Landfill Gases and Some Effects on Vegetation

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ABSTRACT.—Gases moving from refuse landfills through soil were studied in New Jersey. The gases, products of anaerobic decomposition of organic matter in the refuse, caused injury and death of peach trees, ornamentals, and commercial farm crops, and create possible hazards to life and property because of the entrance of combustible gases into residences. Remedial measures are described.

THREE REFUSE LANDFILLS in New Jersey have been under study for the past 6 years because underground gases from the landfills have been moving through the soil into adjacent areas and damaging vegetation.

The New Jersey Cooperative Extension Service, charged with responsibility for responding directly to the needs of the state's citizens, becomes involved with various kinds of problems. One of these has been the underground generation and movement of combustible gases, carbon dioxide, and the odorous gases of sulfur reduction. Although there are many different sources for these gases, we have been working with those arising from the decomposition of organic matter in commercial refuse landfills.

The members of the Rutgers-Cook College faculty who have been involved in these studies include a specialist in environmental sciences, county agents, plant pathologists, entomologists, and soil scientists. In addition, whenever possible we have involved the staffs of the state, county, and municipal health departments, the New Jersey Bureau of Solid Waste Management, the federal solid waste management programs, the owners and operators of the various refuse landfills, and the owners of the properties affected.

The problems described in this paper include the death of peach trees in a commercial peach orchard in Gloucester County, the death of ornamental vegetation in Camden County, and damage to commercial farm crops in Burlington County. All are located in the southwestern quarter of the state. In addition to the death of vegetation, the Camden County case involved a hazard to life and property because of the entrance of combustible gases into private residences adjacent to the landfill.

THREE LANDFILL CASES

The three landfill cases we have followed most extensively during the past 6 years are in Glassboro, Gloucester County; Cherry Hill, Camden County; and Cinnaminson, Burlington County. All were brought to the senior author's attention by Rutgers County Agents responding to complaints of vegetation injury and death from unknown causes. All three cases were associated with landfills where refuse had been deposited in worked-out sand and gravel pits.

Glassboro

The landfill in Glassboro covered about 6 acres. The refuse, which consisted of household and industrial wastes, demolition materials, and sewage sludge, was deposited to depths of 10 to 20 feet. A commercial peach orchard abutted the landfill along about 1,000 feet of its periphery. The balance of the landfill was adjacent to scrub vegetation on land that was apparently not serving any commercial, agricultural, or residential use.

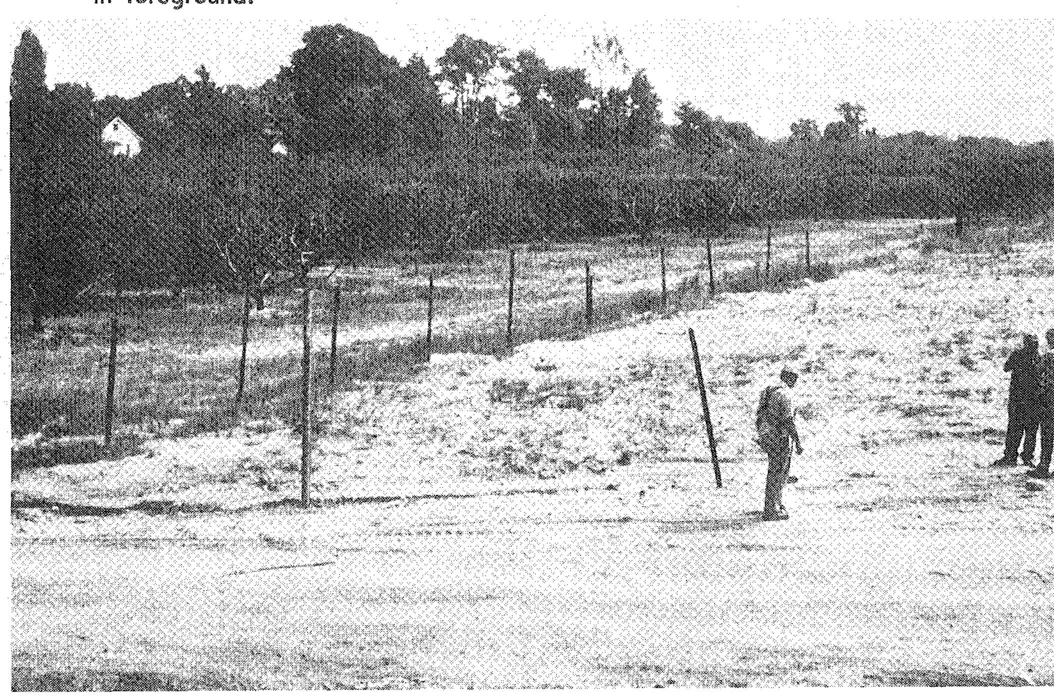
Landfilling at this site began in February 1968. Refuse deposition along the northeast line of the landfill adjacent to the peach orchard was completed in 1969. The peach trees nearest this line began dying during the summer of 1971. Our first inspection of this site was made in September 1972. By that time about 50 peach trees had died (fig. 1). Combustible gases and carbon dioxide were found, along with low oxygen concentrations, in the root zones of most of these dead peach trees. The greatest distance of these dead peach trees from the landfill was 70 feet.

In March 1974, landfill gases were found more than 80 feet from the landfill. By then about 70 peach trees had died. The peach farmer brought the operator of the landfill (the Borough of Glassboro) into the Chancery Division of the Superior Court of New Jersey, and after a week of testimony the case was settled out of court to the plaintiff's satisfaction.

The landfill and peach orchard were examined again in the early summer of 1975. The landfilling was complete and appeared to have an adequate cover of soil material. Some minor settlement had taken place, causing surface water puddles to form. More than half of the mature peach trees adjacent to the landfill in 1971 had been removed as part of the farming procedure and were replaced in 1973-74 with new trees. However, the young trees in the row nearest the landfill died and were replaced with new trees. These too died, in the spring of 1975.

No corrective measures have been taken to reduce the lateral movement of

Figure 1.—Commercial peach orchard adjacent to completed refuse landfill in Glassboro, N. J. Dead peach trees can be seen in the rows nearest the landfill in foreground.



these gases. We expect that the farmer will continue to lose peach trees planted near the landfill.

Cherry Hill, Camden County

This 9- to 10-acre landfill is surrounded by 28 single-family homes that were constructed before landfill operations began. Refuse 10 to 60 feet deep has been deposited in this former sand and gravel pit. When dumping began in the fall of 1963, only bulky wastes and demolition materials were being deposited. However, the nature of the materials being deposited gradually changed later to include general municipal refuse and garbage. Dumping was completed in 1970, and Cherry Hill Township has since been making efforts to turn this former landfill into a municipal park. The fill had been placed in a manner to incorporate esthetically pleasing hills and slopes within the park perimeter; topsoil has been brought in, and the area has been seeded.

We were first called to this area by the Rutgers Camden County Agricultural Agent in January 1969 to help determine the cause of vegetation death in the backyard of a home abutting the landfill. A spruce tree, rhododendron, Japanese yew, azaleas, dogwood trees, flowering peach trees, Scotch broom, arborvitae, Douglas-fir, and an area of lawn grass had recently died. Our soil gas tests indicated the presence of combustible gases, carbon dioxide, putrid ground odors, and the lack of oxygen.

Periodic checks made in this area revealed that vegetation injury and deaths seemed to be progressing gradually from the landfill toward the houses. In June 1971 a general inspection of the entire area indicated that there were clumps of dead vegetation at various points around the entire periphery of the landfill. At this time it was recommended that the responsible government officials check the complete landfill to see if gases might be migrating from the landfill into backyards and toward other homes.

Between December 1971 and January 1973, four different 10- to 15-foot deep stone trenches were installed in an effort to prevent the lateral movement of gases from the landfill to the adjacent properties. Only some of these trenches were successful in stopping this. In April 1974 the legal case between a dozen residents and Cherry Hill Township, the owner and operator of the landfill, was heard in the Chancery Division of the Superior Court of New Jersey. After a week of testimony the case was settled out of court. The plaintiffs received $60,000 in settlement. In addition, the township was required to vent the landfill gases from the periphery of the landfill.

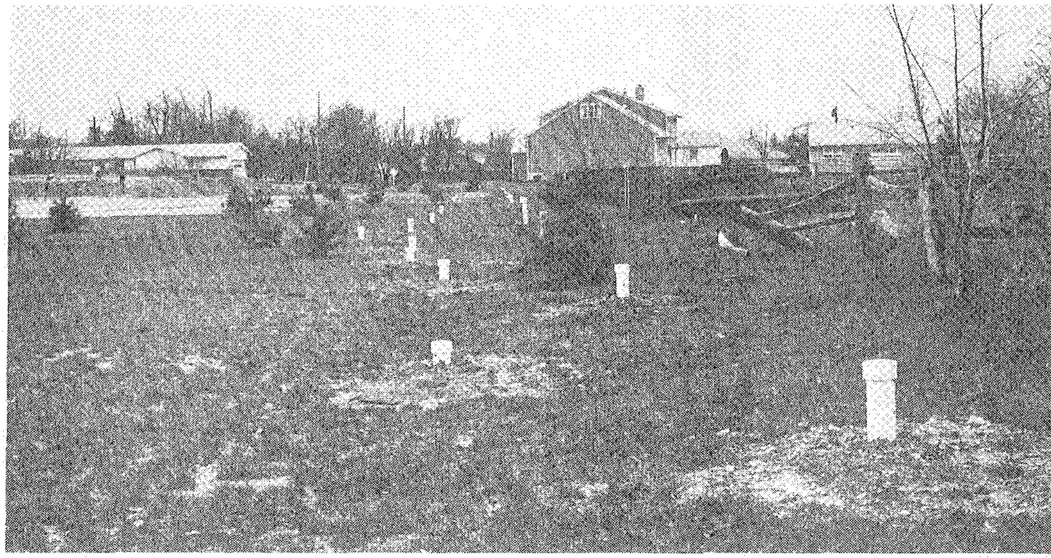
In the fall of 1974 vertical venting pipes were installed on the periphery of the landfill (fig. 2). Many of the vent pipes along the eastern periphery of the landfill have been vandalized and the tops broken by rocks. However, it did not appear that the vandalism decreased the efficiency of these plastic pipes for gas venting.

In April 1974 a single maple tree was planted in the lower elevations of this landfill park. No sign of this maple tree could be found in March 1975. It had disappeared. Only one clump of naturally seeded trees was noted in the spring of 1974. This was a group of maple trees that have been growing for a number of years near the southeastern corner of the landfill. Tests indicated that gases of anaerobic decomposition were not present in the root zone of these trees.

Examination of the landfill park in spring 1975 revealed that a large number of deciduous and evergreen trees had been planted over much of the park area the previous fall. Species included sweet gum, red oak, crab apple, Japanese poplar, white pine, Scotch pine, and fir. No trees were planted on the tops of the high refuse hills.

As of March 1975 many of the evergreen trees looked brown. There were

Figure 2.—Vertical gas venting pipes in place along the periphery of the landfill in Cherry Hill, N. J. Newly planted trees for landscaping are also shown.



also signs of vandalism: some trees had been pulled from the ground; others had limbs broken off; and some had apparently been stolen. The holes left after the trees had been pulled or dug from the ground appeared to be rather shallow, and the soil beneath them appeared to be very well sealed since water puddles remained in them some days after a heavy rain. Examination of these trees indicated that many of the dead trees did not live because of poor planting practice. Only a limited number of the trees revealed the presence of the combustible gases in their root zone.

During the last half dozen years the vegetation in the backyard of the home has continued to die until only that vegetation near the home remains. It will be interesting to see if the gas vents prevent further gas intrusion into these adjacent lands and permit vegetation growth again. We plan to periodically monitor these plantings to see if the landfill gases present any future problems. Perhaps the vertical vents will alleviate the problem at this location.

Cinnaminson in Burlington County

A landfill in which refuse has been placed to depths of 80 feet on about 100 acres is operating on the northern side of Union Landing Road. A 600-foot-long road interface exists between the landfill and the farm on the southerly side of Union Landing Road. The distance between the edge of the farm and the edge of the landfill is 50 to 60 feet. This space is occupied by Union Landing Road and its right of way. Apparently all sorts of refuse materials have been accepted by the landfill, which began operation about 1965.

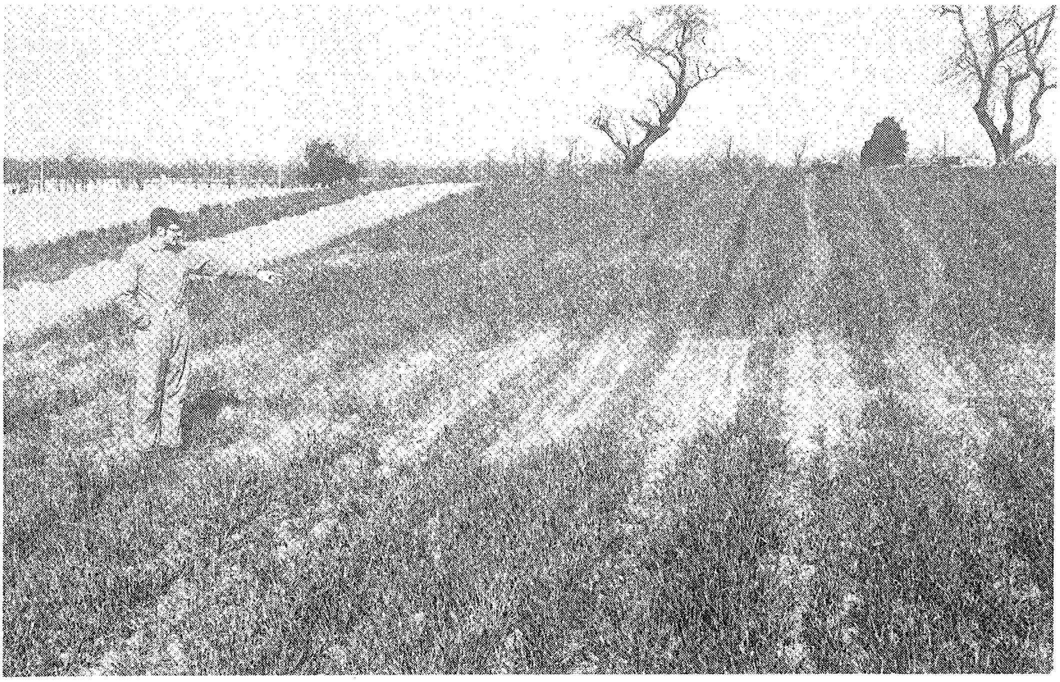
In the summer of 1970 the farmer experienced difficulty in growing tomatoes in fields nearest the landfill. Very unpleasant odors, arising from the area of his field nearest Union Landing Road, were noted by the farmer during the spring plowing of 1971. At that time we examined this field for possible problems associated with the landfill. In the fall of 1971 decomposition gases were discovered 300 feet from the landfill. Since the spring of 1971 the farmer has not cultivated the 2 to 3 acres of his fields nearest Union Landing Road. The death of vegetation in the field resulted in erosion of the surface of the field, and a weed cover crop developed.

By the fall of 1971, the landfill operator had recognized that his landfill was the source of the farmer's problem. He then installed a 600-foot-long, 10-foot-deep, 3-foot-wide gravel-filled trench the total length of the interface between the landfill and the farm. This did not seem to alleviate the problem. Apparently the gases continued to flow from the landfill beneath the trench into the farm field.

In the spring of 1972 soil tests were made in the areas of the farm where vegetation was undamaged and where the vegetation had been killed by the landfill gases. The nutrient quality of both soil areas was found to be the same. In March 1973 the landfill operator installed 4-inch plastic vertical venting pipes along the total length of the landfill-farm field interface. These pipes were put in to a depth of 30 to 40 feet on 20-to 25-foot centers.

In April 1973 the farmer and the landfill operator developed an interim agreement relative to payments for damages claimed by the farmer and corrective actions to be taken by the landfill to alleviate the gas problem. In December 1974 the farmer noted areas farther from the field where his rye cover crop was dying (fig. 3). A check of the ground gases in these areas revealed the presence of combustible gases up to 600 feet from the nearest edge of the landfill. In summer of 1975, combustible gases were found more than 750 feet from the nearest edge of the landfill. At this time they were damaging commercial corn and sweet potato crops. It appears that the venting pipes were not functioning properly; although visual examination indicated that ground gases are being vented to the atmosphere by the pipes. Suggestions made

Figure 3.—Rye planting in farm field adversely affected by landfill gases 600 feet from nearest edge of the landfill at Cinnaminson, N. J.



to improve gas-venting include installing pumps on the pipes to withdraw the combustible gases from the landfill and venting from greater depths.

As indicated above, we found landfill gases 180 feet from the landfill in the spring of 1971, 300 feet from the landfill in the fall of 1971, 600 feet from the landfill in December 1974, and 750 feet this summer (1975). However, the migration of these gases has not been constant. Measurements taken at a number of other times indicated that the gases had apparently retreated toward the landfill. Their outward movement seems to be at an uneven rate, depending upon various factors, many of which are not understood. Incidentally, the consultant hired by the landfill company reported that the degree of migrating gases has decreased with time. Obviously our data conflicts with his. Some of this disagreement might be due to making measurements at different locations and times.

We will continue to follow this situation and determine the ultimate fate of the landfill gases and vegetation growth in the fields. Eight to 10 acres of the farm field are now involved in problems of poor or no vegetation due to the adverse influence of gases from the landfill located to the north of the field.

The landfilling directly north of Union Landing Road is nearly complete. Completion of the landfill will involve filling the westerly corner of this former sand and gravel pit. This additional filling will bring the refuse in contact with the soil along Union Landing Road for an additional few hundred feet immediately opposite the Hunter Farm. This includes an area on which a farmhouse is located plus an additional few hundred feet immediately opposite the Hunter Farm commercial farm fields. It is possible that the refuse will be located against a soil bank within about 100 feet of the farmhouse.

This farmhouse has a dirt-floor cellar, which is used to store various farm crops during the winter. Therefore we have set up permanent gas-sampling stations opposite the landfill area still to be filled. In addition to exposing this farmhouse to possible infiltration of landfill gases, another private home and at least one light-industry building will also be within a couple of hundred feet of the refuse upon completion of the landfill. Unless adequate protective measures, such as a gas barrier or adequate vents or both, are taken to prevent the movement of landfill gases, it is possible that these buildings and additional farm fields will in time become involved with the combustible gases travelling underground from the landfill.

GAS MEASUREMENTS

All our underground gas measurements were made by adapting various gas-measuring equipment that was originally designed for making safety checks and measuring combustion efficiencies. To determine whether or not foreign gases are present in the soil atmospheres, it is necessary in most cases to first make a hole in the ground. Currently we are using a commercial bar hole maker to obtain a 3-foot deep, ½-inch hole. This commercial instrument (fig. 4) incorporates a steel hole-making rod and driving weight in one convenient unit. This same type of unit is used by most gas utility companies when searching for leaks from their underground pipelines. The handle of our hole maker is electrically insulated to prevent a shock should it come in contact with a live underground electric wire.

The sample is withdrawn from the bar hole by use of a 3-foot long nonsparking probe. If desired, a nonconducting probe may be used. A rubber stopper is placed over the upper end of the sampling probe to help seal the bar hole from the ambient air. However, the nature of the sampling method frequently allows large quantities of ambient air to dilute the sample.

Figure 4.—Bar hole maker is held by man on left. Right, reading an MSA Explosimeter to measure the concentration of combustible gases in a sample drawn from the bar hole.

The most convenient test for checking for the gases of anaerobic decomposition of organic matter is with a combustible gas meter. We pass our gas sample, which is drawn from the bar hole, through an M.S.A. Explosimeter, an instrument used by the gas utility companies when checking for leaks in their underground lines. The Wheatstone bridge principle is used in the instrument for determining gas concentration. The combustible gases are burned on a heated catalytic filament, thereby changing its resistance. This unbalances the bridge, giving a reading on the galvanometer.

These combustible gas-measuring instrument readings indicate the percentage of the lower explosive limit of the gases for which the instrument is calibrated. The lower explosive limit for methane is a 5-percent dilution in air. However, it is possible to tell from the response of the meter whether or not the combustible gas concentration is between the lower and upper explosive limits or above the upper explosive limit (15 percent methane in air). By use of a dilution tube on the intake side of the meter, it is possible to theoretically determine the actual combustible gas concentrations up to 100 percent methane. It is also possible to separate heavy petroleum vapors from the lighter hydrocarbon gases by use of an activated charcoal filter on the sampling line. Regular calibration is required.

The carbon dioxide and oxygen concentrations of the ground gases obtained from the bar holes are analyzed by the Orsat method, normally used to measure the efficiency of fossil-fuel-fired furnaces. In our field-test work we use the Bacharach Fyrite carbon dioxide and oxygen indicators. In the carbon dioxide indicator, the CO_2 is absorbed in a potassium hydroxide solution. In the oxygen indicator, a chromous chloride solution is used. Carbon dioxide indicators are available for reading 0 to 20 percent and the 0 to 60 percent concentrations. The oxygen indicators are for determining 0 to 21 percent concentrations.

Unpleasant ground gas odors are frequently an indication of gases of anaerobic decomposition of organic matter. These unpleasant odors can often be checked for by withdrawing a soil sample from the ground and smelling the sample.

We have occasionally used industrial hygiene dry-tube indicators to check for the possible presence of sulfur gases and carbon monoxide. However, in general we find the field test for combustible gases to be the easiest, quickest, and simplest to make. Our next most frequently used field check is for carbon dioxide. Normally we would not expect to record the presence of combustible gases or carbon dioxide with these field-test meters if there were not significant quantities of the gaseous products of anaerobic decomposition present in the soil gases.