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**Exhibit 13**

United States  
Environmental Protection  
Agency

Office of Air Quality  
Planning and Standards  
Research Triangle Park NC 27711

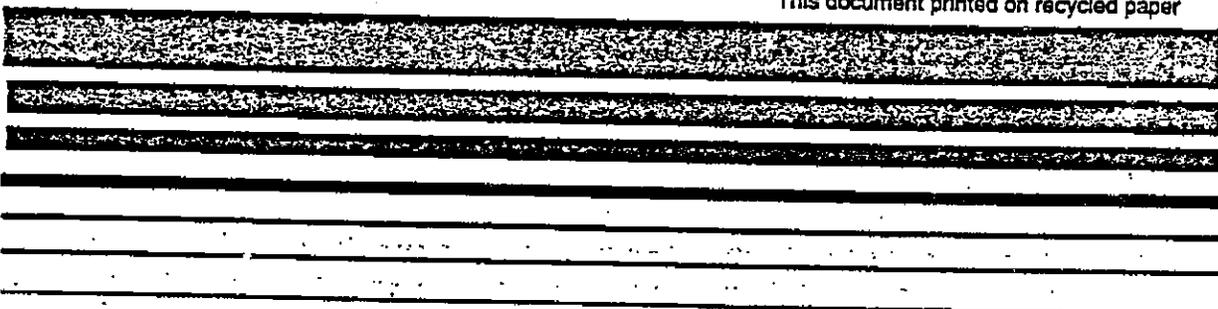
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Air



# Air Emissions from Municipal Solid Waste Landfills - Background Information for Proposed Standards and Guidelines

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# N S W S

## 2. HEALTH AND WELFARE EFFECTS OF AIR EMISSIONS FROM MUNICIPAL SOLID WASTE LANDFILLS

### 2.1 INTRODUCTION

This chapter presents a summary of the potential adverse health and welfare effects of air emissions from municipal solid waste (MSW) landfills. The five major effects of MSW landfill air emissions are (1) human health and vegetation effects caused by ozone formed from nonmethane organic compound (NMOC) emissions, (2) carcinogenicity and other possible noncancer health effects associated with specific MSW landfill emission constituents, (3) global warming effects from methane emissions, (4) explosion hazards, and (5) odor nuisance. In addition, soils and vegetation on or near the landfills are adversely affected by MSW landfill emissions migrating through the soil. The above effects are briefly summarized below and in Table 2-1.

A variety of different NMOCs have been detected in air emissions from MSW landfills. In the atmosphere, NMOCs can contribute to formation of ozone through a series of photochemical reactions. The ozone formed through these reactions can exert adverse effects on human health and on vegetation. The effects ozone exerts on both human health and vegetation are discussed in greater detail in Section 2.2.

There are potential acute and chronic health hazards associated with several chemical species in MSW landfill emissions. The potential cancer risks associated with exposure to MSW landfill emissions have been considered by EPA (see Section 2.3). There are also other chronic noncancer health effects associated with some of the individual chemicals found in MSW landfill air emissions. Qualitative descriptions of both the cancer and noncancer health effects are also included in Section 2.3.

The landfill gas that is generated from the decomposition of municipal solid waste in a landfill consists of approximately 50 percent methane and 50 percent carbon dioxide, and less than 1 percent NMOCs. The methane emissions are of concern for two reasons: 1) methane, one of the "greenhouse gases", contributes to the phenomenon of global warming

TABLE 2-1. SUMMARY OF THE HEALTH AND WELFARE EFFECTS ASSOCIATED WITH MSW LANDFILL EMISSIONS AND COMPONENTS

Component	Health and welfare effects
Ozone	Alterations in pulmonary function, aggravation of pre-existing respiratory disease, damage to lung structure; foliar injury, such as stippling or flecking, reduced growth, decreased yield
Toxics	Leukemia, aplastic anemia, multiple myeloma, cytogenic changes, damage to liver, lung, kidney, central nervous system, possible embryotoxicity, brain, liver and lung cancer, possible teratogenicity
Methane	Death, burns, dismemberment due to explosions and fires; property damage; contribution to phenomenon of global warming; MSW landfill emissions migrating through the soil on or near the landfill inhibits revegetation, causing deep root death
Odor	Odor nuisance, leading to annoyance, irritability, tension, reduction in outdoor activities, reduction in property values, decreased commercial investment leading to decreased sales, tax revenue

(Section 2.4); and 2) the accumulation of methane gas in structures both within and beyond the landfill boundary has resulted in explosions, fires, and subsequent loss of property (Section 2.5).

Pollutants that exert effects on human welfare are pollutants that affect the quality of life, cause damage to structures, or result in a loss of vegetation. The welfare effects of concern associated with MSW landfill air emissions include, in addition to destruction of property by explosions, emanation of odors and effects on soil and vegetation. Although odor perception is extremely variable and subjective, sociological studies have shown extreme annoyance and emotional disturbances in individuals residing in areas where objectionable odors are present. Property values may decrease and economic disadvantages may result in communities in or near a source of perceived malodorous emissions such as those from MSW landfills. Section 2.6 discusses odor generation by MSW landfills and some of the studies and surveys that have been done about the problem of odor nuisance. Also, revegetation of uncontrolled landfills after closure is often unsuccessful because the landfill gases affect plant root structure. This effect is discussed in Section 2.7.

## 2.2 EFFECTS ON HUMAN HEALTH AND VEGETATION CAUSED BY AMBIENT OZONE FORMED FROM NONMETHANE ORGANIC EMISSIONS

### 2.2.1 Health Effects Associated with Exposure to Ozone

Ozone and other oxidants found in ambient air are formed as the result of atmospheric physical and chemical processes involving two classes of precursor pollutants, NMOCs and nitrogen oxides ( $\text{NO}_x$ ). NMOCs are constituents of the air emissions from MSW landfills. Therefore, emissions of NMOCs from landfills also contribute to ozone formation. The effects of ozone on human health are well documented. There are several different mechanisms through which ozone can exert adverse effects on human health. Ozone can penetrate into different regions of the respiratory tract and be absorbed through the respiratory system. Indirect effects of ozone are those such as adverse effects on the pulmonary system resulting from chemical interactions of ozone as it progresses through the system. Finally there may be adverse effects on other body organs and tissues caused indirectly by reactions of ozone in the lungs.<sup>1</sup>

## 2.4 METHANE EMISSIONS CONTRIBUTING TO GLOBAL WARMING

Greenhouse gases serve to trap heat from the sun and maintain the earth's climate. Methane and other greenhouse gases such as carbon dioxide and nitrous oxide occur naturally in the atmosphere. They serve as a thermal blanket allowing solar radiation to pass through the atmosphere while absorbing some of the infrared radiation emitted back from the earth's surface. The absorption of radiation warms the atmosphere and provides the present climate. The earth would be approximately 30 degrees colder without the presence of greenhouse gases. The atmospheric temperature will increase if the concentrations of greenhouse gases are increased.<sup>55-57</sup>

Anaerobic decomposition of municipal solid waste in landfills results in the decomposition of municipal solid waste in landfills results in the generation of methane and carbon dioxide. An estimate of the amount of methane and carbon dioxide from MSW landfills is provided in Chapter 3. Methane is more potent than CO<sub>2</sub> due to its radiative characteristics and other effects methane has on atmosphere chemistry. Molecule-for-molecule methane traps 20-30 times more infrared energy in the atmosphere. Therefore even a small increase in the methane concentration in the atmosphere is a concern to scientists trying to predict the warming of the climate.<sup>58-60</sup>

There is considerable uncertainty with regard not only to the timing but also to the ultimate magnitude of any global warming. However, there is currently strong scientific agreement that the increasing emissions of greenhouse gases such as methane will lead to temperature increases. Within EPA and the international scientific community efforts are underway to reduce these uncertainties, estimate the cost of mitigation, and identify possible control options. Reduction of methane emissions from MSW landfills is one of many options available to reduce possible global warming.

## 2.5 EXPLOSION HAZARDS

### 2.5.1 Health Effects Associated with the Explosivity Of Municipal Solid Waste Landfill Air Emissions

Decomposition of the waste in MSW landfill air emissions produces the explosive methane gas. If the methane accumulates in structures on or off-site, explosions or fires can result. MSW landfill air emissions have