ARE WE READY FOR AMBIENT AIR QUALITY STANDARDS

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The legal basis for the control of air pollution has progressed from nuisance law to the statutory regulation of specific substances as the sophistication of the sciences involved has progressed. But, the control of air pollution by pursuing air pollutants one by one as evidence accumulates against them seems clearly inadequate to a technology producing new pollutants at an almost geometric rate and inappropriate to the gathering body of evidence relating air pollution to health effects. To understand the need for changed control concepts it is necessary to understand the biological problem and the evidence that has been accumulated.

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The philosophy of the health professions in the twentieth century, and increasingly the philosophy of our whole society is that a clean environment contributes to health and well being. From this philosophy and from the scientific evidence that has fathered it, it is not necessary any longer to prove harm to health from air pollution in order to insist upon its control. But control is a joint effort of the public, industry, the academic and other research institutions, and government. When air pollution control is not a joint effort, but rather a battle between opposing forces the ultimate aims are delayed and the final solutions frequently poor and costly.

The air quality standards that have been proposed or enacted into legislation in varying parts of the United States clearly represent the desire of the people to have air that is as clean as can be obtained in our industrialized society.

The paramount question is whether these standards, written into law, will be effective in cleaning the air. And even more, the question might be, will they possibly delay effective air pollution control? It is my opinion that the setting of fixed standards for individual pollutants, one at a time, through the range of known pollutants may signify the desire of a community for clean air but does not rest upon sound evidence nor promote effective air pollution control.

We use the research on the health effects of air pollution to do two things. First, to make us aware of the dangers of fouling our environment and second, to provide a basis for effective control legislation. The precision of the information required for these two aims is quite different and it is important not to confuse the two when legislation is drawn.

It is sometimes difficult to realize how much progress has been made toward the goal of air pollution control in the past decade. An aroused public, an increasingly responsible industry, and responsive government have marked this progress. These changes have been brought about largely through an awareness of the dangers to health of uncontrolled pollution. If these dangers have been overstated on occasion no harm was done, since the purpose of the statement of dangers was to produce a supportive and aware public. If undue emphasis has been given to some pollutants over others in the statements of danger, or the mechanisms of action that were portrayed were inaccurate, again, no harm was done in making the public aware of the need for action. However, if legislation is based on overstated, oversimplified, or inappropriate statements of the evidence then the legislation stands a very good chance of being equally oversimplified and inappropriate. Note clearly that the problem is not should there be air pollution control — but rather, what is the most effective way of achieving control.

The evidence on the health effects of air pollution strongly supports the view that the health effects are not due to a single pollutant acting alone, but rather from the complex interactions of air pollutants and weather in the atmosphere. I would like to discuss at some length the nature of the research problem of determining the effects of air pollution on man. This is a problem in toxicology, determining for humans, the relationship between the dose of the noxious agent in the atmosphere, and the adverse response in man.

Several important factors complicate the research. The examples that follow are based primarily on sulfur dioxide but the generalizations are true of the other pollutants as well. First of all, the dose, sulfur dioxide, except under the most bizarre and rare circumstances is present in the urban atmosphere in very low concentrations and over a very narrow range. The peaks are rarely ten times the daily averages. The peaks themselves, are usually not above one part per million. One part per million is about the bottom of the range frequently used in the laboratory. The highest level to which populations are exposed therefore, are so low that they are seldom used in the laboratory. Second, sulfur dioxide or any other pollutant, does not exist alone in the atmosphere. When it is present, numerous other substances which may or may not have an effect on man are also present. Concentrations of the other substances will be increased at the same time that the sulfur compounds are increased. It is difficult, therefore, for the scientist to know whether an effect he has observed was caused by the sulfur compounds or by the other materials present.

The third, and related complication of such studies is that all the various substances do not coexist without interaction. We are now well aware that the atmosphere is a dynamically active chemical retort in which substances change themselves and react with other materials to produce new and sometimes unknown substances, with this atmospheric chemical factory variously affected by wind, sun and humidity. Fourth, how do we really know what is in the atmosphere? We know about sulfur dioxide, for example, because we have instruments to measure it, and have had for some time. But we all know that there are substances in the atmosphere of whose nature and presence we know nothing, and that the number of such substances probably is increasing as our technology expands. For example, what happens to a plastic bag when incinerated; and what is the effect in the atmosphere of the catalytic metals used as gasoline additives?

The fifth complication is the meaning of what pollution measuring instruments say. When a study reports that the population was exposed to, for example, 0.25 parts per million of sulfur dioxide, what does that really mean? Generally the instrument did not even really measure sulfur dioxide. If it was of the conductivity type commonly in use, the instrument only reflects sulfur dioxide when that gas exists alone — but that ideal is rarely met in the atmosphere. The measurement is interfered with in numerous ways that cast serious doubt on any interpretation of experimental results that are presented as though the exposure were really to sulfur dioxide. In our studies, at one point, we had two instruments side by side, one measuring "true" sulfur dioxide (by

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the West-Gaeke) and the other employing the conductivity method; not infrequently their readings bore no relationship to each other! In our publications we carefully used the words "whatever is represented by the measurement of sulfur dioxide" but when we are quoted, that important note of caution is left out or forgotten. Similarly, in some studies the average sulfur dioxide of one area is compared to that of another and then the research findings are said to be related to sulfur dioxide. But sulfur dioxide levels are an index of many things: the weather, fuel patterns, degree of industrialization, socio-economic level of the population, crowding; and probably a host of other factors all of which have a bearing on disease. But legislation which proposes a numerical standard for sulfur dioxide does not deal with "whatever is represented by the measurement of sulfur dioxide," it deals with the *gas sulfur dioxide.*

Finally, the effect of sulfur dioxide on man is further complicated by the effect of the atmosphere itself. Temperature and humidity have an unquestioned and well known effect on health quite apart from the effect they may have on the pollutants in the atmosphere. The most sharply defined mortality peaks in New York City between 1962 and 1965 occurred during heat waves on two successive summers; and in that three year period there were more than a dozen air pollution episodes. These research difficulties are not blocks to the revelation of the truth, they are a part of the truth itself and they cannot be disregarded in the search for rational air pollution control.

The problems that beset the epidemiologist in trying to determine the degree of exposure of his study population to the pollutant in question are no greater than the problem of trying to determine the responses of the individuals in the population.

There appear to be no responses in man or animals that are solely caused by or unique to the common air pollutants. The effects are primarily the result of irritation of the mucous membrane and as such are shared by a host of other disease determinants: cigarette smoking, infection, allergy, stress, emotional factors, etc.. The problem is further complicated by the fact that there has been no way thus far to get experimental populations who are alike in all respects except their exposure to air pollutants.

The markers we have used to determine an effect of air pollution on health have varied from the certitude of death to the faintest physiologic change. Interference from other hazards to health is inevitable and the interpretation of results is consequently difficult. To disentangle the multiplicity of factors at play we use mathematical tools provided by our statistical colleagues. These tools, so helpful where a single factor, or a few factors are at play, are in their infancy in the interpretation of complicated multifactorial problems. Thus they too add weakness where we would like strength.

These are, in brief, a review of the difficulties that stand in the way of research meant to support the objectives of air quality criteria and the standards based on them; that is, to establish a quantitative relationship between a concentration of a specific pollutant and a specific and reproducible effect in man.

Recognizing these complexities will not weaken air pollution control if it forces us to find contingency solutions that take them into account rather than returning repeatedly to approaches more appropriate to public health problems of the past such as typhoid and tuberculosis where cause and effect seem clear. If simplistic research approaches have failed so probably will simplistic legislative approaches.

Despite all the difficulties and weaknesses in the research, sufficient evidence has accumulated over the past years to allow certain very meaningful conclusions.

The air pollution disasters, laboratory studies, studies on chronic pulmonary disease, and the epidemiology of air pollution in normal populations have been the four main sources of evidence on the effect of air pollution on health. Although the air pollution disasters have been few in number and perhaps over-publicized, they provide inescapable evidence that uncontrolled air pollution may be extremely harmful or fatal.

While initially the air pollution disasters seemed to indict sulfur dioxide as the cause of their health effects, more recent and careful review of the data has seemed to indicate that a complex of factors, including sulfur dioxide, particulate matter, and certain weather phenomenon must be present for the fatal potential to be realized. Higher concentrations of sulfur dioxide occurring in the absence of the other factors has apparently not been associated with mortality. Virtually every common pollutant has been studied in the laboratory to determine its effect on animals and man. Almost all of these studies have shown that the pollutants had adverse effects on health. However, in such studies before an effect could be demonstrated a concentration of the pollutant well in excess of the concentrations found in our dirtiest urban atmospheres has been required. These experiments have shown, for example, that sulfur dioxide, the gas, existing alone is really quite innocuous in the usual atmospheric concentrations. The paradox of an apparent effect in the urban atmosphere and yet little effect in the laboratory has troubled us all. However, in reviewing the evidence relating sulfur dioxide to health, one is forced to conclude that for an effect of atmospheric sulfur dioxide on health to be demonstrated epidemiologically, particulate matter must also be present in the atmosphere. This conclusion finds support in the work of Dr. Mary Amdur and her group, who, over the years, have provided increasing evidence of the mechanism by which sulfur dioxide, sulfuric acid, and certain particles act together to produce adverse physiologic responses in animals. In some of her more recent studies the levels of sulfur dioxide required to produce an effect when the proper

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catalyzing particle was present have approached those found in our urban atmosphere. Findings from our own Cornell Family Illness Study illustrate the interactions at play. Early analyses of the data repeatedly showed relationships between respiratory symptoms in a normal New York City population and certain air pollutants, but the same symptom was associated with more than one pollutant or meterologic variable. Recently more sophisticated analysis has shown how a symptom or symptom complex may be associated with one group of pollutants during one kind of weather and the same symptoms associated with very different pollutants during different weather conditions.

From all the lines of evidence we must come to the same general conclusion:

Air pollution, as a generality, has an unquestionably adverse effect on health varying from the association with symptoms at normal urban concentrations to the association with death during disasters. But the mechanism is complex, and the effect of the whole appears to be greater than the sum of the parts. The ability to provide positive evidence of the effect of air pollution in the natural setting disappears when the individual pollutants are looked to as the unique or direct cause of the illness or mortality. In the face of the foregoing one can understand the difficulties that arise in attempting to set air quality standards. Let us not forget that the biological sciences have provided a firm basis for the belief that air pollution is harmful to health and that therefore there is a rational health basis for the control of air pollution. They have also begun to make clear the multifactorial nature of the relationships and thus cast considerable doubt on individual ambient air standards as a basis for control in the present state of knowledge. The health effects evidence clearly supports air pollution control; it clearly points up areas for further research; but it does not support individual quantitative air quality standards at the present time—no matter how desirable that goal might be. The research has done something else as well. It has provided the basis for a change in public attitude that would not be hard to document. A public apathetic at first and difficult to arouse has now remained interested and active at hearing after hearing in city after city. It has become less necessary to produce marked evidence of the harm caused by individual pollutants while gradually there has been an acceptance of the fact that pollution is bad in and of itself. I think that the evident and growing desire of society for an improvement in the total environment provides a mandate for newer control philosophies and methods. However, the proliferation of air quality standards continues and any person or group that suggests higher numbers would be accused of suggesting dirtier air, and there can be no seemingly effective argument for dirtier air.

But the argument is persuasive that individual standards will not achieve clean air but may well delay effective air pollution control. Standards frequently create a climate of misunderstanding between industry and government; often require local variances that are self defeating; may lull public opinion into quiet, believing that something has been achieved at the very time when continued effort toward cleaner air is required. They are, as has been pointed out, at odds with the scientific realities of the problem.

Meanwhile, other knowledge has grown, allowing considerable sophistication in fuel, combustion process, and emission control as the basis for air pollution abatement if only control philosophy can change sufficiently to allow them free play. But there must be an alternative to control based primarily on ambient air standards and I think that the rise in these abatement technologies plus the other social and scientific change has provided that alternative.

I have suggested in the past that air pollution control be based on the concept of the control of pollutant emissions to the greatest degree feasible employing maximum technological capability. Do not be deceived by the apparent simplicity of this concept. The key words are feasible, and the use of maximum technology. The degree that is presently feasible; what could be done with present knowledge and technique, is quite good, and if this degree were met in all industries, the air would be very much cleaner without necessarily threatening the economic structure of an industry. In addition determining feasibility and technological capability for any process although difficult, is vastly easier than determining the level in the atmosphere at which an individual pollutant may be safe or unsafe. Furthermore, the statements feasible and maximum technological capability have built into them continued progress whereas fixed standards are notably difficult to change. In addition these concepts provide a focus for research and process development, improved fuel and control devices. Industry, the academic community, and government can join together in their pursuit. They are forced apart by the present pursuit of numerical standards. If you think about it, it is actually the method we use. When an ambient air standard is set, it must be translated into an emissions standard to be useful. Where the emission standard is feasible it is forced into effect. When it is not feasible because of the lack of technological capbility or real economic pressure then, generally speaking, a variance is granted or the industry given further time to meet the standard. The problem is, that each pollutant must be dealt with separately awaiting its ambient air standard. It is inconceivable that we will ever develop standards at a rate equivalent to our development of pollutants.

The justification for a change in underlying control philosophy is evident from the nature of the biological problem and research evidence; from the realities of pollutant production and the spawning of new pollutants; and from the increasing mandate from society for a cleaner and healthier environment as the right of man in an affluent state.