UNIVERSITI PUTRA MALAYSIA

# CHARACTERIZATION OF ACID DEPOSITION AT PASOH FOREST RESERVE AND SEPANG FIRE-PEAT SWAMP

TAY AI CHEN

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# CHARACTERIZATION OF ACID DEPOSITION AT PASOH FOREST RESERVE AND SEPANG FIRE-PEAT SWAMP

By

**TAY AI CHEN**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia**
**in Fulfilment of the Requirements for the Degree of Master**

**September 2002**

# DEDICATION

This thesis is especially dedicated to my family and friends who have been giving me lots of support and encouragement as well as advice in my studies.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment
of the requirements for the degree of Master of Science

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**Chairman:** **Dr. Ahmad Makmom Abdullah**

**Faculty:** **Science and Environmental Studies**

Pasoh Forest Reserve is located away from industrialized or urbanized areas. As a remote area, therefore Pasoh Forest Reserve is important to provide baseline information on the level of soil acidification in Malaysia. Furthermore, studies on the natural fires soil such as Sepang fire-peat are rare in Malaysia. The investigation of natural fires soil is essential for comparison purposes to Pasoh Forest Reserve. Hence, the objective of the study was to determine the physico-chemical properties of soils at Pasoh Forest Reserve and Sepang fire-peat swamp for evaluating the extent of acid deposition. Six subplots with dimension of 1 m x 1 m x 1 m were selected at the Pasoh Forest Reserve, while, only one plot with dimension of 1 m x 1 m x 1m was dug at the Sepang fire-peat swamp. Soil samples were taken from every 10 cm layer until 1 m depth. For each soil sample, acidity (pH), moisture content, bulk density, electrical conductivity, available phosphate ($PO_4^{2-}$), available sulphate ($SO_4^{2-}$), exchangeable acidity, exchangeable Al and H, exchangeable base cations, effective cation exchangeable capacity (ECEC) and base saturation were determined. At top part of soil profile at Pasoh Forest Reserve, there was an *A* horizon, characterized by dark brown colour as a result of an accumulation of humified organic matter intimately mixed with mineral matter. Below the *A* horizon, there was an *E* horizon, which was lighter in colour and texture. Below the E horizon, there was an *EB* horizon, which was dominated by the properties of *E* master horizon but with some properties of *B* master horizon. The *B* horizon was granular, blocky, or prismatic structure. The Pasoh Forest Reserve soils are clayey and acidic. The natural soil fires at Sepang caused destruction of soil structure as well as its texture, thus no clear horizon could be observed and the soil was sandy. Throughout 1 m soil depth, Pasoh Forest Reserve and Sepang fire-peat soils showed variation of soil properties. The results indicated that Pasoh Forest Reserve soils were more acidic than Sepang fire-peat soils. By comparing to the Pasoh Forest Reserve soils, the Sepang fire-peat soils showed lower mean values in bulk density and exchangeable acidity, but higher mean values in electrical conductivity, pH, base saturation, available sulphate and available phosphate. Sepang fire-peat soils were also showed relatively high values in exchangeable Mg and Ca, but low values in exchangeable K and Na. Furthermore, mean base saturation values of Sepang fire-peat soils and Pasoh Forest Reserve soils were 97.87 ± 2.42% and 78.77 ± 3.78%, respectively. The base saturation of Pasoh Forest Reserve soil was strongly correlated with the exchangeable Ca, whereas the base saturation of Sepang fire-peat soil was strongly correlated with exchangeable acidity. The significant differences between Pasoh Forest Reserve and Sepang fire-peat soils were attributable to changes of soil composition after soil fires in Sepang causing mineral transformation. However, the physico-chemical properties of Pasoh Forest Reserve soils were similar to the previous findings by the Allbrook (1973) and Yoda (1978). Thus, the Pasoh Forest Reserve soils were presumably not unaffected by acid deposition. Additionally, there was no appreciable soil acidification occurred in the Pasoh Forest Reserve since 1973 (29 years).

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

# PENCIRIAN LONGGOKAN ASID DI HUTAN SIMPANAN PASOH DAN PAYA GAMBUT TERBAKAR SEPANG

Oleh

**Tay Ai Chen**

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**Pengerusi:** **Dr. Ahmad Makmom Abdullah**

**Fakulti:** **Sains dan Pengajian Alam Sekitar**

Hutan Simpanan Pasoh terletak jauh dari kawasan industri dan bandar. Sebagai kawasan terpencil, Hutan tersebut adalah penting untuk memberikan maklumat asas berkaitan tahap keasidan tanah di Malaysia. Tambahan pula, kajian-kajian tentang tanah terbakar semulajadi seperti gambut terbakar Sepang adalah kurang di Malaysia. Penyelidikan tentang tanah terbakar semulajadi adalah mustahak sebagai tujuan perbandingan dengan Hutan Simpanan Pasoh. Maka, objektif kajian ini adalah untuk menentukan ciri-ciri fizikal and kimia tanah Hutan Simpanan Pasoh dan tanah gambut terbakar Sepang untuk menilai tahap longgokan asid. Enam subplot dengan dimensi 1 m x 1 m x 1 m telah dipilih di Hutan Simpanan Pasoh, manakala, hanya satu plot dengan dimensi 1 m x 1 m x 1m telah digali di paya gambut terbakar Sepang. Sampel tanah telah diambil dari setiap lapisan 10 cm sehingga kedalaman 1 m. Bagi setiap sampel tanah, keasidan (pH), kandungan air, ketumpatan pukal, kekonduksian elektrik, ion fosfat ($PO_4^{2-}$), ion sulfat ($SO_4^{2-}$), keasidan bolehtukar, Al dan H bolehtukar, kation bes bolehtukar, kapasiti kation bolehtukar berkesan (ECEC) dan ketepuan bes telah ditentukan. Bahagian atas profil tanah di Hutan Simpanan Pasoh, terdapat A horizon, berwarna perang gelap yang disebabkan oleh timbunan bahan organik basah bercampur dengan bahan mineral. Di bawah A horizon, terdapat

E horizon, yang terang dari segi warna dan tekstur. Di bawah E horizon, terdapat EB horizon, yang dipengaruhi oleh sifat E master horizon dengan sedikit sifat B master horizon. B horizon adalah struktur yang kasar, berbatu, atau dinamik. Tanah Hutan Simpanan Pasoh adalah bersifat liat dan asid. Pembakaran semulajadi tanah di Sepang menyebabkan kemusnahan struktur tanah dan teksturnya, maka horizon tidak jelas kelihatan dan tanah adalah berpasir. Sepanjang kedalaman 1 m tanah, Hutan Simpanan Pasoh dan paya gambut terbakar Sepang menunjukkan kepelbagaian ciri-ciri tanah. Keputusan menunjukkan tanah Hutan Simpanan Pasoh adalah lebih asid daripada tanah gambut terbakar Sepang. Berbanding dengan tanah Hutan Simpanan Pasoh, tanah gambut terbakar Sepang menunjukkan nilai purata ketumpatan pukal dan keasidan bolehtukar lebih rendah, tetapi nilai purata kekonduksian elektrik, pH, ketepuan bes, ion sulfat dan ion fosfat lebih tinggi. Tanah gambut terbakar Sepang mengandungi nilai Mg dan Ca bolehtukar yang tinggi, tetapi nilai K dan Na bolehtukar yang rendah. Tambahan pula, nilai purata ketepuan bes di tanah gambut terbakar Sepang adalah 97.87 ± 2.42% dan tanah Hutan Simpanan Pasoh adalah 78.77 ± 3.78%. Ketepuan bes di tanah Hutan Simpanan Pasoh adalah berkorelasi baik dengan Ca bolehtukar, manakala ketepuan bes di tanah gambut terbakar Sepang berkolerasi baik dengan keasidan bolehtukar. Perbezaan bermakna antara tanah Hutan Simpanan Pasoh dan tanah gambut terbakar Sepang adalah disebabkan perubahan komposisi tanah setelah pembakaran tanah di Sepang mengakibatkan transformasi mineral. Walau bagaimanapun, ciri fizikal dan kimia bagi tanah Hutan Simpanan Pasoh adalah sama dengan keputusan penyelidikan yang dijalankan oleh Allbrook (1973) dan Yoda (1978). Oleh sebab itu, tanah Pasoh boleh dianggap tidak dipengaruhi oleh longgokan asid. Di samping itu, tiada keasidan tanah berlaku di Hutan Simpanan Pasoh sejak 1973 (29 tahun).

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| | |
|---|---|
| Acid Deposition Monitoring Network in East Asia | EANET |
| Acid neutralization capacity | ANC |
| Atomic Absorption | AA |
| Atomic Absorption Spectrophotometer | AAS |
| Base saturation | BS |
| British Standards Institute | BSI |
| Bulk density | $\rho_b$ |
| Cation exchange capacity | CEC |
| Cation-exchange capacities | CECs |
| Dissolved oxygen | DO |
| Effective cation exchangeable capacity | ECEC |
| Electrical conductivity | EC |
| German Standards | DIN |
| High Volume Sampler | HVS |
| International Soil Science Society | ISSS |
| London Chamber of Commerce and Industry Examination Board | LCCI |
| Malaysian Rice | MR |
| Malaysian Science and Technology Congress | MSTC |
| Massachusetts Institute of Technology | MIT |
| Moisture correction factor | mcf |
| Natural Resources and Environmental Management | NREM |
| Soil organic matter | SOM |
| Total acidity | TA |
| U.S. Department of Agriculture | USDA |
| U.S. Public Roads Administration | USPRA |

# CHAPTER I

# INTRODUCTION

Acid deposition has been recognized as a complex scientific problem causing the decline in forest growth and deterioration of fish populations in acidified lakes. The international aspects of acidification are obvious. In most countries, the share of emissions from neighbouring countries in the total deposition is significant. Not only in small countries, but also in large countries with relatively low emissions, a high percentage of the acid deposition can be traced to foreign origin (Alders, 1992). Hence, a large number of specialist fields are involved and international co-operation is also needed in this scientific research (Alders, 1992).

Nearly two decades ago, the Swedish Report to the United Nations forecast forest growth declined of approximately 1.5% per year was caused by acid deposition (Johnson et al., 1992). However, forest declines as the result of soil acidification and nutrient deficiency are concerned until now. Acid Deposition Monitoring Network in East Asia (EANET) has been started in 1998 for soil and vegetation in the participating countries of EANET. East Asian countries have experienced rapid economic growth and industrialization in recent 20 years (Lu, 1999). However the environmental pollution, especially the air pollution and acid rain, is going to be more serious in East Asian region (Lu, 1999). A workshop on Ecological Impact Monitoring of Acid Deposition in East Asia had been held in 1999 and attended by the EANET participating countries (EANET, 1999). The matters discussed were:

(i) the technical information on soil and vegetation survey for the participating countries of EANET,

(ii) the methodologies on soil and vegetation survey and its quality assurance or quality control activities suitable for East Asia and

(iii) the ways for considering the monitoring guidelines and technical manual, and reviewing the quality assurance or quality control program for soil and vegetation monitoring.

The programs that have been carried out by EANET include inter-laboratory comparison, collaboration with other international organizations as well as soil and vegetation monitoring training. It is important because these programs needed to get a comprehensive and systematic manner in monitoring the acid deposition through establishment of good quality database. Furthermore, acid deposition is one of our serious international environmental issues, which requires international cooperation for solution at this moment.

The term "acid deposition" is often used as a synonym for "acid rain" or "acid precipitation" (Schlaepfer, 1992). In more specific manner, the term "acid deposition" can be defined as the input of all components into an ecosystem, which determine the net proton flux in the system. Acid rain in this context is only a part of acid deposition. For determination of total acidity input, the interception of sulphur and nitrogen containing particles as well as the dry deposition of nitrogen dioxide, nitric acid, sulphur dioxide and ammonia have to be concluded. Several processes can result in the formation of acid deposition. Most wet acid deposition forms when nitrogen oxides ($NO_x$) and sulphur dioxide ($SO_2$) are converted to nitric acid ($HNO_3$)

and sulfuric acid ($H_2SO_4$) respectively through oxidation and dissolution. Moreover, ammonia gas ($NH_3$) from natural sources can be converted into ammonium ($NH_4$) to form wet deposition.

Dry deposition may be broadly defined as the transport of particulate and gaseous contaminants from the atmosphere onto surface in the absence of precipitation (Davidson and Wu, 1990). It is worthwhile to consider dry deposition as part of an overall atmosphere-surface change. Gases are sometimes reversibly absorbed onto surfaces only to be reemitted, whereas particles may be deposited and subsequently resuspended (Davidson and Wu, 1990). Accidental exposure to acidic aerosols is a well-recognized hazard (Wellburn, 1993). An aerosol is defined as a suspension of solid or liquid in a gaseous medium (Lipfert, 1991). Acid particles include sulphuric acid, ammonium biosulfate ($NH_4HSO_4$) and certain organic compounds (Lipfert, 1991). Aerosols induce irritations and pulmonary disturbances. The main differences arise from the size of the aerosols droplets. Droplets sizes of 0.8 μm or less are the most harmful. In other words, more lung damage is caused by a lesser amount of acidity if it is more finely divided.

Wet deposition is better described as 'wet precipitation', which, because it is an intermittent event, means that the effects of acidic precipitation are experienced irregularly (Wellburn, 1993). The formation of droplets in clouds, which then removes atmospheric pollutants as it falls as rain-out, is very efficient process.

Acid deposition is defined as the sum of dry deposited sulphur dioxide ($SO_2$) and the wet deposition of strong acid (proton, $H^+$), as these are the most important acidifying components. Dry deposition of gaseous nitric acid ($HNO_3$), hydrochloric acid, sulphuric acid ($H_2SO_4$) or organic acids are not taken into consideration, since these compounds are found at very low concentration levels in the rural area (Hovmand and Bille-Hansen, 1999).

Concern for acidic deposition in North America evolved in the early 1970s to become the major environmental issue of the 1980s. As in Europe, early issues of air pollution in North America dealt with the elimination of black smoke from home chimneys and factories in primarily urban or heavily industrialized settings. With the Scandinavian studies of the 1950s and 1960s, increasing evidence pointed to acidic precipitation as a key factor in the deterioration of fisheries in remote lakes. Sulphate and nitrate from air pollution were blamed for the rainfall's acidity. The pollution in Scandinavia was thought to be from distant sources. In short, the concern for local air quality rapidly evolved into international debates of one country's air pollution affecting other countries downwind (Ellis et al., 1990).

For several decades, Canadian scientists have been aware of the environmental damage to terrestrial and aquatic systems that can result from $SO_2$ emissions from point sources. In fact, the first reported case was a transboundary pollution problem. Sulphur dioxide emissions from a smelter located in Trail, British Columbia, caused environmental damage to areas across the border in the state of Washington (Keith and Dillon, 1990).

Nitrogen oxides ($NO_x$) and sulphur dioxide ($SO_2$) released into the atmosphere from a variety of sources fall to the ground simply as dry deposition.