4. Effect on Public Health

In addressing the effect of acid deposition/rain on human health, the common approach is addressing the gases and fine particulate matters on health. As a result, the health impact from acid deposition is, often, indistinguishable from that of the ambient air pollution. The Hong Kong Environmental Protection Department (HKEPD) had already commissioned studies on the short-term effects of ambient air pollutants on public health and their economic study, the scope of the present study thus emphasized on the assessment of the direct effect of acid deposition on health (section 4.1) in maximizing the resource and avoid duplicated study. The indirect effect of the acid rain precursors, viz. the general ambient air pollutants, should be referred to the reports of the commissioned studies mentioned. To provide a quick reference, key findings of these studies were cited for reference as indirect effect of acid deposition/rain on public health (section 4.2).

4.1 Direct health effects from acid rain/acid deposition

The direct effect of acid deposition *per se* on health refers to the effect(s) as a result of direct contact of the wet or dry deposition on human. Examples include the direct wetting of the skin by rainwater or soaking through the clothing due to wet deposition. Dry deposition often refers to the coarse particulates whose masses are more prone to gravitational settlement. The depositional velocities of these coarse particulates depend, in turn, on key factors such as concentration of the particulates and meteorological conditions. The massive nature of the coarse particulates in the dry deposition shortens their residence time in the atmosphere. Unlike the fine particulate matters such as the Respirable Suspended Particulates (RSP), the coarse particulates are less inspirable down to the fine bronchioles in human lungs as well.

The European Commission (1999) had conducted extensive studies in establishing a comprehensive list of most relevant effects of air pollutants on human health and on other receptors. It was concluded that acidification affects receptors like ecosystems or building materials, but the health experts did not see a direct and significant link between acid deposition on the ground and human health being. Acidification of soil and water bodies might result in secondary effects on health (e.g. due to the mobilisation of metals), which however are considered as very small. In general it is assumed that the deposition of acid substances (i.e. deposition on the ground) does not cause any health effects.

The World Health Organization shares similar view on the insignificant effect on health due to direct acid deposition. The Guidelines for Air Quality of the WHO (2000) lists the key air pollutants to be used for air quality management because of their potential harmful effects on human health. The list consists of a large number of inorganic and organic substances, including acid rain precursors, but does not have the direct acid deposition as a health related pollutant.

The United States Environmental Protection Agency (USEPA) expresses the same view even more explicitly. ‘Acid rain looks, feels, and tastes just like clean rain. The harm to people from acid rain is not direct. Walking in acid rain, or even swimming in an acid lake, is no more dangerous than walking or swimming in clean water.’ – directly quoted from the USEPA web-page (www.epa.gov/airmarkets/acidrain/effects/health.html).

It can thus be concluded that no significant relationship between health and direct acid deposition is evidenced.

4.2 Indirect health effects from acid rain/acid deposition

Despite the insignificant direct effect of acid rain/deposition on the human health, there is an indirect yet significant correlation between the health effects and the precursors of acid deposition in the ambient air. The main gaseous precursors contributing to rain acidity are SO_2 and NO_x. These gases are chemically transformed to sulfate and nitrate particles, which associated closely with the aerosols or particulate matters. Both the gases and these fine particles, unlike the wet or dry deposition of the coarse particulate matter, have a long residence time in air and could be easily inspired deep into the human lungs leading to health problems. These gases, particulate matters, sulfate and nitrate aerosols are known inarguably as significant causative agents on health problems such as respiratory and cardiovascular diseases.

The Hong Kong Environmental Protection Department (HKEPD) had already been aware of the situation and commissioned the Chinese University of Hong Kong (1996/97) and the University of Hong Kong (1997/98) to study the short-term effects of ambient air pollutants (NO_2, SO_2, respirable suspended particulates and ozone) on the public health. Significant correlations were reported between these ambient air pollutants and the hospital admissions and mortalities for respiratory and cardiovascular disease.

The HKEPD had also commissioned the EHS Consultants Limited (1998) further on the economic aspects on the public health from the ambient air pollution based on the results of the Chinese University of Hong Kong and the University of Hong Kong studies. In the EHS study, the use of cost-of-illness (COI) approach had been adopted for calculating the direct cost of hospitalisation and out-patient medical consultation, and indirect cost of loss of earnings and productivity with respect to the respiratory and cardiovascular diseases. A 29-person focus group survey was also conducted by the same study to assess individual's willingness-to-pay (WTP) to avoid hospitalisation and reduction of risk of death for the same disease category as reference as well.

The key results of the EHS study included the estimation for the unit cost for morbidity and mortality with respect to unit increase of the criterion gaseous pollutant (Table 4-1) and the economic cost as a result of the ambient air pollution for the year 1996 (Table 4-2). In the economic cost assessment, the single pollutant model as well as the composite score model for the multi-pollutant effect had been conducted. The composite score model provided a more close-to-reality effect on the multi-pollutants on health yielded an estimate of HK$ 3,841 million and 5,637 million for the COI and WTP, respectively. These accounted for about 0.35% and 0.51% of the GDP in 1996, correspondingly.

Table 4-1. Economic cost for unit increase of the criterion air pollutants based on the COI and WTP models. (From EHS, 1998)

	For unit $\mu g/m^3$ increase	COI (HK$ million)	WTP (for reference only) (HK$ million)
Morbidity	NO_2	17.1	29.3
	SO_2	9.7	16.7
	RSP	9.7	16.7
	O_3	17.1	29.3
Mortality	NO_2	55.9	75.8
	SO_2	--	--
	RSP	18.6	25.3
	O_3	32.6	44.2

Table 4-2. Total health related cost estimated by the COI and WTP models for the Year 1996. (From EHS, 1998)

		COI (HK$ million)		WTP (for reference only) (HK$ million)	
		Single Pollutant	Composite Score	Single Pollutant	Composite Score
Morbidity	NO_2	852.34	1186.68	1462.46	2036.14
	SO_2	487.05		835.69	
	RSP	487.05		835.69	
	O_3	852.34		1462.46	
Mortality	NO_2	2793.02	2654.04	3789.61	3601.05
	SO_2	--		--	
	RSP	931.01		1263.20	
	O_3	1629.26		2210.60	
Total Cost (HK$ million)			3840.72		5637.19
% GDP (1996)			0.35		0.51

Reference

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