

# Report on the State of the Environment of Macao 2002



**環境委員會**  
**CONSELHO DO AMBIENTE**  
**ENVIRONMENT COUNCIL**



## REPORT ON THE STATE OF THE ENVIRONMENT OF MACAO 2002

Jointly prepared by the Environment Council of Macao and the Institute for the Environment of Portugal under the provision of the co-operation agreement between the two entities.

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(Conselho do Ambiente de Macau)

Vong Man Hung	Acting President of the Executive Committee of the Environment Council
leong Kin Si	Senior Officer
Fong Weng Chin	Senior Officer

### INSTITUTE FOR THE ENVIRONMENT OF PORTUGAL

(Instituto do Ambiente de Portugal)

Nélida Miguens	Principal Officer
Margarida Marcelino	Officer
Catarina Freitas Alves	Consultant
Vitor Góis	Consultant

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Government Tourist Office (Direcção dos Serviços de Turismo)  
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# INDEX

Opening Note	5
Foreword	6
Editorial	7
<b>1 Introduction</b>	<b>9</b>
<b>2 Atmospheric Environment</b>	<b>13</b>
2.1 Air Quality	13
2.2 Atmospheric Emissions	16
2.3 Climate Change, Acid Rain, Protection of the Ozone Layer and Photochemical Smog	18
2.4 Energy Sector	21
2.5 Transport	22
<b>3 Water Supply</b>	<b>25</b>
3.1 Drinking Water	25
3.2 Bathing Beaches and Coastal Water	29
3.3 Wastewater Management	34
<b>4 Waste</b>	<b>38</b>
4.1 Quantity of Generated Waste	38
4.2 Composition of Waste	40
4.3 Incineration By-products	41
4.4 Sanitary Landfill	42
4.5 The Basel Convention on the Control of Transboundary Movement of Hazardous Waste and their Disposal	43
4.6 Waste Management Strategy	43
<b>5 Natural Conservation</b>	<b>46</b>
5.1 Green Spaces	46
5.2 Ecological Invasion	48
5.3 Forest Fire	49
5.4 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	50
5.5 Ecological Reserve	51
5.6 Other Initiatives	51
<b>6 Noise Environment</b>	<b>53</b>
6.1 Noise Monitoring	53
6.2 Noise Complaints	58
6.3 Noise Abatement Measures	59
<b>7 Environmental Management</b>	<b>60</b>
7.1 Investment and Expenses on Environmental Management	61
7.2 Public Participation	62
7.3 Environmental Awareness and Education	62
7.4 Inter-regional Cooperation	66
7.5 Implementation of Environmental Management System	67
7.6 International Conventions	67
<b>8 Analysis and Recommendations</b>	<b>69</b>
<b>Annex I - Acronyms and Symbols</b>	<b>73</b>
<b>Annex II- References</b>	<b>74</b>









### Opening Note

The high population density as well as thousands of tourists pose a great challenge to the environmental protection of the Macao Special Administrative Region, particularly in handling three types of pollution (gaseous emissions, solid waste and wastewater). The government continues to take appropriate measures in order to improve and strengthen the environmental protection work through promotion and cooperation with other entities.

In fact, environmental protection is a substantial and long-term task. The increased awareness and demand of the public on environmental protection issues are the driving forces for the government to constantly improve her works. Environmental protection work is not only a slogan or a policy, but also depends upon the mutual participation and efforts of both the government and the citizens in general.

In 2002, Macao started her application for the “Global 500” Laureate awarded by the United Nations. One of the application aims is to increase the public concern towards environmental protection, so as to create a good quality living environment and to confirm sustainable development.

As in previous reports, the publish of the Report on the State of the Environment of Macao 2002 reveals environmental data and information of different aspects, in order to offer the public a better knowledge and understanding of our environment. Furthermore, this report also aims to provide holistic and systematic references and suggestions, which will facilitate the government in establishing environmental protection policies.

I would like to take this opportunity to express my best wishes for the publish of this report.

Secretary for Transport and Public Works,

Ao Man Long





## Foreword

Sustainable development is defined as the “development which meets the needs of the contemporaries without compromising the needs of future generations”. It emphasizes the balance among economy, society and environmental protection. Macao is making her great effort to move towards this direction.

With the advice and the valuable suggestions provided by different entities, the Environment Council elaborated the fourth annual report on the state of the environment – *Report on the State of the Environment of Macao 2002* which makes use of numerous indicators of sustainable development for the assessment and the objective analysis of the state of the environment and problems, hoping to provide an important reference in making the sustainable development strategy of the Macao Special Administrative Region. We hope that the publish of this annual report on the state of the environment will contribute towards a better public knowledge and understanding of the environmental quality in Macao. With all these, we further hope to encourage the public to aware environmental protection, and to actively participate in the related work, thereof, and the preservation of resources.

Macao is still at her developing stage both by the readjustment of her internal economic structure as well as by unification to the external economy. We sincerely hope that the *Report on the State of the Environment of Macao* can be improved on the course of time and becomes an important reference tool for both the assessment on the state of the environment and the policy making of the Macao Special Administrative Region.

President of the General Committee of the Environment Council,

Vai Tac Leong



## Editorial

According to the Law 2/98/M dated on 1<sup>st</sup> June 1998, the Environment Council takes her responsibility for the elaboration and approval of the “Report on the State of the Environment of Macao”.

At a time when Macao regards sustainable development as the main principle in order to be able to explore new economical developments, we hope that the publish of the “Report on the State of the Environment of Macao 2002” may present the general public with updated and relevant information on the state of the environment, as well as an important reference for the sustainable development strategy of Macao.

We would like to take this opportunity to express our sincere gratitude for the cooperation of various associations, companies and government departments in providing valuable information for this report and the Institute for the Environment of Portugal, which collaborates with us in elaboration of this report.

We welcome for all the opinions and suggestions of the present edition for the improvement of future editions.

Acting President of the Executive Committee of the Environment Council,

A handwritten signature in black ink that reads "Vong Man Hung". The signature is stylized and includes a large flourish at the end.

Vong Man Hung











The publish of the fourth Report on the State of the Environment of Macao indicates a mature stage of the report. The report becomes an essential instrument for the diagnosis of the environmental situation and of the degree of the sustainability of the Macao Special Administrative Region (Macao SAR).

This report mainly focuses on the discussion of the state of the environmental of Macao in 2001. It seeks once again to describe different types of correlation between the population, economical development and the environment and presents some of the main challenges to be faced. The report also tries to identify the managerial needs which come thereof within the frame of an integrated analysis of the three pillars of sustainable development: social, economical and environmental aspects.

As in other parts of the world, the Macao population has been increasing in pace with her economic growth (as reflected in the GDP). The effect of this trend is an increased pressure upon the quality and quantity of the available natural resources, which should be faced and overcome with the appropriate measures.

Through analyzing the correlation between economic development and environmental conditions in the world, it is being observed that the aspect on water, air, land and the whole ecosystem are continuously affected by human activities despite the efforts made by countries in balancing them.

However, the correlation between economic development and environmental conditions is not always linear. In numerous cases an increase in some economic and social indicators can also release the pressure upon the natural resources and

the impacts on the environment. This process is known as the “dematerialization of the economy”, meaning that social and economical development does not necessarily happen at the expense of the environment and of which many countries have been adopted as an objective for the modern society in particular after the United Nations’ Conference on Environment and Development held in Rio de Janeiro, Brazil, in 1992.

A decade after the “Earth Summit”, all these concerns and experiences were brought forward in the World Summit for Sustainable Development held by the United Nations, which took place in Johannesburg, South Africa, in August/September 2002. The Secretary for Transport and Public Works and a member of the General Committee of the Environment Council, followed the China’s delegation, had attended this conference. A series of conclusions has been drawn after this important conference, which might be considered as part of the policies and actions to be developed in Macao in the coming years, aiming at implementation of globalization. These include:

- To confirm sustainable development as the main potential commitment in the international agenda, strengthening global action against poverty and encouraging the protection of the environment;
- To widen and reinforce the concept of sustainable development, particularly in the connection that has been established between poverty, environment and the use of natural resources;
- To reach an agreement and reinstatement among governments on a large number of engagements and concrete targets established in the “Political Declaration”



and in the "Implementation Plan", in order to achieve the objectives of sustainable development more effectively;

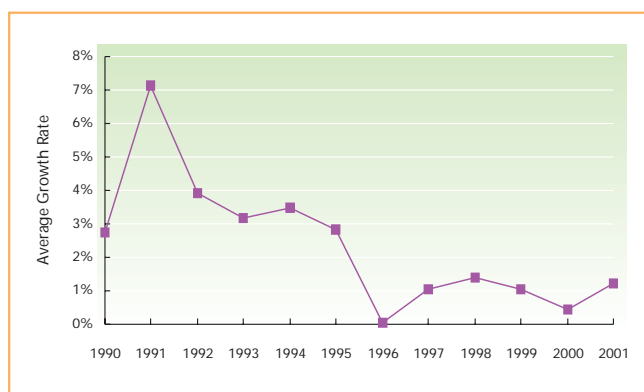
- To support the creation of a world fund as a visible step towards the eradication of poverty;
- To acknowledge that Africa and the NEPAD Strategy deserve the special attention and support of the international community in order to gather all the necessary efforts to face development needs in this continent;
- To reach relevant conclusions in the area of energy and basic drainage system;
- To acknowledge the key role played by civil organizations in the implementation of the conclusions reached in the summit as well as in the promotion of partnerships;
- To reinforce the concept of partnership among governments, companies and associations in the Summit and in the "Implementation Plan".

### The Situation of Macao

According to the latest census (August 2001), Macao has a population of 435.235, 95% of which are Macao residents and around a 5% (21.188) floating population.

Between 1990 and 2001, the average annual population growth rate was 2.31%, showing a slight decline along the years. The number of visitors to Macao has been increased since 1999 after the handover.

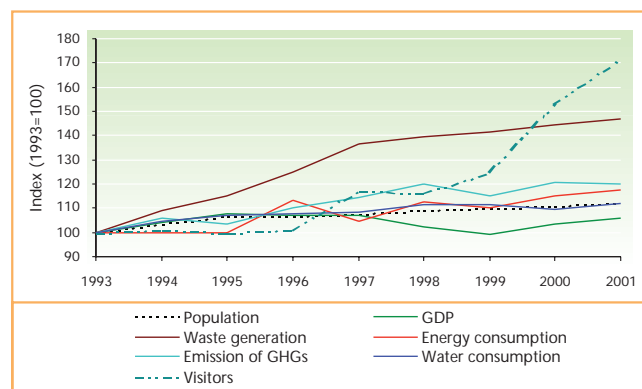
In this last decade immigration has significantly contributed to increase the population when compared to the natural growth rate. According to the Census 2001, 11.5% of the population now living in Macao were residents from China, Hong Kong or Taiwan five years ago.



**Figure 1.1**  
Evolution of the average annual population growth rate in the last 10 years  
(Source: SCS)

GDP growth rate in Macao has reached its peak in 1992 (with an increase of 14.6%) and it has been falling since then, with consecutive decreases from 1996 to 1999. However, an increase of 4.6% and 2.1% has been shown in 2000 and in 2001 respectively.

In a brief analysis of the evolution of some of the socio-economic and environmental variables in the past decade by taking 1993 as a reference, it is found that the increase in the production of greenhouse gases (GHGs) – which reflects the pressure of human activities – is greater than the population growth and the GDP growth. Meanwhile, there is also a significant increase in the amount of waste generated during this period.



**Figure 1.2**  
Evolution of some socio-economic and environmental parameters  
(Source: SCS, OID and EC, 2002)

Natural resources and the quality of the environment are essential factors for the socio-economic development and the quality of life in any country or region. People are the key players who may or may not lead towards sustainable development.

As Macao is well-known as one of the most densely populated places all over the world, the key factor to improve the environmental quality of Macao is to deepen the residents' awareness of their responsibility towards environmental protection and to manage appropriately the balance among economic development, the improvement of quality of life, the intelligent use of resources and the diminishing of the pollution.

Through data analysis, it shows that environmental pressure in Macao has been increasing with the increase in population and social development. In fact, there is room for improvement in environmental management and the sustainable use of resources.

So, a middle or long-term strategy is crucial to ensure a sustainable development in Macao, of which all social and economic sectors in Macao should take part in the development of their organizational format, so as to improve the water usage, waste production and utilization of energy.



The population and different economic agencies or entities have long been encouraged to react to environmental issues, such as saving water, reducing waste, recycling materials and effectively using energy, etc. It is crucial to educate and to motivate different social classes to participate in solving environmental problems and it is essential for the implementation of different measures on environmental protection.

Since international cooperation on global environmental problems is meaningful and positive, it is worthwhile to mention the Co-operation Protocol signed on 11<sup>th</sup> September 2002 between the Institute for the Environment of Portugal

(represented by the President) and the Environment Council of the Macao SAR (represented by the Acting President of the Executive Committee) in a ceremony hosted by the Secretary for Transport and Public Works of the Macao SAR and by the Minister of the Cities, Territorial Planning and Environment of Portugal.







2

# Atmospheric Environment

## 2.1 Air Quality

The dominant urban characteristics of a city – densely populated and with intense road traffic – can be reflected by the air quality monitoring result by the Meteorological and Geophysical Bureau of Macao (MGB) as shown in Figure 2.1-2.3.

The location and the number of monitoring stations has been modified (refer to SoER 1999 and SoER 2000) and four automatic stations are now in operation, which are located at Taipa Grande (Ambient Station), Laboratory (Densely Populated Station), Calçada do Poço (Roadside Station) and Downtown of Taipa (Densely Populated Station). There are also three semi-automatic stations namely Taipa Grande (Ambient Station), Horta e Costa (Roadside and Residential Station) and Ka-Hó.

The result obtained in those monitoring stations are compared with the standards of China, the USA, Portugal (EU), Hong Kong and WHO (World Health Organization) etc. in order to analyse the air quality.

As in the previous years, high suspended particulates and the low pH values are verified. Although there are local pollution sources such as the production of electricity and vehicles emissions (refer to emission inventory), the effects from the emission sources in the Pearl River Delta Region to the local suspended particulates should not be neglected.



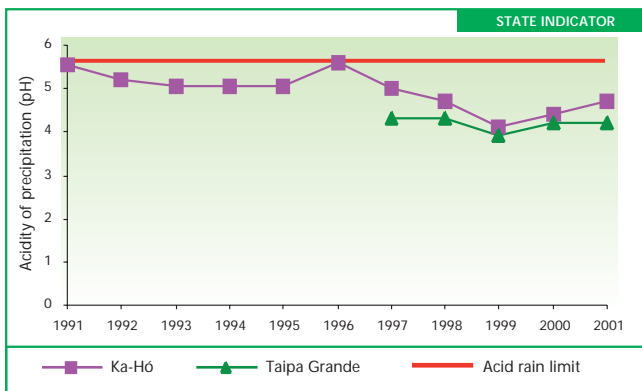
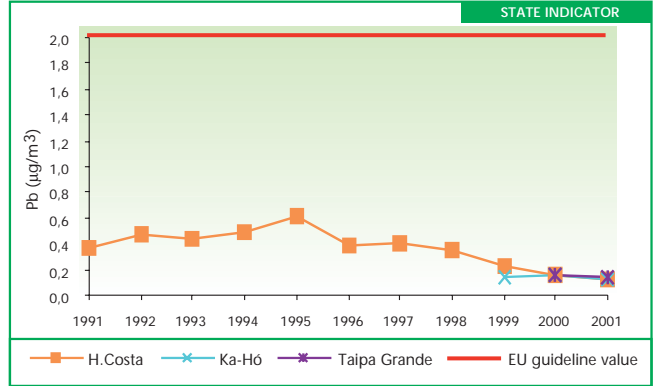
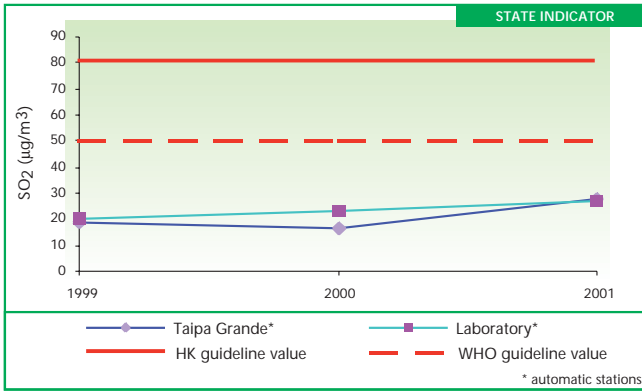
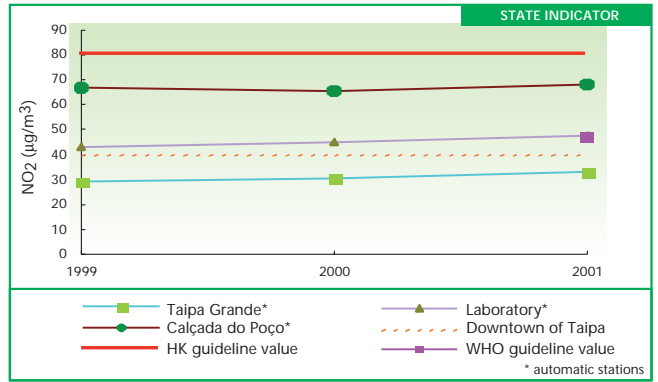
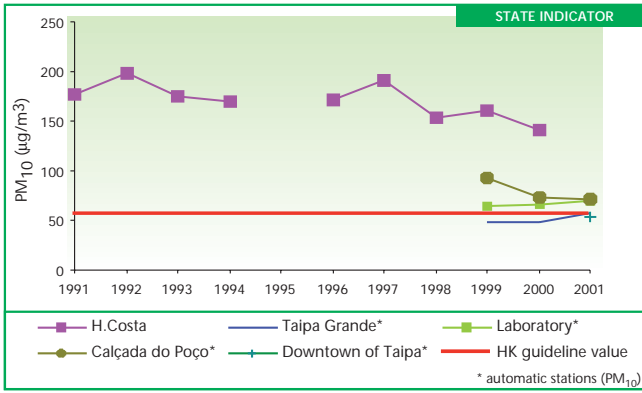
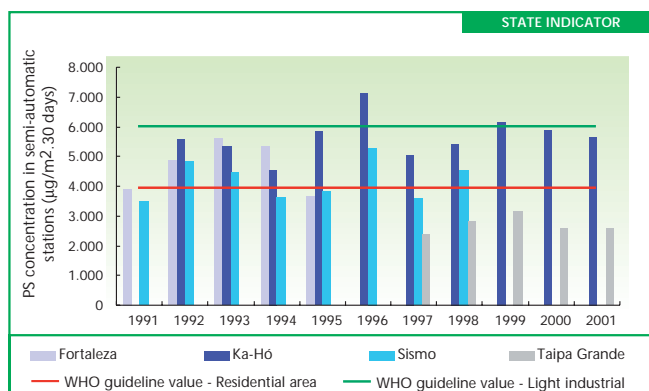


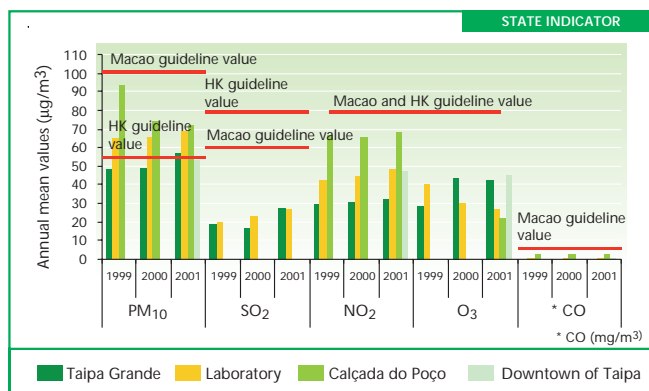
Figure 2.1 Annual mean values of atmospheric pollutants of some automatic and semi-automatic stations (Source: MGB, 2002)







**Figure 2.2**  
Evolution of PS concentration in semi-automatic stations  
(Source: MGB, 2002)

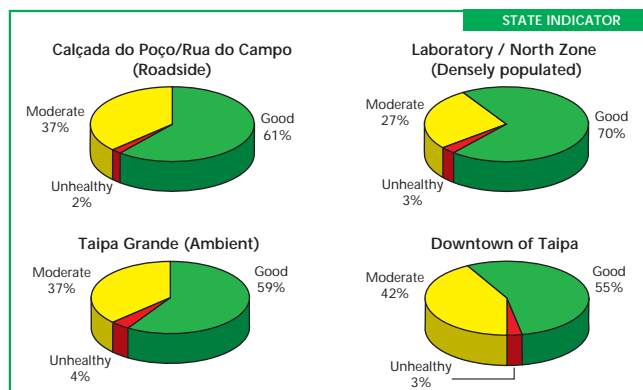


**Figure 2.3**  
Annual mean concentration of some pollutants in automatic stations  
(Source: MGB, 2002)

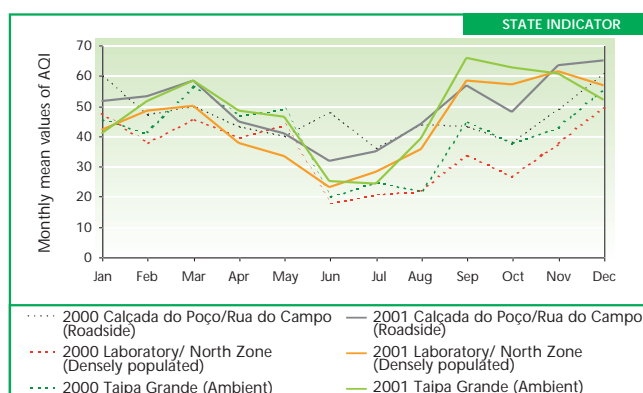
Since Macao is a small geographical area surrounded by water, meteorological factors can deeply affect the air quality. Especially in winter, the concentration of pollutants can vary tremendously from place to place in the same period. Thus, besides the permanent monitoring stations, the MGB also makes use of a mobile station for short term monitoring at different locations. From November 2000 to May 2001 (Autumn to Summer), measurements had been made in Peking Road, Mong-Há Gym and Horta e Costa near Red Market. The obtained result leads to the following preliminary conclusion: the concentration of pollutants is comparatively higher in winter due to meteorological conditions, such as high pressure, stable atmosphere and the prevailing north winds that carry pollutants from the mainland.

The MGB have developed the Air Quality Index (AQI) since April of 1999 and the forecast of the AQI has begun in March 2001. The MGB defined the AQI based on the monitoring of PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>2</sub>, CO, O<sub>3</sub> pollutants concentration and the influential extent of these pollutants towards human health. An index below 100 means that the air quality of station is normal while an index over 100 means that human health may be affected (refer to SoER 2000).

An analysis is made on the variation of the monthly AQI averages in 2000 and 2001, it is found that most of the concentration of pollutants are relatively lower during the wet seasons (April to September). This shows that the pollutants' concentration is greatly affected by the meteorological conditions of Macao, for example the influence of a stable atmosphere during winter months and the strong vertical atmospheric motion in summer.



**Figure 2.4**  
Percentage of occurrence of different AQI classifications in 2001  
(Source: MGB, 2002)



**Figure 2.5**  
Monthly mean values of AQI in 2000 and 2001  
(Source: MGB, 2002)



## 2.2 Atmospheric Emissions

The main sources of atmospheric pollutants by human activities in Macao are combustion facilities such as power stations, industrial boilers, incineration plant, transport and manufacturing industries, etc. Some of the development trend within these industries is not optimistic.

The atmospheric emission inventory of Macao is annually updated and is available from 1990 to 2001. The inventory is based upon the statistical data as well as applies those methodologies which best fit to the characteristics of Macao. They are the result of the compilation of several technical sources: EMEP/CORINAIR *Atmospheric Emission Inventory Guidebook*; IPCC *Guidelines for National Greenhouse Gas Inventories*; US EPA "Compilation of Air Pollutant Emission Factors, AP-42"; PARCOM/ATMOS *Emission Factor Handbook*.

The following charts show the evolution of atmospheric pollutants of Macao and the emission of each pollutant will be assessed annually. The updating of the emissions owing to the main human activities shows that, same as the previous report, the power stations and road traffic are the main sources of emission in Macao SAR. Power generation is the dominant



pollution source of SO<sub>x</sub>, NO<sub>x</sub>, particulates and CO<sub>2</sub>. Road traffic accounts for most of the lead emissions, NMVOC (Non-methane volatile organic compounds) and CO. CH<sub>4</sub> emissions come mostly from the landfill of the urban solid waste, whereas wastewater treatment plants (WWTPs) are the main emission sources of NH<sub>3</sub> and N<sub>2</sub>O.

It is worthwhile to mention the recent decline in lead and sulphur emissions. Lead emissions have declined obviously since the introduction of the unleaded gasoline in Macao. Sulphur emissions have also decreased in 2001 as the Executive Order no.49/2000 has been in place since the 7<sup>th</sup> of August of 2000, which sets the limits of the commercial sulphur content of light diesel for motor vehicles and it should not more than 0.05% by its weight. The decrease in sulphur oxide emissions has decreased less than that of lead due to the contribution of MEC towards sulphur emissions.

With an increasing number of gasoline engine vehicles using catalytic converters, there is a fall in the emissions of CO and VOC, after a maximum value in 1998 and 1999. However, the effect of catalytic converters on reducing SO<sub>x</sub> emissions is not so obvious due to large quantity of MEC's emissions.

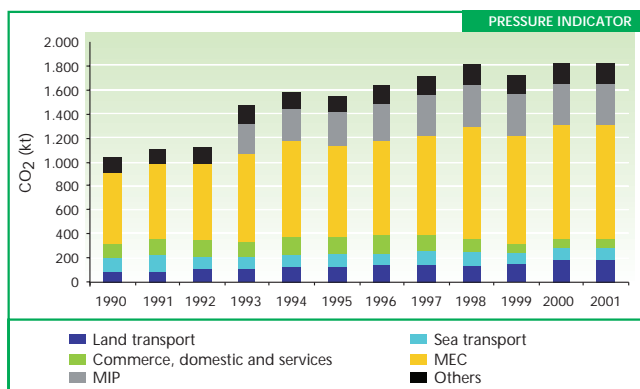


Figure 2.6  
CO<sub>2</sub> emissions  
(Source: IE, 2002)

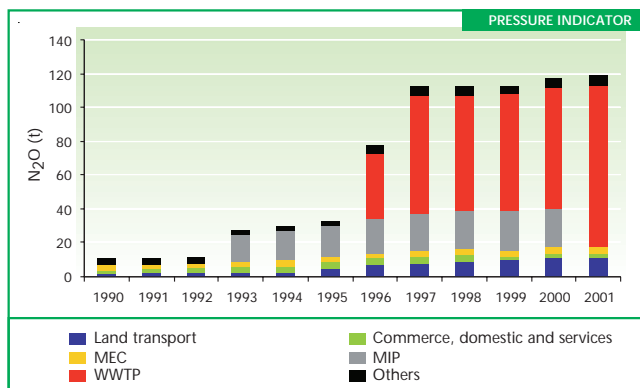
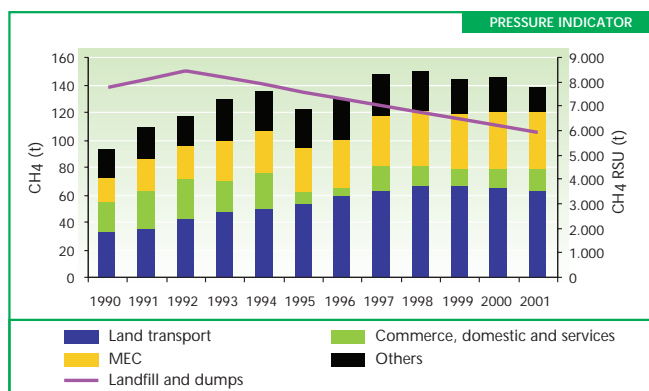
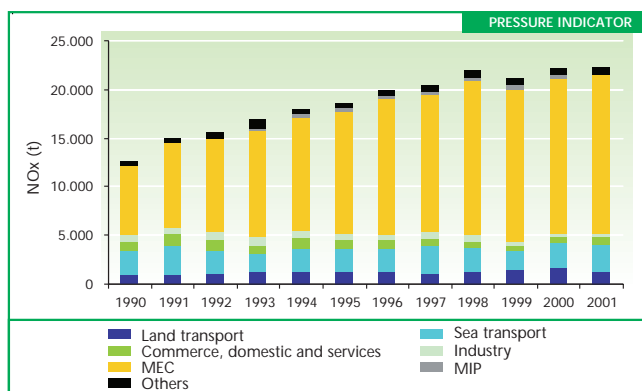


Figure 2.7  
N<sub>2</sub>O emissions  
(Source: IE, 2002)

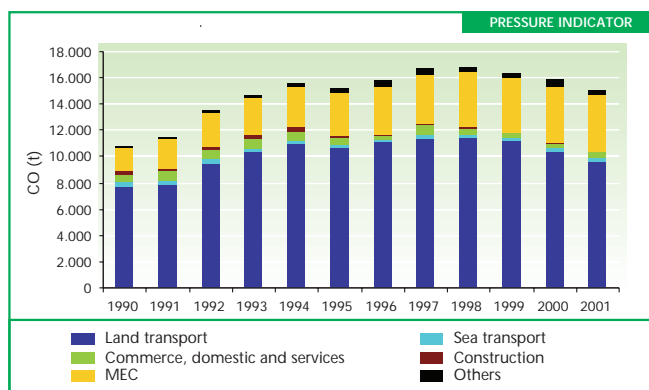




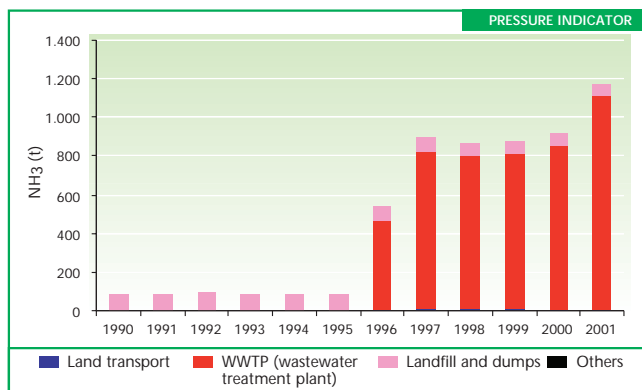
**Figure 2.8**  
CH<sub>4</sub> emissions  
(Source: IE, 2002)



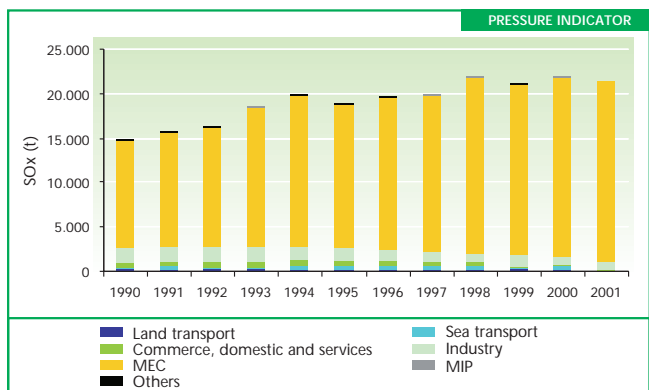
**Figure 2.11**  
NO<sub>x</sub> emissions  
(Source: IE, 2002)



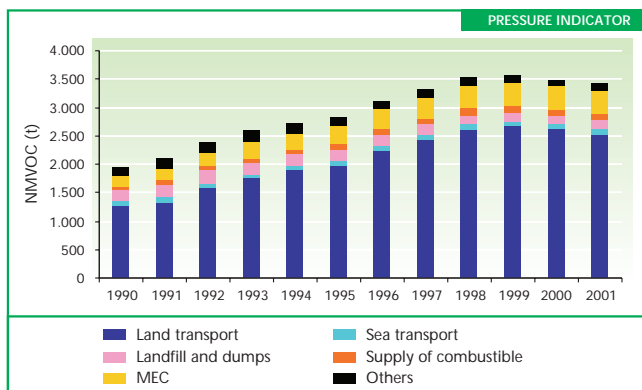
**Figure 2.9**  
CO emissions  
(Source: IE, 2002)



**Figure 2.12**  
NH<sub>3</sub> emissions  
(Source: IE, 2002)

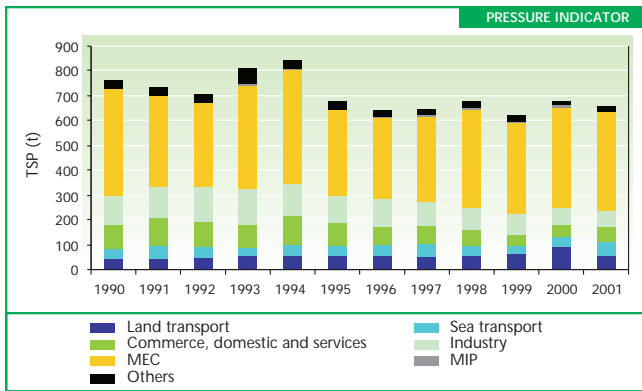


**Figure 2.10**  
SO<sub>x</sub> emissions  
(Source: IE, 2002)

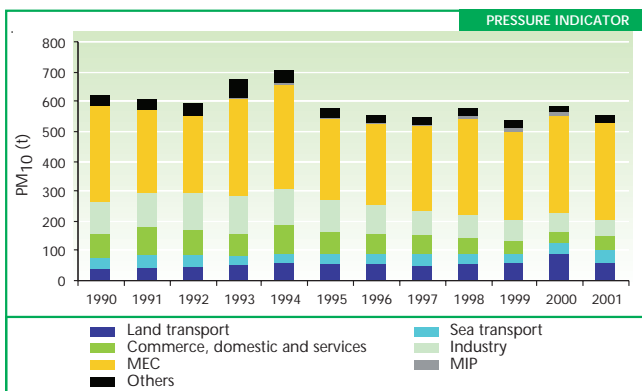


**Figure 2.13**  
NMVOC emissions  
(Source: IE, 2002)

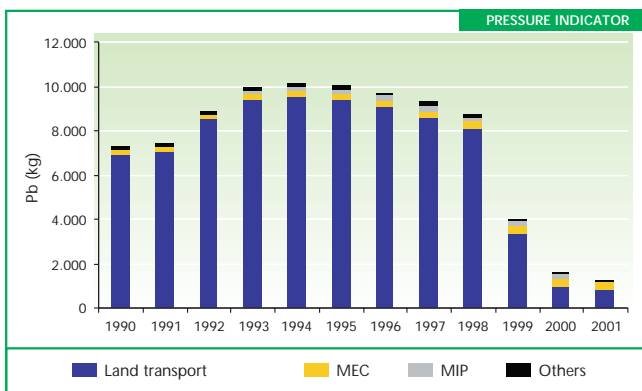




**Figure 2.14**  
TSP emissions  
(Source: IE, 2002)



**Figure 2.15**  
PM<sub>10</sub> emissions  
(Source: IE, 2002)



**Figure 2.16**  
Lead emissions  
(Source: IE, 2002)



### 2.3 Climate Change, Acid Rain, Protection of the Ozone Layer and Photochemical Smog

The concentration of pollutants in the atmosphere mainly depends on the emissions and on the existing meteorological conditions. In some cases, these pollutants are being transported through long distances before they reach the ground. Atmospheric pollution mainly affects urban areas, like Macao, but the problems, which come thereof have no frontiers. This is the reason why such problems become the main concerns in different international agreements and conventions.

Climate change is one of the global environmental problems and has grasped the attention of governments and scientific sectors all over the world. Macao is a member of the Framework Convention on Climate Change of the United Nations and therefore commits to endeavour towards the control of greenhouse gases emission (GHG). The Meteorological and Geophysical Bureau (MGB) is nominated as the focal point in Macao for this convention.

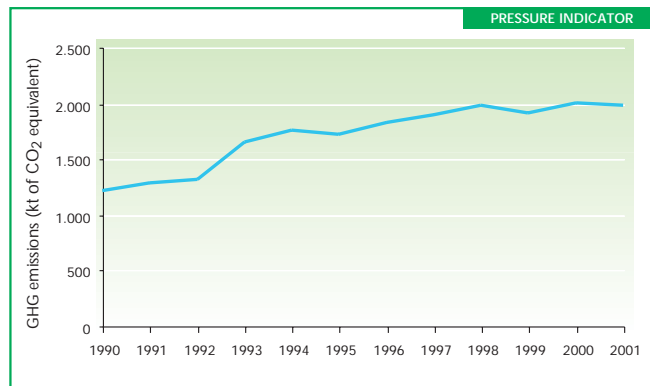
Carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O) and halogenated compounds such as HFCs, PFCs, and SF<sub>6</sub> are gases that contribute most significantly to the greenhouse effect.

For quantifying the effect of greenhouse gases to global warming, these gases are usually expressed in CO<sub>2</sub> equivalent and based on GWP (Global Warming Potential) calcu-



lated over a 100-year period. CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O are generally considered as possessing “global warming potential” greenhouse gases.

Between 1990 and 2001, the total GHG emissions have increased 66%.

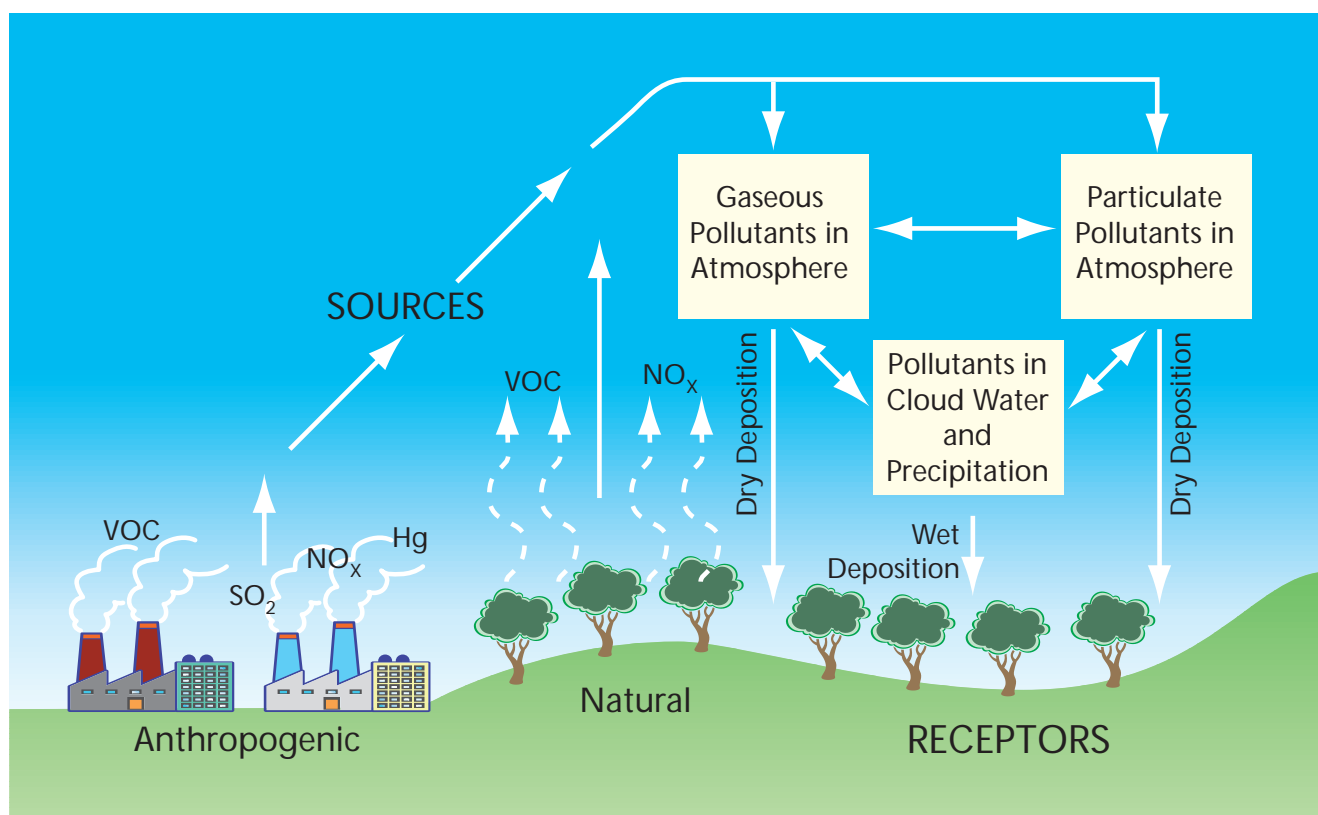


**Figure 2.17**  
Evolution of GHG emissions  
(Source: IE, 2002)

Acid rain occurs in the Pearl River Delta region, mainly due to excessive concentrations of sulphur oxides and nitrogen oxides; smoke and dust generated by local or regional industries and by suspended particulates emitted in the adjoining areas and in the Macao SAR. They are then transported by wind along hundreds of kilometres. These facts have been confirmed through the surveys carried out by the Macao MGB in co-operation with the University of Macao. Therefore, Macao shares its responsibility to the region where it is located.

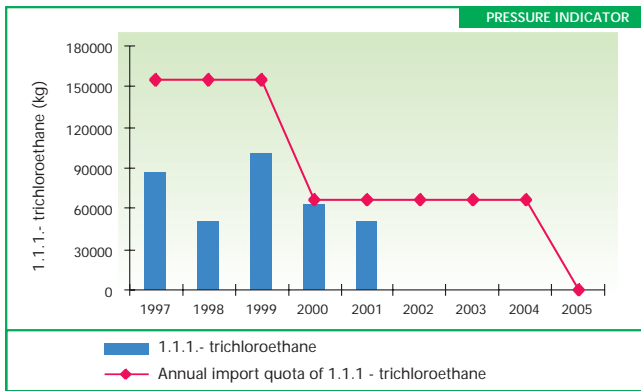
Depletion of the stratospheric ozone layer (generally known as “good ozone”) is another issue with international significance. This layer is the fundamental to protect life on earth because of the fact that stratospheric ozone has the ability to absorb ultraviolet-B radiation (UV-B), which may cause adverse (or even lethal) effects on living organisms.

Among the chemical substances subject to the reduction measures established in the Executive Law no.62/95, the import of 1, 1, 1-trichloroethane is now being controlled according to Order no.78/GM/95 and it is expected that none of them can be imported by 2005.



**Figure 2.18**  
The formation of the acid rain  
(Source: USEPA, 2002)





**Figure 2.19**  
Imports and annual quota of 1,1,1-trichloroethane  
(Source: EC, 2002)

Smog is an English term to describe the combination of smoke and fog. Photochemical smog contains a combination of primary pollutants (nitrogen oxides, hydrocarbons and volatile organic compounds, etc.) emitted into the atmosphere. These pollutants react through a series of complex chemical reactions together with oxidation by sunlight, forming the

tropospheric ozone and commonly known as “bad ozone”. These compounds react with other atmospheric pollutants and end up forming a group of harmful substances ( $\text{HNO}_3$ , PAN, formaldehydes,  $\text{O}_3$ ...) which cause adverse effects on vegetation, eye irritation and respiratory problems.

Although this phenomenon almost takes place in every city in the world, it occurs quite often in urban centers with heavy traffic, industrial areas and specific climate conditions such as a hot climate, stagnant air flow and thermal inversions, which obstruct the air exchange and the pollutants' removal.

The University of Macao and the MGB of Macao collaborate in the study of photochemical smog and the preliminary result shows that temperature, sunlight and relative humidity are some determined factors for photochemical smog. The study also predicts that photochemical smog in Macao will happen when the relative humidity is below 40% in summer or when the temperature is over  $28^\circ\text{C}$  in winter. Based on the above two meteorological conditions, the probability of the occurrence of photochemical smog in Macao is comparatively low.



**Figure 2.20**  
The formation of the photochemical smog  
(Source: USEPA, 2002)



Due to the importance of the energy and the transport sectors regarding the atmospheric environment, for example the emission of pollutants and greenhouse gases, an analysis of these two economic sectors is hereafter presented.

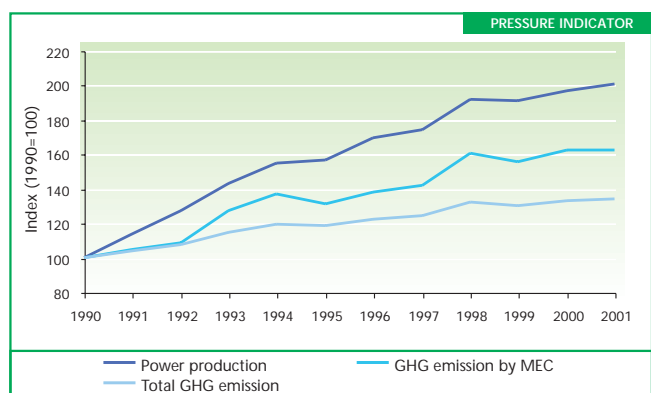
## 2.4 Energy Sector

In the Macao SAR, since there is no alternative energy source (such as wind or solar energy) that can be used, fuel combustion becomes the main source to meet the energy needs as well as the major source of pollutant emission. This activity is carried out by the Macao Electricity Company (MEC) and its production capacity has increased remarkably in the past decade in order to fulfil the increasing electricity consumption demand.

A new power station “Coloane-B” began its operation on 2001. The station uses combined cycle technology which emits 20 times less NO<sub>x</sub> than diesel when used as the combustion fuel.

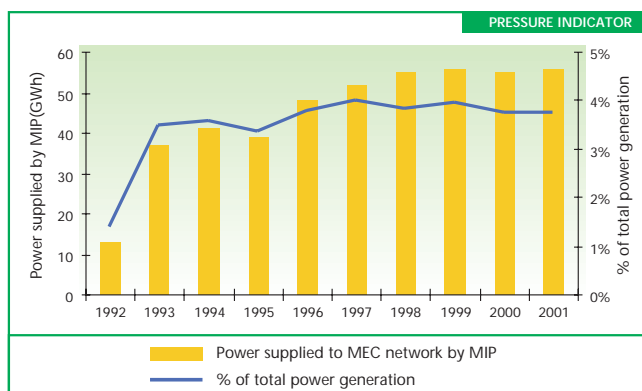
MEC is the main source of atmospheric emissions as well as greenhouse gases and this can be reflected through the portion of energy generation over the whole industrial sector of Macao, the type of equipment used in the stations as well as the lack of facilities to control the pollutant emissions in the Macao Power Station and in Coloane-A Power Station. However, MEC has been endeavouring to reduce, control and implement measures so as to reduce atmospheric emissions.

Analysing both factors, it is found that the increase in the power production has been higher than the emissions of the main GHGs – CO<sub>2</sub>, NO<sub>x</sub> and CH<sub>4</sub>. It shows that there is no correlation between these two parameters.

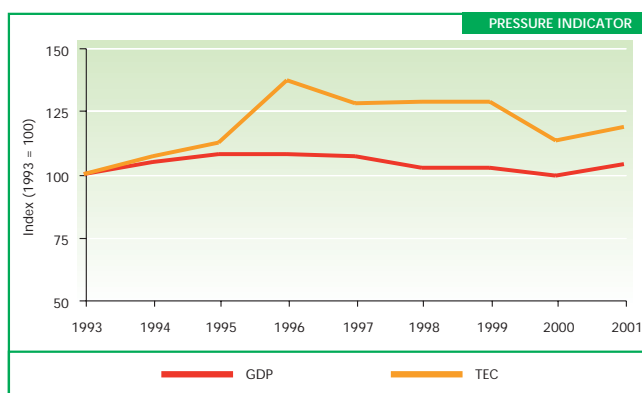


**Figure 2.21**  
Evolution of power generation and GHG emission  
(Source: MEC and EC, 2002)

Since 1992 the heat generated during the incineration of the waste in MIP has been used for the production of electrical power. In 2001, MIP had sold 56 GWh of energy to MEC.



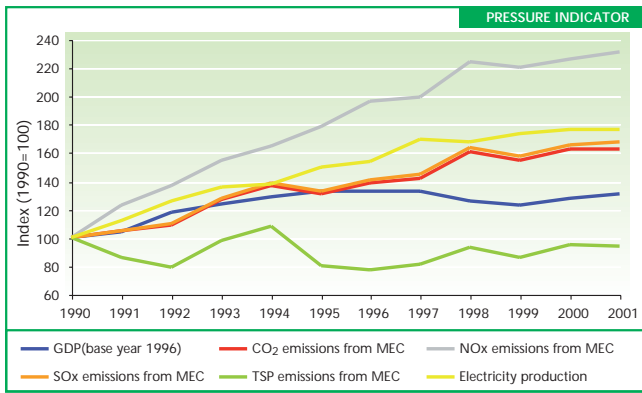
**Figure 2.22**  
Energy supplied to MEC  
(Source: MEC, 2002)



Note: Total energy consumption, GDP at 1996 consumer price  
It includes consumption in industry, construction, transport, commerce, households and others in addition to electricity and traditional fuels.

**Figure 2.23**  
Evolution of the total energy consumption and GDP  
(Source: MEC and SCS, 2002)



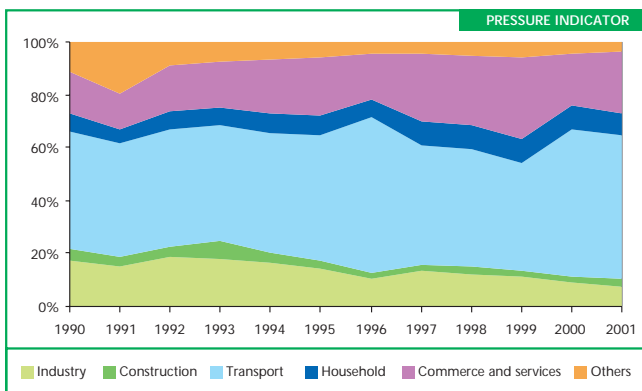


**Figure 2.24**  
Eco-efficiency of the energy sector  
(Source: SCS, MEC, IE, 2002)

## 2.5 Transport

Next to electricity production, the transport sector also has great impact upon the environment. Over the last decades a sharp rise in the development of transport occurred, especially in road transport, and this has decisively contributed to the increase of GHGs.

In Macao, about 46% of the total energy consumed referred to the energy consumption of the transport sector (this total energy consumption does not take into account the consumption of MEC, the supplier of energy). The large number of motor vehicles in circulation (the majority being privately owned cars) causes undoubtedly environmental impacts such as air and noise pollution.

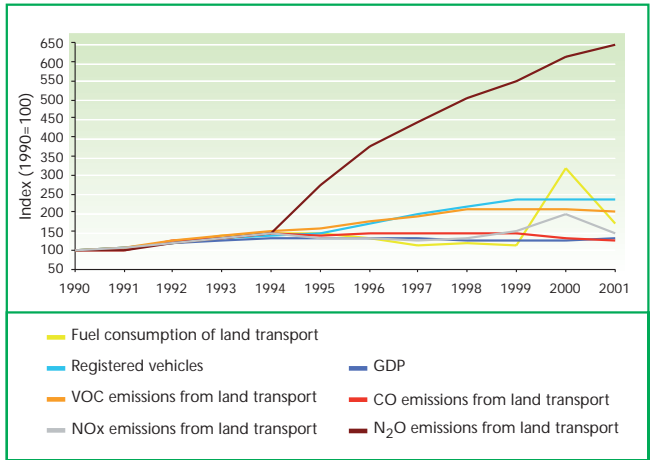


Note: This account does not include neither electricity nor traditional fuels consumption (charcoal, logs, billets, branches or fogots). The transport sector includes the consumption of fuels on road and sea transport only, since data on air transport are classified. "Others" includes fishing, services, electricity (excluding consumption by the MEC) and water.

**Figure 2.25**  
Energy consumption of each sector (excluding MEC)  
(Source: SCS, 2002)

In fact, the advanced technologies in the automobile industry (such as the introduction of catalytic converters in 1995

and the reduction of sulphur and lead content in fuels) have reduced some of the negative effects on the environment (such as particulates, NOx, VOC and CO emissions etc.). However, these measures are not enough to compensate the growing traffic intensity.



Note: During the major part of the analysed period of time the constant increase of the number of vehicles does not correspond to the fuel consumption. It can be concluded that a significant quantity of fuel may not be taken into account. Data from 2000 includes the quantity of fuel that the importers/distributors sold to outlets (refer to Energy Balance, SCS 2000), which justifies for a sharp increase in 2000.

**Figure 2.26**  
Eco-efficiency in the transport sector  
(Source: SCS and IE, 2002)

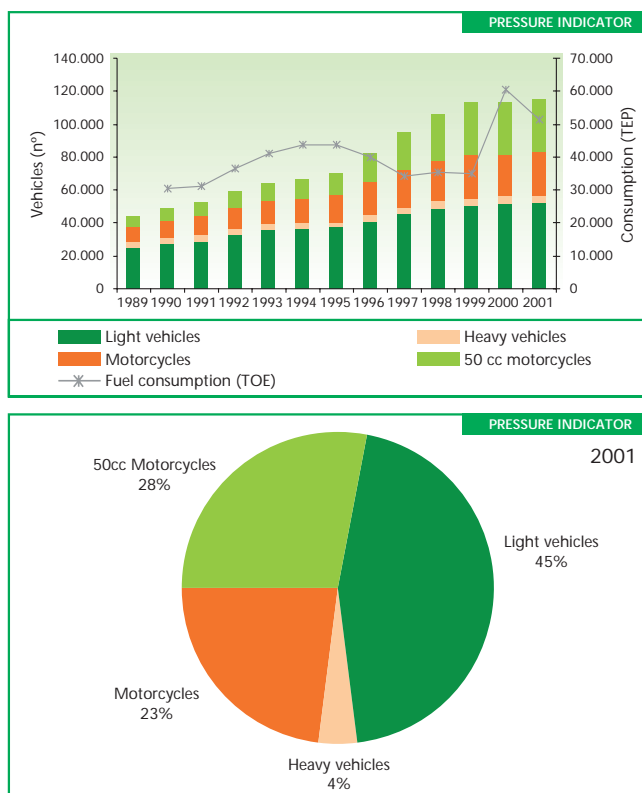
The Environmental Council has started a survey about the "Study of Vehicle Emissions" in 2002, aiming at gathering more precise information regarding the distance completed by vehicles through a questionnaire in order to evaluate and to





characterize the respective emissions. In addition, analysis of the vehicles emission at a low speed is also conducted and the results have been compared with the emission standards of the neighbouring regions, in order to assess the actual situation of the emission of vehicles in Macao.

Although certain kinds of measures have already been implemented in Macao in order to alleviate the impacts caused by the increasing number of vehicles towards the environment, health and quality of life, roads continue to be heavily congested.



**Figure 2.27**  
Evolution of the number of vehicles in circulation and the corresponding fuel consumption  
(Source: SCS, 2002)









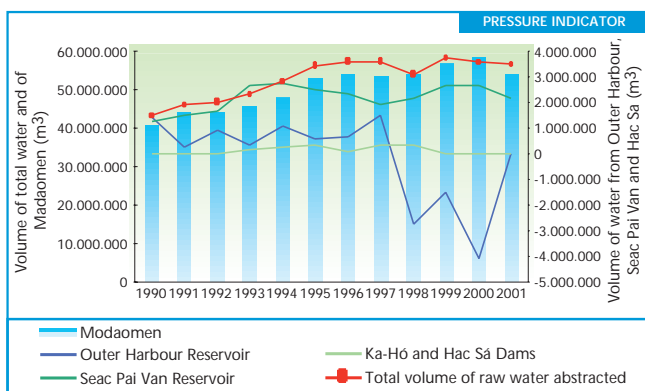
# 3 Water Supply

## 3.1 Drinking Water

### Water Supply

With a small geographical area and the lack of natural water resources limit the availability and the use of fresh water in Macao. Raw water is extracted from the Madaomen Canal (PRC) and then conveyed by gravity to the Ilha Verde Water Treatment Plant. Surplus water is delivered and stored in the Outer Harbour Reservoir in Macao. In addition, the Seac Pai Van Reservoir and the Ka-Hó and Hac-Sá Dams collect and store rainwater.

The raw water abstracted from Madaomen decreased in 2001 compared to 2000. Unlike the last three years, in 2001 there is no need to use the water in the Outer Harbour Reservoir. Hence, its value is zero as shown Figure 3.1.

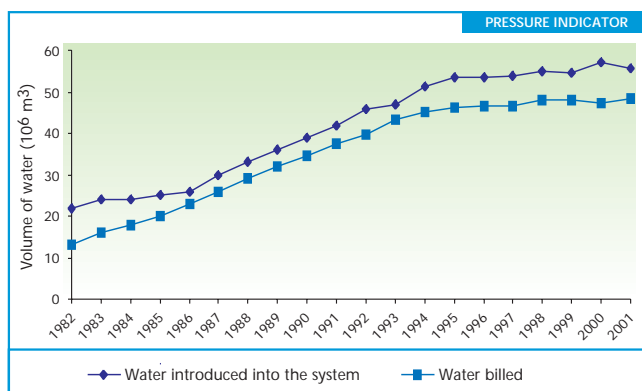


**Figure 3.1**  
Volume of raw water supplied to Macao  
(Source: CMAB/MLM, 2002)

In 2001 there was no salinity problem and therefore, it is not necessary to use the water in the Outer Harbour Reservoir for saline water dilution. However, the Macao Water Supply Company (MWSC), who is responsible for the supply of drinking water in Macao, with the support of the Pearl River Water Resources Committee, had appointed a consultant company to conduct a study in solving the high salinity levels usually found in raw water based on their experiences of previous years. The results of the study indicated that to relocate the point of water abstraction upstream might be a better solution.

### Water Consumption

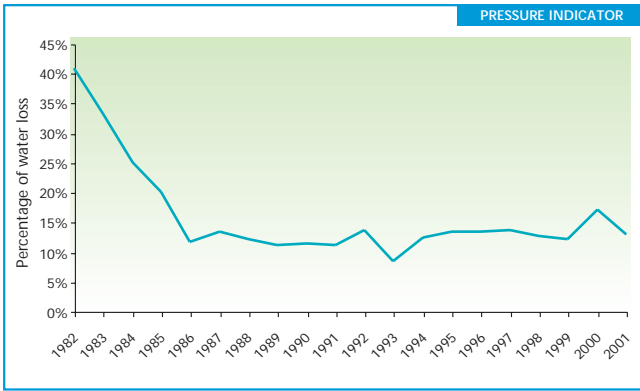
The raw water after treatment is then supplied to the customers through the water distribution network.



**Figure 3.2**  
Volume of water introduced in the system and billed  
(Source: CMAB, 2002)

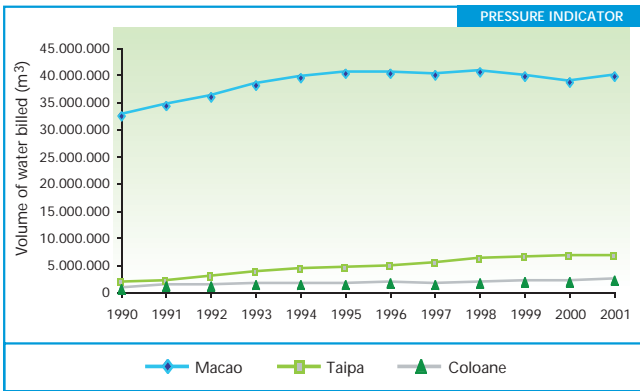




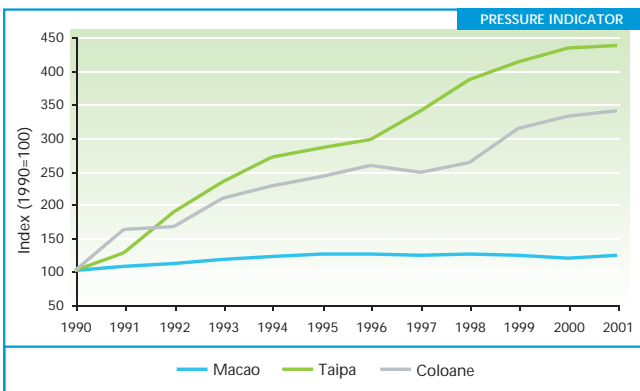


**Figure 3.3**  
Percentage of water loss in the water distribution network  
(Source: CMAB, MWSC, 2002)

It is shown that more water was consumed in the Macao Peninsula. Water consumption in Taipa has also shown a sharp increase in percentage. This indicates the rapid growth of population in Taipa. In fact the number of residents in Taipa has increased about six times during the past decade.

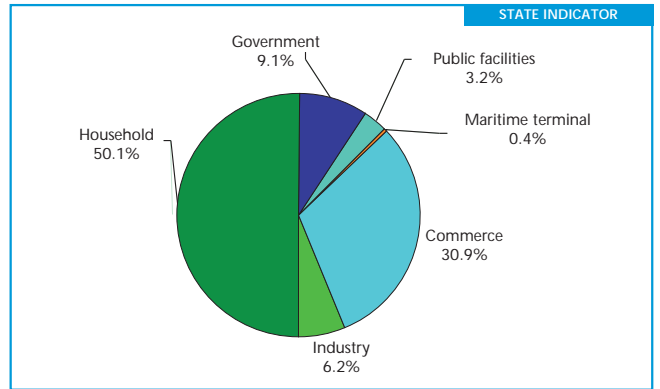


**Figure 3.4**  
Volume of water billed by geographical area  
(Source: CMAB, 2002)



**Figure 3.5**  
Evolution of the water billed volume by geographical area  
(Source: CMAB, 2002)

Similar to previous years, household is the dominant sector in water consumption in the Macao SAR in 2001 (about 50% of the total consumption), followed by the commercial sector (about 30% of the total consumption).



**Figure 3.6**  
Types of water-use distribution in the MSAR in 2001  
(Source: MWSC, 2002)

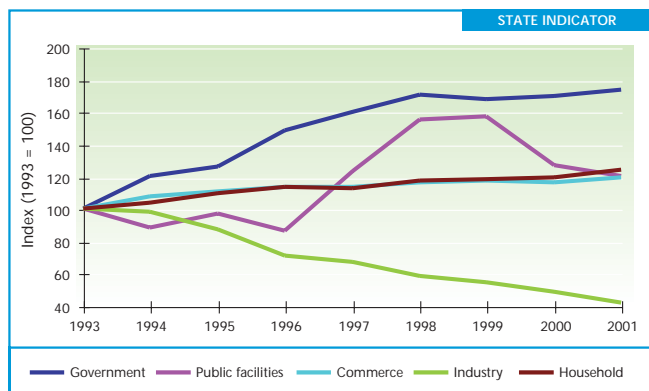
In 2001, household and commerce are the major water consumption sectors in the Macao Peninsula. In Taipa, there is a significant increase in water consumption in both the commerce and household sector, especially in the former. In Coloane, a less populated area of Macao, water consumption in the commerce sector has been increasing in recent years, while the consumption of household section is relatively low.





After analyzing the water consumption in every sector and comparing the results since 1993, it is found that water consumption has sharply decreased in the industrial sector as well as in the public facilities in the last two years. The drop of water consumption in the industrial sector is mainly caused by the decrease in the water consumption of laundry sector, the construction sector and the leather industry.

The water consumption in the government sector has the greatest increase (70%), which is due to the increase of urban water consumption in the Macao Peninsula.



**Figure 3.7**  
Evolution of the water consumption by different sectors since 1993  
(Source: MWSC, 2002)

### Quality of Drinking Water

The raw water quality at Madaomen Canal corresponds to the A2 water standard, i.e., which means the water requires the usual physical, chemical and disinfection treatment before it can be consumed.

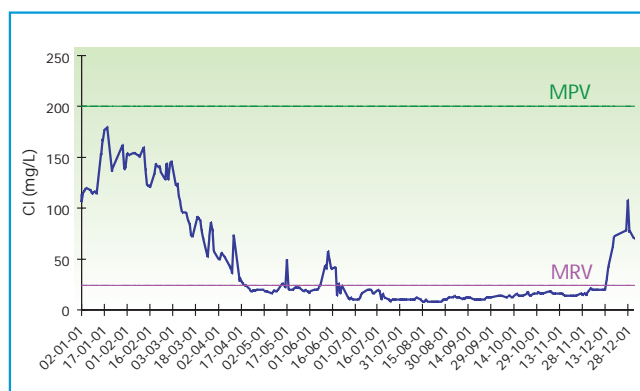
The CMAB, through the Municipal Laboratory of Macao, monitors and controls the quality of the drinking water of Macao. Raw water samples and treated water samples from the three water treatment plants (WTPs), located at Ilha Verde, Outer Harbour, Coloane and distribution network are normally

collected in order to proceed bacteriological, physical and chemical analysis.

As 2000, the chloride concentration did not exceed the Maximum Permissible Value (MPV) in 2001. This parameter normally reaches relatively higher values during the dry season.

The fluoride concentration is still below the Minimum Permissible Value.

The lack of precise data limits a complete analysis of relevant parameters in the various WTPs. The chloride concentration in the Ilha Verde WTP is shown in Figure 3.8.



**Figure 3.8**  
Chloride concentration in the Ilha Verde WTP in 2001  
(Source: MLM, 2002)

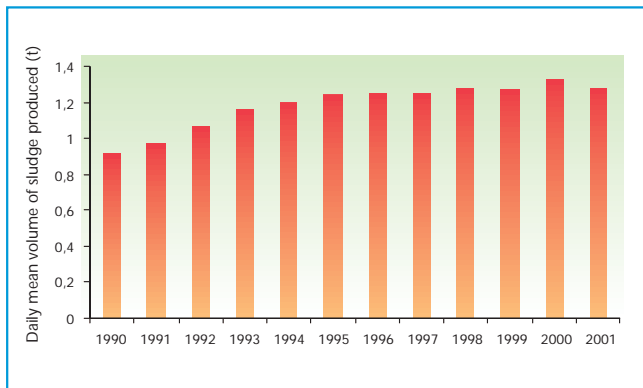
Regarding the analysis of the microbiological parameters in the water distribution networks, there is no available information referred to the violation of standards. The results of the total number of bacteria and coliform in 2001 was not found in both the Macao Peninsula and Taipa networks, but it is registered once in the Coloane network. Regarding the total number of bacteria, the percentage of finding 10 or above bacterial count in network is the lowest in Taipa while it is the highest in the Macao Peninsula.



**Table 3.1**  
 Analysis of the total count of bacteria and coliform in the Macao networks in 2001  
 (Source: CMAB / MLM, 2002)

Parameters	Classification group	Macao Peninsula network Percent(%)	Taipa network Percent(%)	Coloane network Percent(%)
Count of bacteria 37°C	<1	67.3	80.3	72
	1-9	27.8	18.2	26.5
	10-49	3.5	1.5	0.8
	50-99	0.5	0	0
	>100	0.8	0	0.8
Total coliform 37°C	<1	100	100	99.2
	1-9	0	0	0.8
	10-49	0	0	0
	50-99	0	0	0
	>100	0	0	0

In the water treatment process, sludge, which usually contains microorganisms and aluminum salts, is normally produced because of the use of coagulants. In 2001, the daily amount of sludge produced has reached 1.3 ton. The compound contains mostly of microorganisms and aluminum salt. At present, owing to the limited space, no specific equipment has been installed for sludge decantation. Meanwhile, processes of sludge treatment are being studied.



**Figure 3.9**  
 Daily mean volume of sludge produced in water treatment plants  
 (Source: MWSC, 2002)



## 3.2 Bathing Beaches and Coastal Water

### Factors affecting the coastal water quality

The water quality of the coastal areas in Macao is affected by both internal and external factors. Regarding internal factors, the present drainage system of Macao consists both the combined and the separate sewers. The wastewater collected by the separate sewers is transferred to the three wastewater treatment plants (WWTPs) for secondary treatment before discharge. Part of the wastewater collected by the combined sewers is being discharged to the coast prior to treatment. In addition, there are also direct discharges of rainwater, which carry terrestrial and atmospheric pollutants into the estuary during the rainy season and hence aggravating water pollution in the coastal areas.

Regarding external factors, as Macao is located in the southwest of the Pearl River Delta where several river branches flow, the quality of coastal waters is not only affected by local pollution sources but also by pollution from upstream and neighboring tidal flows. Since the Pearl River Delta possesses an actively developing economy as well as a rapidly increasing population, the tremendous amount of domestic, industrial and agricultural wastewater imposes heavy impacts on

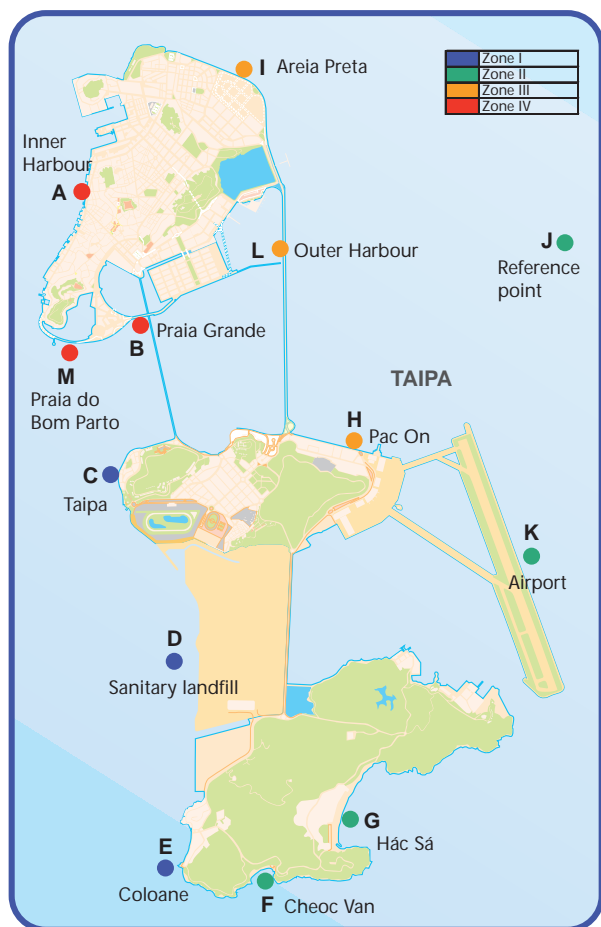
the water environment. During the rainy season from April to September each year, water from upstream flows into the sea through the coastal zones of Macao and the coastal water quality is obviously affected by the upstream flows during this period.

### Monitoring the quality of coastal water

In order to protect the coastal water in Macao, monitoring and assessment of water quality are carried out. The Public Health Laboratory (PHL) of the Health Department (HD) is responsible for the monitoring of coastal water since 1988. The sampling points of the coastal water are shown in Figure 3.10.

### Assessment of water quality

Since 2000 the PHL started to use the pollution index to assess the coastal water quality. The objective is to evaluate the utilization of water body according to certain water quality criteria in order to assess the degree of pollution, the sources and the main types of pollutants as well as their trends. Since the Macao coastal water possesses seawater characteristics, the PHL has been referring to the Class 2 parameters for water quality established in the *Sea water quality standard* of China (GB3097-97). According to the Class 2 standard, the water quality is appropriate for aquiculture, bathing, sports or recreation in which the human body is in direct contact with seawater; it is also considered to be appropriate for food industry. Different parameters are shown in Table 3.2. The pollution index of each parameter, the average pollution index and the nutrient index are adopted for the analysis of the water environment.



**Figure 3.10**  
Location of the sampling points of the coastal water monitoring network (Source: PHL, 2001)

**Table 3.2**  
Maximum permissible values for Class 2 water quality parameters established by the *Sea water quality standard* of China (GB3097-97).

Parameter	Maximum permissible value (mg/l)
pH	7.8-8.5
Dissolved oxygen	>5
Chemical oxygen demand	≤3
Biochemical oxygen demand in 5 days	≤3
Inorganic nitrogen (in terms of N)	≤0.30
Non-ionic nitrogen (in terms of N)	≤0.020
Active phosphate (in terms of P)	≤0.030
Mercury	≤0.0002
Cadmium	≤0.005
Lead	≤0.005
Total chromium	≤0.10
Nickel	≤0.010
Copper	≤0.010
Zinc	≤0.050
Selenium	≤0.020
Arsenic	≤0.03



## Average Pollution Index

The average pollution index is calculated by the arithmetic means of the pollution index of each different parameter. The pollution index of each parameter is defined as the difference between the actual monitoring average value and the maximum permissible value. Analyzed parameters include pH, dissolved oxygen, chemical oxygen demand, biochemical oxygen demand in 5 days, nitrogen and phosphorus-containing nutrient pollutants and heavy metals pollutants.

To facilitate the assessment of the coastal water, seawaters are classified into 4 classes, according to the average pollution index (I):

- Class 1:  $I \leq 0.50$       good water quality, water is not polluted;
- Class 2:  $0.50 < I \leq 0.75$       water with acceptable quality;
- Class 3:  $0.75 < I \leq 1.00$       polluted water that affects the normal growth of plants and organisms;
- Class 4:  $I > 1.00$       polluted water that causes adverse effects on public health.

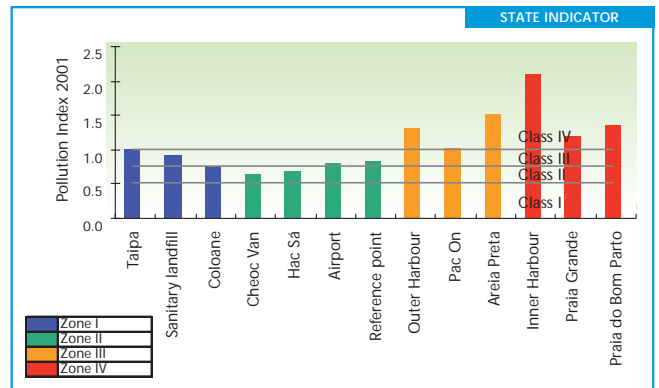
With the use of the index to analyze the Macao coastal water, it is found that all the coastal zones in Macao are classified as between Class 2 and 4, e.g. which means that the water has been polluted to different extent.

Zone II (Cheoc Van, Hác Sá, Airport and Reference Point) shows better water quality, although both the airport and the reference point have already reached pollution level of Class 3, which is a critical pollution level.

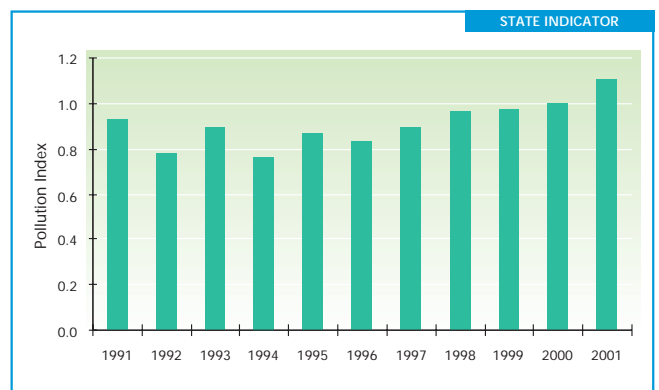
Regarding Zone III (Pac On, Outer Harbour and Areia Preta) and IV (Inner Harbour, Praia Grande and Praia do Bom Parto), all sampling points have reached Class 4 which indicate a serious polluting level.

Although the pollution level of the Inner Harbour still reaches the highest pollution level among all the sampling points, the pollution index at this point has increased linearly since 1996 to 2000. However, there is a slight decrease in the pollution level in 2001.

In 2001, the water quality of the sampling points in Zone I (Taipa, Sanitary Landfill and Coloane) is between Class 2 and 3 as in last year.

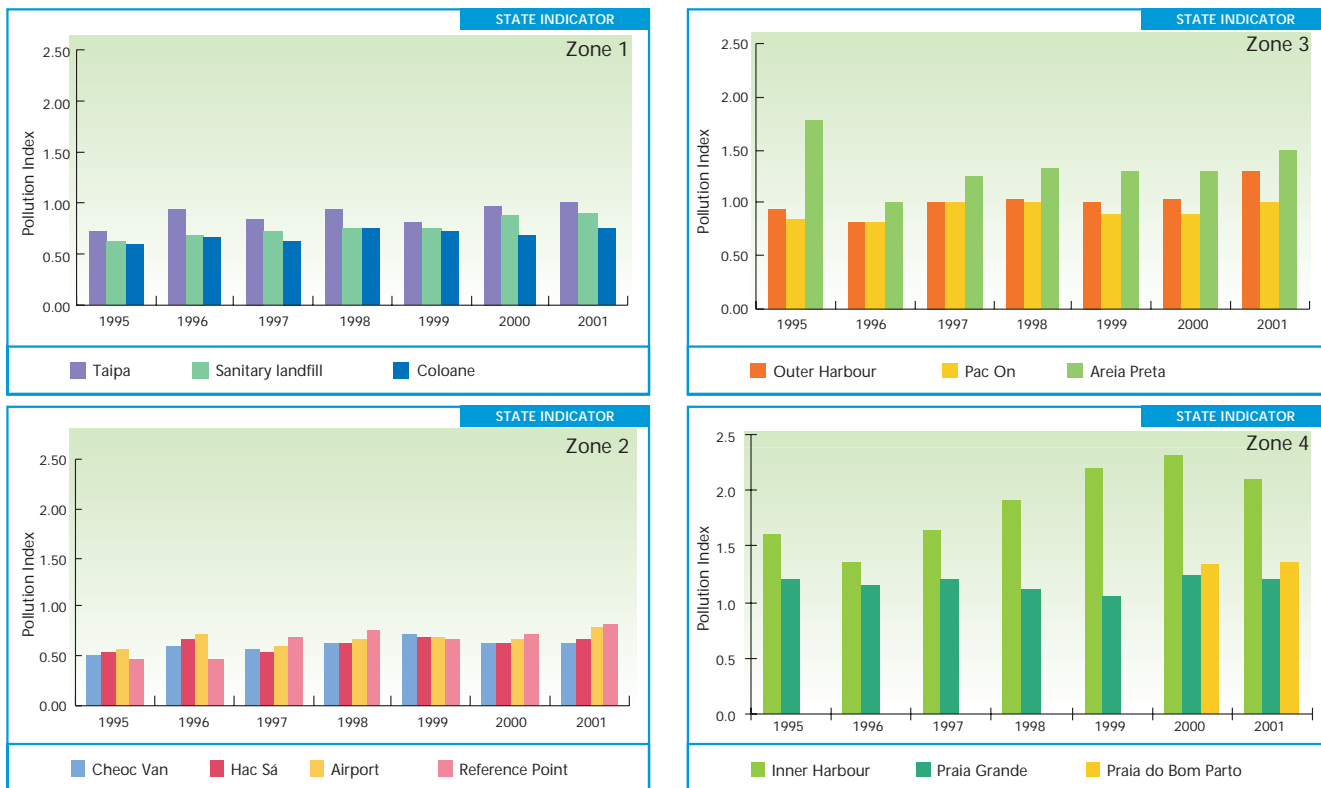


**Figure 3.11**  
Pollution index of each sampling point in 2001  
(Source: HB, 2002)



**Figure 3.12**  
Evolution of the annual mean value of the pollution index of the coastal waters in Macao  
(Source: HB, 2002)





**Figure 3.13**  
Pollution index of different sampling points  
(Source: HB, 2002)



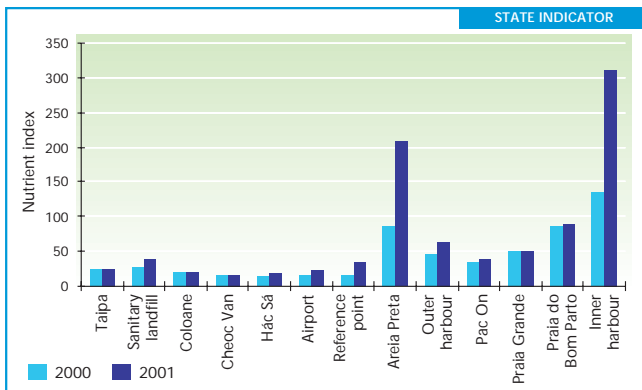
### Nutrient index

The nutrient index is calculated based on the analysis of parameters such as COD, phosphorous and inorganic nitrogen. It represents the eutrophic level of the water. When  $E > 1$ , it means that the concentration of nutrients in water has reached an eutrophic level.

The following figure shows that all sampling points at different Macao coastal zone have the nutrient index greater than 1. The most critical zones are Areia Preta and Inner Harbour, whose values have reached 200 and 300 in 2001 at the sampling points respectively. Even in the less polluted zone of Cheoc Van and Hác Sá, the nutrient index is greater than 10 at the sampling points.

It is worth noticing that the value of the inorganic nitrogen pollution index is greater than 2.0 in all sampling points. In the Inner Harbour, the index is close to 7.0. It shows that the pollution level of inorganic nitrogen is rather high in the Macao water.

Eutrophication of the water body provides the materials and conditions for the rapid and excessive growth of algae as well as other types of plankton and may increase the possibility of red tide occurrence. At the beginning of 2001, 2 red tides with *dinoflagellates*, a type of toxic algae, had taken place.

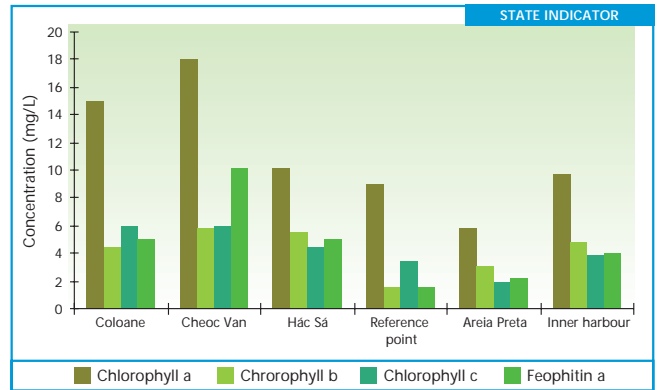


**Figure 3.14**  
Nutrient index of different sampling points  
(Source: HB, 2002)

### Chlorophylls

In order to deepen its knowledge about the red tides in the Macao waters, the PHL began to analyze the chlorophylls-a, b, c, and the feophitin-a from the water samples of the 6 sampling points, namely Hác Sá, Cheoc Van, Reference Point, Areia Preta, Coloane and Inner Harbour since 2000. The concentration of chlorophyll-a is frequently used as an indicator of algae growth. The content of chlorophylls-a, b, and c helps to assess the types of algae and plankton of the water body. The analysis reveals that in the first quarter of 2001, the con-

centration of chlorophyll-a at the sampling point of Cheoc Van and Coloane is obviously high, which seems to have a correlation to the occurrence of red tides during the same period.



**Figure 3.15**  
Concentration of Chlorophyll a, Chlorophyll b, Chlorophyll c and Feophitin a of different sampling points in 2001  
(Source: HB, 2002)

### Heavy metals

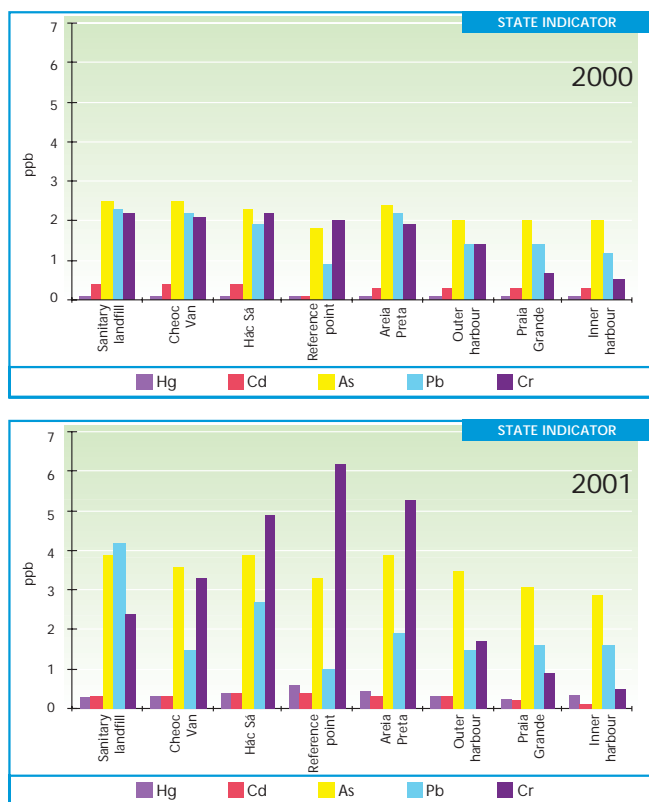
Heavy metals such as arsenic (As), cadmium (Cd), chromium (Cr), mercury (Hg), lead (Pb) and their ionic compounds are toxic and hazardous to human and the water body since they can accumulate in the organic body.

Analysis indicates that concentrations of these compounds have significantly increased in 2001, compared to that of 2000.

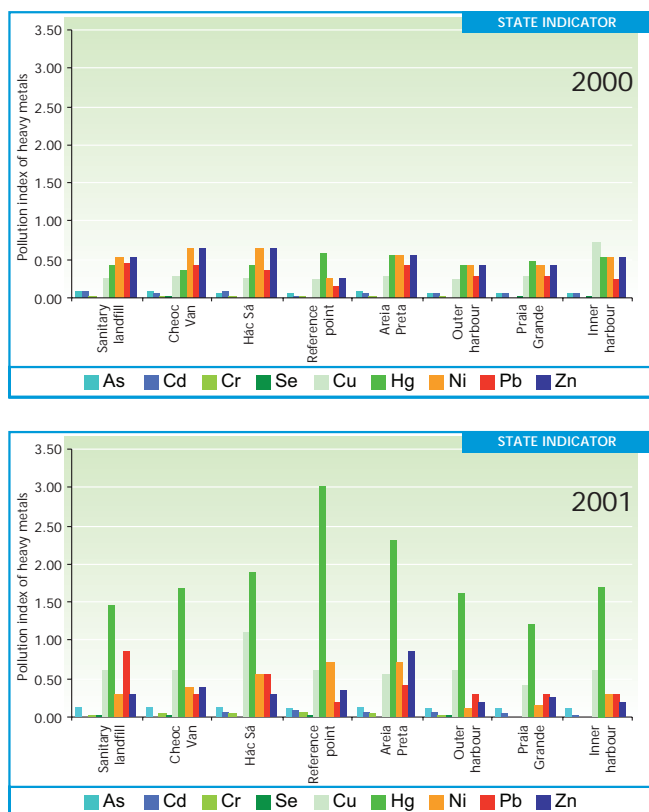
Comparing the values obtained in the various sampling points in Macao with the parameters of Class 2 water quality established by the *Sea water quality standard* of China (GB3097-97), it is found that the mercury concentration is higher than the established limit (0,2 mg/l) in 2001. It is necessary to identify the causes of this problem as well as to take urgent measures to solve the problem.







**Figure 3.16**  
Annual mean values of the heavy metal concentration in 2000 and 2001  
(Source: HB, 2002)

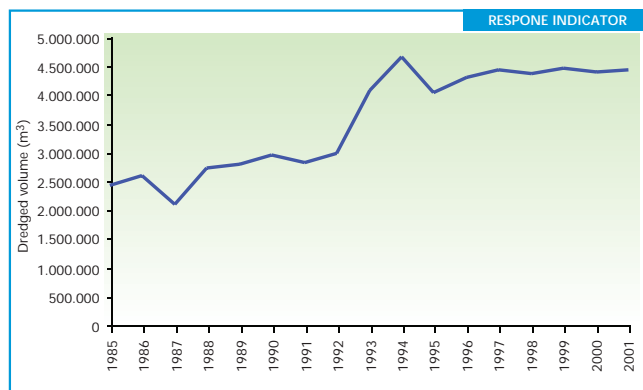


**Figure 3.17**  
Pollution index of heavy metals in 2000 and 2001  
(Source: HB, 2002)

According to the “International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990”, the Guangdong Province, the Hong Kong SAR and the Macao SAR have signed a protocol with the aim of taking joint measures for large scale oil spillage in the Pearl River Delta region in order to protect the coastal water quality.

### Dredging

The sedimentation causes a series of problems such as the elevation of riverbeds and the obstruction of waterways in the Pearl River Delta region. Therefore it is necessary to dredge several million cubic meters of sediments annually. In recent years, the dredged volume remains at the same level.



**Figure 3.18**  
Dredged volume since 1985  
(Source: PA, 2002)

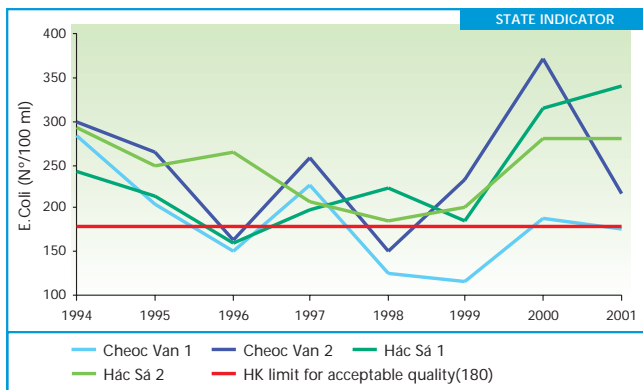
### Bathing water quality beaches

The monitoring of water quality in Cheoc Van and Hác Sá beaches is still the responsibility of the PHL of the Health Bureau. The sampling and analysis is carried out once per month. Analysis includes microbiological, physical, chemical and whenever possible, the results are compared to the limits of China, Hong Kong and the European Union standards. If red tide occurs, it will proceed sampling again.

At present, the *Vibrio cholerae* (cholera virus) and *Escherichia coli* content are indicators being systematically examined for identifying whether the water body is microbiologically polluted. Like in 2000, the cholera virus (*Vibrio cholerae*) was not found in the samples from the beaches in 2001. But by the end of January and in the beginning of February of 2001, red tides have occurred in Cheoc van, Hác Sá and other coastal areas.

As to the content of *Escherichia coli* in 2001, it is found that the content in the Cheoc Van beach are significantly lower than that of 2000 and is close to the acceptable level (based upon Hong Kong standard). On the contrary, the content of *Escherichia coli* found in Hác Sá is worrying since it has increased but not with a high extent.





**Figure 3.19**  
Geometrical mean of the annual mean values of E. Coli  
(Source: PHL, 2002)

### Coastal erosion

Following the project started in the previous year, a monitoring programme has been in place in order to collect regularly the data and information on the amount and the location of sand loss. This programme aims at investigating the driving factors of erosion and finding the appropriate measures. In January 2001, the Port Authority has requested the Civil Engineering Laboratory of Macao to conduct a study so as to analyze the causes of erosion in the Hác Sá beach. The University of Macao has also begun a similar research toward this phenomenon.

Generally speaking, the analysis shows that the coastal zones of Macao become more polluted. The analysis taken by the PHL based on the average pollution index also shows that in some sampling points the values have even reached critical levels. According to the "Report on the State of the Environment of the Coastal Zones of China 2001", it indicates that the main pollutants of the water body of south China are inorganic nitrogen and active phosphate. In some of the coastal zones the values of COD, oil derivatives and lead are above the criteria limit. In Zhuhai, the quality of coastal water is classified as Class 4 and its pollution is being characterized by a high average concentration of inorganic nitrogen, which is very similar to the Macao's situation.



## 3.3 Wastewater Management

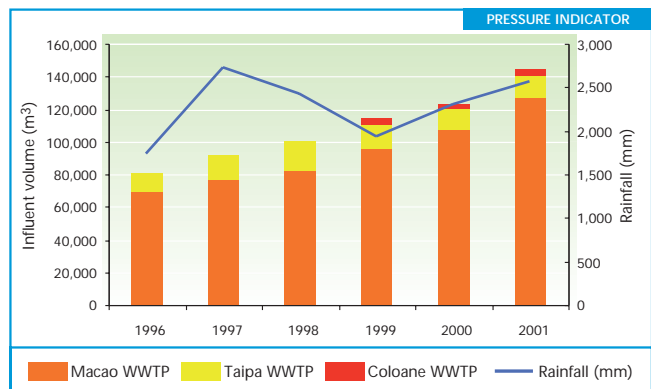
In order to solve the environmental problems caused by wastewater and to protect the water quality of the coastal zones, Macao has planned to improve its wastewater drainage system since the middle of the 80's. The construction of three enclosed and secondary treatment WWTPs with a daily treatment capacity of 234,000 m<sup>3</sup> corresponding to the volume of wastewater produced by a million people in the Macao Peninsula, Taipa and Coloane was concluded in 1995, 1996 and 1999 respectively. It is believed that the capacity will be able to meet the needs of the increasing population and the economic development in the middle and long term. In 2001, the average volume of water treated daily by the three WWTPs is 145,000 m<sup>3</sup>.

Although the drainage system is still unable to cover all the areas of Macao, the improvement on sewers is in progress in order to replace gradually the combined drainage system in the old town by a separate drainage system.

The analysis of the average volume of effluent in each WWTP shows that the total volume of treated wastewater has been increasing since 1996. The treated volume is particularly significant in the Macao Peninsula WWTP, which has been increased 80% in 2001 when compared to that in 1996. In the same period, the volume of water consumed in the Macao Peninsula has also been decreased slightly (about 2%). This shows that through the improvement on the coverage of the drainage system in the Macao Peninsula, the wastewater is being collected and treated before discharge. In 2001, the volume of wastewater treated in the Taipa WWTP has been increased 20% when compared to that of 1996 and 30% in the Coloane WWTP when compared to that of 1999 (the year it started to operate). These two WWTPs maintain enough capacity to cope with the needs for wastewater treatment for the future development of Taipa and Coloane.

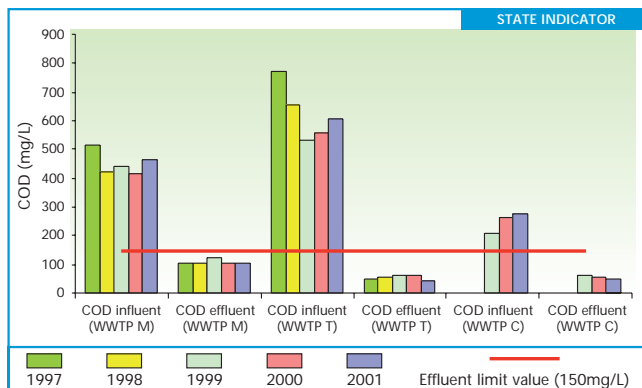
In addition, the Macao SAR also plans to build another WWTP in the Macao International Airport at the end of 2002 in order to improve continuously the facilities for wastewater treatment. Meanwhile, a 10,000m<sup>3</sup> storage tank has been in

operation in 2002 in order to increase the capacity to retain before treating the wastewater influent in the Macao WWTP during peak hours and to reduce the impact of the discharged wastewater towards the water body during those peak periods.

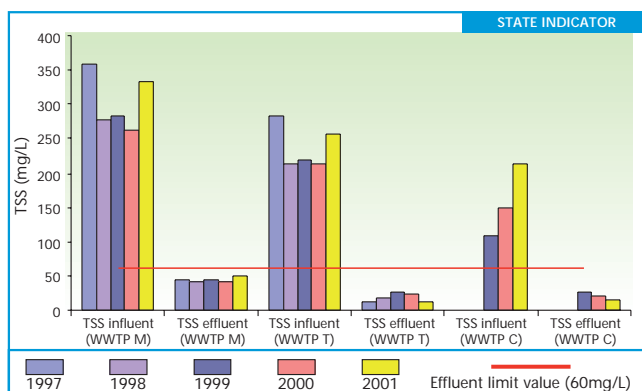


**Figure 3.34**  
Daily mean influent volume to the WWTPs  
(Source: OID, 2002)

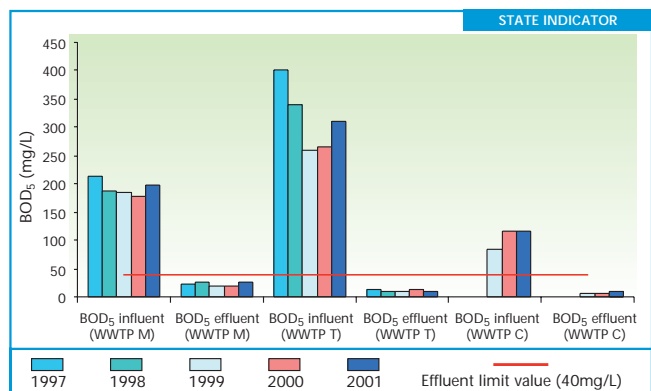
The laboratory will monitor the quality of the effluent and influent at each WWTP. The result shows that the effluent quality of each WWTP is within the limit. Thus, the WWTPs have played a certain role in reducing the pollution of the Pearl River Estuary.



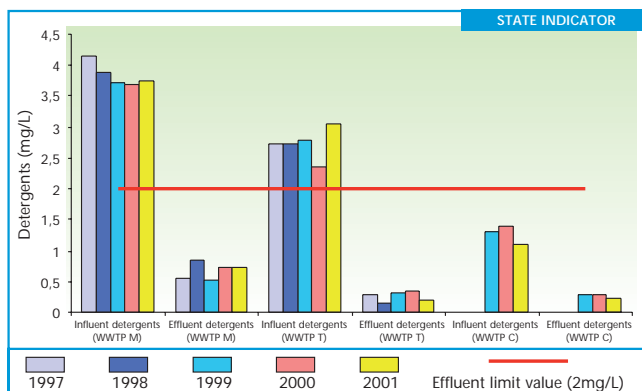
**Figure 3.36**  
Evolution of the chemical oxygen demand (COD) in the influent and effluent volumes of the WWTPs  
(Source: OID, 2002)



**Figure 3.37**  
Evolution of total suspended solids (TSS) in the influent and effluent volumes in the WWTPs  
(Source: OID, 2002)

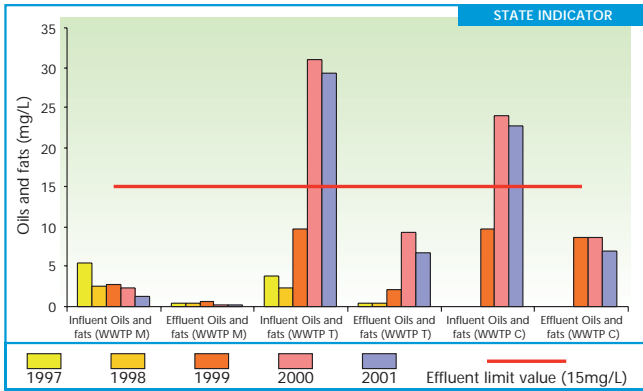


**Figure 3.35**  
Evolution of biochemical oxygen demand (BOD<sub>5</sub>) in the influent and effluent volumes of the WWTPs  
(Source: OID, 2002)



**Figure 3.38**  
Evolution of detergents in the influent and effluent volumes in the WWTPs  
(Source: OID, 2002)





**Figure 3.39**  
Evolution of oils and fats in the influent and effluent volumes in the WWTPs (Source: OID, 2002)

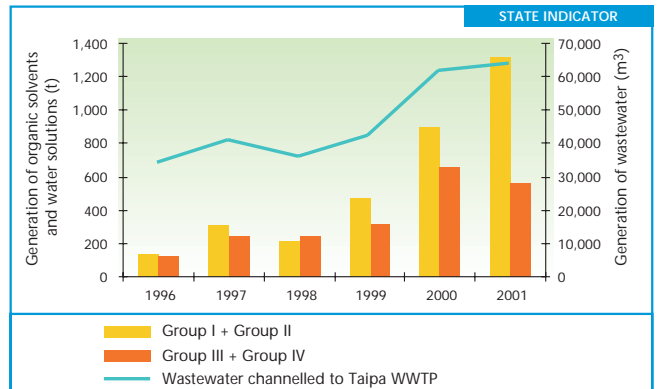
A project coordinated by CMAB aimed at monitoring the water quality at the outlets of the rainwater drainage system was started in 2000 and has been proceeding with gathering and analysis.

Since the consequences on the deterioration of water quality in coastal zones might be affected by the irregular discharge of wastewater, it is important to reinforce the inspection and to put into place the necessary measures to improve the drainage system.

### Industrial wastewater

The impact of industrial wastewater upon the water environment is usually greater than that of domestic wastewater. Some pollutants such as heavy metals and organic solvents often exist in industrial wastewater. Thus, the effective treatment of industrial wastewater is very important.

The data from Hovione Macao Ltd. shows that the volume of wastewater produced and discharged during the production process has been constantly increasing. The wastewater produced contains water-soluble acidic solutions (group I and II) and mixed organic solvents (group III and IV). At present, the discharged wastewater from this company has exerted certain impacts towards the operation of Taipa WWTP. Hence, it is necessary for the company to increase the ability of wastewater pre-treatment in order to fulfil the regulations of the Macao SAR.



**Figure 3.40**  
Evolution of the production of wastewater and organic solvents in Hovione (Source: Hovione, 2002)

Regarding MEC, which is responsible for the electricity supply to Macao, a global plan for the treatment of wastewater in the Coloane Power Station has been implemented since 2001. The plan includes pre-treatment for all wastewater in order to ensure that the discharge complies with the regulations.







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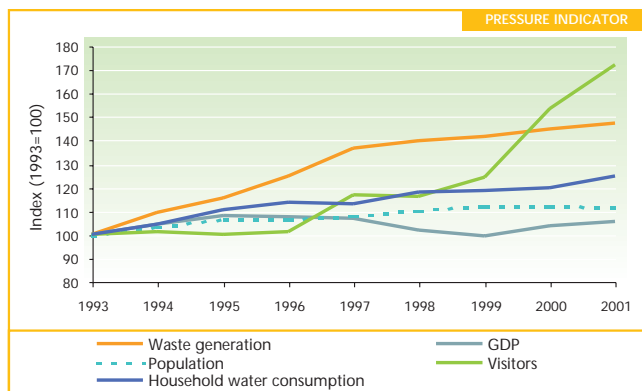
# Waste

## 4.1 Quantity of Generated Waste

Waste generation as a result of consumption growth in both the public and private sectors is a good sign of people's attitude in a region towards sustainable development. Consumption indicates one region's interrelation among economic level, social conditions and the environment.

In fact, any region should utilize natural resources with a minimum impact on the environment in order to improve and reinforce health, education, hygiene services and a better life quality. In other words, it means to minimize solid waste, effluents discharge and gaseous emission etc.

There is still much to accomplish before achieving the above target. However, waste generation rate in Macao has been increasing higher than its GDP growth rate.



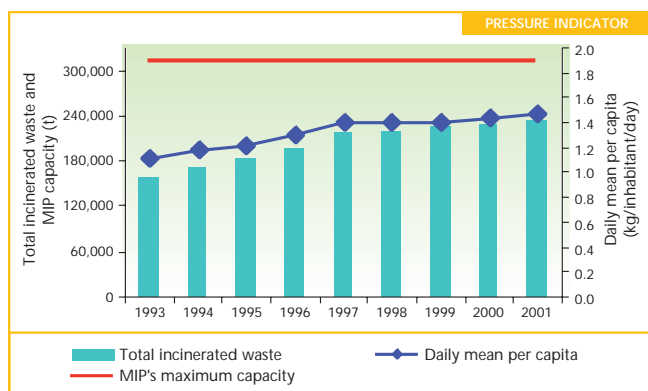
Note: Waste generation indicates the quantity of waste incinerated in the Incineration Plant

Figure 4.1  
Evolution of some indicators in Macao  
(Source: SCS, OID, 2002)

In 2001, the quantity of urban solid waste collected by the Waste Service Company (WSC) reached 232,726 tonnes, corresponding to 1,45kg/inhabitant/day of generated waste and this figure has been gradually increasing.

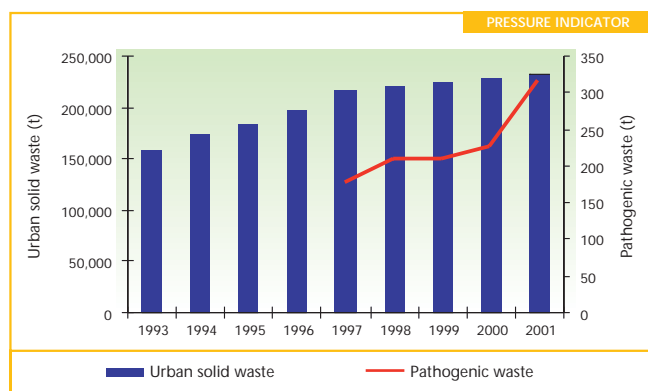
The waste incinerated in MIP includes the urban solid waste as well as pathogenic waste from hospitals. Therefore, the incinerated amount reflects the actual waste scenario in Macao. In 2001, the amount of incinerated waste has increased 1,4% when compared to that of 2000.





**Figure 4.2**  
Evolution of total amount of waste incinerated and daily waste amount per capita  
(Source: SCS, OID, 2002)

In 2001, the total incinerated pathogenic waste was 315 tonnes, i.e. 0,14% of the total amount of incinerated waste and this quantity has been gradually increasing. Although this type of waste is first collected separately and then transported to MIP for incineration, it is recommended to have pre-treatment and the incineration temperature should be higher than that of the urban solid waste.

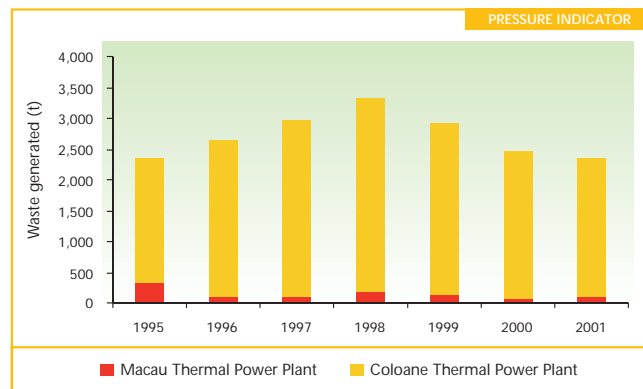


**Figure 4.3**  
Evolution of urban solid waste and pathogenic waste  
(Source: OID, 2002)

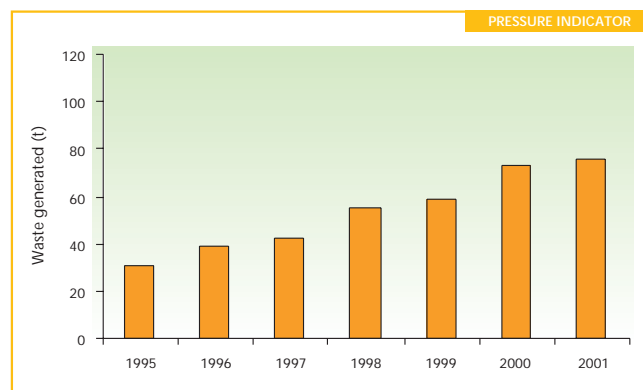
Industrial waste is also being generated in Macao. The MEC generates waste oil, sludge and solidified ash, fly ash and incombustibles, but the amount has decreased both in the Macao and in the Coloane plant. The MEC is responsible in dealing with its own production waste, either by transporting it to the landfill or by reusing it in power generation. In order to reduce the volume of waste oil, the MEC had decided to install its own incinerator at the new Coloane plant.

Hovione generates some solid waste and wastewater effluent during the production process and those quantities (refer to 4.3 Wastewater management) have been increasing. Solid waste includes paper, plastic packages as well as glass fibre containers. Although these are not classified as industrial waste, the quantity has been gradually increasing. These types of

waste are being incinerated in the MIP or being disposed in the landfill.



**Figure 4.4**  
Solid waste generation in MEC  
(Source: MEC, 2002)



**Figure 4.5**  
Solid waste generation in Hovione  
(Source: Hovione, 2002)

At present, it is necessary to conduct future studies on investigating the current situation because of the lack of information regarding the situation of hazardous waste generation in Macao.





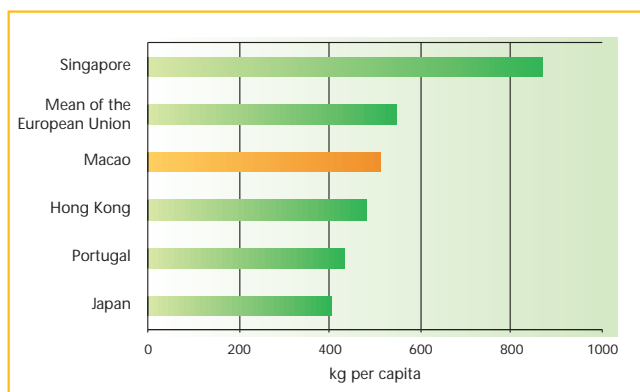
The Port Authority (PA) is the department responsible for the daily collection of solid waste and water hyacinths in the coastal areas as well as for cleaning at sea during special festivals – Lunar New Year, Cheng Ming Festival and Chong Yeong Festival. Waste collected from the sea is mostly the result of activities on the boats docked at the riparian zones or piers (wood pallets, plastic bags, packaging materials) and of water vegetation (water hyacinths etc.).

In 2001, there is a 30% increase of waste collected from the sea when compared to that of 2000. This is mainly due to an increase of the quantity of water hyacinths coming from upstream in mainland. Along the year in 2001, 500 tonnes of water hyacinths has been collected by the PA and is being delivered to the MIP for incineration.

Water hyacinths spread seriously especially in eutrophic environments. They float and are drifted by wind along the stream and gather at the Inner and Outer Harbours, especially in the water channel and piers of the Inner Harbour, Ilha Verde and Fai Chi Kei. They have serious impacts towards the environmental quality, landscape, navigation and other maritime activities. Since this is a regional problem, it will only be solved effectively with the co-operation of the neighbouring cities and through the global management of the Pearl River Estuary. The Environment Joint-Liaison Group for the Co-operation between Macao SAR and Guangdong province has

decided to create a specialized working group to investigate the possible measures in solving the water hyacinths problem.

Comparing the annual average quantity of waste generated per capita in some countries in 1999, it is found that Macao lies in the middle level. Hence, it is necessary to promote sustainable consumption habits to Macao residents and visitors.

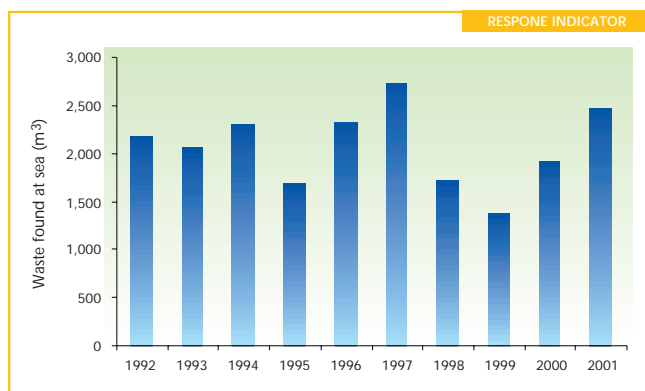


**Figure 4.7**  
Annual average quantity of urban solid waste per capita in some countries/regions in 1999  
(Source: EEA, OID, 2002)

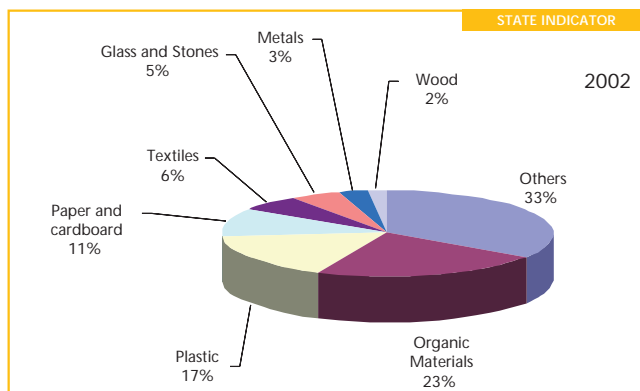
## 4.2 Composition of Waste

Regarding the composition of the urban solid waste incinerated in the MIP, the analysis of 2002 shows that there is a certain quantity of materials that can be recycled, recovered or reused.

The methodology chosen to analyse the physical composition of the waste is to dry the waste under 100°C and the result shows that "Others", characterized with a diameter less than 2cm, is the highest percentage group.



**Figure 4.6**  
Evolution of the quantity of waste found at sea  
(Source: PA, 2002)



**Figure 4.8**  
Physical composition of the urban solid waste  
(Source: OID, 2002)

### 4.3 Incineration by-products

Several by-products of the urban solid waste incineration process include: gases, fly ash, incineration residue and heat energy (which is recycled and converted into electric energy).

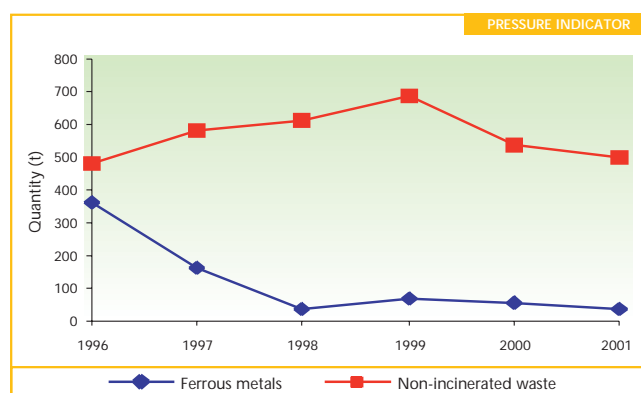
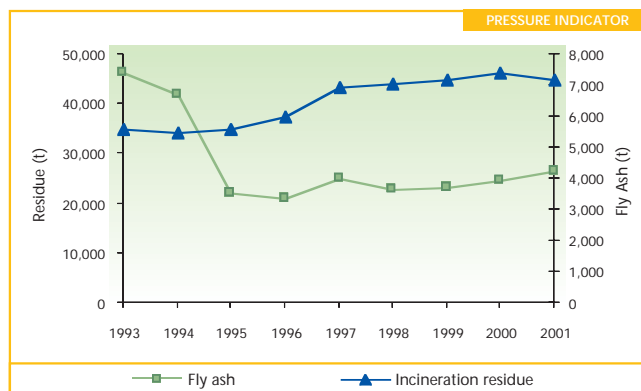
The combustion gases emitted from the Macao Incineration Plant are treated with electrostatic precipitator and neutralized with an alkaline solution. Their concentrations are continuously monitored to make sure that the gases are not exceeding the maximum permissible limits. However, the monitoring of heavy metals (such as lead, cadmium, mercury, chromium, arsenic and cobalt, etc.), dioxins and furans is not yet carried out.

Dioxins are by-products of incineration that have been getting more and more concerns in recent years. The formation of dioxin within the incineration process is complex and it depends, among other factors, on the composition of waste (such as the type and quantity of chlorine waste), the burning conditions and on the presence of catalysts. Since there is no concrete conclusion towards the mechanism of the formation of dioxin, it is therefore important to investigate and study its monitoring and possible minimization methods.

Regarding the evolution of the amount of incineration residue and fly ash generated by the MIP (by-products of incineration and the incinerated waste), there is no significant change since 1995.

The quantity of recovered ferrous metals has also been fairly steady since 1998. Incombustible refuses such as construction waste, air conditioners, refrigerators, etc.) are sent

directly to landfill for disposal. Among them, the quantity of construction waste has been decreasing because of the local and worldwide economic recession.



**Figure 4.9**  
Incineration residue, fly ash, ferrous metals and non-incinerated waste generated by MIP (Source: OID, 2002)





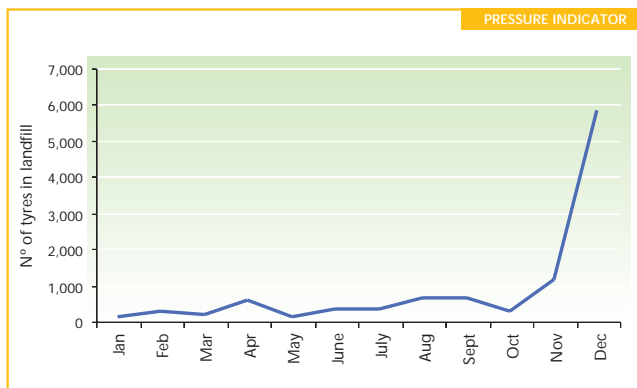
### 4.4 Sanitary Landfill

The quantity of waste for incineration has been constantly rising. Although it has not exceeded the treatment capacity of the MIP, it has nearly reached the capacity of the landfill. Hence, it is of utmost importance to find new solutions.

Waste was still being delivered to the Seac Pai Van Landfill in Coloane. This landfill was divided into three different areas, where the incineration residue and fly ash from the MIP, construction and demolition waste from civil construction and dead animal bodies (horse corpses from the Jockey Club and others entities) were disposed. The responsible department for the management of the landfill is the Civic & Municipal Affairs Bureau (CMAB).

The volume of construction and demolition waste disposed into the landfill has decreased in 2001.

In November 2001, the number of tyres disposed into the landfill has increased tremendously. The CMAB has started to tackle this problem with a feasible solution.

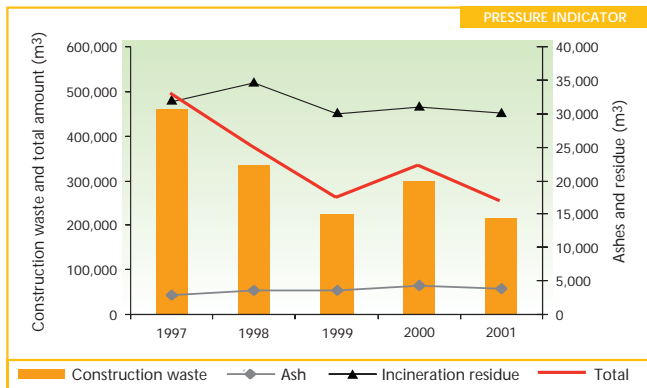


**Figure 4.10**  
Quantity of tyres sent to landfill in 2001  
(Source: CMAB, 2002)

Fly ash is the particulate generated after the waste incineration process and the treatment of flue gas with high voltage electrostatic precipitator. There is no significant change in the generation of fly ash by the MIP: the fly ash produced by per tonne of incinerated waste is 230kg. Fly ash contains harmful substances to both the health and the environment



and is considered as hazardous waste. It is, therefore, being disposed into specific landfill cells. The Municipal Laboratory of Macao (MLM) of the CMAB conducts analysis on the composition of fly ash and the results show that the toxicity of the fly ash has not reached an alert level.



**Figure 4.11**  
Volume of waste deposited into the landfill  
(Source: CMAB, 2002)

As mentioned before, the Seac Pai Van Landfill is reaching its full capacity. There is a plan for another temporary landfill in order to receive and treat the incineration residue, incombustible refuse and construction and demolition waste.

In 2002, the fly ash began to be transferred from the Seac Pai Van Landfill into a new location in the north Coloane for landfill. The capacity of this landfill is assumed to cope with the needs till 2003.

The related entities have to find appropriate solution for the disposal in the near future for the dead animal bodies, since the new landfill does not provide specific landfill cells for their disposal.

All the aforementioned situations point out the need of a middle and long-term strategic action plan for environment management.



#### 4.5 The Basel Convention on the Control of Transboundary Movement of Hazardous Waste and their Disposal

At international level, the Macao SAR is part of the Basel Convention, which controls the transboundary movement of hazardous waste and their disposal. This convention was signed in Basel on 22<sup>nd</sup> March 1989 and modified later according to the decision of the conference of the Member States III/1 dated on 22<sup>nd</sup> September 1995 (Basel Prohibition).

Executive Order no.32/2002 of 5<sup>th</sup> June (see B.O.no.23, Series II) established the publication of PRC notification regarding the enforcement of the Convention in the Macao SAR. In accordance with paragraph 1 of Article 5 of the Convention, it designates the Environment Council of the Macao Special Administrative Region as the competent authority for this Article.

A strategic plan for waste management is urgent in the MSAR. The plan should include the management of hazardous waste in order to facilitate the application of the Basel Convention.

#### 4.6 Waste Management Strategy

Owing to the small and densely populated area of the Macao Peninsula, there are important environmental problems such as on how to manage the increasing waste quantity, how to improve the waste management and to prevent the transboundary of waste, which should cause the attention of the policy maker of the MSAR. These should be priority subjects in Macao due to their growing waste generation rate, the near limiting capacity in some of the infrastructures for final disposal (such as landfills) and the constraints of space to create new ones.

Several other factors such as the liberalization of the gambling activities, the forecast population and economic growth, the exchange of goods within the region and the increase in the number of visitors will increase the pressure upon the existing resources, especially on the waste management system. It should become, therefore, a growing concern for the environmental departments in Macao.

The problems related to waste will surely draw most of the attention within the process of the sustainable development of Macao.

To define and to approve a Waste Management Strategic Plan is therefore urgent. This plan should be based upon the technologies of high efficiency and less pollution in order to promote reuse and recycle of waste. It should also include the management of urban, industrial and hospital waste as well as the licensing procedure for industrial plants (or other enterprises that will cause potential impact on the





environment). The Waste Management Strategic Plan will include:

- To add value and eliminate the type, quantity and the source of waste;
- General technical criteria;
- Specific regulations for treating special waste;
- Appropriate location or installation for waste treatment;
- An estimated budget concerning the operations involving waste to be reused or treated;
- Measures that can encourage waste collection, separation and treatment.

A change in perspective will be based not only on the approval of the referred Strategic Plan but also a change on consumers' behaviour and attitudes which have direct or indirect consequences on the production and wholesale of products as well as the generation of waste.

The establishment of a Framework for Waste Regulation is of the utmost importance. It should indicate the relevant department to define the waste management regulations and for the related inspection work.

From the technical measures that have been recommended previously, the followings need to be emphasized:

- To carry out a detailed assessment on landfill operation;
- To study the feasibility of inactive treatment of the fly ash generated by the incineration plant;
- To assess the feasibility of treating hospital waste at an incinerating temperature above 1,100°C, as recommended by some international organizations;
- To include assessment on the quantity of waste generated by the industry and their respective treatment methods in the industrial licensing process;
- To investigate the waste oil source and establish a system for collection of waste oil as well as to recycle and reuse it as an energy source for the sludge incinerator of the Macao WWTP;
- To encourage the development of "green enterprises" by promoting recycling and the application of anti-pollution technologies in Macao.









5

# Natural Conservation

## 5.1 Green Spaces

Macao has a small geographical area of approximately 25.8km<sup>2</sup>. With a high population density and many large scale projects on the way, the preservation and protection of green spaces are extremely important.

Among those projects, the construction of the Seac Pai Van Park in Macao is one important green area located in Coloane. It was created in 1981 aimed to the preservation of rare flora species and the improvement of local vegetation diversity.

Equally important is the significant improvement of the quality of life of the Macao residents as a result of a careful municipal planning in gardens, parks, children's playgrounds, safety islands and roadside plantation, by means of reforestation or the creation of new ones.



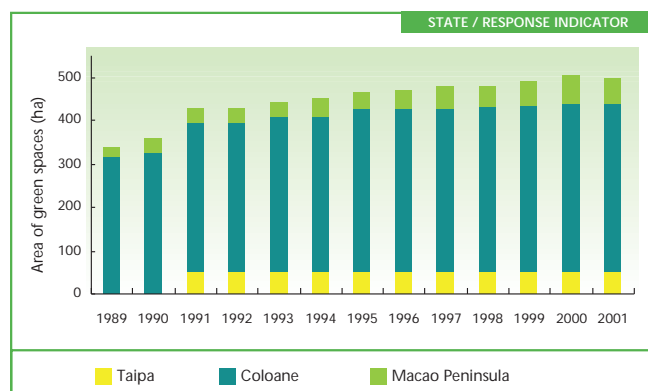
Figure 5.1  
Macao green spaces  
(Source: CCB, 2002)



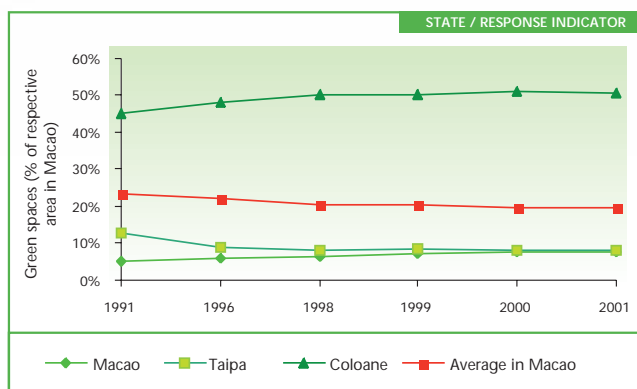


The number of trees in the Macao Peninsula has had a 4% increase compared to that of 2000, rising up to a total amount of 5,634. *Acacia confusa* and *Acacia auriculaeformis* were the main species in the reforestation.

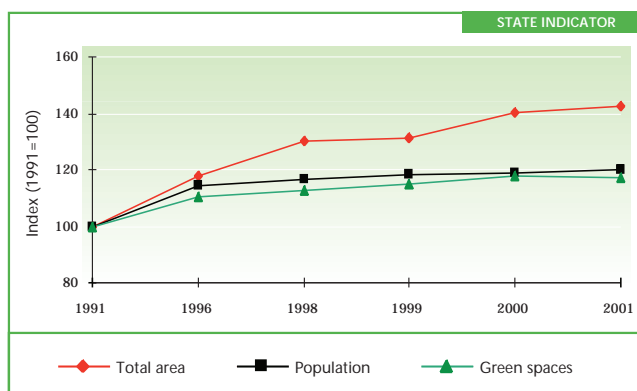
Although the total area of green spaces has an increasing trend in the last decade, its growth has been slower than the total area of Macao.



**Figure 5.2**  
Evolution of the area covered by green spaces in Macao  
(Source: CMAB, SCS, CCB, 2002)



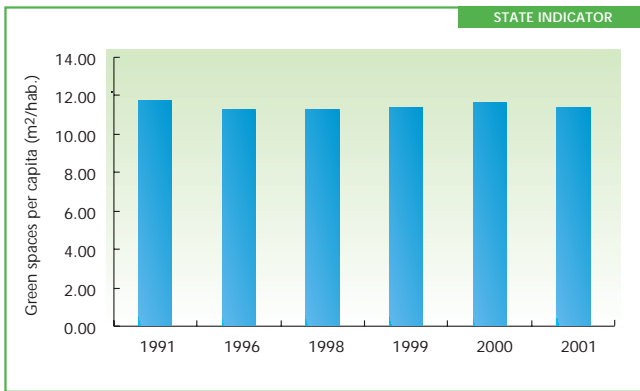
**Figure 5.3**  
Percentage of the region covered by green spaces  
(Source: CMAB, SCS, CCB, 2002)



**Figure 5.4**  
Evolution of total area, population and green spaces  
(Source: CMAB, SCS, CCB, 2002)







**Figure 5.5**  
Area of green spaces per capita  
(Source: CMAB, SCS, CCB, 2002)

## 5.2 Ecological Invasion

In recent years, Macao, the Pearl River Delta as well as the region of Southeast Asia have been affected by *Mikania micrantha* (Mei Gem Gug), commonly known as “plants’ killer”. It is a creeping plant originally from Central and South America that grows rapidly in an environment of high temperatures and humidity. It creeps on other plants and blocks the sunlight to hinder the photosynthetic process, causing plants to wither gradually.

No natural enemy to control the propagation of Mei Gem Gug has been found and therefore, it can only be removed manually.

In 2001, there are thirteen cleaning actions of Mei Gem Gug at the roadside and in the mountains of Taipa and Coloane. At the same time, citizens are informed of the dangerous effects of this plant. CMAB has also been exchanging information and experiences with the relevant departments of the neighboring regions in order to find an appropriate solution for this problem.

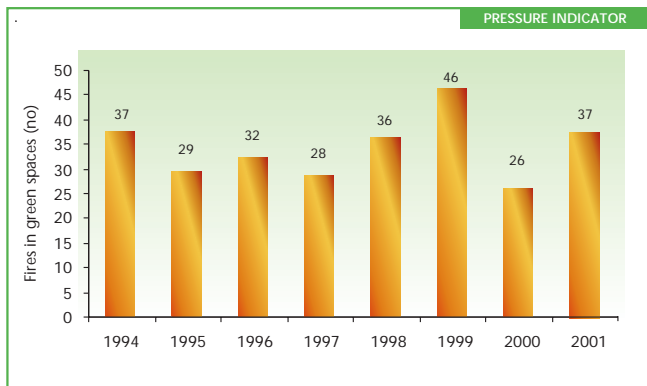
Location	Cleaned Area (m <sup>2</sup> )	No. of Cleaning Actions
1 Lou Wan Seg Min Pun Gu Don Street, Coloane	3,200	2
2 Fu Yung Valley, Coloane	4,000	1
3 Ka Ho Village, Coloane	4,500	2
4 Taipa Grande, Taipa	5,500	3
5 Taipa Pequena, Taipa	3,500	3
6 Tunnel Entrance, Taipa	600	2

**Table 5.1**  
Cleaning of *Mikania micrantha* (Mei Gum Gug) by CMIP in 2001  
(Source: CMAB, 2002)



### 5.3 Forest Fire

Improper human activity is the main reason for most of the fires in the green area of Macao. Therefore, it is extremely important to promote the awareness of fire prevention among the public.



**Figure 5.6**  
Number of fires in green spaces  
(Source: FB, SCS, 2002)





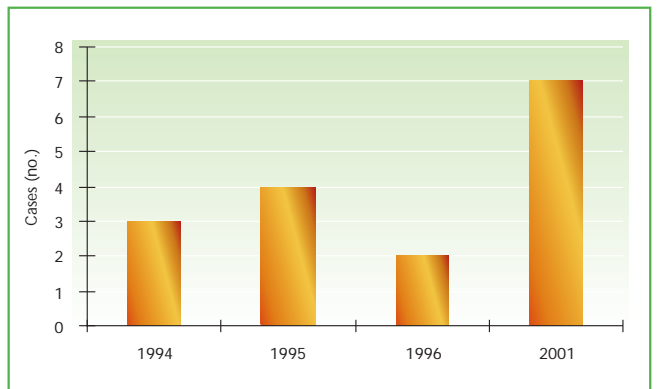
### 5.4 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

In 2001, the Economic Services Bureau in co-operation with the Customs Service inspected and monitored all trade activities controlled under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

A total of 32 processes have been recorded with 30 import and 2 export and re-export cases to and from Hong Kong and Taiwan. However, these are not counted as CITES cases since they do not actually represent import/export between countries.

The 32 cases in 2001 derive, mainly, from the increase in the application of orchids import and export. Illegal imports of orchids confiscated by the Customs Service has also increased in 2001 because most people are not aware that some orchid species are regulated by the CITES.

The Customs Service is also responsible for the confiscation of illegal trade. In 2001, the confiscated products include: *Pitcher plants*, *Arethusa*, *Aloe*, *Cacti*, ivory products and parts of tigers, etc.



**Figure 5.8**  
The number of confiscated cases by the Customs Service  
(Source: Customs Service, 2002)







### 5.5 Ecological Reserve

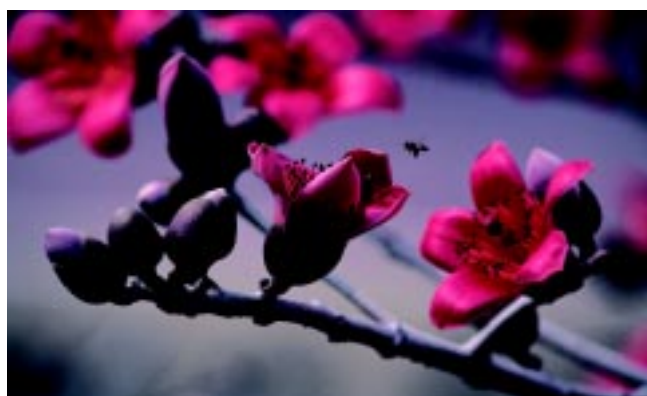
In order to create conditions to enrich the biological diversity and to convey the idea of sustainable development in Macao, the MSAR Government has strategically decided to build the first ecological zone in the Cotai area.

This 55-hectare ecological zone, located near the Lotus Bridge in Cotai, of which 40 hectares are designed for feeding areas, while the remaining 15 hectares is for birds' resting. Some endangered species such as the *Platalea minor* and the *Haliaeetus leucogaster* are found in that neighboring area and therefore, the ecological conservation nearby this area is of utmost importance.

The construction works of the ecological zone is under the supervision of the Office for Infrastructures Development, while the ecological zone design is executed by a private environmental consultant company. The project is coordinated by the Environment Council. The first phase of the construction began in 2002 and the second phase will begin in 2003. In long term, it is expected that the ecological zone may not only achieve an ecological equilibrium purpose, but also brings the mission for environmental protection.

### 5.6 Other Initiatives

CMAB has begun a feasibility study on the construction of a rare species arboretum in Macao. Those species that have been identified in Macao as important national species are now being nourished carefully. CMAB has also engaged in seeds exchange with other countries in order to find suitable species to enrich plant community in Macao.







## 6 Noise Environment

### 6.1 Noise Monitoring

In 2001 the Environment Council continues the work on the "Macao Environmental Noise Monitoring Project". Two automatic stations were built for 24 hours continuous monitoring for the road traffic noise (Horta e Costa Avenue) and ambient noise (Braga Street). In order to expand the monitoring network, a third station located in Venceslau de Morais Avenue, characterising a zone mixed with industrial and heavy traffic, will be constructed.

In addition, the Environment Council has also used a mobile noise station for continuous (several days) monitoring at different locations. The collected data will be good reference for the future environmental noise management strategy. The accuracy of the data is ensured through dividing Macao into different grids for noise monitoring.

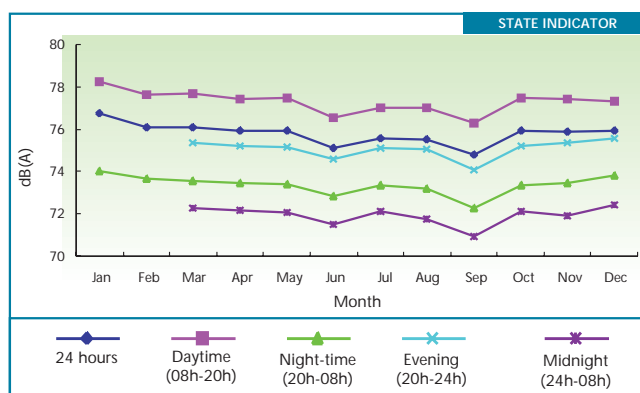
MACAU		
Automatic Stations	Location	Characteristics
1	Horta e Costa Avenue	Traffic
2	Braga Street	Ambient
3	Venceslau de Morais Avenue	Traffic/industrial

**Table 6.1**  
Automatic noise monitoring stations in Macao  
(Source: EC, 2002)

The measurement results of the automatic stations are shown in Figures 6.1 to 6.5.

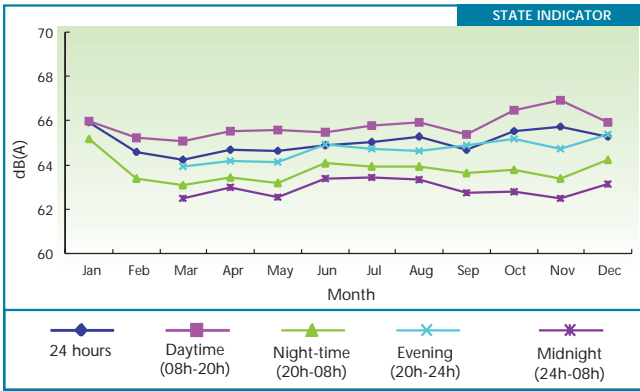
It is found that the difference in values between the daytime Leq (08h to 20h) and the night-time Leq (24h to 08h) in the Horta e Costa station (77.3 dB(A) - 73.4 dB(A)) is larger

than the values of the Braga Street station (65.8 dB(A) - 63.8 dB(A)). As shown in Figure 6.1, the Leq value in Horta e Costa station decreases between June and September 2001 when compared to the values from the rest of the year. Figure 6.2 also shows that the daytime Leq value (08h to 20h) in the Braga Street station is high during October and November of 2001 when compared to other months of the year. According to the 24-hr monitoring data, it is found that during the midnight period (24h to 05h) the Leq values of the two stations decrease significantly (Figure 6.4 and 6.5).

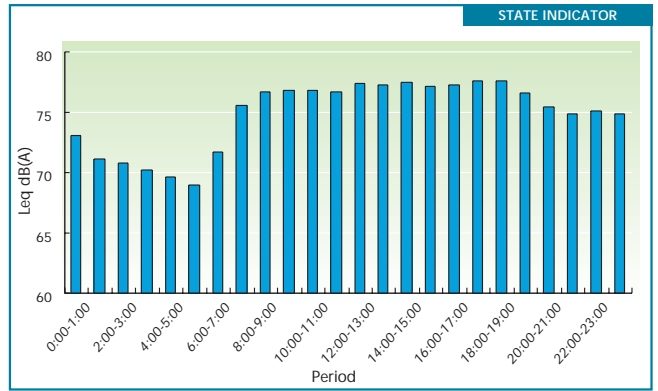


**Figure 6.1**  
Hourly Leq (monthly average) in the Horta e Costa Avenue station  
(Source: EC, 2002)

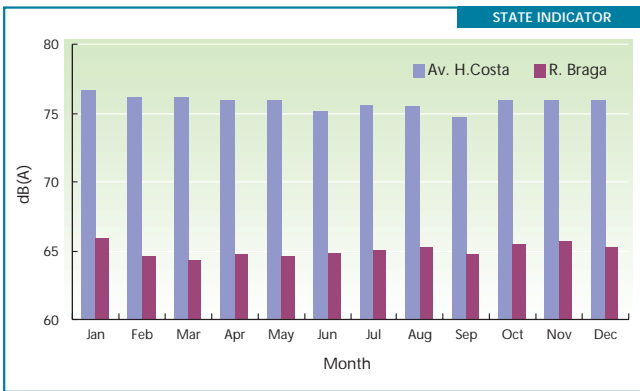




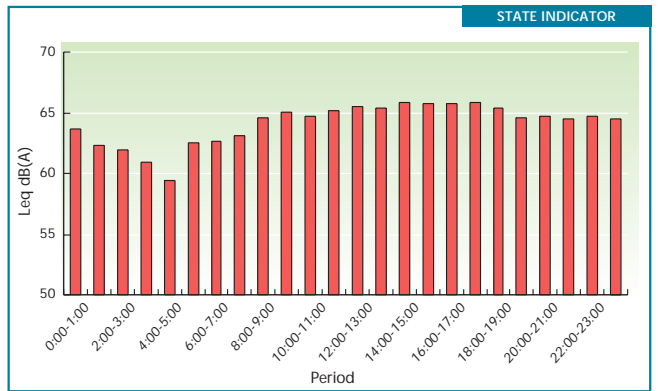
**Figure 6.2**  
Hourly Leq (monthly average) in the Braga Street station  
(Source: EC, 2002)



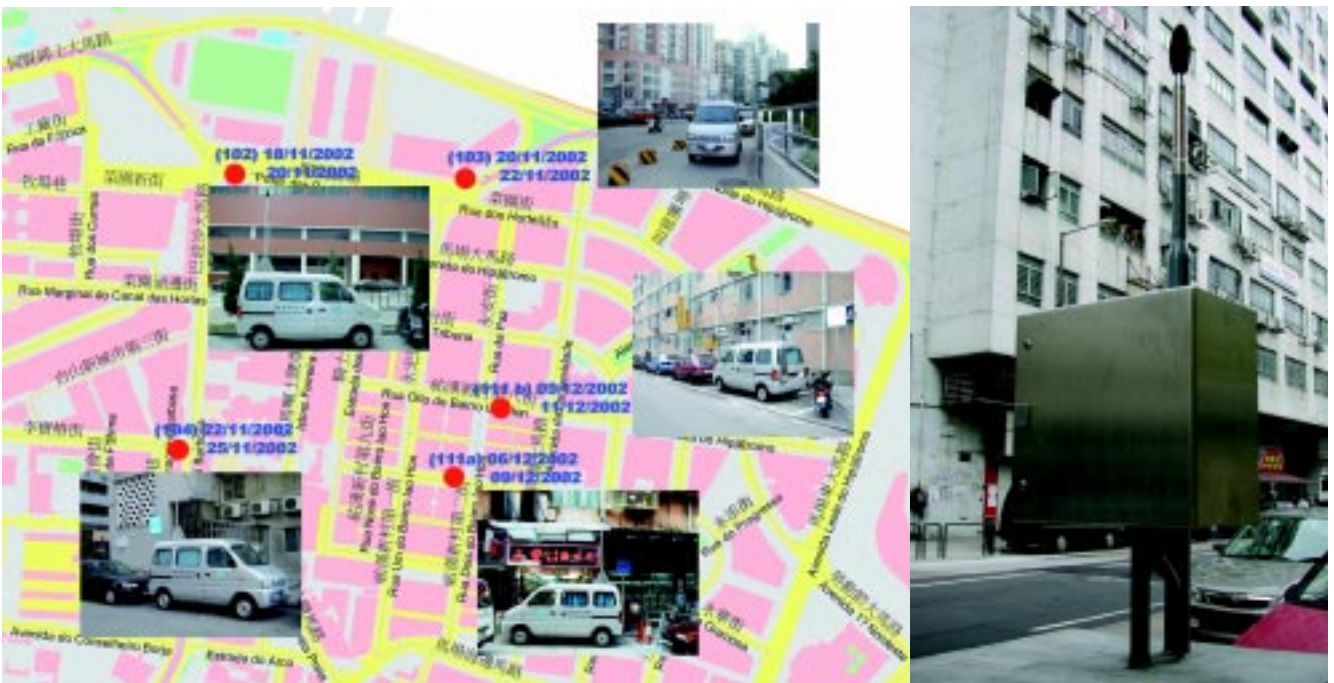
**Figure 6.4**  
Hourly Leq (annual average) in the Horta e Costa Avenue station in 2001  
(Source: EC, 2002)



**Figure 6.3**  
Comparison of daily Leq (monthly average) in the Horta e Costa Avenue station and in the Braga Street station  
(Source: EC, 2002)



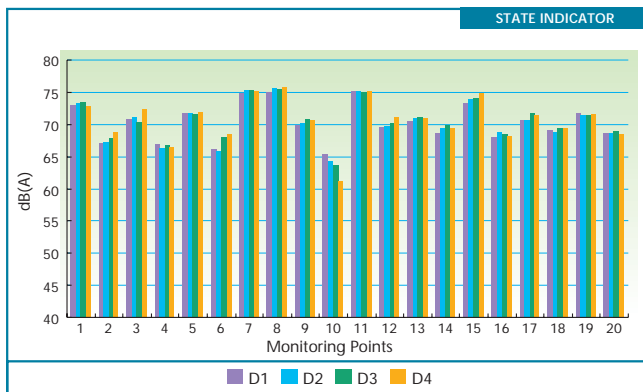
**Figure 6.5**  
Hourly Leq (annual mean) in the Braga Street station in 2001  
(Source: EC, 2002)



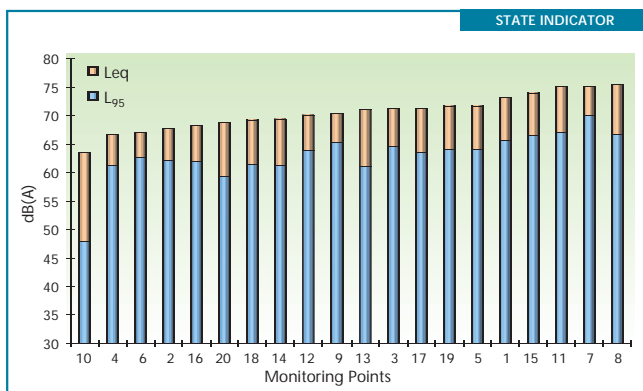


According to information provided by CMAB, the PMM and the PMI continued the noise monitoring programme in 2001, with 20 monitoring points in the Macao Peninsula and 9 monitoring points in the islands. Noise monitoring in the Macao Peninsula is carried out in four different periods: D1 – from 08h to 11h; D2 – from 11h to 14h; D3 – from 14h to 17h; D4 – from 17h to 20h. The main target zones under monitoring include urban areas, residential areas and districts with heavy traffic.

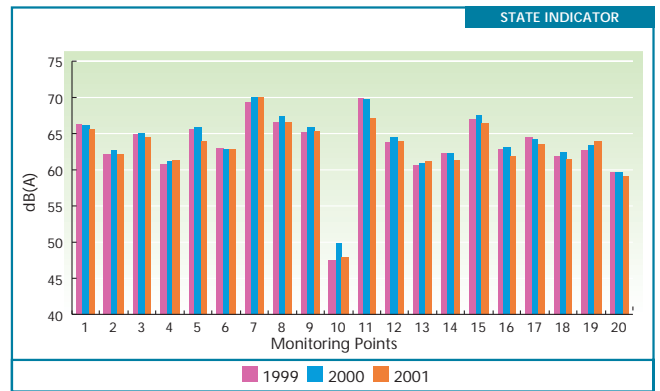
In 2001, there were 12 monitoring points in the Macao Peninsula with a recorded Leq value of over 70dB(A). Among these, the Leq value recorded at the points of the intersection of Campo Street and Pedro Nolasco Street (Point 7), the intersection of Horta e Costa Avenue and Alm. Costa Cabral Avenue (Point 8) and in the intersection of Horta e Costa Avenue and Almirante Lacerda (Point 11) has even reached 75dB(A).



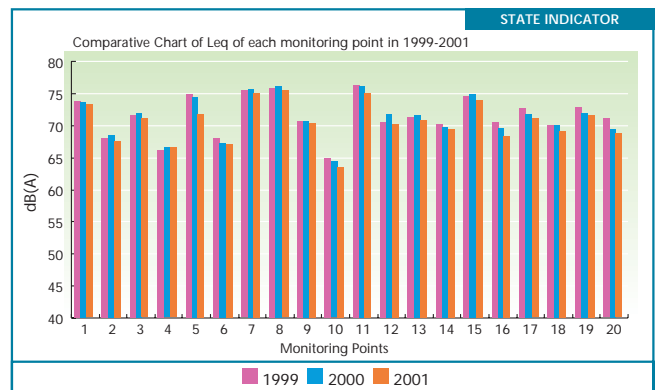
**Figure 6.6**  
Comparison of the sound levels located at the Macao Peninsula in 2001  
(Source: CMAB, 2002)



**Figure 6.7**  
Leq and L<sub>95</sub> on the Macao Peninsula in 2001  
(Source: CMAB, 2002)



**Figure 6.8**  
Comparison of L<sub>95</sub> on the Macao Peninsula  
(Source: CMAB, 2002)

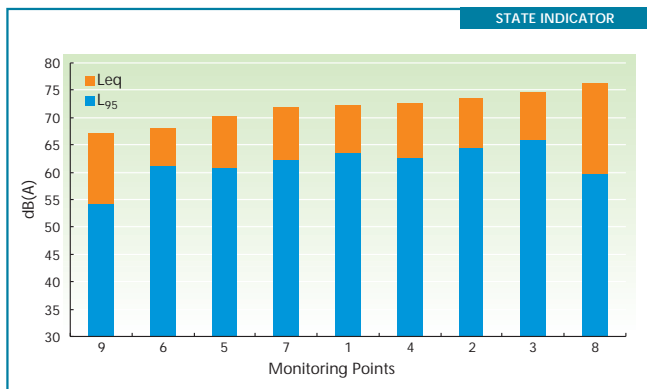


**Figure 6.9**  
Comparison of Leq on the Macao Peninsula  
(Source: CMAB, 2002)

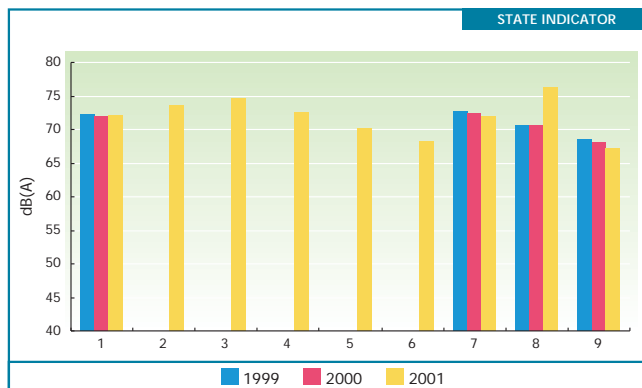




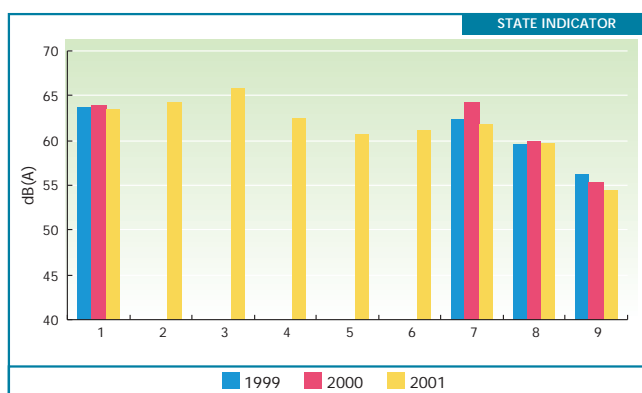
Regarding the monitoring situation in the islands, the number of monitoring points has increased to a total of nine points (mostly in Taipa) and in seven of these nine monitoring points, the recorded Leq value was over 70dB(A) in 2001.



**Figure 6.10**  
Leq and L<sub>95</sub> of the islands in 2001  
(Source: CMAB, 2002)



**Figure 6.11**  
Comparison of Leq values in the monitoring points of the islands  
(Source: CMAB, 2002)



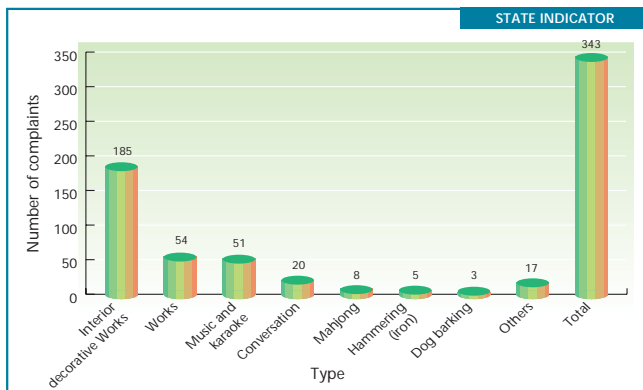
**Figure 6.12**  
Comparison of L<sub>95</sub> in the monitoring points of the islands  
(Source: CMAB, 2002)



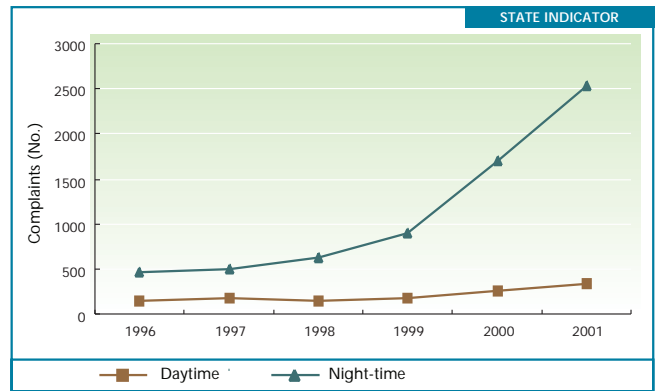
## 6.2 Noise Complaints

Most complaints on noise annoyance are being addressed to the Police Department (PD), the Environment Council (EC) and the Civic and Municipal Affairs Bureau (CMAB).

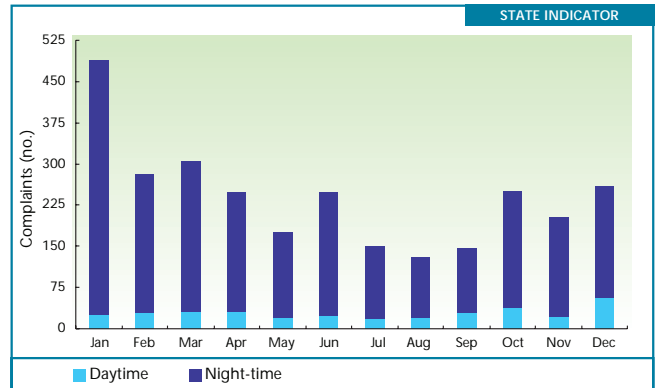
In 2001, the PD (department that receives the most noise complaints) has recorded 2,883 complaints, representing an increase of 49% compared to the previous year. Complaints during night-time occupy about 88% of the total and most of the complaints are classified as “music and karaoke”. During daytime, most complaints are mainly due to “interior decorative works” which consists 12% of the total number of complaints.



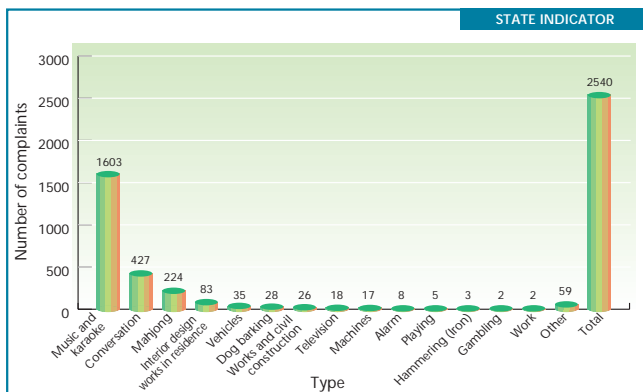
**Figure 6.13**  
Complaints recorded during daytime (08h-20h) according to the PD in 2001  
(Source: “Lotus” - Magazine on the Environment, EC, 2002)



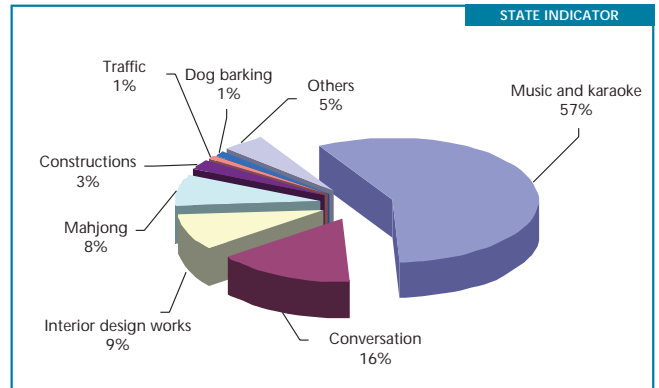
**Figure 6.15**  
Evolution of the number of noise complaints received by the PD  
(Source: “Lotus”-Magazine on the Environment, EC, 2002)



**Figure 6.16**  
Number of noise complaints received by the PD in 2001  
(Source: “Lotus”-Magazine on the Environment, EC, 2002)



**Figure 6.14**  
Complaints recorded during night-time (20h-08h) according to the PD in 2001  
(Source: “Lotus”-Magazine on the Environment, EC, 2002)



**Figure 6.17**  
Noise complaints received by the PD in 2001 in each category (daytime and night-time)  
(Source: “Lotus”-Magazine on the Environment, EC, 2002)

In 2002, the PD has received 2,155 complaints, a 25% decrease compared to that of 2001. Among all categories, there is a sharp decrease, 68%, of the complaints on “music and karaoke”.

### 6.3 Noise Abatement Measures

Macao is a small and highly densely populated city, where heavy traffic and high rising buildings affect the noise propagation. The continuous economic growth together with the increasing number of vehicles not only create traffic congestion, but also make traffic noise a difficult problem to be solved.

There are direct and indirect approaches to reduce traffic noise. The direct measures include study on the implementation of noise standard for vehicle, the installation of noise barriers and road resurfacing with noise absorbing materials. Traffic flow management, traffic planning and restructuring of road networks are some indirect measures.

Although traffic noise is the main source of noise pollution in Macao, "music and karaoke", "gambling", "interior decorative works" and even "conversations" are other causes of noise complaints received by the relevant authorities. The abatement of all these kinds of noise undoubtedly depends not only on the revision of the existing regulations and laws but also on civil and environmental education.

In order to reduce the noise annoyance caused by heavy traffic, 511 meters noise barriers have been installed along the flyovers of Artur Tamagnini Barbosa Avenue and Horta e Costa Avenue.

Regarding the noise caused by commercial and industrial activities, their reduction depends on certain factors such as introducing specific and rigorous evaluation criteria when issuing licenses, enhancing technical support and implementing the legislation already in force. In addition, preventive measures should also be used on situations that could bring adverse impacts on the environment and public health.

It is also necessary to intensify the monitoring and collection of noise data so as to provide a basis for a global and appropriate control of noise pollution in Macao.





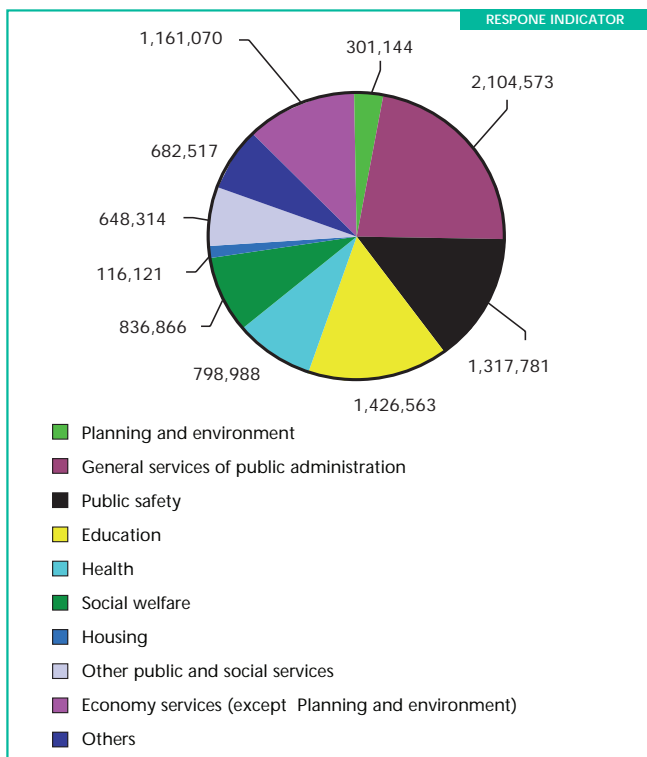




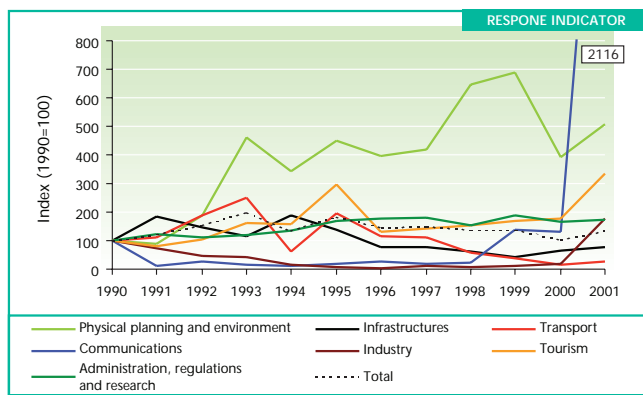
# 7 Environmental Management

## 7.1 Investments and Expenses on Environmental Management

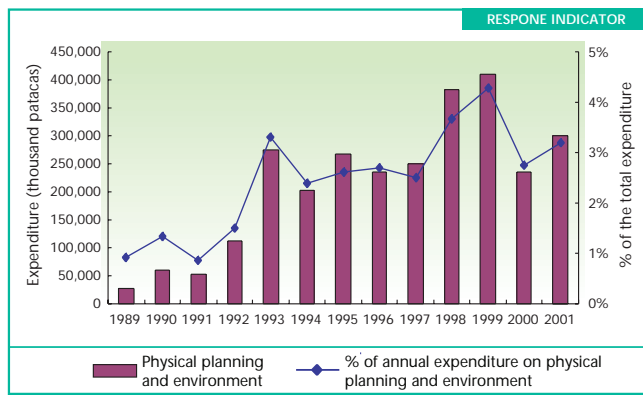
In 2001, the investments on planning and environment amounted to MOP\$301,144,388, representing 3.2% of the total public administration expenditure.



**Figure 7.1**  
Public expenditure (in thousand patacas) by sector in 2001  
(Source: FSB, 2002)



**Figure 7.2**  
Evolution of public expenditure by sector compared to 1990  
(Source: FSB, 2002)



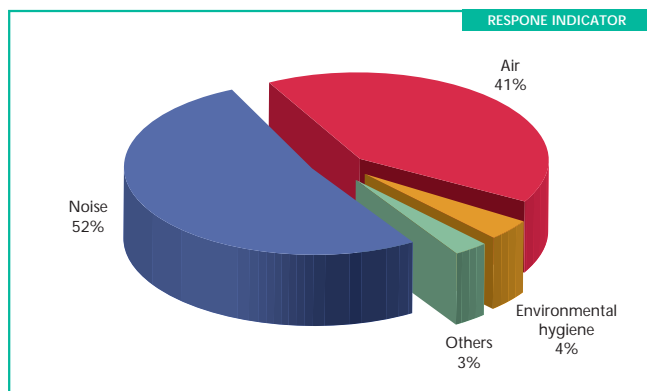
**Figure 7.3**  
Public expenditure (in thousand patacas) in "Planning and Environment"  
(Source: FSB, 2002)



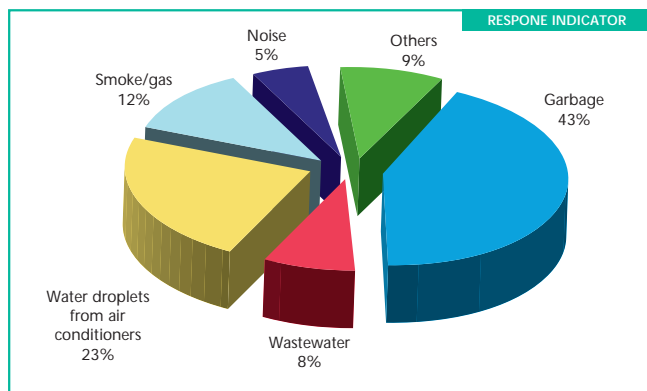
## 7.2 Public Participation

The responsibility and the awareness of citizens towards environmental protection can be observed as they made decision to express affected living quality through complaints.

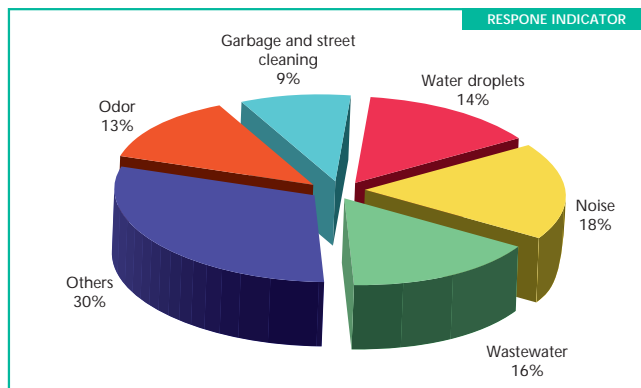
In 2001, the Environment Council received 36 noise complaints, 29 complaints on air pollution (including oily fume emission) and 1 complaint on discharged wastewater. The complaints received by the Provisional Municipality of Macao include 131 cases on noise, 315 cases on oily fume and exhaust gas emissions, 211 cases on the drainage of wastewater onto public roads and 1,106 cases on solid waste. The Provisional Municipality of the Islands has received 17 complaints on noise, 12 on odor, 15 on wastewater and 9 on solid waste. It is worthwhile to note that numerous noise complaints have also been made to the Police Department each year (refer to the chapter on "Noise Environment").



**Figure 7.4**  
Environmental complaints received by the Environment Council in 2001  
(Source: EC, 2002)



**Figure 7.5**  
Complaints on the environment made to PMM  
(Source: PMM, 2002)



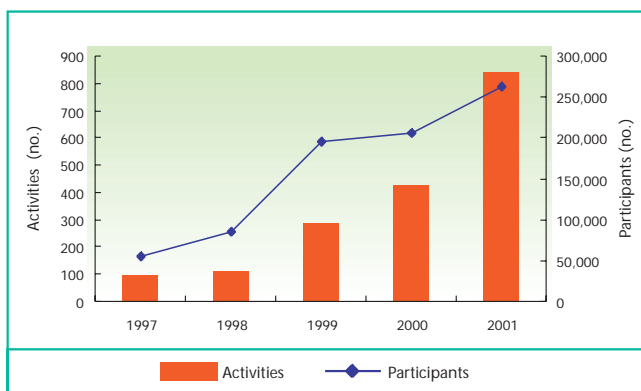
**Figure 7.6**  
Complaints on the environment made to PMI  
(Source: PMI, 2002)

## 7.3 Environmental Awareness and Education

Public awareness and participation play important roles in achieving environmental protection policy. Hence, it is important to develop environmental education in order to raise the environmental awareness of the citizens.

In recent years, the government has organized lots of activities and published many publications to promote the idea of environmental protection. The citizens, private entities and schools have actively responded by participating in a huge number of environmental related seminars, demanding different kinds of environmental education materials and implementing the environmental management system.

The statistics about the environment of 2001 shows that 262,000 participants have taken part in a total of 841 activities with 332 co-organizers. This figure has a significant increase when compared to 2000.



**Figure 7.7**  
Environmental education activities organized by the EC, PMM and PMI  
(Source: Statistics on the environment, SCS, 2002)



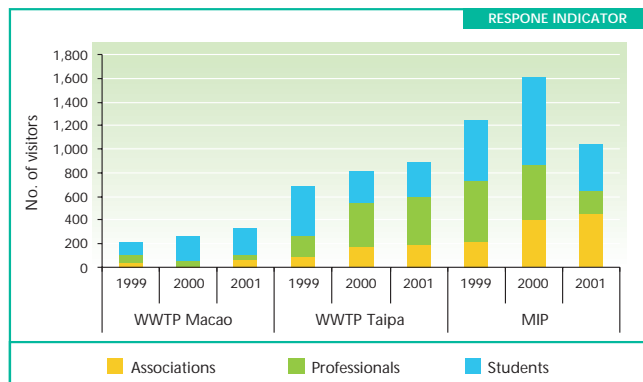
Besides organizing different kinds of activities, the Education and Youth Affairs Bureau (EYAB) also promotes several environmental education programs in schools. During the academic year, there is a month dedicated to environmental protection both in primary and in secondary schools to encourage the preservation of natural resources and environmental protection.

The EYAB and the EC have also organized a summer course on "Environmental Education" in 2001 and 2000. The aim of this course is to educate teachers of kindergarten, primary and secondary schools so that they can effectively promote and educate students the environmental protection. In addition, teachers have also participated in other environmental education courses, such as the "Environmental Summer Camp" and "New Concepts on Environmental Education".

The EC, PMM and PMI have also issued a variety of posters, leaflets and other publications in order to provide to the students and the public more environmental information and to integrate the ideas of environmental protection in their daily life.

In 2001, there were a total of 91,911 visitors to the environmental information centres of the two municipalities and 2,263 visitors have visited the wastewater treatment plants

and the Macao Incineration Plant. These facilities not only minimize the environmental impact on Macao but also act as an environmental education point.



**Figure 7.8**  
Number and type of visitors to WWTP and to the MIP  
(Source: OID, 2002)

In 2001, both the quantity of recycled waste and the number of entities participated in the recycling campaign organized by PMM and PMI have increased. This shows the support of the Macao citizens to this type of campaign.



The following table shows some of the major environmental activities held on 2001. The environmental consciousness and awareness of each citizen have been enriched through all of these activities.

Publications
Report on the State of the Environment of Macao 2001 (Book and CD-Rom)
Lotus, Journal of Environment
- Volumes 17 and 18: Quality of the Environment in the Pearl River Delta II
- Volume 19: Environment and Culture
Environmental Series: Drinking Water in Macao
Leaflets about Environmental Information
Newsletter on the Environment
Proceedings of the 2001 International Conference on Sustainable Development and Green Enterprises
Urban Solid Waste Management (VCR and CD-Rom)
Environmental Education VCD (for primary schools)
Leaflets on Noise, USW, City Cleaning, Water and Energy Saving
Activities
“Green Campaign and Healthy Life” – An activity to celebrate the World Environment Day together with the cities of Shenzhen, Hong Kong, Guangzhou, Zhuhai, Zhongshan and Macao
Green Week Activities in 2001
Earth Day Activities
World Environment Day Activities
Courses on Environmental Protection for Teachers
“Creating a Non-Smoking Working Environment” Campaign
“Environmental Summer Camp – Macao and Guangdong”
Seminar on “Control of Vehicle Emissions”
Contest of the Production of Films on “Environmental Protection”
“Macao, a clean city” Campaign
Exhibitions on the Water Day, Noise Day and Wetland Day
Programme of the Youth Ambassadors for the Environmental Protection of Macao

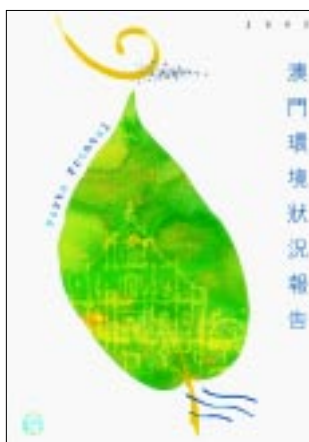
**Table 7.1**  
Major environmental education activities in 2001  
(Source: EC, CMAB, 2002)

The Environment Council has developed a number of contacts and activities in collaboration with the relevant departments of the neighbouring regions and a series of activities were taken place in 2001.

To celebrate the World Environment Day, the Environment Council has organized the “Green Campaign and Healthy Life” activity in collaboration with the cities of Shenzhen, Hong Kong, Guangzhou, Zhuhai and Zhongzhan. The aim of these activities is to facilitate the exchange and the co-operation in the environmental aspect between Macao and the neighbors.









## 2001 International Conference on Sustainable Development and Green Enterprise

In November 2001, the Environment Council has extended the co-operation to an international level by organizing the “International Conference and Exhibition on Sustainable Development and Green Enterprises”. The conference aimed at the reinforcement of Macao being a gateway to China in commercial and technological exchange with other countries, the promotion of green enterprises, the concept of sustainable development and the creation of new partnerships and commercial opportunities in environmental protection.

The Conference had got supports from different entities including the State Environmental Protection Administration of China as the special supporting organization and the China Association of Environmental Protection Industry as the special organizer.

Mr. Edmund Ho (the Chief Executive of the MSAR) hosted the opening ceremony of the conference and Mr. Xie Zhenhua (Minister of the State Environmental Protection Administration of China), with a delegation of government officials, environmental professionals and experts from enterprises had attended the conference. Other honorable guests participated in the conference include Mr. Ravi Sawhney (representative of the United Nations Economic and Social Committee for the Asia-Pacific, ESCAP), Ms. Birgitta Boström (Vice-minister of Ministry of the Environment of Sweden), Mr. Zhang Kunmin (Secretary-General of China Council for International Co-operation on Environment and Development of the PRC) and Eng. Ao Man Long (Secretary for Transport and Public Works of the MSAR).

Speakers of the conference came from different countries and regions, such as China, Portugal, Sweden, Canada, the USA, the UK, Singapore, Hong Kong and Macao. Major topics of the conference include the environment and business, sustainable city, environmental buildings and energy efficiency, urban air and urban water etc. Different organizations from China, Hong Kong, Belgium, Portugal, France, Denmark, Sweden and Macao had participated in the exhibition in parallel with the conference.



The exhibition showed the latest technology in the treatment of water and waste, indoor air quality, noise monitoring equipment, vehicle emission control equipment, renewable energy and ecological construction material.

### 7.4 Inter-regional Co-operation

Since pollution has no frontiers, it is important to cooperate with neighboring regions in order to apply practical measures to protect and preserve the environment.

In 2001, the “Joint-liaison Group for the Environmental Co-operation” – a group within the “Joint-liaison Group for the Macao SAR and Guangdong Province Co-operation” – had been established in order to enhance the discussions and studies in the cooperation of environmental education, training of professionals, as well as the control of water pollution caused by water hyacinths.



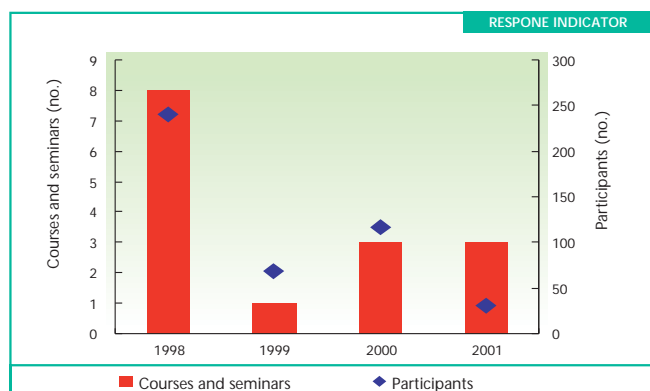
## 7.5 Implementation of environmental management systems

ISO 14001 is an environmental management system aimed to continuously improve the environmental performance of the organizations. This standard has become more important for the enterprises in getting competitive advantages in the market and minimization of the barriers in exportation. Environmental management enhances the concerns of the enterprises to reduce emissions and waste as well as to optimize their production processes. This will enhance a better economy efficiency of enterprises and minimize the impact on the environment.

The number of organizations in Macao that have been certified with ISO 14001 Standard has been increasing from 1 enterprise in 1999 to 8 enterprises in 2002. These enterprises include manufacturing industries, textiles, civil construction, telecommunications, electrical repairing service and wastewater treatment facility. An increase in the number of companies applying for certification is expected.

For the implementation of the environmental management system, it is necessary to know and comply with all environmental legislation requirements. The Environment Council has edited "Macao Environmental Legislation" and "Reference Documentation on International Conventions and Regional Protocols in the Area of Environmental Protection". This information is also available on the website of Environment Council. In addition, the Macao Productivity and Technology Transfer Centre (CPTTM) has invited the Environment Council to introduce the environmental legislation of Macao in environmental management courses.

The CPTTM grants financial support and loans to the organizations applying for the ISO 14001 certification. It also promotes seminars and courses on environmental management system. All these efforts have contributed towards the promotion of ISO 14001.



**Figure 7.9**  
Courses and seminars on environmental management  
(Source: CPTTM, 2002)

## 7.6 International Conventions and Protocols

The MSAR government has actively participated in international environmental activities and is a member of the following protocols and conventions:

1. Vienna Convention for the Protection of the Ozone Layer (1985); Montreal Protocol on Substances that Deplete the Ozone Layer (1987); Amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer (1990) is applied to the MSAR according to executive order no.31/2002 of 5<sup>th</sup> June 2002.
2. United Nations Framework Convention on Climate Change (1992) is applied to the MSAR according to executive order no.33/2002 of 5<sup>th</sup> June 2002.
3. Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973) – CITES is applied to the MSAR according to executive order no.35/2002 of 5<sup>th</sup> June 2002.
4. Convention on Biological Diversity (1992) is applied to the MSAR according to executive order no.34/2002 of 5<sup>th</sup> June 2002.
5. The Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal (1989) is applied to the MSAR according to the executive order no.32/2002 of 5<sup>th</sup> June 2002 and the Amendments to the Basel Convention is applied to the MSAR according to the executive order no.52/2002 of 21<sup>st</sup> August 2002.
6. The Plant Protection Agreement for the Asia and Pacific Region (1956) is applied to the MSAR according to executive order no.30/2001 of 6<sup>th</sup> June 2001.











8

# Analysis and Recommendations

The main objective of this report is both to describe the evolution of the state of the environment of Macao annual and to envisage the trend in the coming years.

We, therefore, believe that it is necessary to include these recommendations in the report, which allows readers to have a quick reference or to conduct an in-depth analysis. Thus, it enables policy-makers as well as analysts to retrieve and to research related information.

We would like to emphasize some recommendations in previous reports. Sustainable development and the environmental problems should not only be focused on local area. Since pollution has no boundary, it is necessary to consider other nearby regions when analysing environmental problems and finding possible solutions.

## Atmospheric Environment

MEC is the dominant pollution source of pollutants SO<sub>x</sub> (sulphur oxides), NO<sub>x</sub> (nitrogen oxides), CO<sub>2</sub> (carbon dioxide) and particulates and road traffic is responsible for most of the lead emissions, NMVOC (non-methane volatile organic compounds) and CO (carbon monoxide). CH<sub>4</sub> (methane) emissions come mostly from urban solid waste landfill, whereas the WWTPs are the most important emission sources of NH<sub>3</sub> (ammonia) and N<sub>2</sub>O (nitrous oxide).

Since Macao has a small geographical area surrounded by water, meteorological factors can deeply affect the air quality. Several studies show that, the concentration of pollutants is higher during autumn and winter due to the meteorological conditions of high cold pressure, stable atmosphere

and with the prevailing northern winds that can easily carry pollutants from the mainland to Macao.

It is worthwhile to mention the recent decline in lead and sulphur emissions. Lead emissions have declined obviously since the introduction of the unleaded petrol in Macao. Sulphur emissions have also decreased in 2001 as the executive order no.49/2000 has been in place since the 7<sup>th</sup> of August of 2000, which sets the limits of the commercial sulphur content of light diesel for motor vehicles (not more than 0.05% by weight). The decrease in sulphur oxide emissions has less than that of lead due to the contribution of power production towards sulphur emissions.

With an increasing number of vehicles installed with catalytic converters, there is a drop in the emissions of CO and COV each year after the peak in 1998 and 1999. However, since power production is the main source of NO<sub>x</sub>, the use of catalytic converters to minimize NO<sub>x</sub> emissions is not obvious.

## Water Resources

The lack of precise data limits a complete analysis of relevant parameters in the various WTPs, but the chloride concentration in the Ilha Verde WTP is introduced. Regarding the analysis of the microbiological parameters in the water distribution networks, no comparison can be made with previous years because of the change of the assessment methods in 2002.

The wastewater drainage system is not yet covered the whole area of the Macao. A great part of the network drains also the rainwater. There are still some networks whose



effluents are directly discharged into the water body without being treated in the WWTP. In order to increase the capacity to retain and treat the influent volume in the Macao WWTP during peak hours, a storage tank with a capacity of 10,000m<sup>3</sup> is in operation in 2002. However, due to the high precipitation volume in Macao, the ideal solution would be the extension and the installation of separate sewers as well as the replacement of the combined drainage network.

Regarding industrial wastewater generated by some companies, an efficient solution for the disposal has not yet been found and this report shows some of the examples. The data from Hovione shows that the volume of wastewater discharged has constantly been increasing. Although the company is utilizing transitory solutions at this moment, this is not the ideal situation. The wastewater from Hovione consists of acidic solution and is neutralized before draining to the Taipa WWTP. Nevertheless they still affect the operation of the Taipa WWTP.

Generally speaking, the analysis of the pollution index shows that the pollution in the Macao coastal zone has been increasing and critical values have been reached in some points. The quality of the Macao coastal waters does not only depend on local pollution sources but also on the whole Pearl River Delta region. Therefore, it is necessary to co-operate with the relevant entities of the adjoining regions in order to find regional solutions for environmental problems and reinforce the control of the pollution sources. According to the "International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990", the Guangdong Province, the Hong Kong SAR and the Macao SAR had signed a protocol aimed to take joint measures for large scale accidental oil spillage in the Pearl River Delta region in order to protect the coastal water quality.

### Natural Conservation

Green spaces possess several important ecological and social quality such as clean air, soil and water conservation, fertilization, absorbing carbon dioxide, releasing oxygen and providing citizens places for leisure activities and nature cognition. Therefore, the management of these green spaces should be of high priority.

Special attention should be paid to the conservation of reforestation areas and their development through carefully selecting appropriate fire-resistant plant species as well as adopting natural means to fight against ecological invasion.

The MSAR Government has strategically decided to build the first ecological zone in the Cotai area in order to create conditions to enrich the biological diversity in Macao. Within the 55-hectare of ecological zone, 40 hectare of land is designed to be the feeding grounds of birds, while the remaining 15 hectares is for the birds' habitat. The aim of this eco-



logical zone is to provide different species including the endangered ones with the suitable feeding and resting grounds.

Efforts should be endeavoured to raise the fire prevention awareness of the population through civic education because the main cause for the devastation of green areas is by human activities or setting to fire.

### Waste

The lack of information regarding the generation and storage of hazardous waste in Macao reveals the need to carry out an in-depth research on the real situation and to promote the campaigns so as to increase the awareness of the population towards resources preservation.

When comparing to domestic solid waste, special attention towards the incineration temperature of pathogenic waste should be paid.

The Macao Jockey Club will find the appropriate solution for dead animal bodies' disposal in the near future since the new landfill will not provide specific cells for the disposal of dead animal bodies.

All the aforementioned situations indicate the need to take strategic environment management in the middle to long term. Thus, it is recommended to establish a Waste Management Strategic Plan.

In the MSAR, especially in the Macao Peninsula (a small area with a dense population), the generation and management of waste and the movement of waste from other regions have become a matter of great urgency for environmental management. These issues should be considered due to the increase of waste generation rate, the near saturated capacity of some final disposal infrastructures (such as landfills) and the limitation of space for new ones.

Several other factors such as the liberalization of the gambling licences, the forecast population and economic growth, the exchange of goods within the region and the increase in the number of visitors will increase the pressure upon the existing resources, especially on the waste management system. It is, therefore, a growing concern of the environmental management departments in Macao.

The problems related to waste will surely draw most of the attention within the process of the sustainable development of Macao.

The introduction and approval of a Waste Management Strategic Plan is therefore urgent. This plan should be based upon the prevention of waste generation, utilizing as much as possible more profitable and less pollutant technologies and consolidating the reuse and recycling of certain products. It should include the management of urban, industrial and hospital waste as well as in the licensing procedure for industry (or other enterprises that cause potential impact on the environment). The Waste Management Strategic Plan will include:

- Type, quantity and waste sources to be valued or reduced;
- General technical criteria;
- Special regulations for specific waste treatment;
- Appropriate location or installation for the waste disposal;
- An estimated cost concerning the operations for waste reutilization or waste reduction;
- Measures that can encourage waste collection, separation and treatment.

A change in perspective will be based not only on the approval of the referred Strategic Plan but also on the change of the consumer's behaviours and attitudes which have direct



or indirect consequences on the production and sale of products.

The establishment of a Framework for Waste Regulation is of the utmost importance. It should also indicate the relevant department for introducing the waste management rules and the relevant inspection work.

From the technical measures that have been recommended previously, the followings need to be emphasized:

- To carry out a detailed assessment on landfill operation;
- To study the feasibility of inactivating the fly ash generated by the incineration plant;
- To assess the feasibility of treating hospital waste at an incinerating temperature above 1,100°C, as recommended by some international organizations;
- To include an assessment on the quantity of waste generated and their disposal in the industrial licensing process;
- To investigate the source of waste oil and establish a system of waste oil collection for recycle for the use as an energy source for the sludge incinerator of the Macao WWTP;
- To encourage the development of "green enterprises" by promoting recycling and the application of anti-pollution technologies in Macao.

## Noise Environment

There are direct and indirect approaches to reduce road traffic noise. The direct measures include study on the implementation of noise standard for vehicles, the installation of noise barriers and road resurfacing with noise absorbent materials. Traffic flow management, traffic planning and restructuring of road networks are among some of the indirect measures.

Although traffic noise is one of the main sources of noise pollution in Macao, "music and karaoke", "gambling", "interior decorative works" and even "conversations" are other causes of noise complaints received by the relevant authorities. The abatement of all these kinds of noise undoubtedly depends not only on the revision of the existing regulations and laws but also on civil and environmental education.

For the abatement of noise generated by commercial and industrial activities, a global assessment on noise pollution should be conducted by the licensing department in the licence granting process. Technical training should be reinforced and legislation should also be promoted and implemented effectively. Preventive measures should be done in advance to situations that may arise serious environmental impacts.

It is also necessary to intensify the monitoring and collection of noise data so as to provide a basis for a more complete and reliable control of noise pollution in Macao.



## Environmental Management

There are special measures and specific items of environmental management mentioned in this report, such as the investments and expenses on environmental management, environmental awareness and education, inter-regional co-operation and implementation of environmental management system. Among all, the implementation of environmental management system and the development of environmental awareness and education are the most important measures towards the sustainable development of Macao.

## Conclusions

With a small area and a dense population in the MSAR, the increasing waste generation rate and the saturated capacity of the final disposal infrastructures (such as landfills) and the lack of space for new ones are some of the essential problems of the MSAR.

In addition, the analysis of the pollution indexes shows that the pollution in the Macao coastal area has been increasing and reaching critical values at some points. The quality of the Macao coastal waters does not only depend on the local pollution sources but also on that of the Pearl River Delta region. Therefore, it is necessary to co-operate with the relevant entities of the adjoining regions in order to find regional solutions for environmental problems.

Since Macao is developing into a tourism and entertainment city, the environmental issues mentioned undoubtedly need to be solved as soon as possible. The development has obviously entered into a new era and therefore it is recommended to establish a holistic environmental policy in order to fulfil the targets of sustainable development of the MSAR at this critical transformation.



## Acronyms And Symbols

<b>A</b>		<b>M</b>	
ADA	Administration of Airports	MCS	Macao Customs Service
AQI	Air Quality Index	ME	Ministry of the Environment (Portugal)
As	Arsenic	MEC	Macao Electric Company
<b>B</b>		MGB	Meteorological and Geophysical Bureau
BOD	Biochemical Oxygen Demand	MIP	Macao Incineration Plant
BOD <sub>5</sub>	5-day Biochemical Oxygen Demand	MLM	Municipal Laboratory of Macao
BS	Black Smoke	MPV	Maximum Permissible Value
<b>C</b>		MRV	Maximum Recommended Value
CCB	Cartography & Cadastre Bureau	MSAR	Macao Special Administrative Region
Cd	Cadmium	MWSC	Macao Water Supply Company
CFCs	Chlorofluorocarbons	<b>N</b>	
CH <sub>4</sub>	Methane	N <sub>2</sub> O	Nitrous oxide
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora	NGO	Non Governmental Organisation
CMAB	Civic & Municipal Affairs Bureau	NH <sub>3</sub>	Ammonia
CO	Carbon monoxide	NMVOOC	Non-methane volatile organic compounds
CO <sub>2</sub>	Carbon dioxide	NO	Nitrogen oxide
COD	Chemical Oxygen Demand	NO <sub>2</sub>	Nitrogen dioxide
CORINAIR	Core Inventory of Air Emissions	NOx	Nitrogen oxides
CPTTM	Macao Productivity and Technology Transfer Center	<b>O</b>	
Cr	Chromium	O <sub>3</sub>	Ozone
<b>D</b>		OECD	Organisation for Economic Co-operation and Development
dB	Decibel	OID	Office for Infrastructures Development
DO	Dissolved Oxygen	<b>P</b>	
<b>E</b>		PA	Port Authority
EEA	European Environment Agency	Pb	Lead
ESB	Economic Services Bureau	PD	Police Department
EGIS	Environmental Geographic Information System	PFCs	Perfluorocarbons
EMEP	Co-Operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe	PMI	Provisional Municipality of the Islands
EPA	Environmental Protection Agency	PHL	Public Health Laboratory
EU	European Union	PM <sub>10</sub>	Respirable Suspended Particles (≤10mm)
EYAB	Education and Youth Affairs Bureau	PMM	Provisional Municipality of Macao
<b>F</b>		PRC	People's Republic of China
FB	Fire Brigade	<b>S</b>	
FSB	Finance Services Bureau	SCS	Statistics and Census Service
<b>G</b>		SF <sub>6</sub>	Sulphur hexafluoride
GHG	Greenhouse Gas	SoER	State of the Environment Report
GIS	Geographic Information System	SO <sub>2</sub>	Sulphur dioxide
GDP	Gross Domestic Product	SOx	Sulphur oxides
GWP	Global Warming Potential	<b>T</b>	
<b>H</b>		TEC	Total Energy Consumption
HB	Health Bureau	THM	Trihalomethane
HCl	Hydrochloric acid	TOE	Tonnes of Oil Equivalent
HF	Hydrogen fluoride	TSP	Total Suspended Particulates
HFCs	Hydrofluorocarbons	TSS	Total Suspended Solids
Hg	Mercury	<b>U</b>	
<b>I</b>		USW	Urban Solid Waste
IE	Institute for the Environment	<b>V</b>	
IPCC	International Panel for Climate Change	VOC	Volatile Organic Compounds
ISO	International Organization for Standardization	<b>W</b>	
<b>L</b>		WHO	World Health Organisation
Leq	Equivalent Sound Pressure Level	WTP	Water Treatment Plant
		WSC	Waste Service Company
		WWTP	Wastewater Treatment Plant



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**ENVIRONMENT COUNCIL**

Rua de Sanches de Miranda n° 3 – Macao

Tel: (853) 725134

Fax: (853) 725129

E – mail: [ca@ambiente.gov.mo](mailto:ca@ambiente.gov.mo)

<http://www.ambiente.gov.mo>

