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CONTROL OF AIRBORNE POLLUTANTS 1/

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Each human uses 15,000 quarts of air per day. Industry requires vast quantities, plants use it, and most transportation equipment would be inoperable without it. Everyone uses air, and it is reused over and over again. One needs only to fly over cities like Chicago or Los Angeles, read his daily newspaper, or watch television to know that the 15,000 quarts of air he uses daily are not clean. Therefore, we should each have a very personal interest in controlling airborne pollutants.

This paper discusses 11 major pollutants of the atmosphere in terms of source, concentration, consequence, and damage in relation to the national air pollution problem; then considers the pollution problem in the Great Plains, indicating those pollutants that seem to be of most concern to the area; and finally, lists some things that the agricultural-industrial community can do to prevent air pollution.

Meteorology

Air is a mixture of gases, liquid particles, and solid particles forming a thin envelope around the earth. It is typically used as a vehicle for the dilution and dispersion of contaminants emitted into the atmosphere. Its capacity to serve as this vehicle is determined by the quantity available and the environment's self-cleansing power.

Although some scientists believe that the earth's atmosphere extends to the magnetosphere some 35,000 miles beyond the earth's surface, 99 percent of its total mass is within 19 miles of the surface of the earth and 80 percent of the total mass, which has the greatest effect on man, is within 7 miles (height to troposphere). Actually, the amount of air available to man is much less than that because it is reduced by geographical and meteorological factors, not yet controlled by man, that define the airshed and determine the rate of diffusion and mixing and hence the environment's self-cleansing power (1).

The environment gains its self-cleansing powers through winds that disperse wastes, processes that convert wastes to less harmful substances, rains that wash away wastes, and seas that dissolve them.

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Wastes in the atmosphere are dispersed by two principal factors: (a) the general "mean" air motion that carries them downstream, and (b) the "turbulent" velocity fluctuations that disperse them in all directions. The most important factor affecting the vertical dispersal of pollutants is the vertical profile of temperature. The rate of temperature change in the vertical profile or "lapse rate" under normal conditions falls as altitude increases. When the actual lapse rate is greater than a theoretical or adiabatic rate of 5.4° F. per 1,000 feet, a parcel of air that begins to rise continues to do so and the atmosphere is "unstable." If the actual lapse rate is less than the adiabatic rate, air that begins to rise tends to sink to the surface and the atmospheric condition is "stable." There is also a condition of "inversion" when the temperature increases with altitude. An inversion acts as a lid by separating layers of air and preventing wastes from rising, and if this condition is accompanied by low winds, then the atmosphere loses its cleansing power rapidly. It also does so when stable periods are prolonged.

When wastes are produced so rapidly or when they accumulate in such concentrations that these normal self-cleansing or self-dispersive propensities of the atmosphere cannot cope with them, we call the air polluted.

Pollutants

Air is polluted by such things as sulfur and its compounds, carbon monoxide, carbon dioxide, oxides of nitrogen, photochemicals, particulate matter, lead, fluorides, carcinogens, economic poisons, and radioactive substances.

<u>Sulfur</u>.--Oxides of sulfur, primarily sulfur dioxide, are probably the most widespread of the manmade air pollutants. The annual worldwide emission of sulfur dioxide in recent years totals 80 million tons: 50 to 60 million tons from coal, about 11 million tons from crude oil refining, 11 to 12 million tons from copper smelters, and 3.5 to 4 million tons from lead and zinc smelters (2). The burning of wood and solid wastes such as paper, cardboard, and rubber tires also adds sulfur dioxide to the atmosphere. It is estimated that the total emission over the United States amounts to 30 million tons each year (3). Sulfur oxides can injure man, animals, plants, and materials. It affects man and animals by irritating the upper respiratory tract and by restricting the finer air tubes of the lung, making breathing difficult. Its toxic effects on man appear to be greater when it combines with aerosols such as sulfuric acid or sodium chloride. Many believe that the illnesses and deaths in the Meuse Valley disaster can be attributed to a mixture of sulfur dioxide and sulfuric acid mist and to other aerosols in conjunction with sulfur dioxide (4). Sulfur dioxide causes both acute and chronic injury to the leaves of plants. Its oxidation-reduction properties that inhibit photosynthesis and kill cells are responsible for its toxic effect. It affects materials by accelerating corrosion in certain metals and converting carbonates to soluble sulfates in building materials such as limestone and cement.

Mercaptans and hydrogen sulfide are also objectionable contaminants, principally because of their distinct and unpleasant odor. They are produced in large quantities in the processing of petroleum, in coking coals, in the operation of paper pulp mills, in distillation of tar, in natural gas refining, and in rayon manufacturing. They also evolve from sewage disposal plants, dumps, and other environments where anaerobic bacteria function. The principal damages from this air pollutant are nuisances from odors, tarnishing of silver and copper, and darkening of houses painted with paint that contains lead compounds. Relatively low concentrations of hydrogen sulfide--less than 0.10 p.p.m.--have been found in some cities, but people can smell hydrogen sulfide in concentrations as low as 0.035 p.p.m. (3).

Carbon monoxide.--Carbon monoxide is one of the three most common products of fuel consumption. Motor vehicles produce much of this gas. Some estimates indicate they may be responsible for producing 60 percent of the existing air pollution in the form of carbon monoxide, unburned hydrocarbons, and nitrogen oxides (5). Global emissions of carbon monoxide are estimated at 200 million tons per year. The mass emission as a result of fuel combustion in the United States is estimated at about 100 million tons per year (4); however, in Los Angeles County, more than 3 million motor vehicles each day pollute the air with 8,000 tons of carbon monoxide, which is more than 5 pounds per vehicle per day. Carbon monoxide is a poisonous inhalant and is especially dangerous because it has a strong affinity for hemoglobin and thus deprives the body tissues of necessary oxygen. Carbon monoxide kills quickly at concentrations of slightly more than 1,000 p.p.m. and most people experience dizziness, headache, and lassitude at approximately 100 p.p.m. Los Angeles has set three alert levels for carbon monoxide at 100, 200, and 300 p.p.m. Present measurements indicate that the 100-p.p.m. level is seldom exceeded in cities of the United States. In the commercial and industrial districts around Cincinnati, Ohio, the concentration has ranged from 0 to 55 p.p.m., with an average of 9.5 p.p.m., and measurements in Los Angeles have indicated the highest concentration at 72 p.p.m. Generally, it is believed that carbon monoxide is oxidized in the atmosphere and, therefore, is not accumulating; however, since there are no measurements of the rate of conversion, this cannot be stated with absolute certainty.

Carbon dioxide.--Carbon dioxide is essential for plant and animal life. The natural atmosphere has a concentration of approximately 300 p.p.m. and there must be at least 5,000 p.p.m. in the air before man's respiration is adversely affected. Carbon dioxide, therefore, is not normally considered an air pollutant; however, worldwide concentrations have been increasing since the middle of the 19th Century from combustion of fossil fuels. About 2,300 billion tons or 342 p.p.m. are now present in the atmosphere. By the year 2000, about 50 percent of the original atmospheric carbon dioxide will have been produced by coal combustion, bringing the concentration to 450 p.p.m. (6). The main problem now from this pollution is deterioration of building stones from the conversion of calcium carbonate to water-soluble bicarbonate by the carbonic acid produced when carbon dioxide comes in contact with water. There is also considerable concern about the possible future effect that carbon dioxide may have on the heat balance of the world's climate. Some scientists believe that the slight rise of average temperature over the entire earth, observed in recent decades, may be due to an increase in carbon dioxide (4).

Oxides of nitrogen.--Oxides of nitrogen are produced during the high temperature combustion of coal, oil, gas, or gasoline in powerplants and internal combustion engines. They are partners in the formation of photochemical smog. Most determinations of oxides of nitrogen combine nitric oxides and nitrogen dioxide, with typical range of concentrations being 0.02 to 0.9 p.p.m. (4). The most extensive measurements have been made in the Los Angeles Basin and indicate that about 750 tons of oxides are released each day--500 tons from moving sources, cars, trucks, etc., and 250 tons from powerplants (7). These oxides have some direct noxious effects on the health and well-being of people, but by far the most objectionable consequence is their contribution to photochemical smog through their reactions with organic matter in the presence of sunlight. Standards have not been set for oxides of nitrogen regarding concentrations in relation to photochemical oxidation of organic matter, but it is believed the permissible level might be as low as 0.1 to 0.2 p.p.m.

Photochemicals.--Photochemical air pollution, "smog," results from a photochemical reaction between oxides of nitrogen and many types of organics in the presence of sunlight. Ozone, peroxyacetyl nitrate, and aldehydes are phytotoxicants formed by the photochemical processes. Substances in addition to oxides of nitrogen responsible for photochemical air pollution are unsaturated hydrocarbons, saturated hydrocarbons, aromatics, and aldehydes. There are many sources of these compounds but the automobile is a major producer of the essential components. The principal area affected by this kind of pollution now is the Los Angeles Basin where a large population, large number of automobiles, vigorous industrial activity, and mountains to reduce winds and impose stable atmospheric conditions combine to produce an extremely high concentration of pollutants, causing serious problems. Problems of lesser consequence also exist along the East Coast and in some of the Western and Midwestern States such as Washington, Utah, Colorado, Missouri, and Illinois. Photochemical pollutants are extremely toxic to plants, especially citrus, forage, vegetables, and coniferous trees. Injury syndromes termed "smog injury," "ozone injury," "weather fleck," and "grape stipple" are generally characterized by collapse of leaf cells. Estimates of damage to field and vegetable crops have run as high as $8 million in California and $18 million along the Atlantic Seaboard. Other consequences from photochemical pollution include deterioration of materials, eye irritation, decrease in visibility, and possibly health injuries in the form of respiratory and cardiac diseases. Concentrations reported as presently in the atmosphere at a given location may vary due to methods of measurement and analytical differences but total oxidant measurements by the potassium iodide method have shown levels as high as 0.75 p.p.m. in the Los Angeles area, with frequent recordings of 0.2- to 0.3-p.p.m. concentrations. California ambient air quality standards have established 0.15 p.p.m. for 1 hour as the "oxidant index" at which eye irritation, plant damage, and reduced visibility occur (4).

Particulate matter.--Aerosol particulates that pollute the air include pollens, spores, molds, yeasts, fungi, bacteria, smoke and hydrocarbons, natural dust, and various metals. These particles range in size from 0.001μ for some smokes to 4,000μ for some heavy industrial dusts (4). Clean air usually has nearly a thousand million aerosol particles per cubic meter, and in conditions of photochemical smog there may be as many as 100,000 million particles per cubic meter (2).

Pollen grains are discharged by weeds, grasses, and trees into the atmosphere and are the major cause of hay fever. Whole grain and fragments transported by the air range between 10 and 50μ in diameter, but some have been measured as small as 5μ and as large as 100μ (8). One acre of ragweed is estimated to produce 50 pounds of pollen and one ragweed plant can pollute the air with billions of pollen granules that become airborne as soon as the pods ripen. It takes only 20 to 25 pollen grains per cubic yard of air to cause a reaction in allergic individuals. Most of the pollution occurs in the immediate vicinity of the infected area but some may be carried to high altitudes and considerable distances. The Public Health Service reports that about 12,646,000 people suffer from asthma and pollen-caused allergies every year and that losses due to absences from work amount to $125 million (3).

Spores, molds, yeasts, fungi, and bacteria abound in the atmosphere either as individual particles or attached to some other particulate substance--usually dust. Rust of wheat and other cereal grains is spread by airborne urediospores. Some investigators of animal diseases believe that bacteria such as that causing anthrax and some viruses are probably disseminated by wind. Nocardiosis and blastomycosis, systemic infections in man resulting from fungus organisms, have been proved to be transmitted through air; and coccidiodomycosis, eryptococcosis, and histoplasmosis are suspected to be transmitted in this way (8).

Smoke is a combination of dust, hydrocarbons, and droplets produced by high temperature volatilization or by chemical reaction. Natural combustion, including that occurring in oil refineries, paper and steel mills, forest and grass fires, furnaces for heating of buildings, and automobiles, is the source of smoke. Forest fires are especially potent contributors and it is estimated that the approximate 150,000 wild forest fires occurring in the United States each year contribute 160 cubic miles of smoke, 34 million tons of particulates, and about 338,000 tons of hydrocarbons (3). Prescribed burning in forests adds another 32 cubic miles of smoke, 6.5 million tons of particulates, and 68,000 tons of hydrocarbons. Grass fires also contribute, and it is estimated that a 1-acre grass fire produces 2×10^{22} nuclei or a concentration of 2 billion particles per cubic centimeter to a height of 10,000 feet (8).

Natural dusts enter the atmosphere mostly from soil blowing caused by tornadoes, hurricanes, gales, and just plain strong winds. Susceptibility to wind erosion is the dominant problem on 70 million acres of land in the United States and, on the average, 4.8 million acres are damaged each year (9). Other sources of dust include smelters, mining operations, cotton ginning, alfalfa dehydration, cement mills, citrus feed drying plants, livestock and poultry feedlots, soil tillage, and mass transportation activities. It is estimated that as much as 30 million tons per year enter the atmosphere from all these sources (3).

The most frequent particulates found in air samples are silicon, calcium, aluminum, and iron. Relatively large quantities of magnesium, lead, copper, zinc, sodium, and manganese may also be found. Sources for these metals include various industrial and mining plants and internal combustion engines.

Lead.--Lead is one of the most widely used nonferrous metals in industry and everyday life. It occurs naturally in soils, rocks, water, and food, but this contributes only a small fraction to air pollution. The average concentration in rocks is about 16 p.p.m.; in soils it ranges from 0.04 in virgin to 1,000 p.p.m. in arable; and water has been reported to contain from 0.001 to 0.04 p.p.m. (4). It is emitted into the atmosphere from smelters and from combustion of fuels containing tetraethyl and tetramethyl lead. The level of lead in the atmosphere varies directly with the size of the community. Los Angeles has the highest concentration, approximately 5 micrograms per cubic meter of air, and urban communities with populations greater than 2 million have 2.5 micrograms. Communities smaller than a million have 2 micrograms and cities with populations less than 100,000 have a mean concentration of about 1.7 micrograms per cubic meter (10). Concentrations of lead may go as high as 44.5 micrograms per cubic meter in tunnels, but the best estimates of rural United States are only about 0.3 migrogram per cubic meter (4). Lead has a particle size that is likely to be retained in the lungs of animals and humans and, therefore, is an air pollutant of considerable concern.

Fluorides.--Fluoride occurs in vegetation and in various minerals. It has been found in natural dusts from soil in certain localities. Some topsoil in Idaho contained up to 1,640 p.p.m. (11), and it is not uncommon to find concentrations as high as 2,000 p.p.m. Fluorides are released into the atmosphere in both gaseous and solid forms by certain industrial processes such as the processing of rock phosphate, the reduction of aluminum, the smelting of iron and nonferrous ores, and the manufacture of ceramics. Fluorides damage plants, and plants have a remarkable ability to concentrate them, hence they have harmful effects on farm animals. Gladiolus, prune, peach, and apricot can be damaged from concentrations as low as 0.0005 p.p.m. Necrosis results when fluorides have accumulated in these susceptible plants to about 50 p.p.m. and more. Foraging animals will show adverse effects when the forage exceeds 30 to 50 p.p.m. At present concentrations, fluorides probably do not have any known adverse effects on human health (4). The mean concentration of fluoride in air in a number of communities ranges from 0.003 to 0.018 p.p.m. The maximum concentration so far measured is 0.08 p.p.m. in Baltimore. While fluoride levels do not seem to be high enough to be harmful to humans, the damage to plants and animals is of considerable consequence, and there have been legal claims for fluoride damage to crops in Utah, Florida, and Idaho totaling $3 million (3).

Carcinogens.--Biological examination of air pollutants has clearly shown the presence of some carcinogenic materials. Studies in this country and abroad have shown that atmospheric pollutants can induce cancer in experimental animals. Other studies have shown that the rate of lung cancer in humans is higher in cities than in rural areas and it is generally concluded that air pollutants have a significant, although minor, role in the incidence of the disease (4). Incomplete combustion of organic materials is the primary source of airborne carcinogenic aromatic hydrocarbons. Some 40 aromatic hydrocarbons have been identified in polluted atmospheres including benzo[a]pyrene, which is a potent carcinogen, and there are many more that have not been tested for carcinogenic activity. The U. S. Public Health Service measured concentrations of aromatic hydrocarbons over 14 cities and found the total amount to range from 5 to 146 micrograms per 1,000 cubic meters of air, with the potent benzo[a]pyrene ranging from 0.25 to 31 micrograms per 1,000 cubic meters. These quantities were considered minute, and the possible carcinogenic effects on humans is not known (4). Expectations of greatly increased emissions of aromatic hydrocarbons from increased combustion of fossil fuels in the years ahead make it imperative that better measurements of carcinogenic materials in the atmosphere be made and a better understanding of their effects be obtained.

Economic poisons.--The Federal Insecticide, Fungicide, and Rodenticide Act (12) defines the term "economic poison" as meaning "1. Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any insects, rodents, nematodes, fungi, weeds, and other forms of plant or animal life or viruses, except viruses on or in living man or other animals, which the Secretary shall declare to be a pest," and "2. Any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant." As generally used, the term refers to insecticides, fungicides, herbicides, rodenticides, arachnicides, and nematocides. In 1964, 470 million pounds of insecticides were used on 83 million acres of land and 184 million pounds of herbicides were used on 97 million acres (3). Use continues to increase and in 1968, 60 percent of the corn acreage received herbicides and 33 percent received insecticides.

There are no good answers to the question of the significance of pesticides to air pollution because there are few good air analyses available. Measurements made by the Midwest Research Institute in Kansas City, Missouri, at 5 urban areas over an 18-month period indicated that pesticide levels were extremely low and probably not dangerous to the general public. The measurements did show, however, that one day when spraying was underway near Orlando, Florida, the level of dieldrin equaled the daily acceptable intake from food. Measurements on 5 different days by the Public Health Service in a cotton growing area during a time when cotton had been given heavy applications of DDT showed 23, 34, 12, 7.4, and 7.4 nanograms of DDT per cubic meter of air, but no real conclusions were made as to whether this was harmful (4). Other air measurements in California during applications of malathion to control mosquitoes in the town of Planada showed a range of atmospheric concentration of 0.05 to 0.125 mg/m^3 during actual spraying and 0.034 to 0.044 mg/m^3 1 hour after spraying (8). It was concluded that these levels did not constitute a hazard to humans.

The problems of entrainment, dispersal, and transport of pesticides are complex and have not been well evaluated. The Midwest Research Institute study showed that pesticides are absorbed on dust particles; and it has been reported that 14 parts per billion of dust falling on the Caribbean island of Barbados is DDT. However, many more studies must be made before definite conclusions can be drawn.

The significance of herbicides as air pollutants is also not well defined. It is known that herbicides, because of drift, have caused considerable damage to orchards, shade trees, shrubs, ornamentals, and agricultural and vegetable crops sometimes at distances as far as 10 miles downwind.

Radioactive substances.--Until 70 years ago, ionizing radiation was due exclusively to natural sources. Today, radioactivity in the atmosphere comes from both natural sources and human activities. Natural radioactivity is either of terrestrial origin, consisting mainly of radioactive gases such as radon and thoron that are released from soils and rocks, or it is produced by the interaction of cosmic radiation with atmospheric constituents. Radioactive pollution is caused by man and results from (2) the reactor-fuel cycle, (b) use of nuclear energy as a source of power, (c) use of radioisotopes in industry, medicine, and scientific research, and most of all (d) testing of nuclear weapons.

Although there is some potential for atmospheric pollution from fission products emitted during the second part of the reactor-fuel cycle (introduction of fuels into reactor and reprocessing of spent reactor fuel), the real danger from this source is the possibility of accidents, such as that in Windscale, England, in 1957 (4). While present contamination from the reactor-fuel cycle is minor, it is believed that increased use of nuclear energy for production of electricity could eventually cause a problem. Estimates indicate thermal power produced by atomic plants may reach 700,000 megawatts by the year 2000 (13).

Nuclear energy is currently being used as a source of propulsive power for submarines and a few surface vessels. It will be increasingly used for such purposes, for rockets, and for measurement and communication systems in space exploration. These uses provide the same opportunities for radioactive contamination of the atmosphere as described for the stationary reactors but with the added complication of a mobile source of contamination, meaning that more people not even close to the reactors can be exposed.

Radioactive isotopes are being used increasingly in research laboratories. Some pollutants result in the form of suspended fine particles which are mostly beta-gamma emitters with short or medium half-life. While these releases into the atmosphere are small from any one installation, some of the isotopes used and planned, such as strontium-90, are highly radiotoxic, and the total over a given area must be considered.

Fallout from nuclear weapons tests is by far the worst contaminator and is subject to the least control. There are three types of fallout from nuclear detonations: (a) large particles of radioactivity that fall a few hundred miles downwind in a few days; (b) smaller particles that enter the troposphere, travel around the world several times in a narrow hemispherically controlled zone, and finally fall out in a few weeks; and (c) still smaller particles that go into the stratosphere where fallout depends on time of injection, yield, and latitude, and may take from one to several years.

Radioactivity affects plants (14), animals (15), and man (4). Since there really is no effective therapy for preventing or curing the harmful effects of internal contamination by radioactive nuclides, reliance for health and plant protection must be placed mainly on measures for insuring that radioactive pollution is adequately controlled. The Radiation Protection Guides (RPG) for man established by the Federal Radiation Council are shown in table 1.

Table 1.--Radiation Protection Guides (RPG) of the Federal Radiation Council (4).

Tissue or organ	RPG for individuals	RPG for average of suitable sample of exposed population
	rem/year	
Whole body	0.5	0.17 rem/year
Gonads	---	5.00 rem/30 year
Thyroid	1.5	0.50 rem/year
Bone marrow	0.5	0.17 rem/year
Bone	1.5	0.50 rem/year

Natural background radiation, given by the United Nations Scientific Committee on the Effects of Atomic Radiation, is 125 millirem per year on whole body, thyroid, and gonads; 137 millirem per year to bone; and 122 millirem per year to bone marrow. Thus, the figures given in table 1 for the average of a sample of exposed population are about 1.3 times that of natural radiation for body, gonads, and bone marrow; about 3.7 times for bone; and about 4.0 times for thyroid. The highest monthly fission concentration measured since routine measurements began in 1956 was 3.35 microcuries per 10,000 cubic meters of air, observed at Salt Lake City in September 1957 during a series of nuclear explosions in Nevada. During 1965 and 1966 the concentration of airborne fission products was little more than the detection limit of 0.001 microcurie per 10,000 cubic meters of air (14).

Air Pollution Problems in the Great Plains

The discussion thus far has provided some concept of the national problem of air pollution. This section will consider the Great Plains in a review of (a) climate, (b) assessment of the present situation, (c) pollutants of most concern to the Plains and agriculture, and (d) control measures.

Climate.--While there is no region, given enough pollution, for which the self-cleansing properties of the atmosphere cannot be overwhelmed, the climate and topography of the Great Plains are not conducive to air pollution problems. The land is mostly flat, generally unstable atmospheric conditions usually prevail, and a large part of the area lies in a region with a clean sweep of winds within the major storm tracks. There are some exceptions, of course, such as Kansas cities located in river bottoms and cities or areas with highly pollutive industrial plants located in or near mountains, such as Denver, Colorado, and Missoula, Montana.

Present situation.--It is difficult to assess the present situation because of lack of good measurements and differences in standards of what constitutes polluted air. If we look at suspended particulate data for urban and nonurban atmospheres, we find that particulate loadings in 1,252 samples from rural areas averaged 39 $\mu g/m^3$ and concentrations from urban areas averaged four times greater (16). Other information indicates that all urban places of 50,000 or more population are considered to have some kind of air pollution problem (4). Of the 64.5 million people who live in such areas, 35.6 million face a major problem, 18.7 million a moderate problem, and 10.2 million a minor problem.

If we apply this data to the 10 Great Plains States, there are approximately 38 places with air pollution problems. Texas has 21, Oklahoma 4, Colorado and Kansas 3 each, Montana and Nebraska 2 each, North and South Dakota and New Mexico 1 each, and Wyoming none. The data do not indicate the occasional pollution problem we have from soil blowing. Chepil and Woodruff (17) found in the 1950's that there could be from 3.1 to 1,290 tons per cubic mile of dust in the air during severe blowing. Twiss (18) found during years of relatively low soil-blowing activity on the Plains that average deposition rates ranged from 19 pounds per acre per month at Riesel, Texas, to 280 pounds per acre per month at Tribune, Kansas. Such data indicate we already have some air pollution problems. Since our population is expected to quadruple by the year 2062 and industrialization to increase, we will have even greater problems in the future.

Pollutants of most concern to the Plains and agriculture.--If we consider the list of 11 pollutants we have discussed and recall that air has no respect for political boundaries, we must conclude that we should be concerned about all of them. We use many automobiles in the Great Plains and their numbers are expected to double by 1985. They produce carbon monoxide, oxides of nitrogen, leads, and various other chemical pollutants. We generate electrical power and burn agricultural and forest wastes, producing smoke and hydrocarbons. We have fertilizer plants that produce fluorides. We have strong winds, drouths, tornadoes, feedlots, cement plants, alfalfa dehydrators, and other sources of dust. We use economic poisons to control insects and weeds, and although we contribute very little to contamination by radioactivity, we are subjected to it.

We in agriculture cannot control radioactivity emissions; neither can we do much about the vast production of chemical pollutants, i.e., the photochemicals, oxides, fluorides, etc. by automobiles and industry. However, we can do something about controlling natural dusts, smoke and hydrocarbons, and allergens; we can have some influence on air pollution by economic poisons; and we can do something about radioactivity and other pollutant damage by developing plants and animals with greater resistance to damage.

Control measures--what can be done.--Some specific control measures and research to improve air quality that the Great Plains agricultural-industrial community can do are outlined as follows:

I. Particulate matter

A. Dusts

1. Prevent soil blowing on agricultural land by: (a) selecting proper tillage implements; (b) practicing stubble mulching; (c) using cover crops; (d) avoiding overgrazing; (e) planting at right angles to prevailing winds; (f) performing emergency tillage; (g) maintaining high soil fertility; (h) using wind barriers; (i) establishing permanent grass on marginal land; (j) using stripcropping and buffer strips; (k) applying spray-on petroleum and chemical adhesives; and (l) leveling or benching land (19, 20, 21).

2. Develop new technology to prevent soil blowing by: (a) studying mechanics of erosion; (b) improving and modifying tillage machines and practices; (c) conducting research to develop better strains of grasses and plants to tie down blowing soil; (d) improving predictions of erosion hazards; (e) improving technology for using wind barriers; (f) improving technology for using spray-on adhesives; and (g) designing landforming systems (3, 20, 22).

3. Install cyclone collectors, after burners, settling chambers, target boxes, baffle chambers, filters, electrostatic precipitators, scrubbers, and washers where applicable on foundries, cement plants, fertilizer plants, feed mills, cotton gins, and all other industries emitting dusts.

4. Utilize newly developed metal salvage incinerators with cool primary chambers to assure complete combustion of gasses, dusts, and droplets.

5. Pave or otherwise hard-surface feed and parking lots.

6. Use wet steam and wet sandblast cleaning methods for renovation of masonry buildings.

7. Use trees and shrubs to screen out particulates and mask factory sites, and conduct genetic research to develop new, more resistant species for this purpose.

8. Control grazing and logging practices on forest lands.

B. Smoke and hydrocarbons

1. Eliminate open-burning dumps and single-chamber incinerators.

2. Use coal stokers and over-fire jet systems in small and medium size heating systems to obtain optimum feeding rate for clean burning.

3. Compost leaf and grass rubbish and use wood chippers and vacuum leaf sweepers.

4. Plow, disk, or otherwise incorporate agricultural field wastes.

5. Use return-stack type heaters for orchard protection.

6. Use signal instruments such as photoelectric smoke detectors in power generating plants to warn operators to adjust feeding rates.

7. Use plant wastes to produce new products, e.g., fiberboard from bagasse, and supplemental livestock feeds from citrus, apple, and cottonseed wastes.

8. Conduct research to develop better prediction of electrical storms, and evaluate cloud-seeding techniques to reduce lightening-caused forest fires.

9. Conduct research to develop: (a) better methods of disposing of organic wastes such as rice and grasses, (b) methods of forest fire prevention, and (c) improved methods of disposing of forest wastes (3).

10. Develop technology to decontaminate gin trash of insect and disease pests, enabling its return to fields (3).

11. Develop shorter straw cereal grains.

12. Restrict prescribed burning of forest, agricultural, and human wastes to unstable weather periods favorable to transport and dilution.

C. Pollens

1. Promote ragweed control programs through spraying, cutting, pulling, etc.

2. Conduct research to devise new ways of eradicating plant species that produce allergenic pollen.

3. Conduct research in phenology of ragweed to determine vulnerable points for more effective spraying programs and other methods of control (23).

4. Conduct turbulence, diffusion, and transport studies to determine thresholds, trajectories, and distances of travel of pollen aerosols to aid in establishing standards for control and warning systems (23, 24).

5. Initiate countermeasures such as allergen injections, symptomatic treatments with antihistamine, and installation of filtering equipment in homes and offices.

II. Economic poisons

1. Improve weather forecasting so spraying can be accomplished during stable atmospheric conditions when there is little turbulence and vertical motion.

2. Develop new materials and less hazardous chemical controls, e.g., insecticides with higher biodegradability and lower persistence and herbicides with more specificity.

3. Develop and use better methods of application that require less material or place the toxic materials more accurately (22).

4. Develop and use nonpesticidal means such as (a) resistant crops, (b) parasites or predators, (c) self-destruction techniques (sterilization, breaking of diapause, etc.), and (d) improvement of cultural practices (22).

5. Carry out comprehensive information and education programs to encourage the safe use of pesticides for protection of the user, the consumer of food and fiber products, wildlife, soil, air, and water (22).

6. Establish suitable monitoring systems to measure extent of pesticide persistence in the atmosphere (25).

7. Support research to obtain a better understanding of the accumulation of pesticides in human tissues and organs in relation to air concentrations and exposure times (25).

III. Radioactivity

There is no therapy for curing the damaging effects of radioactive substances, and little that agriculture can do to prevent pollution of the atmosphere. Possible activities include:

1. Establish monitoring systems to determine the levels of contamination so standards are not exceeded.

2. Be prepared to initiate such countermeasures as: (a) putting cows on stored winter feed; (b) holding polluted milk till iodine-131 decays; (c) placing young children and pregnant women on evaporated or powdered milk; (d) adding iodine to the diet; and (e) removing strontium-90 from milk (4).

3. Continue research to obtain information on behavior of radionuclides on plants and animals (3).

4. Continue engineering development of machinery and techniques for decontamination of soil.

5. Conduct research to determine the genetic lines of feed and food plants that have the physiological capability of excluding radioactive elements (3).

IV. Miscellaneous measures

1. Conduct research to evaluate effects of chemical air pollutants on plants in terms of sensitivity, components causing actual damage, and acute or chronic levels (3).

2. Develop managerial practices to ameliorate pollutant damage and plants and trees with higher tolerance levels (3).

3. Conduct research to determine the rate of removal of air toxicants by plants.

4. Evaluate plants, especially lichens, as sensors or monitors of pollutant levels (26).

5. Conduct meteorological research to obtain a better understanding of atmospheric processes affecting pollutant dilution (27).

6. Support economic studies to determine better estimates of damage due to pollution and of benefits of control. Data available now are not complete. Some estimates indicate $1/2 billion per year damage to agriculture nationwide, but the figure is difficult to verify--better information is essential for development of effective control measures (28).

Conclusion

The previous section has dealt primarily with control technology and has listed a number of "small" but significant control measures that can be carried out to ameliorate air pollution. However, it is important to recognize that control of air pollution is not simple. It goes beyond mere technology, beyond analysis of cost benefits, and beyond knowledge of power of the individual. The effective control of air pollution depends on the combined application of technology and law under a sound administrative program (4). It involves groups of people and therefore public policy and legislation.

The book Air Conservation (4) summarizes the problem well when it states: "The problem of air pollution will probably never be 'solved.' But if man is willing to recognize that the problem exists, if he is prepared to bring to it his political wisdom, scientific knowledge, and technological skills, and if he is willing to work with nature instead of against it, then he can leave to his children and to his children's children something more valuable and more necessary to human life than any of the manufactured products of his civilization. He can bequeath to them the blessing of clean air."

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