

## A.4.2 Taxation System and Public Utilities Charge Collection System

### a. Taxation System - Outline View

Legality, Equality, and revenue assignment, that is, the fundamental taxation principles are enshrined in the Constitution, according to which the federal Congress is empowered to levy taxes necessary to cover federal expenditures. Under the framework of legitimacy in taxation, Mexico has a complex system of intergovernmental fiscal relations, while being characterized by a relatively high degree of expenditure centralization and by limited revenue raising powers of state and municipal government. Numerically, for instance, more than 76.9 percent of general government (Federal, State, and Municipality governments) expenditures were under the control of the federal government, while own revenues (taxes and service fees) generated by states and DF account only for 27.5 percent in 1992 and 30.1 percent in 1998, respectively<sup>38</sup>. The Law on Fiscal Coordination 1980 grants the federal administration jurisdiction over most sources of taxation and specifies a revenue sharing agreement<sup>39</sup>. The 1980 Law also introduced the value-added tax (VAT) as a federal attribution.<sup>40</sup>

In return for the resources transferred from the federal government, state governments mainly levy a few taxes inclusive of payroll tax<sup>41</sup>, tax on transfer of property, motor vehicle tax, as well as fees for services provided such as *derechos, productos y aprovechamientos*, and user charges. Merely, property tax (*impuesto predial*) and administrative service fees and charges are the only sources of own incomes attributed to Municipality governments. With this in view, it would go so far as to describe it that local governments are highly dependent on federal revenue sharing. Other fiscal tool that the federal government relies on is specific purpose grants that promote and finance the provision of certain kind of services by lower level governments, while keeping in mind, at the same time, horizontal equalization among states.

The newly introduced distribution mechanism of revenue sharing (*Fondo General de Participaciones, GRSP*) and the municipal development fund (*Fondo de Fomento Municipal, MDF*) agreements among the federal and states in 1990 retains the three criteria, vis-à-vis, (i) population, (ii) an indicator reflecting tax generation capacity

<sup>38</sup> Reference: Joost Draaisma, *Public Finance and Fiscal federalism in Mexico*, The World Bank, 1997. Hearty gratitude is due to Messrs. Richard L. Clifford and J. Draaisma of WB Resident Mission in Mexico City for their precious and the most relevant information on the issue. Also *Gaceta Oficial del Distrito Federal*, May 1998

<sup>39</sup> It's been noted that efficacy in the central administration of some taxes have often been used as the reason for this type of coordination. Besides, there is a broad consensus in the economics literature that the central government should be assigned taxes that have certain characteristics. That is, those (i) levied on the more mobile tax bases to avoid tax-induced movements of production factors and to avoid tax competition driving down revenues excessively, (ii) more sensitive to changes in income, alternatively saying, having higher income elasticity, to provide central government with stabilization instruments and to shelter, to the extent possible, the budgets of subordinate governments from cyclical fluctuation, and (iii) levied on tax bases that are distributed unevenly across regions. These criteria would argue for the assignment to the central government of corporate taxes (criteria (i) and (ii)) and taxes on natural resources (criteria (iii)). (Reference: Teresa Ter-Minassian, *Op cit.*, 1997, p.9)

<sup>40</sup> Reference: Joost Draaisma, *ibid.*, p3

<sup>41</sup> Payroll Tax (*Impuesto sobre la nomina*) is in most cases 1 percent of the payroll, separate from income tax levied at the federal government.

and revenue raising efforts<sup>42</sup>, and (iii) the inverse of the per capita entitlements resulting from the first two criteria, in lieu of the previous basis of economic and tax generation capacity of states. The weights attached to each of the criteria specified are 45.17 percent for the first two and the balance 9.66 percent for the third.<sup>43</sup> Shared tax with local governments include income taxes, the value-added tax, excises, oil export and import duties, and the tax on the ownership or use of vehicles. Meanwhile, information on general and specific purpose grants is scanty and not suited to detailed analysis.

Numerically expressed, the GRSF coefficient<sup>44</sup> is given by

$$B^i = (CP_{t-1}^i) * (IA_{t-1}^i) * (IA_{t-2}^i); CP_{t-1}^i = B^i * TB^{-1}$$

Where  $IA_{t-1}^i$  denotes assignable taxes collected in state  $i$  in year  $t-1$ , and  $TB$  is a summation of total entitlements,  $\sum_i B^i$ , while  $CP_{t-1}^i$  represents revenue sharing coefficient for state  $i$  in year  $t-1$ , and  $B^i$  is entitlement to state  $i$ .

Despite the government's sheer efforts undertaken to reform the taxation scheme for further horizontal and vertical equality, it's been pointed out that one of Mexico's important fiscal problems has been the lack of coordination of tax policy and administration among levels of government. The lack of uniformity across the states in the kind of taxes levied and their rates, on the property tax in particular, would result in an uneven geographic distribution of the fiscal burden. With this in view, efforts would be made to improve collection efficiency by strengthening the present tax coordination and harmonization agreements between the federal government and states.

A range of taxes assigned and budgetary expenditures accrued to each level of the governments is given in Table A-23, whereas the revenue structure of DF government over the period of 1995 through 1998 and at each of the governments in administrative order in 1994 are respectively provided in Table A-24 and Table A-25, as attached.

<sup>42</sup> This indicator takes into account the state's share in total entitlements of the preceding year, and a "fiscal effort" indicator determined by total revenue generated from taxes on new mobiles, the motor vehicle tax and special taxes on production and services in the preceding year divided by those collected in the year before. (Reference: Joost Draaisma *Ibid.*)

<sup>43</sup> Reference: Joost Draaisma, *Ibid.*, p.2

<sup>44</sup> Juan Amieva-Huerta, *Mexico*, in Teresa Ter-Manassian, *Op cit.*, 1997, p.578

Table A-23: Federal and Local Government Expenditure and Taxes

| Federal government taxes   | Federal government expenditures  |
|--|--|
| Corporate income tax<br>Personal income tax<br>Tax on assets of enterprises<br>Value-added tax (VAT)<br>Duty on oil extraction (royalties)<br>Oil export tax<br>Tax on production and services (excises)<br>Tax on the new cars <sup>45</sup><br>Tax on the ownership or use of vehicles<br>Real estate transfer tax <sup>46</sup><br>Import duties<br>Miscellaneous | Federal administration<br>Service of domestic and foreign debt<br>Defense<br>Post and telecommunications<br>External affairs<br>Irrigation<br>Foreign trade<br>Railways, highways, airways and shipping<br>Federal and border police         |
| Shared taxes   | Shared expenditures  |
| Income taxes<br>Value-added tax<br>Excises<br>Oil export duties <sup>47</sup><br>Import duties<br>Tax on the ownership or use of vehicles<br>Tax on new cars   | Health<br>Education<br>Specific purpose grant program<br>Solidarity<br>Single development agreements, (Convenios Unicos de Desarrollo)<br>Special police<br>National parks   |
| State government taxes   | State government expenditures  |
| State payroll tax<br>Real estate transfer tax<br>Tax on motor vehicles older than 10 years<br>Tax on the use of land<br>Education tax<br>Indirect taxes on industry and commerce<br>Fees and licenses for some public services   | State administration<br>State infrastructures<br>State public order and safety<br>Sanitation and water supply<br>Service of domestic debt<br>Public libraries  |
| Municipal government taxes   | Municipal government expenditures  |
| Local property tax<br>Real estate transfer tax<br>Water fees<br>Other local fees and licenses<br>Indirect taxes on agriculture, industry, and commerce<br>Residential development  | Local administration<br>Local public order and safety<br>Local transportation<br>Local infrastructure including water supply and sanitation<br>Local transit<br>Waste disposal and street lighting<br>Slaughterhouses, cemeteries, and parks |

Source: Teresa Ter-Minassioan, *Fiscal Federalism in Theory and Practice*, IMF, 1997, pp. 572-573.

<sup>45</sup> This tax was suspended for one year on January 1, 1996.

<sup>46</sup> This tax was abolished on January 1, 1996.

<sup>47</sup> Some federal government tax revenues (oil production and export of hydrocarbons) are not included in the computation of the revenue-sharing fund

Table A-24: DF Revenue by Source, 1995-1998

|   | 1995    | 1996    | 1997        | 1998        |
|---|---------|---------|-------------|-------------|
| <b>REVENUE SOURCES (in millions of pesos)</b> |         |         | (Thousands) | (Thousands) |
| <b>Own Revenue</b>                            |         |         |             |             |
| <b>I. TAXES</b>                               | 4,384.7 | 5673.60 | 6,904,116.0 | 8,114,644.0 |
| Land property tax                             | 1,994.7 | 2,787.1 | 3,310,000.0 | 3,839,435.0 |
| Acquisition of real estate                    | 589.4   | 696.5   | 736,893.0   | 761,168.0   |
| On public spectacles                          | 50.3    | 54.5    | 73,101.0    | 101,117.0   |
| On lotteries, raffles, etc.                   | 74.4    | 30.5    | 119,712.0   | 76,762.0    |
| Payroll tax                                   | 1,543.3 | 1,910.5 | 2,428,006.0 | 3,026,646.0 |
| Tenure and use of vehicles                    | 110.20  | 120.90  | 164,991.0   | 231,904.0   |
| Acquisition of used vehicles                  | 22.70   | 25.70   | 23,513.0    | 26,204.0    |
| For rendering lodging services                | 0.00    | 47.90   | 47,900.0    | 51,048.0    |

(P. million)

|   | 1995            |               | 1996            |               | 1997            |               | 1998            |               |
|---|-----------------|---------------|-----------------|---------------|-----------------|---------------|-----------------|---------------|
|   | Amount          | Share         | Amount          | Share         | Amount          | Share         | Amount          | Share         |
| <b>I. TAXES</b>   | 4,384.7         | 24.2%         | 5,673.6         | 22.6%         | 6,904.1         | 22.2%         | 8,114.6         | 21.0%         |
| <b>II. CONTRIBUTIONS FOR IMPROVEMENTS</b>   | 174.6           | 1.0%          | 182.4           | 0.7%          | 200.2           | 0.6%          | 172.1           | 0.4%          |
| <b>III. SERVICE FEES</b>  | 1,700.7         | 9.4%          | 2,302.1         | 9.2%          | 2,895.2         | 9.3%          | 3,538.3         | 9.1%          |
| <b>IV. CONTRIB. NOT INCLUDED IN PREVIOUS SECTIONS, OF PREVIOUS FISCAL YEARS, NOT PAID OFF</b> | 0.1             | 0.0%          | 0.1             | 0.0%          | 0.0             | 0.0%          | 0.0             | 0.0%          |
| <b>V. AUXILIARY ITEMS OF CONTRIBUTIONS</b>  | 195.0           | 1.1%          | 331.4           | 1.3%          | 673.0           | 2.2%          | 614.5           | 1.6%          |
| <b>VI. PRODUCTS</b>   | 1,446.2         | 8.0%          | 2,044.1         | 8.1%          | 2,652.0         | 8.5%          | 3,551.0         | 9.2%          |
| <b>VII. GOOD USE</b>  | 361.5           | 2.0%          | 554.7           | 2.2%          | 619.7           | 2.0%          | 554.3           | 1.4%          |
| <b>VIII. SHARE DUE TO COORDINATION ACTIVITIES</b>   | -               | 0.0%          | -               | 0.0%          | 1,970.1         | 6.3%          | 2,964.8         | 7.7%          |
| <b>IX. FEDERAL TAX SHARE</b>  | 6,839.3         | 37.7%         | 10,602.9        | 42.2%         | 11,201.9        | 36.0%         | 13,495.9        | 34.9%         |
| <b>X. DEBTS FROM PREVIOUS FISCAL YEARS</b>  | 300.0           | 1.7%          | 400.0           | 1.6%          | 500.0           | 1.6%          | 600.0           | 1.5%          |
| <b>XI. OTHER REVENUES</b>   | 2,751.5         | 15.2%         | 3,006.0         | 12.0%         | 3,489.2         | 11.2%         | 5,106.3         | 13.2%         |
| <b>TOTAL</b>  | <b>18,153.6</b> | <b>100.0%</b> | <b>25,097.3</b> | <b>100.0%</b> | <b>31,105.4</b> | <b>100.0%</b> | <b>38,712.0</b> | <b>100.0%</b> |

(P. million)

|   | 1995            | 1996            | 1997            | 1998            | Share 1998    | Growth Rate 95-98 |
|---|-----------------|-----------------|-----------------|-----------------|---------------|-------------------|
| Expenditures of all bodies of the GDF   | 17,682.7        | 18,970.7        | 19,588.4        | 25,784.1        | 60.6%         | 13.4%             |
| Expenditures of all bodies of the GDF of which Department of Works and Services | 12,291.3        | 16,970.7        | 19,588.4        | 25,784.1        | 60.6%         | 28.0%             |
| Expenditures for the delegations  | 3,395.5         | 4,641.4         | 6,087.2         | 6,629.7         | 15.6%         | 25.0%             |
| Expenditures for semi-state entities  | 4,178.5         | 6,052.1         | 7,891.0         | 10,160.6        | 23.9%         | 34.5%             |
| <b>Total</b>  | <b>19,865.3</b> | <b>27,664.2</b> | <b>33,566.6</b> | <b>42,574.4</b> | <b>100.0%</b> | <b>28.9%</b>      |
| <b>Minus</b>  |                 |                 |                 |                 |               |                   |
| Contributions included in the Central Adm. expenditure                          | 2,182.6         |                 |                 |                 |               |                   |
| Expenditures financed with own resources  | 2,037.1         |                 |                 |                 |               |                   |
| <b>Plus</b>   |                 |                 |                 |                 |               |                   |
| Chamber of Representatives DF Assembly  | 117.5           | 196.2           | 255.0           | 310.0           |               |                   |
| Major Accounting Office of the Assembly of Representatives DF                   |                 | 60.0            | 60.0            | 71.9            |               |                   |
| Supreme Court of Justice  | 213.9           | 350.5           | 447.0           | 930.7           |               |                   |
| Supreme Court's Judicature  |                 | 25.5            | 25.1            | 30.7            |               |                   |
| Human Rights Commission   | 40.0            | 50.0            | 50.0            | 61.9            |               |                   |
| Prerogatives of Federal District's Federal Electoral Inst.                      |                 |                 |                 | 200.0           |               |                   |
| Electoral Process   |                 |                 | 360.0           |                 |               |                   |
| Citizen councils  | 32.0            | 40.0            |                 |                 |               |                   |
| Service of the debt of the Central Sector                                       | 220.7           | 1,489.9         | 1,860.4         | 1,500.0         |               |                   |
| Interests and Commissions of Semi-State Companies                               | 1.2             | 109.5           |                 |                 |               |                   |
| Deficits from Previous Fiscal Year  | 250.0           | 300.0           | 400.0           | 500.0           |               |                   |
| A1 Delegations' improvement program   |                 | 500.0           |                 |                 |               |                   |
| A2 Infrastructure development program   |                 | 464.8           |                 |                 |               |                   |
| A3 Urban zone re-generation program   |                 | 475.0           |                 |                 |               |                   |
| <b>Total</b>  | <b>18,557.9</b> | <b>30,197.3</b> | <b>37,055.4</b> | <b>46,212.0</b> |               |                   |

Sources: Gaceta Oficial del Distrito Federal, 1994-1997

Table A-25: Structure of Government by Administrative Order, 1994<sup>48</sup>

|                                  | Federal<br>Government | State<br>Government | Municipal<br>Government | General<br>Government |
|----------------------------------|-----------------------|---------------------|-------------------------|-----------------------|
| (In millions of new pesos)       |                       |                     |                         |                       |
| Total revenue                    | 215,301               | 53,793              | 14,761                  | 283,855               |
| Taxes                            | 160,317               | 2,028               | 3,253                   | 165,598               |
| Non-tax revenue <sup>49</sup>    | 54,984                | 24,827              | 3,060                   | 82,871                |
| Net revenue sharing              | -----                 | 26,938              | 8,448                   | 35,386                |
| Total expenditure                | 221,202               | 49,955              | 16,233                  | 287,390               |
| Administration                   | 111,006               | 28,546              | 10,306                  | 149,858               |
| Transfers                        | 74,792                | 8,396               | 1,101                   | 84,289                |
| Investment                       | 30,422                | 12,508              | 4,337                   | 47,267                |
| Deferred outlays                 | 4,982                 | 505                 | 489                     | 5,976                 |
| Budgetary balance                | -5,901                | 3,838               | -1,472                  | -3,535                |
| Change in third-party<br>account | -4,027                | 5,847               | 292                     | 2,112                 |
| Overall balance                  | -9,927                | -2,009              | -1,764                  | -13,700               |
| Financing (net)                  | 9,927                 | 2,009               | 1,764                   | 13,700                |
| External                         | -6,595                | -----               | -----                   | -6,595                |
| Domestic                         | 16,522                | 2,009               | 1,764                   | 20,295                |
| (In percent of GDP)              |                       |                     |                         |                       |
| Total revenue                    | 16.9                  | 4.2                 | 1.2                     | 22.3                  |
| Taxes                            | 12.6                  | 0.2                 | 0.3                     | 13.0                  |
| Non-tax revenue                  | 4.3                   | 1.9                 | 0.2                     | 6.5                   |
| Net revenue sharing              | -----                 | 2.1                 | 0.7                     | 2.8                   |
| Total expenditure                | 17.4                  | 3.9                 | 1.2                     | 22.6                  |
| Administration                   | 8.7                   | 2.2                 | 0.8                     | 11.8                  |
| Transfer                         | 5.9                   | 0.7                 | 0.1                     | 6.6                   |
| Investment                       | 2.4                   | 1.0                 | 0.3                     | 3.7                   |
| Deferred outlays                 | 0.4                   | -----               | -----                   | 0.5                   |
| Budgetary balance                | 0.5                   | -0.3                | -0.1                    | -0.3                  |
| Change in third-party<br>account | -0.3                  | 0.5                 | -----                   | 0.2                   |
| Overall balance                  | 0.8                   | -0.2                | -0.1                    | -1.1                  |
| Financing (net)                  | -0.8                  | 0.2                 | 0.1                     | 1.1                   |
| External                         | -0.5                  | -----               | -----                   | -0.5                  |
| Domestic                         | 1.3                   | 0.2                 | 0.1                     | 1.6                   |

Sources: Secretariat of Finance and Public Credit and Instituto Nacional de Estadística, Geografía e Informática (1996c).

#### b. Payment System for Public Services in the DF

The main public services provided by the Government of the Federal District are water supply and distribution, drainage, solid waste collection, public roads sweeping and conservation of parks, squares and public areas. The entities, within the DF, which have the legal, technical and administrative duty to provide these services are the Political Delegations. Concerning primary roads cleansing and collection of waste accumulated in public roads, however, the duty for these is shared with the General Direction for Urban Services (DGSU).

The population in general officially pays for water supply every two month through a bill sent by mail by the Water Commission of the Federal District which is dependent

<sup>48</sup> Excludes operations of the social security funds.

<sup>49</sup> Includes hydrocarbon royalties.

on the Secretariat of Works and Services. The population of the Federal District also pays to the GDF for the drainage system, rehabilitation and maintenance of monuments, public parks ornament works, schools, libraries, and social service, culture and sports centers which the DF is in charge of, as well as construction, rehabilitation and maintenance of public markets, secondary roads, gutter and sidewalk in general, bridges and pedestrian bridges for secondary roads through a charge called "Boleta Predial" (Circulation Bill). This "Boleta Predial" is paid annually; the amount is established by the location of the urban area and constructed surface of real property. Payments are done at the different branches of the Government Treasury of the Federal District.

There is also a Tax called "Uso del Suelo" (Land Use) which is paid by those who intend to settle in urban areas designated for commercial, service activities or others. This state is interesting because this type of tax can serve as a mechanism to charge for urban cleansing services.

The Treasury of the GDF under the Finance Secretariat operates as a Taxation Entity which is responsible for the administration and collection of those incomes, as well as federal contributions which are established by the Federal Executive.

Now, regarding urban cleansing services, the Organic Law of Public Administration of the Federal District defines in Article 10 that Public Services are an organized activity which is done accordant to valid Laws or Regulations in the Federal District with the purpose of satisfying collective needs in a continuous, uniform, regular, and permanent manner.

Furthermore, this precepts establishes that an official declaration that a specific activity constitutes a public service, implies that the provision of that service is public utility; consequently, the authority can decree expropriation, limited dominance and temporal use of goods which are required to provide the service.

This regulatory instrument is also entrusted to the authority in charge of fixing and modifying fees for public services given as a concession, and also in charge of supervising the satisfactory provision of the service. In the same manner, it also compels the concessionaire to cover the costs derived from the provision of the service and, to provide this service uniformly and continuously to every person who requests it.

Perhaps due to the reason mentioned previously, the Statute of the Federal District Government states in Article 17 that the residents in the Federal District, under the terms and conditions defined by the law, have a right to be provided with Public Services; consequently, the urban cleansing in Mexico City is provided for free.

However, that service is not totally free from a legal perspective as mentioned in the Article 254 of the Financial Code of the Federal District. The corresponding rights for services of the collection and reception of solid waste provided by the Federal District should be paid for by mercantile, industrial and similar establishments, as well as federal and local entities and dependents in accordance with the following quotas:

- I. For the collection service per each 10 kg or fraction: 4.20 pesos.

- II. For the reception service at transfer stations per each 10 kg or fraction: 1.40 pesos.
- III. For the reception service at final disposal sites per each 10 kg or fraction: 0.50 pesos.

In addition to the previously stated, the **Cleansing Service Regulation** states that collection service will be provided for free if waste generation does not exceed 200 kg/day.

Consequently, it is concluded that for residential sectors the service is free; meanwhile for other type of sources, a quota or fee should be applied as the following figure shows:

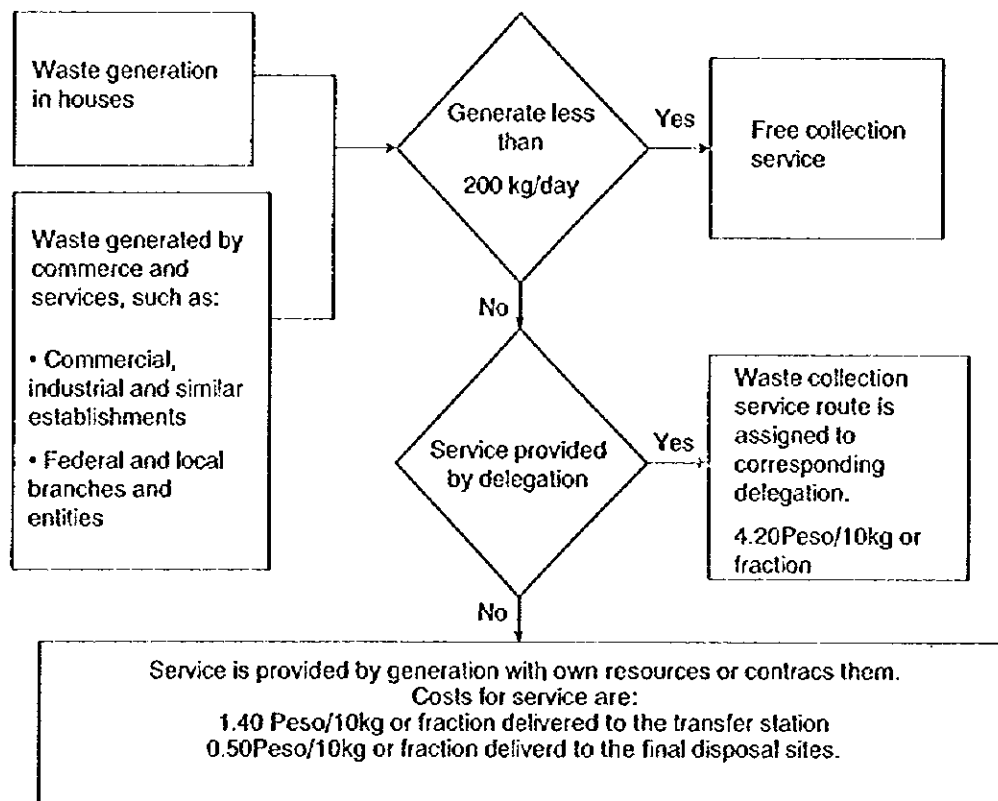


Figure A-8: Identification of Generations of Municipal Solid Waste Who should Pay for Services for Urban Cleansing

The legislative responsibility regarding municipal SWM corresponds to the Legislative Assembly which according to Article 42 of the Statute of the Government of Federal District is empowered to examine, to discuss and to approve *annually* the Law of Revenues and Expenditure Budget of the Federal District. In the same manner, it is empowered to legislate matters such as local Public Administration, public services and its *concession*, and public cleansing service in the local scope of the Federal District.

Regarding the economic aspects of providing the urban cleansing service in the Federal District, the Finance Secretariat works out a plan of revenue for responsible

entities, controls the corresponding budget for the service provision, and charges for this service and any other provided by such entity.

Finally, regarding this issue, it is important to mention that the office, within the Government of the Federal District, which is responsible for carrying out and keeping updated the Cadastral Register is the General Direction of the Public Register on Property and Commerce. It should also be mentioned that it is not convenient to use the Cadastral Register to establish a *fee structure*, given that the residential collection service is practically free. As a result, it is more convenient to utilize the Taxpayer inventory which is kept by the General Direction of the Register and Tax Administrations (Treasury) of the Secretariat of Finance and also to make use of the Ledger of Mercantile Bills and Inventory of Establishments with license in order to offer some type of service that Political Delegations is in charge of. It should be taken into account that information obtainable from these registers refers fundamentally to types of business, establishments and activities which according to the Financial Code of the Federal District should pay for collection and reception of services for the waste generated by them.

## A.5 Environmental Policy

### A.5.1 General Review

Mexico City is a mega-city of the world with about 9.3 % of the Mexico's total population and nearly one third of the industrial production of the whole country. Consequently the city has been suffered with huge environmental stress.

The first incorporation of environmental protection into the Constitution was in 1983, when an undersecretariat for ecology was created. Environmental policy, however, was not systematically executed until the present legal basis, General Law of Ecological Balance and Environmental Protection (LGEEPA; Ley General de Equilibrio Ecológico y la Protección al Ambiente), was issued. The effort to run the practical and effective environmental management had been continued, leading to the 1990-94 National Program for Environmental Protection in which the sustainable development appeared. Sustainable development is now an ultimate political goal set by the new LGEEPA amended in 1996.

Environmental concerns that Mexico has are diverse. The urban areas suffer from the problems of air pollution, water management in terms of quality and quantity and handling municipal and industrial wastes whose amounts are huge. In the peri-urban and local areas, prevailing poverty and the pressure of population growth result in the decrease of the quality of living environment as well as natural assets, such as forest and biodiversity. Mexico is, thus, exposed to environmental problems commonly associated with the process of industrialization but at the same time has to tackle economic and social issues which are threatening natural unrecoverable resources typically found in the third world. Nevertheless, this would be the very reason for the country to have expressed its commitment, in the 1995-2000 National Development Plan, to sustainable and strong economic growth which simultaneously has to go along with environmental protection and facilitate the elimination of social disparities.



## **A.5.2 Organizations Concerned**

### **a. SEMARNAP**

The Ministry of Environment, Natural Resources and Fisheries (SEMARNAP) is the national body in charge of the protection of natural resources and the promotion of sustainable development. It was established in 1994 by combining sections relevant to environment in the Ministry of Social Development (SEDESOL) and Ministry of Agriculture and Water Resources in order to integrate the environmental policy of the country. With its staff of about 40,000, its responsibilities are, among others, as follows:

- foster the protection, restoration and conservation of natural properties.
- formulate and introduce national policies in regard to natural resources, ecology, environmental sanitation, water, and environmental regulation for urban and fishery development.
- administrate, regulate and promote the sustainable use of natural resources which are to be taken care of by the federation.<sup>50</sup>
- establish Mexican Official Norms (NOM; Normas Oficiales Mexicanos) for the protection and restoration of environmental quality; natural ecosystems; sustainable use of natural resources and wildlife; and hazardous materials and solid wastes with participation of other authorities.
- monitor and encourage the implementation of laws, NOMs and programs related to the environment and also impose proper sanctions within its jurisdiction.
- evaluate and comment environmental impact assessment report of development projects in public, social and private sectors and resolve environmental risks.
- coordinate and execute projects of program formation and capacity building for institutions to develop human resources and promote social communication tools for environmental protection activities.
- design and operate, with participation of other ministries and organizations, the adoption of economic instruments for the protection, restoration and conservation of environment.
- foster ecological land use planning in co-ordination with other federal, state and municipal authorities and with the involvement of individual citizens.

SEMARNAP has another 7,700 staff who works for 32 federal delegations in the states and the DF to act as branch offices and to coordinate and assist local administrations.

SEMARNAP also supervises the activities and policies of five affiliated organizations: the National Water Commission (CNA), the National Institute of Ecology (INE), the Office of the Federal Attorney for Environmental Protection

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<sup>50</sup> excluding petroleum, other hydrocarboneous resources and radioactive minerals.

(PROFEPA), the National Institute of Fisheries (INP) and the Mexican Institute of Water Technology (IMTA).

As seen in Table A-26, SEMARNAP itself receives only sixth or seventh of its total budgets: the rest is distributed to these subordinate entities and local states. The transferred budget to states are used for collaborative projects with SEMARNAP and states and/or municipal governments. The reason for a large budget allocated to the CNA is that investment in hydraulic works such as irrigation and water supply distribution is included.

Table A-26: Distribution of SEMARNAP's Budget

(Million Nuevo Pesos)

|                        | 1995  | 1996  | 1997   |
|------------------------|-------|-------|--------|
| Ministry <i>per se</i> | 742   | 929   | 1,053  |
| Subordinate entities   | 4,064 | 5,482 | 5,775  |
| INP                    | 49    | 60    | 59     |
| CNA                    | 3,595 | 4,952 | 5,304  |
| IMTA                   | 99    | 108   | 66     |
| INE                    | 137   | 170   | 155    |
| PROFEPA                | 185   | 193   | 192    |
| Transfers to States    | 3,229 | 3,487 | 3,860  |
| Total                  | 8,035 | 9,899 | 10,688 |

At 1995 prices, adjusted by Government Consumption Deflator

Source: OECD, "Environmental Performance Review: Mexico", 1998

INE and PROFEPA are the main body which leads Mexico's environmental policies. They are further introduced below.

#### a.1 INE

INE is in the center of environmental administration of the country with its principal responsibility to assure the conservation and restoration of ecosystems and their sustainable utilization and development. For this purpose, INE evaluates national environmental policy; formulates legislation in regard to such issues as natural resources, ecology, environmental sanitation, and hazardous wastes; promotes the establishment of environmental information system including monitoring and making inventories of wildlife; evaluates and appraises EIA reports; and implements ecology restoration programs. It consists of six departments as follows.

- Department of regional coordination and nature conservation.
- General direction of wildlife.
- General direction of environmental information and policy.
- General direction of hazardous wastes and substances and dangerous works.
- General direction of environmental protection and environmental impact.
- General direction of environmental regulation.

## **a.2 PROFEPA**

PROFEPA is responsible for the enforcement of environmental legislation by such activities as inspecting stationary pollution generators, giving orders to polluters to improve their facilities, and penalizing them in the case of violation.

A new trend of environmental control is seen in eco-auditing which is conducted through voluntary agreements between industrial sectors and PROFEPA. About 800 audits were carried out during 1992 to 1997. By doing so, it is expected to establish action plans to improve industry's environmental performance and lead enterprises to comply with ISO 14000.

In regard to inspection, that is its main responsibility, PROFEPA carried out about 68,000 visits with a tendency of higher frequency in recent years to inspect and survey the fulfillment to comply with environmental laws, standards and regulations. Compliance has been improved: the number of industrial enterprises which were forced to close as a sanction in 1992 was 922, and that in 1996 dropped to 233.

Other task of PROFEPA is receiving complaints from the general public concerning environment. The number of complaints has been generally increasing over years, showing increasing demand for better environment in consideration of increase in regulatory compliance mentioned above.

## **b. Environmental Organizations in States and Municipalities**

One of the major objectives of the amendments to LGEEPA in 1996 was to introduce decentralization more definitely by allotting responsibilities of environmental management among the Federation, states and municipalities.

In promoting decentralization, SEMARNAP entrusts states governments, state environmental departments or non-governmental organizations with specific responsibilities. This is done taking into account the competence of local parties in terms of manpower, budget and knowledge. In other words, the shortage of implementing capacity can often hamper the decentralization process.

### **b.1 Environmental Organizations in States**

The environmental policies at national level give significant influence on those at the state level. The delegation's administrative structure, however, varies reflecting the characteristics of each state.

Each state is obliged to enforce its own environmental law based on the local environmental conditions and characteristics within its jurisdiction, as the LGEEPA stipulates (see Section A.5.3). It is also incumbent on the states to establish natural protection areas and to monitor the fulfillment of Mexican Official Norms. As for SWM, the states are obliged to regulate the systems of collection, storage, transport, handling, treatment and final disposal of solid and non-hazardous industrial wastes, following the NOMs of the Federation on site selection, design, construction and operation of final disposal for municipal wastes (LGEEPA Article 137). The other important role of them is to evaluate the environmental impact given by the projects which are not specified in the federal regulations in regard to EIA.

The legislative enforcement of states organizations, however, is hindered by short budget allocated to the environmental administration and low priority given to

environmental matters. A lack of continuity of environmental policy due to the shuffles of decision makers at every election hampers the execution of consistent programs.

Each state has its own secretariat to deal with environmental issues. In the state of Mexico, it is the Secretariat of Ecology. The interpretation of "environment" looked after by this secretariat ranges from natural environment to living environment, including solid waste issues.

## **b.2 Environmental Organizations in Municipalities**

As in the case of the states, municipalities are also eligible to set their own environmental legislation within its jurisdiction. In addition, they are taking the responsibilities of urban infrastructure services such as potable water supply, sewerage as well as waste management in a sense of waste collection. The shortage of human and financial resources in most municipalities, however, makes it difficult to play a sufficient role in environmental management. A lack of continuity of the policy due to the re-elected administrations every three years is another impediment to run efficient policy.

## **b.3 Environmental Administration of GDF**

The Secretariat of Environment of the GDF (Secretaria del Medio Ambiente) supervises environmental matters within Mexico City. Their responsibilities are a combination of those of states and municipalities, specifically the formulation of regulations on air pollution, water contamination and wastes, research and development, pollution control and management, application of environmental impact assessment, introduction of monitoring system for polluting substances, and the promotion of environmental education. It should be noted that, according to the legislation, it also bears responsibilities to promote and control the reduction, recycling, treatment and final disposal of solid wastes in cooperation with the Secretariat of Public Works. In fact, however, the Secretariat of Environment is not vested with concrete authority: the Secretariat of Public Works, through the DGSU, holds the practical responsibility of SWM, as already described earlier.

OECD reports that environmental expenditure represents about 8 % of the budget of the GDF.

## **b.4 Regional Organizations**

There are four regional consultative councils which involve government, the private sector, community organizations and people from the academic. The councils cover:

- national, state and municipal legislation and strategies;
- education, training, science, technology and dissemination of information;
- protected natural areas; and
- poverty and sustainable development.

As for the metropolitan area, the Metropolitan Environment Commission (CAM; Comisión Ambiental Metropolitana) was established in 1996 to coordinate environmental cross-boundary issues among national government (SEMARNAP),

Government of the State of Mexico and the GDF. The members include, from the central government, Ministries of Internal Affairs; Credit and Finance; Social Development; SEMARNAP; Energy; Commercial and Industrial Promotion; Agriculture, Livestock and Rural Development; Communication and Transport; Administrative Control and Development; Education; and Health. Governor of the state and Secretary General of the State Government from Mexico State, and the governor of the DF from the GDF also take part in the commission. Besides, there are some other private participants such as Mexican Petroleum, Mexican Institute of Petroleum, Central Federal Commission of Electricity, Refinery Division of PEMEX, Gas Division of PEMEX, and Basic Petrochemical (*Petroquímica Básica*). The commission has several sections which work on specific issues, one of which is waste management.

The practical activities of the CAM are carried out by the working groups of individual topics as below.

- Planning of environment and ecology conservation.
- Environmental education and capacity development.
- Air quality.
- Water quality.
- Quality of soil and subsoil and waste management.
- Natural resources and protected areas.
- Noise, vibration, thermal energy, light and odor.

Each of these working groups has an coordinator who is appointed by the Technical Secretariat of the CAM and who supervise the group's activities. Nevertheless, as a whole commission, achievements so far are rather biased to environmental issues in a narrow sense not giving a high priority on the waste problems.

### **A.5.3 Legislation**

#### **a. Constitution**

The Constitution, issued in 1917 and amended in 1987, gives a foundation of Mexico's environmental policies. It states that the country has a right to control development in order to protect natural resources. It also approves that the Federal Government, State Governments and Municipal Governments establish legislation, within their jurisdiction, with defining their competence for a purpose of environment protection and preservation and restoration of an ecosystem by locally appropriate means.

#### **b. General Law of Ecological Balance and Environmental Protection**

The principal environmental statute is given by the General Law of Ecological Balance and Environmental Protection (LGEEPA). It introduced several key elements into Mexico's environmental policy including environmental impact assessment. LGEEPA was first adopted in 1988 replacing the Law of Environmental Protection of 1982, and largely amended in December 1996 in order to further devolve

environmental responsibilities to the states and municipalities, establish the right of access to environmental information, and modernize environmental regulation by, for example, introducing information technology and creating an emission inventory.

LGEEPA aims to give a foundation for balanced development and protection, recovery, and improvement of environment. For this purpose, it requires the utilization of natural resources without environmental deterioration, harmonization of economic development, social activities and ecological conservation, control of water, air and soil pollution, and a mechanism to facilitate the cooperation and coordination among administrative organizations, social sector, private sector and the general public.

With regard to SWM, LGEEPA gives the base for it by presenting the definitions of waste and hazardous waste as follows.

**Waste:** any material which is generated by the process of extraction, benefiting, processing, production, consumption, utilization, control or treatment and whose quality does not allow another new use at the point of generation.

**Hazardous waste:** any waste which, regardless to its physical state, because of its corrosive, explosive, toxic, inflammable or biologically-infectious nature, presents a risk for ecological balance and environment.

### c. Mexican Official Norms

Mexican Official Norms (NOMs: Normas Oficiales Mexicanas) are the national norms which have the entire power in Mexico. Any statutory bodies have an obligation to make sure that the NOMs are followed and fulfilled by every individuals and entities. In the environmental field, there are 5 NOMs on laboratory methodology for air monitoring, 11 on stationary air pollution sources, 10 on mobile air pollution source, 9 on solid wastes, 4 on natural resources, 4 on noise, and 3 on water.

#### c.1 NOMs on Water

Previous NOMs on water were as many as 44 because they were set based on sectoral emission and discharge limits which were applied throughout the country regardless the local conditions. Recently, however, they were integrated and reduced to only three as a result of the understanding of assimilative capacities of recipient environmental media and the recognition of intended water use. Water discharged into a water body which is used for drinking should meet strict standards while less strict standards can be applied to water discharged into a water body to be used for industrial purpose. Consequently, NOM-001-ECOL-1996 determines the maximum permissible limits of contaminants concentration according to the characteristics of the recipient water body. NOM-002-ECOL-1996 specifies the maximum permissible limits of contaminants concentration in water discharged to the urban or municipal drainage and sewer systems. NOM-003-ECOL-1997 sets the maximum permissible limits of contaminants concentration of treated wastewater which is to be used for public services.

The most crucial concern of the SWM facilities about water is pollution caused by leachate. One of the above three norms will have to be taken into account depending on where leachate is discharged to and/or whether leachate is treated.

## **c.2 NOMs on Air**

In regard to the air contamination which might be caused by the SWM projects, two things should be noted. First, there are no NOMs that specify the air quality which has to be satisfied throughout the country. All NOMs on air pollution from stationary sources limit only the concentration of contaminants in the emitted air "at the end of the pipe". Second, the air pollution sources that the NOMs are focusing on are almost exclusively industrial ones, such as cement plants and oil refineries. Exceptions are two norms on combustion process, which could be applied to waste incinerators. Consequently, any NOMs can not be used to control air contamination from the other types of SWM facilities, such as final disposal sites and composting plants.

## **c.3 NOMs on Wastes**

Out of nine NOMs on wastes, one is dealing with the final disposal of municipal solid wastes, one with the medical wastes, and the other with hazardous wastes. Therefore, the first and second ones are of particular importance in the present study.

NOM-083-ECOL-1996 establishes the conditions which should be applied to the site for final disposal of municipal solid wastes. The aspects specified here include the following.

- General aspects, such as the distance from public facilities and populated areas
- Hydrology
- Geology
- Hydrogeology

It also describes the study procedure for each aspect above.

NOM-087-ECOL-1995 regulates the requirement for the separation, packing, storage, collection, transport, treatment and final disposal of biologically-infectious hazardous wastes generated from medical institutions. Although the SEMARNAP bears the ultimate responsibility to supervise the fulfillment of this norm, attention should be paid to this norm when the facilities for municipal solid waste accept treated medical wastes.

## **d. Regulations**

LGEEPA is complemented with several regulations on such matters as below.

- Prevention of Water Pollution
- Prevention of Marine Pollution
- Prevention of Noise Pollution
- Environmental Impact Assessment
- Hazardous Wastes
- Prevention of Air Contamination by Vehicles in the Metropolitan Area and Surrounding Municipalities
- Prevention of Air Pollution

- Surface Transportation of Toxic Wastes and Toxic Substances
- International and National Parks

As seen in these, non-hazardous wastes either from households or industries are not regulated by the federal level, although NOM-083-ECOL-1996 gives the national standard for a municipal solid waste disposal site which has to be followed throughout the country.

Besides governmental regulations, industry tend to be in favor of signing voluntary environmental agreements with the government. These voluntary agreements stipulate, for example, the monitoring schedule and the emission levels which could be stricter than the standards given by the NOMs. By doing so, the industry can obtain people's acceptance and facilitate the project implementation. Examples of such voluntary agreements in regard to waste management are, however, not reported.

#### **d.1 Regulation on EIA at Federal Level**

##### **d.1.1 Scope and Procedure**

IGEEPA and the regulation on EIA define the areas of projects whose EIA are to be reviewed by the INE within the SEMARNAP. Those are, in general, as follows.

- Public works by the federation.
- Transport works.
- Hydraulic works.
- Oil, gas and coal pipelines.
- Industries of petroleum, petrochemical, chemical, steel, paper, sugar, beverage, cement and electric power.
- Exploration, extraction, treatment and refining of mineral resources.
- Installation of facilities for treatment, confinement and elimination of hazardous wastes as well as radioactive wastes.
- Forest utilization and development.
- Federal tourism development.
- Works whose character and complexity are such that the states or municipal authorities require the participation of the SEMARNAP.
- Activities which potentially have considerable risks.
- Works which might give impact on the environment in more than one federal entities or in international zones.

The regulation does not specify the size of the projects which are subject to the EIA procedure. Instead, it requires project proponents to submit a prevention report (*informe preventivo*) which describes the characteristics of the planned projects. Within 20 days, the INE reviews the prevention report and determines whether or not EIA is required.



EIA under the EIA regulation has three categories, general, moderate and special, according to the nature of the project in question. General EIA is the basic style; moderate EIA is applied to projects by which severe environmental impacts are likely caused if there is no precaution; special EIA is more specifically employed to the complex projects. After the review of the prevention report, the project proponent will be requested to carry out one of these EIA. There are guidelines issued by the SEMARNAP about how the contents of the EIA report should be for each type of EIA. The EIA report is, then, reviewed by the INE and the decision is to be issued within 60-120 days depending on the complexity of the projects and the necessity for the INE to ask for opinions from other authorities. As a result of the review of general EIA, the INE may further require moderate or specific EIA. In due course, the final decision will be one of the following.

- approval.
- conditional approval.
- rejection.

Very few projects are granted simple approval. Generally speaking, four fifths obtain approval with conditions such as modification of design and the execution of mitigation measures, and the rests are rejected.

It has to be noted that the INE expected to rearrange the categorization of EIA presented above within 1998. Accordingly, there will be two types of EIA: local EIA and regional EIA. The former refers to EIA of projects which are carried out individually, while the latter concerns projects with large scope and often incorporating more than one different projects.

As indicated earlier, EIA for projects of non-hazardous solid waste management is not obligatory within the INE's jurisdiction under the EIA regulation. It is not the case, however, if the projects are planned in specially protected areas with particular ecological value and/or the states or municipalities in which the projects are planned require the SEMARNAP to be involved into the EIA procedure. This is simply because any issues regarding the management of solid waste, in terms of either urban services or environmental impact, are to be administered by the states, the municipalities and the DF.

The INE evaluates the EIA reports with taking the following into account.

- Ecology conservation.
- Declarations of nature protected areas.
- Ecological criteria for the protection of wild flora and fauna, rational utilization of natural resources and the protection of environment.
- Ecological regulations of human settlements.
- Other technical and ecological regulations and norms referred to in the LGEEPA

### d.1.2 Achievements

Department of Environmental Impact within the INE bears full responsibility to take care of EIA at the national level. They have totally 90 staff, 40-50 of whom are actually in charge of the evaluation of EIA.

The number of activities which are subject to EIA increased by the 1996 amendments to LGEEPA. According to the *Programa de Trabajo 1998* (Program 1998), issued by SEMARNAP, more than 1,000 projects followed the EIA regulation in 1997 (Table A-27). This means one EIA assessor must handle at least 20 EIA reports in a year.

Table A-27: The Number of Projects Subject to EIA Regulation in 1997 by Sector

| Sector         | Numbers of Projects |
|----------------|---------------------|
| Pemex/CFE*     | 191                 |
| Industry       | 283                 |
| Mining         | 83                  |
| Fishing        | 77                  |
| Tourism        | 97                  |
| Communications | 68                  |
| Services       | 13                  |
| Forest         | 218                 |
| <b>Total</b>   | <b>1,030</b>        |

\* Pemex: Petroleum of Mexico, CFE: Federal Commission of Electricity

Source: INE

In the Program 1998, SEMARNAP pointed out the necessity to raise the evaluation efficiency. For this purpose, it states that the reduction of time to proceed the process and to respond applicants, update of the regulatory framework, decentralization and internal cooperation and coordination have to be improved.

The first issue, i.e. the need to decrease the response time, derives from the fact that there are 180 projects which are fell behind their schedules at the time of the issue of the program, although this number is 10% less than that of 1995.

In order to further accelerate the procedure, part of the SEMARNAP's function in regard to the evaluation of prevention report was entrusted to all SEMARNAP's delegations in 1997. SEMARNAP also considers that their responsibility to review the EIA report is going to be gradually transferred to the SEMARNAP's delegations.

### d.1.3 Public Involvement

The project proponents are obliged to publicize the information of their projects through media by the EIA regulation. The regulation also guarantees the right of any person to express his/her opinions or suggestions for proposed projects during the reviewing process. There are several examples that the INE has received protests from the public against the hazardous waste projects. If needed, the INE sets up a public consultation meeting to provide a chance of mutual understanding between the project proponent and the general public. The INE's experience so far implies that the major reason for the people to become suspicious about the environmental compatibility of the project is often attributed to the insufficient delivery of relevant information. Once enough information is disclosed, most conflicts are settled.

## **d.2 Regulation on EIA at State Level**

The LGEEPA ensures that the local environmental authorities can establish their own EIA codes or regulations. The EIA of states tends to be a replica of the federal one, although their EIA execution is often hampered for lack of adequate technical competence, human resources and financial resources. The following describes the EIA system adopted in the State of Mexico as an example of EIA at State level.

The requirement for EIA to development projects proponents is given by the Law of the Environmental Protection for Sustainable Development of the State of Mexico (*Ley de Protección al Ambiente para el Desarrollo Sustentable del Estado de México*). The details of EIA are further established by a regulation under this law in the matter of environmental impact and risk (*Reglamento de Ley de Protección al Ambiente del Estado de México, en Materia de Impacto y Riesgo Ambiental*).

According to this regulation, the Secretariat of Ecology (*Secretaría de Ecología*) of the State of Mexico is responsible for EIA. Projects of the following categories, among others, are subject to the EIA procedure of the state.

- Installation and operation of a confinement or treatment center for medical wastes or industrial wastes within the state's competence.
- Installation and operation of transfer stations, treatment plants and final disposal sites for municipal solid wastes.

During the EIA process, the municipalities may be involved through an agreement of coordination.

The EIA procedure starts with the submission of a so-called preventive report which has to contain sufficient data for the authority to identify the type of activities of the project. The authority will review the report and determine within 15 working days whether the EIA report (and risk study, if necessary) should be prepared or not.

After receiving the EIA report (and the risk study), the authority has to review it and give a conclusion within 60 working days, or 30 days more if the decision depends on opinions of other authorities. As in the case of the federal EIA system, the decision will be approval, rejection or approval with conditions of project modification.

The examination items required at minimum to include in the preventive report, EIA report and risk study report are listed in the same regulation.

The project proponents are required to publicize the information on environmental impact in order to guarantee opportunities for the general public to be well informed of the project in advance and to express their opinions.

# **Annex B**

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## *Field Investigations*

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## B Field Investigations

### B.1 Waste Amount and Composition Survey

The GDF has conducted annual studies on waste amount and composition since 1993. The large amount of collected data of high caliber will undoubtedly be a valuable reference source for the study. Data on calorific value and ultimate composition analysis are also available from the results of incineration analysis at a testing facility with a handling capacity of 100 ton/24hr, that should be sufficient for this study. The data, however, will not be sufficient to make an inference on the following:

1. Changes in waste amount and composition as a result of workers recycling valuables at the collection and haulage stages.
2. Changes in waste amount and composition as a result of recycling at the S/Ps.

Two supplemental studies described below were implemented by the team.

#### B.1.1 Survey Schedule and Sampling Points

##### a. Survey Schedule

The survey was implemented following the schedule shown in Table B-1.

Table B-1: Schedule of Sampling

| Sampling Points     |                    | August     |            |            |            |            |            |            | September |           |           |           |
|---------------------|--------------------|------------|------------|------------|------------|------------|------------|------------|-----------|-----------|-----------|-----------|
|                     |                    | 25<br>Tue. | 26<br>Wed. | 27<br>Thu. | 28<br>Fri. | 29<br>Sat. | 30<br>Sun. | 31<br>Mon. | 1<br>Tue. | 2<br>Wed. | 3<br>Thu. | 4<br>Fri. |
| Final Disposal Site | Bordo Poniente     |            |            |            |            |            |            |            |           |           |           |           |
|                     | Santa Catarina     |            |            |            |            |            |            |            |           |           |           |           |
| Selection Plant     | Bordo Poniente     |            |            |            |            |            |            |            |           |           |           |           |
|                     | Santa Catarina     |            |            |            |            |            |            |            |           |           |           |           |
|                     | San Juan de Aragon |            |            |            |            |            |            |            |           |           |           |           |

##### b. Sampling Points

The entrances and exits of the S/Ps and two final disposal sites were the sampling points (see Figure B-1).

Samples were taken three times a day (in the morning, at noon and in the evening) for seven days.

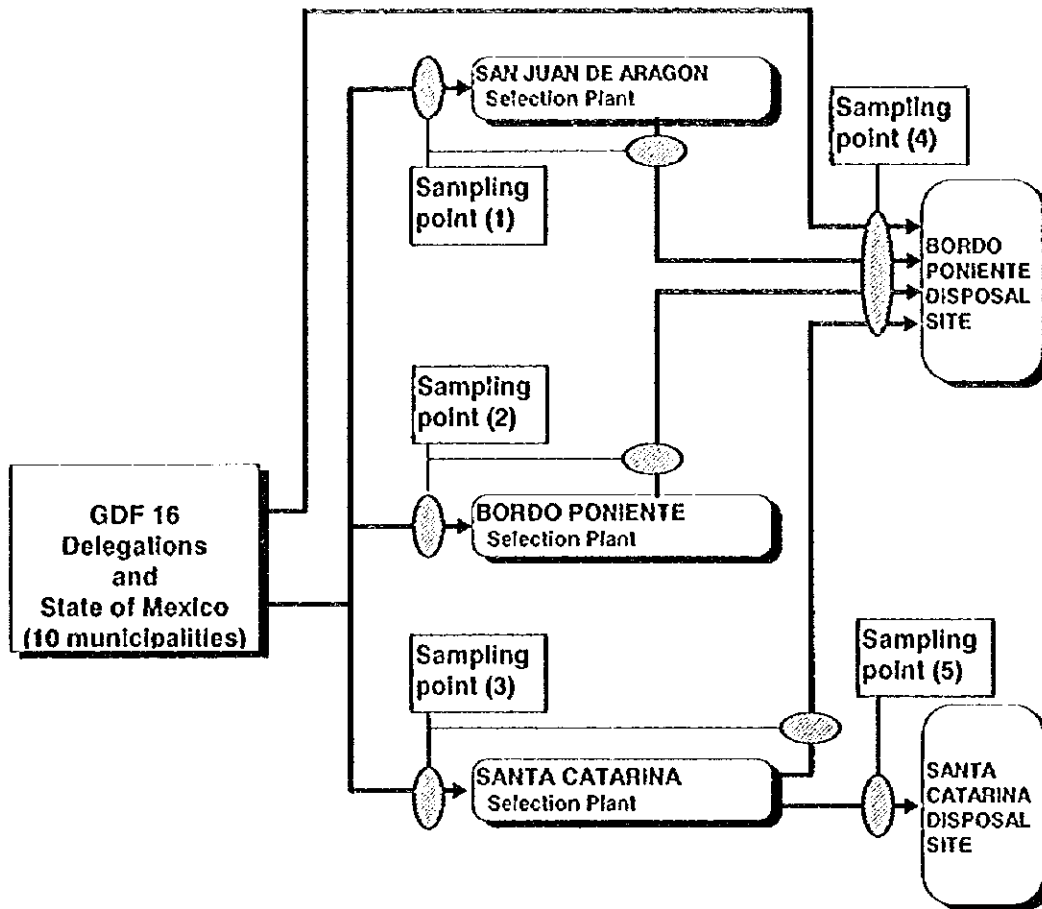


Figure B-1: Sampling Points

## B.1.2 Waste Amount Survey

### a. Survey Method

The waste amount survey was carried out by using the existing weighbridges and the number of waste vehicles (in case where a weighbridge is not available) for seven days at eight sampling points (entrances and exits of the three S/Ps and the two final disposal sites) as shown in Figure B-1.

Table B-2 shows measuring method of each sampling points.

Table B-2: Measuring Method of Each Sampling Point

|                     |                          | Entrance              | Exit                  |
|---------------------|--------------------------|-----------------------|-----------------------|
| Selection plant     | Bordo Poniente           | by weighbridge        | by weighbridge        |
|                     | San Juan de Aragon       | by number of vehicles | by weighbridge        |
|                     | Santa Catarina           | by number of vehicles | by number of vehicles |
| Final disposal site | Bordo Poniente Etapa IV  | by weighbridge        | -                     |
|                     | Bordo Poniente Etapa III | by number of vehicles | -                     |
|                     | Santa Catarina           | by number of vehicles | -                     |

## b. Result of the Survey

### b.1 Number of Vehicle

Number of vehicles that carry the waste in and carry the rejects out from S/Ps, and carry the waste in at final disposal sites are recorded during the survey period as shown in Table B-3.

Table B-3: Number of Vehicles

| No.           | Date     | Selection plant |      |                    |      |                |      | Final disposal site |                      |                |
|---------------|----------|-----------------|------|--------------------|------|----------------|------|---------------------|----------------------|----------------|
|               |          | Bordo Poniente  |      | San Juan de Aragon |      | Santa Catarina |      | Bordo PTE. ETAPA IV | Bordo PTE. ETAPA III | Santa Catarina |
|               |          | Ent.            | Exit | Ent.               | Exit | Ent.           | Exit |                     |                      |                |
| 1             | 25/08/98 | 254             | 89   | 378                | 61   |                |      | 473                 | 59                   |                |
| 2             | 26/08/98 | 197             | 103  | 368                | 22   |                |      | 300                 | 51                   |                |
| 3             | 27/08/98 | 246             | 155  | 369                | 73   | 113            | 80   | 490                 | 40                   | 177            |
| 4             | 28/08/98 | 196             | 145  | 306                | 90   | 117            | 82   | 469                 | 60                   | 166            |
| 5             | 31/08/98 | 241             | 86   | 217                | 53   | 90             | 75   | 275                 | 52                   | 157            |
| 6             | 1/09/98  | 224             | 117  | 334                | 75   | 102            | 72   | 217                 | 56                   | 152            |
| 7             | 2/09/98  | 225             | 16   | 368                | 70   | 133            | 78   | 406                 | 78                   | 160            |
| 8             | 3/09/98  |                 |      |                    |      | 124            | 100  |                     |                      | 156            |
| 9             | 4/09/98  |                 |      |                    |      | 127            | 82   |                     |                      | 165            |
| Total         |          | 1,583           | 711  | 2,340              | 444  | 806            | 569  | 2,630               | 396                  | 1,133          |
| Daily average |          | 226             | 102  | 334                | 63   | 115            | 81   | 376                 | 57                   | 162            |

### b.2 Waste Amount

Table B-4 shows the amount of wastes carried to and out from the facilities recorded during the survey period.

Table B-4: Waste Amount Carried-in and Carried-Out

| No.           | Date     | Selection plant (ton/day) |            |                    |            |                |            | Final disposal site (ton/day) |                      |                |
|---------------|----------|---------------------------|------------|--------------------|------------|----------------|------------|-------------------------------|----------------------|----------------|
|               |          | Bordo Poniente            |            | San Juan de Aragon |            | Santa Catarina |            | Bordo PTE. ETAPA IV           | Bordo PTE. ETAPA III | Santa Catarina |
|               |          | Entrance                  | Exit       | Entrance           | Exit       | Entrance       | Exit       |                               |                      |                |
| 1             | 25/08/98 | 2,427.100                 | 1,836.820  | 2,094.314          | 1,474.710  |                |            | 9,495.096                     | 244.400              |                |
| 2             | 26/08/98 | 1,883.979                 | 2,028.182  | 2,305.987          | 510.150    |                |            | 6,155.460                     | 233.658              |                |
| 3             | 27/08/98 | 2,328.030                 | 3,405.689  | 2,207.129          | 1,785.960  | 1,805.228      | 1,587.840  | 10,233.060                    | 220.922              | 3,437.286      |
| 4             | 28/08/98 | 1,405.070                 | 3,080.250  | 2,050.249          | 2,034.370  | 1,832.232      | 1,627.536  | 9,828.802                     | 249.401              | 3,242.200      |
| 5             | 31/08/98 | 2,475.820                 | 1,932.150  | 1,384.999          | 1,203.820  | 1,377.440      | 1,488.600  | 5,282.064                     | 291.658              | 3,061.186      |
| 6             | 1/09/98  | 2,304.555                 | 2,743.771  | 2,174.835          | 1,909.840  | 1,335.337      | 1,429.056  | 4,471.447                     | 287.919              | 2,940.732      |
| 7             | 2/09/98  | 2,265.210                 | 382.140    | 2,352.444          | 1,733.280  | 1,961.243      | 1,548.144  | 8,812.996                     | 468.441              | 3,114.002      |
| 8             | 3/09/98  |                           |            |                    |            | 1,845.844      | 1,984.800  |                               |                      | 3,021.154      |
| 9             | 4/09/98  |                           |            |                    |            | 1,914.403      | 1,627.536  |                               |                      | 3,210.570      |
| Total         |          | 15,089.764                | 15,409.002 | 14,570.017         | 10,652.130 | 12,071.727     | 11,293.512 | 54,278.925                    | 1,996.399            | 22,027.130     |
| Daily average |          | 2,155.681                 | 2,201.286  | 2,081.431          | 1,521.733  | 1,724.532      | 1,613.359  | 7,754.132                     | 285.200              | 3,146.733      |

Table B-5 presents average loading amount of carrying-in vehicles/trailers and carrying-out trailers calculated from the survey data. It reveals that:

- The average loading amount of vehicles (including trailers) that enter Bordo Poniente S/P and San Juan de Aragon S/P ranges less than 10 ton/vehicle, the latter being, in particular, only about 6 ton/vehicle. It indicates that the majority of entering vehicles of the two S/Ps is collection vehicles. On the other hand, that of the Santa Catarina S/P ranges about 15 ton/vehicle, implying that the majority of entering vehicles is trailers.
- The average loading amount of trailers that exit from the three S/Ps ranges about 20 ton/trailer.
- The average loading amount of trailers that enter the final disposal site (excluding the Bordo Poniente Etapa III) ranges about 20 ton/trailer.

Table B-5: Average Loading Amount of Haulage Vehicle

unit : ton/vehicle

| No.           | Date     | Selection plant |       |                    |       |                |       | Final disposal site |                      |                |
|---------------|----------|-----------------|-------|--------------------|-------|----------------|-------|---------------------|----------------------|----------------|
|               |          | Bordo Poniente  |       | San Juan de Aragon |       | Santa Catarina |       | Bordo PTE. ETAPA IV | Bordo PTE. ETAPA III | Santa Catarina |
|               |          | Entrance        | Exit  | Entrance           | Exit  | Entrance       | Exit  |                     |                      |                |
| 1             | 25/08/98 | 9.56            | 20.64 | 5.54               | 24.18 |                |       | 20.07               | 4.14                 |                |
| 2             | 26/08/98 | 9.56            | 19.69 | 6.27               | 23.19 |                |       | 20.52               | 4.58                 |                |
| 3             | 27/08/98 | 9.46            | 21.97 | 5.98               | 24.47 | 15.98          | 19.85 | 20.88               | 5.52                 | 19.42          |
| 4             | 28/08/98 | 7.17            | 21.24 | 6.70               | 22.60 | 15.66          | 19.85 | 20.96               | 4.16                 | 19.53          |
| 5             | 31/08/98 | 10.27           | 22.47 | 6.38               | 22.71 | 15.30          | 19.85 | 19.21               | 5.61                 | 19.50          |
| 6             | 1/09/98  | 10.29           | 23.45 | 6.51               | 25.46 | 13.09          | 19.85 | 20.70               | 5.14                 | 19.35          |
| 7             | 2/09/98  | 10.07           | 23.88 | 6.39               | 24.76 | 14.75          | 19.85 | 21.65               | 6.01                 | 19.46          |
| 8             | 3/09/98  |                 |       |                    |       | 14.89          | 19.85 |                     |                      | 19.37          |
| 9             | 4/09/98  |                 |       |                    |       | 15.07          | 19.85 |                     |                      | 19.46          |
| Daily average |          | 9.48            | 21.91 | 6.25               | 23.91 | 14.96          | 19.85 | 20.57               | 5.02                 | 19.44          |

### c. Findings

#### c.1 Selection Plant

Table B-6 illustrates the daily average amount of wastes that enter and exit from the S/Ps during the survey period. At the Bordo Poniente S/P, the average exiting amount is a little larger than the average entering amount. This is considered to be mainly attributable to that the standing amount of wastes/rejects in the plant yard is decreased in the survey period (i.e., the total standing amount of "wastes after entrance and before process" and "rejects after process and before exit" in the plant yard on the last day of the survey was much smaller than that amount of the first day of the survey.).

Where it is assumed, ignoring the variation of yard standing amount, that the material recovery amount is "entering amount minus exiting amount", the material recovery ratio of the three S/Ps works out at 10.5%. It almost corresponds to the estimated material recovery ratio (about 10%) that was calculated for the waste stream analysis based on the plants operation records, and is adopted in the present waste stream of the DF (see Section C.2 in Annex C). The average entering amounts recorded for respective S/Ps approximately correspond to the current performance (design) level set for the S/Ps operation.

Table B-6: Waste Amount Carried-in and Carried-out of Selection Plants

|                    | Current Performance (Design) (ton/day) | Enter (ton/day) | Exit (ton/day) | Enter - Exit (ton/day) |
|--------------------|--|-----------------|----------------|------------------------|
| Bordo Poniente     | 2,000                                  | 2,156           | 2,201          | - 45                   |
| San Juan de Aragon | 2,000                                  | 2,081           | 1,522          | 559                    |
| Santa Catarina     | 1,500                                  | 1,725           | 1,613          | 112                    |
| Total              | 5,500                                  | 5,962           | 5,336          | 626                    |
| Ratio (%)          | -                                      | 100             | 89.5           | 10.5                   |

### c.2 Final Disposal Site

Daily average final disposal amount recorded in the survey is 11,186 ton/day, which approximately corresponds to the estimated amount (10,313 ton/day in the year 1998) that was calculated based on the existing information and is adopted in the present waste stream of the DF (see Section C.2).

### c.3 Waste Stream

The waste stream of the S/Ps to final disposal sites calculated from the seven days survey data is illustrated in Figure B-2.

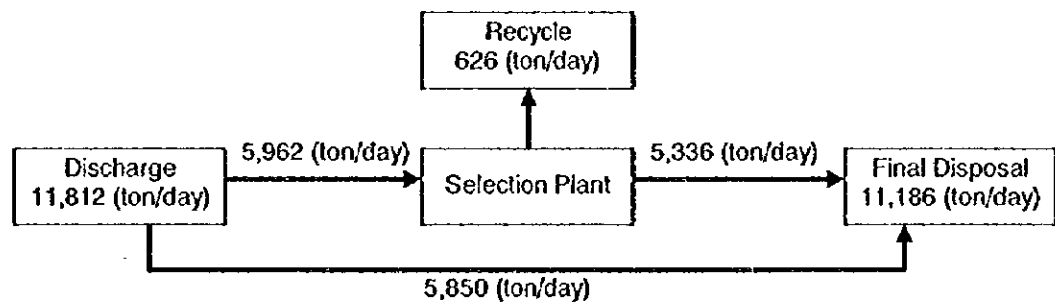


Figure B-2: Waste Stream Calculated From Waste Amount Survey

## B.1.3 Waste Composition Survey

### a. Survey Items and Number of Samples

The waste composition survey included determination of bulk density, wet base physical composition survey, the three components analysis (water, combustibles, and ash), and ultimate analysis (carbon and nitrogen). The classification of physical composition consisting 35 categories used by the GDF was followed in order for the study's analyses to bear some resemblance with previous data. A sample for the three components analysis was prepared by compounding three samples collected in a day. The weight/volume ratio was calculated from the haulage truck loading capacity (70 m<sup>3</sup>) and the weighbridge outputs. The numbers of samples are shown in Table B-7.

Table B-7: Summary of Waste Composition Survey

|   | Waste Composition Survey                    |   |   |   |
|---|---|---|---|---|
|   | Physical Composition                        |   | Three Components, C and N Survey            |   |
|   | Entrance                                    | Exit  | Entrance                                    | Exit  |
| Sampling Point 1:<br>San Juan de Aragon S/P | 3 times per day<br>x 7 days = 21<br>samples | 3 times per day<br>x 7 days = 21<br>samples | 1 sample per<br>day x 7 days = 7<br>samples | 1 sample per<br>day x 7 days = 7<br>samples |
| Sampling Point 2:<br>Bordo Poniente S/P     | 3 times per day<br>x 7 days = 21<br>samples | 3 times per day<br>x 7 days = 21<br>samples | 1 sample per<br>day x 7 days = 7<br>samples | 1 sample per<br>day x 7 days = 7<br>samples |
| Sampling Point 3:<br>Santa Catarina S/P     | 3 times per day<br>x 7 days = 21<br>samples | 3 times per day<br>x 7 days = 21<br>samples | 1 sample per<br>day x 7 days = 7<br>samples | 1 sample per<br>day x 7 days = 7<br>samples |
| Total                                       | 63 samples                                  | 63 samples                                  | 21 samples                                  | 21 samples                                  |
|   | 126 samples                                 |   | 42 samples                                  |   |

**b. Survey Methods**

**b.1 Sampling Methods**

Since the volume of landfill wastes is so large (approx. 11,000 ton) heavy machinery was used to collect the samples. The sampling methods are summarized in Table B-8.

Table B-8: Sampling Methods

| At Entrance   | At Exit   |
|---|---|
| <p>Approximately 1,000 kg of waste is taken as a sample at the entrance platform; the volume is reduced* to about 100 kg by the method described below for the physical component survey.</p> <p>Three such samples taken in a day are mixed and reduced to 20-30 kg by the method below to prepare a sample for the three components survey.</p> | <p>Approximately 1,000 kg of waste that is unloaded is removed as a sample. The volume is reduced* to about 100 kg by the method described below for the physical component survey.</p> <p>Three such samples taken in a day are mixed and reduced to 20-30 kg by the method below to prepare a sample for three elements survey.</p> |

\* Volume reduction method:

First, the waste is mixed; if it contains bulky items, they have to be cut into pieces. Once the mixture is heterogeneous, it is divided into four piles of approximately the same volume. The two portions at diagonally opposite ends are removed and the rest is mixed. This process is repeated until the intended volume remains.

This process is shown Figure B-3.

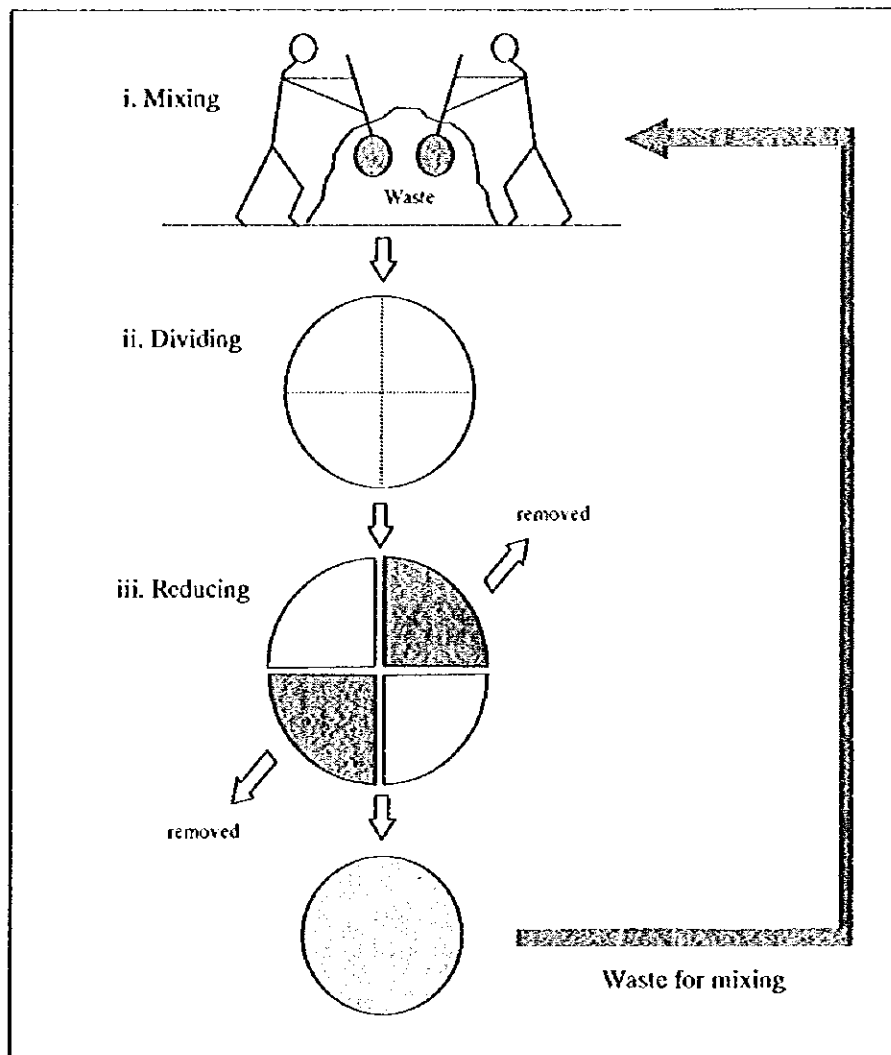


Figure B-3: Volume Reduction Method

## b.2 Wet Base Physical Composition

For the physical composition survey, sampling yards were prepared at each sampling point. The wastes are classified into 35 categories following the GDF's method and waste of each category was weighed.

Table B-9 shows the 35 categories used by the DGSU.

Table B-9: 35 Categories of Waste Composition

| Composition |                          |                     |
|-------------|--------------------------|---------------------|
| 1           | Abatelenguas             | Spatula             |
| 2           | Algodon                  | Colton              |
| 3           | Carton                   | Cardboard           |
| 4           | Cuero                    | Leather             |
| 5           | Envase de Carton         | Paper container     |
| 6           | Fibra Dura Vegetal       | Vegetable fiber     |
| 7           | Fibra Sintetica          | Synthetic fiber     |
| 8           | Gasa                     | Gauze               |
| 9           | Hueso                    | Bone                |
| 10          | Hule                     | Vinyl               |
| 11          | Jeringa Desechable       | Disposable syringe  |
| 12          | Lata                     | Cans                |
| 13          | Loza y Ceramica          | Ceramics            |
| 14          | Madera                   | Wood                |
| 15          | Material de Construccion | Construction waste  |
| 16          | Material Ferroso         | Metal               |
| 17          | Material No Ferroso      | Nonferrous metal    |
| 18          | Papel Bond               | Paper               |
| 19          | Papel Periodico          | News paper          |
| 20          | Papel Sanitario          | Toilet paper        |
| 21          | Panal Desechable         | Disposable diaper   |
| 22          | Placas Radiologicas      | X-ray film          |
| 23          | Plastico de Pelicula     | Plastic film        |
| 24          | Plastico Rigido          | Hard plastic        |
| 25          | Poliuretano              | Polyurethane        |
| 26          | Poliuretano Expandido    | Foamed polyurethane |
| 27          | Residuo Alimenticio      | Food waste          |
| 28          | Residuo de Jardinera     | Garden waste        |
| 29          | Toallas Sanitarias       | Sanitary napkin     |
| 30          | Trapo                    | Rags                |
| 31          | Vendas                   | Bandage             |
| 32          | Vidrio de Color          | Color glass         |
| 33          | Vdrio Transparente       | Transparent glass   |
| 34          | Residuo Fino             | Fine fraction       |
| 35          | Otros                    | Others              |

### b.3 Three Components Analysis

Out of the samples which have used for the physical composition survey, organic materials were mixed and reduced to 20-30 kg and the three components (water, combustibles, and ash) were analyzed in a laboratory.

### b.4 Ultimate Analyses

In the ultimate analysis, carbon and nitrogen contents of the samples from the three component analysis were quantified.



### b.5 Bulk Density

Subsequently the bulk density of the waste sample was calculated by the following formula.

$$BD = \frac{W_w}{V_w}$$

where  $BD$  : Bulk Density  
 $W_w$  : Wet Weight of Waste(kg)  
 $V_w$  : Volume of Waste (l)

### b.6 Water Content

The water content was calculated by the following formula.

$$W_c = \frac{O_w - D_w}{O_w} \times 100$$

where  $W_c$  : Water Contents(%)  
 $O_w$  : Original Weight(g)  
 $D_w$  : Dry Weight(g)

### b.7 Ash Content

The ash content was calculated by the following formula.

$$A_s = \frac{W_a}{O_w} \times 100$$

where  $A_s$  : Ash contents(%)  
 $W_a$  : Weight of ash(g)  
 $O_w$  : Original Weight(g)

### b.8 Combustion Matter Content

The combustion matter content was calculated by the following formula.

$$C_m = 100 - W_c - A_s$$

where  $C_m$  : Combustion matter contents(%)  
 $W_c$  : Water contents(%)  
 $A_s$  : Ash contents(%)

## c. Results of the Survey

### c.1 Physical Composition

Table B-10 shows the summary of physical composition.

Table B-10: Summary of Physical Composition

unit : (%)

| No    | Composition              | Name of S/P         | Bordo Poniente S/P |       | San Juan de Aragon S/P |       | Santa Catarina S/P |       |
|-------|--------------------------|---------------------|--------------------|-------|------------------------|-------|--------------------|-------|
|       |                          |                     | Entrance           | Exit  | Entrance               | Exit  | Entrance           | Exit  |
| 1     | Abatelenguas             | Spatula             | 0                  | 0     | 0                      | 0     | 0.04               | 0     |
| 2     | Algodon                  | Cotton              | 0.42               | 0.09  | 0.07                   | 0.25  | 0.09               | 0.02  |
| 3     | Carton                   | Cardboard           | 5.41               | 5.53  | 5.54                   | 7.33  | 5.43               | 5.35  |
| 4     | Cuero                    | Leather             | 0.46               | 0.93  | 0.4                    | 0.48  | 0.45               | 0.72  |
| 5     | Envase de Carton         | Paper container     | 1.36               | 1.59  | 0.87                   | 1.09  | 0.82               | 1.01  |
| 6     | Fibra Dura Vegetal       | Vegetable fiber     | 0.04               | 0.49  | 0.4                    | 0.1   | 0.24               | 0.16  |
| 7     | Fibra Sintetica          | Synthetic fiber     | 0.23               | 0.5   | 0.13                   | 0.39  | 0.59               | 0.95  |
| 8     | Gasa                     | Gauze               | 0                  | 0.09  | 0                      | 0     | 0.29               | 0     |
| 9     | Hueso                    | Bone                | 0.39               | 0.88  | 0.41                   | 0.71  | 0.39               | 0.4   |
| 10    | Hule                     | Vinyl               | 0.12               | 0.13  | 1.49                   | 0.9   | 0.73               | 0.6   |
| 11    | Jeringa Desechable       | Disposable syringe  | 0.01               | 0     | 0                      | 0     | 0.39               | 0     |
| 12    | Lata                     | Cans                | 0.62               | 0.8   | 0.4                    | 0.68  | 0.85               | 0.49  |
| 13    | Loza y Ceramica          | Ceramics            | 0.75               | 0.28  | 0.15                   | 0.28  | 0.6                | 0.13  |
| 14    | Madera                   | Wood                | 2.01               | 2.16  | 2.56                   | 3.24  | 2.41               | 3.36  |
| 15    | Material de Construccion | Construction waste  | 3.44               | 4.52  | 6.68                   | 6.38  | 3.33               | 4.9   |
| 16    | Material Ferroso         | Metal               | 1.23               | 1.8   | 1.6                    | 0.7   | 1.63               | 1.79  |
| 17    | Material No Ferroso      | Nonferrous metal    | 0.16               | 0.37  | 0.12                   | 0.02  | 0.64               | 0.01  |
| 18    | Papel Bond               | Paper               | 1.58               | 1.7   | 5.89                   | 6.48  | 5.04               | 10.03 |
| 19    | Papel Periodico          | News paper          | 4.28               | 4.57  | 1.29                   | 0.76  | 3.46               | 1.88  |
| 20    | Papel Sanitario          | Toilet paper        | 4.14               | 5.05  | 5.43                   | 3.87  | 3.14               | 2.24  |
| 21    | Panel Desechable         | Disposable diaper   | 5.46               | 4.69  | 4.6                    | 4.27  | 4.49               | 5.14  |
| 22    | Placas Radiologicas      | X-ray film          | 0.04               | 0.04  | 0                      | 0     | 0.78               | 0.01  |
| 23    | Plastico de Pelicula     | Plastic film        | 9.29               | 9.09  | 7.81                   | 8.23  | 7.03               | 7.73  |
| 24    | Plastico Rigido          | Hard plastic        | 4.62               | 5.28  | 3.64                   | 2.1   | 3.35               | 3.19  |
| 25    | Poliuretano              | Polyurethane        | 0.54               | 0.3   | 0.15                   | 0.14  | 0.95               | 0.18  |
| 26    | Poliuretano Expandido    | Foamed polyurethane | 0.22               | 0.19  | 2.25                   | 0.91  | 2.44               | 2.23  |
| 27    | Residuo Alimenticio      | Food waste          | 16.11              | 13.25 | 14.36                  | 12.47 | 15.03              | 13.63 |
| 28    | Residuo de Jardinera     | Garden waste        | 19.56              | 17.23 | 8.35                   | 6.44  | 10.55              | 8.46  |
| 29    | Toallas Sanitarias       | Sanitary napkin     | 0.64               | 0.29  | 0                      | 0.02  | 1.05               | 0     |
| 30    | Trapo                    | Rags                | 4                  | 3.97  | 4.59                   | 4.66  | 4.57               | 5.23  |
| 31    | Vendas                   | Bandage             | 0                  | 0.1   | 0                      | 0     | 1.1                | 0     |
| 32    | Vidrio de Color          | Color glass         | 2.43               | 1.31  | 0.33                   | 0.5   | 1.49               | 0.49  |
| 33    | Vdrio Transparente       | Transparent glass   | 1.15               | 0.61  | 2.15                   | 0.7   | 3.06               | 1.52  |
| 34    | Residuo Fino             | Fine fraction       | 3.14               | 3.84  | 5.45                   | 7.11  | 5.26               | 7.58  |
| 35    | Otros                    | Others              | 6.15               | 8.36  | 12.92                  | 18.82 | 8.32               | 10.59 |
| Total |                          |                     | 100.0              | 100.0 | 100.0                  | 100.0 | 100.0              | 100.0 |

c.2 Bulk Density

Table B-11 shows the summary of bulk density.

Table B-11: Summary of Bulk Density

| Date     | No. | Bordo Poniente                   |                              | San Juan de Aragon               |                              | Santa Catarina                   |                              |
|----------|-----|----------------------------------|------------------------------|----------------------------------|------------------------------|----------------------------------|------------------------------|
|          |     | Entrance<br>(kg/m <sup>3</sup> ) | Exit<br>(kg/m <sup>3</sup> ) | Entrance<br>(kg/m <sup>3</sup> ) | Exit<br>(kg/m <sup>3</sup> ) | Entrance<br>(kg/m <sup>3</sup> ) | Exit<br>(kg/m <sup>3</sup> ) |
| 25/08/98 | 1   |                                  |                              | 255                              | 330                          | 315                              | 272                          |
|          | 2   |                                  | -----                        | 207                              | 258                          | 363                              | 390                          |
|          | 3   |                                  |                              | 210                              | 249                          | 231                              | 423                          |
| 26/08/98 | 1   |                                  |                              | 331                              | 281                          | 310                              | 165                          |
|          | 2   |                                  | -----                        | 340                              | 281                          | 250                              | 255                          |
|          | 3   |                                  |                              | 288                              | 362                          | 250                              | 345                          |
| 27/08/98 | 1   | 245                              | 378                          | 298                              | 355                          | 300                              | 275                          |
|          | 2   | 202                              | 298                          | 391                              | 334                          | 395                              | 295                          |
|          | 3   | ---                              | 377                          | 244                              | 353                          | 230                              | 285                          |
| 28/08/98 | 1   | 145                              | 254                          | 344                              | 299                          | 275                              | 355                          |
|          | 2   | 173                              | 260                          | 228                              | 272                          | 260                              | 355                          |
|          | 3   | 183                              | 327                          | 328                              | 346                          | 370                              | 300                          |
| 31/08/98 | 1   | 351                              | 410                          | 238                              | 307                          | 320                              | 335                          |
|          | 2   | 322                              | 418                          | 246                              | 241                          | 245                              | 270                          |
|          | 3   | 252                              | 283                          | 234                              | 270                          | 280                              | 335                          |
| 1/09/98  | 1   | 226                              | 462                          | 389                              | 307                          | 380                              | 345                          |
|          | 2   | 332                              | 316                          | 283                              | 270                          | 300                              | 370                          |
|          | 3   | 325                              | 317                          | 270                              | 352                          | 370                              | 330                          |
| 2/09/98  | 1   | 267                              | 417                          | 204                              | 251                          | 285                              | 390                          |
|          | 2   | 160                              | 227                          | 304                              | 365                          | 360                              | 340                          |
|          | 3   | 270                              | 342                          | 299                              | 392                          | 392                              | 321                          |
| 3/09/98  | 1   | 350                              | 358                          |                                  |                              |                                  |                              |
|          | 2   | 235                              | 316                          |                                  | -----                        |                                  | -----                        |
|          | 3   | 311                              | 304                          |                                  |                              |                                  |                              |
| 4/09/98  | 1   | 229                              | 378                          |                                  |                              |                                  |                              |
|          | 2   | 229                              | 425                          |                                  | -----                        |                                  | -----                        |
|          | 3   | 309                              | 301                          |                                  |                              |                                  |                              |
| 6/09/98  | 1   | 292                              | ---                          |                                  | -----                        |                                  | -----                        |
| Average  |     | 257                              | 341                          | 282                              | 308                          | 309                              | 321                          |

### c.3 Three Components and Ultimate Analysis

Table B-12 shows the summary of three components and ultimate analysis.

Table B-12: Summary of Three Components and Ultimate Analysis

|             |     | Selection plants |       |                    |       |                |       | Average |       |
|-------------|-----|------------------|-------|--------------------|-------|----------------|-------|---------|-------|
|             |     | Bordo Poniente   |       | San Juan de Aragon |       | Santa Catarina |       |         |       |
|             |     | Ent.             | Exit  | Ent.               | Exit  | Ent.           | Exit  | Ent.    | Exit  |
| Carbon      | (%) | 46.09            | 39.64 | 42.30              | 47.50 | 42.67          | 42.05 | 43.69   | 43.06 |
| Nitrogen    | (%) | 1.82             | 1.58  | 2.06               | 1.74  | 1.88           | 1.95  | 1.92    | 1.76  |
| C/N Ratio   | -   | 25.3             | 25.1  | 20.5               | 27.3  | 22.7           | 21.6  | 22.8    | 24.5  |
| Ash         | (%) | 10.13            | 13.53 | 6.90               | 9.12  | 11.01          | 9.58  | 9.35    | 10.74 |
| Water       | (%) | 67.14            | 60.03 | 67.93              | 69.94 | 67.75          | 64.85 | 67.61   | 64.94 |
| Combustible | (%) | 22.73            | 26.44 | 25.17              | 20.94 | 21.24          | 25.57 | 23.04   | 24.32 |

### B.1.4 Findings

In view of physical composition, garden waste, food waste and plastics account for a substantial proportion, and the entering wastes and exiting wastes show the mostly same tendency in physical composition in respective S/Ps. Even though in comparing item by item of physical composition between the entering wastes and exiting wastes, an item of major proportional change is not found. This implies that the S/Ps' recovery ratios are low.

In categorizing the physical composition items into three (organic, recyclable, others) as shown in Table B-13, recyclable wastes account for about 30%. Therefore, theoretically speaking, if the whole amount of recyclable matter in the S/Ps are recovered, the recovery ratio is raised to 30%.

However in practice, even where waste feeding is controlled at an optimum level and sufficient number of selection workers corresponding to the sorting velocity are allocated to a line, it is estimated that at maximum 70% of recyclable materials fed in a sorting line is recoverable, in view of empirical data of sorting plants in Japan. Therefore, it will be possible to raise the recovery ratio from the present 10% to about 20%, if waste feeding in those S/Ps is controlled at an optimum level and appropriate number of selection workers are allocated to a line.

Table B-13: Categorized Waste Composition Items at S/Ps

| Composition       |                          |                         | Bordo Poniente |              | San Juan de Aragon |              | Santa Catarina |              |
|-------------------|--------------------------|-------------------------|----------------|--------------|--------------------|--------------|----------------|--------------|
|                   |                          |                         | Ent.           | Exit         | Ent.               | Exit         | Ent.           | Exit         |
| <b>Organic</b>    |                          |                         |                |              |                    |              |                |              |
| O                 | Fibra Dura Vegetal       | Vegetable fiber         | 0.04           | 0.49         | 0.4                | 0.1          | 0.24           | 0.16         |
| O                 | Hueso                    | Bone                    | 0.39           | 0.88         | 0.41               | 0.71         | 0.39           | 0.4          |
| O                 | Residuo Alimenticio      | Food waste              | 16.11          | 13.25        | 14.36              | 12.47        | 15.03          | 13.63        |
| O                 | Residuo de Jardineria    | Garden waste            | 19.56          | 17.23        | 8.35               | 6.44         | 10.55          | 8.46         |
|                   |                          | <b>Organic total</b>    | <b>36.1</b>    | <b>31.85</b> | <b>23.52</b>       | <b>19.72</b> | <b>26.21</b>   | <b>22.65</b> |
| <b>Recyclable</b> |                          |                         |                |              |                    |              |                |              |
| R                 | Carton                   | Cardboard               | 5.41           | 5.53         | 5.54               | 7.33         | 5.43           | 5.35         |
| R                 | Fibra Sintetica          | Synthetic fiber         | 0.23           | 0.5          | 0.13               | 0.39         | 0.59           | 0.95         |
| R                 | Hule                     | Vinyl                   | 0.12           | 0.13         | 1.49               | 0.9          | 0.73           | 0.6          |
| R                 | Lata                     | Cans                    | 0.62           | 0.8          | 0.4                | 0.68         | 0.85           | 0.49         |
| R                 | Material Ferroso         | Metal                   | 1.23           | 1.8          | 1.6                | 0.7          | 1.63           | 1.79         |
| R                 | Material No Ferroso      | Nonferrous metal        | 0.16           | 0.37         | 0.12               | 0.02         | 0.64           | 0.01         |
| R                 | Papel Bond               | Paper                   | 1.58           | 1.7          | 5.89               | 6.48         | 5.04           | 10.03        |
| R                 | Papel Periodico          | News paper              | 4.28           | 4.57         | 1.29               | 0.76         | 3.46           | 1.88         |
| R                 | Plastico de Pelicula     | Plastic film            | 9.29           | 9.09         | 7.81               | 8.23         | 7.03           | 7.73         |
| R                 | Plastico Rigido          | Hard plastic            | 4.62           | 5.28         | 3.64               | 2.1          | 3.35           | 3.19         |
| R                 | Vidrio de Color          | Color glass             | 2.43           | 1.31         | 0.33               | 0.5          | 1.49           | 0.49         |
| R                 | Vidrio Transparente      | Transparent glass       | 1.15           | 0.61         | 2.15               | 0.7          | 3.06           | 1.52         |
|                   |                          | <b>Recyclable total</b> | <b>31.12</b>   | <b>31.69</b> | <b>30.39</b>       | <b>28.79</b> | <b>33.3</b>    | <b>34.03</b> |
| <b>Others</b>     |                          |                         |                |              |                    |              |                |              |
|                   | Abatelenguas             | Spatula                 | 0              | 0            | 0                  | 0            | 0.04           | 0            |
|                   | Algodon                  | Cotton                  | 0.42           | 0.08         | 0.07               | 0.25         | 0.09           | 0.02         |
|                   | Cuero                    | Leather                 | 0.46           | 0.93         | 0.4                | 0.48         | 0.45           | 0.72         |
|                   | Envase de Carton         | Paper container         | 1.36           | 1.59         | 0.87               | 1.09         | 0.82           | 1.01         |
|                   | Gasa                     | Gauze                   | 0              | 0.09         | 0                  | 0            | 0.29           | 0            |
|                   | Jeringa Desechable       | Disposable syringe      | 0.01           | 0            | 0                  | 0            | 0.39           | 0            |
|                   | Loza y Ceramica          | Ceramics                | 0.75           | 0.28         | 0.15               | 0.28         | 0.6            | 0.13         |
|                   | Madera                   | Wood                    | 2.01           | 2.16         | 2.56               | 3.24         | 2.41           | 3.36         |
|                   | Material de Construccion | Construction waste      | 3.44           | 4.52         | 6.68               | 6.38         | 3.33           | 4.9          |

| Composition           |                     | Bordo Poniente |       | San Juan de Aragon |       | Santa Catarina |       |
|-----------------------|---------------------|----------------|-------|--------------------|-------|----------------|-------|
|                       |                     | Ent.           | Exit  | Ent.               | Exit  | Ent.           | Exit  |
| Papel Sanitario       | Toilet paper        | 4.14           | 5.05  | 5.43               | 3.87  | 3.14           | 2.24  |
| Panal Desechable      | Disposable diaper   | 5.46           | 4.69  | 4.6                | 4.27  | 4.49           | 5.14  |
| Placas Radiologicas   | X-ray film          | 0.04           | 0.04  | 0                  | 0     | 0.78           | 0.01  |
| Poliuretano           | Polyurethane        | 0.54           | 0.3   | 0.15               | 0.14  | 0.95           | 0.18  |
| Poliuretano Expandido | Foamed polyurethane | 0.22           | 0.19  | 2.25               | 0.91  | 2.44           | 2.23  |
| Toallas Sanitarias    | Sanitary napkin     | 0.64           | 0.29  | 0                  | 0.02  | 1.05           | 0     |
| Trapo                 | Rags                | 4              | 3.97  | 4.59               | 4.68  | 4.57           | 5.23  |
| Vendas                | Bandage             | 0              | 0.1   | 0                  | 0     | 1.1            | 0     |
| Residuo Fino          | Fine fraction       | 3.14           | 3.84  | 5.45               | 7.11  | 5.26           | 7.58  |
| Otros                 | Others              | 6.15           | 8.36  | 12.92              | 18.82 | 8.32           | 10.59 |
|                       | Others total        | 32.78          | 36.48 | 46.12              | 51.52 | 40.52          | 43.34 |

Bulk density as an average of entering wastes is: Bordo Poniente S/P 257 kg/m<sup>3</sup>; San Juan de Aragon S/P 282 kg/m<sup>3</sup>; and Santa Catarina S/P 309 kg/m<sup>3</sup>. That of exiting wastes is: Bordo Poniente S/P 308 kg/m<sup>3</sup>; San Juan de Aragon S/P 282 kg/m<sup>3</sup>; and Santa Catarina S/P 321 kg/m<sup>3</sup>. It resulted that the exiting wastes generally have higher bulk density than the entering wastes.

“Three components” and “ultimate analysis” of both entering and exiting wastes at respective S/Ps show same features, which are on average: carbon 43.06%; nitrogen 1.92%; ash 9.35%; humidity 67.61%; and combustible 23.04%. It resulted with extremely high water content. This is considered to be attributable to that the samples for analysis are limited to organic wastes.

On the other hand the C/N (carbon/nitrogen) ratio turns out to be 22.8 (average of entering wastes) to 24.5 (average of exiting wastes), showing a little diversified range of ratio. However, it is judged that the organic wastes that enter and/or exit the S/Ps have good quality to be used for compost production.

## B.2 Time and Motion Survey

### B.2.1 Objectives

Currently, the waste from the 16 delegations are transported to one of the 13 transfer stations; from there they are hauled to the S/Ps or the final disposal sites in large haulage trailers with loading capacities of 70 m<sup>3</sup> or 19 tons. These large trailers are equipped with a Global Positioning System (GPS) so that their movement can be monitored from the Central Supervising Center that controls their routes and timing to avoid traffic congestion. The center should have data useful for this study.

Waste collection leading up to the transfer stations are a combination of processes either using handcarts – that deliver the waste to collection vehicles – or collection vehicles, that pick up the waste from specified locations.

The purpose of this survey is to obtain data of working efficiency of waste collection vehicles in Mexico city.

## B.2.2 The Survey Schedule

Survey areas and their numbers were set as shown in Table B-14.

Table B-14: Outline of Time & Motion Survey

| Name of delegation  | Number of surveyed trip | Survey period      | Total surveyed hours |
|---------------------|-------------------------|--------------------|----------------------|
| Benito Juárez       | 11                      | 25/Aug - 7/Sept.   | 44.4                 |
| Cuauhtemoc          | 4                       | 31/Aug. - 3/Sept.  | 27.3                 |
| Venustiano Carranza | 4                       | 29/Aug. - 31/Aug.  | 23.3                 |
| Miguel Hidalgo      | 4                       | 2/Sept. - 3/Sept.  | 14.8                 |
| Iztapalapa          | 6                       | 26/Aug. - 28/Aug.  | 18.5                 |
| Gustavo A. Madero   | 7                       | 7/Sept. - 15/Sept. | 41.7                 |
| Total               | 36                      | -                  | 170.1                |

## B.2.3 Survey Records

Table B-15 shows the summary of the Time and Motion survey.

Table B-15: Summary of Time and Motion Survey

| Data   | Benito Juárez | Cuauhtemoc | Gustavo A. Madero | Iztapalapa | Miguel Hidalgo | Venustiano Carranza | Total   |
|--|---------------|------------|-------------------|------------|----------------|---------------------|---------|
| Number of trips                                    | 11            | 4          | 7                 | 6          | 4              | 4                   | 36      |
| Travel distance (m)                                | 153,070       | 62,975     | 115,650           | 33,730     | 64,460         | 31,660              | 461,545 |
| Travel distance for collection (m)                 | 110,498       | 57,630     | 81,500            | 25,130     | 45,960         | 23,710              | 344,428 |
| Number of collection points                        | 272           | 65         | 49                | 53         | 118            | 83                  | 640     |
| Number of beneficiary                              | 3,696         | 833        | 5,057             | 2,962      | 737            | 1,632               | 14,917  |
| (1) Total working hours (hr)                       | 44.443        | 27.337     | 41.734            | 18.511     | 14.814         | 23.289              | 170.128 |
| (2) Travel hours of depot to collection point (hr) | 7.541         | 3.486      | 5.991             | 1.755      | 2.433          | 1.239               | 22.445  |
| (3) Actual working hours (hr)                      | 36.902        | 23.851     | 35.743            | 16.756     | 12.381         | 22.05               | 147.683 |
| (4) Unloading time at T/S (hr)                     | 3.176         | 0.714      | 0.277             | 0.461      | 0.282          | 0.724               | 5.634   |
| (5) Moving hours (hr)                              | 0.938         | 1.399      | 3.567             | 1.532      | 2.905          | 1.599               | 11.94   |
| (6) Total stay on (hr)                             | 32.788        | 21.738     | 31.899            | 14.763     | 9.194          | 19.727              | 130.109 |
| (7) Other purposes (hr)                            | 9.937         | 8.339      | 8.977             | 3.23       | 4.143          | 7.47                | 42.096  |
| (8) Total collection hours (hr)                    | 22.851        | 13.399     | 22.922            | 11.533     | 5.051          | 12.257              | 88.013  |
| Average stopped time (hr/point)                    | 0.12054       | 0.33443    | 0.651             | 0.27855    | 0.07792        | 0.23767             | 0.203   |
| Average collection time (hr/point)                 | 0.08401       | 0.20614    | 0.4678            | 0.2176     | 0.04281        | 0.14767             | 0.138   |
| Average collection time per beneficiary (hr/ben.)  | 0.00618       | 0.01609    | 0.00453           | 0.00389    | 0.00685        | 0.00751             | 0.006   |
| Total average velocity (m/hr)                      | 3,444         | 2,304      | 2,771             | 1,822      | 4,351          | 1,359               | 2,713   |
| Average velocity for collection (m/hr)             | 2,994         | 2,416      | 2,280             | 1,500      | 3,712          | 1,075               | 2,332   |
| Number of beneficiary per point (ben/point)        | 13.6          | 12.8       | 103.2             | 55.9       | 6.2            | 19.7                | 23.3    |

Figure B-4 shows the components of working hours.

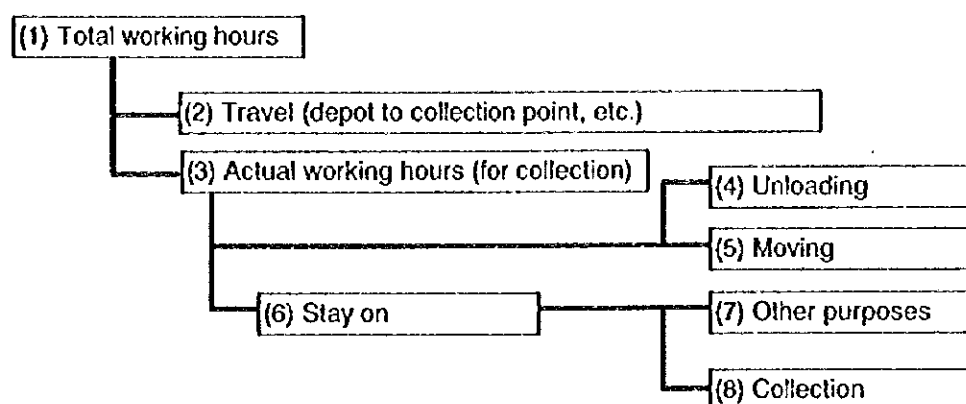


Figure B-4: Components of Working Hours

### B.2.4 Findings

Since it was impossible to weigh the collection waste amount, it was impossible, either, to examine collection efficiency based on the collection amount. Instead, collection efficiency in terms of working hours allocation of the collection vehicles was investigated.

The analysis of the working hours shown in Table B-16 indicates the following.

- The time spent for traveling from the vehicle depot to the collection area, and from the T/S to the original depot accounts for about 13% of the total working hours on average. ((2) of Figure B-4)
- The time for unloading collected wastes accounts for about 3% of the total on average. ((4) of Figure B-4)
- The time for moving within the collection area accounts for about 7% of the total on average. ((5) of Figure B-4)

Therefore the time for these activities sums up to about 23%, and the rest, 77%, is the time while the vehicle stays for collection. The latter is further divided into actual collection works (52%) and other works for non-collection purposes (25%).

It follows that half of the total working time is occupied with works for purposes other than collection. The reduction of these hours and the improvement of collection efficiency are required.

Table B-16: Breakdown of Working Hours

|                               | Benito Juárez | Cuauhtemoc | Gustavo A. Madero | Iztapalapa | Miguel Hidalgo | Venustiano Carranza | Total |
|-------------------------------|---------------|------------|-------------------|------------|----------------|---------------------|-------|
| (1) Total working (%)         | 100.0         | 100.0      | 100.0             | 100.0      | 100.0          | 100.0               | 100.0 |
| (2) Travel (%)                | 17.0          | 12.8       | 14.4              | 9.5        | 16.4           | 5.3                 | 13.2  |
| (3) Actual working (%)        | 83.0          | 87.2       | 85.6              | 90.5       | 83.6           | 94.7                | 86.8  |
| (4) Unloading time at T/S (%) | 7.1           | 2.6        | 0.7               | 2.5        | 1.9            | 3.1                 | 3.3   |
| (5) Moving (%)                | 2.1           | 5.1        | 8.5               | 8.3        | 19.6           | 6.9                 | 7.0   |
| (6) Stay on (%)               | 73.8          | 79.5       | 76.4              | 79.8       | 62.1           | 84.7                | 76.5  |
| (7) Other purposes (%)        | 22.4          | 30.5       | 21.5              | 17.4       | 28             | 32.1                | 24.7  |
| (8) Collection (%)            | 51.4          | 49         | 54.9              | 62.3       | 34.1           | 52.6                | 51.7  |

## B.3 Public Opinion Survey

### B.3.1 Objectives

A public opinion survey was carried out to determine present waste discharge conditions and observe the attitude of the society towards recycling. The opinion of the residents and companies, concerning solid waste management services, their needs and waste discharge manners were aimed to be determined through this survey.

#### a. Targets of Survey

The survey targets were households and institutions that generate municipal waste which has to be handled by the DGSU.

### B.3.2 Number of Samples

#### a. Households

The number of samples required to obtain a 90 % confidence limit for a population of 100,000 is 382, and for a population of 1,000,000, it is 384. The required samples will therefore be approximately 386 for the study area with a population of about 8.7 million. Accordingly four hundred samples were considered to be sufficient.

Questionnaires were distributed taking into account the distribution of population and the divergence of economic status throughout the city. Table B-17 summarizes the number of questionnaires by delegation and by income level of the interviewee's family. Questions were asked by interview.

Table B-17: Number of Samples by Delegation

| Delegation        | Total | Monthly Income (pesos) |               |               |                |         |       |
|-------------------|-------|------------------------|---------------|---------------|----------------|---------|-------|
|                   |       | <1,600                 | 1,601 - 4,000 | 4,001 - 6,400 | 6,401 - 19,200 | 19,201< | n.a.* |
| Alvaro Obregón    | 32    | 16                     | 10            | 2             | 2              | 1       | 1     |
| Azcapotzalco      | 24    | 6                      | 9             | 5             | 3              | 0       | 1     |
| Benito Juárez     | 20    | 2                      | 9             | 6             | 1              | 2       | 0     |
| Coyoacán          | 32    | 11                     | 9             | 5             | 5              | 0       | 2     |
| Cuajimalpa        | 4     | 1                      | 1             | 2             | 0              | 0       | 0     |
| Cuauhtémoc        | 28    | 9                      | 11            | 4             | 3              | 0       | 1     |
| Gustavo A. Madero | 68    | 20                     | 28            | 15            | 2              | 3       | 0     |
| Iztacalco         | 20    | 4                      | 9             | 4             | 2              | 1       | 0     |
| Iztapalapa        | 72    | 20                     | 23            | 14            | 12             | 1       | 2     |
| M. Contreras      | 8     | 4                      | 2             | 0             | 1              | 0       | 1     |
| Miguel Hidalgo    | 20    | 4                      | 8             | 3             | 2              | 0       | 3     |
| Milpa Alta        | 4     | 1                      | 3             | 0             | 0              | 0       | 0     |
| Tlahuac           | 8     | 3                      | 5             | 0             | 0              | 0       | 0     |
| Tlalpan           | 24    | 1                      | 6             | 5             | 10             | 1       | 1     |
| V. Carranza       | 24    | 12                     | 9             | 2             | 1              | 0       | 0     |
| Xochimilco        | 12    | 4                      | 6             | 1             | 1              | 0       | 0     |
| DF Total          | 400   | 118                    | 148           | 68            | 45             | 9       | 12    |

\*no answer

Main characters of the household interviewees are summarized as follows.



- Male : 131 (33%), Female : 269 (67%)
- Average age : 44.2
- Average number of family members : 4.57
- Average monthly income : 4,697.2 pesos

#### **b. Institutions**

Questionnaires were distributed as follows:

- 20 questionnaires to factories.
- 40 questionnaires to offices.
- 40 questionnaires to universities and primary schools.
- 40 questionnaires to markets and shops.
- 20 questionnaires to hospitals.

Similarly to the case of the household questionnaire, those questionnaires were distributed according to the distribution of size and location of each institution in the DF so that the collected answers would well represent the city as a whole.

Questions were asked by interview.

### **B.3.3 Formulation of Questionnaire**

The questionnaires for households, factories, offices, universities/primary schools, markets/shops and hospitals were drafted by the team. Taking into account the comments from the counterpart and the experience of questionnaire surveys by the local sub contractor, which was contracted by the team for this survey, the draft questionnaires were amended and finalized.

### **B.3.4 Results of the Survey**

The results are presented in the Data C of the Data Book.

### **B.3.5 Findings**

#### **B.3.5.1 Household**

##### **a. Waste Collection Services and Waste Discharge Behavior**

###### **a.1 Service Coverage**

Almost all the interviewees, 99%, have the waste collection services. Five interviewees without the collection service live in Cuauhtemoc, Gustavo A. Madero (two interviewees), Iztapalapa and Venustiano Carranza.

Further questions asked to service recipients.

###### **a.2 Type of Waste Collection**

The most common type of collection is bell collection, by which the waste collectors ring the bell on the street and the neighboring residents bring their wastes to the collection vehicle. This is seen among nearly 80% of the service recipients, followed by door-to-door collection (20%). (Plural answer question)

### **a.3 The Collector**

Wastes from 84% of the service recipients are collected by the crew of collection vehicles and the rest by the road sweeper with drums. The fact that 11% of the service recipients did not know where the collectors come from will require attention, since it should be the minimum responsibility of beneficiaries to appreciate what service is provided by whom.

### **a.4 Collection Frequency**

About half of the service recipients receive the service two or three times per week, about 40% receive it four times or more, while 5% answered "once a week". The waste collection service for 40% of the service recipients are, however, not provided at fixed days of the week. Such mismanaged service could make it difficult for people to receive the service every time. It should be noted that bell collection and door-to-door collection service is the service styles whose efficiency is particularly susceptible to whether or not the service is given at expected time.

### **a.5 Service Satisfaction Trend**

The majority of those who have the waste collection service and have lived the present place for more than three years (357 interviewees) do not notice any changes in the service. Although eight interviewees among them feel that the service has got worse, 87 interviewees answer that the service has improved very much or to a certain extent. Therefore, the service is generally evaluated to be somewhat improving.

### **a.6 Service Satisfaction**

Relatively high proportion (79%) of the service recipients express satisfaction with the waste collection service. The most major reason for satisfaction is that the frequency of collection is appropriate. The other minor reasons are that the service helps keep houses clean and that collection time is convenient for them. On the other hand, the most common reason for dissatisfaction is that the frequency of collection is very few. The less common reasons are the bad behavior of the collectors; too early, too late or irregular collection time and high tips. Far collection point was complained by a small number of interviewees, but their situation varies. One answers the current distance to the collection point is 15m and it should be five meters, while another answers the distance should be shortened from 500m to 200m.

In summary, the frequency is found to be the highly critical element for the satisfactory service.

### **a.7 Tentative Waste Discharge**

Due to the inconvenience of the waste collection service above, the service recipients may have to find the other way of waste discharge. The 80 interviewees who are not satisfied with the current service were asked a question "what you do when you have a problem for your waste to be collected". Nearly half of them answered that they would simply wait for the next collection, and 17 interviewees answered that they hand the waste to the sweepers, 14 of whom give the sweepers tips (4.85 pesos on average each time). It should be noted that there are, although small number, people who dispose waste at places which are not dedicated for waste disposal, when they have missed the waste collection service. This actions is also found in the five people

without the waste collection service. Four out of those five want the waste collection service, and three expressed the willingness to pay of 10.7 pesos per week on average for the service.

#### a.8 Waste Containers/Bags

Plastic shopping bags are used by 47% of total interviewees to discharge their wastes, followed by large plastic bags (26%) and dustbins (24%). The interviewees were asked to answer the volume of waste generated in a week by the number of the typical plastic shopping bags, and the average came to 7.25 bags/week. Since the average family size of the interviewees is 4.57, the average waste generation amount per person will be 1.59 bags/week.

It should be noted, however, that the answers about the number of plastic bags and the number of family members are skewed with some exceptionally high values, and the medians of those are 5 bags and 4 people. These gives more realistic and typical value of 1.25 bags/person/week.

#### b. Recycling

##### b.1 Recycling Practices of Bottles, Cans and Paper

Questions about the recycling practices of bottles, cans and paper, recycling of which is in general most commonly attempted, were asked.

The situation is similar in the cases of recycling bottles, cans and paper. About 40% of the interviewees currently separate those from other normal garbage. (Table B-18).

Table B-18: Separation Practice of Recyclable Materials

|                            | Bottles (%) | Cans (%) | Paper (%)                                       |
|----------------------------|-------------|----------|---|
| Yes, currently I separate. | 156 (39)    | 166 (42) | 173 (43)<br>◆ Newspaper: 143<br>◆ Cardboard: 53 |

Most of the separated materials are, however, simply given to the waste collectors (Table B-19). This is particularly the cases for bottles and cardboard. Cans and newspaper which are sold to somebody (either individual people or an private company) are more than those which are given to the collectors. These are also more often given or donated to somebody than bottles or cardboard. This might implies that cans and newspaper have more stable market and/or are considered easy to be recycled by people than bottles or cardboard.

Table B-19: Fate of Separated Materials

|  | Bottle   | Cans    | Newspaper | Cardboard |
|--|----------|---------|-----------|-----------|
| Total effective interviewees who separate them | 156 (%)  | 166 (%) | 129 (%)   | 39 (%)    |
| Give them to the waste collectors              | 105 (67) | 56 (34) | 43 (33)   | 23 (59)   |
| Sell them                                      | 10 (6)   | 62 (37) | 44 (34)   | 10 (26)   |
| Give or donate them to somebody                | 13 (8)   | 31 (19) | 24 (19)   | 3 (8)     |
| Reuse  | 19 (12)  | 15 (9)  | 16 (12)   | 0 (0)     |
| Others   | 9 (6)    | 2 (1)   | 2 (2)     | 3 (8)     |

Average selling prices of bottles, cans, newspaper and cardboard came to 0.73, 6.76, 1.79, and 1.14 pesos/kg.

Those who do not separate materials were asked the reason. The most common reason was that there is no reason or request to do so.

In other words, they are not aware of the merit or necessity to separate waste and take the mixed discharge for granted. The other reasons include "It is troublesome", "The waste collectors do so", and "Lack of time or habit" (See Table B-20).

Table B-20: Reasons for Not Separating Waste

|                              | Bottle (%) | Cans (%) | Paper (%) |
|------------------------------|------------|----------|-----------|
| No reason to separate them   | 111 (45)   | 86 (36)  | 97 (42)   |
| Troublesome                  | 32 (13)    | 32 (13)  | 39 (17)   |
| The collectors separate them | 25 (10)    | 22 (9)   | 15 (7)    |
| Few waste generation         | 7 (3)      | 17 (7)   | 7 (3)     |
| No time                      | 18 (7)     | 14 (6)   | 15 (7)    |
| No habit                     | 18 (7)     | 16 (7)   | 17 (7)    |
| No space                     | 8 (3)      | 6 (3)    | 0 (0)     |
| The collectors mix them      | 8 (3)      | 4 (2)    | 3 (1)     |
| Laziness                     | 6 (2)      | 29 (12)  | 9 (4)     |
| Others                       | 15 (6)     | 13 (5)   | 27 (12)   |

On the contrary, when they were asked if they would separate materials when required, the majority of them (about 90%) answered "Yes". The rest were then asked if they would separate bottles so that the bottles were to be recycled to bring benefit to the community, schools and/or the disabled. Those who answered "No" were further asked if they would separate materials if they could sell them. In this way, the intention to cooperate in separating wastes at different levels were investigated. The results are summarized in Table B-21 and Figure B-5. It is revealed that almost all of people who do not currently separate bottles have potentially high intention to discharge wastes separately.

Table B-21: Cooperation for Source Separation

|                                | Bottles  | Cans     | Paper    |
|--------------------------------|----------|----------|----------|
| Base: not separating currently | 244 (%)  | 234 (%)  | 227 (%)  |
| Yes, if required               | 221 (91) | 211 (90) | 201 (89) |
| Yes, for social benefit        | 19 (8)   | 15 (6)   | 16 (7)   |
| Yes, for my benefit            | 1 (0)    | 2 (1)    | 2 (1)    |
| Never                          | 2 (1)    | 1 (0)    | 3 (1)    |
| Others                         | 1 (0)    | 5 (2)    | 5 (2)    |

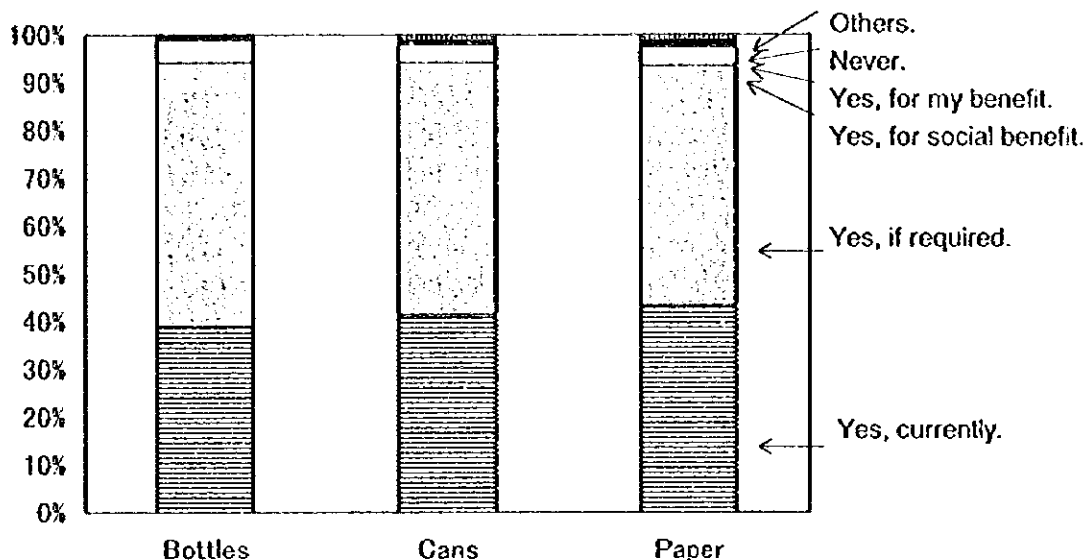


Figure B-5: Cooperation for Source Separation

### b.2 Kitchen Waste

Kitchen waste is separated by 61% of the interviewees. The main purposes for separating kitchen waste are making waste storage easy and clean, preventing odor, making compost and feeding animals. As seen in the cases of bottles, cans and paper, the interviewees who do not currently separate kitchen wastes have intention to do so: more than 90% of them answered yes to the question if they would cooperate in separating kitchen waste to make compost.

### b.3 Other Separated Items

Other than bottles, cans, paper and kitchen waste, glass, metal other than cans, garden waste, PET, other plastics, and textile are separated by a small number of people. Most of them are collected by the waste collectors, but some of them (glass, metal other than cans and PET) are found to be sold.

### b.4 Support for Recycling

As high as 96% of total interviewees answered that they support the idea of recycling. This high rate of support well complies with the results shown in Figure B-5. The main reason for support is the importance of resource saving or resource reutilization, which was answered by half of the recycling supporters. The following reasons were "It is good for efficient waste management", "It brings financial benefit", "Wastes on the street become less", and "The service life of the final disposal site can be extended". On the other hand, the reasons against for recycling varied, such as "I do not have time", "It is difficult to separate", "It is troublesome" and "It requires more garbage containers". It should be stressed that these typically anticipated opinions opposing recycling were expressed by a very small number of people.

**c. Financial Matters**

The majority (81%) of the interviewees pay tips to the waste collectors. Their average value is calculated at 28.3 pesos per month (median is 20 pesos).

Those who pay tips were then asked about the preference of tips or taxes. 80% of them prefer tips, and further asked which they would prefer, tips or taxes of the same amount with better service. 64% of them still prefer tips. The main reason for the preference of tips is related to the collectors: "The waste collectors can benefit" or "It makes the behavior of the waste collectors good". The economical reason is also common, such as "Tips would be cheaper than taxes", "I want pay what I can afford", and "There are many taxes already". On the other hand, the reasons for the preference of taxes include "The quality of the service will be improved", "I will not be required tips", "Tax would be fair" and "Tax would bring social benefit".

In spite of such reluctance to pay taxes within the majority, the amount of waste management taxes which people have the willingness to pay was asked. It averages 13.2 pesos/week (median is 10 pesos), which is about 80% more than the currently paid value.

The current payment and willingness to pay (WTP) for the services of water supply and electricity were also asked. The results are shown in Table B-22 together with the percentages of those to the average monthly family income. It also shows the order of priority of several social services expressed by the interviewees. The willingness to pay for water and electricity supply is lower than the current payment, probably because of the difficulty of thinking of the WTP of its nature.

**Table B-22: Priority of Social Services**

| Order of priority | Public service          | Current payment |                     | WTP             |                        |
|-------------------|-------------------------|-----------------|---------------------|-----------------|------------------------|
|                   |                         | Pesos per month | % to monthly income | Pesos per month | Rate to monthly income |
| 1                 | Water supply            | 94.8            | 2.02                | 85.8            | 1.83                   |
| 2                 | Electricity supply      | 130.4           | 2.78                | 117.1           | 2.49                   |
| 3                 | Surface water drainage  | -               | -                   | -               | -                      |
| 4                 | Security                | -               | -                   | -               | -                      |
| 5                 | Waste collection        | 28.3            | 0.60                | 42.9            | 0.91                   |
| 6                 | Lighting                | -               | -                   | -               | -                      |
| 7                 | Sewerage                | -               | -                   | -               | -                      |
| 8                 | Access road to my house | -               | -                   | -               | -                      |

**d. Cleaning of the City**

Nearly two thirds of the interviewees think the city is not kept clean. The problems they find include litters in public areas, illegal dumping, and blockage of drainage with litter. Most (80%) interviewees think a campaign to raise awareness of people for maintaining the city clean is effective.

The majority of the interviewees (over 80%) clean the road in front of their promises, and as high as 98% of the interviewees answered that they are willing to cooperate in some ways to keep the city clean. Individuals, communities, GDF, delegations and the federal government are considered to take an initiative in keeping the city clean in this order.

Therefore, it can be said that most people are critical of the cleanness of the city, but they are also well motivated and recognized the responsibility of themselves for the clean city.

### **B.3.5.2 Institutions**

#### **a. Waste Collection Services and Waste Discharge Behavior**

(Restricted to municipal waste in case of factories and hospitals)

##### **a.1 Service Coverage**

Among 180 institutions interviewed, only one office does not receive the waste collection service. "Service provision" includes waste collection systems run by themselves, which are found in a few cases.

Further questions asked to service recipients.

##### **a.2 Type of Waste Collection<sup>1</sup>**

Unlike households, the most common type of collection is door-to-door collection. Followed by station collection. Bell collection, which is major in households, is applied only to 15% of institutions.

##### **a.3 The Collector<sup>2</sup>**

More than 80% of the institutions receive the collection service by the delegations. One tenth employs private companies and factories has the highest tendency to do so. There are four institutions who have their own collection system.

##### **a.4 Collection Frequency<sup>3</sup>**

About half of the service recipients receive the service three times per week or less frequently, whereas one third receive it six or seven times and the rest, about 10 %, four or five times. Only one interviewee answered that the service is provided irregularly.

##### **a.5 Service Satisfaction**

Relatively high proportion (80 to 95%) of the service recipients express satisfaction with the waste collection service in all the five types of institutions. Two major reasons for the satisfaction shown by 83% and 45% of the interviewees were the service frequency and the contribution of the service to keep the place clean, respectively. On the contrary, the most common reasons for dissatisfaction are less frequent collection and the irregularity of collection time.

In summary, the frequency is found to be the highly critical element for the satisfactory service, as in the case of households.

<sup>1</sup> Effectively answered by universities/schools, offices, markets/shops and factories.

<sup>2</sup> Ditto.

<sup>3</sup> Effectively answered by universities/schools, offices and markets.

## b. Recycling

### b.1 Recycling Practices of Bottles, Cans and Paper

Questions about the recycling practices of bottles, cans and paper, recycling of which is most commonly attempted in general, were asked.

The rate of those who separate these items to all interviewees is 16%, 30% and 44% for bottles, cans, and paper (of any kind), respectively (Table B-23). It is to be noted that when excluding the cases where the interviewees have too little volume of those items to be recycled, the figures raise to 21%, 38%, and 44%, respectively.

Table B-23: Separation Practice of Recyclable Materials

|                           | Bottles |      | Cans |      | Paper |      |
|---------------------------|---------|------|------|------|-------|------|
| Base: all                 | 160     | (%)  | 160  | (%)  | 160   | (%)  |
| Not separating            | 100     | (63) | 77   | (48) | 89    | (56) |
| Separating                | 26      | (16) | 48   | (30) | 71*   | (44) |
| Generate only few bottles | 34      | (21) | 30   | (19) | 0     | (0)  |

\* Among those, 54 separate cardboard while 24 separate newspaper.

Table B-24 shows the result of the further questions about how they deal with the separated materials. Although most interviewees who separate bottles give them to the waste collectors, the collection by the collectors is not particularly major fate for the other items. If the answers "give them to waste collectors", "bring them somewhere to sell them" and "sell them to somebody who visits here" are combined (shaded part in the table), those who sell bottles, cans, newspaper and cardboard account for 16%, 45%, 62% and 53% of the interviewees, respectively. The difference between these figures well endorses the said result that the institutions separate more paper than cans, and more cans than bottles.

Table B-24: Fate of Separated Materials

|                               | Bottles |      | Cans |      | Paper     |           |    |      |
|-------------------------------|---------|------|------|------|-----------|-----------|----|------|
|                               |         |      |      |      | Newspaper | Cardboard |    |      |
| Base: separating the item     | 26      | (%)  | 48   | (%)  | 18        | (%)       | 48 | (%)  |
| Give them to waste collectors | 19      | (73) | 17   | (35) | 4         | (22)      | 11 | (23) |
| Sell to waste collectors      | 0       | (0)  | 5    | (10) | 1         | (6)       | 7  | (15) |
| Bring them somewhere to sell  | 2       | (8)  | 15   | (31) | 9         | (50)      | 10 | (21) |
| Sell them to somebody         | 2       | (8)  | 2    | (4)  | 1         | (6)       | 8  | (17) |
| Give them to somebody         | 2       | (8)  | 4    | (8)  | 0         | (0)       | 7  | (15) |
| Reuse                         | 2       | (8)  | 6    | (13) | 2         | (11)      | 2  | (4)  |

Those who do not separate materials were asked the reasons (Table B-25). The most common reason was, as in the case of household, that there is no reason or request to do so. In other words, they do not separate wastes merely because they are not motivated to do. The other reasons include "It is troublesome", "It is the waste collectors who separate wastes", "Lack of time or habit, or "No staff for separation". For the final answer, it should be mentioned that separation is carried out by not the waste generators themselves but the cleaning staff of the institutions in most cases.



Table B-25: Reasons for not Separating

| Why not separating       | Bottles |      | Cans |      | Paper |      |
|--------------------------|---------|------|------|------|-------|------|
| Base: not separating     | 100     | (%)  | 77   | (%)  | 75    | (%)  |
| No reason                | 31      | (31) | 29   | (38) | 30    | (40) |
| Troublesome              | 11      | (11) | 10   | (13) | 10    | (13) |
| Collectors separate      | 19      | (19) | 1    | (1)  | 15    | (20) |
| No information how to do | 7       | (7)  | 0    | (0)  | 0     | (0)  |
| No time                  | 11      | (11) | 3    | (4)  | 10    | (13) |
| No staff                 | 5       | (5)  | 5    | (6)  | 2     | (3)  |
| No custom/habit          | 7       | (7)  | 6    | (8)  | 4     | (5)  |
| Other                    | 18      | (18) | 15   | (19) | 8     | (11) |

They were then asked stepped questions to examine their potential intention to cooperate in waste separation at source. The questions were same as used for households, and the result is summarized in Table B-26 and Figure B-6. It is revealed that the majority of them (about 80%) answered "Yes", we will separate waste" if required, and 15% answered "Yes" if the separated materials are to be recycled to bring benefit to the community, schools and/or the disabled. This is not, in fact, surprising because the interviewees currently not separating waste are now given a reason to do (c.f. the main reason for not separating is "no reason to do").

As a conclusion, it is revealed that the most institutions which do not currently separate wastes have potentially high intention to discharge wastes separately.

Table B-26: Cooperation for Source Separation

| Do you separate?     | Bottles |      | Cans |      | Paper |      |
|----------------------|---------|------|------|------|-------|------|
| Base: not separating | 100     | %    | 77   | %    | 95    | %    |
| If required          | 79      | (79) | 61   | (79) | 80    | (84) |
| Yes, for society     | 14      | (14) | 12   | (16) | 10    | (11) |
| Yes, for own benefit | 3       | (3)  | 0    | (0)  | 2     | (2)  |
| Never                | 4       | (4)  | 4    | (5)  | 3     | (3)  |

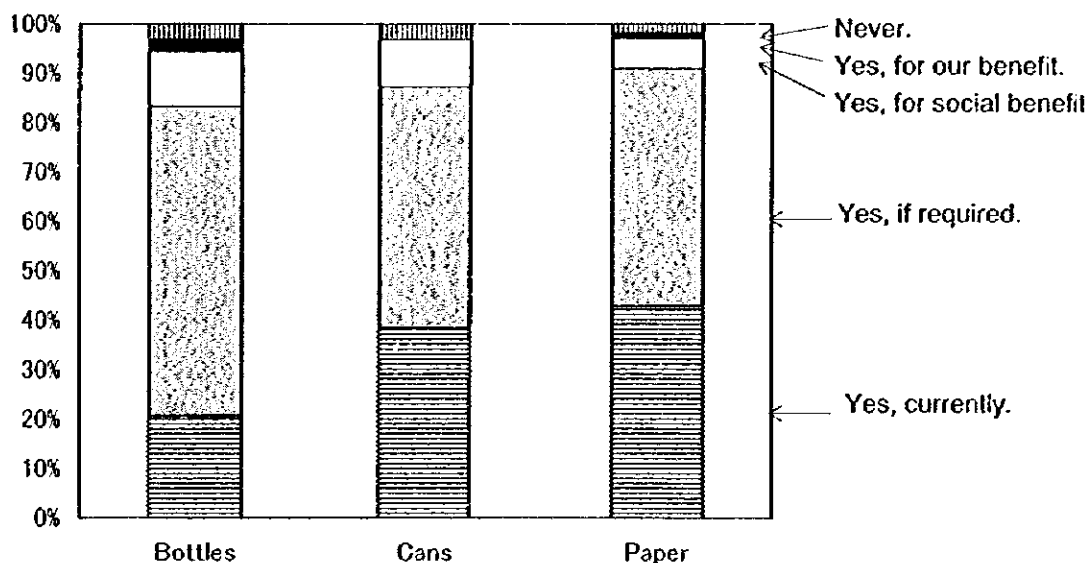


Figure B-6: Cooperation for Source Separation

## b.2 Organic Waste

The handling of organic waste is asked to markets/shops, universities/schools and hospitals.

There are only three markets/shops which utilize organic waste in some ways. Among those which do not utilize it at present, 64% stated that they would separate organic waste if required so (excluding those without organic waste). The reasons of the rest 36% for not willing to separate organic waste were such as "It is troublesome", "It is difficult to separate organic waste from others", and "The waste collectors do".

For the universities/schools and hospitals, the numbers of the answers of those which would separate organic waste if required were 6 out of 8 and 9 out of 10 of those which do not currently separate organic waste although they generate it, respectively.

The reason for lower intention to cooperate in organic waste discharge among markets is probably that the market generates a huge amount of organic waste which originates from different shops in the market, thus it sounds difficult to organize the separation of organic waste.

## b.3 Other Separated Items

Other than bottles, cans, paper and kitchen waste, glass, metal other than cans, garden waste, PET, other plastics, and textile are separated by a small number of institutions. Most of those items separated at households are found to be collected by the waste collectors, while those separated at institutions are more often given or sold to somebody who visits them than just handed to the waste collectors. This implies that there is, although small, a recycling market for those items.

## c. Financial Matters

Financial matters were asked with paying attention to whether collection is conducted by a private company or the delegation. In the former case, the cost for SWM is expressed as "fee" while in the latter case, as "tip"<sup>4</sup>. In addition to this actual payment, the amount of WTP as SWM tax was asked. In this section, average values expressed as pesos per kilogram of waste are weighted averages. Furthermore, wastes referred to here are non-hazardous wastes which are or could be managed by the DGSU.

### c.1 Universities/Schools

Only one school has a contract with a private collection company; the rest receives the collection service of the delegations. Among 38 effective answers of the amount of tips, 24 schools/universities does not pay tips. Excluding the erroneous answer (100 pesos per one kilogram of waste), the average amount of tips for the 37 answers works out at 0.46 pesos/kg of waste discharge.

WTP averages about 0.03 pesos/kg. This is far below the current tip payment and the reasons for this will be explained as below.

- For those who currently pay tips, the amount of tips was asked by pesos per kilogram of waste, so that they could observe their own payment practice more

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<sup>4</sup> This can be called "finca" if it is paid regularly by the institution as quasi-fee.

precisely. They were, however, prone to answer small values as WTP, which was asked by pesos per month.

- For those who currently do not pay tips, the amount of WTP is still low. Even though their answers are not zero, it is obvious that they do not have any real "willingness" to pay for the service since they regard the service as the obligation of the governmental agency.

## c.2 Offices

Wastes from nine offices out of 40 are collected by private companies. Only three offices, however, answered the amount of payment for the collection service, giving an average of 0.435 pesos/kg. More than half (17) of the offices with effective answers about tipping for the delegation collection (29) do not pay tips for the service and average amount of tips among the 29 offices works out at as low as 0.012 pesos/kg. Although a particular question was not included in the questionnaire, it was revealed during the interview that not a few offices consider the existing taxes should cover the SWM cost and extra payment, such as tips, should not be required.

WTP as the SWM tax, asked to all interviewees, averages at 0.047 pesos/kg.

## c.3 Markets/Shops

Four markets/shops answered that private companies collect their waste, but two of them did not answered the amount of payment, one answered zero, and the other answered 20,000 pesos/month, which is equivalent to 0.93 pesos/kg.

33 markets/shops receive the delegations' collection service and answered the amount of tips. It was found that most of them (24) do not pay tips. During the interview, some of them stated that they do not pay tips because the collection fee is paid by the delegation. The total average of tip is calculated at 0.051 pesos/kg.

WTP for the service as tax worked out much lower: 0.024 pesos/kg (30 effective answers). The same observation with the case of schools/universities can be made, in that, those who currently pay tips answered lower WTP. The fact that the relatively large waste dischargers answered low WTP also lowered the average WTP.

## c.4 Factories

The waste discharge manner at factories is complex. Some discharges domestic waste (generated from the daily activities of workers) to the collectors from the delegation and make private collectors collect waste similar to domestic waste but generated from the industrial activities. On the other hand, some discharge both types of waste to the delegations' collectors. Because of such complexity, analysis shown here is restricted to waste collected by the delegations (regardless whether they are "real" domestic waste, or can be regarded as domestic waste but generated from the manufacturing process).

All interviewees who receives delegations' collection service pay tips (14 answers). Among these, 11 answered the waste amount collected by the delegation and the tip amount, giving a weighted average of only 0.018 pesos/kg.

Similarly, looking at the WTP for the delegations' service, the average worked out at 0.016 pesos/kg.

### c.5 Hospitals

There are very few effective answers on the volume of domestic waste and the amount of tips, thus no rational analysis about tipping practice at hospitals is available.

### c.6 Summary of Financial Aspect

The table below summarizes the mentioned above. If compared to households, it can be pointed out that firstly, tip payers account for smaller percentages of service recipients except factories, and second, both the paid tip and WTP are much lower. Influential factors are probably the following.

- Public institutions (schools and markets) consider that waste collection should be done by the concerned governmental bodies.
- Private institutions (offices and factories) considers that the tax already paid should cover the cost for SWM by the government.
- Waste amount of part of institutions is huge, thus the collection can be carried out with higher efficiency.
- Waste from institutions tends to include recyclable elements, from which the collectors can benefit.

Table B-27: Payment for SWM by Institution

|                          | School      | Office  | Market                                       | Factory      |
|--------------------------|-------------|---|--|--------------|
| Tip payers               | 14/38 (37%) | 12/29 (41%)                                   | 11/33 (33%)                                  | 14/14 (100%) |
| Amount of Tip (pesos/kg) | 0.458       | 0.12<br>(0.435 as fee for private collection) | 0.51<br>(0.93 as fee for private collection) | 0.018        |
| WTP (pesos/kg)           | 0.033       | 0.047   | 0.024  | 0.016        |

### c.7 Preference of Tax and Tip

In the question about the preference of tax and tips, it was observed that nearly half of institutions prefer paying tax to tip. Some of the rest answered that they prefer paying tax if the service would be improved. The sum of those two groups accounted for more than half of the interviewees. The result is illustrated in Figure B-7.

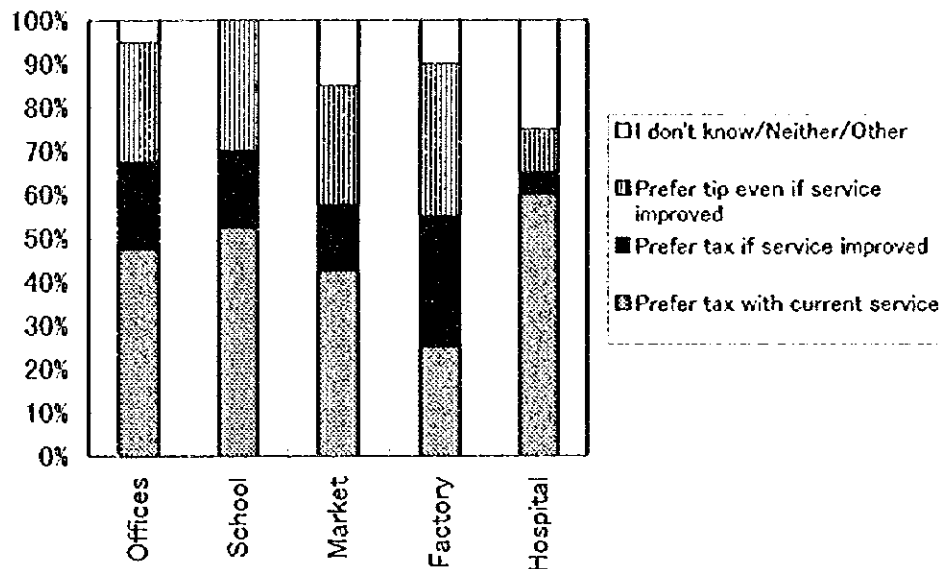


Figure B-7: Preference of Tax and Tip

#### d. Cooperation for Waste Management

##### d.1 General View

Asked about the possibility of doing something for good waste management, 86% of institutions gave positive answers. Further, they answered that they can contribute to waste management by the following.

- Discharging waste neatly.
- Recycling wastes.
- Reusing wastes (factories).
- Separating wastes.
- Providing information to the public (hospitals, universities/schools).
- Raising the environmental awareness of the public/pupils (hospitals, universities/schools).

Different questions depending on the type of institutions and those results are described below.

##### d.2 Universities/School

All universities/schools but one answered that they think recycling at universities/schools can raise the environmental awareness of the students/pupils. All interviewees also answered they think universities/schools should cooperate with the country, city and/or delegation in promoting recycling in the community.

Therefore, it is suggested that universities and schools are well aware of the role posed on an educational institution in SWM not only within them but also in surrounding areas.

### **d.3 Offices**

Highly positive attitude towards SWM was observed in 38 offices out of 40 that answered they would be interested in cooperating with the country, city or delegation for a campaign to raise people's awareness of waste.

### **d.4 Markets/Shops**

Three forms of SWM practices shown below were taken as examples to see the intentions of managing waste issues of the markets/shops. The numbers of markets/shops which answered that they support and/or are interested in the idea are also shown together below (all samples: 40).

- i. Bottle deposit system (15)
- ii. Program to prepare boxes to collect PETs from the community at an request of the delegation (24)
- iii. Scheme to encourage the customers to reuse the shopping bags (33)

As seen in Section d.1, majority of markets/shops expressed the intention to cooperate for SWM, but the interpretation of the result shown above will call for attention. The options i. and ii. require the markets/shops to establish some rules. For the first one, they will need to discuss with the wholesalers and/or manufacturers and the scheme has to be institutionalized in a whole cycle of the commodities. For the option ii., the markets/shops need to provide a space and control the manner of people to throw away PETs into the box. If mismanaged, the box would become a nuisance. On the other hand, the option iii. does not give a particular burden on the markets/shops. They could even save the cost for the shopping bags.

As a conclusion, if markets/shops are to be involved into SWM, it is important to examine the cost and benefit for them in a broad sense brought by a proposed scheme.

### **d.5 Factories**

In relation to the financial aspect of waste management at factory, a question about the trend of the cost for waste management was asked. Factories which answered that it is getting significantly higher/higher/relatively higher accounted for 80%.

Regarding the priority on the waste management, 95% of factories answered that they give very high or moderate priority on it.

The results of these two questions implies that most factories are seriously coping with the waste issue.

On the other hand, 80% of the interviewees answered "Yes" to a question whether they think good waste management could bring them a benefit. Therefore, although the environmental management is in general prone to be considered as external economy, most factories appear to be approaching the issue positively.

### **d.6 Hospitals**

13 hospitals out of 20 answered that the cost for waste management is getting higher, while all hospitals answered that they give very high or moderate priority on this matter. Similarly to the cases of factories, thus, it is concluded that most hospitals are taking SWM seriously in spite of the high cost. It should be noted that those hospitals

are not necessarily profit-oriented unlike the factories, which should have an economic incentive for effective waste management. Therefore, it is assumed that most hospitals will recognize the social responsibility as medical institutions. This is supported by the fact that more than half of the interviewees think that they can promote SWM by raising the environmental awareness of the public.

## B.4 Environment Survey

### B.4.1 Objectives of the Survey

At the initial stage prior to the M/P, the team examined environmental aspects concerning the vertical expansion of the Bordo Poniente final disposal site. They included the current situation of waste disposal, the characteristics of the ground (i.e., the state of consolidation, ground strength, etc.), and the possible impact on the groundwater.

### B.4.2 Methodology

#### a. Sites of Survey

The former landfill areas, Etapa I, II, and III at Bordo Poniente, were investigated.

#### b. Survey Items

Electrical resistance is measured by electric prospecting to understand the spatial boundary and depth of the landfill. Core boring of the entire depth of wastes also conducted to take samples for laboratory soil analysis. Permeability tests at ground surface and in-situ permeability tests at bore holes were also carried out to examine the impact on groundwater by piling up the wastes. Table B-28 summarizes the conducted works. Figure B-8 shows the locations of the electric prospecting survey lines and bore-holes.

Table B-28: Work Quantity

| Survey Items            | Location         | Survey Contents  |
|-------------------------|------------------|--|
| Electric<br>Prospecting | Etapa I          | 2 lines, total 2,000 meter (20 meter pitch)  |
|                         | Etapa II         | 2 lines, total 2,100 meter (20 meter pitch)  |
|                         | Etapa III        | 2 lines, total 3,200 meter (20 meter pitch)  |
| Boring                  | Etapa I          | 2 Bore holes, 20 m deep  |
|                         | Etapa II         | 2 Bore holes, 20 m deep  |
|                         | Etapa III        | 2 Bore holes, 20 m deep  |
| In-situ Test            | 6 bore holes     | In-situ permeability test at each bore hole (6 in total)   |
|                         | 6 locations      | In-situ permeability test at ground level (total 6 Nos.)   |
| Laboratory Test         | 6 boring samples | Liquid and plastic limit test, unit weight test, consolidation test, grain size distribution, tri-axial compression test (6 Nos. each) |

