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LAND FARMING OF WATER PLANT ALUM SLUDGE ON ACID MINERAL SOIL AFFECTED BY ACID WATER

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Abstract

An acid forest surface soil as a land farming medium was treated with a water plant alum sludge at 0 to 18%. Indian mustard was grown in the treated soil in a greenhouse for 5 weeks and watered with pH 4 tap water adjusted with a mixed acid ($1HNO_3$: $2H_2SO_4$) during plant growth. Changes in soil property, leachate chemistry, plant growth, and plant uptake of elements by the sludge treatment were determined. The alum sludge treatment increased buffer capacity to acidity, hydraulic conductivity, water holding capacity, and phosphate adsorption of the soil and decreased bulk density and mobility of small particles. The sludge treatment reduced leaching of Al, Mg, K, Na, and Mn but increased leaching of Ca. The sludge treatment also increased biomass and root elongation. Plant did uptake less amount of the cations and P but more Ca with the sludge treatment.

Key Words: Soil property, P adsorption, leachate chemistry, plant growth.

I .Introduction

Historically, water plant sludge has been discharged to the raw source, stored in lagoons on-site, or discharged to the sewer in Korea. However, increasingly stringent regulatory environment is making it difficult for utilities to continue these practices. Landfill of the sludge has been adapted recently as a disposal method. However, it contributes a significant portion of the cost for tap water supply. Land farming of the sludge as a cost-effective alternative disposal method attracts the interest of environmental engineers and scientists.

Water plant sludge is composed of materials such as clays, organic materials, and products of chemical coagulation (Wang et al., 1992). The most common coagulant in Korea is alum [$Al_2(SO_4)_3 14H_2O$]. Aluminum (Al) in the sludge is predominantly amorphous $Al(OH)_3$, which is more reactive than Al in soils (Elliott et al., 1990). When an Al salt is added to water, the Al^{+3} hydrolysis with water producing H^+ as shown below: $Al^{+3} + 3H_2O = Al(OH)_3 + 3H^+$.

The produced acidity is neutralized generally by the addition of lime. Potential detrimental effects of alum sludge in soils are toxicity to plants and fixation of phosphorus (P) (Grabarek and Krug, 1987).

Acid rain (pH < 5.6) is a well-known world wide environmental problem. Low soil pH due to acid rain can increase dissolved Al and cause leaching of base nutrient cations (Cronan and Grigal, 1995). Aluminum toxicity has been identified as one of the most important factors limiting plant growth in acidic soils. An early and dramatic symptom of Al phytotoxicity is inhibition of root growth (Ryan et al., 1992). Adams and Lund (1966) and Alva et al. (1986) showed a negative relationship between concentration of total soluble Al^{+3} in soil and root elongation.

Aluminum hydroxide has been identified as a strong phosphate adsorbent in soils and sediments (Sanyal and DeDatta, 1991). Aluminum ion also precipitates a number of insoluble phosphate minerals such as variscite ($AlPO_4 2H_2O$), taranakite [$H_6K_3Al_5(PO_4)_8 18H_2O$], and berlinite ($AlPO_4$) and they are considered to be the potential controllers of phosphate solubility in acidic soils (Lindsay, 1979). Phosphorus fixation of calcareous soils has been known in agriculture. In calcareous soils, phosphate is adsorbed on calcium carbonate and precipitated as calcium phosphate minerals (Hamad et al., 1992). Elliott and Dempsey (1991) showed that the soils treated with the alum sludge needed supplemental P fertilization.

Land farming of sewage sludge is one of major disposal techniques since it supplies nutrients such as nitrogen (N), phosphorus (P), and potassium (K) that are valuable in agricultural production. Land farming of water plant alum sludge, which has generally little fertilizer value, modifies soil properties such as soil structure and pH (Elliott and Dempsey, 1991; Rengasamy et al., 1980). According to Rengasamy et al. (1980), the addition of water treatment alum sludge improved soil structure favorable to plant growth. Application of lime-softening sludge to acid soils neutralized their acidity (Elliott and Dempsey, 1991).

More than 80% of Korean soils are acidic (NIAST, 2000). Unpublished data of Korea Basic Science Institute (KBSI) shows that annual average pH value of rainfall in Cheju island, Korea, where is influenced by southeastern industrial area of China, is about 4 and some industrial areas of Korea frequently record the pH value of rainfall below 4.0. The objective of this study was to examine the changes in soil properties and plant growth when a water plant alum sludge was land-farmed under an extreme condition e.g., land farming on an acid forest mineral soil and receiving an artificial acid rain water.

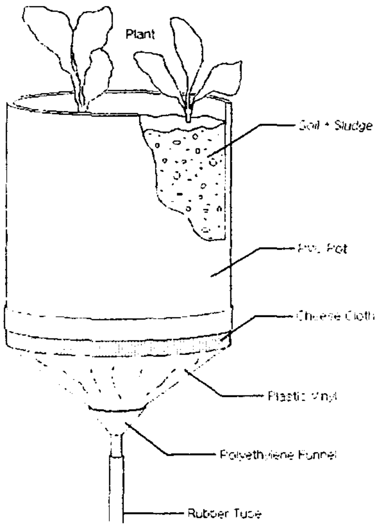
II. MATERIALS AND METHODS

Sampling and analysis of sludge and soil

A water plant alum sludge was collected from Ilsan water clarification plant near

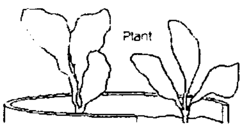
Seoul, Korea. The alum sludge was generated after coagulation process using alum and lime. An acid forest surface soil [Osan sany clay loam soil (Typic Dystrudepts)] was collected as the land farming medium of the alum sludge. All tests except XRD analysis were conducted with duplicate samples.

Greenhouse experiment

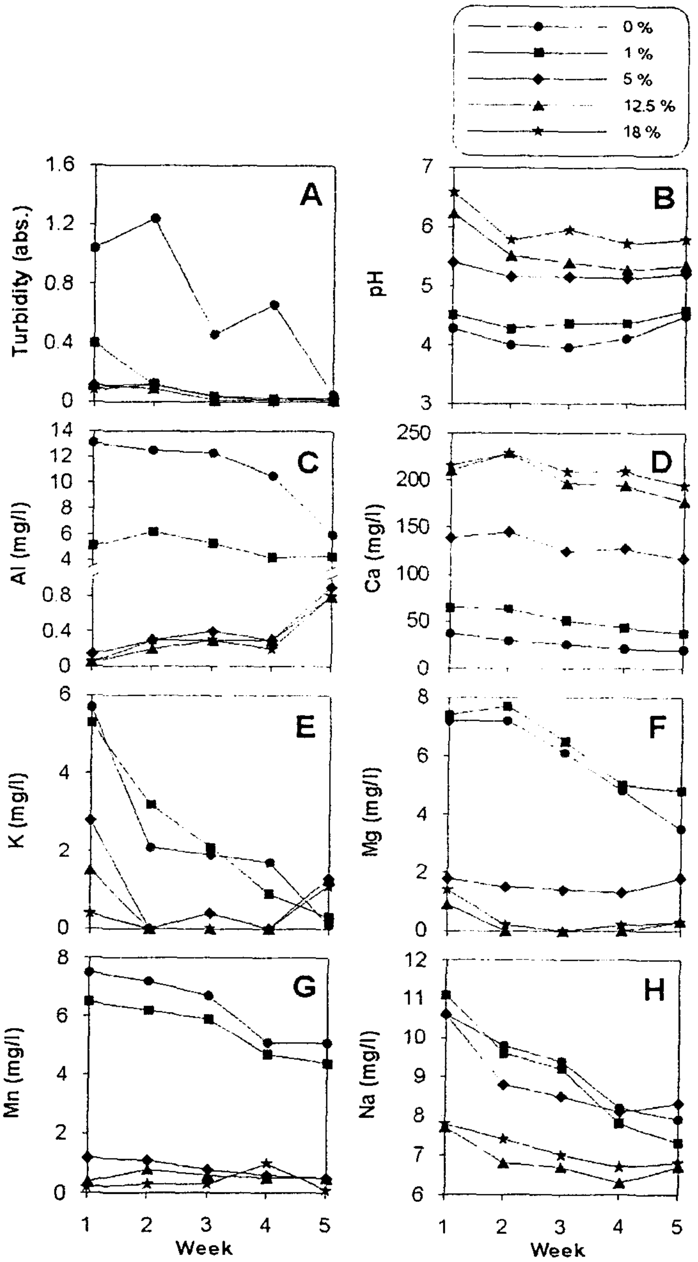


The moist alum sludge and soil without dry and addition of any nutrients were thoroughly mixed at 0 to 18% of sludge. Strait lined PVC pot with 20 cm in diameter and 25 cm in height was filled with 8.0 kg of the mixture (Fig. 1).

Leaf and root were carefully collected from the pots to minimize damage of plant tissue after 5 weeks growth. Before dry, root was washed with distilled water and was scanned with a drum scanner for black and white image. The scanned image was analyzed with PC computer program WinRHIZO (Regent Instruments Inc., Quebec, Canada) for root length. The other analysis and test were conducted with duplicate samples.



Ⅲ.RESULTS AND DISCUSSION



Ⅳ. CONCLUSION

Treatment of the acid forest mineral soil with the water plant alum sludge decreased the bulk density and increased the hydraulic conductivity and water holding capacity. The treatment neutralized acidity of soil and irrigated water and reduced Al toxicity at high rate (> 5%). It also reduced leaching of Mg, K, Na, Al, Mn, and Fe from the soil but it increased leaching of Ca. The treatment may need supplemental P fertilization indicated by the increased P adsorption capacity. It increased the growth of indian mustard e.g., the weight of leaf and root and the root elongation. In this short term experiment, land farming of the water plant alum sludge on the acid soil turned out to be safe and beneficial to plant growth even though irrigating with an acidic water. However, long term effect of the land farming of the alum sludge on plant growth is still in question and a long term experiment may be needed in the future.