## 3 Environmental Administration in Bolivia

### 3-1 Environmental Control Administration

#### 3-1-1 Organization and Management

Figure 3-1-1, 'Organization Chart of Ministry of Sustainable Development and Planning' (MDSP), presents the current national level environment administration organization chart with name of each department, the main operating body for the national level environment administration organization, Vice-ministry of Sustainable Development and Environment (VMDSMA). This to the MDSP actually has 83 employees, 20 working on the Environment Policies and Rules, 49 on the Bio-diversities and 14 on the Special Program.

The MDSP was created by the regulation No. 23660 based on the law No. 1493 on October 12, 1993. It was given the responsibility for the 1) the establishment of a long term national environment protection plan, 2) the conservation of natural resources and 3) the protection of the environment.

As the 1997 yearly budget for the MDSP, the Table 3-1-1 'Budget of Vice-ministry of Sustainable Development and Environment (VMDSMA)' shows the sources of the fund and the total value in excess of s Bs111,000,000, but details of the budget are not made public. Generally, expenditure comes significantly below budget.

Figure 3-1-2, 'Organization Chart of Potosi Prefecture', presents the current prefecture-level environment administration organization chart with name of each department, the main operating body for the prefecture level environment administration organization, the Natural Resources and Environment Department. This belongs to the Division of Sustainable Development and Planning, and is made up of two units, the Unit of Environment Management and the Unit of Territorial Control with one employee for each unit beside a manager.

The administrative organization of the prefecture was reformed based on the new law for the executive power organization, promulgated on September 16, 1997.

The 1997 yearly budget for the Natural Resources and Environment Department is not available but as the Table 3-1-2 'POTOSI Prefecture Budget' demonstrates, the total for prefecture exceeds Bs3,600,000, and the Division of Sustainable Development and Planning has 30% of total yearly budget for the prefecture.

3-1-2 Environment Administration at the National Level

The daily activities of the environment related services are handled by the one of three divisions of the VMDSMA, the Environment Politics and Rules Division, which is made of three units, Planning Policies and Rules, Environment Impact Assessment and Environment Quality Control.

According to the Environment Law, the environmental quality control (CCA) is administrated by VMDSMA, having two main instruments for implementation, Environment Impact Assessment and Environment Quality Control, as shown in the Figure 3-1-3 'Environment Quality Administration Scheme'. The activities for the environment impact assessment (EIA) would be the most practical instrument for the national environment administration to prevent the possible damages to the environment, by evaluating new projects before their implementation. The activities for the environment quality control (CCA) would be the other practical means for the national environment administration to make certain that existing projects and the activities of each company minimize the damages to the environment in accordance with the Environment Law.

Every new project should be evaluated by the competent environmental authorities under the EIA system and the all on-going activities should be evaluated by the competent environment authorities periodically under the CCA system. Those who do not comply with these systems are subject to penalties, as explained in the following chapter.

The institutional frame work of these two systems is presented in Figure 3-1-4 'Institutional Frame', which shows the National Level administration with the relation of Prefecture Level and Sector Level administration.

Actually every issuance of the certificates for Authorization and Declaration of Environment Impact

(DIA) and the Declaration of the Environmentally Adequacy (DAA) and the verification work and approval work are made by the prefectures. In case of national level projects, the verification, approval work and issuance of the certificate is made by VMDSMA. And, additionally, in case of projects in the mining sector and the hydrocarbon sector, which have already started as authorized sectors for the verification and presentation of the opinion for the Environment Note (FA) and the Environment Manifesto (MA), the competent prefectures should make evaluation and their decision of DIA and DAA taking these sectors' opinions into their consideration.

And, monitoring services of each approved projects should only be made by the relevant institutions of the prefectures.

3-1-3 Environment Administration at the Prefecture Level and Municipal Level

The prefecture and municipal environment administration activities have just started. Being as the present work force and their budget very limited, in case of Potosi Prefecture, based on the decentralization policy, up to the end of 1997, three of the sixteen administrative districts in the prefecture have been informed of the system and have been delegated the authority for execution of the main part of the EIA and CCA system.

At the level of Prefecture, the specific environment policy for the area shall be defined by the environment administration of the prefecture in cooperation with the VMDSMA.

In Potosi Prefecture, however, due to the overall decline of the economy of the region, it has become more difficult to keep the ideal philosophy of sustainable development. Because of the mono-cultural industry of the area, that is mining, which gave the historical prosperity to the country but now faces the difficult challenge of recent declines in the international market for mining products, and the obsolete technologies which are employed in the area, makes it too difficult for Potosi Prefecture to provide the financial support to the mining sector to help them to invest in the necessary remedies for the betterment of the situation of the environment.

As one of the example of Potosi Prefecture environmental administration, at the beginning of 1998, one of the biggest companies in Potosi Prefecture announced its Environment Manifesto (MA), as the first application in this prefecture. This could be a good precedent for other companies, projects and entities.

### 3-1-4 Mining Sector Administrative Organization for the Environment Protection

The national level mining sector administration is under the Ministry of Economic Development, and the direct administrative responsibility for the mining sector is lead by the Vice-ministry of the Mining and Metallurgy. The latter has two general directorates, the General Directory for Mining and the General Directory for Metallurgy. The division for environment issues is under the General Directory of Mining as shown in the Figure 3-1-5 'Organization Chart for Mining Administration'.

The mining sector environment administration is obliged to cooperate with the VMDSMA to execute the following activities.

① To propose the policies, rules and activities for the protection and betterment of the environment in harmony with the development of mining-metallurgic industry.

② To comply with the function and activities which are defined in the Regulation for the Environment Law, in the relation to the protection and conservation of environment for the mining-metallurgical activities, beside the check, supervision and control of the applications and the compliance of the regulations.

③ To promote studies for the planning and environment control of the mining-metallurgical activities and also to promote the adaptation of the technology which can contribute to prevent and eliminate the elements which cause damage to the environment.

Table 3-1-1

**Budget of Ministry of Sustainable Development and Planning (MDSP)**
**(Fund Source-wise budget for 1997 in Bs)**

| Fund Source | Value |
|---|---|
| National Treasury General Account | 27,503,205 |
| Transfer from National Treasury | 6,990,899 |
| Transfer of Credit | 38,142,324 |
| Transfer of Donation | 13,760,520 |
| External Credit | 6,250,000 |
| Donation | 18,907,619 |
| Total | 111,554,567 |

Table 3-1-2

## Budget of Natural Resources and Environment Department

(POTOSI Prefecture)

| Fund Source | Value (Bs. & %) | | | | |
|---|---|---|---|---|---|
| | Prefecture A | Division of Sustainable Development B | Rate B/A | Department of Natural Resources and Environment C | Rate C/B |
| Special Resource | 1,916,780 | 546,492 | 28.51 | U.K. | U.K. |
| Transfer from National Treasury | 1,667,346 | 541,103 | 32.45 | U.K. | U.K. |
| Others | 92,380 | 0 | 0 | 0 | 0 |
| Total | 3,676,506 | 1,087,595 | 29.58 | U.K. | U.K. |

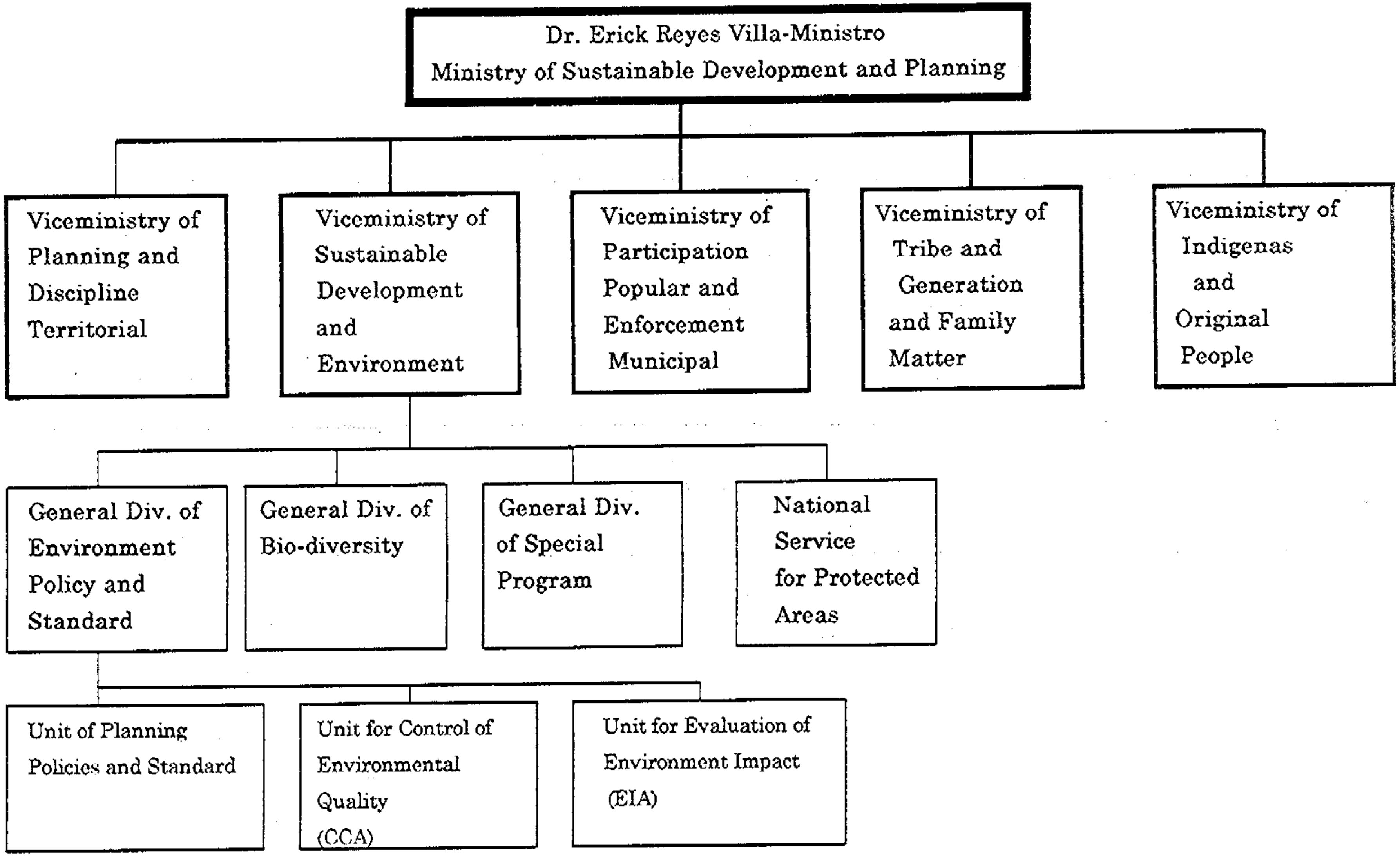


Figure3-1-1 Organization Chart of Ministry of Sustainable Development and Planning (MDSP)

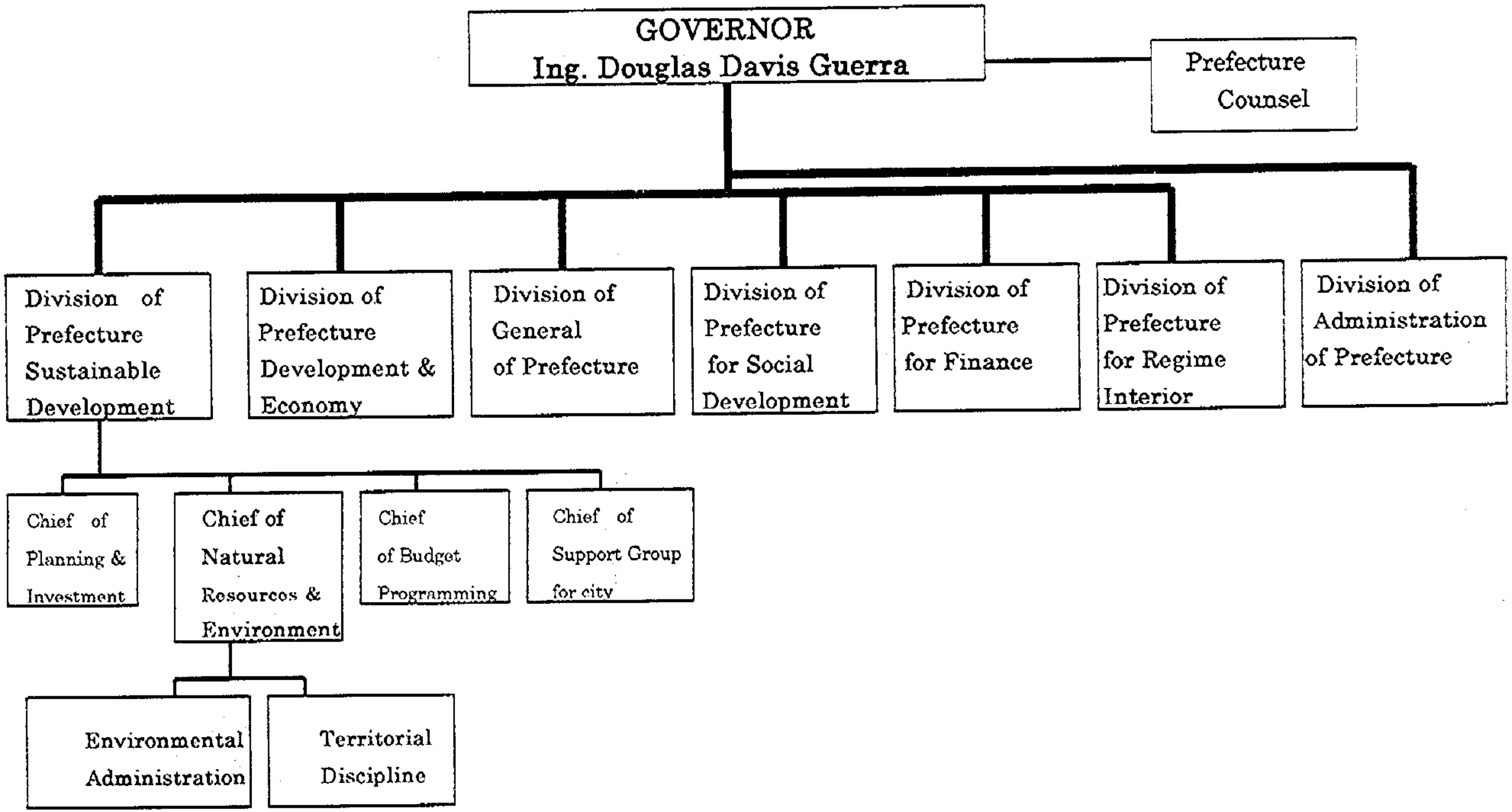
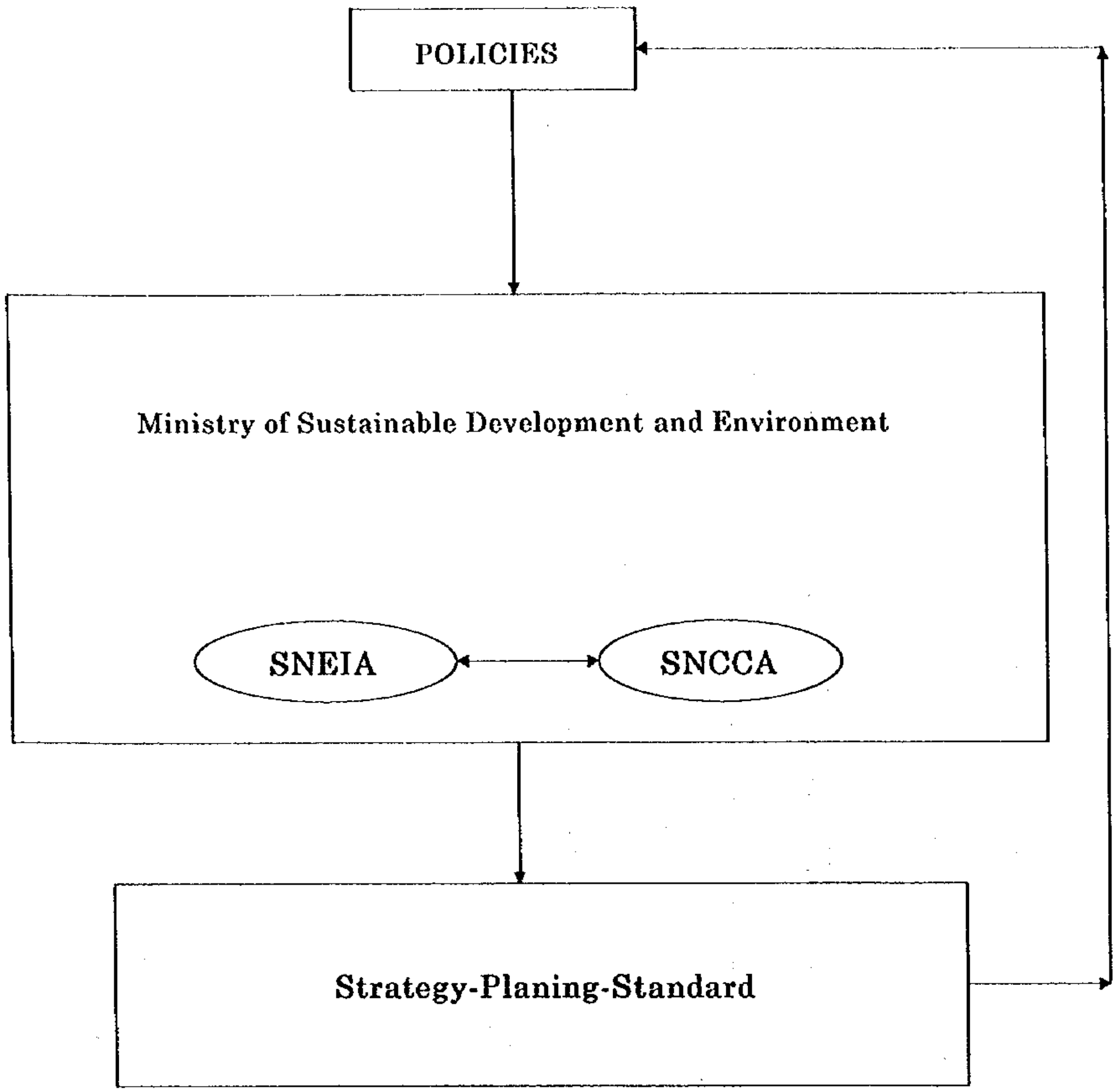



Figure 3-1-2 Organization Chart of POTOSI Prefecture

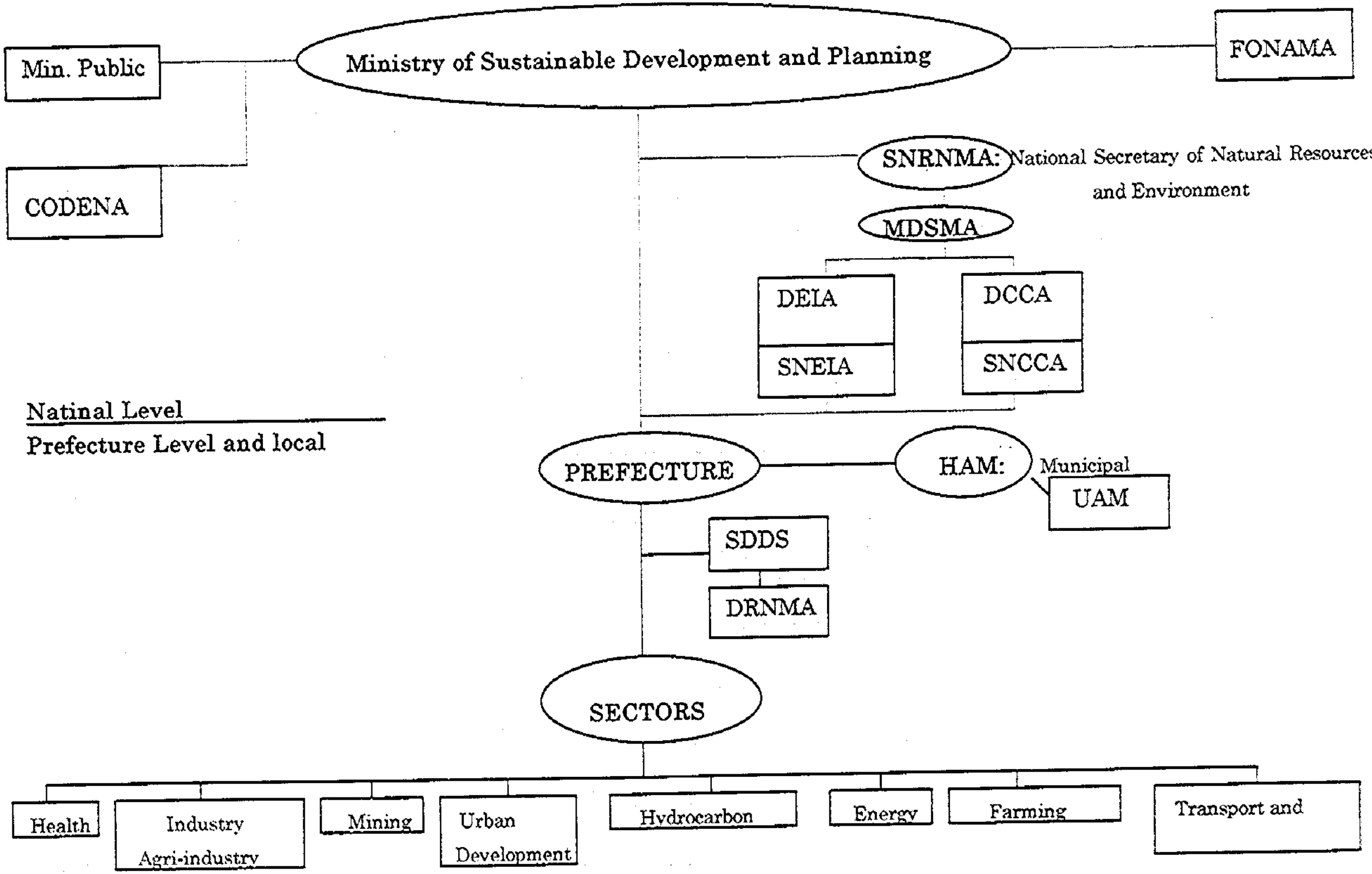



OBS;

SNEIA: National System for Environment Impact Assessment

SNCCA: National System for Environment Quality Control

Figure 3-1-3 Environment Quality Administration Scheme




Communication

Figure 3-1-4 Institutional Frame

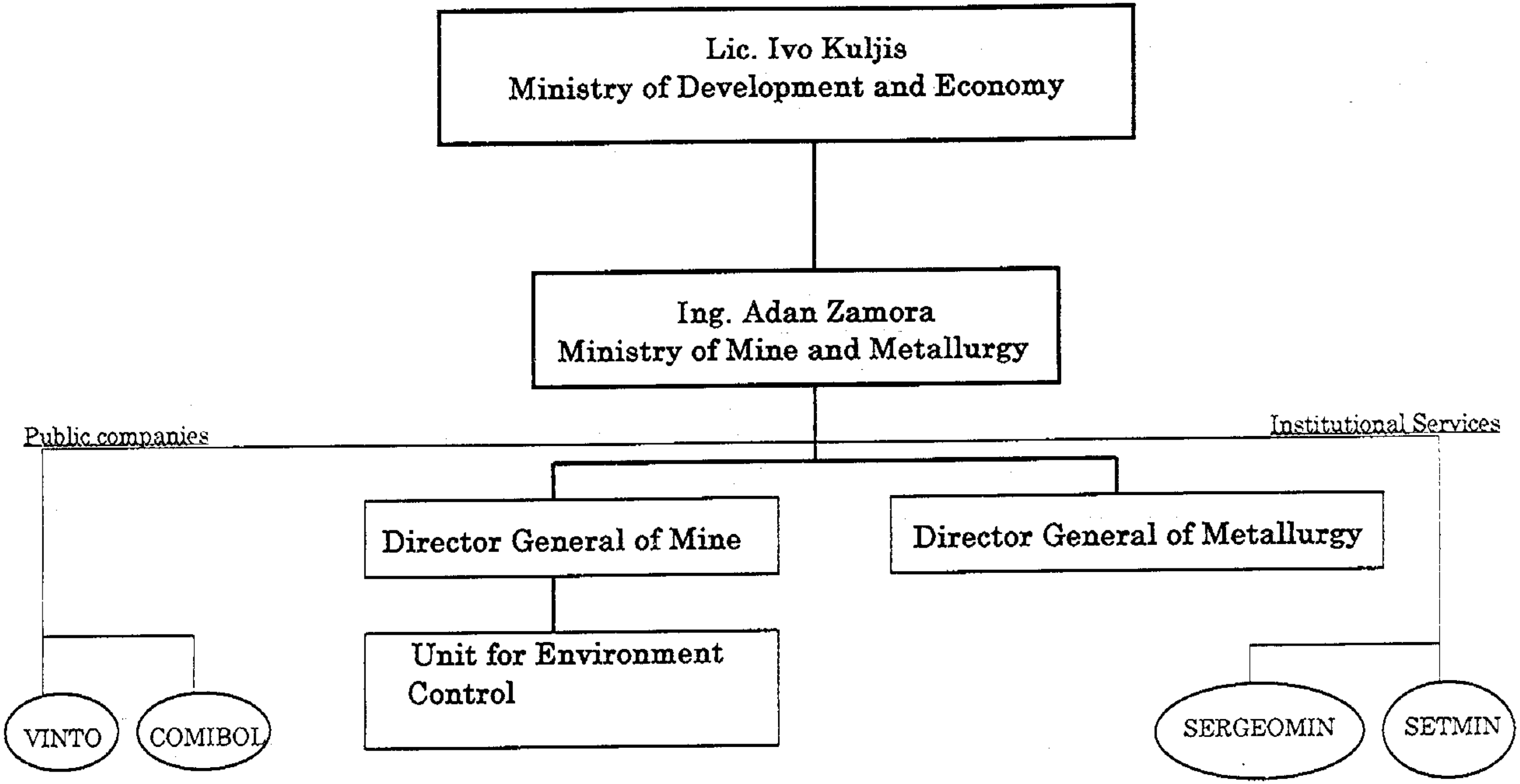



Figure 3-1-5 Organization Chart of Mining Administration

## 3-2 Environment Law and Regulation

### 3-2-1 Environment Law

The law of the environment which is now valid was promulgated on April 27, 1992, as law No. 1333, has general characteristics and does not concentrate on specific activities. The object of the law is to protect and conserve the environment without affecting the development of the country.

The law consists of 118 articles in 12 titles and 34 chapters which contain the general rules on the environmental issues of various aspects including the inhabitants and their health. And this law includes the issues of the natural resources to be recuperative, and environmental education, the people's participation and administrative infractions, etc.

The titles of the law are as follows;

| | |
|---|---|
| Title 1. | General Rule |
| Title 2. | Environmental Control |
| Title 3. | Environmental View |
| Title 4. | Natural Resources in General |
| Title 5. | Inhabitants and Environment |
| Title 6. | Health and Environment |
| Title 7. | Environment Education |
| Title 8. | Science and Technology |
| Title 9. | Promotion and Incentives for the activities of Environment |
| Title 10. | People's Participation |
| Title 11. | Security Methods, Administrative Infraction and Environment Crime |
| Title 12. | Transition Rule |

Figure 3-2-1 'General View of the Environment Protection Related Laws and Regulations' gives a total view of the laws related to environmental protection regulations of which are referred to, in this report.

3-2-2 Regulation for the Environment Law

The Environment Law was augmented, as a practical instrument, by the Regulation for the Environment Law which was promulgated on December 8, 1995(Regulation No. 24176). This is new Regulation integrates 6 regulations, namely those directly concerned with the General Environment Procedure, Prevision and Control of Environment, Air Pollution Materials, Water Pollution Materials, Activities and Dangerous Substances, and Solid Waste Control.

A brief explanation of these six regulations is as follows;

① General Environment Procedure:

Give a general explanation about government decisions and activities on behalf of the sustainable development.

② Provision and Control of Environment:

Refers to environment impact assessment (EIA) and environment quality control (CCA), matters.

③ Air Polluting Materials:

The prevention and control of the air contamination to protect all citizens so that they can enjoy a healthy and comfortable environment.

④ Water Polluting Materials:

The prevention of the contamination of water and control of water quality.

⑤ Dangerous Activities and Substances:

Within the frame-work of sustainable development, the establishment of the management procedures, controls and reduction of the risks in the activities with the dangerous substances.

⑥ Solid Waste Control:

The residual solids which are considered as sensible factor to affect the human health and animal, promoting the adequate usage of the contents in the residual solid.

3-2-3 Standards

The environment standard and regulation of qualities of substances to be emitted or discharged are defined in the Regulation for the Environment Law. The standard for the air quality; (air quality standard and gas emission quality standards) and water quality, (water quality standard and effluent discharging quality standards) are defined.

Regarding the water quality standard and effluent discharging quality standards, the Table 3-2-1 'Water Quality Standard Comparison between Bolivia and Japan' helps to clarify the Bolivian level of the environmental standard and the effluent discharge standard.

3-2-4 Penalties

The Environment Law, Title XI, chapters III and V defines the environmental crimes, identifies the types of crimes and grades of penalties. The Regulation for the Environment Law, article on General Environmental Procedure, Title IX, Chapter I gives, the procedure of the infraction and the administrative sanction with their procedures.

So far there has been no instance of the use of administrative sanctions in Potosi Prefecture or elsewhere in Bolivia, but in relation to the procedures of the environment impact assessment (EIA) work for new projects and the environment quality control work, anyone who does not follow the instructions defined in the law and regulation are subject to be penalized.

The detailed definitions of crimes and penalties in the Environment Law are cited in the Table 3-2-2 'Crimes and Penalties in the Environment Law'. The infractions which constitute violation of the law and the regulation, and the infractions which are subject to the administrative sanction, are described as follows;

① To initiate the activity or to implement the work or a project without getting the suspension certificate or the declaration of environment impact.

② To present to the government the Environmental Note (FA), the study of Evaluation of the

Environment Impact (EEIA), the Environmental Manifestation (MA), or other environmental authorities' report with altered information.

③ Not to present the Environmental Manifestation within the established period.

④ Not to comply the administrative resolution which had been emitted by the competent environment authorities.

⑤ To change, to amplify or to modify the project, work or activities without complying with the procedure of the Environment Impact Assessment (EIA).

⑥ To fail to give any information to the competent environment authorities about the suspension of the projects, works and activities.

⑦ Not to complete the corrective measurement or modification after the inspection within the allowed period.

⑧ Not to implement the approved moderation measurement in the program of prevention and modification and in the plan of adequacy.

Above administrative sanction could take the form of penalty corresponding to the value of 3/10,000 of the total property or declared assets of the company, project or the work and in the worst case the authorization to conduct business would be canceled as the penalty.

3-2-5 Incentives

The Environment Law, Title IX, Chapter II, defines the policy of incentives for the promotion of the environment protection activities. The General Environmental Procedure, Title V, Chapter II, defines the administrative procedures for the incentives.

The incentives are considered as supports by which the state, companies, personnel, public organizations and others can promote environment protection activities. Such support can be made through the mechanisms which are defined in the articles, like the system of concession, direct subsidy, tax incentive, on subsidy to the financial cost for the investment.

The evaluation of each project to be a subject of the incentives shall be made by the competent authorities, using the pre-fixed parameters for the evaluation and taking into the consideration of the following factors;

① Environmental Efficiency

② Economic Efficiency

③ Legal and Institutional Viability

④ Administrative Capability

⑤ Legitimacy and Equality

⑥ Fiscal Impact

⑦ Economic Impact

3-2-6 Policy of Mining Sector for the Environment Protection

Considering the following key characteristics of the mining sector in Bolivia, the Mining Law and the Environmental Regulation for Mining Activities have been prepared as legal instruments, to realize environmental policies in the mining sector,

Key characteristic;

① The employment of old-fashioned technology in the mining sector.

② Insufficient knowledge about the damages that can be caused by the mining and metallurgical industries.

③ Limited capacity of institutional organization, and limited financial support for the effective implementation of the regulation.

④ Economic crises in the mining industries due to the drastic decline of international metal prices which have had strong impacts on the companies' income and personal income.

Main policy of the mining sector:

① To improve the environment in the operation of mine-metallurgical businesses, achieving more efficient operation and a better life for the mine communities.

② To coordinate the mining sector policy with the economical policy for sustainable development.

③ To decontaminate the passive environment. (reduce stock of pollutionants)

3-2-7 Mining Law

On March 17, 1997, the Mining Law (No. 1777) was proclaimed. It contains the general policies related to the mining industries and to attract, on the foreign investment.

Regarding the environment issues for the mining industry, the frames work of regulation is clearly provided in this law, as follows, beside other principal definition for the issues of mining sector.

Principal Environment issues in the Mining Law:

① Who can enter the mining industries, and requirement to follow the principleal ideas of sustainable development.

② Closing legal loopholes regarding the passive environment responsibility.

③ To establish the environment license as the single general principle, this document shall contain the every required authorization for the environment, and doing so, without dispersing the efforts and bureaucratic procedure, the government and business promoters can integrate the every environmental factors.

④ For prospecting and exploitation, such as the activities of a small mining company outside of the protected area, there are to be established general and specific measures of the promotion of the environment protection through the regulation, with the working objective of reducing the cost and bureaucratic procedure for issuing the environment license.

3-2-8 Environment Regulation of Mining Activities

On July 31, 1997, the Environment Regulation for Mining Activities (No. 24782) was proclaimed to enforce the Mining Law specially regarding environment protection.

This regulation was prepared incorporating with the Mining Law No. 1777, the Environment Law No. 1333, and the Regulation for the Environment Law No. 24176 and others, to clarify the rules in the mining industry sector in detail, to promote the smooth implementation, and to promote environment protection activities.

Table 3-2-1

Water Quality Standard Comparison between Bolivia and Japan

| Item | | Bolivia | | | Japan | |
|---|---|---|---|---|---|---|
| Name | Simbol & Unit | Discharge | Environment "B" | Environment "C" | Discharge | Environment |
| Temperature | D.C. | (+)/(-)5 | (+)/(-) 3 | (+)/(-) 3 | | - |
| pH | | 6.9 | 6.0/9.0 | 6.0/9.0 | 5.8/8.6 | 6.0/7.5 |
| Dissolved Oxygen | | - | 70% sat. | 60% sat. | - | >5 |
| Number of colonies of E. Coli | MPN/100ml | 1,000 | <1,000 | <5,000 | 300,000 | <5,000 |
| Suspended Solid (max.) | SS | 60 | 50 | 50 | 200 | <100 |
| Oil | | 20 | nil | 0.3 | - | (Sea Nd.) |
| BOD | | 80 | <5 | <20 | 160 | <8 |
| COD | | 250 | <10 | <40 | 160 | (Sea 5) |
| Arsenic | As | 1.0 | 0.05 | 0.05 | 0.1 | 0.01 |
| Cadmium | Cd | 0.3 | 0.005 | 0.005 | 0.1 | 0.01 |
| Copper | Cu | 1.0 | 1.0 | 1.0 | 3.0 | 3.0 |
| Hexavalent Chromium | Cr6+ | 0.1 | 0.05 | 0.05 | 0.5 | 0.05 |
| Lead | Pb | 0.6 | 0.05 | 0.05 | 0.1 | 0.01 |
| Total Mercury | T-Hg | 0.05 | 0.001 | 0.001 | 0.005 | 0.0005 |
| Selenium | Se | 0.5 | 0.01 | 0.01 | 0.1 | 0.01 |
| Total Cyanogen | CN | 1.0 | 0.1 | 0.2 | 1.0 | Nd. |
| Phenol | | | 1.0 | 5.0 | 5.0 | - |
| Zinc | Zn | 3.0 | 0.2 | 5.0 | 5.0 | - |
| Soluble Manganese | | 10 | 1.0 | 1.0 | 10 | - |
| Soluble Iron | | 10 | 0.3 | 1.0 | 10 | - |
| Iron | Fe | 1.0 | - | - | - | - |
| Phosphorous | P | - | 0.5 | 1.0 | 16 | (Sea 0.09) |
| Nitrogen | N | - | 12.0 | 12.0 | 120 | (Sea 1.0) |
| PCB | | - | 0.001 | 0.001 | 0.003 | Nd. |
| Tri Chrolo Ethylene | TCE | - | - | - | 0.3 | 0.03 |

OBS:1. (Sea :) :means standard to be applied for sea water., 2. Environment :means standard to be applied agriculture usage water : "B" for fresh vegetable and thin skin fruit, "C" for other agricultural products. 3. Unit :means mg/l , PPM, except otherwise defined specifically

4. Other components :there are some other several components defiened in the regulation as controled items both in Bolivia and Japan

Table 3-2-2

**Crimes and Penalties in the Environment Law**

| Number of Article | Crimes | Penalties in Prison (Years) | Other Penalties | Related Artcile No. of Penalty Law |
|---|---|---|---|---|
| 104 | To fire the field for the agriculture or livestock breeding. | 2 to 4 | non | Art. No.206 |
| 105 | To contaminate and poison the water to be prepared for the public use, industry use, farming use and fish breeding use more than limitation established in the regulation. | 1 to 2 | non | Art. No.216, item 2) and 7) |
| 106 | To destroy, damage, steal or export the assets which belongs to the public or other personnel. | 1 to 6 | non | Art. No.223 |
| 107 | To discharge the untreated water, chemicals, bio-chmicals or refuse to any kind of nature exceeding the limit established in the regulation. | 1 to 4 | 100 percent value compenstaion of damages | non |
| 112 | To deposit, commercialize the refuse of industrial liquid, solid or gas putting the human lives and /or environment in dangerous situation. | 2 | non | non |
| 113 | To authorize, cooperate for depositing, introducing or transporting into the national territory the dangerous toxic, radioactive and other foreign origin refuse, and any technologies which introduce the dangerous material. | upto 10 | non | non |

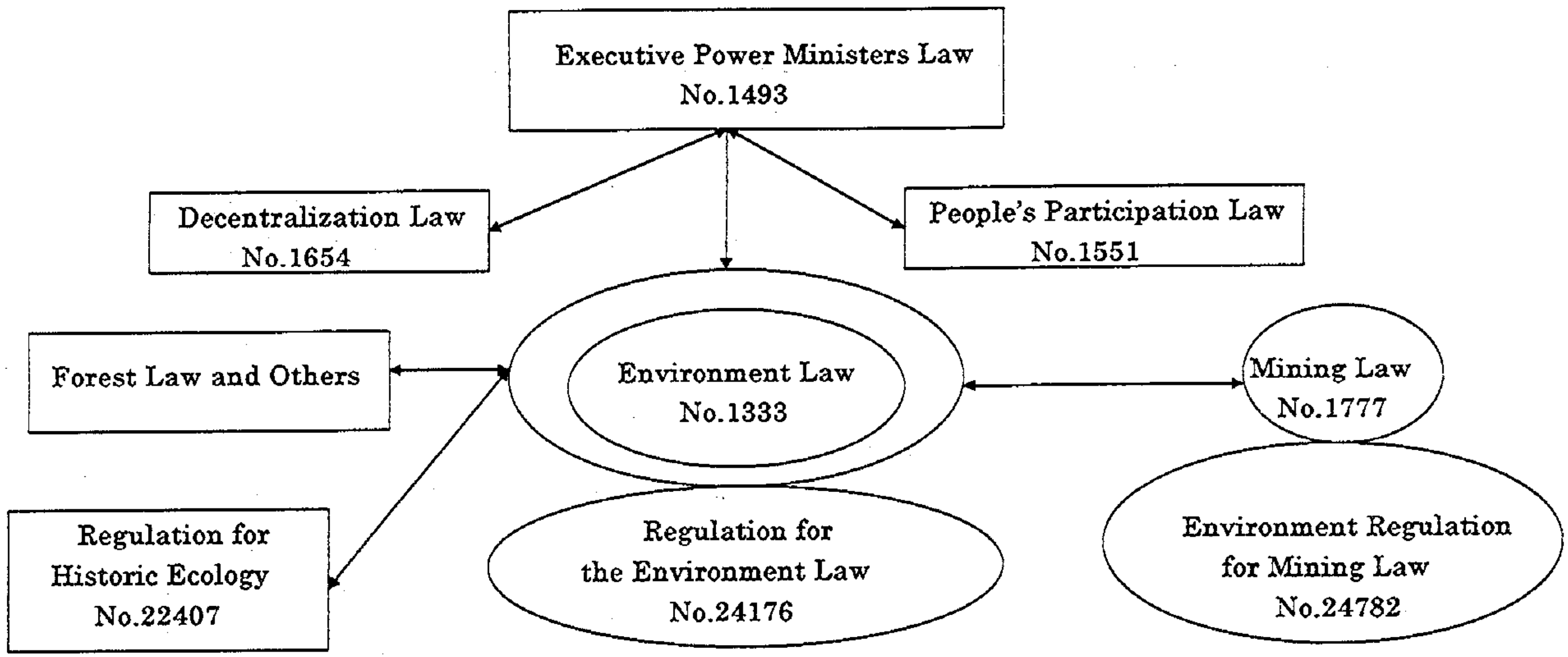



Figure 3-2-1 General View of Environment Protection Related Laws and Regulagtions

## 4 Present Water Pollution of Rivers

### 4-1 Study Area

As expressed in paragraph 1-2-1, the study area of this project is mainly conducted from Rio de La Rivera river of Rio Tarapaya river basins and the basin from the confluence of Rio Tarapaya and Rio Pilcomayo river as far as the Puente Mendez bridge on Rio Pilcomayo river. In addition, it is decided to evaluated water quality of Rio Samaza river which flows east from eastern outskirts of the city of Potosi and its downstream Rio Mataca river in the northern district, and rivers of Vitichi and Tupiza area of southern district of Potosi prefecture.

#### 4-1-1 Outline of Monitoring Design

Water monitoring was practiced for one year as illustrated in diary below. It was agreed to establish 25 sampling points mainly within the study area. The analysis covered the following items: Analysis of each item is carried out due to ASTM, except for ignition loss (JIS K0102).

- Water quality (14 items): pH, SS, As, Sb, Cd, Cr, Cu, Fe, Hg, Mn, Pb, Zn, CN, COD
- Sediment (15 items): Ag, As, Sb, Cd, Cr, Cu, Fe, Hg, Mn, Sn, Pb, Zn, CN, S, ignition loss

Diary of monitoring water

| No. | Date (1998) | Sampling | No. | Date (1998) | Sampling |
|---|---|---|---|---|---|
| 1 | mid January | water | 11 | early May | water, SS, sediment |
| 2 | late January | water, sediment | 12 | mid May | water, SS |
| 3 | early February | water, SS | 13 | late May | water, SS, sediment |
| 4 | mid February | water, SS, sediment | 14 | early June | water, SS |
| 5 | early March | water, SS | 15 | early July | water, SS, sediment |
| 6 | mid March | water, SS, sediment | 16 | early August | water, SS, sediment |
| 7 | late March | water, SS | 17 | early September | water, SS, sediment |
| 8 | early April | water, SS | 18 | early October | water, SS, sediment |
| 9 | mid April | water, SS, sediment | 19 | early November | water, SS, sediment |
| 10 | late April | water, SS | 20 | mid December | water, SS, sediment |
| | | | 21 | Early December | water, SS, sediment |

Table 4-1-1 presents the list of sampling points, and Fig.1-2-4 shows a general map of these sampling points.

Sampling was started on January 14, 1998 and ended in December. Workbenches were installed at two continuous monitoring points for water quality, to facilitate field activities required (See attached photograph in ANNEX(2)). Training was conducted for handling and operation of monitoring equipment. As a result, the data monitoring system was ready to operate in mid-February 1998.

To investigate pollution of rivers in southern district of Potosi prefecture, water samples were collected on the third week of February 1998 (rainy season) and in October (dry season) at six points, each selected in Rio Vitichi, Rio Tumusla, Rio Cotagaita, Rio Tupiza, Rio San Juan del Oro, and Rio Camblaya rivers. In addition, sampling was carried out in Villamontes, the farthermost downstream of Rio Pilcomayo within the country (near the border of Paraguay and Argentina), during the first round of sampling.

4-1-2 Hydrology Survey

Rio Huayanamayu river is the largest stream flow among three small rivers which have their sources on the slope of the Mt. Cerro Rico de Potosi.

Candidate sites for cross-sectional measurement of rivers within the study were selected at 6 points, 4 in the Tarapaya river system (each in Rio de La Rivera, Rio Alja Mayu, Rio Molino, and Rio Tarapaya) and 2 in Rio Pilcomayo (each at Yocalla and at Puente Mendez). These survey points are also shown in Fig.1-2-4. The study team requested for cross-sectional measurement of river and obtained survey data.

The study team provided training for C/P to measure river water flow by using the electric current meter which was supplied to the study. Then the formal survey was started in February 1998. It was mainly conducted at the cross-sectional measurement points. Also, the study team obtained cooperation of Hydrology Department of the Potosi prefecture.

## Table 4-1-1 Sampling Points on Rivers for Water and Sediments Quality Monitoring

| No. | Code | Name of sampling point | Name of river |
|---|---|---|---|
| 1 | P1RI | Origin of Rio de La Ribera | Rio de La Ribera |
| 2 | P2HU | Rio Huaynamayu in front of camp Pailaviri | Rio de La Ribera |
| 3 | P3KO | Rio Korimayu at Puente Espana | Rio de La Ribera |
| 4 | P4HU | Rio Huaynamayu before joining Rio de La Ribera | Rio de La Ribera |
| 5 | P5RI | Rio de La Ribera before joining Rio Huaynamayu | Rio de La Ribera |
| 6 | P6IR | Rio de La Ribera after joining Rio Huaynamayu | Rio de La Ribera |
| 7 | P7HR | Lecherias zone branch of Rio Hualampaya | Rio Jesus Valle |
| 8 | P8HR | Rio Hualampaya before joining Rio Jesus Valle | Rio Jesus Valle |
| 9 | P9JV | Rio Jesus Valle before joining Rio Hualampaya | Rio Jesus Valle |
| 10 | P10J | Rio Jesus Valle before joining Rio de La Ribera | Rio Jesus Valle |
| 11 | P11R | Rio de La Riveva before joining Rio Jesus Valle | Rio de La Ribera |
| 12 | P12A | Rio Aljamayu after joining Rio Ribera and Jesus Valle | Rio Aljamayu |
| 13 | P13K | Rio Korimayu before joining Rio de La Ribera | Rio de La Ribera |
| 14 | P14D | Rio Agua Dulce before joining Rio Aljamayu | Rio Aljamayu |
| 15 | P15A | Rio Aljamayu before joining Rio Huancarani (pt. la Palca) | Rio Aljamayu |
| 16 | P16A | Rio Huancarani before joining Rio Aljamayu (pt. Peatonal) | Rio Huancarani |
| 17 | P17T | Rio Tarapaya after joining Rio Aljamayu and Huancarani | Rio Tarapaya |
| 18 | P18M | Rio Tarapaya at Mondragon village | Rio Tarapaya |
| 19 | P19Y | Rio Pilcomayo at Yocalla village | Rio Pilcomayo |
| 20 | P20D | Rio Huari Huari downstream of Huari Huari Mine | Rio Mataca |
| 21 | P21C | Rio Mayu Tambo at Puente Mayu Tambo | Rio Mataca |
| 22 | P22T | Rio Tarapaya at Miraflores downstream of hotsprings | Rio Tarapaya |
| 23 | P23M | Rio Mataca before joining Rio Pilcomayo | Rio Mataca |
| 24 | P24J | Quebrada Jayajmayu (upstream of Rio Agua Dulce) | Rio Aljamayu |
| 25 | P25P | Rio Pilcomayo at Puente Mendez bridge | Rio Pilcomayo |

## 4-2 The Scope and Grade of Water Pollution

### 4-2-1 Water Pollution of Study Area

#### (1) Analysis Data

Typical analysis results of water and sediment samples were illustrated in Table 4-2-1 (first round, mid-January, example of rainy season) and Table 4-2-2 (ninth round, mid-April, example of at the beginning of dry season). Twenty times of sampling were practiced during the study period. Every data was presented in ANNEX(5).

Acid water was found in Rio Huaynamayu river (sampling point No.2, 4), Rio Korimayu river (No.3, 13), Quebrada. Jayajmayu river (No.24), as originated in Mt. Potosi. Dissolved heavy metals and arsenic were also found rich but the suspended solid (SS) was not much in these river waters. These waters are originated in mining activities either mine drainage or infiltrating water that contacted waste ores or old tailing dams from mineral concentration processes. Similar analytical data were observed in Rio Huari Huari river (No.20), a branch of Rio Samaza river which flows along the Huari Huari mine.

On the other hand, alkaline water, high SS content and COD value was found in Rio de La Ribera (No.5) river. Except the pH value, simular results were observed in the downstream of the river (No.6, 11). Heavy metals were found rich in the SS of Rio de La Ribera. Large amount of sediments were precipitated in the river bottom, and heavy metals were also found rich in these bottom sediments. The cause of the sediment in Rio de La Ribera is come from untreated discharged tailings from ingenios. The strong influence of Rio de La Ribera was also observed in its downstream Rio Aljamayu river (No.12, 15) and Rio Tarapaya river (No.17, 22, 18).

Acid water was found at sampling point No.6 is the most characteristic data in Table 4-2-1. Above sampling point No.6 is the point just after the confluence of Rio de La Ribera (alkaline) with Rio Huaynamayu (acidic). Water of this point showed significant pH variations, due to the number of factors such as volume and quality change of both rivers. The pH readings of sampling point No.6 were observed rather basic for year round between 3 in the rainy season and over 12 in the dry season.

Alkaline water was found in sampling point No.11 in Table 4-2-1 which is located few km downstream of sampling point No.6, after joining discharged water from several ingenios, spring water from near San Miguel Ingenio and Rio Korimayu. Dissolved form of heavy metals and arsenic were not found much in alkaline river water.

Water in other branch rivers and streams showed pH value between 7.5 and 8, and lack of dissolved heavy metals and arsenic. Sediments of those rivers showed poor heavy metals and arsenic contents. These data suggested that there was not any significant polluter, such as mine and ingenio in the region. However COD value was high in the Rio Hualampaya river (No.7, 8) water due to the effect of municipal sewers, looked like as Rio de La Ribera water.

All those water are finally joined and gone down into Rio Pilcomayo river, and passed through Puente Mendez bridge and then farther downstream. Though heavy metals and arsenic were not found much in dissolved form, they were existed in bottom sediment of Puente Mendez bridge of Rio Pilcomayo river.

(2) Rainfall and River Water Flow

Averaged annual precipitation is 405 mm and rainy days are 87 days at Potosi city during recent 40 years (from 1958 to 1997), due to the hydrological record of Hydrology Department of the Potosi Prefecture. Table 4-2-3 is the outline of above data.

The rainy season start from October or December and end in March or April, depending on yearly climate change. It is almost no rain in the dry season. Relative humidity is between 50 and 55% in the rainy season and between 25 and 30% in the dry season. However there was El Niño phenomenon happened from 1997 to 1998, and it rained in August and September 1997 and did not rain until the middle of January 1998. This phenomenon was finished in the middle of 1998.

There is a mountainous region developed in study area, so rich in slope and poor in forest. When it rains, some is returned to the atmosphere at once by evaporation and some flows overland and makes its way to runoff.

After hand rain or sometimes during raining, water level rise rapidly so much as 100 times of normal level of flow in Rio Huaynamayu for example. However the river returns to small stream within a day or so.

The results of flow measurement of rivers are presented in Table 4-2-4, also Fig.4-2-1 for Rio Tarapaya and Fig.4-2-2 for Rio Pilcomayo. The survey was started from February and was conducted at 6 points, as stated in previous paragraph (4-1-2). During flow measuring, no flash flood was occurred in the rivers.

Water flow of Rio Tarapaya river system did not vary much up to May and declined in July through September to reflect the dry season. It rained in October and water flow rose once, but extremely declined in December. In particular, large declines were observed at Molino and Mondragon. On Rio Pilcomayo river, variation of flow varied between different measurement points. The flow decreased at Puente Mendez in March, immediately after the start of survey, and it declined gradually May through September. On the other hand, small changes were observed at Yocalla.

### 4-2-2 Scope and Grade of Water Pollution

(1) Water pollution of Rio Tarapaya river system and Rio Pilcomayo river until Puente Mendez bridge. (Quantitative analysis)

SS including arsenic and heavy metals causes primarily water pollution of Rio Tarapaya river system and Rio Pilcomayo river until Puente Mendez bridge under this study. The source of toxic materials are mainly tailings and untreated discharged water from ingenios, and then mine drainage and infiltrating water that contacted waste ores on the mountain slope or in the sucus or tailing dams from old mineral concentration processes.

Rio de La Ribera, uppermost stream of Rio Tarapaya river system, receives large amount of discharged water and tailings from ingenios. Rio Huaynamayu, the main branch of Rio de La Ribera, receives mine drainage and infiltrating water that contacted waste ores in the sucus or tailing dams from old mineral concentration processes. These are the main causes of water pollution in the river system. The strongest polluter among these sources is the tailings from ingenios which contain large amounts of SS consisting of arsenic and unrecovered heavy metals.

Importantly, the water flow, the SS concentration and the amount of SS carried by water vary greatly within time of data collection. Based on the results of the stream flow measurement and water quality surveys, rough estimation of the amount of SS carried by the rivers was obtained. The amount of SS transported by each river was calculated by using water quality and stream flow data between the end of January and the end of May, and also throughout of 1998 year as summarized in Table 4-2-5. Data base of this calculation is shown in Table 4-2-6. Variations of the amount of SS transport in the Tarapaya river system are shown in Figures 4-2-3 and Pilcomayo river in Figure 4-2-4. As the SS data vary greatly between different sampling points, they are plotted on a semi-logarithmic graph.

As shown in Figure 4-2-3, the data up to May indicate that the SS carried in the Tarapaya river system partially settles upstream to reduce the amount on the downstream side. However, this trend is not always true in the dry season. Since no flash flood occurred at the time of sampling, the amount of SS transport remains fairly stable regardless of the season, as judged from the general trends read from the graph. This indicates that a large amount of SS are carried and contaminate the rivers.

The maximum amount of SS carried from Rio de La Rivera to Rio Tarapaya, on the basis of the available data, was estimated to be over 1,700 tons/day in San Antonio and slightly less than 1,200 tons/day in Potosi, compared to 950 tons/day at Molino and less than 400 tons/day at Mondragon, between the end of January and the end of May. And also averaged SS were carried 1,890 tons/day in San Antonio, 1,110 tons/day in Potosi, 1,010 tons/day in Molino and 606 tons/day un Mondragon, throughout of 1998 year. The difference of those two data are not large and more or less 10%.

Meanwhile, each Ingenio in and around the city processes approximately 1,300 (1,000 - 1,500) tons of ore daily and disposes 1,000 - 1,300 tons of tailings. Besides tailing desposal, Ingenios discharge residual slack lime and various chemicals into the rivers. Because Ingenio facilities consume slack lime that is used to keep alkalinity of water used in the floating separation process and also to acquire another recycle water for the process, as well as various chemicals.

As observed in the upper part of San Antonio in the Tarapya rivers system, a large amount of SS seems to have settled into sediments downstream of San Antonio. Based on the above data, approximately 750 tons/day (yearly averaged 880 tons/day) of sedimentation occurred between San Antonio and Molino and additional 550 tons/day (yearly averaged 400 tons/day) between Molino and Mondragon. Although large amount of SS is carried away to the Pilcomayo river from the Tarapaya river system. While a significant increase in sediment was not seen on the riverside or riverbed during the rainy season in the Tarapayà river system as the settled SS was presumably carried by the flash floods to the Pilcomayo river, a large amount of sedimentation was confirmed on the riverside during the dry season in the Tarapaya river system.

As shown in Figure 4-2-2, in Rio Pilcomayo, the amount of SS carried declines gradually in the dry season due to the decrease in flow and the decline in SS concentration. The difference of SS concentration seems to be nearly 100 times at Yocalla. During the rainy season, the data of same sampling point vary greatly among sampling times. The SS concentration at Puente Mendez is about 10 times larger than that of Yocalla. In particular, large amounts of sediments are washed away by the periodical flash floods to the lower reaches as well as outflow of soil.

Based on raw data shown in next chapter 5 and data in Table 4-2-2, pollutant loads discharged to the Tarapaya river system were estimated to be arsenic 300kg/day, cadmium 80-100kg/day, lead 2 ton/day, zinc 20-30 tons/day, and tin 2-4 tons/day. They represent the level of environment pollution caused by mining activities in Potosi. They are transported to downstream as SS and contaminated water and bottom sediment. As there are many origins of pollution, the main cause are tailings and untreated discharged water from ingenios, and then mine drainage and infiltrating water that contacted waste ores or old tailing dams.

On the other hand, Rio Pilcomayo always receives water containing SS that is polluted by heavy metals from Rio Tarapaya river system. Rio Pilcomayo is obliged to receive an increase in SS concentration when the Tarapaya rises after periodical flash rain, and transports them further downstream. One part of those SS is polluted water as oneself, and the other part is contaminated sediment after to have settled into riverbed.

As observed from the color of water and sediment, most SS carried I the Pilcomayo river seemed to be outflow soil from flash flood in rainy season, it looks like the color of lateritic soil. On the other hand it changes SS color in dry season, as if it seems to be a tailings from mineral concentration processes from the Tarapaya river system to the Pilcomayo river. It shows gray-black color. This estimation is also supported by heavy metals content in the bottom sediment at Puente Mendez, because of poor content in rainy season and rich in dry season.

Rio Pilcomayo runs among the mountains in the study area, so it is very hard to access the riverside. It was difficult to put sampling point other than those two point, Yocalla where there is not influenced by Rio Tarapaya and Puente Mendez. So, it is hard to explain more quantitatively about water pollution and sediment contamination of Rio Pilcomayo river system, until now.

The flow and the quality of river vary from hour to hour, so the mining production and the operation of ingenios. It should be noted, however, that the figures are merely rough estimates at this stage, while actual data change dynamically over time, including water quality parameters, stream flow data and operations by mines and Ingenios. Under any circumstances, they should not be used as the basis of any plans or actions before their validity is confirmed.

(2) Water quality of Rio Mataca river and its tributaries

On the east of the Potosi city area, Rio Samaza river flows and merges with many rivers to become Rio Mataca river. Rio Mataca then joins Rio Pilcomayo river slightly downstream of Puente Mendez. In the Don Diego village along Rio Samaza, there is a metal concentration plant named Ingenio Caballo Blanco, one of the major ingenio in Bolivia. The plant is located on a riverside of Rio Samaza. It mostly treats tailings produced from the separation process and stockpiles them separately in a special dam. Also, process water is totally recycled. Thus, it is generally believed that no water pollution occurs in Rio Samaza.

On the other hand, Rio Huari Huari river flows from Mina Huari Huari (sampling point No.20) before joining Rio Samaza near the Don Diego village. River water showed acidity at the foot of the mine, ranging between pH4 and pH6. 100-200ppm of iron ion and 100ppm of zinc ion were detected in water, while a few ten ppm of arsenic, about 240ppm of lead and 1,000ppm or less of zinc were found in the sediments. Water in the river is slightly brownish-colored by iron ion. On the other hand, contents of SS were small. The river water lost acidity as it flew down. Its color and pH were improved before its confluence with Rio Samaza to lose color and turn into neutrality or alkalinity. At the same time, heavy metals disappeared from water, probably because they precipitated and settled into the bottom.

Analysis of water samples and sediments collected near the Mayu Tambo bridge (No.21), slightly down Rio Samaza, detected presence of arsenic, lead and zinc in the sediments, with concentration levels were much lower than those found near Mina Huari Huari, whereas few heavy metal ions were found in water, including iron, lead and zinc. Thus, little pollution occurs in the river. Heavy metals found in the sediments seem to come from the sediments of Rio Huari Huari that were carried by the floods after heavy rains.

In Rio Mataca near Millares (No.23), situated close to Puente Mendez, turbid water flew during the rainy season, while clear water was seen in the dry season. The pH was neutral or slightly on the alkaline side. Concentration levels of arsenic, lead, zinc and other heavy metals in the sediments were similar or below those found near the Mayu Tambo bridge. Thus, the sediments are not severely contaminated by heavy metals.

Water qualities of Rio Samaza and Rio Mataca are not contaminated much and may suggest a future goal for environmental cleanup of Rio de La Rivera and Rio Tarapaya rivers, which can be expected when adequate pollution control measures are taken. The results of investigation on the two rivers reveal that water pollution can effectively be controlled in a watershed area where mines and processing facilities are located, so far as appropriate measures are taken to prevent or significantly reduce the discharge of polluted water into the river. As a result, water can be kept relatively free from heavy metals, and pollution can be reduced to a minimal level in the lower reaches.

There are only 3 sampling point along Rio Mataca river system and are biased 2 in Rio Samaza. It is necessary to make well-organized program in order to know water contamination above area more exactly.

(3) Water quality of rivers in the southern part of Potosi Prefecture

Figure 4-2-5 shows the outline of river map in the southern part of Potosi Prefecture.

As only two sampling surveys were conducted in the area, once in the rainy season (February) and once in the dry season (October), the study team has limited data and information on pollution in Rio Vitichi, Rio Tumusla and Rio San Juan del Oro rivers. Table 4-2-7 and 4-2-8 present the results of analysis of the collected samples, as well as those collected in Villamontes, downstream of Rio Pilocomayo river, which were sampled during the sampling survey in the rainy season.

A variety of heavy metals were detected in these samples, and they appeared that the sediments collected from all the rivers were contaminated by heavy metals except for chrome, although their concentration levels were much lower than those found in the Tarapaya river system after the city of Potosi. It should be noted that water sample collected in La Laba, located in the upper stream of Rio Vitichi, showed slight acidity, possibly La Laba area is affected by mine acid water.

In Table 4-2-7 and 4-2-8, Vitichi-1 represents the sample at La Lava of Rio Vitichi river, Vitichi-2 is that of Ari Palca of Rio Vitichi river, Cotagaita is that of Cotagaita of Rio Cotagaita river, Tumusla in that of Tumusla of Rio Tumusla river, CB-PV.A is that of Villa Abecia of Rio Tumusla (or Rio Camburaya) river, SJO Tupiza is that of suburbs of Tupiza of Rio San Juan del Oro river, SJO V.A is that of Villa Abecia of Rio San Juan del Oro river, and Pilcomayo is that of Villa-Mantes of Rio Pilcomayo river.

This is only a preliminary survey to see water contamination of Vitichi and Tupiza area. Data are quite limited. Well-organized program is needed to know water contamination exactly in the future.

Table 4-2-1 Water Quality Analysis Results / Monitoring Program (Midterm, Jan. 1998)

| Sample | pH | SS | As | Sb | Cd | Cu | Cr | Fe | Hg | Mn | Pb | Zn | CN | COD | Coment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | - | mg/L | μ g/L | μ g/L | mg/L | mg/L | mg/L | mg/L | μ g/L | mg/L | mg/L | mg/L | mg/L | mg/L | |
| No. 1 | 8.0 | 11.45 | 6.64 | 5.18 | <0.002 | 0.07 | <0.0005 | 0.09 | <0.02 | 0.11 | <0.03 | 0.18 | 0.005 | 12.4 | |
| No. 2 | 2.8 | 486.65 | 2620 | 6.00 | 11.0 | 58.0 | 0.05 | 1780 | 0.12 | 21.2 | 0.09 | 358 | 0.003 | 127.8 | Huaynamayu River |
| No. 3 | 2.8 | 23.45 | 6.90 | 0.16 | 2.10 | 6.20 | 0.05 | 280 | <0.08 | 44.8 | 0.11 | 163 | 0.021 | 49.5 | Korimayu River |
| No. 4 | 3.0 | 1603.1 | 1470 | 10.7 | 1.50 | 11.0 | 0.04 | 500 | <0.08 | 14.0 | 0.22 | 167 | 0.036 | 115.46 | Huaynamayu River |
| No. 5 | 9.8 | 65238.95 | 9.11 | 23.8 | 0.02 | 0.04 | <0.0005 | 0.20 | 0.01 | 0.02 | 0.05 | 0.10 | 0.28 | 70.1 | |
| No. 6 | 6.3 | 39502 | 14.2 | 2.33 | 0.12 | 0.02 | <0.0005 | 93.0 | 0.03 | 7.0 | 0.04 | 56 | 0.08 | 177.32 | |
| No. 7 | 7.8 | 191.6 | 1.37 | 1.16 | 0.07 | <0.003 | 0.01 | 0.08 | 0.03 | 0.14 | <0.03 | 0.01 | 0.045 | 16.49 | Hualampaya-Jesus valle Rivers |
| No. 8 | 8.4 | 151.4 | 1.81 | 1.92 | 0.03 | <0.003 | 0.01 | 0.29 | 0.05 | 0.44 | <0.03 | 0.01 | 0.021 | 8.25 | Hualampaya-Jesus valle Rivers |
| No. 9 | 8.4 | 157.7 | 0.18 | 0.15 | 0.05 | 0.01 | 0.01 | <0.008 | <0.02 | 0.02 | <0.03 | <0.002 | 0.013 | 4.21 | Hualampaya-Jesus valle Rivers |
| No. 10 | 8.6 | 4819.9 | 21.8 | 3.42 | 0.08 | 0.04 | 0.01 | 0.02 | <0.02 | 0.41 | <0.03 | 0.06 | 0.031 | 65.98 | Hualampaya-Jesus valle Rivers |
| No. 11 | 9.0 | 38697 | 9.52 | 20.0 | 0.06 | 0.14 | 0.02 | 0.02 | 0.13 | 0.17 | <0.03 | 0.05 | 0.229 | 53.61 | |
| No. 12 | 7.2 | 10942 | 5.47 | 0.58 | 0.19 | 0.02 | 0.02 | 0.37 | 0.08 | 6.25 | <0.03 | 50 | 0.111 | 32.32 | |
| No. 13 | 2.8 | 181.5 | 106.1 | 0.90 | 1.00 | 22.0 | 0.08 | 530 | 0.14 | 61.25 | <0.03 | 180 | <0.001 | 48.48 | Korimayu River |
| No. 14 | 7.4 | 111.4 | 0.67 | 0.18 | 0.06 | 0.02 | 0.02 | <0.008 | 0.05 | 1.66 | <0.03 | 42.0 | <0.001 | 16.16 | Agua Dulce River |
| No. 15 | 5.8 | 43004 | 12.4 | 2.57 | 1.7 | 0.04 | 0,02 | 59.0 | 0.04 | 20.5 | <0.03 | 208 | 0.192 | 36.36 | |
| No. 16 | 8.2 | 120.7 | 0.74 | 0.5 | <0.002 | 0.02 | <0.0005 | <0.008 | 0.07 | 0.03 | <0.03 | 38.0 | 0.006 | 4.04 | Huancarani River |
| No. 17 | 4.8 | 16176 | 20.3 | 1.42 | 1.7 | 0.06 | 0.01 | 192 | 0.50 | 22.0 | 0.12 | 226 | 0.121 | 32.32 | |
| No. 18 | 7.4 | 11016 | 6.43 | 1.17 | <0.002 | 0.04 | <0.0005 | 0.11 | 0.03 | 0.68 | <0.03 | 36 | 0.04 | 28.28 | |
| No. 19 | 7.7 | 1335.2 | 0.31 | 0.08 | <0.002 | 0.03 | <0.0005 | 1.63 | 0.07 | 0.03 | <0.03 | 37 | 0.028 | 16.16 | Pilcomayo (Yocalla) |
| No. 20 | 3.8 | 115.8 | 6.02 | 0.48 | 0.61 | 0.02 | 0.1 | 280 | 1.15 | 10.3 | <0.03 | 148 | <0.001 | 20.62 | Huari Huari River (Mataka River) |
| No. 21 | 7.9 | 5299.3 | 0.65 | 1.39 | 0.04 | <0.003 | 0.01 | 0.26 | 1.12 | 0.23 | <0.03 | 0.16 | <0.001 | 12.12 | (Mataka River) |
| No. 22 | 8.1 | 8949.9 | 0.03 | 0.28 | 0.01 | <0.003 | <0.003 | 0.2 | 1.56 | 0.16 | <0.03 | 0.11 | <0.001 | 12.12 | Pilcomayo River (Tacobamba) |
| No. 23 | 8.5 | 3077.9 | 2.49 | 0.41 | <0.002 | <0.003 | <0.009 | <0.008 | 1.82 | 0.10 | 0.10 | <0.002 | <0.001 | 4.04 | (Mataka River) |
| No. 24 | 8.5 | 1231 | 0.46 | 0.44 | <0.002 | <0.003 | <0.009 | <0.008 | 2.26 | 0.11 | 0.11 | <0.002 | 0.002 | 4.04 | |
| No. 25 | 8.0 | 38491 | 0.19 | 0.20 | 0.06 | <0.003 | <0.009 | 1.02 | 1.43 | 0.22 | <0.03 | 0.10 | <0.001 | 4.04 | Pilcomayo-River (Mendez Bridge) |

Note; No. 22, Rio Pilcomayo after joining Rio Tacobamba
No. 24, Rio Tacobamba in front of Tacobamba village

# Table 4-2-2 Water, SS and Sediments Analysis Results / Monitoring Program (Midterm April 1998) 1/3

Analitical Results from Laboratory (9th. round, 14/Apr.)

1. Quality of Water

| Sample | pH | SS | As | Sb | Cd | Cu | Cr | Fe | Hg | Mn | Pb | Zn | CN | COD | coment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | - | mg/L | mg/L | μg/L | mg/L | mg/L | mg/L | mg/L | μg/L | mg/L | mg/L | mg/L | mg/L | mg/L | |
| No. 1 | 9.0 | 250 | 0.012 | 0.17 | 0.02 | 0.02 | 0.05 | 0.33 | <0.10 | 0.19 | <0.03 | 0.16 | 0.001 | 4 | |
| No. 2 | 2.6 | 1,230 | 0.076 | 0.81 | 9.3 | 101 | 0.07 | 1,600 | 0.37 | 28.0 | 0.17 | 810 | 0.001 | 54 | |
| No. 3 | 2.8 | 290 | 0.007 | 0.48 | 2.3 | 6.40 | 0.02 | 220 | 0.51 | 39.0 | 0.04 | 106 | 0.001 | 13 | |
| No. 4 | 2.8 | 820 | 0.001 | 1.16 | 2.7 | 25.0 | 0.04 | 568 | 0.39 | 18.2 | 3.39 | 408 | 0.066 | 142 | |
| No. 5 | 11.6 | 58,800 | 0.088 | 1.13 | 0.002 | 0.43 | <0.005 | 0.08 | 0.23 | 0.01 | 0.10 | 0.38 | 0.015 | 83 | |
| No. 6 | 5.0 | 34,200 | 0.019 | 0.85 | 1.2 | 0.05 | <0.005 | 11.8 | 1.07 | 8.90 | 0.23 | 159 | 0.001 | 85 | |
| No. 7 | 8.1 | 480 | 0.003 | 0.29 | 0.02 | 0.03 | <0.005 | 0.32 | <0.10 | 0.14 | <0.03 | 0.22 | 0.004 | 75 | |
| No. 8 | 8.3 | 770 | 0.002 | 0.36 | 0.03 | 0.12 | <0.005 | 0.52 | <0.10 | 0.35 | 0.03 | 0.28 | 0.001 | 71 | |
| No. 9 | 8.4 | 330 | 0 | 0.14 | 0.04 | 0.003 | <0.005 | 0.06 | <0.10 | 0.10 | 0.03 | 0.19 | <0.001 | 8 | |
| No.10 | 8.4 | 820 | 0.017 | 0.28 | 0.05 | 0.03 | <0.005 | 0.20 | <0.10 | 0.18 | 0.03 | 0.28 | 0.001 | 50 | |
| No.11 | 8.4 | 52,600 | 0.022 | 0.76 | 0.05 | 0.16 | <0.005 | 0.02 | 0.13 | 0.03 | 0.03 | 0.16 | 0.084 | 50 | |
| No.12 | 8.7 | 49,600 | 0.02 | 0.6 | 0.05 | 0.15 | <0.005 | 0.06 | <0.10 | 0.33 | 0.03 | 0.21 | 0.001 | 46 | |
| No.13 | 2.7 | 135 | 0.059 | 0.61 | 0.71 | 20.0 | <0.005 | 104 | <0.10 | 44.0 | 0.03 | 111 | 0.015 | 25 | |
| No.14 | 7.9 | 360 | 0 | 0.10 | 0.05 | 0.02 | 0.005 | 0.01 | <0.10 | 0.64 | 0.03 | 22.0 | 0.001 | 4 | |
| No.15 | 8.1 | 48,000 | 0.01 | 0.35 | 0.10 | 0.02 | 0.005 | 5.12 | 0.55 | 5.70 | 0.03 | 36.0 | 0.029 | 17 | |
| No.16 | 8.0 | 410 | 0 | <0.10 | 0.01 | 0.02 | 0.03 | 0.12 | 0.20 | 0.03 | 0.03 | 0.18 | 0.001 | 4 | |
| No.17 | 7.6 | 9,900 | 0.011 | 0.31 | 0.04 | 0.02 | 0.05 | 0.18 | <0.10 | 1.74 | 0.03 | 5.70 | 0.10 | 8 | |
| No.18 | 8.0 | 4,960 | 0.01 | 0.29 | 0.04 | 0.03 | 0.07 | 0.13 | 0.14 | 1.72 | 0.03 | 2.80 | <0.001 | 4 | |
| No.19 | 8.1 | 1,660 | 0.008 | 0.29 | 0.01 | 0.05 | 0.03 | 0.16 | <0.10 | 0.04 | 0.03 | 0.17 | 0.001 | 4 | |
| No.20 | 5.2 | 400 | 0.003 | 0.62 | 0.17 | 0.05 | <0.005 | 68.3 | 0.12 | 3.20 | 0.03 | 58.0 | 0.002 | 2 | |
| No.21 | 8.1 | 390 | 0.002 | 0.70 | 0.002 | 0.01 | <0.005 | <0.01 | <0.10 | 0.02 | 0.03 | 0.40 | 0.002 | 4 | |
| No.22 | 7.8 | 6,470 | 0.012 | 0.57 | 0.06 | 0.04 | 0.03 | 0.10 | <0.10 | 1.70 | 0.03 | 3.20 | 0.005 | 2 | |
| No.23 | 8.5 | 830 | 0 | 0.63 | 0.002 | 0.07 | <0.005 | 5.55 | <0.10 | 0.14 | 0.03 | 16.2 | 0.001 | 8 | |
| No.24 | 4.6 | 300 | 0.003 | 0.47 | 0.08 | 0.33 | 0.02 | 0.17 | 0.10 | 17.3 | 0.03 | 170 | 0.001 | 75 | |
| No.25 | 8.5 | 1,750 | 0 | 0.57 | 0.002 | 0.02 | <0.005 | 0.45 | 0.15 | 0.02 | 0.03 | 0.19 | 0.001 | 4 | |

## Table 4-2-2 Water, SS and Sediments Analysis Results / Monitoring Program (Midterm April 1998) 2/3

2.Analysis of SS

| Sample | (SS) (mg/L) | Ag ppm | As ppm | Sb ppb | Cd ppm | Cu ppm | Cr ppm | Fe ppm | Hg ppb | Mn ppm | Pb ppm | Zn ppm | CN ppm | Sn ppm | S ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. 4 | 820 | 174 | 227 | 411 | 59.0 | 630 | 1.95 | 79,200 | 819 | 23.0 | 2,720 | 11,100 | 0.00 | 4,750 | 55,000 |
| No. 5 | 58,800 | 173 | 218 | 578 | 140 | 620 | 2.44 | 62,500 | 833 | 131 | 4,620 | 17,200 | 1.50 | 3,800 | 59,700 |
| No. 6 | 34,200 | 128 | 228 | 537 | 86.0 | 849 | 185.0 | 77,600 | 815 | 53.9 | 3,730 | 14,500 | 3.50 | 4,750 | 69,200 |
| No.11 | 52,600 | 77.0 | 221 | 286 | 46.0 | 640 | 280 | 67,000 | 589 | 391 | 2,280 | 11,900 | 0.00 | 3,330 | 55,300 |
| No.12 | 49,600 | 91.0 | 140 | 535 | 50.0 | 610 | 2.47 | 85,800 | 526 | 410 | 2,850 | 12,600 | 0.50 | 3,330 | 75,400 |
| No.15 | 48,000 | 96.0 | 241 | 851 | 69.0 | 410 | 1.49 | 91,900 | 688 | 480 | 6,510 | 16,900 | 0.00 | 2,850 | 77,600 |
| No.17 | 9,900 | | | | | | | | | | | | | | |

3.Calculated elements content in SS

| Sample | (SS) - | Ag mg/L | As mg/L | Sb μg/L | Cd mg/L | Cu mg/L | Cr mg/L | Fe mg/L | Hg μg/L | Mn mg/L | Pb mg/L | Zn mg/L | CN mg/L | Sn mg/L | S mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. 4 | 0.00082 | 0.14 | 0.19 | 0.34 | 0.05 | 0.52 | 0.002 | 65 | 0.7 | 0.02 | 2.23 | 9.102 | 0.00 | 0.03 | 45 |
| No. 5 | 0.0588 | 10.17 | 12.82 | 33.99 | 8.23 | 36.46 | 0.143 | 3,675 | 49.0 | 7.70 | 271.66 | 1011.36 | 0.09 | 2.12 | 3,510 |
| No. 6 | 0.0342 | 4.38 | 7.80 | 18.37 | 2.94 | 29.04 | 6.327 | 2,654 | 27.9 | 1.84 | 127.57 | 495.9 | 0.12 | 1.23 | 2,367 |
| No.11 | 0.0526 | 4.05 | 11.62 | 15.04 | 2.42 | 33.66 | 14.728 | 3,524 | 31.0 | 20.57 | 119.93 | 625.94 | 0.00 | 1.89 | 2,909 |
| No.12 | 0.0496 | 4.51 | 6.94 | 26.54 | 2.48 | 30.26 | 0.123 | 4,256 | 26.1 | 20.34 | 141.36 | 624.96 | 0.02 | 1.79 | 3,740 |
| No.15 | 0.048 | 4.61 | 11.57 | 40.85 | 3.31 | 19.68 | 0.072 | 4,411 | 33.0 | 23.04 | 312.48 | 811.2 | 0.00 | 1.73 | 3,725 |
| No.17 | 0.0099 | | | | | | | | | | | | | 0.36 | |

## Table 4-2-2 Water, SS and Sediments Analysis Results / Monitoring Program (Midterm April 1998) 3/3

4.Qality of Sediment

| Sample | Ag ppm | As ppm | Sb ppb | Cd ppm | Cu ppm | Cr ppm | Fe ppm | Hg ppb | Mn ppm | Pb ppm | Zn ppm | CN ppm | Sn ppm | S ppm | Ig.Loss % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. 2 | 23 | 45 | 98 | 5 | 82 | 2 | 48,100 | 296 | 349 | 732 | 1,600 | 0 | 1,700 | 5,900 | 3.0 |
| No. 3 | 47 | 84 | 302 | 2 | 62 | 4 | 86,500 | 507 | 128 | 1,340 | 400 | 0 | 3,800 | 3,900 | 3.2 |
| No. 4 | 138 | 244 | 522 | 99 | 403 | 2 | 190,000 | 822 | 44 | 1,330 | 19,400 | 0 | 5,230 | 68,800 | 13.0 |
| No. 5 | 118 | 271 | 738 | 67 | 305 | 3 | 155,000 | 745 | 142 | 2,280 | 19,100 | 0 | 3,330 | 159,000 | 11.2 |
| No. 6 | 134 | 258 | 513 | 81 | 360 | 2 | 168,000 | 435 | 106 | 1,840 | 19,800 | 0 | 4,280 | 177,000 | 12.1 |
| No. 7 | 10 | 19 | 47 | 1 | 38 | 6 | 24,900 | 4,900 | 240 | 100 | 530 | 0 | 950 | 1,100 | 1.4 |
| No. 8 | 4 | 225 | 1,240 | 0 | 41 | 4 | 62,600 | 16,800 | 238 | 29 | 370 | 0 | 1,430 | 1,300 | 1.2 |
| No. 9 | | | | | | | | | | | | | | | |
| No.10 | 159 | 19 | 40 | 78 | 313 | 5 | 213,000 | 697 | 39 | 3,450 | 20,200 | 0 | 7,120 | 230,000 | 15.5 |
| No.11 | 126 | 263 | 1,110 | 77 | 497 | 2 | 238,000 | 900 | 431 | 3,580 | 20,000 | 0 | 5,220 | 280,000 | 16.1 |
| No.12 | 164 | 1,027 | 1,051 | 30 | 446 | 3 | 252,000 | 691 | 900 | 3,650 | 21,000 | 1 | 4,280 | 268,000 | 17.6 |
| No.13 | 40 | 161 | 289 | 2 | 106 | 3 | 108,000 | 791 | 54 | 1,050 | 1,100 | 0 | 4,280 | 210,000 | 5.0 |
| No.14 | 3 | 18 | 25 | 0 | 31 | 5 | 18,800 | 138 | 277 | 0 | 57 | 1 | 1,430 | 900 | 2.4 |
| No.15 | 60 | 228 | 361 | 36 | 280 | 2 | 23,800 | 485 | 454 | 1,410 | 10,200 | 1 | 2,850 | 75,600 | 6.3 |
| No.16 | 3 | 16 | 17 | 5 | 27 | 6 | 87,500 | 69 | 376 | 0 | 89 | 0 | 1,420 | 600 | 2.5 |
| No.17 | 60 | 239 | 341 | 34 | 295 | 2 | 104,000 | 470 | 439 | 1,490 | 10,700 | 0 | 3,600 | 56,100 | 7.7 |
| No.18 | 45 | 203 | 288 | 34 | 189 | 1 | 66,500 | 472 | 430 | 1,523 | 9,300 | 0 | 2,850 | 90,500 | 5.5 |
| No.19 | | | | | | | | | | | | | | | |
| No.20 | 3 | 27 | 10 | 5 | 44 | 9 | 33,600 | 527 | 309 | 58 | 1,040 | 1 | 1,900 | 2,100 | 1.8 |
| No.21 | 1 | 3 | 27 | 3 | 26 | 2 | 24,900 | 25 | 291 | 14 | 999 | 1 | 1,900 | 50,800 | 1.2 |
| No.22 | 35 | 190 | 300 | 32 | 246 | 1 | 62,100 | 620 | 393 | 1,400 | 9,100 | 0 | 2,380 | 1,000 | 5.7 |
| No.23 | 1 | 3 | 22 | 12 | 23 | 7 | 46,700 | 140 | 407 | 14 | 113 | 1 | 950 | 900 | 2.1 |
| No.24 | 19 | 29 | 69 | 2 | 57 | 3 | 43,200 | 153 | 610 | 410 | 9,010 | 0 | 1,430 | 1,500 | 2.3 |
| No.25 | 1 | 6 | 20 | 1 | 20 | 4 | 23,200 | 118 | 310 | 1 | 118 | 1 | 1,420 | 1,000 | 1.0 |

## Table 4-2-3 Rainfalls in Potosi City

| Months | Precipitation (mm) | Raining days |
|---|---|---|
| January | 92.1 | 18 |
| February | 69.5 | 18 |
| March | 64.3 | 13 |
| April | 18.0 | 5 |
| May | 2.5 | 1 |
| June | 1.4 | 0 |
| July | 0.4 | 0 |
| August | 4.5 | 1 |
| September | 13.0 | 3 |
| October | 23.1 | 5 |
| November | 42.1 | 9 |
| December | 72.4 | 15 |
| Total | 404.9 | 87 |
| Max. (Year) | 656.7 (1984) | 128 (1984) |
| Min. (Year) | 182.6 (1983) | 64 (1969, 1983) |

## Table 4-2-4 Water Flow Measurements

($m^3/s$)

| River | Point | Sampling point number | Feb | Apr | May | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| De la Ribera | Potosi | No. 6 | 0.032 | 0.236 | 0.115 | 0.012 | 0.015 | 0.073 | 0.225 | 0.033 | 0.032 |
| Aljamayu | San Antonio | No.12 | 0.472 | 0.313 | 0.441 | 0.231 | 0.432 | 0.108 | 0.898 | 0.338 | 0.078 |
| Tarapaya | Molino | No.17 | 1.05 | 0.745 | 0.950 | 0.839 | 0.555 | 0.326 | 2.35 | 0.927 | 0.149 |
| | Mondragon | No.18 | 0.951 | 0.737 | 0.948 | 0.903 | 0.741 | 0.451 | 2.18 | 1.18 | 0.162 |
| Pilcomayo | Yocalla | No.19 | 5.16 | 4.14 | 4.51 | 5.16 | 3.82 | 3.28 | 5.38 | 4.84 | 2.82 |
| | Mendez Bridge | No.25 | 22.2 | 12.1 | 14.9 | 12.8 | 9.64 | 8.95 | 15.2 | 19.5 | 5.30 |

## Table 4-2-5 Transported SS Quantity over the Rivers

| Name of River | Measurement Point (Sampling Point Number) | Transported SS Quantity (t/d) |
|---|---|---|
| De La Ribera | Cobija Station (No. 6) | 1,170 |
| Alja Mayu | San Antonio (No. 12) | 1,700 |
| Tarapaya | Molino (No. 17) | 950 |
| | Mondragon (No. 18) | 390 |
| Pilcomayo | Yocalla (No. 19) | 1,010 *(185) |
| | Mendez Bridge (No. 25) | 13,300 *(4,300) |

## Table 4-2-6 Pollution Charge Caused by SS

| River | Place | S.P. No | Mass Flow rate ($m^3/s$) | | | |
|---|---|---|---|---|---|---|
| date | | | Feb-'98 | March | Apr | May |
| La Ribera | Potosi (Cobija) | 6 | **0.236 | | 0.236 | 0.115 |
| Alja mayu | San Antonio | 12 | 0.472 | | 0.313 | 0.441 |
| Tarapaya | P. Molino | 17 | 1.05 | | 0.244 | 0.95 |
| | Mondragon | 18 | 0.951 | | 0.737 | 0.948 |
| Pilcomayo | Yocalla | 19 | 5.16 | | 4.14 | 4.51 |
| | Mendez Bridge | 25 | 22.2 | 13.0 | 12.1 | 14.9 |

| SS concentration (mg/L) | | S.P. No | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| date | | | end/Jan. | beg./Feb | mid./Feb | beg/Mar | mid./Mar | end/Mar | beg./Apr | mid./Apr | end/Apr | beg/May | mid./May | end/May |
| La Ribera | Potosi (Cobija) | 6 | 62,400 | 24,480 | 43600 | 72300 | 97300 | 31200 | 84400 | 34200 | 84600 | 57000 | 209000 | 51700 |
| Alja mayu | San Antonio | 12 | 32,800 | 17,290 | 14400 | 10900 | 78400 | 49600 | 28300 | 49600 | 81900 | 70000 | 20100 | 116000 |
| Tarapaya | P. Molino | 17 | 44,690 | 3,555 | 1540 | 8990 | 3160 | 9800 | 6200 | 9900 | 10100 | 18000 | 13000 | 8270 |
| | Mondragon | 18 | 16,230 | 2702 | 1750 | 2180 | 2230 | 4860 | 2270 | 4960 | 5650 | 6500 | 5300 | 5640 |
| Pilcomayo | Yocalla | 19 | 23,060 | 389 | 300 | 830 | 375 | 400 | 470 | 400 | 570 | 460 | 17 | 240 |
| | Mendez Bridge | 25 | 57,910 | 975 | 14000 | 3160 | 3140 | 1750 | 1570 | 1750 | 850 | 970 | 400 | 660 |

| Pollution of SS (t/d) | | S.P. No | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| date | | | end/Jan. | beg./Feb | mid./Feb | beg/Mar | mid./Mar | end/Mar | beg./Apr | mid./Apr | end/Apr | beg/May | mid./May | end/May |
| La Ribera | Potosi (Cobija) | 6 | 1272.361 | 499.157 | 889.0214 | 1474.226 | 1983.9859 | 636.18048 | 1720.9498 | 697.35168 | 1725.0278 | 566.352 | 2076.624 | 513.6912 |
| Alja mayu | San Antonio | 12 | 1337.61 | 705.1 | 587.2435 | 444.5107 | 3197.2147 | 2022.7277 | 765.32256 | 1341.3427 | 2214.8381 | 2667.168 | 765.85824 | 4419.8784 |
| Tarapaya | P. Molino | 17 | 4054.277 | 322.5096 | 139.7088 | 815.5728 | 286.6752 | 889.056 | 130.70592 | 208.70784 | 212.92416 | 1477.44 | 1067.04 | 678.8016 |
| | Mondragon | 18 | 1333.561 | 222.0136 | 143.7912 | 179.1228 | 183.23107 | 399.3287 | 144.54634 | 315.83693 | 359.77392 | 532.3968 | 434.10816 | 461.95661 |
| Pilcomayo | Yocalla | 19 | 10280.7 | 173.4255 | 133.7472 | 370.0339 | 167.184 | 178.3296 | 168.11712 | 143.0784 | 203.88672 | 179.24544 | 6.624288 | 93.51936 |
| | Mendez Bridge | 25 | 111076 | 1870.128 | 26853.12 | 6061.133 | 3526.848 | 1965.6 | 1641.3408 | 1829.52 | 888.624 | 1248.7392 | 514.944 | 849.6576 |

# Table 4-2-7 Water and Sediments Analysis Results / Southeastern Zone of Potosi (1/2)

Analysis data of Southern part of Potosi (Rainy season-February)

1.Quality of Water

| Sample | pH | SS | As | Sb | Cd | Cu | Cr | Fe | Hg | Mn | Pb | Zn | CN | COD | coment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | - | mg/L | μg/L | μg/L | mg/L | mg/L | mg/L | mg/L | μg/L | mg/L | mg/L | mg/L | mg/L | mg/L | |
| R. Vitichi-1 | 6.44 | 89.4 | | <0.10 | 0.04 | 0.16 | <0.005 | 5.80 | 0.61 | 2.03 | 0.33 | 6.70 | 0.009 | 6.74 | PVI-1 |
| R. Vitichi-2 | 8.03 | 6840 | | 0.02 | 0.01 | 0.02 | <0.005 | 3.01 | 3.69 | 0.89 | 0.24 | 0.03 | <0.001 | 13.48 | PVI-2 |
| R. Cotagaita | 7.71 | 1760 | | 0.25 | 0.03 | 0.08 | <0.005 | 12.4 | 5.16 | 3.14 | 0.21 | 0.30 | <0.001 | 0.50 | CTG |
| R. Tumusla | 7.56 | 11700 | | 0.09 | 0.06 | 0.24 | <0.005 | 17.0 | 6.76 | 5.23 | 0.36 | 4.1 | <0.001 | 13.48 | PTU |
| R. CB-P V.A | 8.16 | 4150 | | <0.10 | 0.02 | 0.01 | <0.005 | 0.14 | 4.92 | 0.19 | 0.22 | 0.03 | <0.001 | 11.24 | CBY |
| R. SJO Tupiza | 7.98 | 8340 | | 0.25 | 0.02 | 0.10 | <0.005 | 11.0 | 6.88 | 5.70 | 0.29 | 0.21 | <0.001 | 13.48 | TPZ |
| R. SJO V.A | 8.18 | 6940 | | 0.14 | 0.01 | 0.02 | <0.005 | <0.008 | 2.21 | 0.26 | 0.21 | 0.01 | <0.001 | 8.99 | SJO |
| R. Pilcomayo | 7.91 | 504 | | <0.10 | 0.03 | 0.20 | <0.005 | 57.0 | 3.19 | 9.82 | 0.48 | 1.13 | <0.001 | 4.49 | VMT |

2.Analysis of SS

| | (SS) | Ag | As | Sb | Cd | Cu | Cr | Fe | Hg | Mn | Pb | Zn | CN | Sn | S | Ig.Loss |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (mg/L) | ppm | ppm | ppb | ppm | ppm | ppm | ppm | ppb | ppm | ppm | ppm | ppm | ppm | ppm | % |
| R.Vitichi-1 | 89.4 | | | | | | | | | | | | | | | |
| R.Vitichi-2 | 6840 | | | | | | | | | | | | | | | |
| R. Cotagaita | 1760 | | | | | | | | | | | | | | | |
| R. Tumusla | 11700 | 3.00 | | 46.64 | 9.00 | 53.0 | 11.76 | 47300 | 497 | 560 | 125 | 304.9 | 0 | 2000 | 2200 | 6.62 |
| R. CB-P V.A | 4150 | 5.00 | | 35.72 | 11.0 | 71.0 | 26.36 | 44800 | 280 | 836 | 100 | 159.9 | 0 | 1800 | 11250 | 9.65 |
| R. SJO Tupiza | 8340 | 5.99 | | 49.23 | 7.00 | 57.0 | 34.11 | 43900 | 467 | 674 | 85.0 | 107.9 | 0.50 | 1900 | 900 | 10.38 |
| R. SJO V.A | 6940 | 4.99 | | 49.96 | 9.00 | 56.0 | 29.76 | 43400 | 557 | 768 | 76 | 138.9 | 0 | 1500 | 5300 | 9.71 |
| R. Pilcomayo | 504 | 8.00 | | 41.73 | 8.00 | 45.0 | 11.3 | 43400 | 386 | 524 | 85 | 131 | 0 | 2000 | 3000 | 5.75 |

3.Caliculated elements content in SS

| | (SS) | Ag | As | Sb | Cd | Cu | Cr | Fe | Hg | Mn | Pb | Zn | CN | Sn | S | Ig.Loss |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | - | mg/L | mg/L | μg/L | mg/L | mg/L | mg/L | mg/L | μg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | % |
| R.Vitichi-1 | 9E-05 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| R.Vitichi-2 | 0.0068 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| R. Cotagaita | 0.0018 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| R. Tumusla | 0.0117 | 0.035 | 0 | 0.5457 | 0.105 | 0.62 | 0.1376 | 553.41 | 5.8149 | 6.552 | 1.463 | 3.5673 | 0 | 23.4 | 25.74 | 0.077454 |
| R. CB-P V.A | 0.0042 | 0.021 | 0 | 0.1482 | 0.046 | 0.295 | 0.1094 | 185.92 | 1.162 | 3.469 | 0.415 | 0.6636 | 0 | 7.47 | 46.688 | 0.0400475 |
| R. SJO Tupiza | 0.0083 | 0.05 | 0 | 0.4106 | 0.058 | 0.475 | 0.2845 | 366.13 | 3.8948 | 5.621 | 0.709 | 0.8999 | 0.0042 | 15.85 | 7.506 | 0.0865692 |
| R. SJO V.A | 0.0069 | 0.035 | 0 | 0.3467 | 0.062 | 0.389 | 0.2065 | 301.2 | 3.8656 | 5.33 | 0.527 | 0.964 | 0 | 10.41 | 36.782 | 0.0673874 |
| R. Pilcomayo | 0.0005 | 0.004 | 0 | 0.021 | 0.004 | 0.023 | 0.0057 | 21.874 | 0.1945 | 0.264 | 0.043 | 0.066 | 0 | 1.008 | 1.512 | 0.002898 |

## Table 4-2-7 Water and Sediments Analysis Results / Southeastern Zone of Potosi (2/2)

4.Caliculated elements content in water

| | (SS) | (Ag) | As | Sb | Cd | Cu | Cr | Fe | Hg | Mn | Pb | Zn | CN | (Sn) | (S) | (Ig.Loss) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mg/L | (mg/L) | μg/L | μg/L | mg/L | mg/L | mg/L | mg/L | μg/L | mg/L | mg/L | mg/L | mg/L | (mg/L) | mg/L | % |
| R.Vitichi-1 | 89.4 | 0 | 0 | 0 | 0.04 | 0.16 | 0 | 5.8 | 0.61 | 2.03 | 0.33 | 6.7 | 0.009 | 0 | 0 | 0 |
| R.Vitichi-2 | 6840 | 0 | 0 | 0.02 | 0.01 | 0.02 | 0 | 3.01 | 3.69 | 0.89 | 0.24 | 0.03 | 0 | 0 | 0 | 0 |
| R. Cotagaita | 1760 | 0 | 0 | 0.25 | 0.03 | 0.08 | 0 | 12.4 | 5.16 | 3.14 | 0.21 | 0.3 | 0 | 0 | 0 | 0 |
| R. Tumusla | 11700 | 0.035 | 0 | 0.6357 | 0.165 | 0.86 | 0.1376 | 570.41 | 12.575 | 11.78 | 1.823 | 7.6673 | 0 | 23.4 | 25.74 | 0.077454 |
| R. CB-P V.A | 4150 | 0.021 | 0 | 0.1482 | 0.066 | 0.305 | 0.1094 | 186.06 | 6.082 | 3.659 | 0.635 | 0.6936 | 0 | 7.47 | 46.688 | 0.0400475 |
| R. SJO Tupiza | 8340 | 0.05 | 0 | 0.6606 | 0.078 | 0.575 | 0.2845 | 377.13 | 10.775 | 11.32 | 0.999 | 1.1099 | 0.0042 | 15.85 | 7.506 | 0.0865692 |
| R. SJO V.A | 6940 | 0.035 | 0 | 0.4867 | 0.072 | 0.409 | 0.2065 | 301.2 | 6.0756 | 5.59 | 0.737 | 0.974 | 0 | 10.41 | 36.782 | 0.0673874 |
| R. Pilcomayo | 504 | 0.004 | 0 | 0.021 | 0.034 | 0.223 | 0.0057 | 78.874 | 3.3845 | 10.08 | 0.523 | 1.196 | 0 | 1.008 | 1.512 | 0.002898 |

5.Quality of Sediments

| Sample | Ag | As | Sb | Cd | Cu | Cr | Fe | Hg | Mn | Pb | Zn | CN | Sn | S | Ig.Loss | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ppm | ppb | ppb | ppm | ppm | ppm | ppm | ppb | ppm | ppm | ppm | ppm | ppm | ppm | % | |
| R.Vitichi-1 | 4.00 | | 40.6 | 8.00 | 46.0 | 5.09 | 33800 | 279 | 410 | 200 | 400 | <0.50 | 976 | 1100 | 3.42 | |
| R.Vitichi-2 | 1.00 | | 46.3 | 8.00 | 30.0 | 4.87 | 40400 | 23.0 | 318 | 60.0 | 90.0 | <0.50 | 1460 | 600 | 2.31 | |
| R. Cotagaita | 3.00 | | 56.1 | 20.0 | 40.0 | 7.26 | 44400 | 135 | 310 | 60.0 | 100 | <0.50 | 976 | 13900 | 2.19 | |
| R. Tumusla | 2.00 | | 54.9 | 10.0 | 80.0 | 5.03 | 37100 | 72.3 | 316 | 60.0 | 100 | <0.50 | 732 | 1400 | 1.77 | |
| R. CB-P V.A | 3.00 | | 34.6 | 20.0 | 20.0 | 8.55 | 29400 | 122 | 259 | 70.0 | 90.0 | <0.50 | 976 | 1200 | 9.19 | CBY |
| R. SJO Tupiza | 1.00 | | 43.5 | 10.0 | 30.0 | 12 | 37600 | 132 | 354 | 50.0 | 90.0 | 0.50 | 976 | 800 | 1.73 | TPZ |
| R. SJO V.A | 1.00 | | 39.7 | 20.0 | 20.0 | 13.4 | 36000 | 102 | 216 | 40.0 | 80.0 | <0.50 | 732 | 1400 | 1.36 | SJO |
| R. Pilcomayo | 3.00 | | 34.3 | 10.0 | 20.0 | 2.71 | 26500 | 207 | 247 | 50.0 | 70.0 | 0.50 | 975 | 1300 | 1.24 | VMT |

**Table 4-2-8 Analysis Data of Southern Part of Potosi (mid. Oct. - dry season sample)**

1.Quality of Water

| Sample | pH | SS | As | Sb | Cd | Cu | Cr | Fe | Hg | Mn | Pb | Zn | CN | COD | coment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | - | mg/L | μ g/L | μ g/L | mg/L | mg/L | mg/L | mg/L | μ g/L | mg/L | mg/L | mg/L | mg/L | mg/L | (Code name) |
| R. Vitichi-1 | 4,7 | 11 | 1,11 | 0,67 | <0.002 | 2,10 | <0.005 | 5,90 | <0.10 | 4,51 | 0,20 | 0,03 | <0.001 | 4 | PVI-1 |
| R. Cotagaita | 8,4 | 70 | 0,97 | 0,50 | 0,03 | 0,01 | <0.005 | 0,19 | 0,51 | 0,12 | 0,17 | 0,03 | <0.001 | 4 | CTG |
| R. Tumusla | 8,6 | 245 | 0,29 | 0,53 | 0,10 | 0,01 | <0.005 | 0,37 | 2,27 | 0,01 | 0,28 | 27,0 | <0.001 | 60 | PTU |
| R. CB-P V.A | 8,7 | 472 | 0,38 | 0,59 | 0,02 | 0,01 | <0.005 | 0,18 | 0,56 | 0,01 | 0,24 | 0,02 | <0.001 | 9 | CBY |
| R. SJO Tupiza | 9,1 | 21 | 0,57 | 0,62 | 0,01 | 0,01 | <0.005 | 0,18 | 1,18 | 0,06 | 0,18 | 0,02 | <0.001 | 4 | TPZ |
| R. SJO V.A | 8,2 | 31 | 0,13 | 0,60 | 0,01 | 0,02 | <0.005 | 0,25 | 1,04 | 0,70 | 0,21 | 0,03 | <0.001 | 30 | SJO |

2.Qaulity of Sediment

Data are not offered from laboratory.

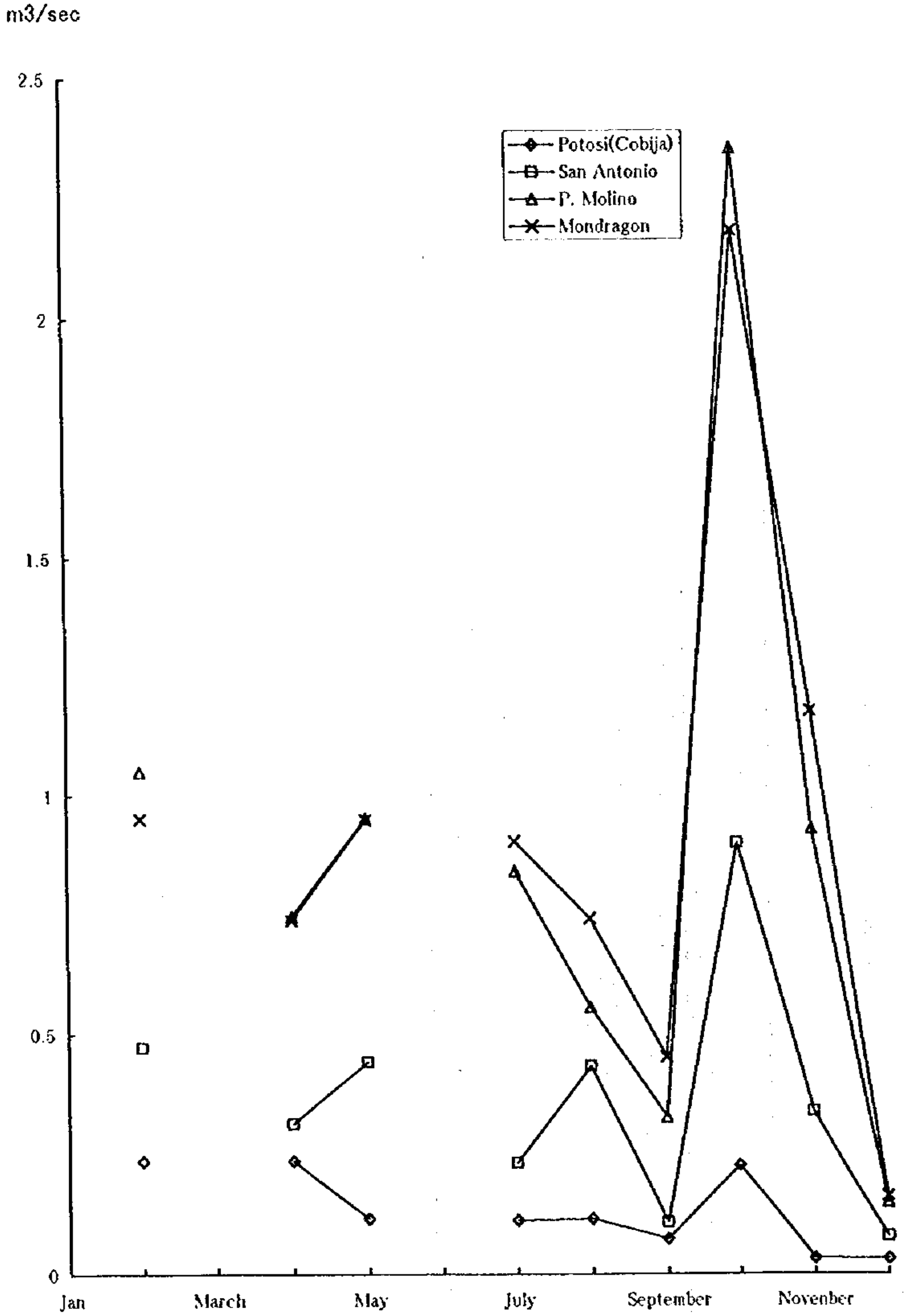



**Figure 4-2-1 Variation of Water Flow at Tarapaya River**

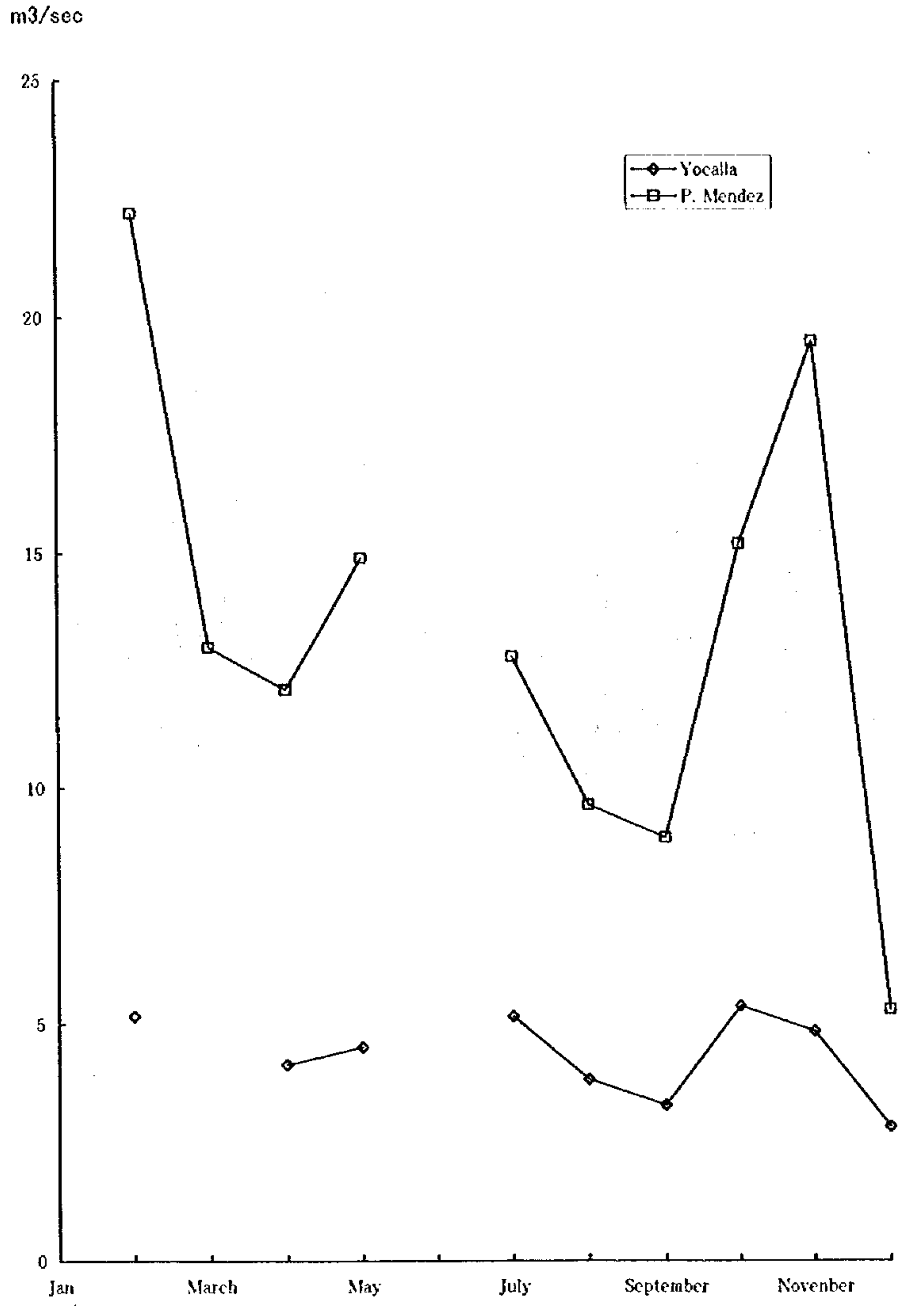



**Figure 4-2-2 Variation of Water Flow at Pilcomayo River (Yocalla and Méndez Bridge)**

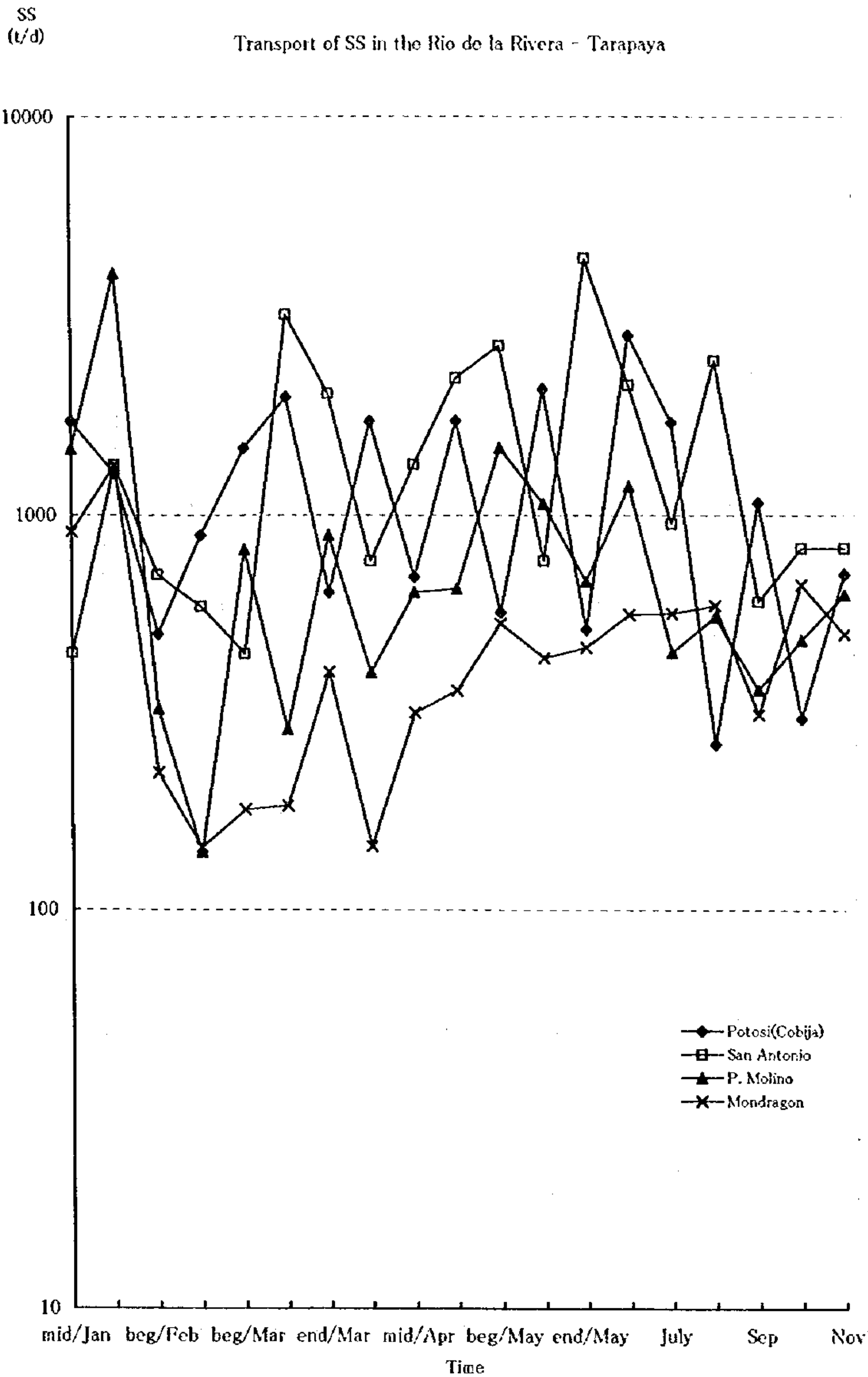



**Figure 4-2-3 Variation of Transported SS over Tarapaya River**

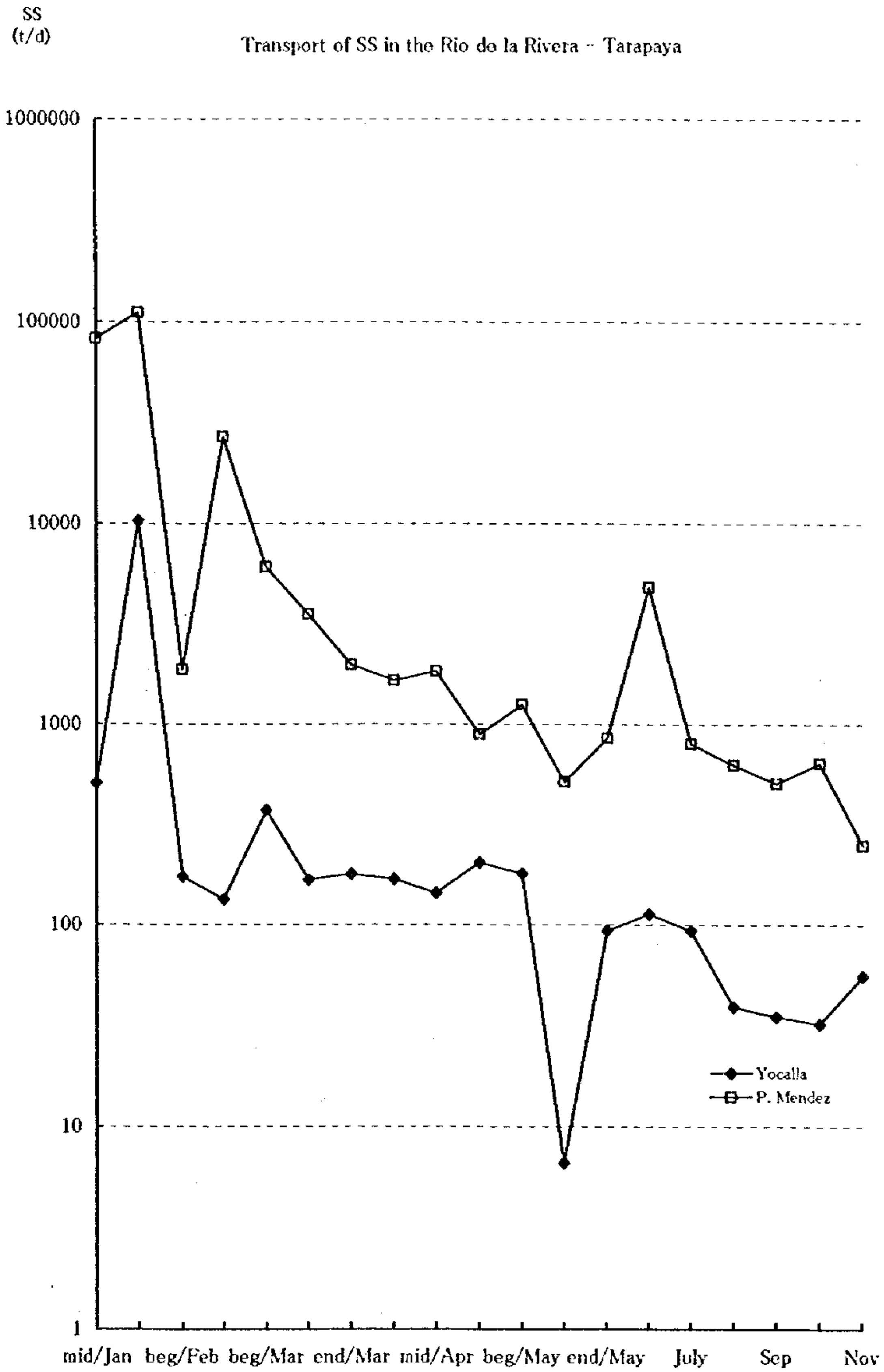



**Figure 4-2-4 Variation of Transported SS over Pilcomayo River**

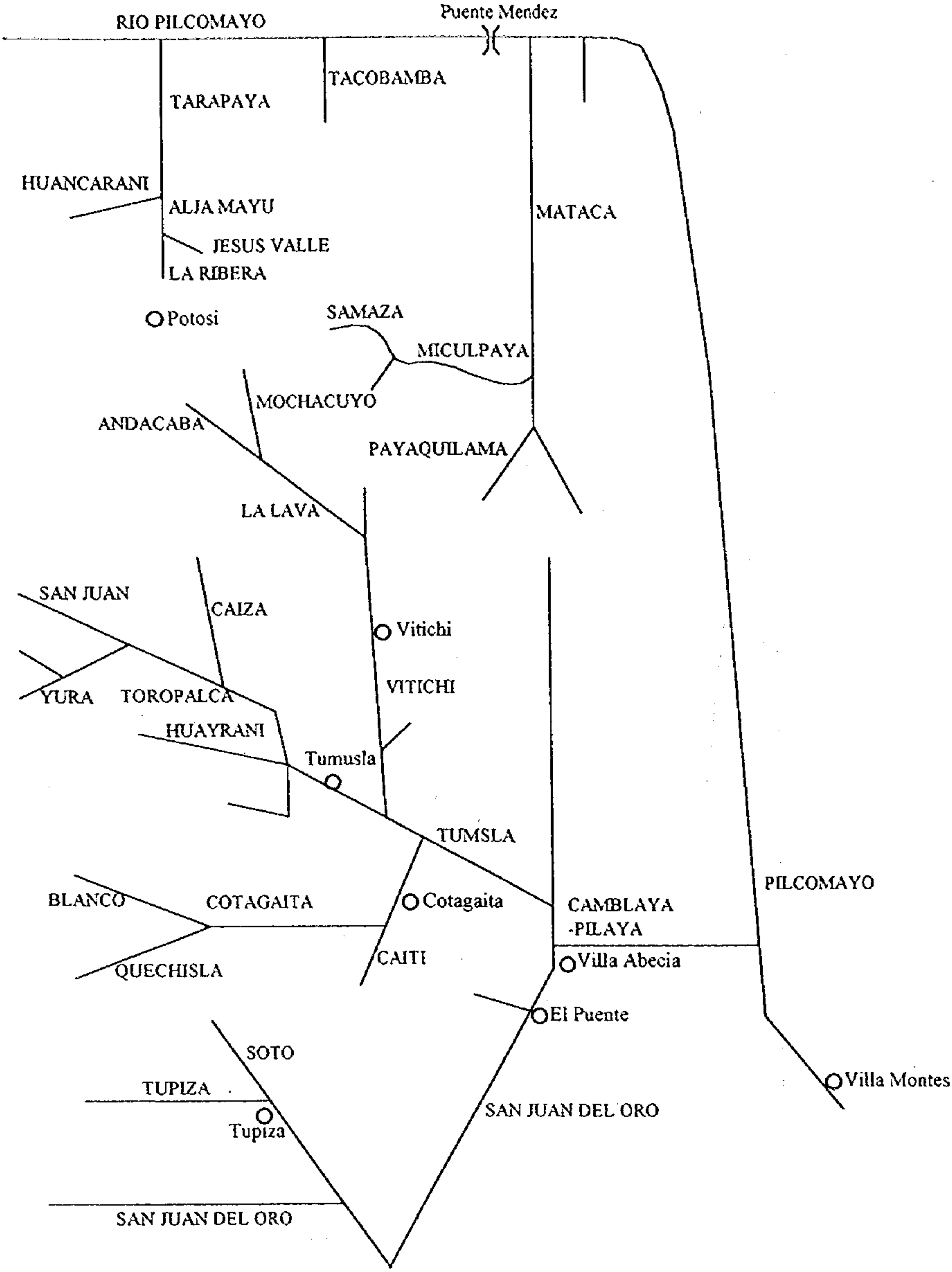



**Figura 4-2-5 Diagrama de estructura hidrológica de la zona sudeste de Potosí**

## 4-3 Area and Impact of Damages

### 4-3-1 Background

(1) Geographical position of the study area

This study covers the area of Potosi City of Tomas Frias Province, the area of the branch stream of Tarapaya River, including Cayara river, Totara D. river, and also the area of Pilcomayo River Basin from Tarapaya main river to the vicinity of Mendez Bridge.

The Pilcomayo River runs the prefectures of Potosi, Chuquisaca and Tarija, and each of them covers areas of 118,218 $km^2$, 51,524 $km^2$ and 37,623 $km^2$, respectively.

According to the CER-DET and QPID (1997), the Pilcomayo River Basin (PRB) covers an area of some 99,110 $km^2$ in Bolivia. The Prefectures of Potosi, Chuquisaca, Tarija and Oruro occupying 42,987 $km^2$, 30,818 $km^2$, 24,591 $km^2$ and 714 $km^2$ respectively. (The 3rd edition of 'Geografia y Recursos Naturales de Bolivia'; gives the Pilcomayo River Basin as covering an area of 98,100 $km^2$)

The Pilcomayo River arises in the Province of Avaroa (Oruro Prefecture) and, ends in the Province of Esmeralda (Tarija Prefecture). Its length is 620 km and it flows into the Paraná River.

Data of the hydrological station of Villamontes (Tarija Prefecture), shows that the river can get as deep as 6.6 m and has a width of 150 m. Its annual average flow is estimated as 203 $m^3$/sec.

The weather that characterizes the basin is variable. In its highest part (altitude up to 4,500 meters) corresponding to the most extended area, a cold arid to semi-arid climate predominates. Downstream, the climate is mild and sub-humid. Close to the border of Paraguay and Argentina (minimum altitude of 250 m), the climate is torrid and arid to semi-arid.

In the high part of the basin, there are important mineral deposits where the most common metals are lead, tin, zinc, silver, antimony, copper and bismuth (see the Pilcomayo River map in the Figure 4-3-1 "The Pilcomayo River Map" for the location of the incidents and mining activities).

(2) Social aspect of the study area

According to official estimates of the National Statistics Institute (INE) the Bolivian population for 2000 will total 8.329 million inhabitants.

The same institution estimates that the prefectures of Potosi, Chuquisaca and Tarija, through which the Pilcomayo River passes, will have the populations, respectively, of 774,000, 590,000 and 403,000 in 2000.

Particularly regarding Potosi Prefecture, the following data shows how severe conditions of daily life are:

① An annual population growth rates for the period of 1990-1995 were, respectively, of 1.1, 2.4, 3.2 percent for Potosi, Chuquisaca and Tarija. The rate of the entire nation was around 2.4%.

② The child mortality rate, for the five-year period of 1990-1995, was very high for Potosi (112 per thousand births). In Chuquisaca (84 per thousand) and Tarija (60 per thousand), their rates lie closer to the national average (75 per thousand).

③ Life expectancies were 53 years in Potosi, 57.8 years in Chuquisaca and 63.1 years in Tarija, while the average at the national level is 59.3 years.

The few alternatives for employment and income generation are being influenced by the decrease of and the irregular quantity of supply of water resources. In fact, in this arid to semi-arid environment, water is of vital importance, for human daily activities as well as for the traditional productive activities (agriculture, stockbreeding and, in certain regions, fishing).

There is no doubt that for the peasant communities living downstream, close to mining operations, the water, soil and food chain pollution has caused deterioration of nutrition and hygiene. All this contributes to the accelerated growth of some cities and to the unplanned colonization of other rural areas of the country.

Nevertheless, the complexity of the predominant social situation, marked by poverty and marginality makes it difficult to determinate exactly the degrees to which the different factors, that together are at the root of the regional socioeconomic crisis, contribute to problems. The migration data of each prefecture indicates the biggest rate of all in Potosi.

Within the study area, the Study Team carried out an impact study of the pollution originating from mining activities. It covers 34,701 people, and 8,070 families in the five districts, out of 120,000 people of twelve districts of Potosi city as urban area sample which correspond with the No. 1, No. 2, No. 3, No. 4 and No. 5 areas of the Figure 1-2-1. As the rural area sample the Study Team selected 7,396 people, and 1,720 families of thirty-seven districts, which correspond with the No. 6 to No. 42 areas of the Figure 1-2-1.

And the Figure 4-3-2 shows the location of 5 districts urban area in Potosi City.

The Figure 1-2-1 shows the location of 37 rural districts.

Table 4-3-1 gives the population and number of families for each district influenced by the mine-caused pollution, including the urban area.

The table distinguished in mark and color the population that lives in the area of the river banks, the population who lives in the area one kilometer from the river, and population that is in the urban area of Potosi City.

Table 4-3-2 shows the interesting behavior of the people. The habitants of almost every rural area, have a strong tendency toward complete or incomplete emigration. The following facts are suspected as the main reasons for this.

① Eight areas near the urban area, few own property and suffer less impact of pollution.

Jesus del Valle (6), Agua Dulce (8), La Palca (12), Santa Lucia (13), Cayara (14), Totara 'D (15), Totara Pampa (16) and Yocalla (17).

② Eight areas is influenced by the contamination of the Tarapaya River, and the Jaya Mayu River, and soil contamination all originating in mine activity.

Jaya Mayu (9), San Antonio (10), La Puerta (11), Molino (18), Aroifilla (19), Tambo Pampa (20), Miraflores (21) and Mondragon (22)

③ Twelve areas influenced by the contamination of Pilcomayo River and the area to be swept away by the inundation.

Sullcari (23), Pallca (24), Juicuni (25), Capilla Rosario (26), Tacuara (27), Talula (28), Ancoma (29), Huerta Khasa (30), Kholu (31), Oyora (32), Chalama (33) and Quebrada (35)

④ Six areas influenced by the contamination of the Pilcomayo River and the lack of cooperation for the protection and recovery of soil;

Aczulipamapa (34), Km127 (36), San Antonio (37), Vina Pampa (38), Tuero (41), Puente Mendez (42).

(3) Economic aspects of the study area

The principal economic sector that suffers from the PRB's pollution is agriculture.

The peasant sector is constituted of thousands of poor families who are close to the subsistence level and can rely only on activities of low profitability and high risk.

The low and extremely volatile prices paid for the traditional products of this region (potatoes, maize, wheat, barley, meat, wool, fish, etc.) do not permit a sustainable growth of these activities. As a consequence, there is a very low level of reinvestment in these production systems, which contributes to the gradual reduction of the productive capacity of the ecosystems.

According to the INE (1996), the shares of the departments of Potosi, Chuquisaca and Tarija were, respectively, 6.7%, 8.2% and 5.9 % of the gross national product obtained by agriculture in 1993. The agricultural gross product of these three prefectures were, for 1993, of some 157, 192 and 138 million Bolivians i.e. 37, 45 and 32 million US$, respectively.

The following are the details information about commercial activities of the study area which is affected by the contamination of river water, including the urban area.

1) Urban area

As shown in the Table 4-3-3, the main commercial activities of the urban area is retailing and it's share is more than 50% of the total commercial activities. In both the large and small business sectors alike, retailing occupies the main commercial activities in the town, including official and unofficial. The second largest commercial activity is mine-related activity, which is also important for the local economy. Meantime the enterprises that are working in the mine-related activity area, have only small scale production capacity, primitive technology and a weak financial base, so their standpoint is very sensitive to the international price competition.

As the result these mine related activity enterprises are not in a position to compete with the big international firms who employ advanced technology. That means the mine related activity firms, being a declining sector, can not absorb emigrants from rural area. As a consequence it provoke the social instability and increase of unofficial economical activities.

2) Rural area

The main commercial activities in the rural area are agriculture and stockbreeding. Beside the agriculture activity in San Antonio and Aroifilla, there are ingenio and, in the center of village activities.

3) Emigration

As shown in Table 4-3-2, we can see the fact that the contamination of water causes economical aggravation and oppression of people's lives.

During the drought of 1983 and the worst period of Pilcomayo River water contamination in 1970's and 1980's, the number of emigrants sharply increased. Santa Cruz Prefecture and Cochabamba Prefecture were two main domestic destinations and Argentine was the main foreign destination.

4-3-2 Damages Impact Data

Dozens of mineral concentration plants which are presently operating or which are inactive, and hundreds of abandoned and operative mines, located in the territory of Potosi, are at the root of the current pollution processes of the Pilcomayo River Basin.

Nevertheless, the existence of other pollution problems generated within and outside the territory of Potosi should not be ignored. Those problems are magnified through management problems of the basin by farmers, stockbreeders, wood collectors and mining industries. In fact, the lack of planning of the use of natural resources and the adoption of management systems without use of sustainability criteria are causing a process of regional deforestation and serious disturbances of the water cycle.

We can see cases of social-economic impact caused by the inappropriate management of the economic activities in the follow five published study reports study mission survey.

| Study | Area |
|---|---|
| (1) The Case of Villamontes | Pilcomayo River Tarija Prefecture |
| (2) The Case of Tarapaya River | Tarapaya River, Molino Mondragon |
| (3) The Case of La Palca | Tarapaya River, La Palca |
| (4) The Case of Potosi City | Potosi City De la Ribera River |
| (5) The Case of Study Area Survey | De la Ribera River to Mendez Bridge |

(1) The Case of Villamontes

①Project Implementers: CER-DET and QPID-1997

②Study Area: A three areas in Tarija Prefecture

③Study Purpose:

- To analyze the concentration of lead and other toxic metals in the enter bodies of the silver fishes.
- To analyze the concentration of lead and zinc in the human blood.

④Study Method:

• Laboratories' analysis of chemical elements the bodies of the fishes.

• Laboratories' analysis of chemical elements the human blood (Guaranian).

⑤Principal Impact:

⑤-1 Fish:

During the three study period, the average concentration of lead in the tested fish was detected as 6.96 ppm and 5.56 ppm for the first and the third period, respectively.

⑤-2 Human Blood:

The test result for second and third period were 4.94 $\mu$g/dl and 16 $\mu$g/dl, respectively, as lead concentration.

⑥Detailed comments:

In the report there is no indication about the permissible limits of lead concentration in the entire fish and human blood. However it is pointed out that the children absorb 50% of the lead consumed against 10% in the case of adults, so it is necessary to be more careful about toxic metal caused aliment among children. The reported average levels of metal concentration registered in fish are summarized below:

| Location | Comments | Pb (ppm) | Zn (ppm) |
|---|---|---|---|
| Villamontes | Near Argentine | 2.11 | 13.31 |
| Puerto Margarita | Between V. and Y. | 7.76 | 35.64 |
| Yukimbia | Near Potosi | 6.82 | 33.48 |

(2) The Case of Tarapaya River

①Project Implementers: MEDMIN–1995 (Organization to support medium and small mining operators)

②Study Area: Tatapaya River. (Refer the Figure 1-2-1, corresponds to the areas of number 18, Molino to 22, Mondragon.)

③Project Purpose: To identify the social-economic impact around the area of the river Ribera and Pilcomayo between Potosi City and Mendez Bridge.

④Principal Impact:

The following gives, the summarized principal impacts which affect the study area.

④-1 Human health:

| |
|---|
| Contact with water causes irritation, blooding and/or cracking of skin. |
| Drinking water causes intestinal and stomach diseases. |

④-2 Agriculture:

| |
|---|
| Production of carrots require 3 times more seeds, for a lower productivity (by 70%). |
| Abnormally slow growth of plants. |
| Death of plants. |
| Low productivity. |

④-3 Stockbreeding:

| |
|---|
| Intestinal disease when drinking water. |
| Degradation of nails after prolonged or frequent contact with water. |
| Low productivity. |

④-4 Bio-diversity:

| |
|---|
| Disappearance of vegetation on river banks. |
| Disappearance of aquatic life. |

⑤Observation:

There are lots of beautiful farming area alongside the river Talapaya, even though the river itself is strongly contaminated with heavy metal, like the district of Molino. The farmers of the area do not use the contaminated river water for their agricultural work, but are using the irrigation systems with supplied clean water from other water sources.

Meantime some of the dwellers who live in the place located after the Mendez bridge have less opportunity to use the clean water for their agricultural works, and only have the polluted Pilcomayo River water, making the productivity of such area very low.

So it is recommendable to extend the study area for the impact and not to limit the area to Potosi Prefecture.

(3) The Case of La Palca

①Project Implementers: Centro para el Desarrollo Regional (C.D.R.)

②Study Area: La Palca area in - Tarapaya River (Refer the Figure 1-2-1, corresponds to number 12, La Palca area)

③Study Purpose: Socio-Economic impact study of the mining activities

④Sampling Method: Interviews with the leaders of the districts

⑤Principal impact:

⑤-1 Agriculture

| |
|---|
| Farms in the area which produce the broad bean using the Tarapaya River water, only can get the half of the yeild, 30qq/ha, compared with the non-contaminated water production, 45qq/ha production, and some of contaminated water farming only can produce 0.37qq/ha. 1 quintal (qq) is 100 kg. |

⑤-2 Stockbreeding

| |
|---|
| The pastors who have their sheep around the area of the Tarapaya River, could produce only half the volume of products compared with results for previous years. |

(4) The Case of Potosi City

①Project Implementers: Centro para el Desarrollo Regional (C.D.R.)

②Study Area: five of twelve districts of Potosi City, which are alongside of the river Ribera. (Refer the Figure 1-2-1, areas of San Juan (1), San Cristobal (2), San Pedro (3), San Benito (4) and Cantumarca (5))

③Study Purpose: Socio-economic impact study of the contamination in the river

④Sampling Method: 500 samples in all with 100 from each of the five districts.

⑤Principal Impact:

| |
|---|
| Diseases of digestive and respiratory systems, caused by contact with river water. It is believed that frequent occurrence of these diseases productivity of human resources. |

⑥Observation:

Beside diseases caused by the contact with river water, due to the massive dust from ingenos the habitants reported the origin diseases caused by air contamination.

(5) Study of the area to be influenced by the contaminated river water

①Project implementor: Study Team researched the situation with the assistance of CDR (NGO of the local area)

②Study area: Five districts of Potosi city urban area and the 37 districts of the rural area of Pilcomayo River basin villages from the Potosi City to Mendez Bridge, which have been influenced by contaminated water. (Refer the Figure 1-2-1)

Urban area; 1.San Juan (1), 2.San Cristobal (2), 3.San Pedro (3), 4.San Benito (4), 5.Cantumarca (5)

Rural area; 1.Jesus Valle (6), 2.Cebadillas (7), 3.Agua Dulce(8), 4.Jaya Mayu (9), 5.San Antonio (10), 6.La Puerta (11), 7.La Palca (12), 8.Santa Lucia (13), 9.Cayara (14), 10.Totora D. (15), 11.Totora Pampa (16), 12.Yocalla (17), 13.El Molino (18), 14.Aroifilla (19), 15.Tambo Pampa (20), 16.Miraflores (21), 17.Mondragon (22), 18.Sullcari (23), 19.Pallka (24), 20.Juicuni (25), 21.Capilla Rosario (26), 22.Tacuara (27), 23.Talula (28), 24.Ancoma (29), 25.Huerta Khasa (30), 26.Kholu (31), 27.Oyora (32), 28.Chalama (33), 29.Aczulipampa (34), 30.Quebrada (35), 31.Km127 (36), 32.San Antonio/Sucure (37), 33.Vina Pampa (38), 34.Talula (39), 35.Tasa Pampa (40), 36.Tuero (41), 37.Puente Mendez (42)

③Study Purpose: To investigate the environment damage impact to the human health, agriculture and stockbreeding.

④Study Method: Interviews at each village of study area.

⑤Impact Study Result:

The study area can be clarified into four types, (a) Complete Potable Water System area, (b) Fountains base area, (c) Lorry service areas, and (d) Pilcomayo River water area.

⑤-1 Human Health:

(a) Complete Potable Water System area:
As indicated in Table 4-3-5, the potable water supply system in the urban area serves every habitant, and only less than 10% of habitants use well water as an auxiliary.

(b) Fountains base area:
In the rural area, seventeen districts have a potable water supply system that uses concrete setting tanks. The resources of these potable water are mainly fountains and even the quality of which are not tested, users have no claim about that.
The remaining seventeen rural area districts (listed below), also use the water from the fountains but only a very simple setting tank, and the water quality there has not been examined. People waste much time and energy for the transportation of potable water from the fountains to their home, a job which is a very heavy burden to women and children.
1.Jesus Valle (6), 2.Cebadillas (7), 3.Agua Dulce (8), 4.Jaya Mayu (9), 5.San Anotonio (10), 6.Sullcari (23), 7.Pallka (24), 8.Juicuni (25), 9.Capilla Rosario (26), 10.Tacuara (27), 11.Talula (28), 12.Ancoma (29), 13.Huerta Khasa (30), 14.Kholu (31), 15.Oyora (32), 16.Chalama (33) and 17.Quebrada (35)

(c) Lorry service areas:
Regarding the San Antonio district (10) and Yocalla district (17), because of lack of potable water resource, the habitants get the potable water service by water tank lorry from Potosi City.

(d) Pilcomayo River water area
It is necessary to point out the fact that the river water of Pilcomayo is used as the potable water for the habitants of the districts of Aczulipampa (34), Km 127 (36), San Antonio/Sucre (37), Vina Pampa (38), Talula (39) and Puente Mendez (42). And even among people who take the river water as potable after processing the filtration with river sand, there are many cases of the stomachache and diarrhea.

(Diseases in rural area)

As shown in the Table 4-3-6, there are two principal diseases which are caused by water contamination.

- Dermatopathy: On chapped on hands and feet.
- Gastroenteritis: Diarrhea because of the disorder of stomach and intestines.

The incidence of diseases has become fewer than in previous years, but this is because of the deepened awareness about the contamination. That means there is no alteration about the contaminated area but the peoples are paying more attention to self-protection.

Meanwhile, in the districts of Mondragon (22), Sullacari (23), Juicuni (25), Tacuara (27), Aczulipamapa (34), Quebrtada (35), Km 127 (36), San Antonio/Sucre (37), Vina Pampa (38), Talula (39) and Puente Mendez (42), because of necessity, peoples use the contaminated water for irrigation and occasionally they come into direct contact with the contaminated river, by touching the water when using it for transportation, that has provoked several type of problems among the habitants.

There has not been any report of a mortality case but among the people who are using the polluted water as potable water, it is reported that there are many cases of nausea, stomachache and diarrhea.

(Diseases in urban area)

Table 4-3-7 we can see the main 13 types of diseases in the urban area and the human health condition in five urban districts.

We can see the fact that there is a correlation between the area highly contaminated being equal with the area have dense activities of mine-related enterprises. These enterprises increased their pollution whenever they increased production capacity.

The raw materials and the semi-products, after being processed by ingenios, are stocked in open areas without shelter, because of the severe weather of Potosi City, with its strong temperature alternation, and strong and continuous wind, spreads them into air and causes human health problems, especially asthma.

The effluent and solid waste from the mine activities enterprises are discharged into the river and such materials accumulate on the riverbed, causing harm to the habitants, especially women and children, who have no preventive methods they can use except to avoid the contact with the contaminated water, but they must rely on the river for transportation.

Since these rivers are used as a part of the waste, disposal system due to the incompleteness of the solid waste collection system, the river water has become ever more contaminated, and more incidents of causes the diarrhea and stomachache.

⑤-2 Agriculture

(Back ground)

Not only are almost every irrigation channel but also entire irrigation systems made of soil, these irrigation systems are the key to survive the dry weather and support highland agricultural activities. The farm land in the study area is divided into small parcels due to the land ownership pattern, and this is one of the structural reasons for out ward emigration. There are many cases of abandonment of irrigated farming land, due to decreased fertility of soil caused by polluted irrigation water.

(Damages)

Table 4-3-8 indicates the overall picture of agricultural damage in the study area.

In the districts of Aczulipampa (34), Km 127 (36), San Antonio/Sucre (37), Vina Pampa (38), Talula (39), Tasa Pampa (40), Tuero (41) and Puente Mendez (42) to obtain the required level of germination, it is necessary to use more than two or three times the quantity of seed compared with standard situation, even to get only a 60 to 70 % germination rate.

And in the districts of Talula (39), Chalama (33), Km 127 (36), San Antonio/Sucre (37), Vina Pampa (38) and Tuero (41), there have been causes of damage of fruit trees seen in the phenomenon of decreased productivity and withered trees.

The followings are six concrete phenomena of pollution damages.

- The shrinkage of and yellow coloration of a bud after the germination.
- Withered leaves and stems.
- Decreased productivity.
- Enameled plants.
- Immaturity of infant roots.
- Low germinative rate

⑤-3 Stockbreeding

(Background)

Table 4-3-9 shows the abundant stockbreeding field and it is available to be used as a stock farm every slop of hills and mountains regardless their sizes. And principally, domestic animals live close to the human habitation, but there is no irrigation system for stock farm, as the result there is no chance to come into contact with polluted water and there is no polluted grass.

The areas of stock farms are measured including the spaces between rivers and hills, which is practically equal with the administrative boundary.

One reason for erosion of land is the current stockbreeding methods, which permits the domestic animals to eat completely the grasses and trees of land surface.

(Damages)

As shown in Table 4-3-10 the damages analysis was made by classifying the owners of livestock into three groups based on the number of animals.

(A)First group.

Where one family keeps the twenty sheep and two goats, as the districts of La Puerta (11), La Palca (12), Aroifilla (19) and Tambo Pampa (20)

(B)Second group.

Where one family keeps the fifteen sheep and fifteen goats, as the districts of Mondragon (22), Sullcari (23), Juicuni (25), Capilla Rosario (26), Tacuara (27), Ancoma (29), Huerta Khasa (30) and Kholu (31).

(C)Third group;

Where one family keeps the three sheep and twenty-five goats, like as the districts of Aczulipampa (34), Km 127 (36), San Antonio/Sucre (37), Vina Pampa (38), Talula (39), Tasa Pampa (40), Tuero (41) and Puente Mendez (42).

The breeding methods for sheep and goats are the same and it is understood that both animals are damaged equally by the polluted water and the risk of reduced productivity for both types is same. It is suspected that the following damages are caused by polluted river water.

The difference of number of livestocks and type of livestocks do not effect their illness.

- Deformity : Maternity of deformed children with weight and legs.
- Gastroenteritis : Diarrhea.
- Dermatopathy : Diseases of outside skin.

Regarding the above diseases, the following should be understood.

a. For the deformed animals, the habitants pointed out the polluted water as the reasons, but it is requested to ascertain if this is true by using scientific analysis.

b. Regarding the mortality, the third group reports a high mortality rate for young goats (less than 4 months old) 40 %, which is far higher than the normal mortality rate, 5 %.

4-3-3 Summary of Pollution Impact

Taking the above facts into the consideration, the main impacts caused by the Pilcomayo River Basin can be classified as follows:

(1) Social Impact:

1) Poverty caused by the difficulty or the impossibility to maintain traditional productive activities.

2) Migration caused by poverty, particularly during winter and spring when there is a scarcity of good water resources, and the risk of catching sickness, the frequent disease mainly related with digestion, which could eventually be serious.

3) Migration and poverty are damaging the structures of the traditional social organizations.

(2) Economic Impact:

1) Decrease and destabilization of the production capacity of fishing, agriculture and livestock raising.

2) Decrease of economic activities due to decreasing human resources.

3) Reduction of the economic and political importance of the farming sector in the Pilcomayo region's economy.

(3) Environmental Impact:

1) The accumulation of, heavy metal, toxic, chemical elements in rivers, soils and food chains.

2) Increase of the suspended solids in the Pilcomayo River.

3) Increase of the ecosystem's sensitivity in the face of disturbing factors (human or natural ).

4-3-4 Consideration of Causes and the Estimated Magnitude of Damage

(1) Consideration of causes

The Pilcomayo River is polluted in biological, chemical and physical terms. This situation is due to the past and current human activities as well as, although to a lesser extent, to geological natural processes. And several human activities are the roots of the pollution problem of this river basin.

1) Towns and cities

Towns and cities, being areas of concentrated economic activity, produce certain quantities of gases as well as solid and liquid waste materials which affect the water quality of rivers.

Judging from the scale of the urban population, however this factor seems not very true in the prefecture of Potosi since it does not have big urban areas. The only important city is Potosi which has 120,000 inhabitants. But due to the lack of any type of sanitation facilities for drainage in Potosi City, we can anticipate contamination by the colon bacillus. Currently with German support, two sewerage plants are planned to be installed.

2) Agriculture

Chemical products used in farming and livestock raising for the protection and development of crops and stockbreeding. These products are sometimes toxic and they do not always degrade before being carried away to the rivers. Moreover, farming activities and the felling of trees to burn the wood for energy affects soils and vegetation communities stability; this loss of ecological stability intensifies at the same time the natural processes of soil and water erosion as well as of sedimentation.

Due to the fact that regional ecosystems are globally overused by poor farmers and even the use of agrochemical products is limited by cultural and economical factors, it can be considered that soil erosion and sedimentation constitute the pollution source originated by this sector.

3) Industries

The prefecture of Potosi is characterized by very limited industrialization and the most important industry is mining. Mining activities have caused chronic and sometime acute pollution within several sub-basins of the Pilcomayo River Basin.

The dumping of residual water that comes from the ingenios, the accumulation of mineral tailings in precarious conditions and the loss of water from active and abandoned mines constitute the bulk of the pollution sources generated by this sector.

And the increasing small size of suspended solids, it should be emphasized that the dramatic substitution of gravity method beneficiation plant 'Ingenio' by the floating method ingenios, after the 1985, started to increase the fine suspended solid in the discharge of the each ingenio.

Such technical alteration was caused to meet the market demand of zinc, lead and silver than tin at the same period.

4) Environment Damage Matrix

Summarized in Table 4-3-4 is the relation between the causes of pollution and the victims of the pollution. Even from this environment damage matrix, we can see the fact that the study area bears a heavy environmental burden.

(2) The estimated magnitude of damages

Since we do not have enough reliable data and information, it is not justified to make any estimation of damages caused by the water contaminated by mining activities, but to have a rough perception of the magnitude of the impact, it might be able to use the following data.

Hereunder the table shows the estimated opportunity loss in human force, agriculture, livestock and fisheries became of the water pollution, to be caused by the mining activities;

| Section | | Estimated Impact in million US$ | Observation |
|---|---|---|---|
| Human Force (1994) | | 22.7 | The possible increase of GDP with the national level life period US$400×(59.3-53)×1/53×478,000 |
| Agriculture (1993) | Case 1 | 3.7 | The possible increase of agricultural production with the national level productivity for the Pilcomayo basin area (1,723Bs/ha-1,353Bs/ha) × 116,000ha × 0.364 ÷ 4.27Bs/US$ |
| | Case 2 | 0.28 | The possible increase of agricultural production with the national level productivity for the study area {1,537ha × (1,723Bs/ha-1,353Bs/ha)+ 361ha × 1,723Bs/ha} ÷ 4.27Bs/US$ |
| Livestock Breeding (1993) | | 1.8 | The recoverable value with assumption that the actual productivity is limited at the half level of normal condition. |
| Fisheries (1993) | | 0.2 | With the assumption that the same size of production with the actual production can be recoverable without contamination. |
| Total | Case 1 | 28.6 | |

1) Number of peoples to be affected by the contamination in Potosi and other prefectures in Bolivia, the health of these peoples can be affected in some mode:

Number of rural area habitants for the, Potosi, Chuquisaca and Tarija prefectures are 478, 336 and 146 thousand, respectively (in 1993).

The areas of each prefecture, Potosi, Chuquisaca and Tarija as indicated at the paragraph 4-3-1 are 118, 51 and 37 thousands $Km^2$, respectively. The area of the Pilcomayo River Basin in each of the three prefectures are 43, 30 and 24 thousands $km^2$ respectively, and which corresponds with 36.4, 59.8 and 65.4% of each prefecture area, respectively.

Then we can estimate the gross number of peoples likely to be affected by the mining-origin water contamination as, 234, 201 and 96 thousand respectively, for Potosi, Chuquisaca and Tarija, taken not only rural data into consideration but also including half of the citizens of Potosi City.

The total number of population and family living alongside of the Pilcomayo River, who can be considered as being affected by the polluted river water from the Potosi City to the point of 180 km down stream at the Mendez Bridge vicinity are, as mentioned in the paragraph 4-3-2 5), 42,097 habitants and 9,790 families.

The average expecting lives in birth during the years of 1990 and 1995, in Potosi and Chuquisaca, are 53 years old and 57.8 years old, which are less than national average 59.3 years old.

The reasons of the shorter lives in these two prefectures are not investigated will, meantime, if the water contamination caused by mining activities is one of the main factors, we have to pay attention to the economic loss of work force in the area.

Now we can compute the domestic production loss of each prefecture because of the earlier missing of work force with US$22.7 million and US$5.1 million, considering the each per capita gross domestic product as US$400 and US$581, respectively.

2) Possible opportunity loss of agricultural production in Potosi and other prefectures as follows:

The value of agricultural production per year for the three prefectures and the total production in Bolivia are 157, 192, 138 and 2,347 million bolivians, respectively (in 1993).

The area of agricultural land for each prefecture are 116, 149, 69 and 1,362 thousands hectares.

The value average output per unit agricultural area (ha) are Bs1,353, Bs1,289, Bs2,000 and Bs1,723, respectively.

Then if the average production rate in Bolivia can be realized in these prefectures, the estimated maximum recuperative production shall be Bs43.8 and Bs64.5 million for Potosi and Chuquisaca, in US$ 10.0 million and 15.2 million respectively.

Based on certain assumptions of the paragraph 4-3-2 (5), within the study area, from Potosi City to the point of 180 km downstream on the Pilcomayo River, Mendez bridge, the possible increase of value of agricultural production would be Bs1,191 thousand, in US$ 280 thousand, in case the nonpolluted water irrigation becomes available. This calculation was made based on the assumption of possible increase of productivity with Bs375 per ha, which is the balance of national average productivity for the current farming land, 1,537 ha and additionally the possible production with national average productivity, 1,723 Bs per ha, to the newly prepared farming land by introducing the irrigation system with non-polluted water, 361 ha.

The ANNX(9) shows the location of farming field in the study area pparately the areas irrigated by non polluted water and polluted area, in addition to the possible recoverable area.

3) Possible opportunity loss of stockbreeding in Potosi and other prefectures:

Referring to the case of La Palca, as one of the example of stockbreeding damages caused by the Pilicomayo River contamination, the number of animals which each stockbreeder could keep, would be able to expect the double of the present one due to the contaminated water.

And estimating from the present stockbreeding production in each of three prefectures we can obtain the magnitude of the damages in the stockbreeding area, as follows.

The current stockbreeding production volumes in Potosi, Chuquisaca and Tarija are, Bs33,807, Bs95,904 and Bs59,526 thousands (in 1993).

The shares of the Pilicomayo River Basin in each prefecture area are, 36.4%, 59.8% and 65.4%, respectively, as indicated in the paragraph 4-3-1.

Then, considering the rate of the productivity the area of the Pilicomayo River Basin as 50% on average, the estimated recuperative production value for each prefecture would be Bs7,521, Bs40,906 and Bs28,921 thousands for Potosi, Chuquisaca and Tarija, and which correspond with US$1.8, US$9.6 and US$6.8 million, respectively in the value of 1993.

4) Possible opportunity loss of fishing in Potosi and other prefectures:

Even we do not have enough data for fishery damages of the Pilcomayo River using the data of the Case of Villamontes in Tarija area, we might be able to estimate the magnitude of damages as follows. Since the data of Case of Villamontes indicates the fish of the area are contaminated by lead, even though the rate of contamination is not so significant, we can consider that these fishes have no value commercially, in a severe judgement.

Then the total production value of fisheries in these areas Potosi, Chuquisaca and Tarija can be considered the maximum damaged value due to the impact of mining activities of the areas, which would be Bs1,036, Bs1,191 and Bs9,784 thousand for the three, and which correspond with US$ 0.2, US$ 0.3 and US$ 2.3 million, respectively in 1993.

In the study area, from Potosi City to the point of 180 km down stream of the Pilcomayo River, Mendez Bridge, especially the farmers living near from the Mendez Bridge, traditionnaly used to get their principal nutrition from the fish of the river, but today there are no fish there.

## Table 4-3-1 Population of Study Area

**Prefecture of Potosí, Province of Tomás Frías**

| No | City | Village | Community | No of Family | Population |
|---|---|---|---|---|---|
| 1 | Potosí | Potosí | San Juán * | 1 330 | 5 719 |
| 2 | | | San Cristóbal * | 1 227 | 5 276 |
| 3 | | | San Pedro * | 1 739 | 7 478 |
| 4 | | | San Benito * | 2 184 | 9 391 |
| 5 | | | Cantumarca * | 1 590 | 6 837 |
| 6 | | | Jesus Valle | 15 | 65 |
| 7 | Yocalla | Santa Lucía | Cebadillas | 16 | 69 |
| 8 | | | Agua Dulce | 40 | 172 |
| 9 | | | Secc. Jaya Mayu | 4 | 17 |
| 10 | | | San Antonio | 108 | 464 |
| 11 | | | La Puerta | 24 | 103 |
| 12 | | | La Palca | 78 | 335 |
| 13 | | | Santa Lucía | 89 | 383 |
| 14 | | | Cayara | 120 | 516 |
| 15 | | Totora "D" | Totora D | 130 | 559 |
| 16 | | | Totora Pampa | 175 | 753 |
| 17 | | Yocalla | Yocalla | 80 | 344 |
| 18 | Potosí | Tarapaya | El Molino | 120 | 516 |
| 19 | | | Aroifilla | 39 | 168 |
| 20 | | | Tambo Pampa | 50 | 215 |
| 21 | | | Miraflores | 20 | 86 |
| 22 | | | Mondragón | 14 | 60 |
| 23 | Tinguipaya | Tinguipaya | Sullcari | 20 | 86 |
| 24 | | | Palika | 5 | 22 |
| 25 | | | Juicuni | 25 | 108 |
| 26 | | | Capilla Rosario | 6 | 26 |
| 27 | | | Tacuara | 16 | 69 |
| 28 | | | Talula | 160 | 688 |
| | | | **Sub total riverside** | **8 595** | **36 959** |
| | | | **Sub total listed** | **9 424** | **40 523** |

[ ] Community of riverside

[ ] Community more than 1km far from river

* Urban area of POTOSI city

Prefecture of Potosí, Province of Cornelio Saavedra

| N° | City | Village | Community | N° of family | Population |
|---|---|---|---|---|---|
| 29 | Tacobamba | Ancoma | Ancoma | 7 | 30 |
| 30 | | | Huerta Khasa | 2 | 9 |
| 31 | | Tacobamba | Kholu | 1 | 4 |
| 32 | | | Oyora | 2 | 9 |
| 33 | | | Chalama | 20 | 86 |
| 34 | | | Aczulipampa | 34 | 146 |
| 35 | | Rodeo | Quebrada | 4 | 17 |
| 36 | Betanzos | Potobamba | Km. 127 | 30 | 129 |
| 37 | | Tuero | San Antonio | 48 | 206 |
| 38 | | Millares | Viña Pampa | 50 | 215 |
| | | | **Sub total riversidel** | **198** | **851** |

Prefecture of Chuquisaca, Province of Oropeza

| N° | City | Village | Community | N° of family | Population |
|---|---|---|---|---|---|
| 39 | Sucre | Quila Quila | Talula | 38 | 163 |
| 40 | Yotala | Yotala | Tasa Pampa | 73 | 314 |
| 41 | | Tuero | Tuero | 35 | 151 |
| 42 | | | Puente Mendez | 22 | 95 |
| | | | **Sub total riverside** | **168** | **722** |

| | | | | | |
|---|---|---|---|---|---|
| | | | **TOTAL Riverside** | **8 961** | **38 532** |
| | | | **TOTAL Listed** | **9 790** | **42 097** |

| Legend | |
|---|---|
| ☐ | Community of riverside |
| ☐ | Community more than 1km far from river |

* Urban area of POTOSI city

Tablo 4-3-2

## Emigration

## (Expressed in %)

Prefecture of POTOSI, Pvovince of Tomás Frías

| Nº | Community | Population (hab) | | Emigration (%) | |
|---|---|---|---|---|---|
| | | 1970 | Actual | Temporally | Definitive |
| 6 | Jesus Valle | no data | 65 | no data | no data |
| 7 | Cebadillas | 90 | 69 | 56.52 | 23.33 |
| 8 | Agua Dulce | 419 | 172 | 65.36 | 58.95 |
| 9 | Secc. Jaya Mayu | no data | 17 | no data | no data |
| 10 | San Antonio | 834 | 464 | 35.12 | 41.96 |
| 11 | La Puerta | 258 | 103 | 34.95 | 50.00 |
| 12 | La Palca | 479 | 335 | 60.00 | 30.00 |
| 13 | Santa Lucía | 510 | 383 | 69.40 | 24.90 |
| 14 | Cayara | 645 | 516 | 50.00 | 20.00 |
| 15 | Totora D | 745 | 559 | 50.10 | 24.96 |
| 16 | Totora Pampa | 941 | 753 | 23.90 | 19.97 |
| 17 | Yocalla | 491 | 344 | 34.89 | 29.93 |
| 18 | El Molino | 1290 | 516 | 39.92 | 60.00 |
| 19 | Aroifilla | 311 | 168 | 39.88 | 45.98 |
| 20 | Tambo Pampa | 413 | 215 | 52.11 | 47.46 |
| 21 | Miraflores | 242 | 86 | 69.77 | 64.46 |
| 22 | Mondragón | 200 | 60 | 78.33 | 70.00 |
| 23 | Sulcari | 215 | 86 | 38.37 | 60.00 |
| 24 | Palika | no data | 22 | no data | no data |
| 25 | Juicuni | 154 | 108 | 39.80 | 29.87 |
| 26 | Capilla Rosario | no data | 26 | no data | no data |
| 27 | Tacuara | 99 | 69 | 33.33 | 43.43 |
| 28 | Talula | 955 | 688 | 39.97 | 27.96 |
| | **Sub total riverside** | **4495** | **2322** | **47.42** | **50.29** |
| | **Sub total listado** | **9291** | **5822** | **47.99** | **41.22** |

| | |
|---|---|
| ☐ | Community of riverside |
| ☐ | Community more than 1km far from river |

Prefecture of POTOSI, Pvovince of Cornelio Saavedra

| N° | Community | Population | | Migration | |
|---|---|---|---|---|---|
| | | 1970 | Actual | Temporally | Definitive |
| 29 | Ancoma | 200 | 30 | sin esp. | 85.00 |
| 30 | Huerta Khasa | no data | 9 | no data | no data |
| 31 | Kholu | 200 | 4 | 0.00 | 98.00 |
| 32 | Oyora | 180 | 9 | 0.00 | 95.00 |
| 33 | Chalama | 123 | 86 | no data | 30.11 |
| 34 | Aczufipampa | 228 | 146 | 39.73 | 35.96 |
| 35 | Quebrada | no data | 17 | no data | sin esp. |
| 36 | Km. 127 | 179 | 129 | 65.00 | 27.93 |
| 37 | San Antonio | 294 | 206 | 80.00 | 29.93 |
| 38 | Viña Pampa | 537 | 215 | 40.00 | 59.96 |
| | **Sub total riverside** | **1941** | **851** | **37.46** | **57.74** |

Prefecture of Chuquisaca, Pvovince of Oropeza

| N° | Community | Population | | Migration | |
|---|---|---|---|---|---|
| | | Before | Actual | Temporally | Definitive |
| 39 | Talula | no data | 163 | no data | no data |
| 40 | Tasa Pampa | 418 | 314 | 32.48 | 24.88 |
| 41 | Tuero | 201 | 151 | 25.16 | 24.87 |
| 42 | Puente Mendez | 173 | 95 | no data | 45.10 |
| | **Sub total riverside** | **792** | **722** | **28.82** | **31.62** |

| | | | | | |
|---|---|---|---|---|---|
| | **TOTAL Riverside** | **7228** | **3896** | **37.90** | **46.55** |
| | **TOTAL Listed** | **12024** | **7396** | **38.09** | **43.52** |

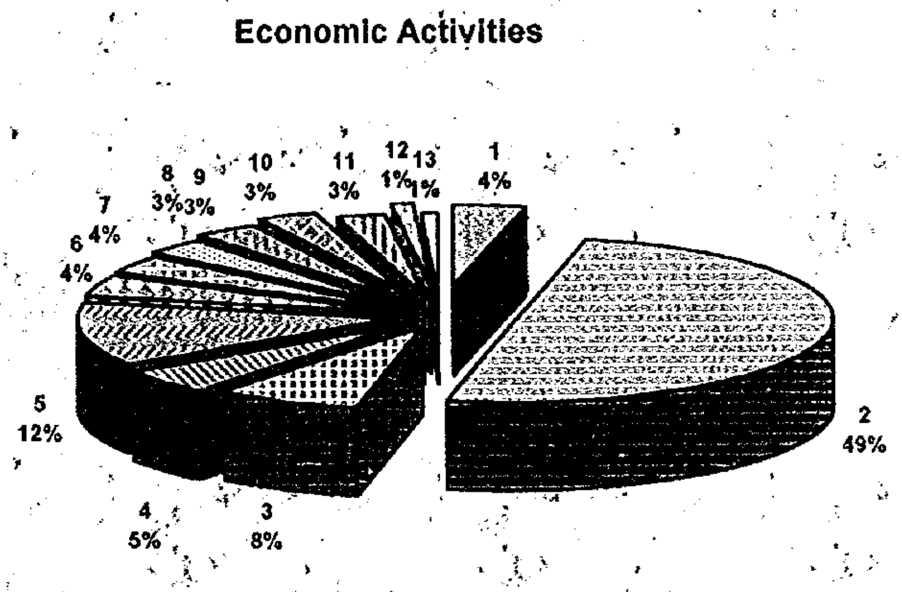
Community of riverside

Community more than 1km far from river

## Table 4-3-3 Occupation Classification in City Area

(Expressed in % of Population)

| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
|---|---|---|---|---|---|---|---|
| 1 | Livestock Farming | 0.00 | 0.00 | 0.00 | 0.00 | 18.00 | 3.60 |
| 2 | Commercial | 59.00 | 60.00 | 61.00 | 59.00 | 9.00 | 49.60 |
| 3 | Mining | 8.20 | 8.40 | 8.50 | 9.00 | 4.00 | 7.62 |
| 4 | Teachers | 4.20 | 5.00 | 6.30 | 5.50 | 3.50 | 4.90 |
| 5 | Medical Services | 5.40 | 4.20 | 4.00 | 5.70 | 44.00 | 12.66 |
| 6 | Others | 4.80 | 4.00 | 4.50 | 4.00 | 3.00 | 4.06 |
| 7 | Without specification | 4.00 | 5.00 | 3.00 | 3.50 | 3.00 | 3.70 |
| 8 | Industries | 3.50 | 3.00 | 4.00 | 3.10 | 1.00 | 2.92 |
| 9 | Construction | 3.50 | 3.00 | 1.70 | 4.00 | 5.00 | 3.44 |
| 10 | Transportation and Com. | 3.00 | 4.00 | 2.00 | 2.50 | 3.50 | 3.00 |
| 11 | Hotel & Restaurant | 2.00 | 1.90 | 3.50 | 1.50 | 3.80 | 2.54 |
| 12 | Public Administration | 1.50 | 1.00 | 1.00 | 1.80 | 0.00 | 1.06 |
| 13 | Third Countries Org. | 0.90 | 0.50 | 0.50 | 0.40 | 2.20 | 0.90 |




Source: INE Census 1992, II Census Economic Establishment

Note: In graph the average numbers are used.

Table 4-3-4

## Environment Damages Matrix

| Type | Causes of Pollution | Pollutants | Victims: Humankind | Agriculture | Stock Farming | Fishery | Forestry | Social Life |
|---|---|---|---|---|---|---|---|---|
| **Mining Industry Sector Related Issues** | | | | | | | | |
| **Water** | | | | | | | | |
| | Mining Activities Drainage | Heavy Metal, Arsenic, etc | Diarrhea, Stomach Ache, Increment of Heavy Metal in Blood | Less Productivity | Less Productivity | Less Productivity | Less Productivity | No Recreation at River Side |
| | Waste Rock Drainage | Heavy Metal, Arsenic, etc | Diarrhea, Stomach Ache, Increment of Heavy Metal in Blood | Less Productivity | Less Productivity | Less Productivity | Less Productivity | No Recreation at River Side |
| | Beneficiation Plant Drainage | Heavy Metal, Arsenic, Chemical, etc | | Less Productivity | Less Productivity | Less Productivity | Less Productivity | No Recreation at River Side |
| **Air** | | | | | | | | |
| | Mining Site Activities, Drilling etc | Dust | Asthma | | | | Less Productivity | |
| | Beneficiation Plant Activities, Grinding etc | Dust | Asthma, Nose and Throat Pain | | | | Less Productivity | No Adequacy for Housing |
| **Soil** | | | | | | | | |
| | Mining Activities, Drainage, Solid Waste | Heavy Metal, Arsenic, etc | | Less Productivity | | | | |
| | Beneficiation Plant Activities, Drainage, Solid Waste | Heavy Metal, Arsenic, Chemical, etc | | Less Productivity | | | | No Adequacy for Housing |
| **Noise & Vibration** | | | | | | | | |
| | Mining Site Facilities | Noise & Vibration by Rotating Machine | Deaf, Numbness | | | | | No Adequacy for Housing |
| | Beneficiation Plant Facilities | Noise & Vibration by Rotating Machine | Deaf, Numbness | | | | | |
| **Solid Waste** | | | | | | | | |
| | Selection of Rock and Beneficiation Process | Waste Rock and Drained Waste Solid | Asthma, Nose and Throat Pain | | Land Occupation | | | |
| | | Waste Rock: 1,450t/day | | | | | | |
| | | Drained Waste Solid: 1,300t/day | | | | | | |
| **Stink** | | | | | | | | No Adequacy for Housing |
| | Beneficiation Plant Activities | Chemical Materials | Nose and Throat Pain | | | | | |
| **Other Environment Related Sectors Issues** | | | | | | | | |
| **Water** | | | | | | | | |
| | Humankind Used Water | No Treatment Facilities for 100liters/sec (8,640t/day) for City | Diarrhea, Stomach Ache, Increment of Heavy Metal in Blood | | | | | |
| | Industries Used Water (Including Beneficiation Plant) | No Treatment Facilities for 50liters/sec(4,320t/day) for City | Diarrhea, Stomach Ache, Increment of Heavy Metal in Blood | Less Productivity | Less Productivity | Less Productivity | Less Productivity | No Recreation at River Side |
| | Hospital Used Water | No Treatment Facilities for Possible Contamination | Diarrhea, Other Possible Contamination | Less Productivity | Less Productivity | Less Productivity | Less Productivity | No Recreation at River Side |
| **Air** | | | | | | | | |
| | Automobile | No lead gasoline but dust and diesel oil gas | Asthma, Nose and Throat Pain | | | | Less Productivity | |
| | Exhaust from Industries and Home Fume | Diesel oil gas exhaust but no coal fume | Asthma, Nose and Throat Pain | | | | Less Productivity | |
| **Soil** | | | | | | | | |
| | Agricultural Chemicals for Insect Prevention | Chemical Materials | Diarrhea, Stomach Ache, Increment of Heavy Metal in Blood | Less Productivity | Less Productivity | | | |
| **Noise** | | | | | | | | |
| | Automobile | Crowded Transport | Deaf, Numbness | | | | | |
| **Land Subside** | | | Asthma, Nose and Throat Pain | | | | | |
| | Underground Water Usage | | | | | | | |
| **Solid Waste** | | | | | | | | |
| | Family Origin Solid Waste | 18,000t/year for all Potosi with 120,000 population ( about 0.5kg/day Person) | Asthma, Nose and Throat Pain | | Land Occupation | | | |

**Table 4-3-5**

## System of Portable Water for Each Community

**(% is measured by number of families)**

Prefecture of Potosí, Province Tomás Frías

| N° | Community | System of Portable Water | | Without Potable Water System | | | |
|---|---|---|---|---|---|---|---|
| | | Domestic | Public | River | Spring | Well | Other |
| 1 | San Juán | 75.0 | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2 | San Cristóbal | 55.0 | 45.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3 | San Pedro | 85.0 | 15.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4 | San Benito | 60.0 | 40.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5 | Cantumarca | 80.0 | 20.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 6 | Jesus Valle | 0.0 | 0.0 | 0.0 | 20.0 | 80.0 | 0.0 |
| 7 | Cebadillas | 0.0 | 0.0 | 62.5 | 0.0 | 37.5 | 0.0 |
| 8 | Agua Dulce | 0.0 | 0.0 | 60.0 | 0.0 | 40.0 | 0.0 |
| 9 | Secc. Jaya Mayu | 0.0 | 0.0 | 0.0 | 75.0 | 25.0 | 0.0 |
| 10 | San Antonio | 0.0 | 0.0 | 0.0 | 0.0 | 5.5 | 94.5 |
| 11 | La Puerta | 12.5 | 79.0 | 8.5 | 0.0 | 0.0 | 0.0 |
| 12 | La Palca | 79.5 | 20.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| 13 | Santa Lucia | 40.5 | 55.0 | 4.5 | 0.0 | 0.0 | 0.0 |
| 14 | Cayara | 75.0 | 20.0 | 5.0 | 0.0 | 0.0 | 0.0 |
| 15 | Totora D | 70.0 | 20.0 | 10.0 | 0.0 | 0.0 | 0.0 |
| 16 | Totora Pampa | 80.0 | 14.9 | 5.1 | 0.0 | 0.0 | 0.0 |
| 17 | Yocalla | 75.0 | 20.0 | 2.5 | 1.3 | 0.0 | 1.3 |
| 18 | El Molino | 45.0 | 50.0 | 5.0 | 0.0 | 0.0 | 0.0 |
| 19 | Aroifilla | 79.5 | 20.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| 20 | Tambo Pampa | 74.0 | 20.0 | 0.0 | 6.0 | 0.0 | 0.0 |
| 21 | Miraflores | 70.0 | 30.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 22 | Mondragón | 7.2 | 71.4 | 0.0 | 21.4 | 0.0 | 0.0 |
| 23 | Sullcari | 0.0 | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 |
| 24 | Palika | 0.0 | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 |
| 25 | Juicuni | 0.0 | 0.0 | 24.0 | 76.0 | 0.0 | 0.0 |
| 26 | Capilla Rosario | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 |
| 27 | Tacuara | 0.0 | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 |
| 28 | Talula | 0.0 | 0.0 | 20.0 | 80.0 | 0.0 | 0.0 |
| | **Riverside Average** | **40.2** | **24.2** | **7.6** | **22.4** | **0.3** | **5.3** |
| | **Listed Average** | **38.0** | **20.2** | **11.0** | **20.7** | **6.7** | **3.4** |

| Legend | |
|---|---|
| ☐ | Community of Riverside |
| ☐ | Community more than 1 km far from riverside |

Continue

Prefecture of Potosí, Province Cornelio Saavedra

| No. | Community | System of Potable Water | | Without Potable Water System | | | |
|---|---|---|---|---|---|---|---|
| | | Domestic | Public | River | Springs | Well | Other |
| 29 | Ancoma | 0.0 | 0.0 | 0.0 | 57.0 | 43.0 | 0.0 |
| 30 | Huerta Khasa | 0.0 | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 |
| 31 | Kholu | 0.0 | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 |
| 32 | Oyora | 0.0 | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 |
| 33 | Chalama | 0.0 | 0.0 | 5.0 | 95.0 | 0.0 | 0.0 |
| 34 | Aczulipampa | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 |
| 35 | Quebrada | 0.0 | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 |
| 36 | Km. 127 | 33.0 | 40.0 | 0.0 | 27.0 | 0.0 | 0.0 |
| 37 | San Antonio | 0.0 | 22.9 | 0.0 | 77.1 | 0.0 | 0.0 |
| 38 | Viña Pampa | 60.0 | 40.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Riverside Average** | **9.3** | **10.3** | **10.5** | **65.6** | **4.3** | **0.0** |

Prefecture of Chuquisaca, Province Oropeza

| No. | Community | System of Potable Water | | Without Potable Water System | | | |
|---|---|---|---|---|---|---|---|
| | | Domestic | Public | River | Springs | Well | Other |
| 39 | Talula | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 40 | Tasa Pampa | 0.0 | 90.4 | 0.0 | 9.6 | 0.0 | 0.0 |
| 41 | Tuero | 11.0 | 86.0 | 0.0 | 3.0 | 0.0 | 0.0 |
| 42 | Puente Mendez | 18.0 | 68.0 | 0.0 | 14.0 | 0.0 | 0.0 |
| | **Riverside Average** | **7.3** | **86.1** | **0.0** | **6.7** | **0.0** | **0.0** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Riverside Average** | **18.9** | **40.2** | **6.0** | **31.6** | **1.5** | **1.8** |
| | **Listed Average** | **18.2** | **38.9** | **7.2** | **31.0** | **3.7** | **1.1** |

Community of Riverside

Community more than 1 km far from riverside

Table 4-3-6

## Record of Human Sickness

**Prefecture Potosí, Province Tomás Frías**

(% is indicated with number of patient at survey time)

| No. | Community | Dermatitis | | Gastroenteritis | | Observation |
|---|---|---|---|---|---|---|
| | | Number | % | Number | % | |
| 1 | San Juán | 1773 | 31% | 2345 | 41% | |
| 2 | San Cristóbal | 580 | 11% | 1741 | 33% | |
| 3 | San Pedro | 2019 | 27% | 3066 | 41% | |
| 4 | San Benito | 2817 | 30% | 2911 | 31% | |
| 5 | Cantumarca | 1026 | 15% | 2188 | 32% | |
| 6 | Jesus Valle | 0 | 0.0% | 0 | 0.0% | |
| 7 | Cebadillas | 0 | 0.0% | 0 | 0.0% | |
| 8 | Agua Dulce | 0 | 0.0% | 0 | 0.0% | |
| 9 | Secc. Jaya Mayu | 0 | 0.0% | 0 | 0.0% | Recently river is contaminated |
| 10 | San Antonio | 0 | 0.0% | 0 | 0.0% | |
| 11 | La Puerta | 8 | 7.8% | 0 | 0.0% | |
| 12 | La Palca | 0 | 0.0% | 0 | 0.0% | |
| 13 | Santa Lucía | 0 | 0.0% | 0 | 0.0% | |
| 14 | Cayara | 0 | 0.0% | 0 | 0.0% | |
| 15 | Totora D | 0 | 0.0% | 0 | 0.0% | |
| 16 | Totora Pampa | 0 | 0.0% | 0 | 0.0% | |
| 17 | Yocalla | 0 | 0.0% | 0 | 0.0% | |
| 18 | El Molino | 0 | 0.0% | 0 | 0.0% | |
| 19 | Aroifilla | 5 | 3.0% | 0 | 0.0% | |
| 20 | Tambo Pampa | 5 | 2.3% | 0 | 0.0% | |
| 21 | Miraflores | 0 | 0.0% | 0 | 0.0% | |
| 22 | Mondragón | 12 | 20.0% | 10 | 16.7% | Diarrhoea by ocasional consumption |
| 23 | Sulicari | 15 | 17.4% | 10 | 11.6% | |
| 24 | Palika | 0 | 0.0% | no data | | Diarrhoea by ocasional consumption |
| 25 | Juicuni | 16 | 14.8% | 0 | 0.0% | |
| 26 | Capilla Rosario | 0 | 0.0% | 0 | 0.0% | |
| 27 | Tacuara | 2 | 2.9% | 0 | 0.0% | |
| 28 | Talula | 5 | 0.7% | no data | | |
| | **Avaerage riverside** | **8278** | **10.1%** | **12271** | **11.5%** | |
| | **Average listed** | **8283** | **6.5%** | **12271** | **7.4%** | |

| | |
|---|---|
| ☐ | Community of riverside |
| ☐ | Community more than 1 km far from river |

Continue

**Prefecture of Potosí, Province Cornelio Saavedra**

| No | Community | Dermatitis [illegible] | | Gastroenteritis [illegible] | | Observation |
|---|---|---|---|---|---|---|
| | | Number | % | Number | % | |
| 29 | Ancoma | 0 | 0.0% | 0 | 0.0% | |
| 30 | Huerta Khasa | no data | | no data | | |
| 31 | Kholu | 0 | 0.0% | 0 | 0.0% | |
| 32 | Oyora | 0 | 0.0% | 0 | 0.0% | |
| 33 | Chalama | 0 | 0.0% | 0 | 0.0% | |
| 34 | Aczulipampa | 20 | 13.7% | 0 | 0.0% | |
| 35 | Quebrada | 4 | 23.5% | no data | | |
| 36 | Km. 127 | 35 | 27.1% | 15 | 11.6% | Diarrhoea by river water drink |
| 37 | San Antonio | 48 | 23.3% | 20 | 9.7% | Diarrhoea by river water drink |
| 38 | Viña Pampa | 20 | 9.3% | no data | | Diarrhoea by river water drink |
| | **Avaerage riverside** | **127** | **9.7%** | **35** | **2.1%** | |

**Prefecture of Chuquisaca, Province Oropeza**

| No | Community | Dermatitis [illegible] | | Gastroenteritis [illegible] | | Observation |
|---|---|---|---|---|---|---|
| | | Number | % | Number | % | |
| 39 | Talula | 22 | 13.5% | no data | | Diarrhoea by river water drink |
| 40 | Tasa Pampa | 0 | 0.0% | 0 | 0.0% | Diarrhoea by river water drink |
| 41 | Tuero | 25 | 16.6% | 24 | 15.9% | Diarrhoea by river water drink |
| 42 | Puente Mendez | 15 | 15.8% | 8 | 8.4% | Diarrhoea by river water drink |
| | **Avaerage riverside** | **62** | **11.6%** | **0** | **6.1%** | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Avaerage riverside** | **8467** | **10.4%** | **12306** | **6.6%** | |
| | **Average listed** | **8472** | **9.2%** | **12306** | **5.2%** | |

| Legend | |
|---|---|
| (box) | Community of riverside |
| (box) | Community more than 1 km far from river |

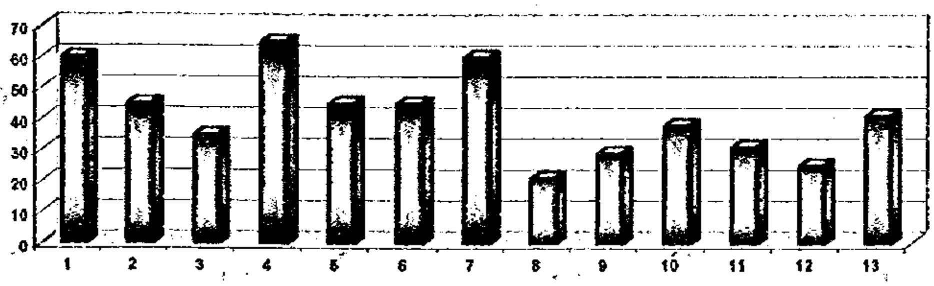
Table 4-3-7

**Type of Sickness at Urban Area (% is indicated with number of patients at survey period.)**

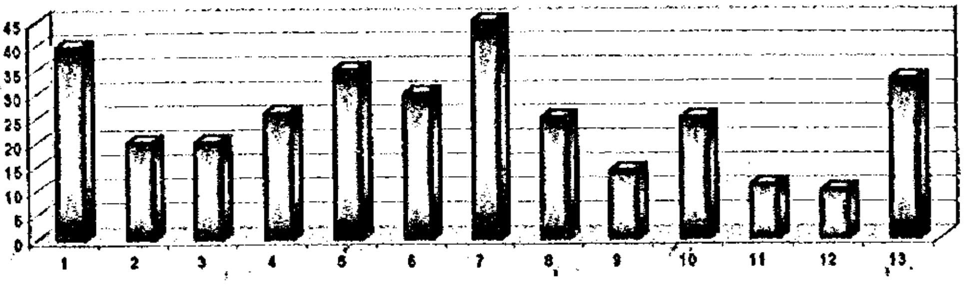
| [illegible] | [illegible] | Description |
|---|---|---|
| 1 | **Tonsilities** | Headache due to absorption of dust and offensive smell during operation of ingenios. |
| 2 | **Gatrities** | Effect to the digestive organ due to absorption of dust originated from the waste of ingenios. |
| 3 | **Lung Problem** | Effect to the digestive organ due to absorption of soil of river which keeps the offensive materials of the contaminated water. |
| 4 | **Pharyngitis** | Effect to the throat due to absorption of dust originated from the waste of ingenios. |
| 5 | **Pharyngitis** | Effect to the throat due to absorption of dust of copper sulfat or salt sulfat of road and houses. |
| 6 | **Conjunctivitis** | Effect to the eyes due to absorption of dust of copper sulfat or salt sulfat. |
| 7 | **Conjunctivitis** | Effect to the eyes due to absorption of dust during operation of ingenios. |
| 8 | **Dermatitis** | Effect to the skin due to the contamination of metal. |
| 9 | **Dermatitis** | Effect to the skin due to the contact with contaminated refuse. |
| 10 | **Dermatitis** | Effect to the skin due to the contact with soil contaminated by copper or salt sulfat. |
| 11 | **Dermatitis** | Effect to the skin due to the contact with contaminated water. |
| 12 | **Dermatitis** | Effect to the skin due to the contact with city water drainage. |
| 13 | **Gastrointestinal** | Diarrhea |

| [illegible] | [illegible] | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **San Juan** | 60 | 45 | 35 | 65 | 45 | 45 | 60 | 21 | 29 | 38 | 31 | 25 | 41 |
| 2 | **San Cristóbal** | 40 | 20 | 20 | 26 | 35 | 30 | 45 | 25 | 14 | 25 | 11 | 10 | 33 |
| 3 | **San Pedro** | 54 | 23 | 35 | 43 | 40 | 47 | 35 | 15 | 25 | 37 | 27 | 22 | 41 |
| 4 | **San Benito** | 43 | 47 | 27 | 57 | 59 | 61 | 53 | 30 | 19 | 33 | 30 | 17 | 31 |
| 5 | **Cantumarca** | 10 | 25 | 20 | 45 | - | - | 55 | - | 20 | - | 10 | - | 35 |

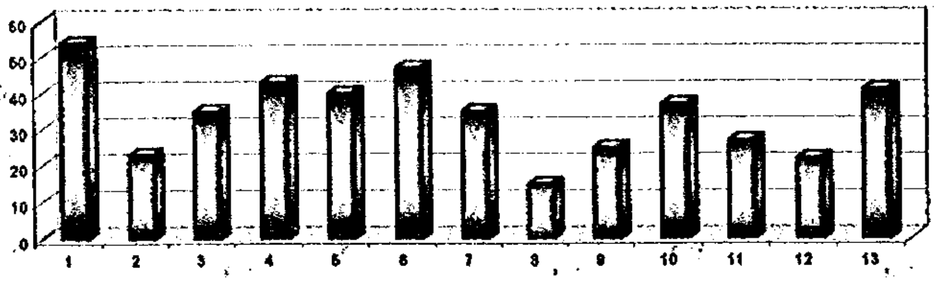
**San Juan**



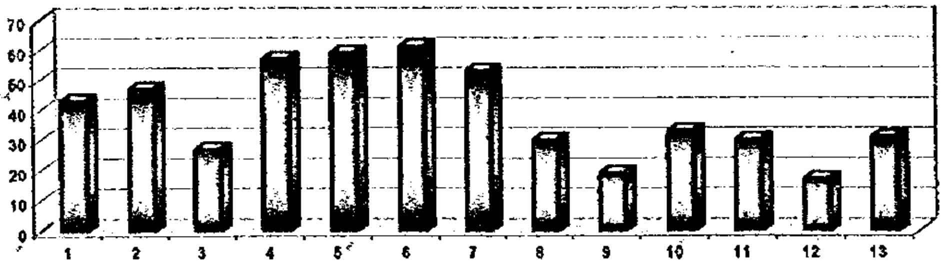
## San Cristóbal



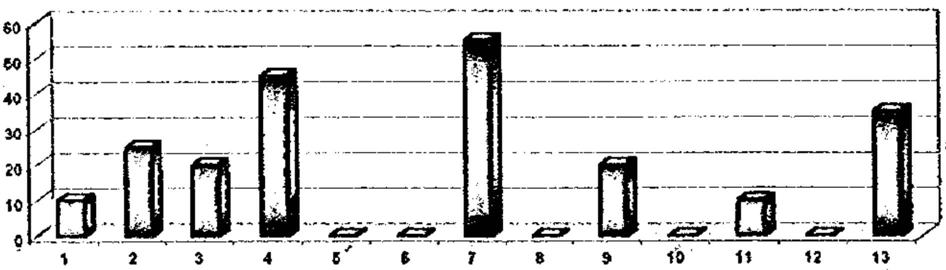

## San Pedro




## San Benito




## Cantumarca



## Table 4-3-8 Estimated Contamination in Agricultural Area

**Prefecture of Potosí, Provice Tomás Frías**

| [illegible] | [illegible] | [illegible] | | | | | |
|---|---|---|---|---|---|---|---|
| | | [illegible] | [illegible] | Barley | Wheat | Corn | [illegible] |
| 1 | San Juán | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | San Cristóbal | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | San Pedro | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | San Benito | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | Cantumarca | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | Jesus Valle | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | Cebadillas | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | Agua Dulce | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | Seco. Jaya Mayu | 2 (c,e) | 0 | 1 (c,e) | 0 | 0 | 0 |
| 10 | San Antonio | 6 (c,e) | 11 (a,b,c) | 6 (c,e) | 5 (c) | 0 | 0 |
| 11 | La Puerta | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | La Palca | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | Santa Lucía | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | Cayara | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | Totora D | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | Totora Pampa | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | Yocalla | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | El Molino | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | Aroifilla | 0 | 5 (a,c) | 0 | 0 | 0 | 0 |
| 20 | Tambo Pampa | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | Miraflores | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | Mondragón | 0 | 3 (a,b,c) | 2 (c,d,e) | 0 | 5 | 0 |
| 23 | Sullcari | 1,5 (e) | 1 (a) | 5 (c,d,e) | 0 | 7 (d) | 0,5 (c) |
| 24 | Palika | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | Julcuni | 0 | 0 | 1 (e) | 0,5 (c) | 0,5 (d) | 0 |
| 26 | Capilla Rosario | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | Tacuara | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | Talula | 0 | 0 | 0 | 0 | 0 | 0 |
| | **Sub total riverside** | **7.5** | **20.0** | **14.0** | **5.5** | **7.5** | **0.5** |
| | **Sub total listed** | **9.5** | **10.0** | **15.0** | **5.5** | **7.5** | **0.5** |

Community of riverside

Community more than 1 km far from riverside

(a) Curl phenomenon of germination

(b) Blight of leaves and stalk

(c) Low productivity

(d) Stunted plants

(e) Effect to roots due to the contamination caused by mining activities and ingenio

(f) Bad germination

Continue

**Prefecture of Potosí, Pvrovince Cornelio Saavedra**

| Nr | Community | Cultivated (Ha) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Potato | [illegible] | Barley | Wheat | Corn | Vegetable |
| 29 | Ancoma | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | Huerta Khasa | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | Kholu | 0 | 0 | 0 | 0 | 0 | 0 |
| 32 | Oyora | 0 | 0 | 0 | 0 | 0 | 0 |
| 33 | Chalama | 0 | 0 | 0 | 0 | 0 | 0 |
| 34 | Aczulipampa | 0 | 0 | 0 | 0 | 0 | 0 |
| 35 | Quebrada | 0 | 0 | 0 | 0 | 0 | 0 |
| 36 | Km. 127 | 0 | 0 | 0 | 0 | 2 (d) | 5 (c,f) |
| 37 | San Antonio | 0 | 0 | 0 | 0 | 2 (d,f) | 6 (a,c,f) |
| 38 | Viña Pampa | 0 | 2 (a) | 0 | 0 | 3 (d,f) | 5 (c,f) |
| | **Sub total rivera** | **0** | **2** | **0** | **0** | **7** | **16** |

**Prefecture of Chuquisaca, Provincia Oropeza**

| Nr | Community | Cultivated (Ha) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Potato | [illegible] | Barley | Wheat | Corn | Vegetable |
| 39 | Talula | 0,5 (e) | 0 | 0 | 0 | 1,5 (d) | 3 (a,c,f) |
| 40 | Tasa Pampa | 0 | 0 | 0 | 0 | 0 | 0 |
| 41 | Tuero | 0 | 0 | 0 | 0 | 2 (d) | 30 (a,c,f) |
| 42 | Puente Mendez | 0 | 0,2 (a,c) | 0,1 (c) | 0 | 0,7 (d) | 4 (a,c,f) |
| | **Sub total rivera** | **0.5** | **0.2** | **0.1** | **0.0** | **4.2** | **37.0** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Sub total riverside** | **8.0** | **22.2** | **14.1** | **5.5** | **18.7** | **53.5** |
| | **Sub total listed** | **10.0** | **12.2** | **15.1** | **5.5** | **18.7** | **53.5** |

Community of riverside

Community more than 1 km far from riverside

(a) Curl phenomenon of germination

(b) Blight of leaves and stalk

(c) Low productivity

(d) Stunted plants

(e) Effect to roots due to the contamination caused by mining activities and ingenio

(f) Bad germination

**Table 4-3-9**

## Pastorel Area

**Prefecture of Potosí, Province Tomás Frías**

| N° | [illegible] | [illegible] |
|---|---|---|
| | | [illegible] |
| 1 | San Juán | 0 |
| 2 | San Cristóbal | 0 |
| 3 | San Pedro | 0 |
| 4 | San Benito | 0 |
| 5 | Cantumarca | 0 |
| 6 | Jesus Valle | 120 |
| 7 | Cebadillas | 115 |
| 8 | Agua Dulce | 67 |
| 9 | Secc. Jaya Mayu | 25 |
| 10 | San Antonio | 224 |
| 11 | La Puerta | 50 |
| 12 | La Palca | 300 |
| 13 | Santa Lucía | 291 |
| 14 | Cayara | 320 |
| 15 | Totora D | 177 |
| 16 | Totora Pampa | 158 |
| 17 | Yocalla | 157 |
| 18 | El Molino | 164 |
| 19 | Aroifilla | 130 |
| 20 | Tambo Pampa | 160 |
| 21 | Miraflores | 15 |
| 22 | Mondragón | 80 |
| 23 | Sullcari | 90 |
| 24 | Palika | 45 |
| 25 | Juicuni | 95 |
| 26 | Capilla Rosario | 125 |
| 27 | Tacuara | 78 |
| 28 | Talula | 200 |
| | **Sub total riverside** | **1 556** |
| | **Sub total listed** | **3 186** |

Community of riverside

Community more than 1km far from riverside

Continue

**Prefecture of Potosí, Province Cornelio Saavedra**

| N° | Community | Potential (Ha) Hectare |
|---|---|---|
| 29 | Ancorna | 80 |
| 30 | Huerta Khasa | 15 |
| 31 | Kholu | 20 |
| 32 | Oyora | 60 |
| 33 | Chalama | 80 |
| 34 | Aczulipampa | 135 |
| 35 | Quebrada | 50 |
| 36 | Km. 127 | 130 |
| 37 | San Antonio | 110 |
| 38 | Viña Pampa | 120 |
| | **Sub total rivera** | **800** |

**Prefecture of Chuquisaca, Province Oropeza**

| N° | Community | Potential (Ha) Hectare |
|---|---|---|
| 39 | Talula | 200 |
| 40 | Tasa Pampa | 60 |
| 41 | Tuero | 110 |
| 42 | Puente Mendez | 23 |
| | **Sub total rivera** | **393** |

| | | |
|---|---|---|
| | **Sub total riverside** | **2 749** |
| | **Sub total listed** | **4 379** |

Community of riverside

Community more than 1km far from riverside

Table 4-3-10

## Sickness and Death Rate of Animal

## (Expressed in % of Livestock)

**Department of Potosí, Provice Tomás Frías**

| No. | Community | Group | [illegible] | Diarrhea | Dermatitis | Death Rate | Observation |
|---|---|---|---|---|---|---|---|
| 1 | San Juán | | 0 | 0 | 0 | 0 | |
| 2 | San Cristóbal | | 0 | 0 | 0 | 0 | |
| 3 | San Pedro | | 0 | 0 | 0 | 0 | |
| 4 | San Benito | | 0 | 0 | 0 | 0 | |
| 5 | Cantumarca | | 0 | 0 | 0 | 0 | |
| 6 | Jesus Valle | | 0 | 0 | 0 | 0 | Clean Water |
| 7 | Cebadillas | | 0 | 0 | 0 | 0 | Clean Water |
| 8 | Agua Dulce | | 0 | 0 | 0 | 0 | Clean Water |
| 9 | Secc. Jaya Mayu | | 0 | 0 | 0 | 0 | |
| 10 | San Antonio | | 0 | 0 | 0 | 0 | |
| 11 | La Puerta | 1 | 0 | 0 | 20 | 0 | Cross river/Drink water |
| 12 | La Palca | 1 | 0 | 0 | 20 | 0 | |
| 13 | Santa Lucía | | 0 | 0 | 0 | 0 | Clean Water |
| 14 | Cayara | | 0 | 0 | 0 | 0 | Clean Water |
| 15 | Totora D | | 0 | 0 | 0 | 0 | Clean Water |
| 16 | Totora Pampa | | 0 | 0 | 0 | 0 | Clean Water |
| 17 | Yocalla | | 0 | 0 | 0 | 0 | |
| 18 | El Molino | | 0 | 10 | 0 | 0 | Drink water |
| 19 | Aroifilla | 1 | 0 | 5 | 0 | 0 | Drink water |
| 20 | Tambo Pampa | 1 | 0 | 15 | 10 | 0 | Drink water |
| 21 | Miraflores | | 0 | 0 | 5 | 0 | Cross river |
| 22 | Mondragón | 2 | 0 | 40 | 0 | 7 | Cross river/Drink water |
| 23 | Sulicari | 2 | 0 | 10 | 0 | 4 | Drink water |
| 24 | Pallka | | 0 | 0 | 0 | 0 | No effect |
| 25 | Julcuni | 2 | 0 | 8 | 0 | 0 | Drink water |
| 26 | Capilla Rosario | 2 | 0 | 20 | 0 | 0 | Drink water |
| 27 | Tacuara | 2 | 0 | 25 | 6 | 0 | Cruzan el río / beben agua |
| 28 | Talula | | 0 | 0 | 0 | 0 | No effect |
| | **Average riverside** | | **0** | **7** | **3** | **1** | |
| | **Arverate listed** | | **0** | **5** | **2** | **0** | |

Community of riverside

Community more than 1 km far from riverside

Continue

Prefecture of Potosí, Province Cornelio Saavedra

| N° | Community | Group | Bad Format | Diarrhoea | Dermatitis | Death Rate | Observation |
|---|---|---|---|---|---|---|---|
| 29 | Ancoma | 2 | 0 | 40 | 0 | 0 | Drink water |
| 30 | Huerta Khasa | 2 | 0 | 50 | 0 | 0 | Drink water |
| 31 | Kholu | 2 | 0 | 50 | 0 | 0 | Drink water |
| 32 | Oyora | | 0 | 0 | 0 | 0 | No effect |
| 33 | Chalama | | 0 | 0 | 0 | 0 | |
| 34 | Aczulipampa | 3 | 0 | 10 | 0 | 20 | Drink water |
| 35 | Quebrada | | 0 | 0 | 0 | 0 | |
| 36 | Km. 127 | 3 | 0 | 35 | 0 | 60 | Drink water |
| 37 | San Antonio | 3 | 0 | 50 | 20 | 30 | Drink water |
| 38 | Viña Pampa | 3 | 0 | 30 | 0 | 30 | Beben agua |
| | **Promedio rivera** | | **0** | **27** | **2** | **14** | |

Prefecture of Chuquisaca, Province Oropeza

| N° | Community | Group | Bad Format | Diarrhoea | Dermatitis | Death Rate | Observation |
|---|---|---|---|---|---|---|---|
| 39 | Talula | 3 | 0 | 30 | 0 | 0 | Drink water |
| 40 | Tasa Pampa | 3 | 0 | 20 | 0 | 0 | Drink water |
| 41 | Tuero | 3 | 1 | 50 | 0 | 50 | Drink water |
| 42 | Puente Mendez | 3 | 0 | 100 | 0 | 40 | Drink water |
| | **Average riverside** | | **0** | **50** | **0** | **23** | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Average riverside** | | **0** | **28** | **2** | **12** | |
| | **Average riverside** | | **0** | **27** | **1** | **12** | |

| | |
|---|---|
| ☐ | Community of riverside |
| ☐ | Community more than 1 km far from riverside |

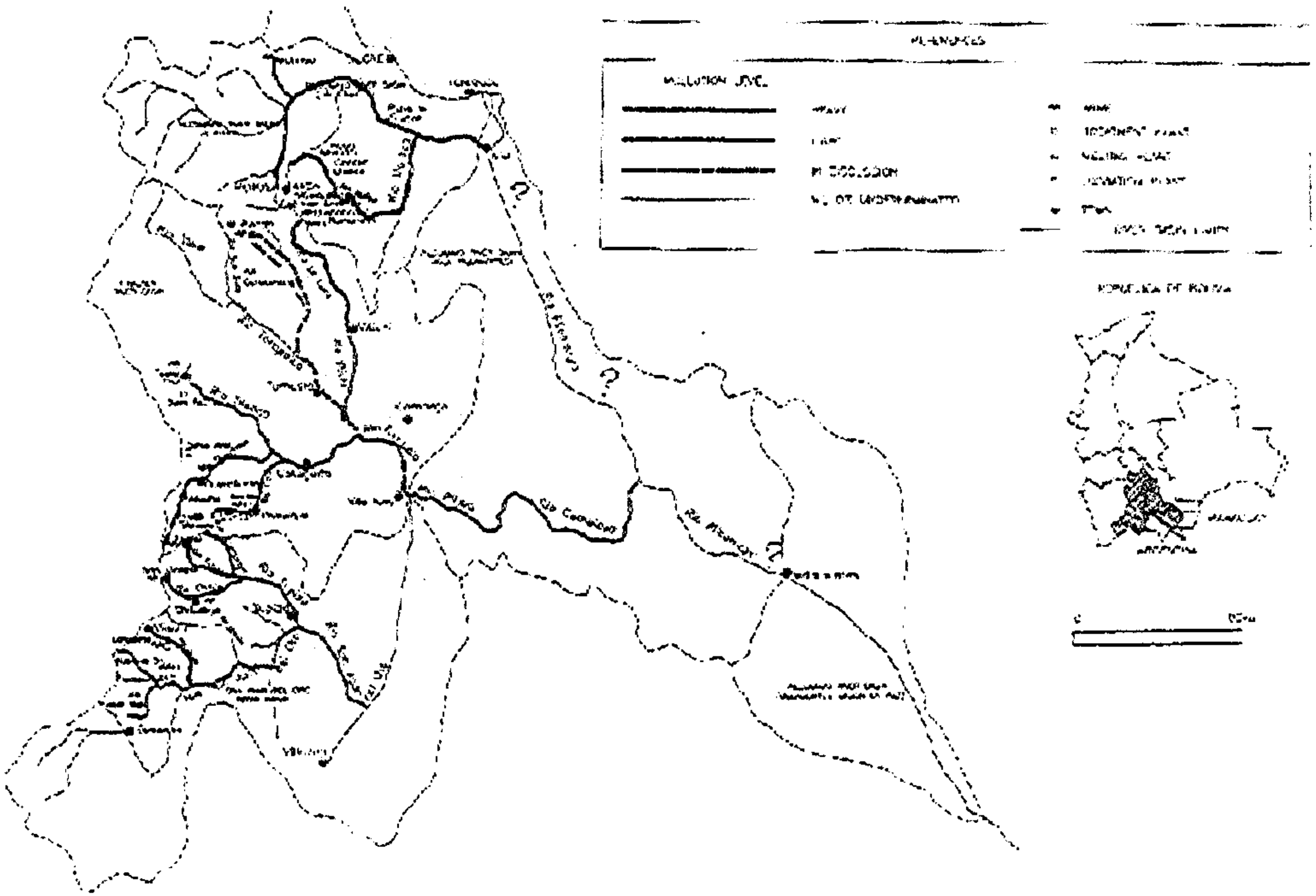
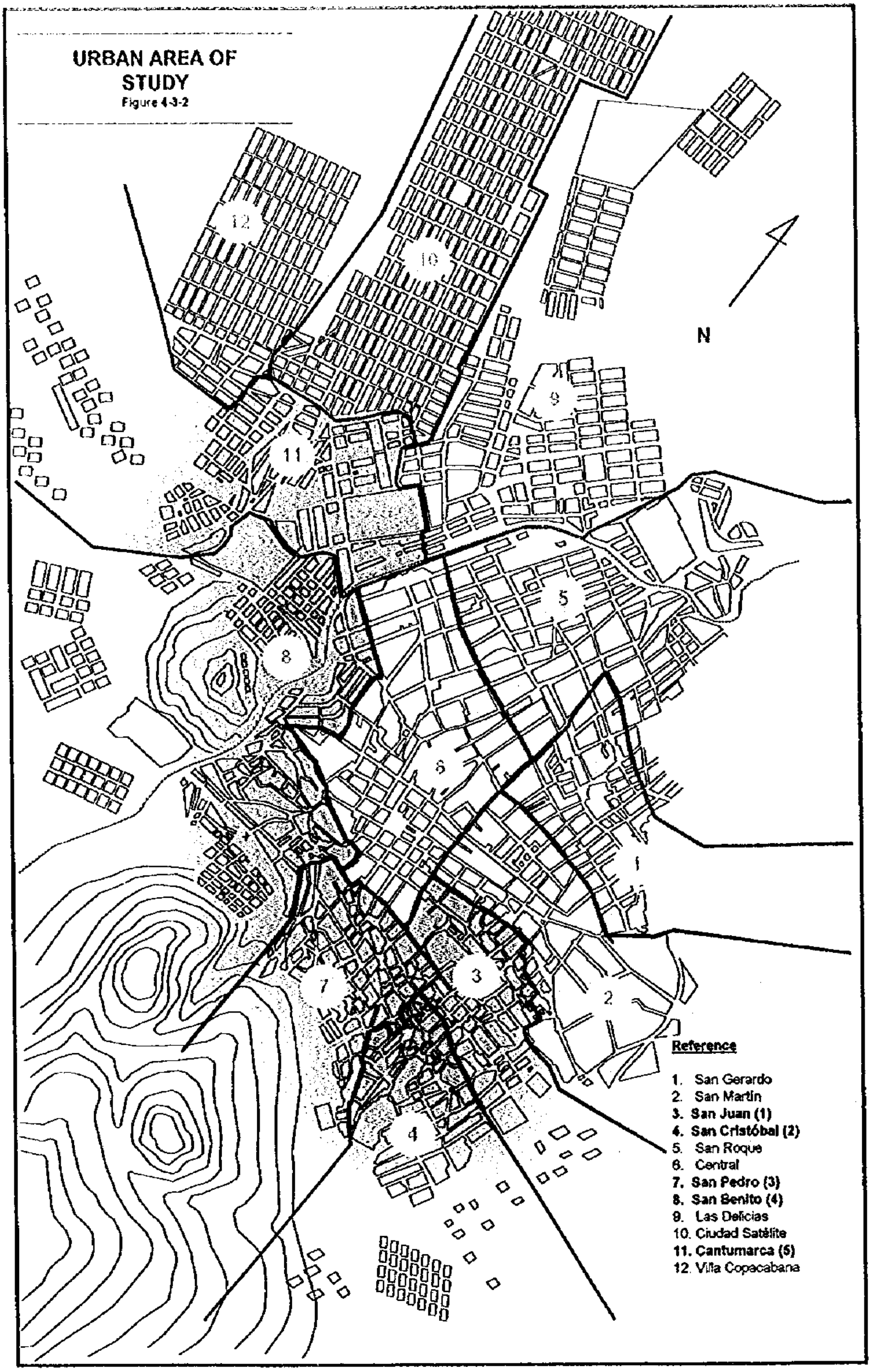


Figure 4-3-1 The pilcomayo river map


URBAN AREA OF STUDY
Figure 4-3-2
N
12
10
9
11
5
8
6
1
7
3
2
4
Reference
1. San Gerardo
2. San Martín
3. San Juan (1)
4. San Cristóbal (2)
5. San Roque
6. Central
7. San Pedro (3)
8. San Benito (4)
9. Las Delicias
10. Ciudad Satélite
11. Cantumarca (5)
12. Villa Copacabana