generation sources are implemented first.

Measures for generation sources are roughly divided into two categories: non-point and point source countermeasures (see **Table 5-1**). Non-point source countermeasures will be given importance as 85% of the runoff load in the Mar de Dentro area originates from non-point sources. Recently, related studies have been systematically carried out in the USA, and the results led to the quantitative evaluation of the effects of various methodologies. **Table 5-2** shows the evaluation of the applicability of various countermeasures, including their impacts, in Mar de Dentro.

For the preservation of the water quality of Patos Lake, it is imperative that load reduction measures be applied first in areas close to the lake. In addition, to gain the cooperation of land users for the implementation of non-point source countermeasures, a demonstration should be carried out in the Mar de Dentro area to evaluate not only the load reduction effects, but the impacts that would improve land productivity.

## 5.4 Scale of Load Reduction Measures

In Mar de Dentro, 85% of the TP runoff load originates from non-point sources. Non-point source countermeasures are very necessary, therefore, to prevent eutrophication. The scale of the countermeasure, which basically stipulates the construction of suitable wastewater treatment facilities in point sources where load runoff is comparatively easy to control, and the reduction of the rest of the load at the non-point source, was calculated. Appropriate load reduction rates will be decided for every countermeasure based on available data.

The calculation results show that the implementation of countermeasures that would separately reduce runoff from urban areas, rice paddies, fields and pastures down to 50% is an indication that the target reduction load is almost within reach.

This trial calculation is carried out assuming no changes in present land use conditions. If the discharge load can be reduced by converting the use of the land (forestation, etc.), the scale of the countermeasures can be reduced. Although this trial calculation assumes measures for generation sources, this may also be used to verify any improvements in water quality when applied in the measures for the runoff process and measures within the lake.

## Table 5-1 Load Reduction Measures and Their Application Conditions

| Targets | | Method | Principle | Points to consider (when applied in the Mar de Dentro Area) |
|---|---|---|---|---|
| **Generation Source (Point source)** | Households | Improvement of sewage treatment rate (especially for urban areas) | Effective removal of pollutants (organic substances, bacteria, nutrient salts) from sewage from a densely populated area. | • Though there are many treatment methods, the method that involves a low cost but a high removal ratio of nutrient salts as well as organic substances, will be selected.<br>• A treatment method that uses the nutrient removal function of aquatic plants is considered suitable in view of the number of wetlands around Patos Lake. |
| | Factories/ Enterprises | Installation and adequate maintainance of wastewater treatment plant | Construction of a wastewater treatment plant that meets the wastewater standards, and the adequate operation and maintenance of the plant for the effective reduction of effluent load. | • To establish effluent standards, that include nitrogen and phosphorous, by type of industry<br>• Appointment of an effluent caretaker by each industry and the periodical submission of monitoring results. |
| | | Adequate storage and disposal of sludge | To prevent the runoff of sludge from a wastewater treatment plant into rivers and canals. | • Notification of authorities of the depository, the company contracted for disposal, and the disposal site.<br>• Registration of company contracted for disposal and its approval by relevant authorities. |
| | | Introduction of the "Cleaner Production" concept | To reduce wastewater and wastewater load from industries by improving the production process. | • To verify that improvements in the manufacturing process lower manufacturing cost and make managers of the respective industries to understand this.<br>• To give economic incentives to promote "cleaner production" |
| | Solid waste disposal site | Construction of sanitary landfill site | To reduce load from solid waste disposal site through the construction of leachate treatment facilities. | •Municipalities are legally required to construct a sanitary landfill site in urban areas. |
| | | Treatement of leachate from the existing disposal site | To reduce load from the existing solid waste disposal site without leachate treatment facilities, through improvement works | • **Actual leachate contamination conditions should be studied.** |
| **Generation Source (Non-point source)** | Urban area | Construction of retardation pond | To reduce waste and pollution load by directing initial rainwater runoff from urban areas to a retardation pond | • It is dfficult to secure lot for the retardation pond in an urban area.<br>• Periodical dredging is necessary. |
| | | Improvement of solid waste collection rate | To reduce litter in the urban area in order to reduce pollution load resulting from waste. | |

## Table 5-1 (continuation)

| | | | | |
|---|---|---|---|---|
| **Generation Source (Point source)** | Farmlands | Soil conservation | To redufce runoff load of organic substances, nutrient salts and agro-chemicals through the prevention of soil erosion and soil runoff using mechanical and agronomical methods | • There is a need to develop and popularize an environmental conservation oriented agriculture suitable to the Patos lake basin.<br>• To popularize an environmental conservation oriented agriculture, environmental education and economic incentives should be carried out for the farmers<br>• Soil conservation shall be introduced on the slope with a gradient of more than 5 degrees. |
| | | Adequate use of fertilizer | To reduce runoff amount of nutrient salts by controlling fertilizer input. | |
| | | Adequate use of agricultural chemicals | To reduce runoff amount of agricultural chemicals by controlling their input | |
| | | Adequate water management in paddy fields | To reduce dicharge load from paddy field by controlling excess water | |
| | Others | Protection and development of forests | To reduce load from fields and pastures by converting these areas into a forest with low generation load. | • An arable land that inclines to more than 25 degrees shall be converted into a forest.<br>• The stabilization of water sources and prevention of flood are also realized. |
| **Runoff Process** | Rivers | Protection and development of riverine forests | To reduce runoff load by using the riverine forest as a buffer zone for soil runoff. | • Contributes not only to the reduction of runoff load but also to protect the habitat. |
| | | Prevention of riverbank erosion | To prevent soil runoff through forestation on a river bank | |
| | Wetlands | Conservation of wetlands | To conserve water quality using the purifying functions of the wetland | • Contributes to the protection of habitat. |
| | | Development of artificial wetlands | To reduce load flowing into a lake by developing articicial wetlands that would also serve as a retarding pond | • Contributes to the protection of habitat |
| **within a Lake** | Water body | Improvement of water circulation | To facilitate load outflow by improving water circulation in the area where pollutants retard. | • Applicable in inlets or bays. |
| | | Water conveyance | To dilute polluted water with good quality water from other water sources | • Reduction in the dicharge of rivers which supplies dilution water. |
| | Bottom mud | Dredging | To reduce erosion load by removing polluted bottom sediments. | • To reduce inflow load by sewage treatment etc. is a precondition.<br>• The impacts of dredging does not continue for a long time in spite of its high cost. |

## Table 5-2 Comparative Evaluation among Load Reduction Measures

| Object (wastewater) | Method | Load Reduction Rate (%) | | | | Evaluation Items | | | | | | Comprehensive Evaluation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BOD | TN | TP | TSS | Load reduction effect | Cost effective ness | Quickness in effect | Local suitability | Technical ease | Impact on Environment | |
| Domestic w.w. | Oxidation ditch+wetland | 90 | 90 | 80 | 90 | ◎ | ○ | ○ | ○ | ○ | ○ | ◎ |
| | Stabilization pond | 90 | | | 90 | ○ | ◎ | ○ | ○ | ◎ | ○ | ◎ |
| | Activation sludge method | 90 | | | 90 | ○ | △ | ○ | ○ | ○ | ○ | ○ |
| | Combined type private sewerage system | 65 | | | 65 | △ | ■ | ○ | ○ | ■ | ◎ | △ |
| Industrial w.w. | Wastewater treatment Plant | | | | | ◎ | △ | ○ | ○ | ○ | ○ | ○ |
| | Adequate treatment of Sludge | | | | | ○ | △ | ○ | ○ | ○ | ○ | ○ |
| | Cleaner production | | | | | ○ | ○ | ○ | ■ | ○ | ○ | ○ |
| Urban w.w. | Retardation pond | 10-90 | 10-90 | 10-90 | 50-90 | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Artificial wet pond | 20-80 | 0-40 | 0-80 | 50-90 | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Improvement of solid waste collection rate | 20-28 | 3.6 | 1.7 | 25-40 | ○ | ○ | △ | ○ | ○ | ○ | ○ |
| Agricultural w.w. (Field) | Reduced Tillage system | | 55 | 45 | 75 | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Diversion System | | 10 | 30 | 35 | ○ | △ | △ | ○ | ○ | ○ | ○ |
| | Terrace System | | 20 | 70 | 85 | ○ | △ | △ | △ | ○ | ○ | ○ |
| | Tilter Strip | | 70 | 70 | 65 | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Fertilization control | | 15 | 35 | - | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Riparian buffer strip (Width:4.1m) | | 4.0 | 28.5 | 61 | ◎ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Riparian buffer strip (Width:9.2m) | | 22.7 | 24.2 | 74.6 | ◎ | ○ | ○ | ○ | ○ | ○ | ○ |
| Agricultural w.w. (Paddy) | Controlled Drainage | | 45 | 47 | 25 | ○ | ○ | ○ | ○ | ○ | ◎ | ○ |

Note:◎:Excellent,○:Fair,△:Good,■:Poor, U:Unknown, Source:

Load reduction rate was quated from the following materials

1) IDI-Japan(1993) : Technical guidelines for the treatment of urban wastewater and sewage in developing countries
2) EPA(19992) : Guideline specifying management measures for source of nonpoint pollution in coastal waters
3) North Carolina State University(1997) : Selected agricultural best management practive to control nitrogen in Nuese river basin