54. J. R. Sadler and A. Novick, *ibid.* **12**, 305 (1965).
55. E. H. Y. Chu, as reported at the Annual Meeting of the Genetics Society of America, Madison, Wisconsin (1969).
56. L. H. Thompson, R. Mankovitz, R. N. Baker, J. E. Till, L. Siminovitch, G. F. Whitmore, *Proc. Nat. Acad. Sci. U.S.* **66**, 377 (1970).
57. P. D. Scotti, *Mutat. Res.* **6**, (1968).
58. R. H. Epstein, A. Bolle, C. M. Steinberg, E. Kellenberger, E. Boy de la Tour, R. Chevalley, R. S. Edgar, M. Susman, G. H. Denhardt, A. Lielausis, *Cold Spring Harbor Symp. Quant. Biol.* **28**, 375 (1963).
59. G. A. O'Donovan and J. L. Ingraham, *Proc. Nat. Acad. Sci. U.S.* **54**, 451 (1965); S. Condon and J. L. Ingraham, *J. Bacteriol.* **94**, 1970 (1967).
60. C. Guthrie, H. Nashimoto, M. Nomura, *Proc. Nat. Acad. Sci. U.S.* **63**, 384 (1969); P.-C. Tai, D. P. Kessler, J. Ingraham, *J. Bacteriol.* **97**, 1298 (1969).
61. R. Rosenbluth, H. Mayoh, D. Ezell, W. Willis, M. G. Somero, *Can. J. Genet. Cytol.* **12**, 394 (1970).
62. M. J. Whitten, personal communication; C. F. Wehrhahn, personal communication; R. H. Smith, personal communication.
63. The research discussed has been supported by the National Research Council of Canada (grant A-1764), the Atomic Energy Commission of the United States [contract AT (45-1)-1924], and the National Cancer Institute of Canada (grant 6051). The studies reported here were initiated by the energetic enthusiasm and efforts of Dr. Leonie K. Piternick and have been extended by a succession of people who invested a period of their lives in this work: Burton Ayles, Barbara Bahner, David Baillie, Paul Baumann, Jill Cameron, Diana Combes, Peter Duck, Udo Erasmus, Dean Ezell, Geoffrey Foster, Donna Gibson, Thomas Grigliatti, Susi Hayashi, Jeanette Holden, Richard Kiyomoto, Helen Mayoh, Rachel Pratt, Douglas Procunier, Raja Rosenbluth, Thomas Sanders, Michael Schewe, Lorne Shaw, Meredith Gould Somero, Elaine Tasaka, Mary Tarasoff, Rodney Williamson, William Willis, and Katherine Yang. Credit for any work of worth belongs to these individuals. I also thank Dr. John Lucchesi, Dr. Barry Keifer, and Mrs. Shirley Macaulay, who contributed their unique expertise to a part of these investigations.

Environmental Protection in the City of New York

Urban pollution control presents problems of great technical, legal, and political complexity.

Merril Eisenbud

The City of New York, by reason of its size, its geographic position in the midst of the world's most densely populated region, and decades of neglect, has been beset acutely with environmental problems. As has been generally true at all levels of government, a comprehensive approach to environmental protection had been handicapped in the past by traditional organizational separation of responsibilities, with inadequate coordination among the organizational units. To provide a unified approach, Mayor John V. Lindsay created the Environmental Protection Administration (EPA) in March 1968 to consolidate former administratively separate functions concerned with environmental hygiene. With its formation, EPA became responsible for street sanitation, water supply, water pollution control, air pollution, and noise abatement. It is an organization of more than 20,000 employees, with an annual operating budget of about $275 million, and a construction program of more than $2 billion during the next 5 years.

This article will deal with some of the pitfalls and successes of the program during its first 2 years of existence. Although no two communities are alike in all respects, the pollution problems of all cities do have many characteristics in common, and one generalization that can surely be made is that problems of urban pollution control present aspects of enormous legal, technical, sociological, and political complexities. No substantial progress can be made without huge expenditures of money and many years of sustained effort.

Air Pollution Control

The present active program of air pollution control began in the mid-1960's in response to widespread public interest. In 1965 Councilman Robert Low and the then mayoral candidate Lindsay began campaigns to strengthen the local laws governing air pollution control. A series of hearings before the City Council developed the first comprehensive report (*1*) of the problems of air pollution control in New York City, and early in 1966 a second report was published by a mayoral task force chaired by Norman Cousins (*2*). These two reports laid the groundwork for the energetic program developed by Commissioner Austin N. Heller, who headed the Department of Air Resources (*3*) from the late spring of 1966 until February 1970.

A new air pollution control law (Local Law 14) was passed by the City Council early in 1966 and mandated certain basic requirements among which were the following. (i) The sulfur content of all fuels burned in New York City would be limited to 1 percent by the 1969 to 1970 heating season. (ii) No incinerators could be installed in newly constructed buildings. (iii) All existing apartment house incinerators were to be shut down or upgraded according to a specified timetable. (iv) Emission controls were to be installed as soon as possible on all municipal incinerators. (v) All open burning of leaves, refuse, and building demolition materials would be banned within city limits.

The overall emissions of sulfur dioxide to the city's atmosphere were reduced by 56 percent by the end of 1969. This has been reflected by progressive reductions in the hourly peak concentration of SO_2 (Fig. 1). The annual maximum hourly concentration, which was 2.2 parts per million (ppm) in 1965, was reduced to 0.8 ppm by 1969, and further improvement has been observed in the early months of 1970.

Dust and soot are the most annoying form of air pollution in many cities. The sources of the particulate emissions in New York City are shown in Table 1, which indicates that space heating, municipal incineration, apartment house

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incineration, and power generation account for about 80 percent of the 69,100 tons (1 ton = 907 kilograms) emitted per year to the atmosphere as of November 1969.

During 1969, three of the city's eleven municipal incinerators were shut down, and another is scheduled to be closed as soon as alternate means of handling refuse can be arranged in the next year or two. The remaining seven incinerators are sufficiently modern so that air-cleaning equipment can be installed at a cost of about $12 million. However, because no equipment manufacturer would offer performance warranties, and in the absence of experience, an experimental program was designed to obtain the information needed to make the required engineering decisions. In addition to pilot plant tests of various air-cleaning techniques, full-scale installations have been made of two electrostatic precipitators and one Venturi scrubber. The early experience at these installations has been encouraging (Fig. 2), but, because of the corrosive nature of the effluents and the generally arduous service to which equipment of this kind must be put, many months of testing will be necessary. These are the first installations of this type in the United States, and the information being obtained will be generally useful to communities throughout the country.

The largest single source of particulate emissions to the air of New York City is space heating from about 30,000 apartment houses that burn No. 6 residual fuel oil. The black smoke that one sees curling up from apartment house rooftops during the heating season is usually the result of improper operation of residual fuel oil boilers. Local Law 14 mandates installation of equipment modifications that will result in increased combustion efficiency and less particulate emission, and these are working well in about 1,500 furnaces where the change has been made.

The second largest source of particulates is apartment house incinerators, about 17,000 of which were constructed between about 1947 and 1967.

The improvements required for incinerators and residual oil burners proved practical, but the apartment owners nevertheless brought suit against the city, charging that the law was unconstitutional and imposed unreasonable hardships on the landlords. This suit has stalled compliance with the provisions of Local Law 14 that pertain to apartment house oil burners and incinerators.

Table 1. Sources of particulate emissions to the atmosphere of New York City in November 1969 [from (*3*)].

Source	Amount (ton/year)	Percent
Space heating	22,300	32.3
Municipal incineration	13,330	19.3
On-site incineration	12,690	18.4
Mobile sources	9,900	14.3
Power generation	6,400	9.2
Industrial sources	4,500	6.5
Total	69,120	100.0

The city has installed an aerometric network consisting of 38 stations that began operation in late 1968. Data from ten of the stations are telemetered directly to the laboratory, and the others are manually operated. The Department of Air Resources has also developed an alert warning system that mandates progressively more stringent steps to reduce contaminant emissions in the event of an air pollution emergency. Should the SO_2, particulate, or CO concentrations reach predetermined values, various controls would go into effect, including reduction of municipal incineration, shifts to the less polluting fuels, and, if necessary, a gradual reduction of industrial processes, power generation, and incineration. The diminution that is continuing to take place in sulfur and particulate emissions makes it increasingly unlikely that stringent curtailment of activities will ever be necessary.

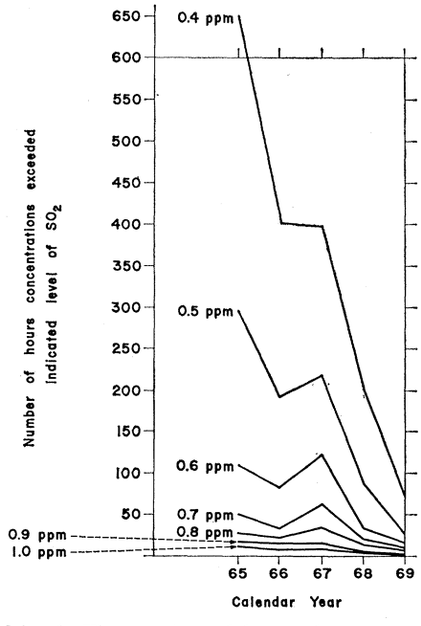

Fig. 1. The number of hours the concentration of SO_2 exceeded the indicated level, 1965–69 [from (*3*)].

The internal combustion engine is the main source of CO in urban atmospheres at the present time. The concentration of CO exceeds the air quality target of 15 ppm near some heavily used streets, but it is not known to what extent people are exposed to these concentrations on a continuing basis. It is commonly believed that the automobile is the main source of urban pollution. This is certainly true in some localities where photochemical reactions involving components of automobile exhausts are known to contribute in a major way to the irritating smog characteristic of Los Angeles and certain other cities. However, this phenomenon has been less of a problem in New York City, where the subjective complaints due to air pollution can more properly be ascribed to sulfur oxides and particulates.

Another popular misconception is that the automobile is the main polluter because its emissions are greater in quantity than any other source of air pollution. Thus in New York City in 1967 it was estimated that automobiles discharged 1.7 million tons of CO per year. The next largest pollutant was SO_2, which was being emitted to the atmosphere at a rate of 828,000 tons per year. However, SO_2 is far more noxious than CO, for which the tentative air quality criterion is 15 ppm in New York State, as compared to about 0.1 ppm for SO_2. Thus the SO_2 emissions, though only about 48 percent of the CO emissions, are far more significant because its permissible concentration is less than 1 percent of that for CO.

The main source of CO exposure of city dwellers is apt to be cigarettes, the CO content of mainstream smoke being over 40,000 ppm (*4*). Smoking one pack of cigarettes per day is said to be equivalent to continuous exposure to 50 ppm of CO in ambient air.

As the air of our cities gradually becomes cleaner, many communities will have to answer the questions, "How clean is clean?" or "How much is clean air worth?" Unfortunately, there is often insufficient basic knowledge with which to answer such questions intelligently. Air pollution imposes economic losses due to soiling and corrosion and also causes health effects. The economic losses due to air pollution include shorter shelf life of many types of goods, higher cleaning costs, and cor-

rosion of certain materials. The economic loss in large urban areas is thought to average $65 per person per year, but there have been no studies as to how these costs can be apportioned among the various sources of air pollution.

One could argue that every city should have the cleanest air possible. The problem is that air pollution abatement measures cost a good deal of money, and the costs increase exponentially as the goals become more strict. The measures that must be adopted in New York City to implement the present provisions of the air pollution control law will cost about $500 million by about 1972. If the economic losses due to air pollution are as high as has been estimated, this is obviously a good investment, since the city's 8 million residents would receive a return on their investment of more than 100 percent per year, assuming the estimated economic loss to be $65 per capita.

There are many epidemiological studies in the literature, but there is as yet no satisfactory way of appraising the health effects of air pollutants at the concentrations experienced where reasonable abatement procedures are in effect. The results of these studies are highly equivocal at the levels of atmospheric pollution that will be reached when the present control program is fully implemented in 1972 to 1973. Should pressures develop for a higher degree of abatement than is now contemplated by Local Law 14, one would be justified in asking at what point any further investment would be less wisely spent on air pollution control than on housing, elimination of lead poisoning in the ghettos, better nutrition, better hospital service, or any other of the unlimited number of ways by which one can benefit the public health. We will see that this question arises again in connection with current policies on water pollution control.

For lack of a cost-benefit approach to the hygiene of urban atmospheres, we are doing surprisingly little about one class of particularly noxious pollutants, the aero-allergens. There are few data on the societal costs of disability from hay fever, but one source (*5*) estimates that 8 million people suffer from hay fever in the United States, that prescribed medicines for treatment of this affliction cost $65 million in this country in 1964, and that 25 million days are lost from work. The aero-allergens probably impose a greater cost in impairment of health than can be ascribed to any of the atmospheric pollutants for which control measures are now being developed. As noted earlier, about $500 million will be spent in New York City to implement the provisions of the air pollution law. This money will be spent over about a 5-year period and will be followed by increased annual operating costs of many millions of dollars per year. Nationwide, the Department of Health, Education, and Welfare estimates (*6*) that the annual cost of sulfur and particulate control in the United States, based on the use of 1 percent sulfur oil, will be about $500 million in 1971. In contrast, the total budget for ragweed control in New York City is about $5000 per year, which allows hardly enough to answer an occasional complaint.

If expenditures for ragweed control were of the same order of magnitude as for other pollutants, it might be feasible to control the pollen in a variety of ways. For example, specific herbicides might be developed, or the growth of ragweed might be controlled by some ecological process such as by adjusting the quality of soil in vacant fields and other areas where ragweed tends to grow. Or, as a last resort, the ragweed could be pulled out by hand, which would provide much needed summer employment for city youths. No doubt more meaningful control techniques would be suggested if there had been adequate research into the subject. Here clearly is an example of an environmental factor that deserves a higher priority.

Asbestos is an example of a relatively new contaminant of urban atmospheres, and there are ominous indications of the need for stringent controls (*7*). When sprayed on structural steel, asbestos makes an excellent fire-retardant material, but it contaminates the urban atmosphere at the time of application and again when the building is demolished. It is known that inhaled asbestos can produce a rare form of cancer, mesothelioma, after long incubation periods, but there is as yet no information about the relation of the incidence of this disease to the concentration of asbestos in urban air. There is evidence that mesotheliomas are now being seen more frequently in the general population, and it has been suggested that this may be due to asbestos pollution. Cases being seen today may be due to exposure two or three decades ago, when exposure was presumably much less than it is today. However, today's exposure may not produce cases for 20 or 30 years. Thus, the people living in today's cities may be committed to a higher incidence of mesothelioma in the future. A thorough study of the use of asbestos in the building trades is needed, and recommendations must be developed to minimize urban exposure or to find a substitute for the asbestos. This is being done in New York City, and rules for the safe handling of asbestos are about to be issued.

When most people complain about air pollution they are referring to the dust that settles on furniture and other surfaces. Chemical and optical techniques must be developed that make it possible to apportion the settled dust among the various possible sources of pollution. Sometimes the sources are obvious, but sometimes not, and techniques are needed that would make it possible to ascertain if oil burners, incinerators, demolition dust, or natural dust is the offender in any given instance. Only with such information can one intelligently design a program of particulate emissions control.

The long-range prospects for clean air in New York, as in other large cities, are good and will be achieved in part as a by-product of the development of nuclear power. These plants are relatively pollution-free and will in time replace the fossil fuel plants unless the very existence of nuclear power as an alternative to fossil fuels causes the latter to undertake research and development that leads to a high degree of air pollution control. Recent developments in sulfur removal suggest that this may already be happening.

Whether the electrical generators operate on nuclear power or pollution-free fossil fuels, the central stations are destined to provide an increasing percentage of the energy needs of the community. Truly clean air will not be achieved until the thousands of inefficient individual space-heating boilers are eliminated in favor of steam or electric heat supplied from well-controlled central generating stations.

Noise Abatement

The law that established the Environmental Protection Administration specified that it should develop a noise abatement program, the broad outlines of which were developed by a task

force that spent 3 years preparing a thoughtful analysis of the noise problems of the city together with recommendations for the future program (*8*).

A program of noise abatement in any large city is destined to be a long and arduous one. High on the list of priorities should be construction machinery, automotive equipment, aircraft, rooftop air conditioners, sirens, horns, and subways. A model noise abatement law, similar to the law dealing with air pollution control, must be developed, and rules and regulations must be adopted for enforcement purposes. Finally, new technological approaches must be developed.

Some progress has already been made in New York City in a small way. From the joint efforts of the Task Force, industry, and the Department of Sanitation, have come improvements now being incorporated into New York City's purchasing specifications which allow a marked reduction in the noise levels from sanitation trucks. Progress has also been made in the partial quieting of diesel compressors used in construction work.

Step by step it should be possible to provide a more quiet city. However, many of the sources of noise are beyond a city's powers to control. For example, all automotive equipment is subject to State control. The acoustic standards established by New York State call for a limit of 88 decibels, 50 feet (1 foot = 0.3 meter) from a truck. This may be satisfactory for a throughway in the open country, but is not acceptable for a truck passing through city streets where people are located closer than 50 feet and where the sound reverberates from buildings. Accordingly, state legislation is being prepared that will mandate acoustic specifications for motor vehicles that are more appropriate for urban needs.

Aircraft noise, so troublesome to many communities, is preempted by the federal government, and the city's role is therefore limited to persuasion or such influence as can be mounted by the collected efforts of legislators from urban areas.

Water Supply

The City of New York is blessed with a supply of excellent water carried in deep rock tunnels from reservoirs located on watersheds as far away as 125 miles. The city must provide water for its own needs, and is also required by state law to provide water to eight upstate counties.

Fig. 2. Effectiveness of electrostatic participation for removal of visible emissions from a municipal incinerator. The structures shown are a cooling tower and precipitator for one furnace. Two furnaces were in operation at the time of the photograph, one on each stack. There are four furnaces at this incinerator, thus requiring that the installation illustrated be quadrupled to clean the particulate emissions from the four furnaces. [Courtesy American Wheelbrator Company]

The per capita demand for water has been rising steadily from about 25 gallons per day (gpd) (1 gallon = 3.8 liters) in the early 19th century to more than 150 gpd at present. The demand for water by the people living in the area served by the system is now 1400 million gallons per day (mgd) and is expected to increase to 2200 mgd by 2020, at which time the extrapolated per capita daily consumption would be about 185 gpd. Present projections indicate that the demand for water will exceed the dependable yield of the present system by sometime in the late 1980's unless steps are taken to conserve the use of water.

The extent to which water can be conserved is not fully understood. Intensive educational campaigns during past periods of drought have reduced water use by about 150 mgd, but public cooperation to this extent can reasonably be expected only during periods of near emergency—not under normal conditions. In the future, water conservation should be sought by adoption of a program of universal water metering and encouragement of plumbing manufacturers to develop fixtures that use less water.

New York is almost alone among the larger cities in not having a system of universal water metering. About 170,000 meters have been installed in commercial buildings and in about 20,000 residences, but this accounts for only about 23 percent of all water accounts. Nevertheless, the per capita rate of water use is not excessive. Of the eleven largest cities in the United States, among which the per capita consumption of water ranges from 132 to 235 gpd, only three cities consume water at a rate lower than that of New York City. The reason for the wide range of per capita consumption among the various cities is not understood.

With metering, water charges could be adjusted to discourage the unnecessary use of water. Rating systems presently charge less for water as the use increases. A system must be devised that will not be punitive and will not discourage the use of water for sanitary or other purposes within reasonable limits, but that will result in increasing unit costs for water as the use increases. Before this can be done, it will be necessary to know much more than we do about the way in which water is used in the household and the minimum quantities that can be used for various purposes.

A major objective of the water management program should be to stabilize, and possibly reduce, the per capita demand. In order to do this, one must first undertake studies designed to elucidate the reasons why the per capita demand is increasing. Second, there is a need to design plumbing fixtures that use less water. An excellent example is the toilet flush tank which in most cases uses about 6 gallons per flush. Assuming that the average person flushes the toilet four times per day (and there aren't even good data on this), this use would consume 24 gallons per day, or about 15 percent of the per capita consumption. Flush tanks are available that perform their function in a satisfactory manner with only 2 gallons per flush. The gradual changeover to more efficient tanks in the years ahead would thus reduce the per capita consumption of water by about 10 percent or more. This kind of innovation is also needed in kitchen faucets, shower

baths, laundry machines, and other household or commercial plumbing fixtures.

Unless the use of water can be stabilized, additional sources of supply will be necessary in the decades ahead. Recent studies suggest that the Hudson River, which is now in the process of rehabilitation, could be used as a source of water in the latter part of this century. It will be necessary to assure that the freshwater flow is adequate to keep the saltwater tidal intrusion well below the proposed intakes presently planned for Hyde Park, and for this purpose water stored in Adirondack Mountains reservoirs would be released to the Hudson River during the dry summer months.

It is possible that, in time, reuse of water will become feasible on a scale suitable for large cities, or that large-scale desalination will be possible. Every effort should be made to further technology in these areas, but for potable water in the quantities required by large cities, no practical choice other than impoundment of surface water is available for the foreseeable future in many parts of the country.

Water Pollution Control

New York City currently provides some degree of secondary treatment for about 75 percent of the 1300 mgd of sewage generated. About 325 mgd of raw sewage continue to be discharged into the estuary, mainly from the west side of Manhattan. With the aid of the New York State Pure Waters Bond Issue, which provides for 60 percent reimbursement of expenditures for sewage plant construction, a $1.2-billion program has been started by New York City which, when completed in 1975, will provide high-degree secondary treatment for all its dry-weather waste water.

When the new plants are completed, there will remain the problem created by the fact that New York City, like many communities, uses combined sewers to collect both sanitary and storm drainage. The storm waters overwhelm the capacity of the sewage treatment plants, causing overflow of untreated sewage into the estuary. This problem is particularly acute in the 30-square-mile Jamaica Bay, which drains major portions of Brooklyn and Queens and which is intended to be included in the Gateway National Park, the first national park to be located within a city. Following completion of secondary sewage treatment facilities, a second program, not likely to be completed until the mid- or late 1980's, will provide for treatment of storm waters. In preparation, a $1-million ecological study of Jamaica Bay, financed by the Federal Water Pollution Control Administration, has been undertaken to provide a quantitative understanding of the hydrological, biological, and chemical characteristics of the bay. A demonstration storm water treatment plant is being built on the shore of Jamaica Bay and will serve as a prototype for a ring of several additional plants that will ultimately be built on its periphery. These plants will impound storm water which will be degritted, filtered, and chlorinated before being discharged into the estuary. Additional plants of this type will be constructed in the East Bronx. It is anticipated that by the late 1980's the estuary will have been sufficiently restored so that virtually the total shoreline of New York City may be available for recreational bathing.

The purpose of estuarine pollution control is to protect the water quality for recreational purposes, seafood harvesting, and wildlife preservation. Chemical indices of pollution such as biochemical oxygen demand (BOD), concentrations of nutrient ions and toxic substances, as well as biological indicators, such as the concentration of coliform organisms, are necessary adjuncts to a water pollution control program, but many of the standards currently in use have little basis, either theoretical or empirical, despite the fact that the standards have a fundamental influence on the design of sewage treatment plants and their cost. In most cases there is inadequate information about the hydrological and ecological characteristics of an estuary, and hence the design of water pollution control plants cannot be optimized in relation to the nature of the receiving waters. Sewage sent to plants located in one part of an estuary may require a higher degree of treatment than that treated in a plant located elsewhere. Moreover, the location and design of outfalls may influence the treatment requirements, and these designs should be based on the characteristics of the estuary. In the New York estuary, as in most places throughout the country, sufficient information does not exist. This is unfortunate because hundreds of millions of dollars are involved in decisions as to whether a plant should be designed, for example, for removal of either 67 or 90 percent of the BOD. There may, in fact, be no ecological or health gain in going to the higher value in one place, whereas in other cases a need for the highest possible secondary or even tertiary treatment might be indicated.

Each estuary should be studied thoroughly so that as complete as possible a mathematical model of the hydrological and biological characteristics can be developed. Such a program might take as much as 10 years to complete, and it should be financed out of the appropriations for capital construction.

Bathing water standards for saline waters are long overdue for reexamination; as in the case of certain of the air quality criteria, there is a need for extensive epidemiological research to provide a more quantitative understanding of the relation of various amounts of pollution to the public health. Recent literature (*9*) has suggested that the U.S. approach to the subject has been too conservative. The British, on the basis of studies of the health of bathers at a number of beaches in the United Kingdom, have concluded that marine beaches can be used for bathing if the water is esthetically acceptable! As earlier, we are faced with the question, "How clean is clean?"

Solid Waste Management

The City of New York is faced with enormous crises because of the burgeoning volume of solid waste. The streets are increasingly dirty, and the city will run out of disposal sites by the mid-1970's.

New York City's 8 million people live on 6000 miles of streets. They are joined each workday by an influx of more than 2 million people, approximately the population of the nation's second largest city, who come from outlying suburbs to earn their living. The rate of solid waste generation is increasing 2 to 4 percent per year and is currently about 5 pounds per capita per day. Depending on the part of town, the cost of collecting refuse varies from $15 to $30 per ton, and has increased steadily in recent years. The sanitation industry is one of the few in which wages have increased during the past decades without a commensurate increase in the productivity of labor, and it is frequently said that the only change in the technology of

garbage collection is that the internal combustion engine has replaced the horse.

The garbage can is one of the principal impediments to higher efficiency and is long overdue for replacement. Numerous options are available as alternatives that will make the job easier for the sanitation man, thus increasing his productivity and making it possible to provide cleaner streets at less cost. Experiments conducted during 1969 demonstrated that plastic or paper bags are an efficient and sanitary alternative and that their use should be encouraged. The main advantage is that the sanitation man is no longer required to pick up a heavy can and laboriously shake the refuse from it. Bags have found to be popular with both the householder and the men, and their use is increasing. The cost to the householder at the present time is approximately 8¢ per day per bag, and this will undoubtedly decrease as the bags are made available in mass distribution.

New high-rise apartment houses are still being built with no provision for refuse handling other than the garbage can. One large housing complex was planning to use 400 cans per day. While plastic or paper bags offer a suitable alternative for private homes or small multidwelling buildings, a whole spectrum of still more efficient alternatives are available for the larger buildings. These range from containers of 1-yard capacity that can be handled manually, to large 10-yard containers which are handled mechanically by special trucks. The building codes should be changed to require all future buildings to incorporate efficient methods of handling solid waste.

Toward the close of 1969, the federal government agreed to support a demonstration of a vacuum system for handling solid refuse within a large housing complex. When completed in 1971, the housewife will drop her refuse into a conveniently located hopper from which the garbage will be transported pneumatically to a central location where it can be compacted and mechanically loaded for removal by the Sanitation Department.

Another possibility for more efficient waste handling might utilize the existing or proposed subway systems. One can visualize that all buildings along a subway route might drop their refuse to compactors below street grade with provision for transfer to special subway cars that would be used for hauling containerized wastes during the night hours. Still another method, which might be suitable for buildings located near the waterfront, would be to transfer the refuse pneumatically or by some other methods to hoppers that could discharge directly into barges. This would be an excellent objective at the proposed Battery Park City, which will accommodate 50,000 people and will generate approximately 1,235 tons of garbage a day. There is no reason why the streets of a city should be used for the transport of garbage if some other means can be found, especially if the alternate means are cheaper, cleaner, and more efficient.

The streets of a city become littered partly because of inefficient garbage collection activities and partly because of the high population density and the style of life in big cities. The origins of street litter are found deeply rooted in the complex technical and social system that comprises the metropolis. Economic trends, social mores, the complexities of the criminal courts system used to enforce the sanitary laws, and vehicular traffic congestion are all part of the problem.

The scrap automobile is a case in point. Until a few years ago the market for scrap steel was such that a scrap car could be disposed of by its owner at a price that offered incentive for him to arrange for its removal from the city streets. Changes in economics of the steel industry have altered this situation to the extent that in most parts of the city it costs more to remove a car than the car is worth. This has resulted in automobiles being abandoned on the streets of New York at an increasing rate—the total in 1969 was more than 57,000. The city has recently franchised scrap dealers to collect these cars from various parts of the city. In some cases, the scrap dealer is subsidized by the city and in others he pays the city a small price for the car. It is illegal to abandon a car in the city streets, but when the last owner removes the license plates and files off the engine number, it becomes prohibitively costly to trace him.

The nonreturnable bottle and its close relative the aluminum and steel can are another costly and offensive form of litter that owes some of its origins to the economics of our times. The beverage distributors insist that until recently a deposit bottle made as many as 30 round trips between the distributor and the customer, but that because of the indifference of the consumers to even a 5¢ deposit, the number of round trips in many communities gradually diminished to as few as four or five before the bottle was discarded. This is given as the reason for the shift from deposit bottles. There is little question that the consumer prefers the nonreturnable container, as does the supermarket, some of which will no longer handle deposit bottles. The result of this is an enormous net increase in the volume of solid waste imposed on the city and a very considerable amount of additional litter. The nonreturnable bottle and the abandoned vehicle are examples of problems that can only be solved by the local community with the greatest of difficulty. National policies are needed that apply uniform rules on a countrywide basis.

Vehicular congestion contributes as much to the littered appearance of streets as any other factor. Because it is prohibitively expensive to sweep streets by hand, most large cities have acquired mechanical brooms which are effective only when the curb is clear. In New York City, alternate side of the street parking rules have been promulgated that theoretically should make it possible to sweep the curbs mechanically, but these rules are honored as much in the breach as in their acceptance. The basic problem is that for lack of comfortable mass transportation there are too many cars in the city. Fewer cars would make the city a far more pleasant place, would avoid the enormous economic waste of traffic congestion, and would reduce air pollution. It would, incidentally, make the streets easier to clean.

The difficulties of enforcing alternate side of the street parking rules illustrate some of the frustrations of city government. For one reason or another the Police Department was unable to enforce the parking rules with sufficient stringency, and the mayor attempted to obtain authority for the uniformed Sanitation Department officers, of whom there are about 1000, to issue summonses for parking violations. However, the state law specified that only a police officer could issue a summons. When city-sponsored legislation was introduced in Albany to make it possible for the Sanitation Department to issue summonses, its passage failed for two consecutive years. During the third year the law was passed, and late in 1969 the Sanitation Department began to issue summonses at a rate of about 5000 per week. However, within only a few

months the new procedure, which was working very satisfactorily, was frustrated in the courts by a legal technicality. The ruling of the court in this case was so broad that it successfully blocked all the enforcement agents of the Environmental Protection Administration from issuing any summonses. No longer could the Sanitation Department officers issue summonses for littered sidewalks or could be the air pollution inspectors issue summonses for violation of local air pollution control laws. This matter has not as yet been resolved.

The Waste Disposal Crisis

This is a major problem to New York City because its refuse disposal sites will be exhausted by the mid-1970's. Ever since colonial days the city has followed the common practice of disposing of its solid wastes by filling its lowlands, and at the present time about 11 percent of the present land area of the city has been created in this way, including some of the most valuable commercial and recreational areas.

The largest land fill in the world is at Fresh Kills on Staten Island, but this will be completely filled by 1975. Smaller land fills exist in other parts of the city, and they too will be exhausted by that time.

The city at present produces about 21,000 tons of refuse per day, of which about 7,000 tons pass through municipal incinerators before going to the land fills. A basic strategy, therefore, must be to increase the municipal incineration capacity to reduce the volume of waste and to convert the refuse to a less offensive and more manageable form. A $200-million capital program has been begun, and construction of four giant incinerators is now contemplated; this will reduce the mass of refuse by about 75 percent, leaving a relatively innocuous ash that will occupy about 10 percent of the original volume. The present generation of municipal incinerators is one of the principal sources of atmospheric particulates. However, as noted earlier, these incinerators are being equipped with air cleaning equipment, and all new units will be provided with modern stack cleaning equipment. Since contemporary refuse has a heat value of about 5000 British thermal units per pound, every effort should be made to dispose of the heat either for power production or for generation of steam. It is estimated that the city can in this way recover about $2 per ton of refuse burned or as much as $12 million per year. The basic economics of such heat recovery is sound, assuming that the incinerators can be built near a market for the steam, and this practice is desirable from the conservation point of view.

In the long range, one must stabilize or, better yet, reverse the rising trend in the per capita production of refuse and use of water and other resources. To accomplish this will require development of new technology, changes in the habits of people, and new kinds of governmental regulation and participation. For example, New York City disposes of 350,000 tons of newsprint per year, at great cost in dollars, air pollution, and litter. From every point of view, including conservation of resources, it would be desirable to recycle this paper. By processing the paper in a modern, pollution-free plant for reuse by the newspaper industry, the streets and skies of New York would benefit, the tax dollar would go further, distant streams would be less polluted by effluents from paper mills, and extensive woodland areas would be conserved. Other examples could be given to illustrate the ways in which our economy must close on itself to reuse the products of its industry. This objective is one of the great technological challenges of the 1970's.

Conclusion

Before ending this account of the status of environmental protection in the nation's largest city, some additional thoughts may be desirable.

First, it should be stressed that in the long run environmental protection must go beyond pollution and must ultimately deal with other pressing problems including population control, poverty, raw materials conservation, vehicular traffic management, and land planning. A city that has clean air, clean streets, and clean water will not bring true quality to the way of life of its citizens until these and other monumental socioenvironmental problems are solved.

Second, it must be recognized that deficiencies in the political apparatus of communities have traditionally frustrated an orderly solution to complex problems, and it is hoped that this factor will not be an impediment to effective environmental rehabilitation. The elected officials, the bureaucracy of government, the unions, the community action groups, and the newspapers are important components of the social substrate from which all governmental programs must be developed and nourished. Professional environmental health specialists can define the objectives, develop the timetables, estimate the costs, and, as we have seen earlier, be given substantial sums of money with which to do the job. But factors that are related to the peculiar needs of the individual components of the political apparatus frequently cause issues to arise that seem extraneous to the job that must be done. The original objectives are sometimes overlooked, and priorities become misaligned. An important function of government is to permit the development of thoroughly considered plans of action that can be implemented by professional leaders who are given authority commensurate with the responsibilities assigned to them. A community that allows itself to fail in these respects will be unable to deal successfully with the ecological problems that face it.

References and Notes

1. Special Committee of the City Council of the City of New York to Investigate Air Pollution, "Air Pollution in New York City: An Interim Technical Report," *The City Record,* 24 June 1965.
2. Mayor's Task Force on Air Pollution in the City of New York, *Freedom to Breathe* (City of New York, New York, 1966).
3. Department of Air Resources, *Annual Report* (Environmental Protection Administration, New York, 1968).
4. Advisory Committee to The Surgeon General of the Public Health Service, *Smoking and Health* (U.S. Government Printing Office, Washington, D.C. 1964).
5. H. Finkelstein, *Air Pollution Aspects of Aero-allergens* (National Air Pollution Control Administration, Washington, D.C., 1969), contract PH-22-68-25.
6. Department of Health, Education, and Welfare, *The Cost of Clean Air* (U.S. Government Printing Office, Washington, D.C., 1969).
7. J. G. Thomson and W. M. Graves, *Arch. Pathol.* **81**, 458 (1966).
8. Mayor's Task Force on Noise Control, *Toward a Quieter City* (City of New York, New York, 1970).
9. J. M. Henderson, *Proc. Amer. Soc. Civil Engrs.* **94**, 1253 (1968).

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