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# The influences on leachate from landfill of incineration residuals by acid precipitation

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**Abstract**

Incineration of municipal solid wastes (MSW) is the main method of waste management in Taiwan. Although the incineration of MSW processes the solid wastes at 850–950 °C and destroys most of the organics, the content of incineration ashes is still a problem for landfill. Moreover, acid precipitation is much worse than before in Taiwan, especially in the northern areas. For instance, the occurrence probabilities of acid precipitation measured from 1991 to 1998 in Taipei increase from 73% to 85%. Therefore, it is more important to get a series of data that will help explore the influence of acid precipitation during disposal on characterization of pollutants than to analyze the ash properties after the incinerators have been constructed and regularly used.

In this investigation, the disposal site of incineration ashes is simulated in laboratory by test columns. An irrigation experiment is taken to simulate the acid precipitation at room temperature. In order to explore the exact influence on leachate quality of the main chemical composition of acid precipitation, columns are migrated with different concentrations of sulfate in acid precipitation. This investigation showed that the sulfate concentration of acid precipitation has an increasing effect on the accumulative release of heavy metals, such as Zn, Pb and Cu, from leachate. The sulfate concentration of acid precipitation, however, will not influence the trend of chemical oxygen demand (COD), biochemical oxygen demand ($BOD_5$) and total organic carbon (TOC) in the leachate release.


*Keywords:* Municipal solid wastes; Incineration ashes; Leachate; Acid precipitation

## 1. Introduction

Incineration of municipal solid waste is the principal waste management policy in areas such as Taiwan, which faces severe space constraints. People have been ignoring the influence of municipal solid waste incinerator and the problem of ash disposal. Consequently, misunderstanding the uses of the incinerator, residents in the neighborhoods where incinerators are to be built always fight against the government's policy. That is the subject we are concerned here, for municipal solid waste incinerators are being built and operated every year. In the neighboring Japan, most of municipal solid waste has been treated by way of incineration and construction of incineration ash landfills has been a common solution to the problem of incineration ash treatment. But the treatment process of wastewater from incineration ash landfills has always been based on data obtained from operating landfills other than those of any given ash landfill itself. Obviously, the above approach is inadequate when it comes to assessing the environmental problems involved with the impact of incineration ashes on landfills.

The major purpose of this investigation is to explore the possible influences of chemical composition of acid precipitation in landfills on leachate quality. According to data taken from the longitudinal analysis monitor station of Environmental Protection Administration in Taiwan, and owing to the facts of industrialization and long-range transport of acidic species from offshore areas, the occurrence probability of acid precipitation is still high in Taiwan. The occurrence probabilities of acid precipitation measured from 1991 to 1998 in Taipei increase from 73% to 85% [1,2]. Since a survey of the results from researches reveals that acid precipitation could affect the composition of soil, we infer that acid precipitation could probably also affect the release of pollutants from incineration ashes. We, therefore,

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must consider the impact of acid precipitation on the incineration ash landfill leachate when an incineration ash landfill is being constructed.

Owing to different viewpoints of researches, the information on the possible influences of chemical composition of acid precipitation in landfills on leachate quality is still inadequate. What has always been on our minds is that if this investigation can obtain the related data by lysimeters test and batch experiment, it will be the first serial systemized observations on the influences of acid precipitation in landfills on pollutant leaching. The above process is aimed to obtain the leaching quantity of both the organic materials and the inorganic materials in the ashes; it is also designed to explore the characteristics of migration distribution applicable in describing the leaching potential of pollutants in landfills containing incineration residuals.

Aside from the general properties of incineration ashes exploring the relation between air pollution and the pH of rainfall and investigating the pH and composition of rainfall constantly for the weather station of Taipei (Lu et al. [3]), this investigation tries to establish a local research on the influence of pollutants from landfill of incineration ashes by acid precipitation. Although the reaction mechanism of the pollutant has not been explored, the data of acid precipitation can also be served as reference. Calvert et al. [4] points out that the reaction mechanism of sulfate and nitrate includes homogeneous reactions, the phenomena of which change from gas to liquid. Meanwhile, heterogeneous reaction occurs on particulate matter such as dust or water drops. This investigation evaluates the reaction mechanism of sulfate and nitrate from acid precipitation and tries to describe the phenomena of acid precipitation in the industrialized regions. Owing to the fact that the pH value always responds to the solubility of $CO_2$, Seinfeld [5] solves the pH value of rain at natural temperature that derives from the solubility of $CO_2$ at saturation. This research provides a simple index to determine the occurrence probability of acid precipitation based on the pH value of rainfall. But the characteristic of composition of acid precipitation is not completed. The formation of acid precipitation is relevant to chemical and physical reactions of pollutants in the atmosphere. Chen and Qiu [6] describes the process of acid precipitation generated by pollutants, such as transport, diffusion, transformation, adsorption, deposition and removal in the atmosphere. Chen [7] notes that the composition of acid precipitation is influenced by changes of the seasons. Meanwhile, the trend of acidic and alkaline materials like $SO_4^{2-}$, $H^+$, $Ca^{2+}$, $NH_4^+$, $Na^+$, $Mg^{2+}$ and $Cl^-$ fits the trend of changes in the seasons. Lin and Chen [8] mentions that the rainfall in spring and the frontal rainfall in winter are the most acidic. Chang and Lin [9] employs the ISCST3 (Industrial Source Complex Short-Term, 1995) model to simulate the process involved in transport, diffusion, transformation, adsorption and deposition of pollutants in Taoyuan area to assess the relation between the pollutant and the acceptor.

Researches [10–13] on the characteristics of incineration ashes have been widely disseminated, but most of the analyzes have been limited to the inorganic properties of incineration ashes. Furthermore, difficulties in controlling experimental conditions hamper the accuracy of the results. Consequently, the approach adopted above is inadequate when it comes to assessing the environmental problems concerning the impact of incineration ashes on landfills.

The characteristics of landfill leachate have been widely modeled. A survey of the results from the papers listed below has inspired the development of models to describe the phenomena of landfill leachate. Examining the characteristics of leachate from a landfill containing incinerator ashes, Kenneth et al. [14] simulates the leachate quality of a 25-year-old landfill in laboratory and compares it with that of a sanitary municipal solid waste landfill. The pH value of leachate from the municipal solid waste incineration ash landfill is 10.2–10.6, higher than that from the municipal solid waste landfill. Since the leachate quality of the high alkaline ash landfill cannot be neutralized by acid precipitation, it remains highly alkaline. Moreover, the values of TOC, COD and $BOD_5$ of the municipal solid waste incineration ash landfill are lower than those of the samples from the municipal solid waste landfill. Therefore, the organic content of the leachate from municipal solid waste incineration ashes is pretty low. The leachate from the municipal solid waste incineration ash landfill contains high levels of salts, such as $K^+$, $Na^+$, $Ca^{2+}$, and $Cl^-$, just like what are found in the municipal solid waste landfill. Chen and Yang [15] employs ten lysimeters to simulate the leachate from the landfill. The quantity of leachate decreases with increased addition of rainfall, while it increases with greater burial depth. The pH is around 6–8 and remains uninfluenced by rainfall intensity. The chloride level of the leachate, nonetheless, increases with greater burial depth, while the COD level of the leachate decreases with lower burial depth. Chow and Gau [16] notes that bottom ash of municipal solid waste is highly alkaline. Unlike the change of chloride, the pH and COD are stable at burial depths between 120 cm and 180 cm. In other words, given the burial depth of 180 cm, incineration ashes display adsorbability.

The fact that the presence of acid precipitation has become more frequent, the leaching characteristics of leachate in landfill containing incineration residuals related to acid precipitation is now available to be observed. In this sense, this investigation also serves to describe the influences of acid precipitation at a landfill site.

## 2. Experimental methods

The test materials, that is, the bottom ashes, are sampled from the municipal solid waste incinerators. Five laboratory scale lysimeters are designed to simulate the disposal site of incineration ashes in the laboratory. Before the test materials are placed into the lysimeters, the moisture of test materials is modified with distilled water to the original value, 23 wt.%, and the top of the lysimeter is covered with a 15 cm layer of soil sampled from landfills site of municipal solid waste.

The experiment consists of lysimeters test and extraction experiment. The lysimeters test focuses on explorations of the influence of acid precipitation and burial condition. The lysimeters are irrigated with simulated acid precipitation. Given the fact that the composition of acid precipitation in Taiwan (Chang