Objectives, Rationale for, and the Design of the Malé Network

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Objectives of the Malé Network

- To provide a common understanding of the state of acidic deposition problems in participating countries.

- To provide decision-support inputs at local, national and regional levels aimed at preventing/ reducing adverse impacts of acidic deposition on human health and the environment.

The tasks required to fulfill these objectives are:

- To do capacity building to enable participating countries to monitor acidic deposition and their impacts.

- To monitor the environment for acidic deposition and their impacts.

- If acidic gas deposition and their impacts are observed in any of the participating countries, to determine the sources of the emissions.

These tasks do not include steps required to mitigate acidic gas deposition.

Rationale for the Malé Network

- Economic growth in South and East Asia is high. South Asia has grown at 5% over the last two decades and is expected to maintain or exceed this growth rate in the coming decade as well.

- Energy consumption has grown at nearly 6% per person per annum over the last 25 years. The total per capita final energy consumption in South Asia was 0.38 tones of oil equivalent (TOE) in 1999, as against 0.1 TOE in 1975.

- With a population growth rate (1.84% per annum) significantly lower than the per capita energy consumption, South Asia is attempting to catch up with north nations, whose per capita energy consumption was 5.34 and 2.77 TOE in Northern America and Western Europe in 1999.

- Electricity generation has grown at 7.8% per annum over the last two decades in South Asia. These high growth rates are likely to be sustained in the near future. Eg, India plans to increase power-generating capacity from 105,000 MW in 2,000 to 176,000 MW by 2012. 70% of the generating capacity is thermal power.

- Consequently, acidic gas emissions are projected to grow very rapidly in Asia.

- Over the next 2 decades, SO_2 emissions will grow at 6% per annum in South Asia and 3.2% per annum in East Asia. Between the years 2000 and 2020, SO_2 emissions are expected to treble in South Asia.

SO2 Emissions (Thousand Tonnes)

	2000	2010	2020	Annl Growth (%)
South Asia				
Bangladesh	165	330	525	6.0
Bhutan	5	7	12	2.7
India	6,494	10,931	18,550	5.4
Iran	760	NA	NA	
Maldives	NA	NA	NA	
Nepal	156	194	247	2.3
Pakistan	1,553	3,684	7,527	8.2
Sri Lanka	132	171	239	3.0
Total (minus Iran)	**8,505**	**15,317**	**27,100**	**6.0**
East Asia				
China	34,328	47,840	60,688	2.8
Indonesia	1,085	1,868	3,162	5.4
Japan	997	1,048	1,120	0.6
Dem Rep of Korea	2,802	4,033	5,537	3.5
Malaysia	242	342	410	2.7
Philippines	627	1,071	2,037	6.0
Singapore	358	653	1,033	5.4
Taiwan	765	1,086	1,478	3.3
Thailand	1,901	3,277	4,638	4.5
Total	**43,105**	**61,218**	**80,103**	**3.2**

Source: Downing, 1997.

- With greater consumption of hydrocarbons in Asia, NO_2 emissions will also increase.

- NO_2 emission data for South Asia is scanty. NO_2 emissions are approximately 15 million tones per annum; and their growth rate is higher than that of SO_2.

- The consequences are the decrease in the pH of rainwater. Over the last 30 years, pH of rainwater has been reported to have decreased in India and Sri Lanka.

India

Jodhpur	1976	1977	1979	1996	1997
pH	7.96	8.28	7.16	6.1	5.9

Agra	1963	1984	**Delhi**	1965	1984
pH	9.1	6.3	pH	7.0	6.1

Sources: Mohan, 1998; Kumar, 2000

	pH Trends	Acid rain obs
Allahabad	Decreasing	0
Jodhpur	Decreasing	0
Kodaikanal	Decreasing	3
Minicoy	Decreasing	1
Mohanbari	No trend	2
Nagpur	Increasing	1
Port Blair	Decreasing	5
Pune	Decreasing	0
Srinagar	Decreasing	0
Visakhapatnam	Decreasing	0

Source: Mohan, 1998

Sri Lanka

pH Values in Horton Plains During 1995-96

Stream water	5.81-7.45
Rain water	5.37-7.47
Throughfall	5.80-7.57
Cloud water	3.88-6.52

Source: Ileperuma, 1998

Range of pH Values at Different Locations

	pH		
Stn	Min	Max	Avg
AP	4.89	6.97	6.00
BD	6.11	7.11	6.64
BW	5.78	6.72	6.24
CB	5.32	6.68	5.89
GL	5.35	7.90	6.45
HT	5.79	5.99	5.89
KG	4.92	6.67	6.28
MI	5.09	6.54	6.07
NE	4.36	6.96	6.18
PT	6.21	7.31	7.00
RP	5.88	6.49	6.25
UNI	4.68	7.27	6.26

Source: Ileperuma, 1998

- If this trend continues unabated, it is probable that areas that have soils with low buffering capacity (soils with high sensitivity for acidic deposition) may corrode.

- The acidification of soils in South Asia may lead to:

    1. Forest diebacks and loss of biodiversity.
    2. Lowering of agricultural productivity.
    3. Acidification and eutrophication of inland water bodies.
    4. Alteration of aquatic ecology in affected water bodies and loss of livelihood to those dependent on these water bodies.

- Acidic deposition may pose the biggest risk to Indian forests in this century and put 35 million ha, ie, 55% of India's forests in the Western and Eastern Ghats, the Himalayas and Northeastern India and the Andaman Islands at risk to forest dieback. These forests host about 80% of India's 126,000 known species, and may probably have many other species that are yet unidentified.

- Yet, the question of development vs preserving the environment hangs fire.

SO_2 Emission Intensity, Per Capita Emissions and Emission Densities in Asia and Selected Western Countries in 1990

Region/ Country	Emission intensity kg/1000 US$ at 1990 prices	Per capita emission kg	Emission density T/km^2
North-east Asia	**7.88**	**22.03**	**2.58**
China	71.35	22.86	2.79
Hong Kong	3.45	23.88	138.50
Japan	0.29	6.90	2.25
Korea, Rep of	6.98	21.93	0.03
Taiwan	3.35	25.38	14.24

South Asia	**14.39**	**5.07**	**1.11**
Bangladesh	4.10	0.77	0.61
Bhutan	7.23	1.33	0.04
India	16.29	5.99	1.50
Myanmar	0.96	0.53	0.03
Nepal	9.05	1.48	0.20
Pakistan	15.74	5.54	0.78
Sri Lanka	3.79	1.79	0.46
South-east Asia	**8.18**	**6.63**	**0.71**
Brunei	1.87	15.26	0.64
Cambodia	12.22	2.35	0.11
Indonesia	6.51	3.85	0.36
Laos	4.84	1.01	0.02
Malaysia	5.02	12.07	0.65
Philippines	9.40	6.78	1.38
Singapore	5.23	70.44	190.89
Thailand	12.93	18.49	2.02
Vietnam	10.37	2.03	0.41
Asia	**8.47**	**13.19**	**1.86**
United States	**3.81**	**84.27**	**2.25**
Germany	3.76	89.96	2.17
United Kingdom	3.84	65.84	15.43

Source: Shrestha, 1996, 1997.

- PM_{10} will provide the clue to the origin of the pollutants. Black carbon and fly ash of anthropogenic origin were monitored to constitute 10-14% and 5-6%, respectively in the ABC, providing clues to their origin.

Design of the Malé Network

- Some fundamental decisions

1. The monitoring for transboundary air pollution and their impacts would be done at two levels—NIAs and other

stakeholders. Accordingly, instrumented and non-instrumented methods would be made available in the monitoring manual so that stakeholders other than NIAs (NGOs, etc) could also effectively participate in this programme. This would help increase the area monitored by this programme.

2. Transboundary air pollution would be monitored by monitoring wet and dry deposition, soils, vegetation, water bodies and aquatic ecology.

3. The parameters for dry deposition would be: SO_2, NO_2, TSPM, PM_{10}; and for wet deposition would be: pH, electrical conductivity (EC), Mg^{2+}, Na^+, K^+, Ca^{2+}, NH_4^+, SO_4^{2-}, NO_3^-, Cl^-.

- STRATEGY

1. Only a limited number of sites that can be monitored on a sustained basis be initially selected.

2. The first 5 years of the monitoring programme should be devoted to acidification trend monitoring only.

3. Paired sites, one on either side of the border, should be established to engender cooperation between neighbouring countries and confidence in the monitoring results.
4. To the extent feasible, the monitoring of all the parameters at a set of paired station should be done jointly by scientists from both the neighbouring countries.

5. To the extent feasible, the analysis of samples requiring laboratory analysis, should be done in the country where the samples were collected as well as the neighbouring country.

6. The suggested monitoring sites are based on the discussion that MoC had with the NIAs and factors such as regional meteorology, source locations, terrain, etc. NIAs may do the final site selection in consultation with neighbouring countries. NIAs may change the site locations, if necessary, in the first year of the monitoring programme, after consulting with the neighbouring country and the Technical Committee. Thereafter, the sites should be frozen for the next 4 years, unless there are very compelling reasons.

7. The selection of the NIA monitoring sites along a border should preferably be done jointly by NIAs from both countries and if necessary with the help of UNEP. Field visits must be made before a site is chosen.

8. The monitoring manual may be revised after three years to incorporate the experience gained during this period as well as allow for new monitoring methods to be introduced.

9. The number of sites monitored by NGOs and educational institutions be at least ten times as many as those being monitored by the NIAs. This dual level monitoring exercise would increase the probability of detection of acidification at

an early stage. If an acidification process is reported at a particular site by an NGO, the NIA should verify this. If warranted, the NIA should monitor at this site with instrumented methods.

- Site selection criteria

1. Two types of sites are required—deposition monitoring sites for monitoring wet and dry deposition, and ecological monitoring sites where soils, vegetation, water bodies and aquatic ecology would be monitored. Deposition monitoring should not be done in forests as vegetation will absorb a part of the pollutants, thus giving erroneous results.

2. Monitoring should be done at remote sites as close to the border as possible and at least 50 km away from the nearest town/ large industry and 25 km away from the nearest highway/ small industry.

3. To the extent possible, there should be minimal human habitation/activity or other emission sources close to the site. Population density around the sites should be low and should be expected to remain low in future.

4. The sites should be downwind of major emission sources in neighbouring countries and upwind of major emission sources in the country in which the monitoring is being done.

5. The sites for monitoring the ecological parameters should be in a good natural forest that is likely to remain undisturbed in future.

6. Unless unavoidable, the sites should be sufficiently inland to avoid the influence of coastal breezes.

7. The terrain between the emission sources in the neighbouring country and the monitoring sites should preferably be flat.

8. Ecological sites should have a fresh water lake that does not receive polluted water from any source.

9. The sites should be accessible and secure from wild animals and human marauders. The sites should also preferably have a power connection and should be habitable for short periods, if necessary.

10. The sites located in flat terrain should preferably have a meteorological station within about 25 km of them.

11. The site should be preferably be within 12 hours travel time from the place where the samples (other than passive samplers) will be analyzed.

12. A few of the ecological monitoring sites should be in areas that are at high risk to acidification effects, eg, acidic soils and those high in iron and aluminum content.

It is probable that all the above criteria will not be met at all the monitoring sites. To the extent possible, the first six criteria should be met.

- Suggested monitoring sites

- Monitoring protocol

HVS	**PM and** *Gaseous samples:* 10 samples of 24 hrs each to be done for 10 days each month between 5th-25th of each month. Valid sample: when machine up time is >60% of sampling time
Passive samplers	1 month for SO_2 and NO_2
Wet only collector	1-week sample
Bulk collector	1-week composite sample. Collector must be cleaned thoroughly at the beginning of each week to ensure that there is no dry deposition in the collector from the previous week

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Health and Safety issues when monitoring and analyzing air pollution

General

1. Accidents do not happen. So, always take all necessary precautions (refer to the Envirotech manual).

2. Make sure that you know where the medical kit is housed and that it is up to date and well stocked.

3. Never do anything in the laboratory in a rush. Take your time and think about the procedure you are trying to follow, especially if the chemicals are toxic.

4. Never have food and drink while analyzing the samples.

5. Do not place bottles, sample bottles or beakers with chemicals near the edge of a table.

6. Always be careful with glassware.

7. Never tamper with electrical connections when power is switched on. Always check at the plug. Beware of extension cords.

8. Avoid making temporary power connections. Use electrical insulation tapes where appropriate.

9. Do not put bare wires into an electrical socket. *Remember!* Water and electricity make bad bedfellows.

10. If the HVS fuse blows, *do not replace it with a piece of wire, but with an approved fuse.*

11. Switch off the mains power when equipment is not in use.

12. Connect the spectrophotometer through a voltage stabilizer.

13. Switch off the distillation unit at the end of the distillation process (clean the reservoir periodically).

14. Do not tamper with the insides of equipment when they are working, especially the HVS.

In the field

1. Take care when using ladders, especially while carrying loads, eg, HVS.

2. Take care when moving heavy equipment. Do not take short cuts. Do not lift heavy objects by yourself. Take the help of another person.

3. If a biocide like thymol is used to preserve rainwater samples, care should be taken to avoid contact with hands and eyes.

4. Use footware with good grip on slippery surfaces.

5. Equipment, especially an HVS, should be placed on a flat surface.

In the laboratory

1. Always read the label of any chemical that you use in the laboratory to understand the health risk and safety precautions to be taken.

2. Always wear a lab coat in a laboratory to avoid skin contact with chemicals.

3. Always wear gloves when handling dangerous chemicals, eg, TCM, thymol.

4. Do not pipette liquids with mouth. Use a rubber bulb or

In case of accidents

1. If there is a chemical spill, follow the recommended procedure for spill control and cleanup.

2. If the spill gets into your eye, rinse eye with lot of water and seek medical attention immediately.

3. If a toxic substance is swallowed, seek medical attention immediately.

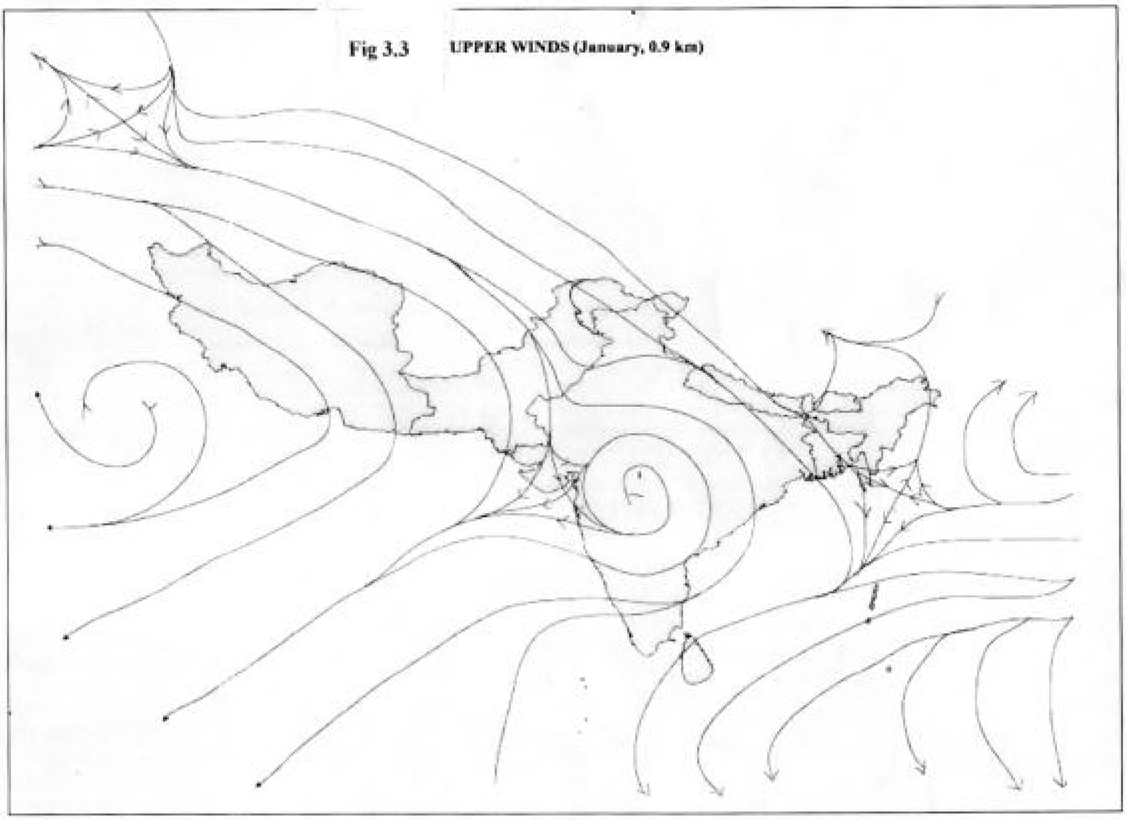

Fig 3.3 **UPPER WINDS (January, 0.9 km)**

Fig 3.2 UPPER WINDS (July, 0.9 km)