Some Ramifications of Air Contamination

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THE PUBLIC EFFECT of air pollution, from the standpoint of general community interest and normal governmental regulatory procedures for the country as a whole, is probably the latest area to be added to the list of environmental influences of direct concern to man. No longer do we accept that the world's air resources are unlimited. In a very short period of time we have been brought face to face with a problem which can under proper conditions—or improper—result directly in impairment of health and even death. However, disregarding these spectacular occurrences, the problem is day by day becoming of increasing importance to the community, in that air pollution more and more is making its impact on the everyday living of man by its direct manifestations—eye irritation, visibility reduction, and plant damage, to name a few. More importantly, it poses the broader question of the long-term effects on health and causes one to ponder the future course of the battle between man's quest for a higher standard of living for increasing numbers of people and the garbage they produce. Let us take a brief look at some of the problems we have with us today, with some indication of the work cut out for us in the immediate future.

A statistical study of comparative mortality of 102 causes of death in 163 metropolitan areas in the United States has failed to establish a disease entity for which air pollution could be cited as the sole cause (*1*). However, this study did suggest that air pollution in large industrial and population centers contributes in part to the incidence of primary cancer of the trachea, bronchi, lungs, and esophagus. The death rate from emphysema, nonoccupational tuberculosis, and arteriosclerotic heart disease also was considerably higher in metropolitan than in rural areas, but a causal relationship between community air pollution and these diseases has not been established.

Even so, there is still room for speculation along several lines. Repeated exposure to relatively low levels of air pollution may have a causal relation to the development of chronic degenerative diseases; the presence of well-known chemical carcinogens such as benzopyrene has been demonstrated in urban community air; extracts of particulate material obtained from a number of cities have produced skin cancer in mice; the irritant nature of air pollution may contribute to the development of cancer by inhibiting the body defense mechanism which normally would remove carcinogen-laden particulate matter from the lungs and respiratory tract; air pollution, as well as smoking, may be a contributing factor to the increasing incidence of lung cancer; in Great Britain there is a specific disease entity, chronic bronchitis, which seems specifically related to air pollution; certain pulmonary or cardio-respiratory diseases may be aggravated by interference with gas diffusion across the respiratory membranes during peak urban air pollution; certain air pollutants may combine with body proteins to form allergenic substances and lead to sensitization and allergic response; and

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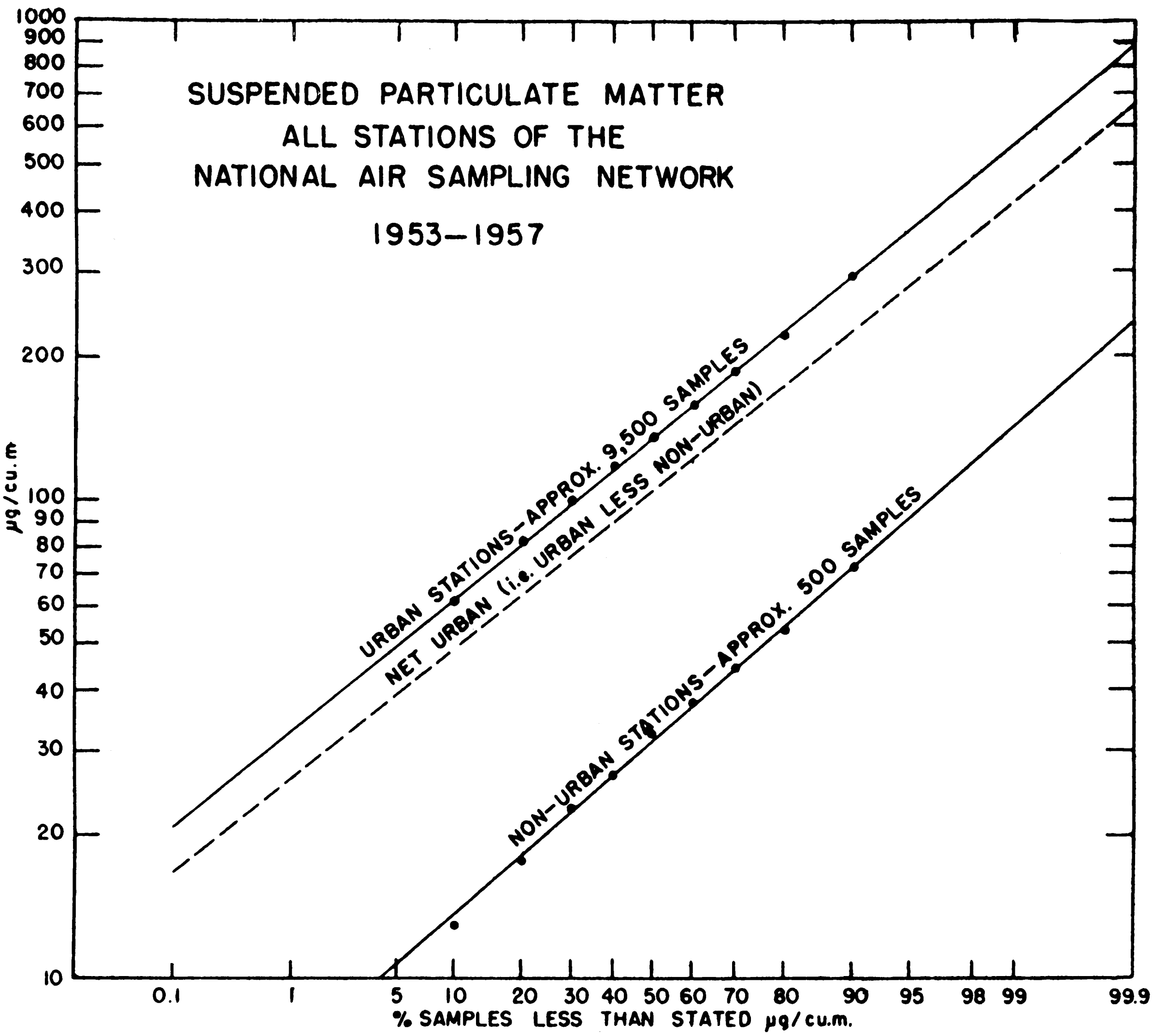
finally, there may be more than irritation of the eyes, nasal passages, and the respiratory tract associated with "Los Angeles type" smog, even though overall mortality rates in urbanized areas in California do not differ significantly from the rate in rural areas of that State.

This thumbnail report of the effects of air pollution on health is hardly detailed enough to really assess the problem. What it does serve is to point out that the effects of air contaminants are subtle and hidden, evidently seeking out first those whose resistance to stress is minimal—the very old, the chronically ill, and the young, exposed around-the-clock and over the years. It behooves us to continue our efforts to seek and find the relationship of community air pollution to health, and until that time to take all reasonable measures to control pollutants in all of their forms and to the greatest extent economically feasible. Our desire for a higher standard of living resulting in increased industrialization and larger populations concentrated into urban complexes all adds up to larger quantities of air garbage going into the same atmosphere which is limited in its capacity by relatively unchanging topographical and meteorological conditions; only by reducing the quantity per con-

Figure 1. Cumulative frequency distribution of suspended particulate matter for all stations of the National Air Sampling Network, 1953–57



tributor in direct relation to the increase in the total contribution can we expect to hold our own.

Next, consider the effects of particulate material in the atmosphere, and its effects on the community. In relation to our previous discussion on health, there are convincing laboratory data on animal studies which suggest that the physiological effects of irritant vapors are potentiated in the presence of aerosols. It has been proposed that the effects of air pollution disaster episodes were the result of the synergistic action of two or more atmospheric contaminants, one of which may well have been particulates.

The quantity of dirt contained in the atmosphere is expressed in terms of the sum of suspended material and that which settles out on a plane surface as settleable dust. Measurements made by the Public Health Service's National Air Sampling Network, comprising some 265 stations located throughout the Nation, indicate an alarming difference between the cleanliness of air over our cities, expressed in terms of suspended particulates, as compared with the rural areas. The latter in a broad sense might be considered the "background" level. The National Air Sampling Network collects suspended particulate matter by use of a High-vol sampler, wherein 70,000 cubic feet or so of air are sampled over a 24-hour period. Particulates varying in size from well below a micron to approximately 100 microns are retained on a glass fiber filter.

The results of sampling over the period 1953–57 (fig. 1) indicate a geometric mean particulate concentration over urban areas of 136 micrograms per cubic meter as compared with 33 for nonurban areas, or roughly four times as great (*2*). Since the distribution of samples is the same—that is, the standard geometric deviations are about equal as shown by the parallelism of the two plots, we can deduct the latter from the former and come up with a plot of "urban minus nonurban," which difference may then be considered as the contribution of urban living to pollution of the air—roughly 100 micrograms per cubic meter. In terms of the air we breathe, amounting to about 200,000 cubic feet of air yearly, the intake of dirt into our lungs attributable to urbanization comes to about a half a gram per year, not an imposing quantity at first glance, but quite significant in terms of numbers of particles, surface area, penetration into the respiratory system, and chemical content.

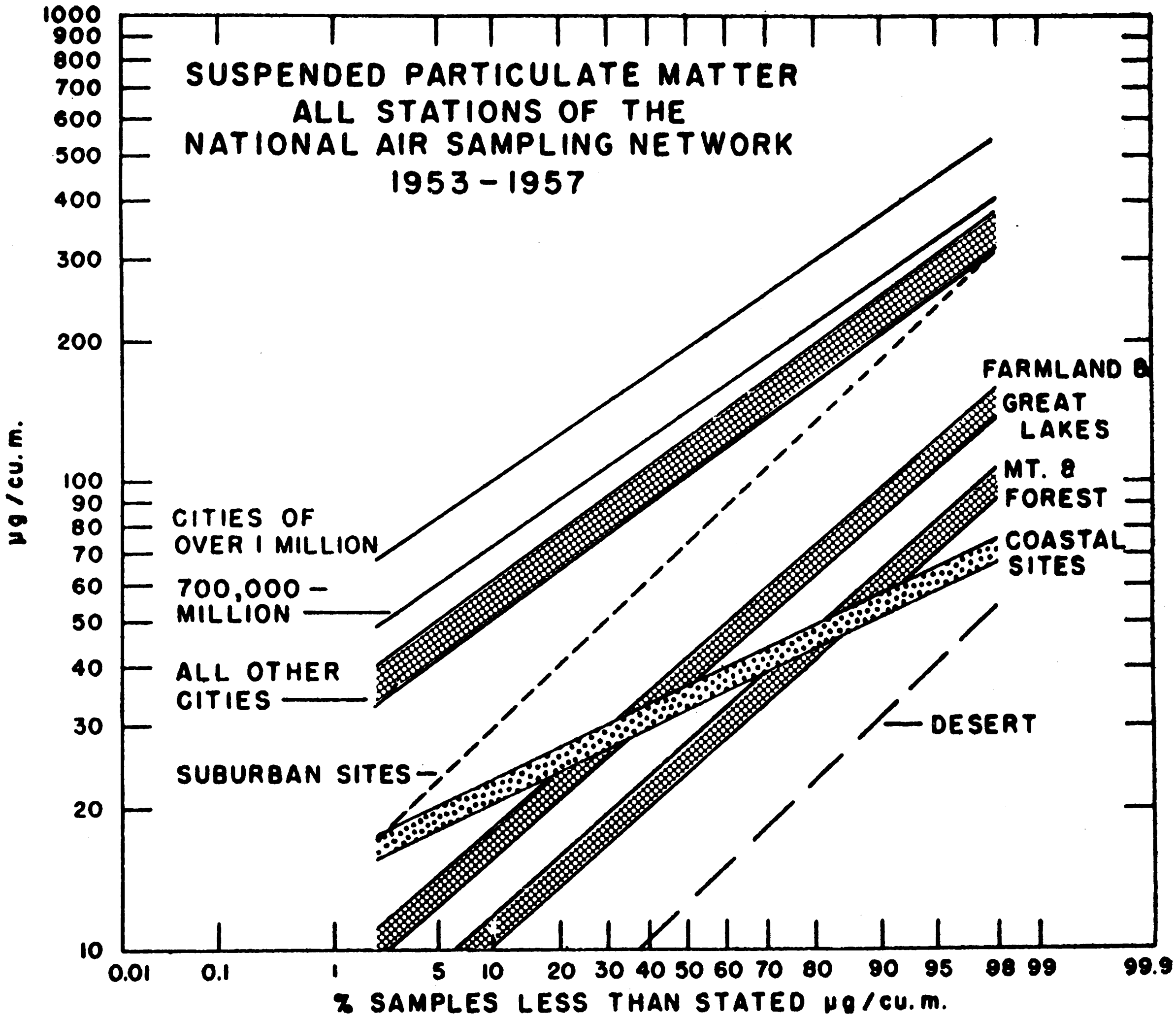
Further analysis of these data (*3*) indicates that dirtiness and population size are related (fig. 2). Even the dirtiest of nonurban sites is much cleaner than the suburban or urban site categories. The 117 cities in the "less than 700,000 population" category are dirtier than their own suburbs, and cleaner than the 11 cities with more than this population. Coastal sites show a markedly different distribution of particulate matter attributable to a constant base of salt from sea sprays.

In terms of settleable dust, sampling over the years from several large cities shows the impact of control measures, but the curves level off indicating the limits imposed by the practicability and economics of further removal (fig. 3). Nonetheless, even for a relatively clean atmosphere with an average of 50 tons of dust per square mile per month, this amounts to about 5 pounds per year on a 9-foot by 12-foot rug, if we care for a comparison in terms of the housewife who is most aware of the annoyances connected with such dustfall.

Concerning the detailed analyses of suspended particulate matter collected by the National Air Sampling Network, a comparison of ratios of the organic fraction to the total particulate collected has been made. The ratio is essentially constant for all categories of stations and equal to about 7 percent of the total particulate. The following tabulation indicates a further breakdown of the organic fraction in terms of the well-known carcinogen, benzo [a] pyrene, for nine American cities in November 1958 (*4*).

City	*µg. BaP/gram of particulate*	*µg. BaP/1,000 m.³ of air*
A	5.1	1.9
B	30.0	3.2
C	32.0	2.9
E	29.0	7.0
D	54.0	7.6
I	70.0	10.3
H	98.0	14.4
F	102.0	19.6
G	106.0	29.9

Figure 2. Cumulative frequency distribution of suspended particulate matter by population and geographic categories



Plots of the spectra of chromatographic fractions from a large number of air particulate samples indicate that the concentration of benzo[a]pyrene denotes an increase in the concentration of other well-known polynuclear hydrocarbons including the possibility of other polynuclear carcinogens (fig. 4). The peaks at 377, 379, and 382 millimicrons indicate the presence of benzo[a]pyrene, at 401, benzo[k]fluoranthene, at 434, perylene, and at 330, benzo[a]-pyrene.

The significance of these data on suspended particulates and settleable dust lies not only in the quantitative amounts and the influence of urbanization and associated industrialization but in the trends which are indicated. Certainly we expect an increase in urbanization, now estimated to be in direct numbers equal to the Nation's increase in population. This means more and larger cities with a direct increase in the activities necessary to support these populations, both domestic and industrial. Added to this are the waste problems associated with increased per capita production that is inherently coupled with improved standards of living. When these trends are viewed from the standpoint of removal efficiencies for particulate control equipment, the result is even more significant. It is the residual which passes through control devices which must be reduced in direct proportion to the increase in total contribution if we are to even maintain the present status, let alone effect additional cleanup beyond present levels.

So far we have given attention only to particulate pollutants in the air. Much less work has been done on general monitoring for gases and vapors on a national scale than for particulates; however, more intensive investigations have been made locally in connection with specific problems. Gaseous pollution problems have invariably been associated with combustion processes: the generation of power, basic metals production, industrial processing, waste disposal, or the operation of family automobiles and house heating. All of us are contributors in direct relation to the type and quantity of fuels we use and the combustion efficiency of the equipment used. In this latter context we refer to total destruction of organic fuels to their basic combustion products—carbon dioxide and water—not merely the recovery of the heating value of the fuel.

Sulfur dioxide has long held the stage as a universal air pollutant. When one considers that coal, the major source of SO_2, will continue to be the major source of fuel in the world for some time to come and that vastly larger quantities will be consumed, the picture is not promising, especially in the light of general downgrading in the quality of coal. The trend toward conversion to gas as a fuel source, particularly in the home, and the centralization of coal use for power development in large installations, where combustion is efficient and control is most feasible, promises some improvement. The ultimate solution rests, however, with the development of an economical means for sulfur dioxide removal from flue gases. This is being worked on.

The photochemistry of atmospheric reactions which take place among pollutants after their discharge to the atmosphere opens a whole new field for investigation. Hydrocarbons in general, and in particular the more reactive species, such as olefins, together with nitrogen oxides,

Figure 3. The trend in atmospheric settleable dust loadings for four American cities

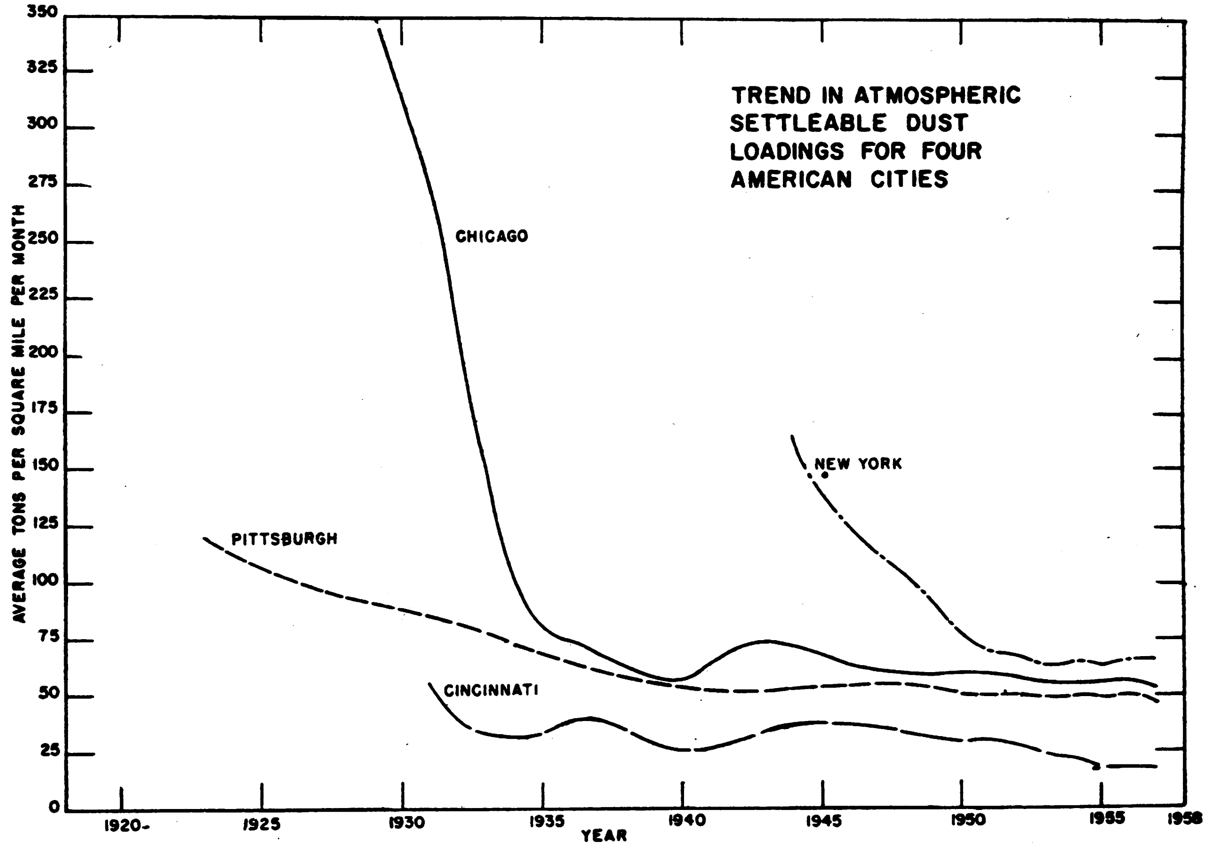
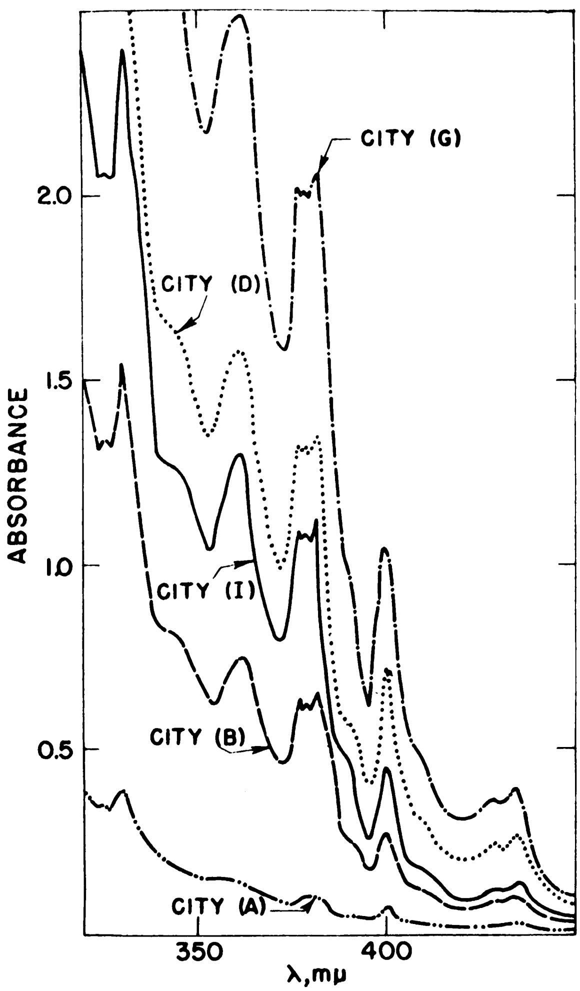


Figure 4. The ultraviolet-visible absorption spectra in pentane of some benzopyrene chromatographic subfraction for five American cities



are at present the major suspects in the fight against "Los Angeles type" smog, with the role of sulfur dioxide and particulates still neither clearly indicted nor exonerated. The intensive endeavors of the past 10 years have increased immensely our store of knowledge of what is happening and how to measure it, but at the same time have broadened the vistas as to possible offending precursor agents and their interactions. The concept of a universal photolyzed reaction product responsible for all effects—eye irritation, plant damage, and visibility reduction, to name the major ones—is giving way to the notion that perhaps different products or families of products are responsible for the various effects, and that these products may have various modes of formation depending on the vagaries of the precursors, accumulation resulting principally from meteorological conditions, and sunlight conditions.

Next, what are some of the community effects of air pollutants which directly result in economic loss roughly estimated to be around $2 billion or about $10 per capita annually? These have been listed many times by many authors, and comprise the gamut from additional cost of soap in the home to depreciation of property values. To name a few we have the extra cost of such household expenses as more frequent laundering, cleaning, redecorating, and replacement of furniture, clothing, and other household or personal materials; similar additional costs in commerce and industry, including more rapid deterioration of products and foodstuffs; increased costs of structural maintenance reflected in cleaning, painting, renovation, and replacement; reduction in life of various types of machinery due to both gaseous and particulate pollutants; increased use of artificial lighting due to reduction in light intensity; the necessity for increased use of air filtration equipment for protection of health or production of special equipment; increased expenses for navigational equipment at municipal airports due to increased visibility restriction by pollutants; additional medical expenses due to both increased irritation of the mucous membranes and accidents attributable to pollution; and finally, as previously mentioned, the added cost of accelerated property deterioration. Indirectly, communities, or the people who live in them, encompassing the major portion of the population, must bear the added expense of services or products required to offset the effects of air pollution. This would include such items as increased costs of agricultural products, both vegetable and animal, due to air pollution.

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Environmental Radiation Studies

The first two studies of a nationwide series aimed at determining the effects of environmental radiation on the health of large population groups have been initiated by the Public Health Service in cooperation with State and local health authorities. One study will involve residents of San Juan County, N. Mex. The second will focus on the St. Louis, Mo., region, beginning with the St. Louis milkshed.

The locality for the San Juan study is one of the largest uranium producers in the country. Earlier studies have shown that radioactivity from radium in the surface water of the Animas River has been higher than that found in most areas in the United States.

Effective steps have been taken recently to reduce the amounts of radioactive waste discharged into the rivers of this locality. However, extensive data have already been obtained on radioactivity in this environment. Consequently, the area presents an unusually good opportunity for further study to determine the amounts of radioactivity in the elements currently being taken in by people, the amounts of radioactivity they retain, the total "body burden," and the effects upon their health.

In the current project detailed medical and laboratory examinations will be given approximately 100 families totaling about 400 individuals. Teams of Federal and State physicians, nurses, and technicians will obtain complete medical histories of each individual in the cooperating families and determine a typical week's diet. Exact duplicates of typical diets will be analyzed to determine the amount of radioactivity taken in. Body wastes and breath samples will be collected and analyzed to determine the amount of radioactivity excreted.

Exhaustive study will also be made of the vital statistics of the area. Some aspects of the project will require followup interviews, medical examinations, laboratory studies, and statistical analyses extending for several years. In the near future, this study will be applied to other areas along the Animas and San Juan Rivers.

The St. Louis study seeks to determine the significance of previous findings concerning radiation levels in the area and, in its initial phase, whether previous strontium 90 findings obtain throughout the entire St. Louis milkshed, or only part of it. Though the levels of strontium 90 have been somewhat higher in the St. Louis milkshed than elsewhere, average levels for St. Louis have been below those which the National Committee on Radiation Protection and Measurements considers permissible for lifetime exposure by the general population.

A preliminary survey of dairy farms in the various milksheds serving St. Louis will consist of investigations of water supplies, sources of animal food, climate, farming and animal feeding practices, and other variables that may be associated with different types and levels of radioactivity in milk. The final phase of the milkshed study will consist of field experiments to determine whether, if necessary, the radioactive content of milk can be reduced by modifications in dairy farming practices.

Techniques developed in the St. Louis study will be applied to similar milkshed investigations being planned for several other major metropolitan areas in the United States.