The Ilo Clean Air Project: a local response to industrial pollution control in Peru

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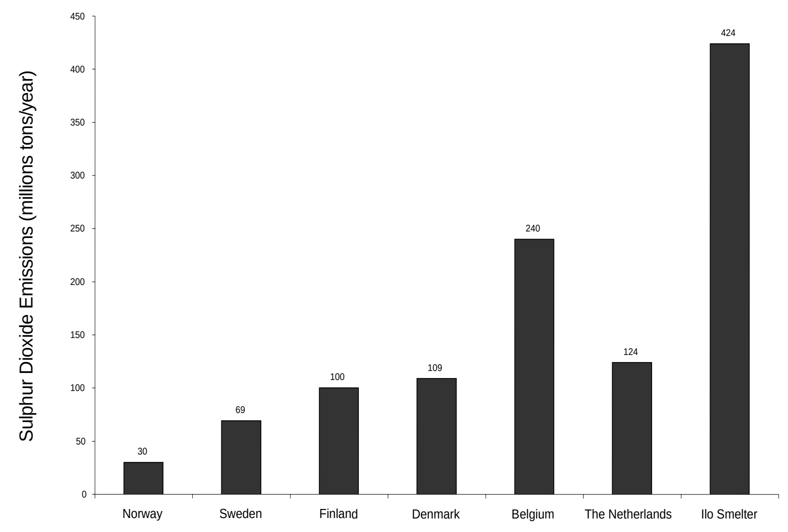
SUMMARY: *This paper describes the very high levels of air pollution generated in the city of Ilo and its surroundings by a nearby copper smelter, and the efforts of the local authorities to address the problem. After many years of limited results in seeking to persuade the copper smelter's owners to reduce emissions, in 1997 Ilo's local authorities began implementing the Ilo Clean Air project, with support from international organizations including the World Health Organization (WHO) and the International Council for Local Environmental Inititiatives (ICLEI). A system that monitors levels of sulphur dioxide and suspended particulate matter was developed. The project also assesses the impacts of air pollution on the health of children and on crops, and it has developed a contingency plan to limit health impacts during air pollution episodes. The Ilo Clean Air project complements many other environmental management innovations implemented over the last 20 years for which Ilo has become well-known. Past experience shows that a positive vision of the future, a local authority committed to consultation, and consistent leadership are key factors in successful urban management.*

I. INTRODUCTION

ILO, A CITY with a population of 70,000 people, is located on Peru's southern coast and, as a result of its industrial sector, suffers one of the world's highest levels of air pollution. Annual sulphur dioxide emissions from a nearby copper smelter exceed the combined annual emissions of Sweden, Norway, the Netherlands, Finland and Denmark (see Figure 1). Nonetheless, at the second UN Conference on Human Settlements (Habitat II) in Istanbul in 1996, Ilo was conferred second award as a best practice example for its innovative urban environmental performance.[1] This paper focuses on the efforts of Ilo's local authorities to reduce the city's levels of air pollution. In addition, it highlights the local authorities' potentials and limitations as a regulatory authority addressing the most serious environmental problems affecting the population within their jurisdiction.

Ten per cent of the copper smelters in the world lack sulphur dioxide emission controls. Most of these smelters with low or no sulphur capture are located in South America, Africa and Asia, excluding Japan.[2] Whilst technology exists that reduces sulphur dioxide emissions by up to 99.9 per cent, its implementation depends on the political and economic context. It is in this light that Ilo's environmental management committee

Figure 1: A comparison of sulphur dioxide emissions for the Ilo smelter and for selected European nations



is trying to influence the process towards a sustainable industry.

The Ilo Clean Air project launched Peru's first continuous and automatic public air quality monitoring network. It is established at seven locations north and south of the smelter. As an environmental management tool, the air quality network aims to generate an air quality database to be used as a basis for environmental action plans to improve the local air quality.

II. THE URBAN ENVIRONMENTAL MANAGEMENT CONTEXT IN PERU

THE CONCEPT THAT cities have a vital role in social and economic development in all countries is increasingly gaining acceptance. Urbanization, if accompanied by appropriate management and the necessary governmental structures, can be a process that helps create more diversified and dynamic economies. Only when essential infrastructure and services are provided and environmental problems are addressed can urbanization result in improved well-being. However, rapid growth of cities can be threatened by environmental deterioration. Ignoring environmental problems can lead to a continuous accumulation of costs and problems and might discourage future investments. Therefore, cities need to find better ways of balancing the pressures of urban growth, taking into consideration the restrictions and limits imposed by the environment.

This can be achieved through a process of comprehensive urban environmental management, with special emphasis on the interrelations between the urban actors in the public and private sectors. Successful urban environmental management requires clear governmental structures that use various mechanisms, including regulatory (prohibitions, laws and regulations), economic (taxes, charges, tariffs, subsidies and environmental licences) and communications mechanisms (environmental

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The municipality of Ilo is grateful to the following international organizations for their support for the Ilo Clean Air Project: the World Health Organization and its affiliated Centro Panamericano de Ingeniería Sanitaria y Ciencias del Media Ambiental (CEPIS) for their technical advice and for facilitating the donation of the air quality monitors; the International Council for Local Environmental Initiatives (ICLEI) for strengthening the Environmental Management Committee; the Dutch National Institute for Public Health and the Environment (RIVM) for donating six sulphur dioxide monitors and for providing training; the Canadian Embassy for donating a multi-gas calibrator and a meteorological station; the Dutch Development Cooperation, the Dutch Association of Municipalities (VNG) and the municipality of Deventer for the provision of Dutch expertise; the Belgian National Centre for Development Cooperation (NCOS) and the Chilean Latin-American Observatory of Environmental Conflicts for their financial support.

education and citizens' participation). Additional technical mechanisms of urban management, such as information-gathering and processing (environmental monitoring, environmental reviews, environmental impact studies, risk analysis, environmental reports) and planning instruments, including a land use plan, are necessary.(3)

In Peru, both the government and the private sector have operated without an adequate consideration of the environmental repercussions of their actions, which poses a present and future risk for the population. The risks are particularly serious in urban areas. The environmental problems faced by Peru's cities differ in size and characteristics, depending on the scale, the type of day-to-day activities and the type of urban growth. Peru's legal framework assigns authority for environmental issues to the sectors involved. In practice, decisions taken within these sectors might reflect their interests and could fail to take into account other sectors with which they share resources. There are also overlapping functions and responsibilities among the national, regional and local government institutions.(4)

With regard to policy, the tradition of each sector working in isolation makes task-sharing and consultation difficult. The absence of effective decentralization means that decision-making and resources are concentrated with the central government. Inadequate coordination among the various governmental institutions, without clear action plans, leads to duplicated efforts and an inefficient use of resources. Local governments have limited functions and authority to improve environmental management and most are ineffective in promoting and supporting individual and community initiatives related to environmental protection and conservation. When these limitations are combined with the shortage of economic resources and the economic interests of enterprises that fail to consider environmental factors in their operations and development, serious environmental problems are the inevitable result.

In the case of Ilo, as described here, the same political and legal context is evident, except for one great difference. Ilo's local authorities, through a participatory approach, have succeeded in taking a leading role in the environmental protection of its jurisdiction and its community.

III. BACKGROUND INFORMATION ON ILO

ILO IS SITUATED 200 kilometres from the border with Chile (see Map 1). Its hyper-arid environment contrasts with the depth of its bay, its abundant marine resources and its narrow valley, where the predominant crops are olive trees (which cover 480 hectares). Ilo is considered a moderate-sized city in terms of population. Its principal economic sectors are mining, fishing and port activities. The copper refinery and the copper smelter – located seven and 17 kilometres, respectively, north of Ilo – process 60 per cent of Peru's copper. Fishing activities, which are the most dynamic, include five operating fish meal and oil plants, processing 120,000 metric tonnes per year. Ilo's population is primarily migrant, and its considerable South Andean component has a strong tradition of community service. By 1980, Ilo was an isolated, polluted "company town" with serious water shortages. In 1983, a partial solution was found to the water shortage problem, by drawing water from a nearby basin. With the recent Pasto Grande project, Ilo has doubled its water supply since 1999. In 1984, the municipality implemented its development master

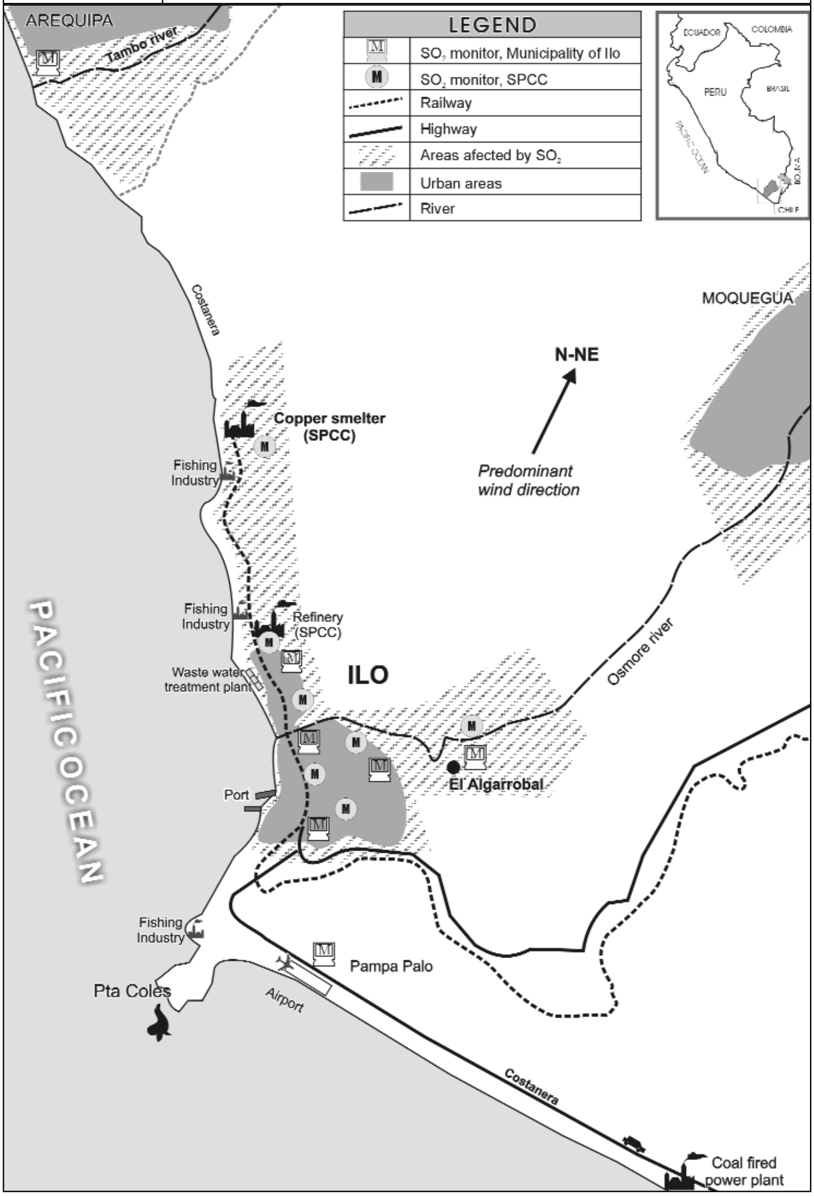
1. Balvin Díaz, Doris, José Luis López Follegatti and Micky Hordijk (1996), "Innovative urban environmental management in Ilo, Peru", *Environment and Urbanization* Vol 8, No 1, April, pages 21-34; also López Follegatti, José Luis (1999), "Ilo: a city in transformation", *Environment and Urbanization* Vol 11, No 2, October, pages 181-202.

2. http://innovations.copper.org/1998june/outokumpu.htm

3. Storksdieck, Martin (1994), *Environmental Management Instruments and Tools*, ICLEI's Guide to Environmental Management for Local Authorities in Central and Eastern Europe, Volume 5, ICLEI European Secretariat GmbH, Freiburg, Germany.

4. Miranda, Liliana and Michaela Hordijk (1998), "Let us build cities for life: the national campaign of Local Agenda 21s in Peru", *Environmental and Urbanization* Vol 10, No 2, October, pages 69-102.

Map 1: Ilo and its surrounds



plan and proposed converting Ilo into a "city to live in". In 1993, the urban development master plan was updated to reflect Ilo's new development conditions. During the 1980s, management committees emerged as a mechanism to address issues such as transportation, including its routes and tariffs, water and electricity supplies and solid waste management; and they participated in the decision-making process together with the municipality authorities. Projects such as the construction of the sea pier, the paving of roads and paths and the development of green areas, as well as improvements to housing and residential areas, were carried out.[5]

In 1989, one of the most important steps toward consultation was taken

5. See reference 1, Lopez Follegatti (1999).

– with the approval, by consensus, of the environmental rehabilitation plan. A multi-sector technical commission was established to assess the environmental damage resulting from mining, industrial and domestic activities, with representatives from the central government, the municipality of Ilo, the fishing industry and the smelter company. The commission prepared, and approved, a rehabilitation plan, including an installation to capture 30 per cent of sulphur dioxide emissions.[6]

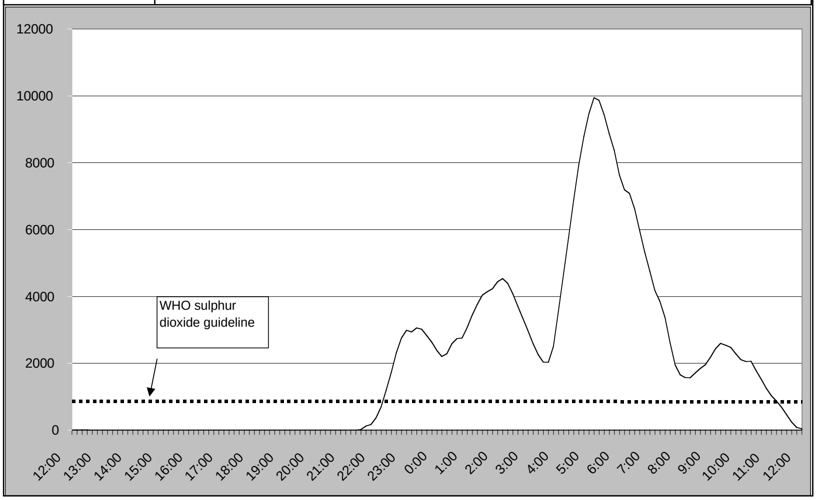
After the implementation of the rehabilitation plan, the question of the city's poor air quality was still unresolved. In order to tackle this problem, in 1996 the municipality of Ilo established the Environmental Management Committee (EMC), with representatives from the public and the private sectors.[7] The EMC's mission was to plan, execute, supervise, consult and assess programmes and projects related to environmental protection, basic sanitation, food hygiene and natural resource management in order to improve quality of life and promote sustainable development. Accordingly, the EMC launched the Ilo Clean Air project in 1997.

IV. AIR POLLUTION IN ILO

SINCE 1960, DUE to the city's nearby copper smelter, Ilo's air quality has been poor. The smelter produces 300,000 tonnes of copper per year, one of the ten largest copper smelters in the world.[8] The Ilo smelter mainly processes copper concentrate (containing 33 per cent sulphur) from the Toquepala and Cuajone mines. During the smelting process, the sulphur and copper concentrate components oxidize to form sulphur dioxide.

Sulphur dioxide has been emitted into the atmosphere with no controls for 35 years. In 1995 and 1998, two sulphuric acid plants were installed, which now convert 30 per cent of the sulphur dioxide into sulphuric acid. Together, these plants produce 300,000 tonnes of sulphuric acid per year, which is used in the mining process and sold to third parties. Currently, the smelter emits 424,000 metric tonnes of sulphur dioxide into the atmosphere per year [9] (see Figure 1). In 1997,

Figure 2: Sulphur dioxide concentration at Ciudad Jardin, Ilo, 07-04-1999



6. See reference 1, Balvin Diaz, Lopez Follegatti and Hordijk (1996).

7. It includes members from the Ministry of Health represented by the Ilo Basic Health Unit and the Directorate-General for Environmental Health (DIGESA); Directorate of the Moquegua Health Subregion; *Universidad Nacional Jorge Basadre Grohman*, Tacna; *Universidad Nacional San Agustín*, Arequipa; Ministry of Fishery; *Empresa Pesquería Austral; Pesca Perú; Empresa Pesquería Hayduk*; the NGO Labor; Provincial Municipality of Ilo; comunity-based organizations and CONAM, by invitation. It originally included a representative from the copper smelting company but they resigned in 1997.

8. Metallgesellschaft AG (1993), *The World of Metals: Copper*, Geography, Mining, Smelting Trading.

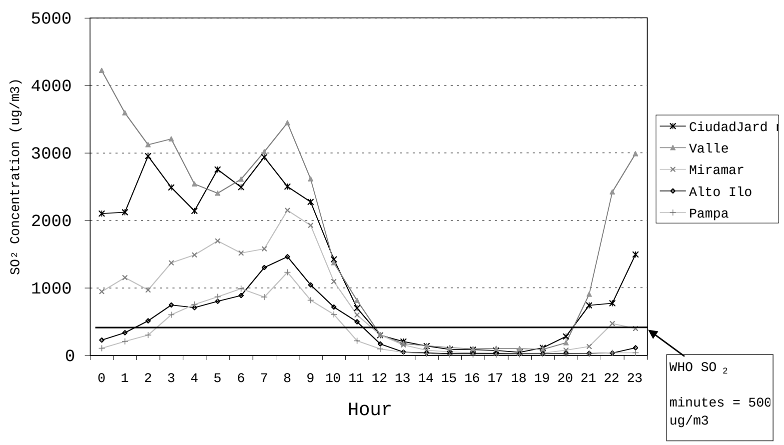
9. Walsh Peru (1997), "Programa de adecuacion de manejo ambiental: Southern Peru Copper Corporation", Walsh Peru.

Table 1: The area of influence or impact from the Ilo smelter emissions		
Area	Impacts	Information available
	Sulphur dioxide	
City of Ilo	Health of 70,000 citizens	Data on sulphur dioxide exposure are available
Ilo Valley	300 hectares of agricultural area	The farmers receive compensation for their loss of production
Lomas (natural desert vegetation)	Acid deposition	Quantification of impact still to be implemented
Moquegua Valley	Health of 35,000 people 10,000 hectares of agricultural area	The valley is located 60 kilometres inland Quantification of impact still to be implemented
Tambo Valley	Health of 10,000 people 10,000 hectares of agricultural area	The valley is 60 kilometres downwind of the predominant wind direction. Quantification of impact still to be implemented
	Metal emissions	
Ilo	Soil contamination Health of 70,000 people	Quantification of impact still to be implemented

a WHO mission expressed concern about the health risks to Ilo's population from respiratory diseases, asthma, chronic bronchitis and additional total mortality; there was special concern for children.(10) In addition to sulphur dioxide emissions, the smelter emits suspended particulate matter, which contains heavy metals, into the atmosphere. According to the WHO, the particulate matter emissions do not affect public health to the same degree as sulphur dioxide.(11) An inventory has been made of the possible impacts of the smelter emissions (see Table 1) but, as can been seen, there is a lack of data that would allow a quantification of the impacts of the smelter emissions.

In April 1999, peak levels for sulphur dioxide of 10,000 μg/m³ were registered in Ilo, 20 times the WHO 10-minute guideline of 500 μg/m³

Figure 3: Sulphur dioxide concentration 95th percentile, Ilo



10. Schwela, Dietrich and Sergio Caporali (1997), "Mision del Dr Dietrich Schwela, OMS, y del Sr Sergio Caporali CEPIS, a la municipalidad de Ilo, Peru 26-27-28 de Abril de 1997", World Health Organization.

11. Dr Dietrich Schwela, personal communication during a WHO mission to Ilo, 26th April,1997.

(see Figure 2). From Figure 3, which shows the 95th percentile for sulphur dioxide measurements, we learn that the levels of sulphur dioxide increase during the night and reach their peak in the morning. Due to its geography, the valley of Ilo shows peak levels during the night and, in the afternoon, the sulphur dioxide level is close to zero.

The population of Ilo is aware of the problems resulting from air pollution. According to a survey conducted by the local NGO Labor in 1997, more than 90 per cent of Iloans were aware that air pollution existed and recognized the impacts of pollution: on the respiratory system (81 per cent), the skin (52 per cent), headaches (24 per cent), the eyes (23 per cent) and vomiting (11 per cent). Although the population is aware of the health impacts of sulphur dioxide, 56 per cent take no precautions. Among the population that does take precautions, 8 per cent remain indoors until the smog has dispersed, 11 per cent cover their nose and mouth with a handkerchief, 8 per cent close their doors and windows and 4 per cent remain indoors, cover their noses and close their homes up completely.(12) This survey suggests that the majority of the population does not take adequate precautions despite an awareness of the negative health impacts of exposure to sulphur dioxide.

12. Failoc Rivas, Julio (1997), "Sondeo de opinión sobre las percepciones de la población en relación a la contaminación atmosférica", Asociación Civil Labor, Peru.

V. LEGAL FRAMEWORK

a. Peruvian regulations

IN 1996, PERU'S Ministry of Energy and Mines established national regulations to control the metallurgical industry's atmospheric emissions.(13) Under these regulations, a maximum 12 per cent sulphur dioxide is allowed in atmospheric emissions from metallurgical facilities such as the Ilo copper smelter. The ministry has also set emission standards for particulate matter, lead and arsenic (see Table 2). The government has given the facilities ten years to meet these standards and the industry is required to submit an Environmental Management Adaptation Programme (in Peru known as PAMA) for that purpose.

13. Resolución Ministerial No 315-96-EM/VMM (19th July,1996), "Aprueban niveles máximos permisibles de elementos y compuestos presentes en emisiones gaseosas provenientes de las unidades minero-metalúrgicas", El Peruano page 141,259.

Table 2: Maximum emission standards (RM No 315-96-EM/VMM)

Sulphur dioxide	Depends on sulphur inflow; for Ilo smelter, 12% of sulphur dioxide mass
Particulate matter	100 mg/m3
Lead	25 mg/m3
Arsenic	25 mg/m3

Mining companies are meant to obtain licenses to operate new facilities and to continue operating existing ones, in order to meet the emission standards set by the 1996 regulations. For metallurgical facilities, companies are required to provide the ministry with an Environmental Impact Assessment (EIA) for new facilities or a PAMA for existing ones. Furthermore, the ministry organizes a public hearing in Lima, which is announced 12 days in advance. With respect to approval of the Ilo smelter company's PAMA, participation by the local authorities was limited to being able to ask questions during the public presentation in Lima.

Peruvian regulations also require the smelter company to implement a meteorological, emission and air quality monitoring programme. The monitoring programme has to comply with the ministry's air quality and emission-monitoring protocol.(14)

14. Marlatt, W (1993), *Protocolo de monitoreo de calidad de aire y emissiones*, Ministry of Energy and Mines, Peru

b. Implementation of the regulations by the Ilo smelter

The smelter company has implemented a monitoring programme, with 11 monitoring stations (for an overview see Table 3). The aim of the monitoring network is to protect the population of Ilo from adverse health effects caused by the company's activities. In 1995, the company also launched an intermittent control programme in order to reduce the smelter operations when sulphur dioxide concentrations reach significantly high levels in populated areas. The implementation of this programme is supported by a dispersion model developed by the company.(15)

The smelter company presents quarterly results for the monitoring programme to the Ministry of Energy and Mines. The reports contain 24-hour averages from a monitoring station in the centre of Ilo and present a sulphur material balance in which sulphur dioxide emissions

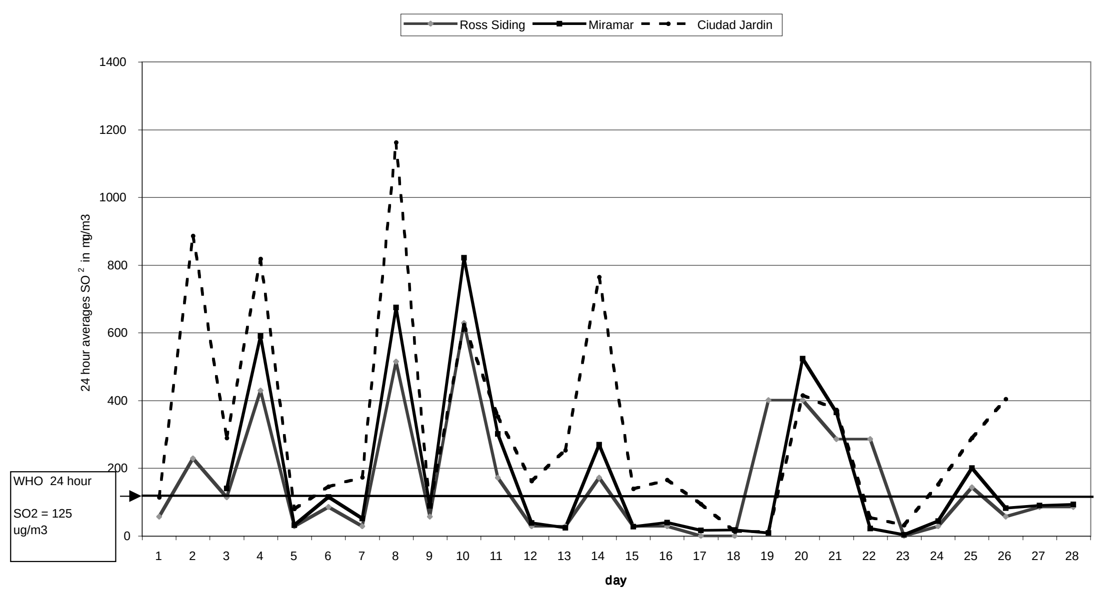
15. Asarco Corporation (1997) "Southern Peru Copper Corporation environmental record", press release 12th December, 1997.

Table 3: Comparison of Peruvian regulations and the monitoring programme of the Southern Peru Copper Company (SPCC)

Peruvian regulation		Monitoring programme of the smelter company (SPCC)	
Parameter	Frequency of registration*	Monitoring programme	Monitoring reports
Source emission			
Sulphur dioxide	Not specified Annual material balance	One sample Material balance	No results Monthly averages
Lead Arsenic Particles	Not specified Not specified Not specified	One sample One sample One sample	No results No results No results
Air quality			
Sulphur dioxide	1, 3 and 24-hour averages	7 continuous samplers	Daily averages of 1 monitor
Particulate matter	24 hour averages every third day	PM_{10} every sixth day	24-hour averages of two monitors every sixth day
Lead	24 hour averages every third day	Not mentioned	No results
Meteorolgy			
Wind speed Wind direction Temperature	Hourly average Hourly average Hourly average	10 monitoring stations parameters not specified	Every sixth day 24-hour averages of wind speed and direction for two monitoring stations

* Quarterly monitoring reports have to be submitted to the Ministry of Energy and Mines
** For the determination of the atmosphere stability and the altitude of the inversion layer

Figure 4: Comparison of monitoring results from the copper smelter company (Ross Siding) and the municipality of Ilo (Miramar y Ciudad Jardin) February 1999



are calculated. Table 3 shows that the reports do not mention all the parameters requested by the ministry. Between January and November 1999, the sulphur dioxide standard for 24 hours was exceeded six times and went as high as four times the standard (572 μg/m3).[16] All the monitoring stations are located south of the smelter and the predominant wind direction is from the south-south-west. This does not allow for an evaluation of the impact of sulphur dioxide emissions in the valleys of Tambo, located 60 kilometres north-west of the smelter, and Moquegua, located 50 kilometres north-east of the smelter. Figure 4 compares the results from the two different monitoring networks, namely, the smelter company's and the municipality's. As the Miramar station is approximately 300 metres from the smelter company's Ross Siding monitor, the results from the two monitoring stations can best be compared. The Ciudad Jardin monitoring station is located in the urban area closest to the smelter, at a distance of 12 kilometres. From a comparison of the monitoring results, we can see the importance of the location of the monitoring station. In February 1999, the Ross Siding monitor exceeded the 24 hour sulphur dioxide emission standard on one day only whilst, in the same month, the Ciudad Jardin station exceeded it on five days.

In order to comply with emission standards, the smelter is to be modernized at an estimated cost of US$ 625 million. The modernization has to be completed by 2006 and will control 93 per cent of the sulphur dioxide emissions.[17] During the implementation of the PAMA, the smelter company will be allowed to emit in excess of the maximum levels if the company can prove that the national air quality standards are not exceeded (see Table 4 for transitional air quality standards set by the Ministry of Energy and Mines).

16. SPCC Servicios Ambientales (1999), "Reporte de emissiones atmósféricas (RM No 315-96 EM/VMM)", primer trimestre, secundo trimestre, tercer trimestre y cuatro trimestre.

17. See reference 9.

Table 4: Maximum permissible air quality standards adopted by the Ministry of Energy and Mines valid until national air quality standards are approved (RM No 315-96-EM/VMM)

Parameter	Average daily arithmetic concentration µg/m³ (PPM)	Average annual arithmetic concentration µg/m³ (PPM)	Average annual geometric concentration µg/m³
Sulphur dioxide **	572 (0.2)*	172 (0.06)	-
Particulate matter	350*	-	150
Lead	-	0.5	-
Arsenic	6	-	-

* Should not be exceeded more than once a year
** WHO guidelines: 24 hours 125 µg/m3, annual 50 µg/m3
Should be further considered:
Monthly lead concentration = 1.5 µg/m3
30 minutes arsenic concentration = 30 µg/m3 (should not be exceeded more than once a year)

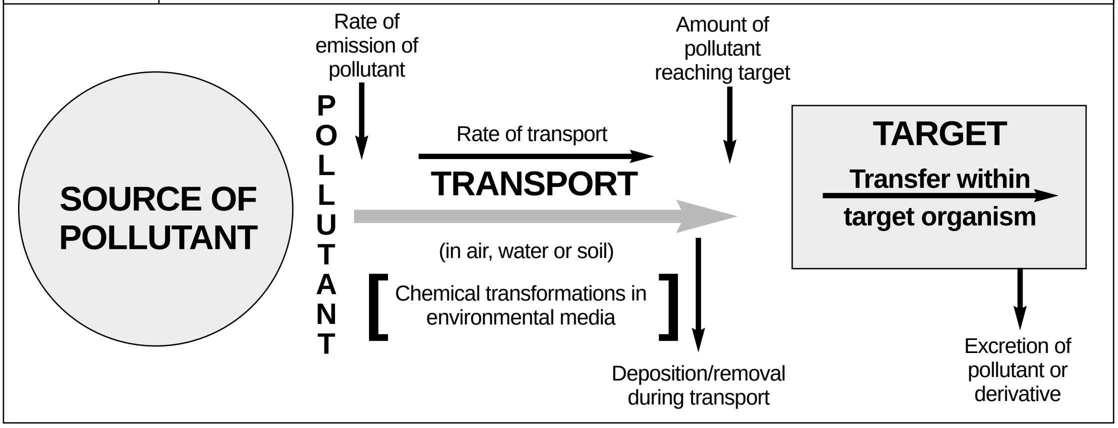
VI. THE ILO CLEAN AIR PROJECT

a. Air pollution sources in Ilo

HOLDGATE'S SIMPLIFIED ENVIRONMENTAL pollution model illustrates Ilo's environmental conditions regarding air quality (see Figure 5). Where Ilo is concerned, the main source of contamination is the copper smelter. The principal contaminant is sulphur dioxide and its transport medium is air. Sulphur dioxide undergoes chemical conversion, the most important being the conversion of sulphur dioxide into airborne sulphuric acid.

Sulphuric acid is deposited in the soil and water or is taken in by a receptor. The atmospheric emission of sulphur dioxide and its conversion

Figure 5: A simplified model of environmental pollution



SOURCE: Holdgate, M W (1979), *A Perspective of Environmental Pollution*, Cambridge University Press, Cambridge.

into sulphuric acid has led to the spread of environmental problems and is one of the main causes of acid deposition, which is more commonly known as acid rain. The ecological impacts from sulphur dioxide emissions can be felt hundreds of kilometres from the sources of emission.

The primary receptor of the sulphur dioxide from Ilo's copper smelter is the city's population and agricultural and urban centres situated 60 kilometres north of the smelter, such as Punta de Bombón and the valley of Moquegua. Sulphur dioxide enters the body through the respiratory system, moves into the bloodstream and is finally excreted. Inhaled sulphur dioxide can cause respiratory illnesses such as inflammation of the alveoli and bronchial constriction (a reduction in the size of respiratory passages as occurs with asthma), and can cause chronic bronchitis and asthma as a result of changes in the pulmonary mechanisms.

Vegetation is another receptor. Peru's hyper-arid coast limits this receptor to the Ilo Valley (480 hectares) and to the agricultural areas of Punta de Bombón and Moquegua (10,000 hectares each). The natural desert vegetation, called *lomas*, has almost totally disappeared from the region. The cell membrane is not an effective barrier to the transport of sulphur dioxide.[18] More acute physical effects on vegetation and crops result from cell ruptures caused by hydration in plant leaves, producing withering in the most affected part of the plant, potentially reducing photosynthesis and, in the end, killing the plant. Farmers have received compensation from the smelter company for crop damage in the Ilo Valley. In Punta de Bombón and Moquegua, the farmers are also claiming for crop damage but, as yet, they have not been able to reach a settlement with the smelter company. As discussed above, the smelter company does not have a monitoring programme in this area.

18. Hove, L W A (1995), *The Impacts of Air Pollution on Crops and Natural Vegetation*, reader, Wageningen University, the Netherlands.

b. Setting it up

The local authorities' weak position within strategic planning has been taken into account in establishing an adequate urban environmental management scheme. In Ilo, limited access to relevant information on atmospheric contamination by the municipal authorities and the population has been identified as a principal obstacle to addressing the problem.

Table 5: The three phases of the air quality project

Air Quality Project		
Phase I (1997)	Phase II (1998-2000)	Phase III (2001)
Indicative monitoring	Continuous monitoring system	Continuous monitoring system
Suspended particulate matter monitor Passive tubes to monitor sulphur dioxide concentrations	Seven continuous SO_2 monitors One high volume sampler One meteorological station Real time central data registration for two monitors Contingency plan - Population awareness	Contingency plan Bio-monitoring Shortened hospitalization
Meteorological report		Epidemiological study Dialogue with smelter company and authorities

To overcome this, the Environmental Management Committee (EMC) decided to draw up and implement the Ilo Clean Air project, reflecting the authorities' decision to take an active role in addressing air pollution. This project is executed by the EMC and the activities planned in connection with the project are divided into three phases, as shown in Table 5.

The objectives of the project are:

- to quantify the magnitude of the air pollution through scientific research, with the establishment of an air quality monitoring network, an epidemiological study and a bio monitoring study;
- the implementation of a contingency plan which will prevent some of the adverse health effects on the local population;
- to initiate a dialogue in order to improve the regional air quality.

The main participants in the Ilo Clean Air project are the provincial municipality of Ilo, the Ministry of Health (including the Directorate-General for Environmental Health/DIGESA and the General Epidemiology Office), the Ministry of Social Security, the Universidad Nacional San Agustín and the NGO Labor.

c. Phase I of the Ilo Clean Air Project

Project implementation began in 1997 with the establishment of a preliminary monitoring system using Palmes Tubes, a passive sampling method that is relatively low-cost and easily implemented. Palmes Tubes were set up in five different locations in the city and were replaced every two weeks for a period of one year. Placing Palmes Tubes in different locations indicates the dispersion of sulphur dioxide in different areas of the city. The indicative monitoring system also included a monitor to measure total suspended particulates, for which a high-volume sampler was used.[19] The results of the indicative monitoring programme showed the need for a permanent monitoring programme.[20]

A meteorological report was prepared, providing meteorological features for the region and the atmospheric dispersion dynamics of sulphur dioxide.[21]

d. Phase II of the Ilo Clean Air Project

In 1998, the Dutch National Institute for Public Health and the Environment (RIVM) donated six continuous monitors for the measurement of sulphur dioxide. These monitors were installed during phase II of the project and have been functioning since July 1998. Members of the Physics Department of Universidad Nacional San Agustín have been trained in the Netherlands to operate the monitoring system and are following the guidelines issued by the Peruvian Ministry of Energy and Mines to ensure that the data generated by the network meet appropriate quality standards.

An overview of the equipment in the network is provided in Table 6. The sulphur dioxide monitors and meteorological equipment feed the monitoring data into a computer, which transfers the data to a central computer by modem each day, or instantly if levels exceed WHO guidelines. The filter for the high-volume sampler which measures total suspended particulate matter will be analyzed by the Ministry of Health's Directorate-General for Environmental Health's laboratories (DIGESA). The monitoring network will operate permanently in order to enable the local authorities to assess the impacts of the measures taken by industry

19. Equipo Tecnico (1997), "Programa de monitoreo indicativo de calidad de aire en Ilo, junio 1997-junio 1998", Comité de Manejo Ambiental, Ilo, Peru.

20. Equipo Tecnico (1999), "Monitoreo indicativo de calidad de aire en Ilo; resultados y evaluacion 1997-1998", Comité de Manejo Ambiental, Ilo, Peru.

21. Flores Cútulo, Roberto I (1997), "Informe meteorológico y su incidencia en la contaminación atmosférica en el sur del Perú", Asociación Civil Labor, Peru.

Table 6: Ilo air quality monitoring network

Monitor	Locations	Frequency	Maintenance	Recording of analysis
SO_2 continuous monitoring	7	Every 10 minutes	Municipality of Ilo UNSA	Computerized (two are connected to a central computer)
Suspended particulate matter monitor High volume sampler	1	24 hours, every third day	DIGESA	Manually
Central computer	1	Download of data once per day or when attention level is reached	Municipality of Ilo UNSA	Computerized
Meteorological equipment	1	Every 10 minutes	Municipality of Ilo UNSA	Computerized

to reduce sulphur dioxide emissions.

Contingency plan. As mentioned above, more than 90 per cent of the population is aware of the effects of air pollution although only 20 per cent take adequate precautions such as closing windows and remaining indoors during episodes of high air pollution levels. Furthermore, 90 per cent of the population says that it is interested in knowing what the air quality in the city is.[22] Bearing this in mind, the EMC has implemented an awareness campaign to be combined with the introduction of a contingency plan.

22. Failoc, Julio, Hernan Pacha, Ever Arosquipa (1999), "Sondeo de opinion: medidas de prevención contra la contaminación, bases para la implementación del plan de contingencia atmosferica", Consorcio Economista y Ingenieros.

The population that is sensitive to exposure to sulphur dioxide form the target groups for the awareness campaign. These are children, elderly people, people with respiratory diseases or asthma, pregnant woman and those engaged in sports. It has been the strategy of the EMC to approach those groups, as they are more likely to change their behaviour in order to protect their health. Intermediary groups such as medical staff, teachers, local media and the social care programme "Glass of Milk" have all been involved in order to reach the target group effectively.

The aim of the contingency plan is to reduce the health impacts from exposure to sulphur dioxide, whose levels, in Ilo, rise at particular times of the day. For most of the time, the air quality is good, especially in the afternoon when sulphur dioxide levels are often close to zero. But, on average, on one day a week, high levels of sulphur dioxide are reached, with peaks between eight and ten in the morning. With the implementation of the contingency plan, the health impacts can be reduced significantly if the population takes precautionary measures during these episodes. This is of particular interest to the vulnerable groups identified and an information strategy has been developed to inform the population about the episodes. The municipality has real-time access to sulphur dioxide levels from two monitors which register the city's air quality. The EMC, with support from the WHO, has developed precautionary guidelines for the population, relating to different levels of sulphur dioxide (see Table 7). When air quality reaches these levels, various means are used to inform the population. These include coloured balloons above schools, radio announcements and a siren when the emergency level is reached.

For the implementation of the contingency plan, the municipality of Ilo

Table 7:	Ilo contingency plan proposed by the WHO		
Air quality	SO_2 level (in µg/m3)	Recommended measures	Actions
Good	0 - 500	–	–
Attention	500 - 1,500 for three hours	Avoid outdoor activities for vulnerable groups Avoid physical exercise for the rest of the population	Authorities should be informed, also health centres and schools Contact involved companies
Alert	1,501 - 2,500 for two hours	Avoid outdoor activities for vulnerable groups Windows and doors should be closed Recommend limited outdoor activities for the rest of the population	Inform competent authorities, health centres and schools Contact involved companies
Emergency	> 2,500 for 90 minutes	Outdoor activities should be avoided by the population in general Windows and doors should be closed	Inform competent authorities, health centres and schools Contact involved companies Close doors and windows of classrooms, cancel gymnastics and avoid activities in school playgrounds Immediately contact local radio and television stations Activate siren

SOURCE: Korc, Marcelo E (PhD) (2000), “Plan de urgencia atmosférica paraIlo, Perú”, CEPIS-PAHO/WHO

has elaborated a municipal ordinance, with the participation of relevant sectors such as the media, the Ministry of Health, the National Environmental Council (CONAM), the Ministry of Energy and Mines, and the Ministry of Education.

e. Phase III of the Ilo Clean Air Project

During phase III, the operation of the monitoring network and the implementation of the contingency plan will continue, as discussed in connection with phase II.

Epidemiological research. This is required in order to assess the public health impacts of air pollution in the region. The objective of the research is to evaluate the relationship between the respiratory health of Ilo’s population and air pollution. The results will be used to develop policies to protect the population’s health.

The epidemiological research will focus on children. This group was selected for three reasons. First, they do not have occupational exposure and they normally do not smoke, thus the impact of air pollution is more easily detected. Second, they are likely to be more sensitive to air pollution than other groups. Third, they can easily be accessed through the school system.

A proposal for epidemiological research has been formulated. A database will be generated that registers medical consultations for acute respiratory infections in children aged 0-12 years old. The database will register on a daily basis and will be correlated with sulphur dioxide levels. A protocol for the implementation of this database has to be developed and the medical staff need to be trained in order to implement it. The results can be processed locally. For an evaluation of the results, external expertise will be required. The advantage of this methodology is that the database can be incorporated into the daily practice of the health care centres. The EMC is aware of the need for national or international support for the implementation of this study so that the results will be accepted by all parties. For this reason, DIGESA and the WHO have been asked to support the implementation of this proposal.

Shortened hospitalization. The EMC has also investigated possibilities for improving the treatment of children affected by the city's air quality. In Chile, the Ministry of Health has set up a successful treatment which they call "shortened hospitalization", for children with acute respiratory infections. Shortened hospitalization takes a maximum of two hours and children receive adequate medicine and massage to overcome any acute bronchial obstruction crisis. If the treatment is unsuccessful, the child is kept in hospital for further treatment. Children with severe respiratory problems are directly hospitalized. Paediatricians specializing in pneumonia, trained physiotherapists and rooms equipped with oxygen and medicines are provided. During the treatment, parents receive information on how to prevent respiratory infections in their children. The results of this programme in Chile have been very positive. Hospitalization of children with acute respiratory infections has been reduced from 50 per cent to 5 per cent and pneumonia and mortality rates have also been reduced. The programme is cost effective as treatment expenses have been reduced by up to 70 per cent.(23) The Ilo-based Ministry of Health and the Ministry of Social Security have shown interest in implementing this programme in Ilo.

23. Interview held with Ruben Gamboa, Pedro Astudillo and Pedro Manzila, Ministry of Health, 13th January, 2000.

f. Bio-monitoring

Bio-monitoring research will assess the impacts of atmospheric pollution on crop losses and food quality in agricultural areas of the region. Bio-monitoring is an internationally accepted method for assessing crop losses in the agricultural sector arising from atmospheric contamination. There are two main objectives: to measure the impact of atmospheric contamination on crops; and to make the Peruvian authorities aware of the impacts of atmospheric contamination on output losses in the agricultural sector.

The following will be studied in connection with the first objective:

- impact area;
- spatial variation;
- estimated crop losses;
- formulation of appropriate measures.

Table 8: The factors to be investigated by the biomonitoring research

Passive	Active
Field inspection of the sensitivity and intensity of symptoms as a function of distance from emission sources and crops in agricultural areas compared with plant ranking and symptoms in the scientific literature.	Quantification of the relationship between field of exposure and testing fields through the assessment of active and passive samples with bio-monitoring Measurement of the heavy metals content of crops and soil and comparison of the results with national and international standards
	Identification and modelling of local crop sensitivity Quantification of crop losses

Bio-monitoring will focus on the agricultural areas of Ilo (480 hectares, primarily planted with olive trees) and Punta de Bombón and the valley of Moquegua (10,000 hectares each, planted with a variety of crops). Table 8 gives more details. A proposal for the implementation of bio-monitoring has been elaborated and has gained the interest of the Agricultural University La Molina in Lima. The proposal is approved by CONAM and funding is pending.

VII. DIALOGUE

WITH THE IMPLEMENTATION of the Ilo Clean Air project, the EMC will take an active role in addressing the city's air quality. Through dialogue, the municipality will try to reach agreement with the smelter company on the modernization of its smelter and on compensation for the affected population. In addition, the municipality will be able to assess the implementation of the PAMA. On the one hand, the smelter company has invited the EMC to visit the company's monitoring and intermittent control programme. On the other, the company has shown no interest in implementing the modernization of the smelter before 2006, nor in compensation for the negative health impacts. Since 1999, when the smelter company was taken over by a Mexican group, little progress has been made in reaching any agreement.

In 2000, a 250 MW coal-fired power plant started operating 25 kilometres south of Ilo, emitting oxides of nitrogen, sulphur dioxide, particulate matter and carbon monoxide (see Map 1). The urban centre of Ilo is located downwind of this new source of emissions. The plant lacks the facilities to capture sulphur dioxide and will control its emissions through the purchase of low-sulphur coal. Although the emissions are considerably lower than those from the smelter, the population feels sandwiched between the two emission sources north and south of the city. In order to monitor the plant's atmospheric emissions, the Ilo Clean Air project has defined the sulphur dioxide ambient air quality levels as indicators for the evaluation of the dispersion model used in the plant's environmental impact assessment. One continuous monitor has been located close to the coal-fired power plant.

The municipality has also involved the Ministry of Energy and Mines, the Ministry of Health, the Ministry of Education and the National Environmental Council (CONAM) in the progress of the project. The opinion of the Ministry of Energy and Mines has been asked on the implementation of the company's monitoring programme and on the results of the reported data. The Ministry of Health has not taken a clear position on the issue yet but DIGESA has a covenant with the municipality of Ilo for the implementation of the monitoring programme. DIGESA has also been asked to support the implementation of the epidemiological study. A decision concerning the involvement of the Ministry of Education, which is important for the implementation of the contingency plan, has been delayed as a result of the country's political turbulence in the last year. Finally, CONAM fulfils a key role as coordinator for the elaboration of national ambient air quality guidelines, for which a first draft, in consultation with different sectors of government and society, has been published in the national legal newspaper El Peruano.[24] In this proposal, Ilo is one of 13 regions where an air quality management plan is to be formulated. Planned and executed activities under the Ilo Clean Air

24. Consejo Nacional del Ambiente (1999), "Anteproyecto de decreto supremo que abrueba el reglamento de estándares de calidad de aire", resolucion presidencial No 078-99-CONAM/PCD, El Peruano, 8th December, 1999, pages 181,186-181,190.

project are partly projected in the proposed plans, which means that the project will be supported by central government, with the advantage that local authorities gained a leading role and built expertise for the implementation of the national regulations.

VIII. CONCLUSIONS

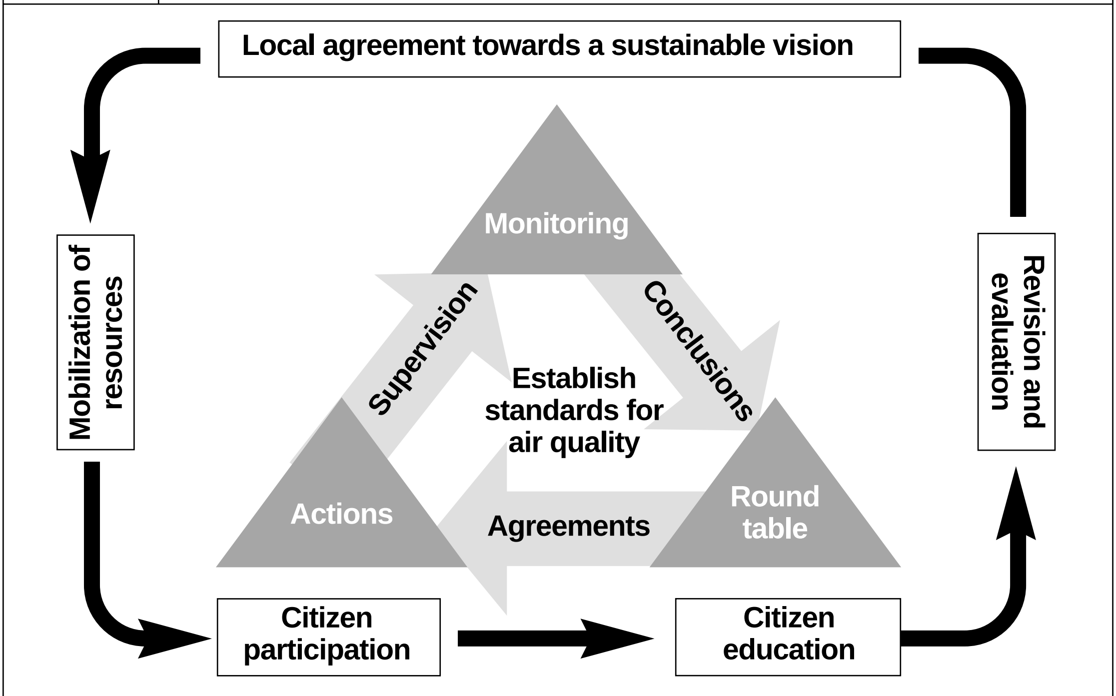
ONE WORD TO keep in mind is "process". We speak constantly of the process of urban environmental management, as urban planning and management is an interactive, dynamic and flexible process rather than a static plan or final document. Urban environmental planning and management is a process that needs to be renewed, enriched, adjusted and continued.

The local urban management process developed in Ilo creates efficient mechanisms to promote public and private awareness, with citizen participation, and has been implemented by Ilo's local government leaders since 1980. They took responsibility for managing the development of their jurisdiction within the existing legal framework. One of the key issues was to develop planning instruments (1984 master plan) to give the city a framework for action and to facilitate the process of constructing a vision for Ilo's future. According to López, Ilo's vision is a synergetic result of the desires of the leaders and the dreams of the people.[25]

25. López Follegatti, José Luís et al. (1996), "La concertación en la gestión urbana ambiental: la experiencia de Ilo" in Miranda, Sara Liliana et al., *Ciudades para la vida*, PGU Serie Gestión Urbana N-6, Lima, Peru.

The implementation of the Ilo Clean Air project provides a point of departure from which to observe the continuation and improvement of Ilo's urban environmental management within the framework of interactive and cooperative dynamics between the various actors involved. The

Figure 6: The monitoring triangle in the framework of urban environmental management



project facilitates access to environmental information. Access to the results of public monitoring is often difficult in Latin America (and also in Asia and Africa) and is one of the main objectives of the Ilo Clean Air project. The involvement of members of the Environmental Management Committee guarantees the transparency of the monitoring results. These results are published annually and the local press is informed weekly. The incorporation of air quality monitoring as a management instrument, to supplement the concept of urban environmental management, is illustrated in Figure 6. The air quality monitoring triangle of the Ilo Clean Air project shows the steps involved in reaching the objectives. Its incorporation into the urban environmental management process shows how air quality monitoring helps build and enhance local capacity with a view to the final goal of sustainability.

In reviewing each individual step in Figure 6, we note that, where Ilo is concerned, air quality monitoring will be consistent with the implementation of urban environmental management. When the vision for the future is decided, air quality monitoring will be supplemented with an appropriate system of environmental indicators to reflect the current state of Ilo's environment. This will help mobilize available resources to develop a process of citizens' participation and consultation, with a view to analyzing the adverse impacts on health and ecosystems. Dissemination of the findings from the monitoring will show the health impacts of pollution and will promote local capacity to identify the goals and objectives of environmental policy in light of Ilo's specific circumstances. Monitoring serves to assess the success of environmental policies, projects and programmes, in order to develop a process in which all the key actors feel a sense of ownership and commitment (including local government, NGOs, communities, competent authorities, the Ministry of Health and the Directorate-General for Environmental Health). With this multisectoral perspective, the air quality monitoring system can be used to help the local authorities establish their environmental management policy and implement an environmental action programme.

The successful execution of the Ilo Clean Air project helps to strengthen local capacity, which is vital in helping all actors involved to understand the limits and the distribution of the costs and benefits among the different groups involved. This will ensure that the actions, as determined by the actors, are not only an ideal strategy on paper but also a strategy of consensus that they can implement themselves through the formulation of urban environmental management policy.

In conclusion, we should note that urban environmental management cannot promise easy solutions to all urban problems. As urban environmental management is a newly proposed comprehensive process, we are now beginning to gain a more detailed understanding of how urban processes function, and are seeking solutions. Cities cannot wait any longer. And urban problems are complex, with no easy solutions.