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| [Abstract](http://docs.google.com/abstract.html)  [Introduction](http://docs.google.com/intro.html)  [Hypothesis/Prediction](http://docs.google.com/hypo.html)  [Materials](http://docs.google.com/material.html)  [Protocol](http://docs.google.com/protocol.html)  [Literature Review](http://docs.google.com/lit.html)  [Data](http://docs.google.com/data.html)  [Statistical Analysis](http://docs.google.com/stats.html)  [Graphs](http://docs.google.com/graphs.html)  [Images](http://docs.google.com/images.html)  [Conclusion](http://docs.google.com/conc.html)  [Works Cited](http://docs.google.com/works.html)  [Recommendations](http://docs.google.com/recc.html)  [Acknowledgements](http://docs.google.com/ack.html)  [Biology Updates](http://docs.google.com/updates.html)  [Home](http://docs.google.com/home.html) | **Review of Literature**  On December 4, 1952, London, England, became known to have "Killer fog," also known as smog. During this winter, London residents burned excessive amounts of coal to keep their houses warm. As a result of stagnant air, lacking normal wind currents, and the household habits, a dense fog layered the city of London. A few days after this horizontal wall set �in; pollutants mixed with other pollutants forming hazardous fumes. Four days after the "killer fog" started, the pollution was blown out of place by a new weather pattern, but not before leaving four thousand dead and many others with associated illnesses. Scientists have stated that these deaths were directly associated with the chemical pollutants found in London�s thick "Killer Fog" (Luoma 19-22). Today, acid rain has attributed to 187, 686 deaths in the United States (Luoma 22). Although measures have been taken to reduce pollution, the environment still requires a natural defense to restore the delicate balance of the eco-system.  Acid rain, the silent killer, results from the emission of sulfur dioxides and nitrogen oxides into the atmosphere. Although the environment contributes to the problem, humans are responsible for 90% of the sulfur emissions and 95% of the nitrogen emissions (Environment Canada). Today, fuel combustion from cars and fossil fuel coal plants create a danger for the environment. As the sulfur dioxides and nitrogen oxides gather in the atmosphere, the gases form sulfuric acid and nitric acid, secondary pollutants. However, these two chemicals are hydrophilic (water soluble) and quickly bond with the cloud precipitation where the pollutants can travel miles before reaching the earth�s surface once again.  Uncontaminated precipitation tends to be slightly acidic ranging in pH between 5.6 and 5.7 (Boyle 17). The abbreviation "pH" stands for Potential of Hydrogen. Acids and bases are ranked on a scale of zero (most acidic) to fourteen (most basic), with the pH of seven considered neutral. The pH scale is logarithmic so water with a pH of 3 is ten times more acidic than water with a pH of 4. The average pH for acid rain is 4.4, but every year a pH of 2.8 or below is measured in the northeastern Appalachian Mountains (Boyle 18). Acid rain was measured in its highest levels in the United States in Wheeling, West Virginia in 1978. During a three day drizzle the United States EPA recorded pHs less than 2. In comparison, the pH for lemon juice is 2.1 and vinegar has a pH around 3. Despite the infrequency of these levels of acid rain it still remains an issue in the United States. The environment requires an ecological balance in which alkaline or basic chemicals found in ground cover, streams, and soils buffer the slightly acidic precipitation. A problem arises when the precipitation becomes too acidic and the environment runs out of its natural buffers; environmental destruction takes over. When water in lakes and streams becomes overly acidic, fish and sea-life begin to deplete, and in a forest soil begins to kill its newly formed vegetation. When the environment lacks balance the ecosystem becomes disrupted which in-turn may cause long term damage.  The government first acknowledged the serious repercussions of acid rain during the Reagan administration. In 1990, Congress passed the Clean Air Act Amendments in hopes to reduce the emissions of Sulfur dioxide and Nitrogen oxides into the atmosphere. Under Title IV of the amendments, Sulfur emissions were going to become governmentally regulated. The cap amount of Sulfur emissions released by electric companies was set at one-half of the actual amount emitted in 1980 (Resources for the Future). Despite the United States regulations, pollution knows no boundaries; both Canada and European countries are coming to this realization.  The term acid rain was first associated in Manchester, Britain, 100 years ago. Still today, Britain is plagued with the repercussions of acid rain in their forests and streams. Other European countries, such as Norway and Sweden, remain devastated from the damage acid rain continues to leave. In Sweden 4,000 lakes have completely lost their fish stock and in Norway approximately 60% of the lakes and streams are threatened to lose their fish stock (Environment Canada). Forests are affected by acid rain when nitric and sulfuric acids allow aluminum, found in soil, to become soluble. Aluminum in high concentrations becomes toxic to tree roots and impedes forest vegetation. Soil that has come in contact with high levels of acid rain generally becomes stripped of nutrients that are essential for plant growth. Farmer�s crops such as cabbage, alfalfa, soybeans, spinach and peas are sensitive to Sulfur Dioxide. When these plants, as well as other domesticated plants, come in contact with concentrated amounts of acid rain the cuticle (waxy protective coating) begins to deplete allowing the plant to become vulnerable and no longer able to photosynthesize or carry out transpiration in certain regions. In turn, these plants begin a slow dying process as food is produced in smaller quantities and nutrients are becoming scarce in the surrounding soils (EPA). Astonishingly enough, the trees that are most susceptible to acid rain damage are pine, aspen, and paper birch trees.  Scientists have developed a four-prong test to describe the acid-rain chain. First, pollutant gas must be present in the earth�s atmosphere. Second, certain weather patterns must exist to assist in the formulation of acid from the pollutant gas. Thirdly, there must be a weather system present that is capable of carrying the polluted precipitation miles before dispersing it over the fertile land. Lastly, the land receiving the acid rain must be what scientists call a, "sensitive receptor," or a piece of land susceptible to damage (Luoma 35). It is imperative to realize that our eco-system in order to maintain balance creates a recycling system, constantly retrieving new matter and redesposing it in other locations. The problem arises when the system is thrown out of balance, this occurs when too much of a solute or substance remains on land or in the atmosphere. Although a "climax" forest can take low levels of acid rain it cannot, however, maintain stability during long duration�s of highly acidic rain. Not only are certain habitats more susceptible to acid rain but entire states and regions as well. In the United States, the east coast and the Midwest tend to have higher frequencies of acid rainfall (see United States chart).  States with notable acid rain include: Massachusetts, Maine, West Virginia, New Jersey, Michigan, North Carolina, and Minnesota (Boyle 15). According to the 1983 Northeast Damage Report, "The probability of dying from air-pollution-related diseases is twice as high in the Northeast than in other regions of the United States."  In the past decade a company by the name of Phytotech Inc. located in Monmouth, New Jersey studied the ability for plants to act as a decontaminate. Two of their better-known studies dealt with sunflower plants and their ability to absorb uranium at the Chernobyl site in Russia and mustard seed plants and their ability to absorb toxic amounts of lead from the Magic Marker site in Trenton, New Jersey (Princeton Packet). The company is devoted to finding natural methods to deal with human pollution and contamination. Phytotech as well as numerous other companies are using small living microbes and plants to naturally develop a decontamination system opposed to the use of chemicals to buffer other toxic chemicals. In both cases the plant�s root system would absorb the contaminate up into the vascular tissue and into the stems and leaves of the plants, thus making it easier to discard the pollutants. After several harvests at the Magic Marker site, the lead concentration fell below the State mandate, thus making the site habitable by people and industries.  These findings lead to the idea of using highway durable grasses as a decontaminate for acid rain and other highway pollutants. Eventually the project was narrowed to just acid rain because cadmium, a highly toxic chemical found in car oil, was far too dangerous for controlled use. Aside from avoiding dangerous substances, it was necessary that the chemicals used be water-soluble. Solutes lacking water solubility would not be able to be absorbed into the root system of plant or grass.  As a result of the findings, Ryegrass was chosen for use in the research of natural acid rain decontamination in soil. Ryegrasses have numerous desirable characteristics. The grass itself grows rapidly and generally maintains a long growing season, allowing this experiment to be completed in the time frame given. Ryegrass is generally known to be a grass that prefers a wet, colder climate. Although the grass desires a well-drained soil, it unlike other grasses can tolerate excessively dry or wet conditions for short periods of time. Ryegrass is indigenous to Europe, Asia, and North Africa. In North America Ryegrass is used as a ground cover and farm grass mix because of its dense and long-lasting quality characteristics. Ryegrass should be planted between .25 and .5 inches below the soil surface. The choice of Ryegrass was mainly decided because of its pH preferences. Ryegrass best germinates and grows in an optimum pH between 6 and 7, or neutral. However, this grass has been effectively grown in a soil pH around 5. As stated earlier the environment tends to act as a buffer when dealing with acid rain. Therefore the pH of the precipitation may have been much more acidic than the pH of 5 seen in the soil. With this assumption an experiment using Ryegrass as a decontaminate for the soil is feasible.  The research project required creating an environment that lacked exchange of gas or any other substance or solute. Therefore, a biodome was created, limiting the number of lurking variables that may result if the project had been left unmonitored. According to the scientific method, the protocol must make an attempt to refute the hypothesis. The hypothesis for this research project stated, "Ryegrass is an effective decontaminate for soil that is inflicted with various pH levels of acid rain." Therefore the project needed to be designed at an extreme. If Ryegrass could handle strong undesirable levels of pH than it would be a safe assumption that at higher pH levels Ryegrass would maintain acting as a soil buffer protecting the nutrients from the acid releasing toxic levels of aluminum. |