Measures and Policies against the Eutrophication for Lake Water Quality in Japan

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Abstract: Lakes and marshes are valuable water resources and natural environments for the human beings, it is necessary to preserve and improve their water quality. Since experiencing severe pollution problems during the 1950s and 1960s, Japan has been strengthening its environmental policy. Regulations over the quality of water were enforced under the Water Pollution Control Law, resulting in the successful reduction of pollutants during the 1970s and 1980s. In this paper, the present status of the special measures for conservation of lakes water quality in Japan, and the measures for reducing influent loads from point and non-point sources, dredging of the sediment contamination on the lake bottom and water purification by means of vegetation, wetland, restoration of the lake’s original landscape and integrated watershed management etc. are discussed.

Keywords: Eutrophication, point source, non-point source, nutrient, watershed management

1. Introduction

Lakes and reservoirs are very important property for people’s life, industrial activities and so on. They provide various benefits to us, such as securing water resources for drinking, agriculture and industrial use, fishery resource, flood control functions and ecosystem integrities. However, because of the closed nature of lakes’ water system, pollution tends to accumulate therein, and once water is polluted, it is difficult to improve the water quality. In addition, the situation at hand is that a remarkable improving tendency of the water quality of lakes is not seen due to the increase of the pollutant load by the economic change and the increase of the population as well as the change in the lake environment etc. Water environment in lakes and marshes is remarkably awful compared to rivers and sea areas worldwide. However, lakes and marshes are the valuable water resources and natural environment for the human beings, thus it is necessary to preserve and improve the water quality of lakes and marshes. The lake water quality improvement in Japan was insufficient only by the restriction of Clean Water Law, thus, the lakes and marshes water quality control special measures law (lakes and marshes law) were enacted in 1984. Although the lakes and marshes law has been enacted and 20 years have passed, the water quality improvement of the lake is not admitted as expected. In this paper, the history and special measures and policies for the conservation of the lake water quality in Japan are reviewed and the guideline of measures to manage non-point source pollution and its prospective were discussed.

2. History of water pollution control in Japan

Water pollution has a long history in Japan. In the 19th century, local residents in the lower region of the Watarase River suffered from pollution caused by a copper mine upstream. In 1956, an outbreak of Minamata disease was first reported when people became sick from eating fish caught in Minamata Bay that had been contaminated by methylmercury discharged from chemical plants into the bay.

During the 1960s, problems of environmental pollutants in water increased. For example, cadmium contamination in the Jinzu River caused a disease that made the bones brittle. In addition, increases in organic matter decreased oxygen in many rivers, bays and lakes, causing local people to suffer from bad smells, diminished fish populations, and poisonous planktons and bacteria which grew in such water.

Thus, the Water Pollution Control Law was legislated in 1970, and the Interim Law for Conservation of the Environment of the Seto Inland Sea was legislated in 1973. The Seto Inland Sea, located between Honshu and Shikoku, requires special measures to limit the total amount of pollutants. The interim law became permanent in 1978. The Law Concerning Special Measures for the Preservation of Lake Water Quality was legislated in 1984. The law system was well established to prevent eutrophication in closed water bodies. These laws encouraged the development and commercialization of advanced technologies to remove COD, nitrogen and phosphorus.

In 1990s, "Basic Environment Law" was legislated to set environmental quality standards for water quality, etc. "Drinking Water Sources Law ", "Laws Concerning Special Measures for
Conservation of Drinking Water Sources" and "Law on Livestock Excreta Management and Recycling" were enacted to keep water sources from being polluted.

In the early years of the 21st century, pollution caused by hazardous substances began posing a new problem. So "Law Concerning Special Measures against Dioxins" and "Soil Contamination Countermeasures Law" were enacted. Furthermore, environmental quality standards for water were also established for the preservation of aquatic plants/animals, tightening the regulations for the protection and improvement of water environment.

Table 1 shows the chronology of water environmental management in Japan.

3. Special Measures for the Preservation of Lake Water Quality

Despite various efforts to improve water quality of lakes, such as establishing and upgrading national standards for water effluent and constructing comprehensive sewerage systems, there has been little improvement in lake water quality in Japan. Rather, water pollution of lakes has become more severe due to following reasons:

1) Lakes and marshes are enclosed water bodies. It is easy for pollutants to flow into lakes and marshes and accumulate because the bulk of the water remains relatively stagnant. It is necessary to significantly reduce the influx of pollutant loads from their inflow rivers in order to improve the lake water quality.

2) Lakes and marshes pollution is caused by various nutrient sources such as point sources including industrial and domestic wastewaters, and non-point source with agricultural runoff, livestock runoff, and nutrient loads from aquatic culture. Therefore, conventional measures that simply focus on establishing effluent standards for industrial and domestic wastewater and sewerage systems are not effective enough. More comprehensive countermeasures that

<table>
<thead>
<tr>
<th>Year</th>
<th>EVENT</th>
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<tbody>
<tr>
<td>1891</td>
<td>The Ashio Copper Mine issue discussed in Diet session</td>
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<tr>
<td>1897</td>
<td>Ashio Copper Mine Pollution Investigation Group organized</td>
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<tr>
<td>1948</td>
<td>Agricultural Chemical Registration Law enacted</td>
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<tr>
<td>1949</td>
<td>Mine Safety Law enacted</td>
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<tr>
<td>1956</td>
<td>Minamata Health Center discovers a &quot;strange disease&quot;</td>
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<tr>
<td>1958</td>
<td>Water Quality Conservation Law and Factory Effluent Control Law enacted</td>
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<tr>
<td>1961</td>
<td>Total odor from fish on and off the coast of Minamata becomes an issue</td>
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<tr>
<td>1965</td>
<td>Special Committee for Environmental Pollution established in both the Upper and Lower Houses</td>
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<tr>
<td>1967</td>
<td>Basic Law for Environmental Control enacted</td>
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<tr>
<td>2005</td>
<td>Amendment of the Law concerning Special Measures for the Preservation of Lake Water Quality</td>
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</table>
3) Condition of water quality and causes of water pollution vary among lakes and marshes. Conventional standardized measures are not effective enough. Therefore, it is important to devise individualized measures for each lake and consider the whole watershed’s unique natural and social conditions. It is also important that these measures be implemented in a well-planned and organized manner.

Therefore, it is important to establish cooperation among related ministries, agencies and divisions of national government, local government, municipal governments, private industries and citizens for the integrated measures in order to make progress towards these integrated measures. With this awareness, the Lake Law was enacted in 1984.

3.1 Purposes of the Lake Law

The conceptual purpose of the lake law is to improve water quality of lakes and marshes and to protect public health and the living environment. The primary purpose of the law is to establish basic policies for the preservation of lake water quality and to formulate a plan regarding measures for the preservation of water quality of those lakes that are identified by the Prime Minister as “designated lakes”.

The report submitted in 1981, by the Central Environment Protection Committee, proposed a legal system that protects not only lake water quality but also the natural environment around lakes as a holistic ecological system. However, it has been argued that the existing laws such as the “Natural Environment Protection Law”, “Forest Law”, and “Urban Planning Law” already addressed the issue concerning protection of the natural environment around lakes. As a result, the Lake Law centers on addressing lake water quality protection.

The Law targets mainly those lakes where water quality improvement is urgently needed. After the Prime Minister identifies lakes as “designated lakes”, the central and local governments are obliged to improve water quality using various measures.

3.2 The Contents of the law concerning special measures for protection of lake water quality

In 1984, the law concerning special measures for protection of lake water quality (Clean Lake Law) was adopted to control water pollution in lakes and marshes. This law required the overall and deliberate implementation of projects to contribute to the protection of water quality. This included construction of sewage systems, and strict regulations of various pollution sources, for designated lakes and marshes. This law initiated systematic efforts against urban pollution by domestic sources.

The following summarizes the law.

1) The national government prepares the Basic Policy for Conservation of Lake Water Quality, which describes the basic strategy for the protection of water quality in lakes and marshes.

2) The Prime Minister designates certain lakes and marshes, where extensive measures should be taken to protect water quality. In addition, he shall also designate areas that would influence water quality degradation in these designated lakes and marshes.

3) On the basis of the Basic Policy for Conservation of Lake Water Quality, governors prepare a Plan for Conservation of Lake Water Quality for each of the designated lakes and marshes. The Plan describes the policy for protection of water quality and projects, such as construction of sewage systems that will contribute to the protection of water quality of lakes.

4) The following special measures are taken to protect water quality in the designated lakes and marshes.

a) The first is the regulation of effluents from factories and business establishments in the designated area. In addition to conventional regulations on the concentration of pollutants, governors can set regulatory standards for the pollution load in the industrial effluents. When he recognizes that an effluent from new or expanded establishments specified by the Water Quality Control Law does not comply with these regulatory standards, he can issue an order so that necessary measures are taken for improvement.

b) The second is the regulation of effluents from those facilities that are not the specified facilities, but regarded in same manner. These include facilities permitted by cabinet orders to discharge wastewater to lakes and marshes. Permitted facilities include private sewage treatment tanks smaller than a certain size. Because of their large numbers they (collectively) are regarded as equivalent to the specified facilities, under the Water Quality Control Law, and are subject to the provisions of this law.

c) The third is the requirement for notification of the establishment of designated facilities. This includes, for example, feed lots smaller than a certain size. If a governor recognizes that these facilities do not comply with the standards, say for proper construction, he can recommend improvement and also order the improvement.

d) Forth is the reduction of pollutant loads. Measures are taken to reduce total pollutant loads to designated lakes and marshes, where effluent standards alone, due to the concentration of industries and human population in the lake basin cannot achieve water quality standards.

e) Fifth is the requirement for protection of the natural environment around lakes. This includes preservation of green areas to serve as buffers to help protect water quality in designated lakes and marshes.

5) In addition to above, the law provides, if appropriate, the guidance and assistance required
for the protection of water quality in lakes and marshes, and cooperation among the relevant administrative organizations.

The major aims of the law can be summarized as follows:

1) To introduce special regulations to control pollutant discharges into the watersheds of designated lakes based on the existing regulations of the Water Pollution Control Law.

2) To carry out comprehensive lake water improvement measures by achieving cooperation and consensus between the central and local governments for each of the designated lakes. The comprehensive measures should include projects for

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**Fig. 1 Legal System concerning the Lake Law**

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1. **Basic Policy for the Conservation of Lake Water Quality**
   - Basic lake water quality conservation concepts
   - Fundamental issues concerning the measures for the conservation of water quality for designated lakes

   - **Prime Minister** → **Cabinet decision**

2. **Request by Prefectural Governors (designation of lakes)**

3. **Designation of Lakes and Watersheds**

   - **Prime Minister** → **Cabinet decision**

4. **Plan for the Conservation of Lake Water Quality** (renewal every five years)
   - Policy on the conservation of water quality in designated lakes
   - Matters concerning projects contributing to the conservation of water quality
   - Regulations and other measures

   - **Hearing of the opinions of the concerned prefectural governors**
   - **Hearing of the opinions of the concerned municipal leaders**

5. **Implementation of Projects Contributing to the Conservation of Water Quality**

   - **Sanction of Prime Minister** → **Conference on Environmental Pollution Control**

   - **Drafted by prefectural governor**

6. **Regulations to Reduce Pollutant Load**

   - (1) Pollutant load restrictions on newly built or expanded factories and other business establishments in designated watersheds
     
   - (2) Effluent regulations on “regarded-as-specifies” facilities

   - (3) Controls on the structure and operations of designated facilities and quasi-designated facilities

   - (4) Total pollutant load control

7. **Other Measures**

   - Guidance, advice and recommendations to people other than those responsible for the facilities subject to regulations
   - Efforts to protect the natural environment on the lake shores, such as the conservation of greenery areas
improving sewerage systems and some action plans for implementation of regulations that will protect lake water quality. Figure 1 summarizes the overall approach of the Law.

As of March 1997, ten lakes have received designated status, i.e., Kamafusa dam, Lake Kasumigaura, Lake Inbanuma, Lake Teganuma, Lake Suwa, Lake Nojiri, Lake Biwa, Lake Nakaumi, Lake Shinji, and Lake Kojima.

3.3 Guidelines for water quality preservation measures for designated lakes

Guidelines for water quality preservation measures for designated lakes are mentioned in the Basic Policy for the Preservation of Lake Water Quality:

(1) Construction of sewerage and night soil treatment facilities

The construction of public sewerage systems should be promoted because these systems are effective in reducing pollution loads from households and industries. Construction of treatment facilities for human waste and gray water should also be promoted by considering the unique condition of each area.

(2) Reduction of pollutant loadings from industries

Existing effluent standards are enforced only for specific industries and business facilities that are regulated by the Water Pollution Control Law. The Lake Law, however, can extend its application of the effluent standards to facilities that are not regulated by the Water Pollution Control Law. There should be a concerted effort to enforce the Law against all industries and businesses.

(3) Reduction of pollutant loadings from households

Proper installation and maintenance of septic tanks (Johkaso) should be promoted for those areas not served by public sewerage systems. Furthermore, treatment of gray water should be promoted by introducing proper facilities such as “Johkaso”. Active campaigns should also take place to educate citizens on matters concerning the problems of discharging suspended solids from household kitchen activity.

(4) Reduction of pollutant loadings from livestock

Pollution loads from livestock should be reduced by enforcing effluent standards and maintenance standards for livestock sheds and feed lots. Construction of treatment facilities for livestock excretion should also be promoted actively.

(5) Reduction of pollutant loadings from fish cultivation facilities (fish hatcheries)

Pollutant loadings from fish hatcheries can be very high, therefore fish cultivation structures and maintenance systems should be improved to reduce their pollution discharges.

(6) Reduction of pollutant loadings from other sources

Other pollution sources such as nonpoint source pollution from farmland should be reduced, but not without consideration for the livelihood of farmers and farmland activities.

Other nonpoint sources such as runoff from urban areas should also be reduced. To that end, appropriate methods for measuring and assessing pollution loads from runoff and their effects on lake water quality should be developed.

(7) Dredging of bottom sediment and other measures for the improvement of lake water quality.

In lakes and rivers where organic substances have accumulated in the bottom sediment, measures such as dredging of the bottom sediment, aeration, introduction of clear water from outside sources, and aquatic weed removal should be implemented.

(8) Protection of forests and natural environments in lake watersheds.

In addition to the above mentioned measures for reducing pollution loads, existing laws, such as the Natural Environment Protection Law, Natural Park Law, Forest Law, Urban Planning Law, Urban Green Area Conservation Law and River Law should be applied to promote the protection of forests in lake-watershed areas and lakeshore natural environments.

(9) Other considerations

In addition to the above mentioned, the following issues are considered important for the improvement of lake water quality.

(a) Water quality improvement activities for lakes that are not designated lakes.

(b) Improvement of water quality monitoring systems.

(c) Promotion of research and development of technology for water quality conservation.

(i) Research on lake ecosystems.

(ii) Research on fresh water red tide generation mechanisms.

(iii) Measurement of pollution loads from forest areas, farmland, and urban areas.

(iv) Evaluation of water purification functions by forests, wetlands, and lakes themselves.

(v) Development of treatment technology for various kinds of wastewater.

(vi) Development of measures for improving lake water quality.

(vii) Development of technology for water quality monitoring.

(d) Information dissemination concerning lake water quality and improvement measures.

3.4 Lake Water Quality Preservation Plan

The main contents of the Lake Water Quality Preservation Plan are as follows:

1) The basic policy concerning the preservation of the water quality, the plan period and the target water quality value at the last year of the plan period are shown in the Plan.

2) The building and maintaining of drainage system, the other household wastewater treatment facilities, the
animal manure waste treatment facility, the waste
disposal facility, and the purification measures of
lakes and reservoirs, and the purification measures of
river water, etc. are shown as projects contributing to
the preservation of the water quality in the Plan.
3) The restriction to the pollutant load from the factory
drainage, the household wastewater, and a livestock
industry, fish culture, and the measures to control the
non-pointed-source of pollution, and the conservation
of green area and the other natural environment in the
vicinity of the lake, etc. are shown as restriction
measures for the preservation of the water quality in
the Plan.
4) The measurement of water quality in public waters,
promotion of the research study, and securing the
cooperation with local residents, the adjustment with
the related regional plans, and the promotions to the
business sector, etc. are shown as concerning
necessary measures in the Plan.

3.5 Establishment of a Plan for Preserving Lake
Water Quality by Local governments
When designated lakes and designated areas are
determined in accordance with the Lake Law, the
Governor of Prefectures, as stipulated in “the Basic
Policy for Preservation of Lake Water Quality”, shall
prepare a plan (hereinafter referred to as “Plan for the
Preservation of Lake Water Quality”). This plan should
be revised every five years. The purpose of revising the
plan every five years is to assess the outcome of implemented measures and to adjust the plan
accordingly.
When preparing the Plan for the Preservation of Lake
Water Quality, the governor of each prefecture should consult with agencies that will be implementing the plan, the mayors of the cities, towns and villages concerned, and the agencies in charge of managing rivers. The Governor should then obtain final approval from the Prime Minister.

3.6 Amendment of the Law concerning Special
Measures for the Preservation of Lake Water
Quality
Although conformity with the environmental
quality standard for chemical oxygen demand (COD)
in lakes and reservoirs reached 50.9% in FY 2004, the
water quality is still far from satisfactory. In view of
this, the government amended the Law concerning Special Measures for the Preservation of Lake Water
Quality (Clean Lake Law) in June 2005 to establish a
new Scheme of the Special Area for Non-point Source
Pollution. This designates urban areas and farmland in
specified areas as requiring pollutant load control
measures from non-point sources and formulates plans
to implement measures, and to establish a new Lake
Environment Protection Area System to properly
protect the environment of lakes and reservoirs for
better water quality. The main items of the regulation's amendment include defining the regulatory standards for pollutant discharge load for existing facilities, specifying categories of plants which are to be protected by the lakeside environment protection area scheme, and defining the details of the notification procedure for activities to be conducted in the lakeside environment protection areas. The effective date of the amendment is April 1, 2006.

The Cabinet adopted a Bill Partially Amending the
Law Concerning Special Measures for the Conservation of Lake Water Quality on March 8 and submitted the bill to the 162nd Session of the Diet. The improvement of lake water quality has been stagnant although the Law has been enforced for more than 20 years. Taking this into consideration, necessary amendment is made to promote further improvement of water quality of lakes and reservoirs. The outline of the Amendment is as
follows:
1) Further reduction of pollution load flowing into lakes
and reservoirs
(1)Establishing an area for effluent control;
To designate areas where control of pollution load in the effluent from agricultural and urban areas is necessary.
To formulate plan for control of pollution load in the effluent and promote necessary measures for it.
(2)Expanding the scope of regulation for factories and
business establishments
Pollution load control which was applied only to newly established or expanded factories and business establishments shall be newly applied to the existing factories and business establishments.
2) Protection of appropriate lake environment to secure
water purification capacity
Establishing protected areas in the surrounding areas
of lakes and reservoirs.
Designating areas where special protection is required
for water quality preservation (eg. reed bed
surrounding lakes and reservoirs)
Requiring notification for activities such as plant
3) Others
To incorporate hearing the views of local residents
concerned into formulating process of the lake water
quality conservation plans.

4. Strengthen implementation of nutrient
reduction measures for lakes
The so-called non-point source pollution that
flows with rainwater is one of the main causes of
water pollution. To take effective measures to tackle
non-point pollution sources such as urban areas and
farmland, the government formulated and reviewed
plans for model lake basins. In order to reduce the
pollutant discharge load that flows into public waters
when raining from urban areas such as residential
areas and roads, local governments, river management
agencies, sewerage management agencies, and
concerned parties all joined forces to formulate the
Emergency Action Plan for Improvement of Water
Environment (Clear Water Renaissance II) so as to take comprehensive, urgent, and priority measures to improve the water environment.

Besides the nutrient reduction measures; from the viewpoint of reducing environmental burden and promoting a sound material cycle for highly sustainable agricultural production, the government has promoted designation of so-called “eco-farmers” who use compost for soil conditioning while reducing the use of chemical fertilizers and agricultural chemicals based on the Law for Promoting the introduction of Sustainable Agricultural Practices. As of the end of March 2005, 75,699 farmers have been approved. The government also gave assistance to help promote appropriate application of fertilizer that corresponds to local situation such as climate conditions and soil type, and to set up guidelines to promote proper fertilizer application.

Furthermore, the Ministry of the Environment established "Lake Water Study Committee" in March, 2004 to study lake water environment conservation suited for current situation. Recently, the report of the study was compiled.

Outline of the report is as follows:

1) Appropriate evaluation of water environment of lakes and marshes
   (1) Enhancement of monitoring system for analyzing contamination mechanism.
   (2) Construction of a system, which enables public to participate from target setting of a conservation plan to its evaluation, such as setting easy to understand indices.
   (3) Promotion of a conservation plan with cooperation and participation of local residents and people concerned.

2) Promotion of effective measures to reduce pollution load
   (1) Point source of pollution
      • Consideration on measures to improve treatment ratio of domestic effluent through improving contact ratio by public enlightenment, and to improve treatment capacity by applying advanced treatment technology.
      • Consideration on making pollution load measurement as a requirement for existing facilities and application of waste water treatment standard to facilities not subjected for control.
   (2) Non-point source of pollution
      • Consideration on selective measures by designating a catchment area having large pollution load from non-point sources and figuring out the effects of the measures taken.
      • Consideration on promotion of appropriate fertilization through Eco-Farmer System and publicizing its effects on water quality improvement to obtain understanding and consensus on measures from local residents.
   (3) Application of natural purification capacity

   • Consideration on measures to utilize natural purification function: such as selecting an area to restore, conserve vegetation in lakeshore, and to have thorough management of the area.
   • Consideration on elimination of fish giving adverse impacts on water environment of lakes and marshes, and possible improvement of water quality by bio-manipulation based on features of lakes and marshes.

3) Perspective for comprehensive planning
   (1) To incorporate into policy and measures, of perspectives which are closely connected to lake water quality; such as catchment area management, recovery of water cycle, conservation of ecological system, and responding to the needs of local residents.
   (2) To create systematic measures based on the features of lake and present long term vision.
   (3) To clearly indicate the public participation from planning, implementation and up to evaluation.

4) Promotion of measures based on precise evaluation
   (1) Quantitative evaluation of measures and system based on the quantitative evaluation.
   (2) Enhancement of monitoring system for water quality of catchment area including lake water.
   (3) Information sharing among the people concerned.
   (4) Increasing designated lakes and marshes.

5. Major tasks for the water environmental preservation of lakes and marshes in the future

Although the lakes and marshes law has been enacted and 20 years have passed, the water quality improvement of the lake is not admitted as expected. Therefore the lakes and marshes law was revised in 2005, and the non-point source load measures, the waterside vegetation protection measures, and regulations on total emission, etc. have been introduced. It is not enough to only control the pollutant from land region because there are internal loads from the bottom mud occupying about 30 to 50% to pollutant load (COD, TN, TP) of lakes and marshes. Generally, the pollutant load from the domestic wastewater system still occupies a large percentage. However, COD and nitrogen from the non-point source are larger than the domestic wastewater system. Moreover, the nitrogen from livestock wastewater is the second largest source. The proportion of pollutant load from non-point source depends on the characteristic of the catchment of the lakes and marshes. However, the measures against pollutant load from non-point source are essential. The reproduction of lakes and marshes (eutrophication measures) should not be represented by the water quality value itself, it should be considered the reproduction strategy based on entire environmental
conditions including microorganisms, sediment, eco-tone environment etc. Moreover, it is preferable for evaluating the water quality not only COD, T-N, T-P, but also the transparency, DO in the bottom layers, Chl-a. In order to preserve the lake environment, it is important to reduce the COD, T-N, T-P load from the inflow and the load released from bottom mud.

Environmental conditions within lakes and marshes and in their watershed all influence eutrophication. Rivers and streams are major routes of the transfer of nitrogen and phosphorus, and they integrate point and non-point sources of nutrients. Recycling of nutrients from sediments to overlying waters can sustain eutrophic conditions for long periods after the external loading is reduced. The primary step in the reduction of eutrophication of a lake or marshes or reservoir is to limit, divert, or treat inputs of nutrients and associated particles. However, because lakes and reservoirs can trap and recycle nutrients and organic matter, reduction in loading from the watershed may not reverse the impact of eutrophication. Therefore it may be necessary to modify internal chemical, biological and physical processes. Evaluation of eutrophication, particularly in developing countries, must balance benefits gained from increased fertility of lakes or reservoirs against problems associated with the degraded quality of water used for domestic and industrial purposes.

The following are the major tasks to be considered for the water environmental preservation of lakes and marshes.

1) It is necessary to catch lakes and marshes as watershed management, and to limit the land use in the target catchment.
2) Non-point sources strategy, especially to reduce the load from urban storm, and agricultural discharge.
3) To remove the nitrogen and phosphorus from domestic, industrial, factory and business, small-scale wastewater.
4) To restore the eco-tone in the lakes and marshes area.
5) To prevent the expansion of exoticism and secure and maintain the species diversity.

6. Summary

Despite the implementation of various measures for improving water quality, such as legal regulation of effluent and construction of sewerage systems, water quality of lakes in Japan have not improved noticeably. This clearly indicates that, once degraded, it is extremely difficult to restore lake water quality. The following summarized the necessity of the main points for further improvement of lake water quality.

1) Removal and reduction of nutrients in wastewater both from point sources and non-point sources considering regional, natural, and social conditions;
2) Nutrient removal in wastewater from small-scale factories and business facilities;
3) Development of unique measures suitable to specific regional conditions and research on land use regulations;
4) Promotion of research on ecological effects and risk assessment relative to degraded lake water quality.
5) Restoration of the eco-tone in the lakes and marshes areas.
6) Integrated approach for the lake basin management and the cooperation amongst the local residents, the municipalities and the related ministries.

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