Study of Acid Rain in Hong Kong

Provision of Service to the Environmental Protection Department, HKSAR (Tender Ref AS 99-417)

Executive Summary

In Hong Kong, the Environmental Protection Department (EPD) started an acid rain monitoring program since the middle of 1980s. The present study was a desktop review exercise on the local available data in assessing the current situation of acid rain and its potential trend for the future. Acid rain data (wet and dry deposition) collected by the EPD stations and other sources were systematically reviewed and statistically analysed. The potential impacts by acid rain *per se* on the local ecosystems were assessed both in physical and monetary terms as far as possible. Major conclusions drawn from the studies are listed below.

1. Acid rain phenomenon (rainwater pH < 5.0) is persistently recorded in the two acid rain monitoring stations in Hong Kong.
2. Data collected from the two stations are of high quality in terms of charge balance between the cations and anions.
3. Both the Factor Analysis and Multiple Regression agree well with each other that sulfate and nitrate are the major potential acids in the rainwater. The contribution of nitrate in the acidity of local rainwater becomes more significant as revealed from the Multiple Regression, Trend Analysis and the ratio of NO_3^-/non-seasalt SO_4^{2-} over the year 1993 to 1999. No significant trend of change is found for SO_4^{2-} from the deposition data although a significant reduction in the local SO_2 emission is noted.
4. The non-sea salt SO_4^{2-} is still the major acid contributor in Hong Kong rainwater. Its loading is about 3 to 4 folds that of NO_3^-. Loading of nitrate is likely of local sources while there is no clear indication for sources of sulfate loading from the deposition data.
5. Rain acidity in terms of pH in Hong Kong is moderate (KT-4.87 and CW-4.75) in 1999 and comparable with Taiwan (4.8-5.1) and Compton of London (4.9). It is less acidic than West Point of New York (4.47) and Woburn of London (4.6). In terms of the extent of acidification as revealed by the ratio of NO_3^- /nss-SO_4^{2-}, Hong Kong is still amongst the lowest with a range of 0.38 to 0.43 in 1998 and 1999 when compared with other metropolis such as Tokyo (0.71), New York (0.50) and London (0.85-0.99).
6. Despite the existence of the acid rain phenomenon over the year 1993 to 1999, no acidification (drop in pH), acute or chronic, of the surface water and aluminum toxicity is evidenced from the natural acid deposition *per se* in the local freshwater streams, rivers and reservoirs with no or minimal anthropogenic source of pollution. Acidification due to acid deposition is also absent from the natural coastal waters with little anthropogenic disturbance.
7. The natural soil of Hong Kong is acidic, low in cation exchange capacity and base saturation as a result of the parental bedrock materials. With the data

assessable in this study, soil acidification due to natural acid deposition *per se* is not evidenced.

8. Direct acid deposition, wet or dry, has insignificant effect on local agricultural crops such as vegetables and flowers, which accounts for over 95% of the local annual crop production.
9. Aluminum toxicity, the major hazard of acid deposition, is not observed in the local freshwater systems as reflected by the pH and Al level in the waters with no or minimal anthropogenic pollution. Mobilization of Al from soil to surface water is also not evidenced from the available data.
10. Direct wet and dry deposition is not related to and will not cause significant effect on health and public well-being. It is the gaseous precursor such as SO_2 and NO_3 that induce health effect. The EPD has already launched studies in the economic impact of the air pollutants. Details should be referred to reports of these studies.
11. Effect of acid rain on material damage is assessed basing on the European ExternE model as a result of unavailability and incompleteness of the local or regional data. With the assumption of 'Hong Kong in Europe Context', a very rough estimation of HK 400 to 500 Million dollars (0.03 to 0.05% GDP) is subjected to material damage as consequence of acid rain.
12. The annual economic loss due to acid deposition of the present study is summarized in the following.

	Monetary loss (HK M$$_{1999}$)	Production-based GDP (%)
Impact on Ecosystems		
- Freshwater	No major impact at the present state	Not applicable
- Coastal water	No major impact at the present state	Not applicable
- Crop production	24.74 (relatively minimal)	0.002
- Natural soil and vegetation	Insignificant effect found at present status	Not applicable
Health Impact	No direct effect*	Not applicable
Material Damage	400-500	0.03 – 0.05
Total loss	About 500	About 0.05

*Please refer to the EHS report in 1998 for the indirect effect from the gaseous precursors.

13. The estimated economic loss as result of direct acid deposition is about 0.05% of the local production based GDP. This is about one-tenth of the 0.51% GDP_{1996} reported by the EHS Consultants Limited on the Study of Economic Aspects of Ambient Air Pollution on Health commissioned by HKEPD in 1998.