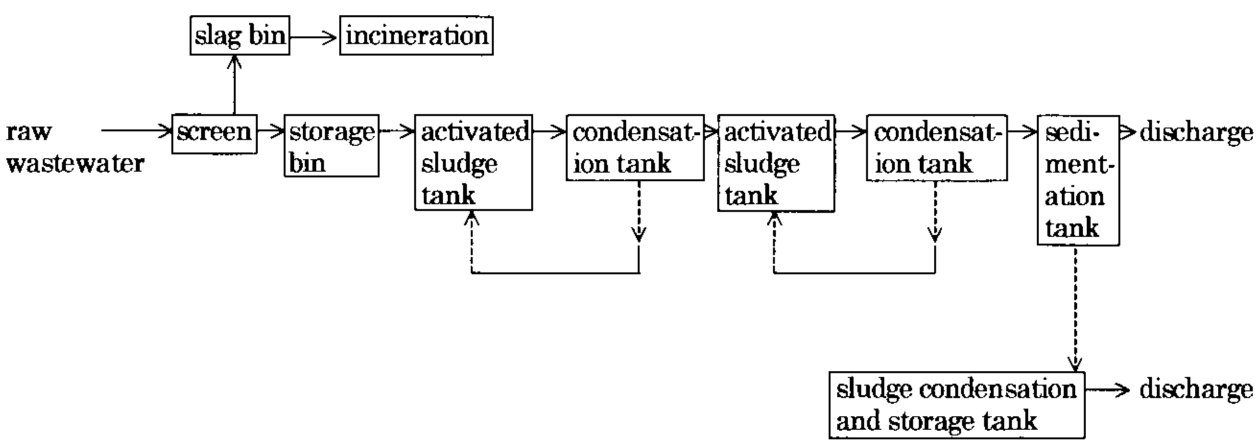
(3) Installation of organic wastewater treatment equipment and waste incinerator

Wastewater of high BOD and high SS was generated from broiler treatment process, and it was discharged after only solid substances were removed.. And, crows flocked together on sludges and flown meat cuts, and resultantly damaged the crops in nearby farming area.. Following the claims from local residents and administrative guidance by the Municipality, organic wastewater treatment equipment and waste incinerator were installed..

Main product and production scale	Broiler Sales output: 2,232 million yen/year
Improved facility and reason for improvement	● Solid substance treatment equipment, multi-bin type sedimentation tank Wastewater amount : 50m³/d Wastewater quality BOD 1,200 mg/l, SS 250 mg/l
Content of improvement (Capacity, effect)	● Installation of 2-stage activated sludge treating equipment and screen sludge incinerator Quality of treated water: BOD 30mg/l, SS 50 mg/l
Improvement cost (fund source)	12 million yen (JEC 80.0%, other loan 0.0%, own fund 20.0%)
Content of work (Cost ratio)	Construction work (24.6%), mechanical equipment (29.9%) electrical equipment (19.8%), others (25.7%)
Maintenance control cost	60,000 yen /month (power cost 25,000 yen, slag incineration 35,000 yen)

※ Water quality standards under the Municipal Regulations: BOD 70mg/l, SS 70mg/l

◇ Treatment flow after improvement



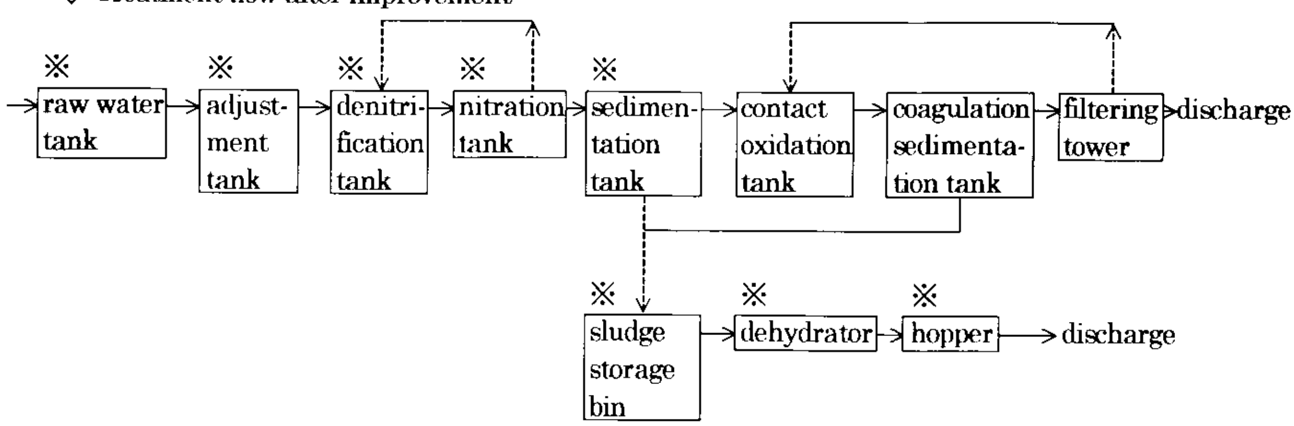
(4) Installation of equipment for organic wastewater treatment and nitrogen/ phosphorus removal (1983)

Since wastewater from broiler processing plant is not only organic, but has much nitrogen and phosphorus, when the plant was expanded, the existing contact oxidation treatment equipment and coagulation, sedimentation treatment equipment were improved to remove nitrogen and phosphorus to meet the effluent standards set by Municipal Regulation to prevent eutrophication of the lake into which the wastewater was discharged.

Main product and production scale	Broiler Sales output: 25.455 million yen/year
Improved facility and reason for improvement	● Contact oxidation treatment equipment, Coagulation sedimentation treatment equipment Wastewater amount : 250m³/d Attempt to remove nitrogen and phosphorus to prevent eutrophication of the lake with wastewater.
Content of improvement (Capacity, effect)	● Installation of nitrogen/ phosphorus removal equipment and improvement of sludge treatment. Treatment capacity : 450m³/d Quality of treated water: : BOD 10mg/l, SS 15 mg/l, T-N 11.4mg/l, T-P 0.2mg/l
Improvement cost (fund source)	12 million yen (JEC 80.0%, other loan 0.0%, own fund 20.0%)
Content of work (Cost ratio)	82 million yen (JEC 38.7%, other loan 61.3%, own fund 0.0%) denitrification and phosphorus removal equipment (86.8%) dehydrator (13.1%)
Maintenance control cost	unknown

※ Effluent standards under the Municipal Regulations: BOD 15mg/l, SS 20mg/l, T-N 20mg/l, T-P 3 mg/l

◇ Treatment flow after improvement



Note) ※ indicates new equipment. Others are existing equipment.

(5) **Installation of organic wastewater treatment equipment (1967)**

With increased production, the capacity of wastewater treatment equipment became insufficient, and increased complaints were placed by fishers operating in the water area to which it was discharged .Then, wastewater treatment equipment was improved following the administrative guidance.

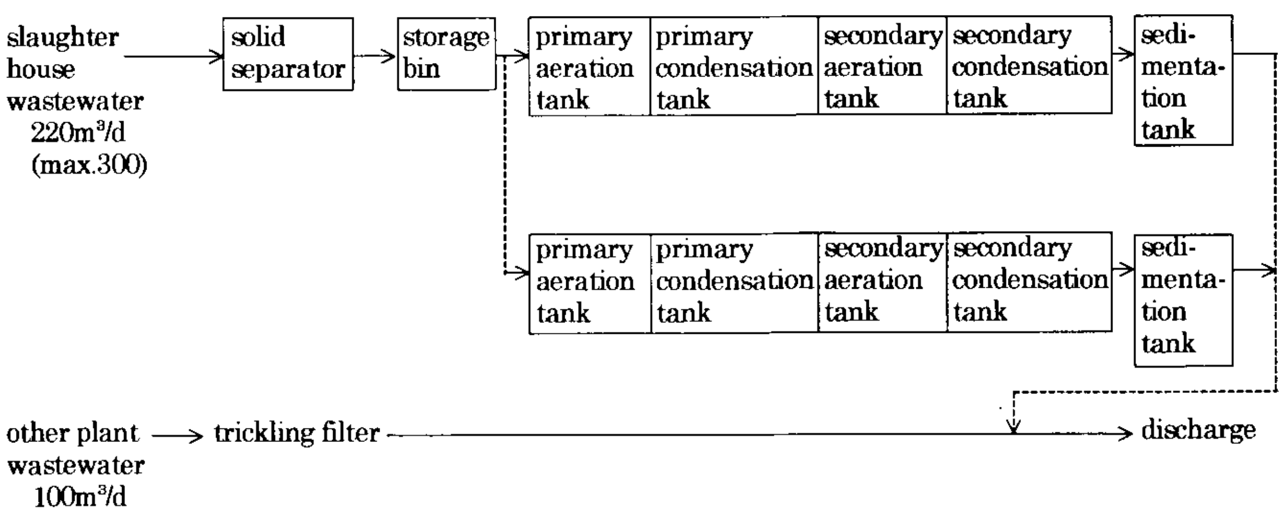
Main product and production scale	Ham, sausage, meat Sales output: 1,084 million yen/year
Improved facility and reason for improvement	● Wastewater treatment equipment for slaughter house and other meat processing. Wastewater volume : 220m³/d Measures to cope with deterioration of quality of treated water due to insufficient treatment capacity Existing capacity 120m³/d Wastewater quality: BOD 900 ～ 1000 mg/l
Content of improvement (Capacity, effect)	● Treatment capacity is expanded to 270m³/d Quality of treated water : BOD 30mg/l
Improvement cost (fund source)	10 million yen (JEC 80.0%, other loan 0.0%, own fund 20.0%)
Content of work (Cost ratio)	Activated sludge treatment equipment (100%)
Maintenance control cost	unknown

(6) Expansion of organic wastewater treatment equipment (2-stage activated sludge equipment) (1970)

The treatment capacity of 2-stage activated sludge equipment for slaughter house wastewater became insufficient due to increased slaughter production. Then the equipment was improved and expanded in response to the administrative guidance. Treatment of wastewater from other process is continued utilizing the existing trickling filter.

Main product and production scale	Meat and daily dish Sales output: 1,771 million yen/year
Improved facility and reason for improvement	● Trickling filter, 2-stage activated sludge equipment Wastewater volume : 320m³/d Wastewater quality: pH 7.5, BOD 100mg/l
Content of improvement (Capacity, effect)	● Additional installation of 2-stage activated sludge equipment (150m³/d) Quality of treated water quality :BOD 50mg/l
Improvement cost (fund source)	8 million yen (JEC 78.7%, other loan 0.0%, own fund 21.3%)
Content of work (Cost ratio)	Activated sludge treating equipment (97.9%), electric work (2.1%)
Maintenance control cost	unknown

◇ Treatment flow after improvement



(7) Installation of organic wastewater treatment equipment (2-stage activated sludge equipment) to meet the revised effluent standards. (1973)

Wastewater from meat processing plant was conventionally treated by bulkhead separating tank and discharged. However, it failed to comply with the revised effluent standards. Then, 2-stage activated sludge equipment was installed followoing the administrative guidance for improvement of equipment.

Main product and production scale	Sausage, ham, raw meat Sales output: 2,384 million yen/year
Improved facility and reason for improvement	● Wastewater treatment equipment (bulkhead separating tank) Wastewater volume : 120m³/d Treating equipment is upgraded to comply with the revised standards. Wastewater quality: pH 6.4, BOD 593mg/l, COD 122mg/l, SS 120mg/l, oil 11mg/l
Content of improvement (Capacity, effect)	● Installation of 2-stage activated sludge treatment equipment Quality of treated water : BOD 25mg/l, COD 25mg/l, SS 50 mg/l, oil 11mg/l
Improvement cost (fund source)	27 million yen (JEC 80.0%, other loan 0.0%, own fund 20.0%)
Content of work (Cost ratio)	Activated sludge treating equipment (81.8%), electric work (14.1%), other (4.1%)dehydrator (13.1%)
Maintenance control cost	unknown

※ Effluent standards set by Municipal Regulations:
pH 5.8 ~8.6, BOD 60mg/l, COD 60mg/l, SS 110mg/l, oil 30mg/l

◇ Treatment flow after improvement

wastewater → [screen] → [storage bin] → [primary aeration tank] → [secondary aeration tank] → [sediment-ation tank] → [adjust-ment tank] → [sterilization tank] → discharge

6.3 Survey and Research Program by JEC

6.3.1 Survey and Research relating to Advanced Treatment Techniques on Dyeing Wastewater

(1) Purpose

Generally, dyeing wastewater rarely contains the hazardous substances specified by the Water Pollution Control Law, but has large variation in water quality and quantity. Furthermore, as the wastewater contains substance persistent to biological treatment, like dye or surface active agent, it is hard to establish an appropriate treatment plan. And, in closed water basins, severe wastewater standards of COD (Mn) 15mg/l, SS 5mg/l are set. Therefore, for dyeing wastewater with high COD, advanced wastewater treatment technologies must be developed. JEC has made a research in order to establish an advanced treatment technique which is technically manageable..

(2) Contents

(a) Taking an integrated wastewater from typical dyeing plant as raw wastewater, the effect of the conventional method (activated sludge process, coagulation and sedimentation and filtration) were evaluated.

(b) The functions of different advanced treatment methods were evaluated.
- (1) Chlorine oxidation method
- (2) Ozone oxidation method
- (3) Activated carbon adsorption method
- (4) Photoradiation and chlorine oxidation method

(c) Investigation of installation cost and operation cost for conventional treatment facilities.

(3) Results

(a) Effect of conventional treatment (activated sludge process, coagulation and sedimentation, and filtration)

- a) The wastewater has large variation in both quantity and quality. For appropriate treatment, it is necessarily needed to segregate or to average the quantity and quality as integrated wastewater.
- b) Average segregate quality of raw wastewater was BOD 200mg/l, COD (Mn) 170mg/l, SS 50mg/l as integrated wastewater. The relationship between BOD and COD was not constant, but there was correlation between COD (Mn) and COD (Cr).
- c) Average quality of the treated water by conventional treatment (activated sludge process, coagulation and sedimentation, and filtration) is; BOD 20mg/l or less, COD (Mn) 40mg/l or less, SS 5mg/l or less.
- d) It is hard to judge the most appropriate sequence of activated sludge process or coagulation and sedimentation. It must be decided according to the properties of the wastewater.

(b) **Functional test of advanced treatment (see Fig.6-3-1)**

a) Pre-treatment is essential before advanced treatment is conducted..
b) Chlorine oxidation method and ozone oxidation method give little effect and the treatment up to COD (Mn) 15mg/l is difficult. However, ozone oxidation method is effective for decoloring.
c) Activated carbon absorption is effective for treatment of COD contents and decoloring.
d) Photoradiation (ultraviolet ray irradiation) chlorine oxidation method is effective for treatment of COD contents.
e) From economical point of view, it is advantageous to apply activated carbon absorption method after treatment by photochemical (ultraviolet irradiation and chlorine) oxidation method. However, in order to identify the most appropriate treatment method, it is necessary to consider the actual wastewater condition and merit and demerit of respective treatment methods. And, activated carbon should be recycled. (heated in furnace).

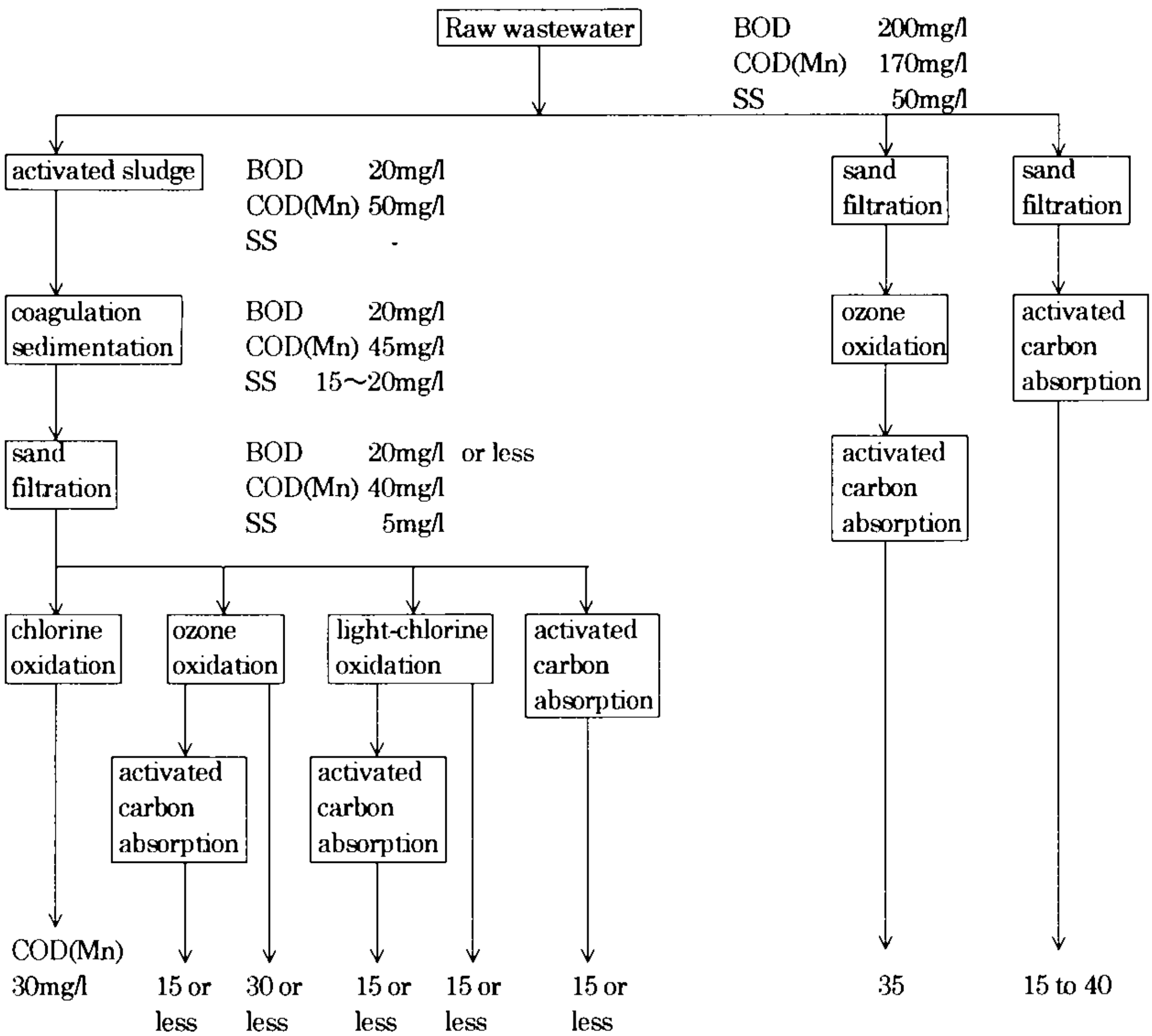


Fig.6-3-1 Functional test result of high level treatment

(c) Investigation of installation and operation cost for conventional treatment facilities

a) Water quality condition

	pH	BOD	COD(Mn)	SS
raw water	6.5 ～ 10	200 mg/l	170 mg/l	50 mg/l
Treated water	6.8 ～ 8.6	20 mg/l	40 mg/l	5 mg/l

b) Treatment condition

- Activated sludge Aeration tank volumetric load: 0.8kg BOD/m^3.d, MLSS:3,000 ～4,000mg/l
  Nutrient: urea, phosphoric acid
  Sedimentation tank water area load: 15m^3/m^2.d, sludge return amount:100%
- Coagulation and sedimentation
  Chemical dose: PAC 200mg/l, polymer coagulant:1mg/l
  coagulation tank retention time:20 minutes, coagulation tank water surface area load: 25m^3/m^2.d
- Sand filtering Type: pressurized, 2-layer type, filtering speed: 10m/h
- Sludge treatment High molecular (polymer) dehydrant: 1.5% (to drying matter)
  Sludge generating : 0.15kg (drying matter)/m^3 (wastewater)

c) Installation cost

Wastewater amount	1,000 m^3/d	3,000 m^3/d	6,000 m^3/d
Activated sludge	32,000,000 yen	65,300,000 yen	104,700,000 yen
Coagulation, sedimentation	11,600,000	25,200,000	40,900,000
Filtering	10,300,000	19,800,000	32,700,000
Sludge dehydration	14,300,000	31,100,000	52,500,000
Building	22,500,000	30,000,000	42,000,000
Electric, instrumentation	31,700,000	64,300,000	106,100,000
Total	122,400,000	230,700,000	378,900,000 yen

d) Operation cost

Wastewater amount	1,000 m^3/d	3,000 m^3/d	6,000 m^3/d
Electric power cost	7,300 yen	16,200 yen	26,800 yen
Chemicals cost	14,350	43,050	86,100
Sludge treatment cost	10,000	20,000	30,000
Total	31,650	79,250	142,900
Treatment unit cost	31.2 yen/m^3	26.4 yen/m^3	23.8 yen/m^3

Note) Labor cost is not included in the operation cost.

6.3.2 Control of Inorganic Nitrogen by Automatic Analyzer in the Controlled Aeration Activated Sludge Process (1985)

--- Survey and study on preventive measures for eutrophication of closed water area such as lake, pond etc.---

(1) Purpose

As for removal technique of nitrogen and phosphorus which causes eutrophication of closed water areas, although its basic technique has been established, it is still incomplete in terms of stability and economy in the actual application. Therefore, complete study on this respect was urgently required.

This study has been conducted for the purpose that the condition for effective operation control of the controlled aeration activated sludge treatment method, which is one of biological nitrogen and phosphorus treating processes, is identified.
It was attempted to prove in the on-site pilot test that through automatic measurement of nitrate nitrogen and nitrite nitrogen (NOx - N) in the biological reaction tank and automatic control operation of treatment process on the basis of the measured data, nitrogen and phosphorus are removed in high efficiency, and to investigate the technical and economical feasibilities.

(2) Contents

(a) Experimental installation of NOx - N automatic analyzer and evaluation of its performance

To automatically control the treatment process by NOx-N measurement in biological reaction tank, stable measuring ability, quick response, and easy on-line system are required. Then, in this study, we installed on an experimental basis, an automatic NOx-N analyzer in the biological reaction tank, evaluated its performances, and investigated into necessary conversion formula.

(b) Test at pilot plant

Installing NOx-N automatic analyzer in the pilot plant for the controlled aeration activated sludge process, we made control over the retention time in aerobic treatment process, taking NOx-N concentration as index, and also made control over chemicals dose in denitrification process. Thus, we assessed the performance ability of biological nitrogen and phosphorus treatment process and its stability.

(3) Result

In the controlled aeration activated sludge process, we detected the NOx-N concentration in the biological reaction tank by automatic analyzer.

Optimization of the process control was achieved for the pilot test plant, and the stability of the treatment was also proved. In sewage treatment, we could make stable treatment with treated water BOD 20mg/l or less, T-N 5mg/l or less, T-P 0.5mg/l or less.

The result has proved that this method can fully satisfy the intensified standard for nitrogen and phosphorus by the Water Pollution Control Law. The process is evaluated effective for eutrophication prevention, being high in treating ability and economical, as equipment maintenance and control cost is reduced.

(a) NOx-N automatic analysis

In this study, we planned to make NOx-N measurement by ultra-violet ray (UV) absorptiometry. Therefore, it was necessary to establish the relation among composition of filtered solution, absorbance, and NOx-N concentration. To compensate the UV absorbance of micro amount of organic substance in filtered solution, we intended to calculate NOx-N concentration from the difference of absorbance between wave length 220μm and 260μm. We measured the absorbance and NOx-N concentration for biologically treated sewage and that of pig barn wastewater, and resultantly obtained following equations.

Sewage biological treating water : NOx - N =4.46 (E220 - 1.81 E 260)
Pig barn wastewater biological treating water : NOx - N =4.43 (E220 - 2.33 E260)

(b) Pilot plant test

We obtained the following results by the continuous automatic operation test at the pilot plant with capacity 6m^3/d .

1) In NOx - N measurement in biological reaction tank, we could exactly trace the fluctuation of NOx - N concentration in raw water, aeration process, and denitrification process in the controlled aeration activated sludge process.
2) As for the dose of denitrificating agent (methanol) in denitrification process, if it was too little, the removal of T-N and T-P decreases, and if it was too large, BOD in treated water increases. However, proper control of the chemical dose enabled to attain the treating water quality BOD 20mg/l or less, T-N 5mg/l or less, T-P 0.5mg/l or less at all times.
3) The controlled aeration activated sludge process operated with NOx-N automatic analyzer realized the simultaneous removal of nitrogen and phosphorus at high level due to its excellent treating effect. The maintenance control cost was also reduced.

4) According to our hypothetic calculation, in the sewage treatment facilities with capacity of 1,500 m^3/d, it can reduce the operating cost (chemical cost + power cost) by 4.3 million yen annually if the raw water concentration is normal. And, in pig barn wastewater treatment facilities with capacities of 300 m^3/d scale, it can reduce the operating cost (chemical cost + power cost) by 9.8 million yen annually. For pig barn wastewater of high organic concentration, the effect of controlled operation with NOx-N automatic analyzer is significant.

6.3.3 Survey and Research relating to Advanced Treatment of Food Processing Wastewater (Controlled Aeration Activated Sludge Process) (1983)

(1) Purpose

To the plant located in the basins of closed water areas, the regulations relating to the discharging water quality against nitrogen and phosphorus has been established and executed for the prevention of eutrophication. In the food industry as well, in many cases, enterprises have adopted the treatment technique combining the nitrogen treatment technique by biological nitration and denitrification process, with the phosphorus treatment technique by coagulation and sedimentation with chemicals. However, these conventional treatment process has demerits such as installation of large treatment equipment, complex operation, large amount of sludge generation, high cost etc. Therefore, they are rather problematical to adopt in the small and medium sized enterprises.

In this study, instead of these conventional process, the application of the advanced treatment process for food production wastewater including nitrogen and phosphorus treatment, which could be adopted to food plants of small and medium scale, was studied.. Survey and study on its treatment effect and economy are carried out..

(2) Contents

(a) Treatment process and tasks

This study intends to develop the controlled aeration activated sludge process as an advanced treatment technology for food plant wastewater.
As for the treatment of various kind of organic wastewater from food industry, though the activated sludge process showing high treatment efficiency has widely prevailed, many food plants of small and medium scale have problems as described below, though depending on the characteristics of the wastewater..If conventional activated sludge process is adopted as it is, crucial sludge bulking occurs and, as a matter of fact, no sufficient treatment effect can be attained.

a) Products and production amount vary from a season to another. Therefore, wastewater amount and quality also fluctuate significantly.
b) Most of wastewater quality is as high as around BOD 1,000 mg/l.
c) Wastewater is discharged mainly at daytime.
d) Lack of expertise and staff assigned for maintenance control of wastewater treatment facilities.

A study was carried out to evaluate the bulking restriction effect of this process, treatability of organic components such as BOD and COD, and to assess the enhanced performances of nitrogen and phosphorus removal.

(b) Facility and wastewater applied in the test

The wastewater from soy sauce maker, broiler dressing industry, soy bean curd maker, was applied to the experimental treatment facility. The treatment performance was evaluated in terms of BOD, COD, nitrogen, and phosphorus contents. The structure and flow of the controlled aeration activated sludge process is indicated in Fig. 6-3-2..

(c) Contents

The test was performed in two stages; bench scale batch test and on-site test with continuous flow. At first, the treatment condition was set through the bench scale test, using wastewater from different manufacturing processes, and then the on-site test was performed at the soy sauce plant.

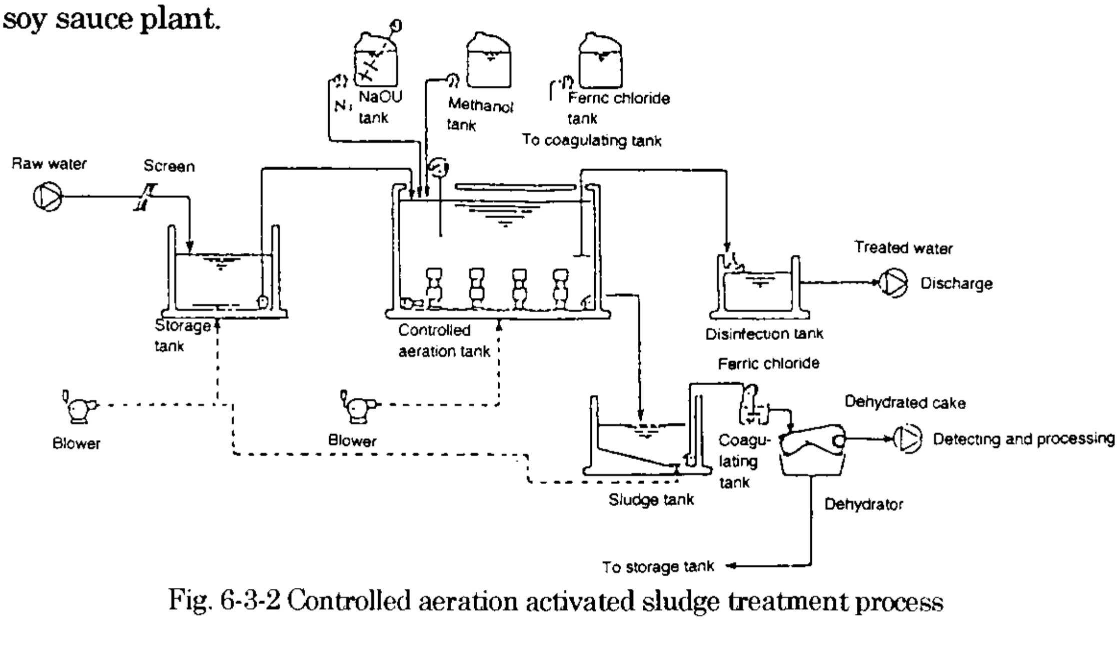


Fig. 6-3-2 Controlled aeration activated sludge treatment process

(3) Results

1) Research was conducted regarding the controlled aeration activated sludge process as advanced treatment technique of food plant wastewater of small and medium scale. It was confirmed that stable treatment is achieved by controlling the bulking that is the greatest interference for the activated sludge process, and simultaneous removal of nitrogen and phosphorus is also achieved. It was also acknowledged that this process is excellent in economical aspect as well as maintenance control aspect, and that it is the appropriate treatment technology for the food industry wastewater.
2) Raw water quality of wastewater from different plants are shown in Table 6-3-1.

Table 6-3-1 Quality of wastewater from different plants

(mg/l)

Plant	pH	SS	TOC	COD	BOD	K - N	T - P	Cl	color
A	6.7	760	600	980	1400	133	17.4	520	205
B	6.9	389	370	410	900	163	17.3		9
C	5.13	288	1920	2720	3420	136	15.6		254
D	5.86	244	653	1150	1450	22.9	4.2	177	53

3) Operational factors, such as anaerobic and aerobic program cylce were set through the bench scale test, and the full scale test with continuous flow was conducted on site. As the results, the treatment efficiency of BOD 98%, TOC 91%, COD 90%, nitrogen 90%, phosphorus 95% or more, was attained.
4) In comparison with the conventional treatment process combining the biological nitrogen removal and coagulation phosphorous removal, this process is more compact and more rationalized, that is, its configuration consists of the adjusting tank and the aeration tank, consequently the area required for the installation of this process can be as small as 70 to 78% of the conventional process area, and the operation cost can be reduced by 43 to 45%.

6.3.4 Survey and Research relating to the Separation of Phosphorus contained in Organic Wastewater (1980)

--- To gain high efficiency of coagulation and sedimentation process by solid solution separating device using fin-attached inclined plate ---

(1) Purpose

As typical phosphorus removing techniques applied for organic wastewater, there are coagulation and sedimentation process, crystal separation process, and biological phosphorus removal process. Such processes have been developed on the basis of experiments at sewage treatment stations.

In this survey and research, technical and economical investigation was made on phosphorus removal technique for organic industrial wastewater.

(2) Contents

(a) Treatment method

Considering that there was an urgent need to develop phosphorus removal technique for small and medium sized industry, the modification of coagulation and sedimentation process was attempted, using fin-attached inclined plate.

This modification is expected to increase sedimentation speed, compared with the conventional process, and reduce the plant site area and the cost.

The principle of the solid-liquid separation device using fin-attached inclined plate is illustrated in Fig.6-3-3. Fins stand at equal interval on the flat plate and when the raw water containing coagulating flocks passes through fins, cylindrical whirl is generated by fins, then flocks are forcibly caught toward the inside of the whirl, resultantly they fall down rapidly. Thus solid-liquid separation is performed.

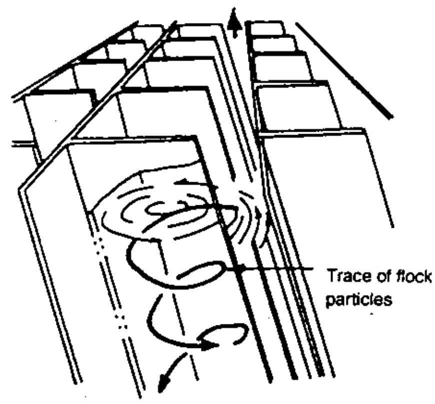


Fig. 6-3-3 Structure of solid-liquid separation device, using fin-attached inclined plate

(b) Raw wastewater applied

We have selected cake making ("bean paste" or "soy jam" making) wastewater, as the raw water for the experimental purpose, considering following points.

1) This business is conducted mainly by small and medium sized industries.
2) Phosphorus concentration in the wastewater is high, so comparatively high treatment efficiency is required.
3) If the treatment technique can be established for this wastewater, it can be easily applied to other organic wastewater. .
4) There is a need to develop the technique which requires rather small area of plant and easy maintenance and small cost.

(c) Testing method

The experimental raw wastewater (coke-making wastewater treated by activated sludge process) was fed to the test plant.. Before starting test plant operation, dosing rate (mainly aluminum sulfate) and pH range was investigated by jar test to set operating conditions.

(3) Results

(a) Quality of raw wastewater

As shown in Table 6-3-2, the properties of raw wastewater was low in SS and COD, compared with secondary treated sewage, and high in T-P value 10 times of the treated sewage.

Table 6-3-2 Example of water quality

(mg/l)

Specimen	COD	P	SS
Experimental raw wastewater	13.6	18.2(PO_4 - P)	1.7
Secondary treated sewage	14.0	1.6(T-P)	14.6

COD is tested by Mn process.

(b) Study on treatment function

Generally speaking, to achieve phosphorus removal of more than 90%, the aluminum sulfate is required more than Al/P=2 in mol ratio. In this study, Al/P = 1.95 in jar test, and Al/P =1.44 in the test plant, which was a little smaller than normal amount. The reason for the test plant result being worse than the jar test result was that sludge control in the plant was problematical. It is assumed that due to inappropriate sludge draw-out, phosphorus has dissolved from deposited sludge.

For coagulating pH range it was 4.5 ～ 5.5 in this study, compared with 6.2 ～ 6.8 normally. Although it was clarified that more aluminum sulfate expand pH range, the optimum pH range should be 5.0 ～5.5, in terms of phosphorus removal rate and chemicals dose.

As for sludge return, it was found that the best effect was attained when the sludge generated in the state of high Al/P mol ratio was returned. However, even in this case, if sludge could not be drawn out smoothly, phosphorus dissolved to deteriorate the quality of treated water. It is a matter of consideration when the process is put into practical use. To execute sludge return effectively, 2-stage coagulation and sedimentation process (see Fig.6-3-4) seems to be effective.

(c) Study on economic factors

As solid-liquid separation process in aluminum sulfate coagulation process, comparative study was made on circulating sedimentation process and pressure floatation process, in parallel with fin-attached inclined plate process. Furthermore, hydrated lime 2-stage coagulation process was also tested. Presented in Table 6-3-4 are results of rough calculation for the economic factors of the actual facility, construction cost, and operation cost under the basic condition shown in Table 6-3-3.

It should be noted that in case of utilizing sludge as fertilizer, aluminum sulfate is not allowed to use, Therefore, other chemicals such as hydrated lime etc. should be applied.

Table 6-3-3 Basic condition

Volume of treated water	item	raw water quality	Treating water quality
300(m^3/d)	pH	6.0 ~8.0	5.8 ~8.6
	SS (mg/l)	20 or less	20 or less
	BOD (mg/l)	25 or less	10 or less
	COD (mg/l)	25 or less	10 or less
	T-P (mg/l)	20 or less	2 or less

Table 6-3-4 Rough calculation of required area, construction cost, operation cost for actual facility

	Aluminum sulfate coagulation				Hydrated lime coagulation
	Fin-attached inclined plate	circular sedimentation pond	pressure floatation	2-stage coagulation sedimentation	2-stage coagulation sedimentation
Required area (m^3)	40	60	50	48	80
Construction cost (million yen)	2,310	2,531	2,620	2,550	2,930
chemical cost yen/d	6,346	6,346	6,346	5,590	4,310
Power cost (yen/d)	3,750	3,870	7,920	4,380	5,190
Sludge processing cost yen/d	3,000	3,000	3,000	2,250	4,500
Total cost yen/d	13.096	13.216	17.266	12.220	14.000

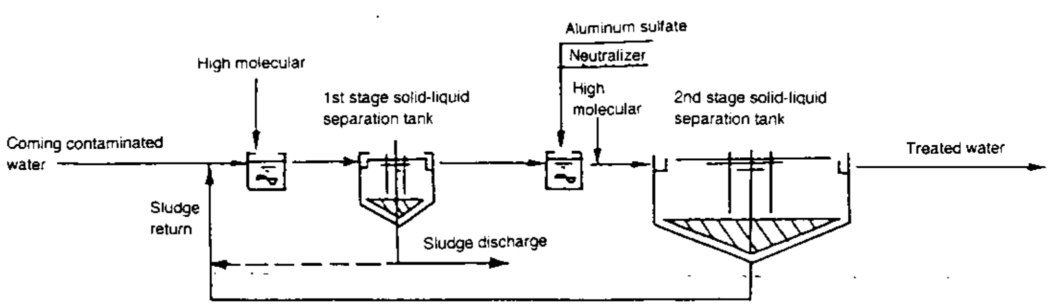


Fig. 6-3-4 Flow chart of 2-stage coagulation and sedimentation process

6.3.5 Survey and Research relating to Separation System of Nitrogen and Phosphorus contained in High Concentration Organic Wastewater (1986)

(1) Purpose

Regarding organic wastewater having high concentration in BOD, nitrogen, and phosphorus, investigation was carried out on the treatment function of the combined system of fixed bed type anaerobic treatment and batch type activated sludge treatment, designed for simultaneous removal system of BOD, nitrogen, and phosphorus.

(2) Contents

As for organic wastewater with high concentration of nitrogen and phosphorus, the following was examined;.

1) In the fixed bed type anaerobic treatment which can greatly increase the concentration of micro organism, rapid degradation of organic substances and methane gas recovery performances was studied.
2) Possibility of biological denitrification and phosphorus removal for high concentration wastewater by anaerobic- aerobic processes were applied .for high .concentration wastewater.

(3) Results

Through this research, not only superiority of fixed bed type anaerobic treatment process was proved, but also validated was possibility to remove BOD, nitrogen, and phosphorus simultaneously in high concentration organic wastewater economically by combining batch type activated sludge treatment with revolving iron disk plate treatment.

(a) Fixed bed anaerobic treatment

1) For BOD load of 5 to 11 g/l per day, very high BOD removal rate, as high as 85% or more, was obtained with treated water of BOD 1000 mg/l.
2) Nitrogen removal rate in anaerobic treatment was about 12%, and phosphorus removal rate was 5% or less. Though these values are rather low, it was found that the effect of the anaerobic treatment is to change the form of nitrogen and phosphorus to such form, as NH4 - N or PO4 – P, that is easy to remove in the latter stage of batch type activated sludge treatment
3) Excess sludge is estimated to generate 7 to 12% per removing BOD, which is as little as 1/3 or 1/5 of those in the case of aerobic treatment for the same wastewater.

4) It was found that about 40% of TOC (total organic carbon) contents in the wastewater is converted to methane gas, and about 10% of it to carbon dioxide, and that about 60% of total removed TOC was converted to gas. Methane gas concentration in generated gas was 78 to 80%, and it contained about 2000ppm of hydrogen sulfide.

5) Methane gas generated amount was 0.28 to 0.36 l/g per TOD (total oxygen demand) removal, which is equivalent to 80 to 100% of the theoretical amount. Gas generated amount was 4 to 5 Nm^3/m^3.d per effective volume of the reactor, which is 4 or 5 times as large as those in the conventional gas fluidized bed system. It is high volume effect

(b) Batch type activated sludge treatment

1) The BOD-SS load for optimum BOD removal is 0.3g/g.d or less, and BOD in treated water was 30mg/l or less for raw water of BOD 1000mg/l.

2) In case of BOD-SS load less than 0.3 g/g.d , T-N removal rate was about 93%, and T-N in treated water was 15mg/l or less for raw water of T-N 220 mg/l. It was clear that perfect removal of NH4-N (nitration) is essential to attain high T-N removal rate, and that removal of NH4-N is greatly influenced by water temperature.

3) T-P removal rate for BOD-SS load less than 0.3g/g.d is about 30%, and T-P in treated water is merely 55mg/l for raw water of T-P 80mg/l. This does not satisfy the treatment target (1.5 mg/l).

4) Sedimentation of sludge is as high as 145 to 228 in SVI, which is not satisfactory. MLSS concentration is desired to be about 5000 mg/l. Sludge generated per removing BOD was 0.45 ～ 0.65 (g-MLSS/g-removing BOD) within the range of BOD-SS load 0.15 ～ 0.35 g/g.d.

(c) Coagulation and sedimentation treatment and rotating disc treatment

1) Coagulation and sedimentation

Treated water of T-P 1.5mg/l or less by adding about 3000 mg/l of aluminum sulfate to raw wastewater of T-P 60mg/l, was stably obtained...

2) Rotating iron disc treatment

Treated water of T-P 1.5mg/l or less was attained under condition of raw wastewater load of 2 l/l.d (phosphorus load 0.6g/m^3.d) and raw water quality of T-P 60mg/l and pH7.5 or less.

Table 6-3-5 Effect of each treatment system (quality of raw water and treated water)

	Raw water	Fixed bed type anaerobic treatment	Batch type activated sludge treatment		coagulation and sedimen-tation or revolving iron disk plate process	Treatment target value
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
BOD	7,500	1.000	30 or less	30 or less	30 or less	30 or less
T-N	250	220	25	15 or less	15 or less	15 or less
T-P	80	80	60	55	1.5 or less	1.5 or less
Treating condition		(1)	(2)	(3)		

(1) BOD load 0.3g/l.d, water temperature about 36°C
(2) BOD load 0.3g/l.d, 3 cycle, DO control, MLSS 5000mg/l
(3) BOD load 0.3g/l.d, 3 cycle, DO control, MLSS 5000mg/l, methanol adding

6.3.6 Survey and Research relating to Separation of Nitrogen in Organic Wastewater (1979)

(1) Purpose

As for the technique to remove nitrogen compounds in organic wastewater which causes problems of eutrophication of lake and pond, and excessive nitrogen in rice farming water, biological nitrating denitrification process was evaluated, taking the livestock industry wastewater as experimental example.

(2) Contents

(a) Raw wastewater applied

As the raw wastewater applied for this experiment, pig barn wastewater was selected, because livestock processing wastewater and marine product processing wastewater contains comparatively high concentration of nitrogen compounds.

(b) Treatment method

In this study, among the treatment processes for BOD and nitrogen composition, we have selected the biological nitrification and denitrification process by nitrifying solution circulation system which is now considered the most excellent process in respect of treatment effect and economy.

(c) Test plant and outline of test

The flow sheet for the test plant is shown in Fig. 6-3-5. Pig barn wastewater after removing dregs is diluted to 3 times the original volume and ammonia nitrogen concentration is adjusted to about 670mg/l as the standard raw water. The circulating nitrating liquid is to be 5 times raw water volume and the return sludge is to be equivalent to raw water volume.

The quality target of treated water is BOD 40mg/l, ammonia nitrogen 3 mg/l, nitrate nitrogen 2mg/l, organic nitrogen 45mg/l. In activated sludge treatment process of pig barn wastewater, the generated sludge does not readily sedimentate. In this test as well, since suspended substances were carried over from the sedimentation tank and the quality of treated water became unstable, coagulation and sedimentation equipment using aluminum sulfate was installed in the sedimentation tank.

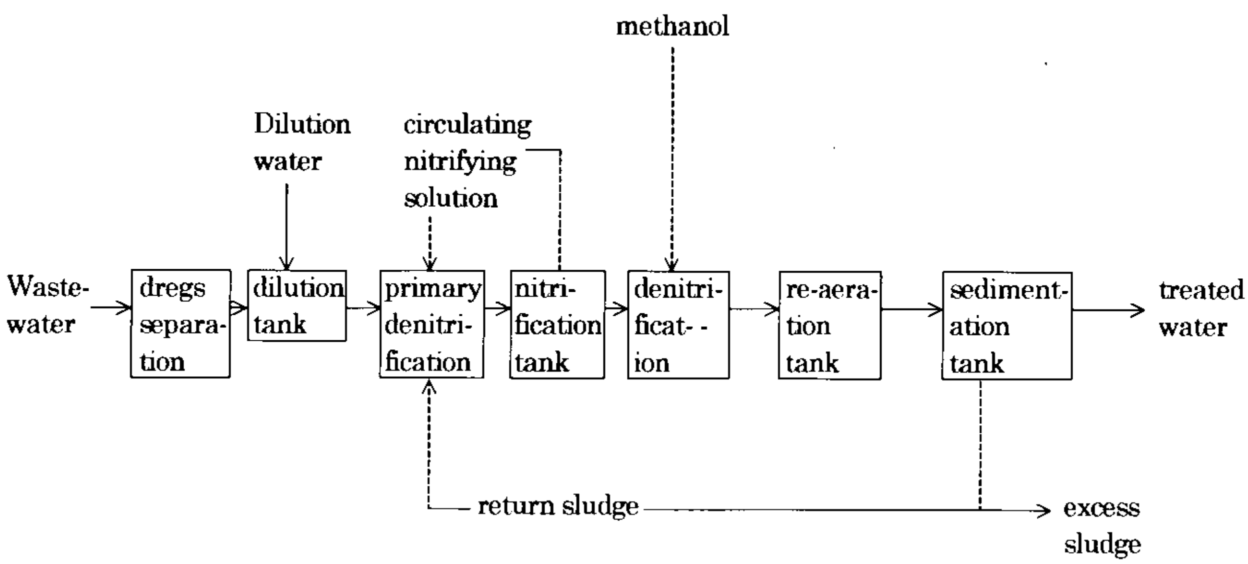


Fig.6-3-5 Flow sheet of testing appliance

(3) Result

As for wastewater from livestock production (pig barn), it was clarified that the combination of nitrifying solution circulating type biological nitrification denitrification process and coagulation sedimentation treatment process can attain the quality of treated water BOD 10mg/l and T-N 12 mg/l. Investigation was made on characteristics of pig barn wastewater, treatment effect in each treatment process, standard construction cost, and operation cost, as described below.

(a) Characteristics of pig barn wastewater

a) The relationship among BOD, COD, and ammonia nitrogen (NH4-N) of pig barn wastewater is described below. It was observed that there is clear correlation between BOD and ammonia nitrogen. Figures in parenthesis presents the fluctuating range.

BOD/COD = 3.0 (2.3 ~4.0) standard deviation 0.48

BOD/NH4 - N= 4.3 (3.1~5.9) standard deviation 0.89

COD/NH4 - N=1.4 (1.2~2.1) standard deviation 0.14

b) In general, one of major causes for difficulty in treatment of livestock processing wastewater is that the quality of raw water greatly fluctuates with the amount of floating fiber substance in the wastewater. Since these floating substances mainly come from excrement, it is greatly influenced by dunging rate in pig barn. Dunging means to collect and dispose of excrement in pig barn separately. Table 6-3-6 indicates the relationship between dunging rate and pollutant load in pig barn wastewater.

Table 6-3-6 Dunging rate and pollutant load in pig barn wastewater (as per Ministry of Agriculture, Forestry, and Fisheries)

		0%	50%	60%	70%	80%	90%	100%
Excrement and urine requiring treatment (kg/cap/d)	excrement	3	1.5	1.2	0.9	0.9	0.3	0
	urine	3	3	3	3	3	3	3
	total	6	4.5	4.2	4.2	3.9	3.3	3
BOD (g/cap/d)	excrement	160	90	70	54	36	18	0
	urine	20	20	20	20	20	20	20
	total	200	110	90	74	56	38	20
Suspended substance (SS) (g/cap/d)	excrement	700	350	280	210	140	70	0
	urine	-	-	-	-	-	-	-
	total	700	350	280	210	140	70	0

(b) Treatment efficiency in each treatment process

a) In the primary denitrification tank, the load of nitrite and nitrate nitrogen was in the range between 0.01 and 0.03 kg/kg-MLSS/d, and the concentration of nitrite and nitrate nitrogen of the outflow never exceeded 1mg/l. The removal rate of nitrite and nitrate nitrogen was 99% or more.
The maximum load of nitrite and nitrate nitrogen for which the treated water of nitrite and nitrate nitrogen not exceeding 1mg/l would be achieved, was obtained by batch test operated separately as 0.05mg/l.

b) In nitrifying tank, when the load of incoming ammonia nitrogen was less than 0.05 kg/kg-MLSS/d, the average nitrification rate (NH4-N reduction rate) was 95%, which meant that good nitrification was performed. At that time, BOD in outflow was less than 20mg/l.

c) When the load of incoming ammonia nitrogen in nitrifying tank exceeded 0.05 kg/kg-MLSS/d, the nitrification rate was lowered, and the nitrification rate remained 64.2% at the time of 0.066 kg/kg-MLSS/d. Then pH in the nitrifying tank became more than 8.0, and the concentration of nitrite nitrogen in outflow became high and unstable.

d) The maximum load of ammonia nitrogen in nitrifying tank is 0.05 kg/kg-MLSS/d (15 ℃,DO>3mg/l) in case of ammonia nitrogen concentration in nitrifying solution being less than 5mg/l.

e) In the secondary denitrification tank, methanol is added as carbon source to remove nitrogen. The maximum incoming load of nitrite and nitrate nitrogen not exceeding 2mg/l in the concentration of nitrite and nitrate nitrogen is 0.05 kg/kg-MLSS/D(10~15℃).

f) The re-aeration tank is not only to release nitrogen gas in the secondary denitrification tank, but also to reduce BOD caused by excessive methanol. The BOD load to attain BOD removal rate more than 90% was 0.15 kg/kg-MLSS/d or less.. It is noted, however, that retention time must be decided considering the time required for releasing N_2 gas.

g) As advanced treatment coagulation and sedimentation with aluminum sulfate 120mg/l and high molecular coagulant 4mg/l was executed to obtain the effluent quality of BOD 10mg/l, T-N 12mg/l.

(c) Situation of sedimentation tank

Owing to insufficient sedimentation and sludge floatation by denitrification, which is characteristic of pig barn wastewater treatment, suspended substances continued to carry over from the sedimentation tank. Consequently the accurate balance of sludge could not be obtained through the period of this testing.

(d) Water quality throughout treatment process

Fig. 6-3-6 shows the change in water quality in each process of pig barn wastewater treatment by nitrifying solution circulating type, biological nitrification and denitrification process and coagulating sedimentation process.

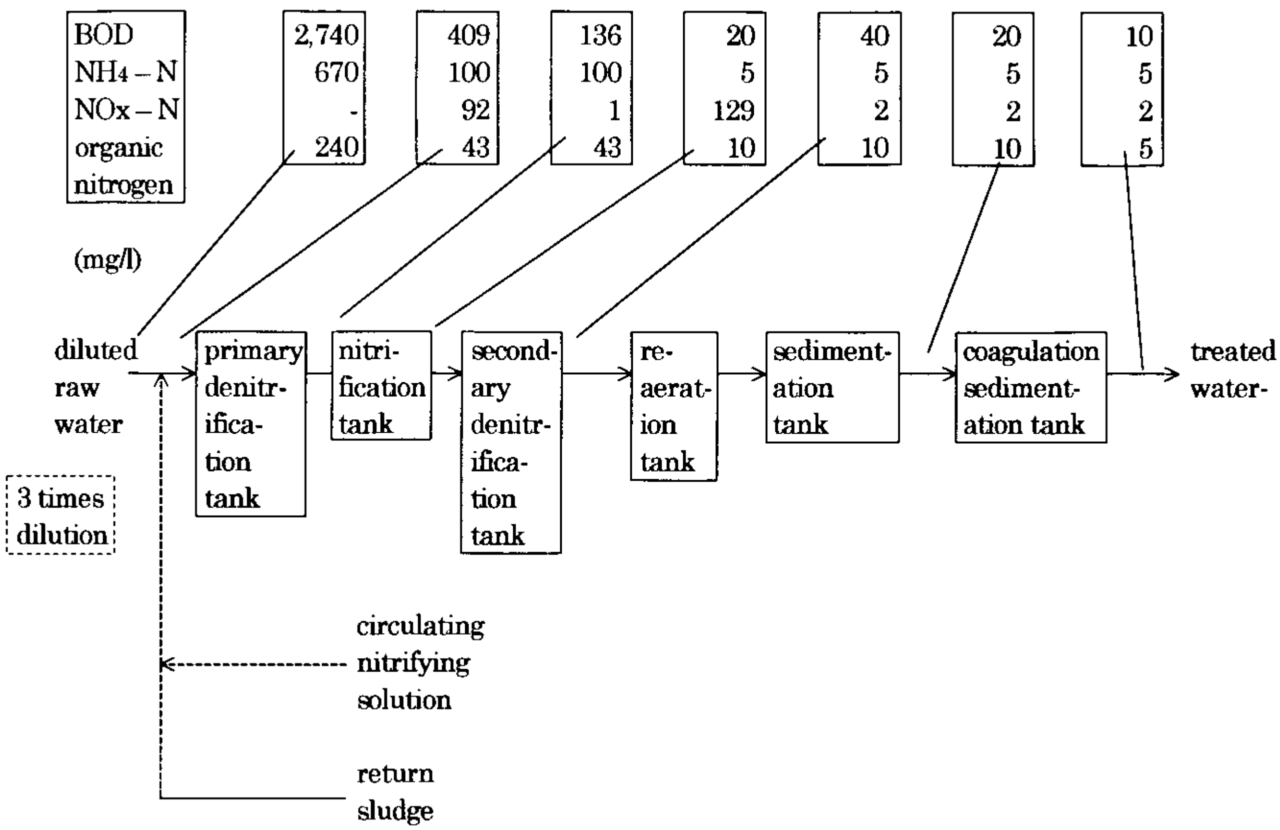


Fig.6-3-2 Change of water quality in nitrating liquid circulating, biological nitrification and denitrification process + coagulating sedimentation process

(e) Construction cost and operation cost

Construction cost and operation cost for pig barn wastewater treatment equipment is calculated for each scale, as shown in Table 6-3-7. These costs exclude the pre-treatment cost (dregs separation cost), sterilization cost and sludge treatment/disposal cost.

Table 6-3-7 Construction cost and operation cost of pig barn wastewater treatment equipment

		200 m³/d	400 m³/d
Construction cost (thousand yen)		350,000	610,000
Operation cost	power cost (yen/d)	42,000	76,300
	chemicals cost (yen/d)	48,000	97,200
	total (yen/d)	90,000	173,500

where,

Unit cost of power : 12 yen/kWH

Unit cost of chemicals:

- methanol : 80 yen/kg
- aluminum sulfate: 60 yen/kg (as aluminum sulfate salt containing 18 mol. water)
- caustic soda 45 yen/kg (24% solution)
- high molecular (polymer) coagulant: 1,100 yen/kg

6.3.7 Survey and Research relating to Oil-containing Wastewater Treatment Techniques (1973)

(1) Purpose

As for environmental contamination by oil containing wastewater, wastewater containing mineral oil is particularly problematical, polluting rivers and oceans, resulting in great amount of damage to fishery industry.

In this study, as means of technical and economical investigation, we have selected oil-containing, emulsifying wastewater which contains water soluble oil agent discharged from metallic product industry, general machinery and appliance industry, and non-ferrous metal and non-ferrous metallic alloy rolling mills and so forth. For this purpose, established was the Oil-containing Wastewater Treatment Technical Committee (chairman of the committee: Mr. Osamu Katori) to proceed the investigation and research.

(2) Contents

Basically, oil-containing wastewater treatment process consists of primary treatment mainly by oil-water separation, secondary treatment to improve the quality of separated water, and treatment of sludge generated. In this study, taking up each treatment process of oil-containing emulsifying wastewater discharged from various kind of metal industries, treatment effect and technical problems at each process was investigated in experiments, and studied about the economy and maintenance control associated. On-site experiments were executed by 13 related companies contracted with JEC.

(a) Treatment system to be studied

Following treatment systems are taken for this study.
They are (1) electrolytic system (2) salting out system (3) coagulation system (4) adsorption system, (5) bubbling association system, (6) secondary treatment system for reduction of COD in separated water, and (7) sludge treatment system.

(b) Goal for treatment

The goal for treatment was to achieve the effluent standards set by the Water Pollution Control Law by treating oil containing, emulsifying wastewater discharged from various kind of metal industries. (animal and vegetable oil 30mg/l or less, mineral oil 5mg/l or less).

(c) Items to be studied

Treatment effect and technical problems, economic and other factors on maintenance control, etc. were studied in regard to various treatment systems.

(3) Results

The following is briefly summarized for the results.

1) For primary treatment, though electrolytic method and coagulation method were found effective, either of them could not achieve the water quality goals without secondary treatment.

2) For secondary treatment system, activated carbon treatment and special filter treatment were found effective, but if oil and COD were intended to be removed simultaneously, there remained problem in terms of economy.

As this study is not intended to select the optimum treatment system, various kinds of treatment systems were studied in parallel. As a result, following problems were pointed out.

(a) Primary treatment

1) As for electrolytic treatment method, any system studied could not achieve the water quality goal by itself. It could be effective to combine it with secondary treatment such as activated carbon treatment, special filter filtration etc. Even in this case, removal of COD originating cutting oil additives was difficult.
2) Salting out treatment method is difficult to achieve the target water quality by itself without use of supplementary chemicals. It is necessary to combine with secondary treatment.
3) As for coagulation treatment method, either coagulation sedimentation treatment, coagulation floatation treatment, or coagulation sand filtration treatment could not achieve the target water quality. It requires to be combined with secondary treatment such as activated carbon filtration or activated carbon adsorption.
4) The effect of primary treatment was recognized for adsorption treatment method, using special adsorbent and montmorillonite. However, the treatment with special adsorbent is very costly.
5) As for bubbling association method, it was effective to oil containing wastewater mainly consisting of suspended oil, however, there was little effect in wastewater mainly consisting of emulsifying oil.

(b) Secondary treatment

To complement the insufficiency of treatment effect attained in the primary treatment mainly of oil-water separation, there are secondary treatment methods, uch as activated carbon filtering method, powdery activated carbon method, and special filter filtration method. Presented are some findings.

1) Fluidized bed type activated carbon adsorption method was effective for COD removal, but required high construction cost and recovery of activated carbon. Therefore, it would be rather difficult to adopt to small and medium sized industry,. in terms of economy.

2) It is assumed that filtration method with activated carbon added as absorbent is comparatively simpler than the activated carbon filtration method.
3) Secondary treatment by special filter is simple and effective, but has no major effect in COD removal, and poses problems in terms of maintenance such as clogging.

(c) Treatment of sludge

As a result of oil containing wastewater treatment, a large amount of sludge is generated. in either method.

1) The following method is also considered as one of sludge treatment methods, that is, oil emulsion is decomposed by acid or salting out, and collected as oil to reduce even a small amount of sludge.
2) Oil containing sludge is not readily filtrated or dehydrated, in conventional methods. In this case, pre-coat filtering method is effective.

3) The calorie of sludge is 4,000～10,000 Cal/kg, which means that natural combustion is possible in most cases.

(d) Study on construction and operation cost

1) As for calculation result for construction cost, though estimation condition is so different by treatment methods, that estimated figures cannot be compared in parallel, there is a tendency that higher construction cost is required for attaining advanced treatment effect.
2) As for operation cost for primary treatment, adsorption method is very costly, except for montmollironite adsorption method. Other methods are relatively cheap.
3) As for required personnel, there is no remarkable difference between methods. However, required site area varies.

(e) General summary

1) Treatment of scum and separated oil generated in primary treatment should be also studied.
2) As secondary treatment method, new techniques including activated carbon treatment must be urgently developed. Especially for activated carbon treatment, duration of adsorptivity and factors concerning its recovery must be technically investigated and effective activated carbon at cheap cost must be selected.
3) As for electrolytic treatment method, generation of film on electrode and consumption of electrode, etc. should be investigated by long-term continuous experiment.
4) To develop compact, and economical technology for small and medium sized industry, comprehensive treatment technology including disposal of scum and separated oil must be established. For the same purpose, combustion method should also be investigated from different viewpoints.

5) Judging from the result of this study, since oil removal and COD removal have many problems, research should be continued with more comprehensive target, including production process improvement, such as type and dose of surfactant to be added to cutting oil, which is high in COD content.

Conclusion

Since 1992, Japan Environment Corporation has established "Overseas Environmental Information Transfer Database Building Investigation Committee" and summarized techniques, costs, and effects regarding execution examples of construction and transfer business of pollution control facilities possessed by JEC, and repeatedly discussed about effective methods to transfer them to developing countries as information contributing to the environment and maintenance of those countries.

Based on the policy studied there, in 1993 fiscal year, JEC prepared a report titled "Outline and Example Execution of Japan Environment Corporation" describing JEC's function and experiences, case example of construction and transfer business (case file) and sent them to the governments of developing countries. On the other hand, examples of financing were summarized in the form of data sheet and put into computer for use as data base, and they have been delivered as printing book of existing data sheets (670 cases) since 1994 fiscal year.

This paper was prepared to complement the report of "Outline and Example Execution of Japan Environment Corporation". In other words, taking up JEC's business examples, we have summarized the subjects relating to pollution control technology for each line of business, with viewpoint of small and middle scale of corporations in developing countries who cry for urgent improvement of pollution control equipment and facilities. In 1995 fiscal year, we summarized about "metal finishing industry" and "marine product processing industry" while in this 1996 fiscal year, we have done for "dyeing, finishing industry" and "meat processing industry". We plan to spread the object business more widely and proceed such summarization work.

The authors for this report are Minoru Tanaka (Jan Environment Corporation), Masakazu Ichimura and Mikihiro Aikawa (Overseas Environment Cooperation Center), and Osamu Suda (Nissui Kon Co.). The copyright of this report lies in JEC.

It is our sincere desire that Japan's experiences for pollution control measures will be utilized by the countries who are tackling to pollution control for reference, and contribute to maintenance of global environment through this report.

For preparation of this report, following literatures are used as references. Therefore, for detail technical information, please refer to them.

Reference literatures

General relation for industrial pollution measures

(1) UNEP: Industry and Environment "Guidelines for Asessing Industrial Environmental Impact and Environmental Criteria for the Siting of Industry" 1980
(2) UNEP: "Industry and Environment "Audit and Reduction Manual for Industrial Emissions and Wastes", 1991
(3) JEC: "Technical Manual on Industrial Pollution Control, Part I" (Metal finishing industry, marine products processing industry) 1996 March
(4) JEC: " Outline and examples of Japan Environment Corporation" 1994 March
(5) Kuribayashi: "Advanced treatment and re-use" (sewage practice lecture 7) 1989
(6) Pollution Control Corporation: Ten Years' History of Pollution Control Corporation", 1976 March
(7) PCC: "25 Years' History of Pollution Control Corporation" 1991 March
(8) Pollution Control Techniques and Law-making Committee "Pollution Control Technology and Law" (air) 1995
(9) above Committee "Pollution Control Technology and Law" (water quality), 1995
(10) UN Conference on Environment and Development Agenda 21, 1992
(11) Food industry center: Food Industry Wastewater Treatment Techniques, 1972
(12) New Environment Control Equipment Dictionary Edition Committee: Water quality contamination preventing equipment 1995
(13) Above committee : Air pollution prevention equipment 1995
(14) Honda: Industrial wastewater reduction measures 1992
(15) Above author: Wise environment measures for food industry (Daily Industrial Newspaper) 1992
(16) Above author: Industrial wastewater reduction measures available with cheapest cost (Daily Industrial Newspaper) 1992 August
(17) Nisuikon: Survey report about nitrogen and phosphorus wastewater criteria in night soil purifying tank1988
(18) Yamamoto, Umetani, Sasaki: Practical pollution control for wastewater in dyeing plant

Dyeing, finishing industry

(1) Environment Agency, Water Control Dept. "Nitrogen and phosphorus instruction policy-making investigation" 1979 ~1983 March
(2) Pollution Control Corporation, Dyeing Wastewater Advanced Treatment Technique Study Committee : "Report of dyeing wastewater advanced treatment technique study committee" 1975 March
(3) Above Corportaion, Study on COD advanced treatment of organic wastewater, 1980 March

Meat processing industry

(1) Okitani: "Science of meat" Asakura Shoten 1996 May
(2) Kamata "Mechanical appliances for meat processing" Korinshorin 1963 August
(3) above author "Unit process of meat processing" Korinshorin 1963, February
(4) Environment Agency, Water Control Dept. "Revised small scale corporation wastewater treatment policy" Pollution Control Technical Association
(5) Ibaragi Prefecture Living Environment Dept., Kasumigaura Policy Section : "Nitrogen, phosphorus reduction policy manual for food industry" 1995 March
(6) Ministry of Agriculture, Forestry, and Fisheries, Stock raising dept., egg section: "Pollution control standard in food product manufacturing process" 1980 Mach
(7) Pollution Control Corporation "Technical survey and research report relating to phosphorus removal in organic wastewater" 1961 February
(8) Above Corporation "Technical survey and research report relating to advanced treatment of food industry wastewater" 1984 March
(9) Above Corporation "Canned food (mandarin) wastewater treatment technical committee report" 1976 March
(10) Yamaguchi "Textbook of meat" 1992 April
(11) Offensive odor prevention technical manual editing committee "Offensive odor technical manual", Pollution control measures technical association, 1988 March.
(12) Meat Tsushin "Japanese Meat Yearbook 1997" 1997 February

Reference information – 1

Example of Wastewater Treatment in Meat Processing Industry in Korea

As major meat processing corporations in Korea, there are three companies. Two companies among them are located in the industrial area , where wastewater is discharged to final treatment plant after primary treatment, therefore, they have no treatment facilities at their own sites.

In this report, A plant of A company which has largest facility in Korea and B plant which is the fourth scale, were picked up as examples for introduction of wastewater treatment and scale of facilities.

1. Case of A plant

(1) Outline of plant

A plant performs meat processing and beverage product processing and the production capacity and manufacturing process are as follows.

1) Plant site and building

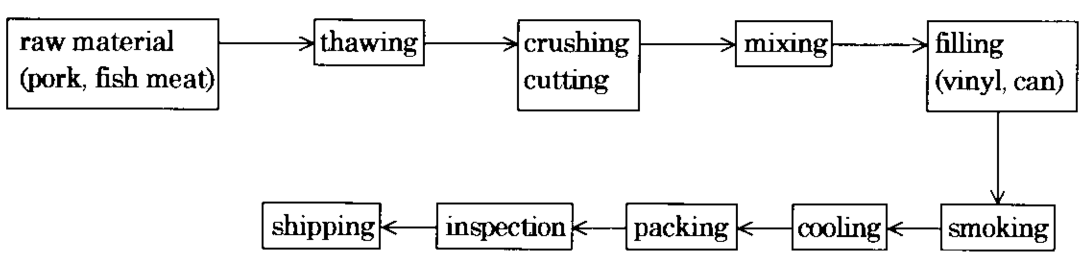
Item	Area m^3 (tsubo)
Plant area	53,809 m^3 (29,598)
Building area	17,253 m^3(9,490)

2) Production capacity and sales output

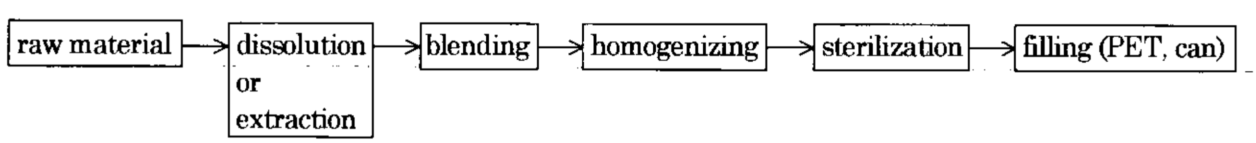
Item	Meat product	Beverage product	Total
Production capacity	59 ton/day	430 ton/day	589 ton/day
Sales output	1,790 million yen	670 million yen	2,460 million yen

3) Manufacturing process

1) Manufacturing process chart for meat



2) Manufacturing process chart for beverage and teas



2 Environmental management

<Condition of locality>

Application district: semi agriculture and forestry district
Water supply source special control district
Covered river is located 1km downstream from the plant.

1) Fact of water quality control

Classification : Class 2
Permitted discharge amount: 1,700 m^3/day

① Legal standards and quality of plant discharge

Item	pH	BOD	COD	SS	n-Hexane	total N	total P
Standards	5.8～8.6	40 or less	50 or less	40 or less	5.0 or less	30 or less	4 or less
Discharge	6.8～7.2	8	10	6	1.1	1.3	1.2

② Characteristics of wastewater

Beverage system wastewater mainly consists of hydrocarbon (sugar) and fiber (fruit juice) with high concentration (BOD 5,000mg/l). In meat processing wastewater, animal oil content is comparatively high. (90mg/l) Because of high concentration of sugar, oil, and starch, it is wastewater which is easy to generate bulking by filiform bacteria in activated sludge treatment.

③ Wastewater treatment method

Wastewater treatment method is a combination of physical treatment, chemical treatment, and biological treatment. For stable treatment as shown in ⑤, the wastewater is divided into beverage system and meat and other system and collected. The beverage system wastewater is mixed with meat processing wastewater after making pre-aeration treatment separately, then mixed wastewater is rendered further aeration treatment, but to remove oil in the wastewater, chemical treatment is performed as pre-treatment. Photo 1 and 2 show complete view of treatment facilities.

④Cost for water quality control

Division		Treatment cost			ratio
		Yearly cost (thousand yen)	Wastewater treatment cost per ton (unit cost) (yen)	Product treatment cost per ton (unit cost)(yen)	
Wastewater treatment cost	Labor cost	119,510	235	1,541	41%
	Chemicals cost	86,620	169	1,117	30%
	Sludge treatment cost	51,050	100	658	17%
	Power cost	25,740	51	332	9%
	Self measurement cost	8,710	17	112	3%
Total		291,630	572	3,760	100%

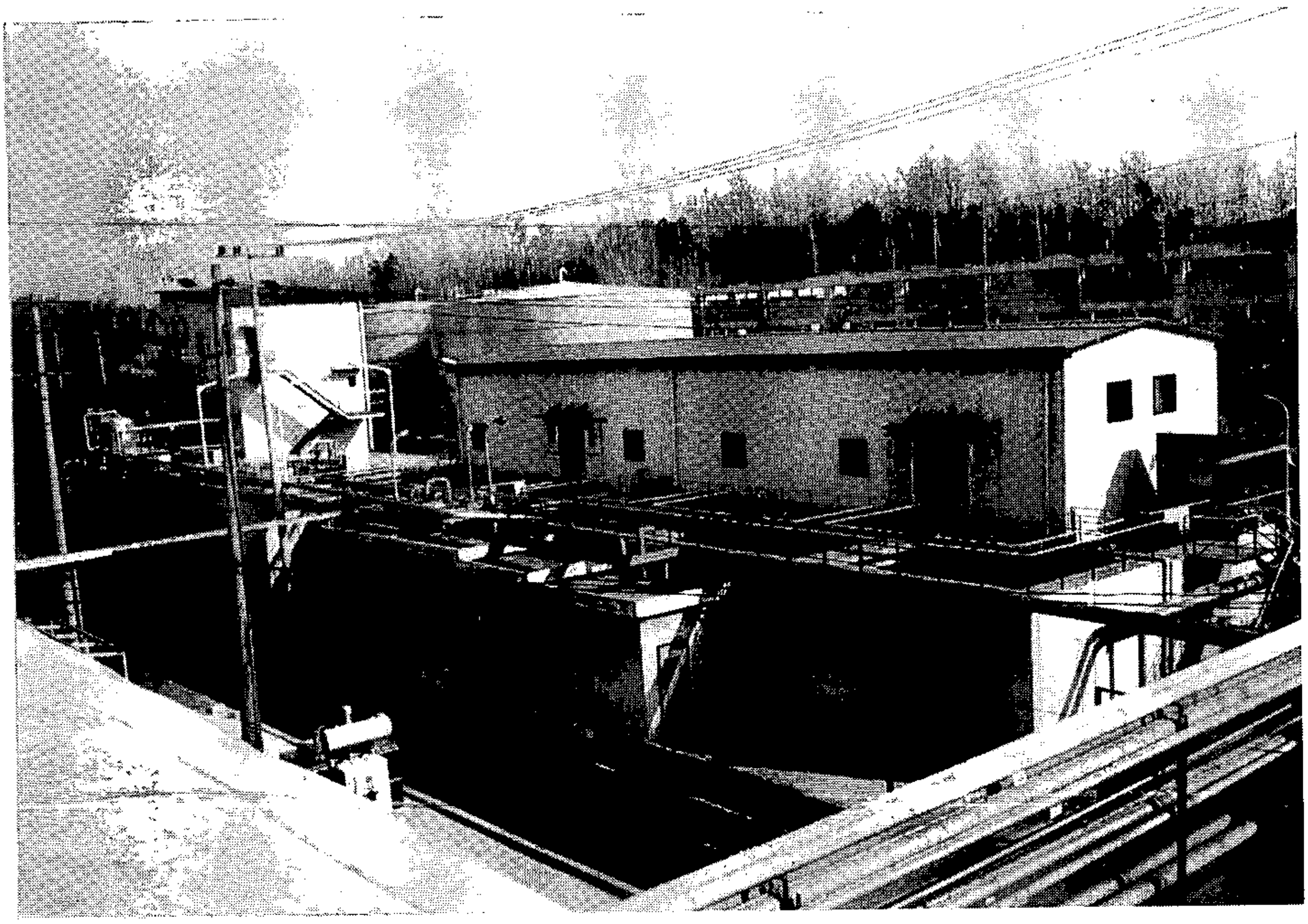
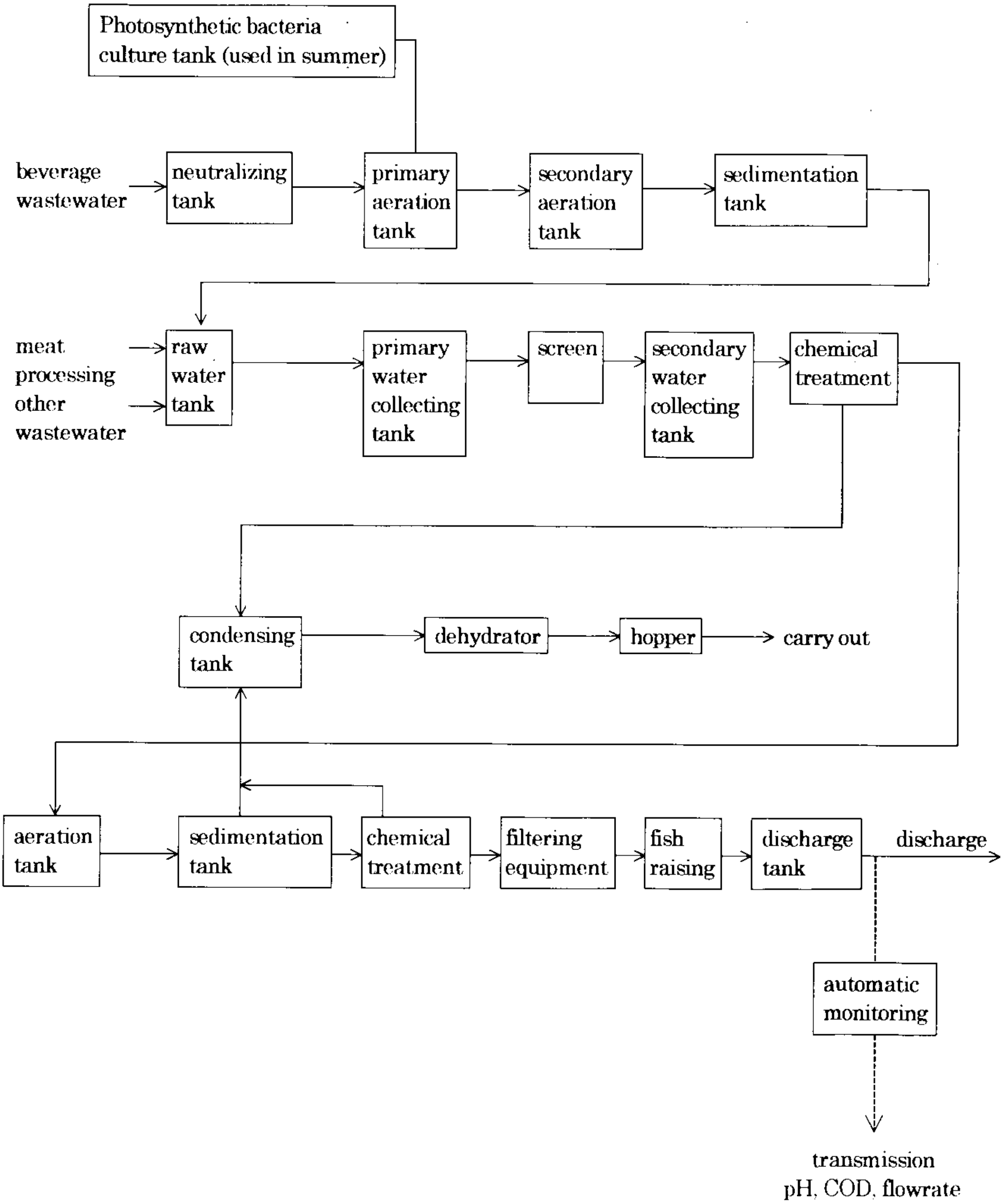


Photo 1 Complete view of wastewater treatment facilities

Photo 2 Fish raising pond for water quality monitoring of treating water using fishes.

⑤ Wastewater treatment process chart



5) Name and capacity of wastewater treatment facilities

Name of facilities	Capacity (m^3)	Quantity
Screen tank	18	1
Water collecting tank	540	1
Sedimentation tank	132	1
Sedimentation tank	100	1
Screen tank	0.75 mm	1
Water collecting tank	1,200	1
Aeration tank	600	1
Sedimentation tank	132	1
Dehydrator	4 m^3/hr	1
Screen tank	0.7	1
Water collecting tank	44	1
Sa;nd basin	5.6	1
Neutralizing tank	13.8	1
Coagulation tank	13.8	1
Pressure floating tank	14.4	1
SCUM storage tank	2.73	1
Aeration tank	612	2
Neutralizing tank	13.8	1
Coagulation tank	13.8	1
Floating tank	35.7	1
Treating water tank	86.5	2
Disinfection tank	1.0	1
Discharge tank	1.5	1
Condensing tank	54	1
Dehydrator	4 m^3/hr	2
Aeration tank	540	1
Sedimentation tank	29	1
Aeration equipment	406	1
Neutralizing equipment (pH adjusting tank)	2	1
Flow rate adjusting tank (treated water tank)	3	1
Bubble removing water tank	7	1
Discharge water filtering equipment	60 m^3/hr	2
Photosynthesis bacteria culture tank	2001	3

6) Promotion activity of environment control

(1) Activities for accident prevention

Section			Number of persons		Remarks
Group Technical Team		General manager, manager, staff, other plant manager	4	once/quarterly	
Plant inspection	Special inspection team	Chief of environment and general affairs, mechanical, electrical, civil, building, production sections	7	once a week	
	Environment safety team	Team chief and staff	1	everyday	
Environment , safety committee		Plant director, section managers, staff, labor union chairman	32	once a month	

(2) Nature protection activities

Division	Place	Number of times	Remarks
One company for one mountain	mountain	once half a year	
One company for one river	river	twice quarterly	
Cleaning around plant	roads and rivers	twice a month	

(4) Plan in future

Kind of field	Plan
Water quality	To control wastewater to BOD within mg/l with facility investment.
	To promote activity relating to reduction of contaminated substances through plant improvement
Waste	To promote activity to introduce advanced technology for waste reduction.
	To promote waste treatment by own corporation.
Others	To execute activities relating to judgment for environment safety continuously.
	To execute the activity "One company in charge of one mountain or one river".
	To promote designation of environmentally-sound corporation.

2. Case of B plant

(1) Fact of plant

1) Outline of plant

- Foundation date: November 3, 1995
- Construction cost: 40 billion yen
- Scale of plant:
  Site area: 63,547 m^3
  Building area 26,835,77 m^3

2) Raw material and production

Raw material			Product		
Raw material	Using (amount/day)	Using (amount/month)	Product	Production (amount/day)	Production (amount/month)
pig	2,000 pigs	50,000 pigs	pig meat	72 tons	1,800 tons
underground water	1,881 m^3	50,000 m^3			

3) Working time
Working time: 8 hours/day
Working time: 25 day (200 hours)/month
Working time: 300 days (2,400 hours)/year

Production item: partial meat and ham, sausage

(2) Outline of environment control

1) Authorization

- Classification: water quality class 2
- Effluent standards: BOD 800mg/l, COD 90mg/l, SS 80mg/l, N-hexane 30mg/l, pH 5.6-8.6
- Business category: Manufacture and processing of beverage and food
- Discharge water system : final discharge outlet→ piping → river → sea

2) Outline of wastewater treatment facilities

Installation cost : 4 billion yen
Wastewater treatment capacity : 2,000 m^3/d
Water use : 1,881 m^3/d (groundwater)
Wastewater discharging amount: 1,881 m^3/d

3) Main of tasks of water quality control offices

- Matters relating to operation of wastewater treatment facilities
- Matters relating to maintenance and inspection for environment associated facilities
- Matters relating to utilities and control for corporation self measurement

- Matters relating to industrial waste treatment and reuse
- Matters relating to purchase of material and chemicals for waste treatment
- Matters relating to utilities contract for waste treatment
- Matters relating to other environmental problems

4) Environmental managers

environment engineer for water quality (class 1) : 3 persons
environment engineer for water quality (class 2) : 1 person
environment engineer for atmosphere (class 1) : 1 person
environment engineer for atmosphere (class 2) : 2 persons

(3) Outline of process and quality of process wastewater

B Plant executes slaughtering, meat processing, and others, and the outline of each process and discharging water quality etc. are indicated as follows.

1) Slaughtering process

	Process	Outline of process	Raw material charging amount /day	Pollution substance generating amount /day	Related discharge equipment
1	Carry-in, inspection	Ecological survey Classification of abnormal pigs Separation of diseased livestock	2000 pigs		
2	Slaughtering	Slaughtering by automatic electric killing machine (Blood which falls vertically at slaughter and is collected is solidified and then treated by contractor.)	water use : 1500 m^3	Wastewater generating amount : 1,500 m^3 pH:6~8 BOD: 1500mg/l COD: 1100mg/l SS : 1100mg/l oil 500mg/l Loliform: 20,000 pc/ml	Slaughtering facility 4,493 m^3 (including indoor area)
3	Head and feet cutting	Head and feet are cut.			
4	Skin removing	Removing of raw skin by machine			
5	Removal of internal organ	Belly cutting, internal organ cutting			
6	Classification	Cutting for each place and classification			
7	Measurement, refrigeration shipping	Export: 300 pigs Domestic demand: 1,000 pigs Raw material : 700 pigs			

2) Meat processing process

	Process	Outline	Raw material charging amount /day	Pollution substance generating amount / day	Related discharge equipment
1	Reception of raw material meat		Raw material meat: 700 pigs		
2	Cleaning, grading and comminution	Selection for each application and comminution	service water $18m^3$	Wastewater generating amount: $18m^3$ pH :6.8 - 7.0 BOD: 650mg/l COD: 300mg/l SS : 500mg/l oil : 460mg/l	comminut-ing machine
3	Mixing and protein activation	Body fluid injection and mixing	Body: 520kg service water: $94m^3$	Wastewater generating amount : $100m^3$ pH :6.8 ~ 7.0 BOD: 520mg/l COD: 250mg/l SS : 310mg/l oil : 460mg/l	Mixing equipment Nature equipment Cleaning equipment Recovering equipment
4	Removal of internal organ	Belly cutting, removal of internal organ			
5	Smoking	Smoking process by smoke			
6	Cooling		Service water : $69m^3$	Wastewater generating amount : $69m^3$ pH :6.8 ~ 7.0 BOD: 230mg/l COD: 140mg/l SS : 110mg/l oil : 150mg/l	Pond sinking equipment
7	Pasteuization				
8	Packing and shipping	Ham:13 tons/day Bacon:2 tons/day Sausage:9ton/day			

3.) Other process

	Process name	Outline	raw material amount /day	Pollution substance generating amount per day	Treating and discharging equipment
1	Car washing	Washing of transfer car: 100 cars/day	water use: $10m^3$	Wastewater generating amount : $69m^3$ pH :6 - 7 COD: 250mg/l SS : 300mg/l oil : 25mg/l	Car washing equipment
2	Incineration	Incineration of pig excrement and discarded internal organ generated in slaughter house	water use: $10m^3$	Wastewater generating amount : $10m^3$ pH :4 - 7 COD: 120mg/l SS : 200mg/l oil : 20mg/l	Cleaning, dust collecting equipment
3	Purifying water	To purify water for use in the plant	water use : 2,000 m^3	Wastewater generating amount : 2000 m^3 pH :6 - 7 BOD: 100mg/l COD: 100mg/l SS : 150mg/l	Purifying equipment
4	Physical and chemical test	Process laboratory	water use: 3 m^3	Wastewater generating amount : $3m^3$ pH :4 ~ 10 BOD: 250mg/l COD: 150mg/l SS : 100mg/l oil : 20mg/l	Physical and chemical laboratory
5	Deodorization and dust collection	Ventilation and dust collection in slaughter house	water use: 48 m^3	Wastewater generating amount : $48m^3$ pH :4 ~ 7 COD: 120mg/l SS : 200mg/l oil : 20mg/l	Deodorizing and dust collecting equipment

(6) Quality of wastewater from each process

1) Process wastewater

	Maximum	Average
Water amount (m^3/day)	2,000	1,761
Water quality		
pH	6 - 8	6 - 8
BOD	1,500 mg/l	1,300 mg/l
COD	1,100 mg/l	1,000 mg/l
SS	1,100 mg/l	1,000 mg/l
oil	500 mg/l	400 mg/l
Coliform	20,000 /ml pcs	16,000 /ml pcs

2) Utility wastewater

Water amount (m^3/day)	120 (average)
Water quality	
pH	6 - 8
BOD	200 mg/l
SS	200 mg/l

3) Wastewater fed into primary water collecting tank after mixing

Item	Process wastewater amount	Living wastewater amount	Mixed water
Water amount (m^3/d)	1,761	120	1,881
Water quality			
pH	6 - 8	7	6 - 8
BOD	1,500 mg/l		1,500 mg/l
COD	1,100 mg/l	200 mg/l	1,100 mg/l
SS	1,100 mg/l	200 mg/l	1,100 mg/l
oil	500 mg/l		500 mg/l
Coliform	20,000 pcs/ml		20,000 pcs /ml

(4) Type of waste and volume of its discharge

1) Sludge

Sludge generation in terms of SS:

$(1{,}100 - 20) \times 2{,}000 \times 10^3/10 \quad \times (1 - 0.8) = 10{,}800$ kg/d

Sludge generation in terms of BOD:

$1{,}500 \times 0.2 \times 2{,}000 \times 10^3/10 \quad \times (1 - 0.8) = 3{,}000$ kg/d

2) Animal remains

2kg/head x 2,000 = 4,000kg/day

3) Treatment method

At present, animal remains are treated by contractor waste trading company or other related companies, but a by-product fertilizer plant of this company is planned to be completed in 1997. Afterwards the entire amount of animal remains will be treated by own corporation for sales.

(5) Design index of pollution control facilities

1) Type of wastewater : slaughtering livestock and meat processing

2) Wastewater volumes

Process wastewater : $1{,}761m^3$

Utility wastewater and others : $120m^3$

Total : $1{,}881m^3$(about $2000m^3$)

3) Water quality

	Before treatment	After treatment	Effluent standards
pH	6-8	6-8	5.8 - 8.6
BOD	1,500mg/l	20mg/l	80mg/l
COD	1,100mg/l	20mg/l	90mg/l
SS	1,100mg/l	20mg/l	80mg/l
oil	500mg/l	5mg/l	30mg/l

For wastewater quality, see (6)

For treatment efficiency for each process, see (7).

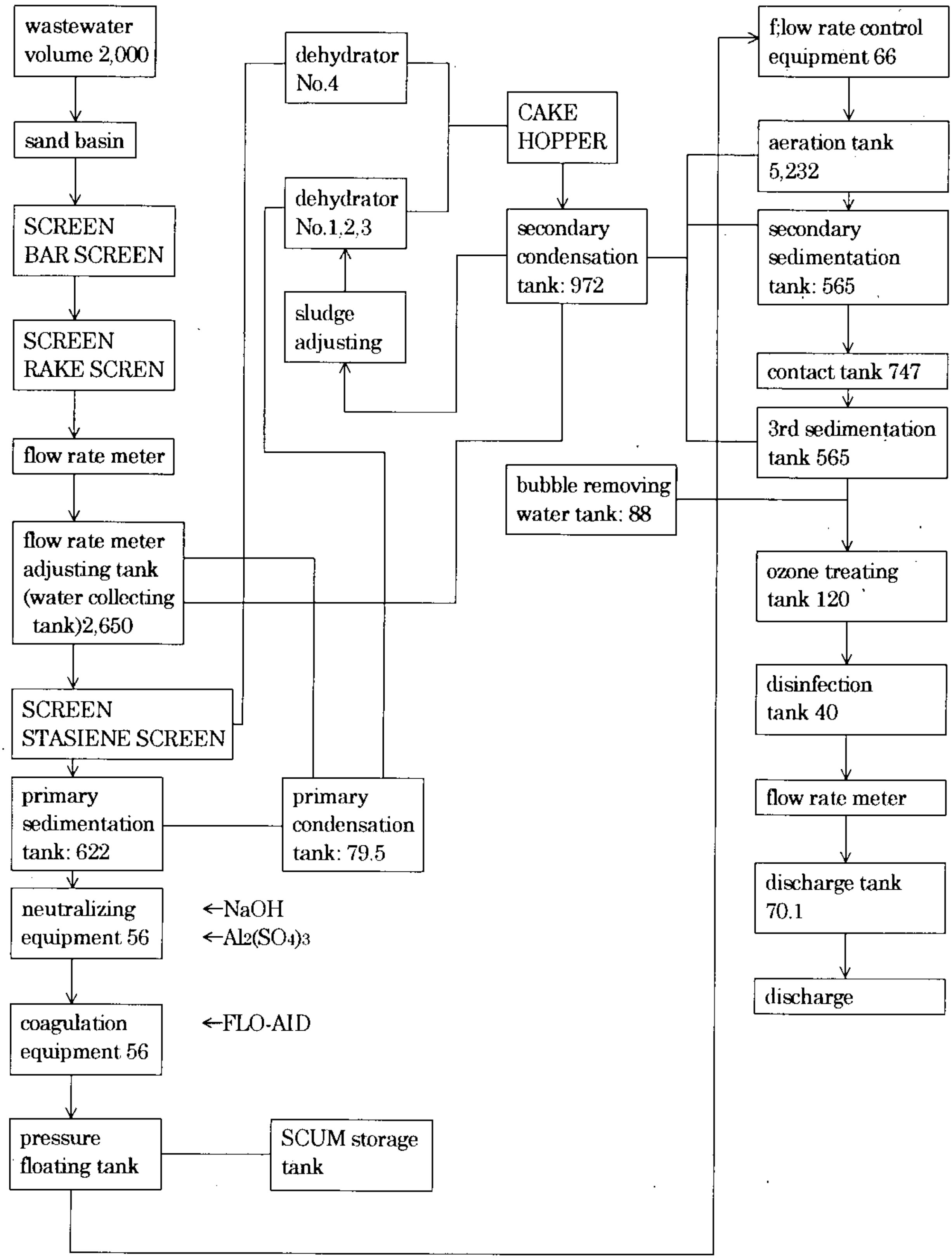
4) Treatment method

The wastewater treatment facilities consist of the following basic structure, and the treatment process is shown in the following flow chart.

Physical and chemical treatment and sedimentation pressure floating treatment → biological treatment → biological treatment (activated sludge treatment using contact material → ozone treatment

Treatment process flow

(unit : m³)



5) Installation of treatment facilities

Equipment	Capacity	Quantity
1. Physical treatment facility		
1) Screen		
bar screen (automatic)	10mm	2
rake screen (automatic)	3mm	2
sive screen	0.75mm	3
2. Grit removal equipment		2
1) Screen tank	$21.6m^3$	1
2) Water collecting tank	$2650m^3$	1
3) Flow rate adjusting tank	$66m^3$	1
4) Bubble removing water tank	$88m^3$	1
5) Discharging water tank		1
3. Coagulation equipment	$70.1m^3$,$56m^3$	1
4. Floating equipment	$70m^3$	1
5. Sedimentation equipment		1
1) Primary sedimentation tank	$622m^3$	1
2) Secondary sedimentation tank	$565m^3$	1
3) Final sedimentation tank	$565m^3$	1
6. Condensation equipment		1
1) Primary sludge storage bin	$37.5m^3$	1
2) Secondary sludge storage bin	$22.5m^3$	1
3) Final sludge storage bin	$22.5m^3$	1
4) SCUM storage bin	$7.5m^3$	1
5) Raw sludge condensing tank	$38.5m^3$	1
6) Superfluous sludge concentrating tank	$972m^3$	1
7. Dehydrator		3
1) Belt press	$5\text{-}13m^3/hr$	1
2) Belt press	$3\text{-}6m^3/hr$	1
8. Neutralizing equipment	$56m^3$	1
9. Disinfection equipment	$40m^3$	1
10. Sedimentation improving equipment	$2.25m^3$	1
11. Aeration equipment	$1,308m^3$	4
12. Contact tank	$747m^3$	1
13. Ozone equipment	$120m^3$	1

(7) Treatment efficiency table

Index			pH	BOD	COD	SS	Oil	Remarks
Raw wastewater			6 - 8	1,500	1,100	1,100	500	
Treatment Efficiency	Grit removal tank and screen	removal rate		5%	3%	15%	20%	
		mg/l		1425	1,067	935	400	
	Primary sedimentation treatment	removal rate		10%	5%	20%	30%	
		mg/l		1,282	1,014	748	289	
	Chemical coagulation and pressure floating treatment	removal rate		59.5%	45.8%	41.5%	91.5%	
		mg/l	7-8	519	549	438	24	
	Primary biological treatment	removal rate		92.3%	90%	93%	62.5%	
		mg/l		40	55	30	9	
	Secondary biological treatment (contact tank)	removal rate		25%	27.3%	17%	22.2%	
		mg/l		30	40	25	7	
	Ozone treatment	removal rate		33%	50%	20%	28.6%	
		mg/l		20	20	20	5	
Total removal rate				98.6%	98.2%	98.2%	99%	
Concentration of final treated water mg/l			7	20	20	20	5	

(8) Construction and maintenance control cost of treatment equipment

1) Construction cost

(Unit: million yen)

Construction	Cost
Civil engineering work	1,080
Machinery and instrumentation work	1,100
Building work	145
Piping work	96
Electric work	151
Ozone treatment equipment work	300
Other work (including test run)	18
sub-total	2,890
General management and surcharge, other expenses	1,930
Total	3,920

2) Maintenance control cost

(unit: thousand yen)

Item	cost/day	cost/month
Cost for chemicals	210	6,300
Power cost	330	9,900
Sludge treatment cost	360	9,000
Labor cost	250	7,500
	1,150	32,700

(9) Investment plan for equipment

Since the institution of basic imposition tax is executed from 1997, we can acquire the budget of about 60 million yen for 1997 fiscal year. Therefore we are ready to actively respond to Government's pollution control policy in terms of wastewater treatment by installing activated carbon treatment and sand filtration treatment facilities together with the pretreatment by ozone.