Governmental responses to air pollution: summary of a study of the implementation of *rodízio* in São Paulo

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SUMMARY: *This paper describes the "rodízio" programme in São Paulo which has sought to reduce air pollution by banning the use of every car for one day a week. After summarizing the serious problems that São Paulo faces from air pollution and the extent to which these are generated by motor vehicles, it describes the difficulties the city authorities faced in getting approval for this programme, including opposition of the press. However, it has still been implemented - for a month in 1996 and for the period June-September in 1997 and 1998 - and accompanied by a large information programme. Its implementation brought significant reductions in some air pollutants and reduced traffic congestion. It also received considerable public support. The paper ends by reflecting on this experience in the light of the need for city authorities to increase information about environmental risks and ensure democratic interaction between local government and citizenry about environmental priorities.*

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I. INTRODUCTION

FOR MANY YEARS, the industrial chimneys in the city were seen as a sign of progress; they also used to be the main source of air pollution. Today, the major emitters of air pollutants are motor vehicles – another icon of modern life.

While the use of automobiles is closely associated with the *paulista* way of life, the environmental consequences of its use are being heavily debated. A recent policy initiative to reduce air pollution from vehicles - *rodízio* - which involves vehicles with certain licence numbers being retained from circulation on certain days according to a fixed schedule, is the subject of this study.

This paper provides a summary of the document *Poluicão do ar em São Paulo e Resposta da Acão Pública.*[1]

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II. SÃO PAULO'S AIR POLLUTION IN CONTEXT

DURING THE 1960s and 1970s, São Paulo grew very rapidly, creating an enormous concentration of industrial wealth as well as a road network constructed in tandem with growing middle-class automobile ownership. The São Paulo metropolitan area is now one of the largest urban agglomerations in the world, with over 17 million inhabitants. Urban space was continuously extended to cater for private automobiles, thus reducing the role of collective transport (see Table 1). The existing subway network, introduced in 1974, operates with only three lines, totalling 44 kilometres, and thus caters for only a small part of the city; it currently ferries some 2.3 million passengers per day but almost no investment has been made in the last decade. The 190 kilometres of train tracks carry some 1.2 million people per day[2] and cater for some of the long-distance commuting in the metropolitan area, which stretches over some 8,000 square kilometres.

Table 1: Travel Patterns within São Paulo

Percentage of motorized trips undertaken by different means of transport

Means of transport	1967 (%)	1977 (%)	1987 (%)
Bus	59.1	54.1	42.8
Metro	-	3.4	7.6
Train	4.4	3.2	4.4
Taxi	8.1	3.5	0.7
Car	25.9	34.8	41.9
Other	2.5	0.9	2.6
Total	100.0	100.0	100.0

SOURCE: Pesquisa Origem-Destino, 1987/97 - Metrô. In *Engenharia* (1995), page 66.

The vehicle fleet is estimated at some 4.5 million cars, constituting 25 per cent of the national fleet, and is increasing by an average of 1,000 vehicles each day.[3] In addition, 12,000 buses circulate within São Paulo. Traffic congestion is a serious problem, with over 100 kilometres of roads in the city becoming congested at peak hours. Average traffic speed for cars is around 20 kilometres per hour, the occupancy rate is 1.5 persons per car and 3,200,000 cars are estimated to circulate each day.[4]

Because of topographic and climatic factors, combined with an excess of private cars, the city faces severe problems of air pollution. The atmospheric conditions particular to the region create a phenomenon of strong thermal inversion during the winter, worsening the air pollution problems and their impacts on health. The air quality standards are frequently exceeded; those that are surpassed most often are for suspended particulate matter, carbon monoxide and ozone levels and, to a lesser degree, sulphur dioxide emissions, nitrogen oxides and organic compounds. Between 1987 and 1994, air quality standards for total atmospheric particulates were regularly exceeded on both a daily and a yearly basis. Daily and yearly standards were also regularly exceeded with regard to smog and carbon monoxide. During periods unfavourable to pollutant dispersion,

1. Jacobi, P., Segura, D.S.B., Tella, M.A.P. and R.A. da Silva (1997), *Poluição do ar em São Paulo e Resposta da Acão Pública,* Final Report, CEDEC, São Paulo, 102 pages.

2. EMPLASA (1993), *Por Dentro da Grande São Paulo,* Emplasa, São Paulo, 109 pages.

3. Governo do Estado de São Paulo (1997), *Operacão Rodizio na Caminho Certo*, São Paulo, 122 pages.

4. CETESB (1995), *Relatório de Qualidade do Ar em São Paulo,* Cetesb, São Paulo; also Sobral (1995).

concentrations of particulates regularly exceed warning levels. There are three "alarm" levels: *attention* (when total particulates exceed 375 microgrammes per cubic metre of air over a 24-hour period) when the recommendation is given for people to avoid unnecessary use of their cars; *alert* (when total particulates exceed 625 microgrammes per cubic metre) which should lead to restrictions on vehicle use and industrial activities; and *emergency* (in excess of 825 microgrammes per cubic metre) which should lead to a ban on all polluting activities.

Initially associated with industrial production (point sources), air pollution today is mostly produced by motor vehicles, on average accounting for 90 per cent of the total, with differences emerging between gasoline, alcohol-run and diesel vehicles. Gasoline and alcohol-run vehicles are the main emitters of carbon monoxide and hydrocarbons, while diesel trucks and buses are the main polluters in terms of suspended particulate matter, sulphur dioxide and nitrogen oxides. Aldehyde emissions are caused by alcohol based fuels (see Table 2). Furthermore, emissions levels are closely connected to the level of maintenance of the engines.

Table 2: Principal Sources and Impacts of Selected Air Pollutants

Pollutant	Source	Health and environmental impact
Sulphur dioxide (SO_2)	Burning of fossil fuel (coal and petroleum)	Aggravates respiratory diseases; increases risk of cardiovascular disease; contributes to acidification of water and soils
Oxides of nitrogen (NOx, NO, NO_2)	Burning of fossil fuel (coal and petroleum)	Damages human lungs, certain sensitive plants, as well as physical structures; can increase susceptibility to contracting viral disease; contributes to acidification
Carbon monoxide (CO)	Combustion - in relation to motor vehicles, industrial processes and burning of refuse	Weakens the blood's capacity to transport oxygen to cells; affects the cardiovascular, nervous and pulmonary system; contributes to (ground level) ozone formation
Organic compounds (hydrocarbons and aldehydes)	Motor vehicles - principally those fuelled by alcohol fuels Industry	Some compounds can cause mutations and cancer; contributes to (ground level) ozone formation
Ozone (at ground level)	Secondary pollutant resulting from the chemical reaction between oxides of nitrogen and organic compounds in the presence of solar radiation	Irritates eyes, nasal congestion, reduction of lung function,decreased resistance to infections, and premature ageing; harms vegetation; the principal component of dense smog
Particulates	Incomplete combustion of fuels and industrial additives Diesel vehicles Soil dust	Respirable particulates affects the lungs; particulates from diesel engines are potentially carcinogenic; provokes allergies, asthma and chronic bronchitis

SOURCES: *Manual Global de Ecologia* (1993); CETESB (1993), *Relatório de Qualidade de Ar*; Artaxo (1991) in *Boletim Debates Sócio-Ambientais* No.2 (1995).

Concern with air pollution in São Paulo has been heightened by the observation that increases in pollution (particularly from nitrogen oxides and suspended particulate matter/dust) are associated with a significant increase in mortality from respiratory diseases in the elderly and children in the two days following these rises in pollution levels. Furthermore, an increase of 25 per cent in the demand for public health care in children's hospitals has been recorded in the two days following the occurrence of high concentrations of pollutants in the atmosphere, as well as an increase of 12 per cent in the mortality rates of those over the age of 65.[5]

In the past few years, there has been an expansion in the so-called critical areas of air pollution which, previously, had been confined to the more central areas of the city. The increased deterioration in the city's air quality has had as its main consequence a heightened risk of health problems such as respiratory and cardiovascular diseases. The main victims are malnourished children, the elderly and people suffering from chronic respiratory diseases, mainly asthma and bronchitis.

5. Saldiva, P. (1995/96), "Efeitos da poluição atmosférica na saúde", *Debates Sócio-Ambientais* Vol.3, No.26, Cedec, São Paulo.

III. HOUSEHOLDS' PERCEPTIONS OF ENVIRONMENTAL PROBLEMS

THE 1991/92 SURVEY of household environmental problems undertaken by Cedec and SEI shows air pollution to be people's major environmental concern. These findings, from 1,000 representative households in the municipality of São Paulo (mainly women respondents), supported the authorities' move to further combat air pollution through the restriction of vehicle circulation, as expressed in the preamble to the law instituting the *rodízio*.[6]

Table 3 shows that, from a considerable list, air pollution was the most common choice (13 per cent) of "main neighbourhood

6. See reference 3.

Table 3: Main Neighbourhood Problem

	Percentage of households
Air pollution	13.3
Violence	12.8
Health	10.4
Lack of green areas	8.3
Sewage	6.6
Water quality	6.5
Flooding	6.1
Lack of collective transport	6.1
Pollution of rivers	5.7
Lack of day care centres	5.7
Noise pollution	4.8
Solid waste	3.8
Traffic	3.6
Others	6.2
Total	**100.0**
Number of households: 890	

SOURCE: SEI/Cedec Household Environment Data Base 1991/92.

problem". If one also includes lack of collective transport (6 per cent), noise pollution (5 per cent) and traffic (4 per cent), transport related problems score even higher. However, there are major differences between socio-economic strata and, for high-income households, air and noise pollution, along with violence, are clearly seen as the main neighbourhood problems. For lower-income households, violence, along with the lack of health services and collective transport, as well as sewage problems are their main neighbourhood problems. Air pollution *per se* is less of an issue for lower-income households.[7] Geographically, concerns relating to air and noise pollution are concentrated in the central areas of the city.[8]

7. Jacobi, P. (1995), *Environmental Problems Facing Urban Households in the City of São Paulo, Brazil*, Stockholm Environment Institute, Stockholm, 151 pages.

8. Jacobi, P., Kjellén, M. and Y. Castro (1999), *Household Environment Problems in São Paulo: perceptions and solutions from centre to periphery*, Urban Environment Series No. 5, Stockholm Environment Institute, Stockholm.

Table 4: Perceptions about Air Pollution Problems

Percentage households experiencing air pollution: 63.2	
Number of households: 1,000	
Type of air pollution experienced	(% of households)
Dust	75.9
Vehicular pollution	74.4
Bad smell	52.3
Soot	51.7
Industrial pollution	36.1
Number of households: 630 (multiple choice question)	
Perception of air quality	(% of households)
Good	4.4
Fair	13.4
Bad	39.2
Very bad	42.9
Total:	**100.0**
Number of households: 989	

SOURCE: SEI/Cedec Household Environment Data Base 1991/92.

While about 13 per cent of households consider air pollution as the major problem, 63 per cent express concern about air pollution in one form or other. Households most often classify air pollution problems as relating to vehicular pollution and dust, followed by bad smells and soot, and few people considered the air quality as being good. Right across the socio-economic strata, health problems are seen as the major consequence of air pollution.[9]

9. See reference 7.

Table 5: Prioritized Solutions to Air Pollution Problems

Control emissions of industrial pollutants	20.9
Control emissions of pollutants from vehicles	18.7
Improve collective transport	13.7
Remove polluting industries from inhabited areas	13.0
Create new green areas and enlarge existing ones	12.4
Reduce the number of cars in circulation	9.0
Plant trees along roads	6.7
Pave the roads	3.6
Other	2.0
Total:	**100.0**
Number of households: 942	

Emission controls, in both industry and the transport sector, are the most favoured solutions. The control of industrial pollutants actually scores higher than the control of vehicular pollutants in spite of a much smaller number of people identifying air pollution problems with industrial emissions. Interestingly, reducing the number of cars in circulation (which is exactly what the *rodízio* does) was not the most favoured way of addressing air pollution problems. However, in the context of an interview situation, it is not surprising that people opt for the longer-term investment oriented solutions.

IV. INITIATIVES TO CURB AIR POLLUTION

AIR POLLUTION MONITORING started in 1973 through the State Environment Protection Agency (CETESB) with the systematic manual measurement of the air quality (sulphur dioxide and smoke levels) in the metropolitan region by a complex system of mobile and fixed sampler stations. From 1976, carbon monoxide levels were also measured and, from 1983, suspended particulate matter. In 1991, an automatic network was introduced consisting of 25 fixed and two mobile stations. The concentrations of carbon monoxide frequently exceed the air quality standards by a large margin in almost all monitoring stations.[10]

In 1986, the National Environmental Council enacted a resolution establishing a nationwide automotive emissions control programme under the name PROCONVE. This programme, through agreements with the automobile industry, helped extend the use of electronic injection and catalytic converters in order to reduce emissions. The emissions limits have become progressively more stringent and the law establishes a maximum of 24 grammes/kilometre of carbon monoxide. Since 1992, new legislation requires catalytic converters in new cars and maximum carbon monoxide emissions of 12 grammes/kilometre. This represents progress but is still far behind the requirements of cities in Northern countries. In 1997, the threshold was reduced to two grammes/kilometre.

The federal and state governments are discussing the implementation of a Programme of Inspection and Maintenance of Vehicles in Use (I/M), which would put in place the compulsory inspection of the fleet in circulation by authorized stations in cities that have critical air pollution problems. The programme was proposed for the whole São Paulo metropolitan area and detailed by CETESB and, in 1994, the municipality of the city of São Paulo opened the tender for private companies to bid for the inspection service. This generated a conflict of authority between state and municipality, and a judicial dispute on the creation of a monopoly to execute public services because of the dubious bidding process. During 1995, and to some extent in 1996, there was a dispute in defining the control of this programme and the outcome is still uncertain.[11]

10. Segura, D. and M.A. Tella (1995/96), "Poluição atmosférica: um quadro preocupante", *Debates Sócio-Ambientais* Vol.2, Nos.4-5, Cedec, São Paulo.

11. Demajorovic, J. and S. F. MacDowell (1996) "Meio ambiente, condiçoes de vida e políticas sociais", *Boletim de Conjuntura, Política Social*, Fundaçao do Desenvolvimento Administrativo – FUNDAP, No. 22, São Paulo, May-August.

V. THE CASE OF *RODÍZIO*

THE FIRST INITIATIVE to control vehicle circulation took place in 1988 when the authorities, given the very dangerous levels of air pollution, declared an emergency prohibition in the central area of the city of the circulation of vehicles for one day. This was only applied once, as an experiment, although since then, other attempts have been made to restrict the circulation of vehicles; however, none have been formalized.[12]

12. Debates Sócio-Ambientais 2 (1995/96), *Poluição Atmosférica,* Cedec, São Paulo.

In 1995, the environmental agencies reintroduced into their agendas some of the main control mechanisms, namely *rodízio* (reduction in the use of cars once a week according to registration plates) and the compulsory inspection of vehicle emission levels, following the experiences of other metropoli such as Mexico City and Santiago de Chile. As a preventive measure, in 1995, the State Secretariat of Environment implemented *Operação Rodízio* in the winter, when pollution levels increase due to thermal inversion. The justification was the need to remove a daily percentage of cars in circulation thus reducing the levels of emissions and traffic congestion. For one week, an experimental and non-compulsory programme was implemented and it divided opinions between specialists and society in general. Critics of the programme said that it hardly represented a mitigating measure and, given the poor state of the public transportation system, could not justify the imposed costs on society. Those in favour of the initiative considered that it was successful, achieving the support of 38 per cent of drivers during the whole week; this was a good figure, considering that the programme was voluntary, that there were no sanctions and that dissemination was poor. The exercise also lacked support from the municipal authorities. Despite its short duration, an effect on air quality was observed, namely a reduction in carbon monoxide levels.

The programme's level of success encouraged the State Secretariat of Environment to propose its implementation on a compulsory basis, with a US$ 200 failure-to-comply penalty, for the months of June-August 1996. From its inception, the programme was presented as an emergency measure (because data on health indicated that certain measures had to be taken during the winter season) and a civil defence measure. But the proposal had to be sent to the State Assembly to be voted on as law. After a session of intense negotiations, the law was voted in but with changes that might jeopardize the programme's future. The time period was reduced to cover only the month of August (between the hours of 7 a.m. and 8 p.m.) and excluded buses, trucks and school buses. From this moment, the *rodízio* was no longer voluntary and became compulsory, with a penalty of US$ 100 set by the legislature. All this increased the existing level of controversy concerning the proposal. The main obstacle involved the operationalization of the programme and the poor quality of the public transportation system. Drivers pointed out also that it is a mitigating measure that does not solve the problem, as there are no complementary measures to improve circulation in the city such as increasing the network of subway and urban trains.

Several initiatives were attempted by those who opposed the programme, but none succeeded, and *Operação Rodízio* was implemented although without any support from the press. Various activities were developed in the weeks prior to the programme's implementation, including the distribution of pamphlets in the streets and in schools, and some public debate to stimulate interest. All of this was carried out almost without any public resources because of state budgetary restrictions. Some private companies participated in tele-marketing activities aimed at the people, including 3,200,000 telephone calls, 430 outdoor displays, eight electronic panels, publicity in the newspapers, 9,500,000 folders distributed in the streets and at important crossings, 1,000,000 stickers and other publicity devices. During the whole month of August, a series of activities to involve the population were initiated; 15 debates, four conferences on international experiences and 80 presentations in schools where 1,300 kits on "Operation São Paulo Breathes" were distributed.

The results presented in official reports from the State Secretariat of Environment are relevant and indicate the success of this complex initiative. The average adherence during the whole month of August was 95 per cent, representing the withdrawal of 456,000 cars per day. Consequently, there was an estimated reduction in carbon monoxide emissions of almost 330 tonnes per day, representing an overall reduction of almost 15 per cent. The official data indicate that there was an improvement in the air quality and, moreover, that there was a reduction in traffic congestion in the city. An assessment of the average fleet withdrawn and the effects of the improved fluidity of the circulating fleet show an estimated carbon monoxide reduction of almost 530 tonnes per day. The average speed of buses increased from 16 to 20 kilometres per hour, implying an increase of 2 per cent in the number of daily trips. During the month, almost 170,000 penalties were applied.[13]

13. Secretaria do Meio Ambiente (SEMA) (1996), *Balanço da Operação Respira São Paulo,* SEMA , São Paulo.

After the conclusion of *Operação Rodízio,* public opinion was consulted. Research undertaken by one of the most influential newspapers in the country indicated that 57.7 per cent of the population thought the programme should continue. This positive evaluation, even given that the air quality was not significantly affected, shows that it is possible for the *paulistano* (inhabitant of the city of São Paulo) to do something concrete to improve the quality of life in the city.

A survey among 700 first and second grade school children undertaken by Cedec, produced some interesting findings on how few negative consequences were experienced during the 1996 *rodízio* exercise.

Close to half of the school children regularly going to school by car had to change their routine, to car-pooling or some other means of transport. However, this rarely implied any time loss; due to the decrease in traffic congestion in the city, 22 per cent spent a shorter time getting to school during *rodízio* and only 4 per cent took longer. Regular bus users were those who most frequently noted time savings during the month (40 per cent). Given the time gains and the few difficulties experienced during

Table 6: School Children and *Rodízio*

Main means of transport regularly used:	Car	Walk	Collective transport	School bus	All
Frequency	283	233	109	44	66
Row percentage	42.3	34.8	16.3	6.6	100.0
Change of transport routine					
Yes	46.6	1.4	17.4	20.5	24.7
No	53.4	98.6	82.6	79.5	75.3
Column total	100.0	100.0	100.0	100.0	100.0
Change in time spent on transport					
Longer time	4.3	2.2	8.4	2.4	4.1
Same time	66.8	95.6	51.4	57.1	73.7
Shorter time	28.9	2.2	40.2	40.5	22.2
Column total	100.0	100.0	100.0	100.0	100.0
Experienced difficulties during *rodízio*					
Yes	18.0	6.6	13.0	2.3	12.2
No	82.0	93.4	87.0	97.7	87.8
Column total	100.0	100.0	100.0	100.0	100.0
Opinion about *rodízio*					
Very good	19.8	37.8	30.3	25.0	28.1
Good	36.4	30.9	35.8	29.5	33.9
Regular	27.9	19.7	22.9	38.6	25.0
Very bad	14.5	7.3	7.3	4.5	10.2
Does not know	1.4	4.3	3.7	2.3	2.8
Column total	100.0	100.0	100.0	100.0	100.0

SOURCE: Cedec Survey (1996), implemented in collaboration with the State Secretariat of Environment, with support from Sida/SEI.

rodízio, it is not surprising that most school children have positive attitudes towards the exercise.

VI. CONCLUSIONS

AN IMPROVEMENT IN São Paulo's air quality in the long term will require substantial investment in public transport as well as concerted action towards improving the state of repair of many vehicles. *Rodízio* is not a final solution but its full implementation in 1996 showed that it is possible to reduce air pollution substantially by only slightly reducing the number of vehicles in circulation. The larger gain during the implementation of *rodízio* is attributed to a reduction in congestion, making both public and private transport substantially more efficient.

Whilst several public opinion polls have favoured *rodízio*, the mass media has been relatively negative. This is possibly a reflection of an over-representation of car owner interests in the press. The users of collective transport - the major winners in the exercise - may be less vocal. Furthermore, the debate around air pollution also made the government increase enforcement of other initiatives to reduce air pollution.

The successful experience of *Operação Rodízio*, although it

had its limitations, indicates that there is a need for the public authorities to be innovative and audacious in formulating and implementing environmentally concerned public policies. The programme can be seen as a large-scale environmental education experience where the process, based on a penalty, created the necessary conditions for putting into practice an initiative that affected vested interests. It was an excellent opportunity to debate the crisis management of environmental degradation in mega-cities. There are no easy answers. Most of the experience had to be based on co-responsibility and a positive test of citizenship; also on the need to implement complementary measures that relied not only on the fact that the population was doing its part but also that public authorities at all levels had to implement interventions to reduce the acute public transport problems and stimulate more collaborative partnerships and cooperation with those who had to make concessions (drivers).

What has to be stressed is that the implementation of non-conventional policies and programmes to prevent environmental degradation is very complex. In recent years, only *Operação Rodízio* can be considered innovative because of the institutional engineering on which it is based. The main elements of this initiative link the need to increase public information on existing environmental risks with the importance of the public's willingness to participate in the positive outcomes of public policies. This is part of a necessary democratic interaction between local government and citizenship. To confront the prevailing logic of government protection, there are reasons to open more democratic doors, so local government can bolster the positive incentives for participation by encouraging citizen commitment through a knowledge of environmental risks and alternative practices that are in the public interest. By doing so, this ensures conservation of the natural collective goods that are basic to the public's survival.

The implementation implies not only articulation between politics and society but also agreement with the basic idea that a process is not only proposed but made public. In addition, the process entails dissemination through public information campaigns and consultative mechanisms oriented towards building the capacity of the community to stimulate and consolidate an efficient and consistent participation process.