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# ANALYSIS OF WET ACIDIC DEPOSITION IN PETALING JAYA

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## ABSTRACT

Ten year (1982-91) wet fallout data published by Malaysian Meteorological Services has been analyzed to find the trend and nature of acidic deposition in Petaling Jaya. The pH of rainwater shows a downward trend, indicating gradual increase of acidity with time. Seasonal variation of pH and ionic concentration of $SO4^{--}$, $NH4^{+}$ and $Ca^{++}$ in rainwater shows that $SO4^{--}$ is the main source of free acidity in the wet deposition, while $Ca^{++}$ and $NH4^{+}$ ions act to neutralize the free acidity.

## INTRODUCTION

Wet acidic deposition is an environmental problem associated with air pollution. Acidification of rain water has caused serious environmental problems in North America, Europe as well as in China. The acidification of watershed areas, forest damage and destruction of aquatic life are some of the problems associated with acid rain. Gaseous air pollutants of natural and anthropogenic origins undergo through a complex transformation processes before ultimately deposited back to earth surfaces in the form of dry or wet fallout deposition.

In Malaysia due to heavy annual rainfall, wet deposition of pollutants is significant. The pollutants are captured from atmosphere by in-cloud and below-cloud mechanisms and fall down as dissolved ionic compounds in rainwater. The wet deposition data could reveal the extent of an air pollution problem in a given region.

The pH level indicates the degree of acidification of rainwater. However, pH of a natural rainwater is slightly acidic due to the presence of dissolved $CO_2$ gas. A low pH of less than 4.6 is considered to be highly acidic [2]. The deposition of anions and cations (besides pH) having acidifying and neutralizing effects must also be taken into consideration when analyzing deposition data in order to understand the whole process of acidification and neutralization of rainwater in the atmosphere.

This paper presents the results of a preliminary analysis of the wet fallout data collected from 1982 to 1991 in Petaling Jaya. The objective was to examine the trends in the variations of pH and ionic concentrations and to provide possible explanations thereof.

## MATERIALS AND METHODS

### Source And Analysis of Data

Malaysian Meteorological Service (MMS) has been monitoring dry and wet fallout through out Peninsular Malaysia since 1977. The published data on wet fallout deposition for Petaling Jaya from 1982 to 1991 were analyzed in this study. The concentration of anions and cations along with the amount rainfall based on a monthly basis were studied. The sample was collected by the MMS using Automatic Dry and Wet Fallout Collector and was analyzed by the Department of Chemistry [1].

In this study , the dataset was converted into equivalent weight basis from mass basis to take into account the molar interrelationship of ions . The monthly and yearly average fallout of different anions and cations and pH was calculated. The averaging of pH was done by converting pH into equivalent $H^+$ ion [2]. The effect of rain fall intensity has been minimized by taking rain fall weighted average.

**Site Description**

Petaling Jaya is located in Klang Valley Region (KVR). It is the major industrial area in Malaysia and is situated 10 km Southwest of the Federal capital Kuala Lumpur which is the most urbanized location of the country (Fig. 1). Due to the unified geography of the region, wet fallout in Petaling Jaya can be considered as representative of the whole Klang valley.

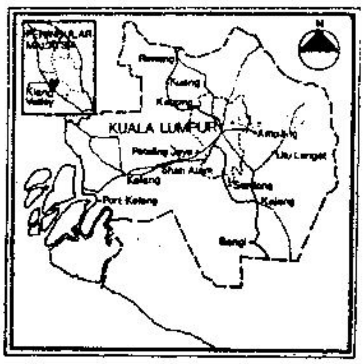


Fig. 1 Sampling Site Location

## RESULTS AND DISCUSSION

**General Observations**

Table 1 presents the mean, standard deviation and ranges of pH and ions related to acidic deposition ( $SO_4^{--}$, $NO_3^-$ ) and neutralizing process in the atmosphere ( $Ca^{++}$, $NH4^+$) .

The average rain water pH of the ten years is 4.65±0.367 (± standard deviation). The value is slightly above the high acid rain level of pH 4.6. However in the last five years , 68% of all the monthly observations (41 out of 60 months) show pH lower than 4.6.

The 25th, 75th percentile and median of data is shown in the Box Whisker plot in Fig. 2. The data shows considerable bias above the median value probably due to fluctuations in emission level during the decade.

Table 2 lists the results of some similar studies done in other parts of the world. The $SO4^{--}$ and $NO3^{-}$ level in Petaling Jaya wet fallout is low compared to that of China, Japan and Taiwan and is comparable to Northwestern United States. However the pH level is comparable to that of Japan, Taiwan and Northwest and West-midwest of United States.

Table 1 Mean, Standard deviation, ranges of pH, anions and cations in wet deposition at Petaling Jaya on monthly basis (1982-91).

| Parameter | Mean | Std. dev. | Range |
|---|---|---|---|
| pH | 4.65 | 0.37 | 4.05 - 6.3 |
| $SO4^{--}$ (µ eq $L^{-1}$) | 8.05 | 5.39 | 1.04 - 46.2 |
| $NO_3^{-}$ (µ eqL-1) | 6.47 | 5.65 | 0.32 - 25.6 |
| $NH_4^{+}$ (µ eqL-1) | 15.8 | 11.0 | 0 - 66.7 |
| $Ca^{++}$ (µ eqL-1) | 8.52 | 5.17 | 1 - 27.5 |

Table 2 Comparison of wet acidic deposition in some selected locations. [3,4]

| Site | pH | $SO_4^{--}$ | $NO_3^{-}$ | $NH4^{+}$ | $Ca^{++}$ |
|---|---|---|---|---|---|
| Petaling Jaya | 4.65 | 8.05 | 6.47 | 15.85 | 8.52 |
| Japan | 4.7 | 26.4 | 18.7 | 26.6 | 18.5 |
| China | | | | | |
| Acidrain area | 4.1-4.9 | 56.2-198 | 16-32.2 | 50-105 | 2.5-115 |
| Non acidrain area | 6.3-6.7 | 81.2-167 | 29-80.6 | 127.7-222 | 142-380 |
| Taiwan | 4.91 | 57.6 | 11.5 | 35.9 | 64.5 |
| England | 4.5 | 89.6 | 35.5 | 29.5 | 29.8 |
| Hungary | 4.7 | 9.6 | 13.5 | 77.7 | 22.0 |
| United States | | | | | |
| North-West | 5.1-5.2 | 5.5-13.88 | 1.6-3.2 | 1.11-2.22 | 5-17.5 |
| West-midwest | 5-5.1 | 27.7-41.6 | 14.5-30.6 | 11.11-38.88 | 5-17.5 |
| North-East | 4.1-4.2 | 3.3-111 | 30.6-35.4 | 16.6-22.22 | 5-7.5 |

**Seasonal Trends**

Seasonal trends of wet deposition are described by monthly mean variations of pH and ions in rain water throughout the years. A plot of monthly mean pH along with $SO4^{--}$ and $Ca^{++}$ is presented in Fig. 3 and Fig. 4. pH was low during inter-monsoon season of April-May probably due to mixing and turbulence caused by occasional thunder storms. During this period the concentration of $SO_4^{--}$ was also high. $Ca^{++}$ concentration in rain water was high during Northeast monsoon period (January-March) because of wind carrying soil dust from the inland.

Generally the increase of $SO4^{--}$ in rainwater caused a decrease in pH, and an increase of $Ca^{++}$ ion in rainwater resulted in an increase of pH. This may be attributed to the acidifying effect of $H^+$ ions accompanying the $SO_4^{--}$ ions and neutralizing effect of the $Ca^{++}$ ions. However there were some exceptions which can be explained. From April to May, pH decreased even though there was a simultaneous decrease of $SO4^{--}$. This may have been caused by the increasing role of HNO3 in acidification as indicated by the yearly peak of $NO3^-$ in rain water(8.72 μeq $L^{-1}$) during that period.

**Annual Trends**

The annual trends in pH of rainwater and $SO4^{--}$ and $NH4^+$ in wet fallout were investigated by regressing the yearly average values and concentration on the year number (i.e. first year of data was taken as year 1, and second year as year 2 and so on).

The pH showed a downward trend (r=0.76) indicating increase in acidification of rain water (Fig. 5 ). The increasing concentration of sulfate in rainwater over the years ( Fig. 6 ) could be the cause of the increase in free acidity. The upward trend of sulfate in rainwater may have been the result of increasing SO2 emission from industrial and anthropogenic activities in the region. At the same time the concentration of $NH4^+$ has been decreasing with time(r=0.71) as shown in Fig. 7 . This was probably due to decrease in biological activities (producing NH3 gas) caused by the rapid urbanization process in the region.

## CONCLUSION

The wet fallout data for Petaling Jaya has been analyzed. $H_2SO_4$ has been found to be the main contributor to the acidity of rain water while $Ca^{++}$ ion is believed to have a major neutralizing role.

Although there is calcareous soil in the region having the capacity to neutralize the acids but its buffering capacity is not unlimited. The annual average of pH of rain water has gone down from 4.71 in 1982 to 4.48 in 1991 implying that, with further increase in emission level, acid rain could become a serious environmental problem in the future. Some measures should be taken to check any drastic increase in the present level of air pollution emission in the context of the industrialization in the country.

## REFERENCES


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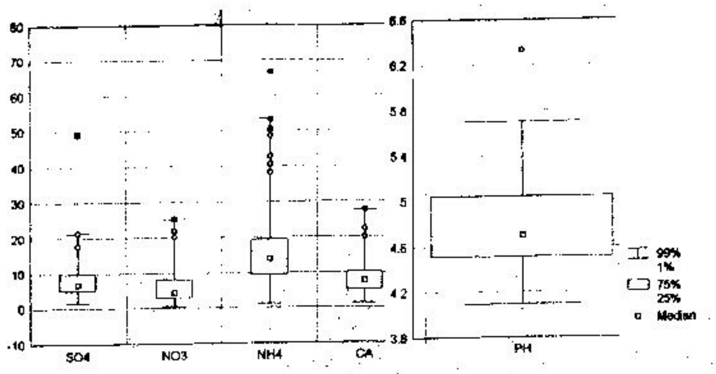


Fig. 2 Distribution of Dataset

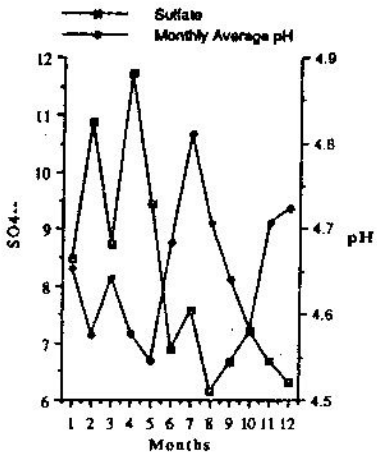


Fig. 3 Seasonal variation of $SO_4^{--}$ Deposition

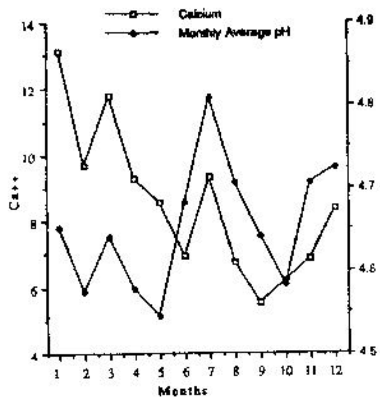


Fig. 4 Seasonal Variation of $Ca^{++}$ Deposition

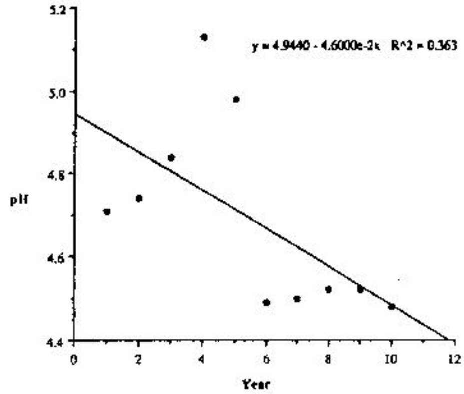


Fig. 5 Annual Trend of pH

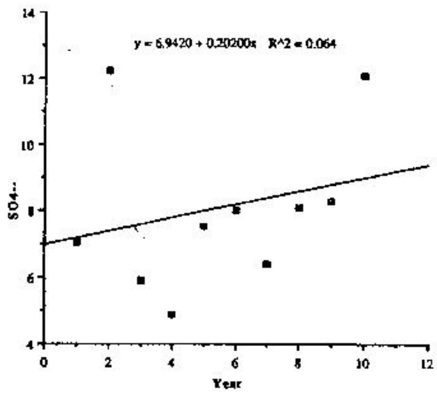


Fig. 6 Annual Trend of $SO4^{--}$ Deposition

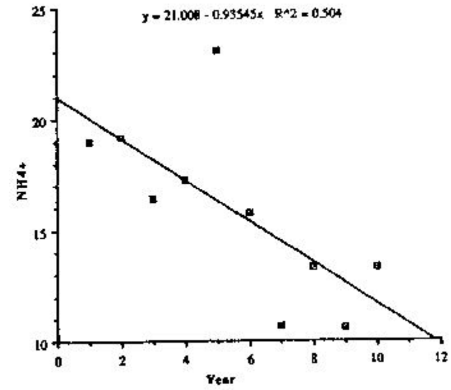


Fig. 7 Annual Trend of $NH4^{+}$ Deposition