Air Pollution and Ecosystems in the United Kingdom

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Objectives

- Background pollution climate of the UK
- Changes 1986-2003..highlights of NEGTAP
- Surprises
- Focus for nature conservation
- Exceedances of critical loads
- Conclusions
Transboundary Air Pollution: NEGTAP report 2001

Terms of reference:

• Quantify current exposure, deposition and effects of acidifying and eutrophying pollutants on UK ecosystems.

• Review chemical and biological trends in the UK environment.

• Quantify prospects for ecosystem recovery resulting from reductions in pollutant emissions to date and those to which the UK is committed.
In short

• Is ‘acid rain’ a problem of the past?

• What are the current regional air quality problems?

• Has enough been done to protect the UK ecosystems from current and future air quality problems?
Progress in controlling emissions

<table>
<thead>
<tr>
<th>Emissions kTonnes S,N</th>
<th>peak</th>
<th>2000</th>
<th>2010</th>
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<tbody>
<tr>
<td>SO₂</td>
<td>3259</td>
<td>594</td>
<td>312</td>
</tr>
<tr>
<td>NO₂</td>
<td>850</td>
<td>488</td>
<td>359</td>
</tr>
<tr>
<td>NH₃</td>
<td>300</td>
<td>287</td>
<td>255</td>
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<tr>
<td>VOC</td>
<td>2500</td>
<td>1700</td>
<td>1200</td>
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UK emissions of NH$_3$
What are the key findings?

• Air Quality
  – Large reductions in UK emissions of sulphur (80%) since peak in 1970.
  – Nitrogen oxides down by 40% since peak in 1990.
  – VOC down by 32% since the peak in 1989.
  – Large reduction in concentrations of SO$_2$ and NO$_2$, throughout the UK.
  - No change in NH$_3$ emissions
Rain ion concentration of non-seasalt sulphate – 1986

**μeq l⁻¹**

- above 83
- 74 - 83
- 56 - 74
- 38 - 56
- 28 - 38
- below 28
Enhanced wet deposition of non-seasalt sulphate – 1986

kg S ha⁻¹ y⁻¹
- above 15
- 11 – 15
- 9 – 11
- 8 – 9
- 6 – 8
- below 6

C3_F12a_wd_nssSO4_86
Trends in sulphur deposition throughout the UK.

Group 1*: \[ \text{nss-SO}_4^{2-} = -3.25 \, y + 6542 \]
Group 2*: \[ \text{nss-SO}_4^{2-} = -1.06 \, y + 2159 \]
Group 3 : \[ \text{nss-SO}_4^{2-} = -0.21 \, y + 459 \]
Group 4 : \[ \text{nss-SO}_4^{2-} = -0.11 \, y + 237 \]

* Statistically significant, \( P < 0.01 \)
Concentrations of $\text{SO}_2$
Dry deposited NO$_2$-N and HNO$_3$-N (kt)
Wet and Cloud deposited NH$_4$-N

![Bar chart showing the trend of wet and cloud deposited NH$_4$-N from 1986 to 2001.](chart.png)
Concentrations of NO$_2$
NO$_3$ trend

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<tbody>
<tr>
<td>concentration, $\mu$eq l$^{-1}$</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
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Group 1: $y = -0.82x + 1675$, $R^2 = 0.46$
Group 2: $y = -0.18x + 394$, $R^2 = 0.05$
Group 3: $y = 0.04x + 71$, $R^2 = 0.00$
Group 4: $y = -0.01x + 31$, $R^2 = 0.00$
Atmospheric budget of reduced nitrogen (2000) for the UK kTonne N yr$^{-1}$
Atmospheric budget of oxidized nitrogen (2000) for the UK kTonne N yr\(^{-1}\)

- **INPUT**: 63
- **EMISSIONS**: 460
  - **DRY DEPOSITION**: 89
  - **WET + CLOUD DEPOSITION**: 96
- **EXPORT**: 338
- **EMISSION DEPOSITION**: 185
- From non-UK/Europe
Total nitrogen deposition, 1997
Changes in species composition close to the NH₃ source

Log distance (m) from poultry houses at farm E

- Deschampsia flexuosa
- Holcus lanatus
- Chamaenerion angustifolium
- Oxalis acetosella
- Dryopteris dilatata
- Moss species

% cover in a 5 x 2 m transect
$O_3$ concentrations have roughly doubled since the early 1900's.
Somerton - Enhanced Background Concentrations

- Hourly Average
- 7d RM 1000-1800 average

Avg. 7d RM 1996-2000
- 2030
- 2060
- 2100

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- National air quality strategy guideline: daily maximum of running 8 hour mean (d.max 8hrm) not to exceed 50 ppb more than 10 times per year by Dec. 2005.

- 99.95% exceeded in 1996


Trends in the d.max 8 hrm of around -2 days y⁻¹ (1986-2000) indicate the standard will not be met across the whole country by 2005 although the magnitude and area of exceedance will be greatly reduced (to ~25%).
AOT40

Crops and semi-natural vegetation 1997-2001

- Critical levels for vegetation were exceeded over ~7% for forests and 65% for crops in 1994-98; in 1997-2001 no exceedance for forests and 35% for crops.

- Although the magnitude and area of exceedance are declining at present, the number of exceedances of 40 ppb are increasing and occurring earlier in the year.

- Changes in the ozone climate could have significant effects on UK vegetation and new critical levels based on ozone uptake rather than concentration will be needed.
Modelled surface ozone concentration (STOCHEM)

a. 1990, mean = 21 ppb
b. 2030, mean = 26 ppb
c. 2060, mean = 29 ppb
d. 2100, mean = 36 ppb

ppb

0  15  30  45  60  75  90
Impact on AOT40

% of Daylight Hours Above 40 ppb

Aston Hill

1996-2000
2030
2060
2100

% Hours Above 40 ppb

Dunslair Heights

1996-2000
2030
2060
2100

% Hours Above 40 ppb

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Annual Mean Ozone Trends at 2 Rural Sites

- For Bush:
  \[ y = 0.18x - 169 \]
  \[ R^2 = 0.27, \ P = 0.04 \]

- For Mace Head:
  \[ y = 0.32x - 602 \]
  \[ R^2 = 0.52, \ P = 0.01 \]
Conclusions
Ozone

- Peak concentrations are declining but mean concentrations are increasing (0.2 to 0.5 ppbV per year.
- Substantial exceedance of critical levels for semi-natural vegetation
- Large increases in exceedance expected over the next few decades.
- It will not be long at current rates of increase in background ozone concentration before the background will exceed thresholds for effects on sensitive species.
Potential damage from acid deposition

- 71% of UK ecosystems currently exceed critical loads for acidification, this will decline to 47% by 2010, according to current knowledge.
Exceedances

- 40% of UK semi natural ecosystems exceed critical loads for eutrophication, this will decline to 32% by 2010.

- The exceedances of critical loads for eutrophication are mainly due to $\text{NH}_3$.
Recovery

• There is recovery, but it is patchy
• Some areas of the UK show large reductions in acid deposition while other areas (eg Wales and Western Scotland), including some very heavily affected areas have changed little.
• Lots of non-linearities are being detected, few are included in the current models.
• Overall, the deposition of nitrogen in the UK has changed little with time.
• Nitrogen compounds dominate the sources of acid deposition.
• The deposition of nitrogen is mainly $\text{NH}_3$ and $\text{NH}_4^+$, whose emissions have not changed significantly.
Focus for conservation

- Effects of Nitrogen deposition and especially reduced Nitrogen on semi-natural plant communities
- Ozone effects on semi-natural and crop plants
- Quantifying recovery of fresh water ecology from the effects of acidification