TRENDS IN SMOKE CONCENTRATIONS BEFORE AND AFTER THE CLEAN AIR ACT OF 1956

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(First received 27 February 1972 and in final form 11 May 1973)

Abstract—Claims made on behalf of the Clean Air Act of 1956 are examined in the light of long-term data on smoke concentrations from Kew. If the trends observed prior to 1956 are extrapolated to 1970/71, the result appears to be not greatly different from what has been observed and credited to the operation of the Act. Short-term records from three cities (Norwich, Brighton and Plymouth)
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THE SUCCESS OF THE CLEAN AIR ACT

During the past few years newspapers and magazines around the world, as well as technical and scientific journals, have carried stories of the spectacular success of air pollution control measures in Britain. The recent improvements in air quality over London and to a lesser extent over other large cities have been widely credited to the success of the government's pollution control programme, especially the measures under the Clean Air Act of 1956. That the smoke content of the atmosphere has declined is evident. The extent to which this can be attributed to the Clean Air Act of 1956 is less certain.

While there is no doubt that legislation like the Clean Air Act gives impetus and means for control and abatement of air pollution, there is evidence to suggest that a decline in smoke concentrations might have taken place in any case. This is due, at least in part, to improvements in technology available for industrial, commercial and domestic use. CRAXFORD, WEATHERLEY and GOORIAH (1971, p. 118) remark that in regard to “the reasons for the decrease in smoke, it is impossible to decide from the data to what extent the Clean Air Act of 1956 has been responsible or to what extent it has been due to modernization of habits of living”.

It seems significant to point out that unwarranted reliance on the efficacy of legislation and enforcement of measures like the Clean Air Act of 1956 can lead to undue complacency and misinformation concerning the control of air pollution. Certainly claims for the success of the Clean Air Act must be treated with caution and viewed in the light of other factors contributing to the lessening of smoke concentrations in the atmosphere. Such a perspective does not emerge from the First Report of the Royal Commission on Environmental Pollution (1971, para. 36, p. 11) which states: “Since the first Clean Air Act became law in 1956 there has been a steady reduction

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in the emission of smoke and sulphur dioxide into the air over Britain...". The report goes on to warn that "the downward trends in smoke and sulphur dioxide pollution are encouraging, but they will continue only if there is no relaxation in applying the provisions of the Clean Air Acts and the Alkali Etc. Works Regulation Act" (para. 38, p. 12, italics added). The implication seems clear that the Clean Air Acts are responsible for improvements in air quality, and that their continued application is necessary if further improvements in air quality are to be achieved.

Similarly, a report prepared for the Boroughs' Division, GLC Research and Intelligence Unit, states that "smoke concentrations have decreased by 80 per cent since 1958 in Central London", and "winter visibility has increased threefold since the Act came into force" (1970). Mr. F. E. Ireland, the Chief Alkali Inspector, writing in Clean Air (1971, p. 8) stated: "It is estimated that, since the Clean Air Act of 1956, smoke emissions have been reduced to such an extent that average ground level concentrations in urban areas have decreased by 60 per cent". A report from the National Survey of Air Pollution (Crawford, Goorih and Weatherley, 1970, p. 6) states that "between 1958 and 1969 the annual average concentration [of smoke] fell from about 150 $\mu$g m$^{-3}$ to about 50 $\mu$g m$^{-3}$."

Most statements of this kind are accompanied by graphs showing a decline in smoke concentrations. Examples are shown in Figs. 1 and 2, which are designed to convey

![Graph showing decline in smoke concentrations from 1958 to 1968](image.png)

**Fig. 1.** Average smoke concentration near ground level in the U.K., 1958–1968; Source: Royal Commission on Environmental Pollution (1971), First Report, p. 17.

the same message, namely to show significant declines in smoke concentration since the Clean Air Act of 1956. Although most reports speak of "trends in smoke concentration", the data shown do not go back in time much before the passing of the Clean Air Act. This can be partly explained by the fact that the majority of the smoke recording stations have themselves been established only since 1956. Comparable regional data for longer time periods are not available. Nevertheless, some stations with longer records do exist, including Kew Observatory where data have been collected on smoke concentrations from 1922 onwards. It is surprising that such long-term records have not been more widely reported, especially in view of the
recognition that improvements in air quality are due to long-run trends as well as the application of the provisions of the Clean Air Act of 1956. A Warren Spring Report states: “This continued replacement of coal by oil [in industry] suggests that it is reasonable to credit the Act with having greatly accelerated developments which would, however, of themselves, have taken place slowly but inevitably. In fact, like other successful legislation the Clean Air Act was ‘swimming with the tide’ of industrial development” (Craxford, Gooriah and Weatherley, 1970, p. 2). And, it should be added, with the tide of domestic heating practices, especially in more affluent areas. In these circumstances it seems reasonable to examine long-term trend data to see if they support the exceptional claims made on behalf of the Clean Air Act.

**EVIDENCE FROM KEW**

The site of the Kew station, although well inside the London urbanized region, is sufficiently exposed to be affected to only a minor degree from local emissions. It is reported that higher pollution levels are not associated with wind direction from the nearest built-up areas (0.5 km to the west), but with east–northeast winds coming across 2 km of open space from the direction of the major pollution sources (Lawrence, 1969). This Kew data may be taken as a good indicator of long-term trends in the London region, although not perhaps of central London.

Mean smoke levels for the calendar months of the heating season (October–March inclusive) were averaged to provide a single value for each winter beginning with 1922/23 and continuing to 1970/71. The means are plotted in Fig. 3. Means for 1939/40, 1940/41 and 1970/71 are based on the values of 5 months only. On visual inspection, a pronounced downward trend is apparent both before and after the 1955/56 season. The widely reported improvements since the Clean Air Act of 1956 do not seem significantly more remarkable than those which preceded the Act. It does seem that there has been a consistent decline in the years 1963/64, 1964/65, 1965/66, 1966/67 and 1967/68. This decline has now levelled off, and the overall magnitude of the decline as
well as the rate of decline on an annual basis does not appear unduly large when compared with similar declines that have occurred in the past (Table 1).

The line of least squares for the period 1922/23–1956/57 is plotted in Fig. 3. If extended to 1970/71 it predicts a level of smoke concentrations for that year very close to the observed level. This suggests that the decline in smoke concentrations at Kew and in the London region since the Clean Air Act of 1956 is almost what might have been expected from the trends that had been underway before 1956. Caution should be exercised, however, in the interpretation of the data and analysis presented in Fig. 3. It would, in our view, be as inappropriate to deny the value of the Clean Air Act on the basis of Fig. 3 as it is to assert its success on the basis of Figs. 1 and 2. The processes involved are complex and interactive. Emissions of smoke may have been reduced in response to the application of the Clean Air Act or in anticipation of its application. Emissions have also declined as a result of industrial and commercial change-over to oil in place of coal as a source of heat and energy. On railways, diesel and electricity-powered engines have replaced steam. Residential users have converted from the coal fire to electric and gas fires, and to oil and electric central heating. The changes have been influenced in particular places and at certain times by urban renewal and slum clearance, by the availability and price of coal, and by other factors, including the Clean Air Act.

**Cities without Smoke Control**

If the decline of smoke concentrations at Kew, or in the London region generally, is due to the efficacy of the Clean Air Act, then there should be much less evidence
### Table 2. Smoke decreases at Norwich, Brighton and Plymouth

<table>
<thead>
<tr>
<th>Site</th>
<th>Type</th>
<th>First year of complete and available records</th>
<th>Smoke levels year 1 $\mu g\ m^{-3}$</th>
<th>Smoke levels final year $\mu g\ m^{-3}$</th>
<th>Smoke decreases $\mu g\ m^{-3}$</th>
<th>Smoke decreases/year $\mu g\ m^{-3}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norwich 4</td>
<td>$B_3$</td>
<td>1959/60</td>
<td>120</td>
<td>47</td>
<td>73</td>
<td>6.6</td>
</tr>
<tr>
<td>Norwich 6</td>
<td>$C_2$</td>
<td>1962/63</td>
<td>145</td>
<td>55</td>
<td>90</td>
<td>11.3</td>
</tr>
<tr>
<td>Norwich 7</td>
<td>$A_3$</td>
<td>1963/64</td>
<td>213</td>
<td>41</td>
<td>172</td>
<td>34.4</td>
</tr>
<tr>
<td>Norwich 8</td>
<td>$D_7$</td>
<td>1963/64</td>
<td>136</td>
<td>49</td>
<td>87</td>
<td>12.4</td>
</tr>
<tr>
<td>Norwich 9</td>
<td>$A_2$</td>
<td>1962/63</td>
<td>152</td>
<td>43</td>
<td>109</td>
<td>13.6</td>
</tr>
<tr>
<td>Brighton 1</td>
<td>$A_3$</td>
<td>1963/64</td>
<td>133</td>
<td>59</td>
<td>74</td>
<td>12.3</td>
</tr>
<tr>
<td>Brighton 2</td>
<td>$A_2$</td>
<td>1963/64</td>
<td>175</td>
<td>64</td>
<td>111</td>
<td>18.5</td>
</tr>
<tr>
<td>Brighton 3</td>
<td>$B_1$</td>
<td>1966/67</td>
<td>56</td>
<td>43</td>
<td>13</td>
<td>3.3</td>
</tr>
<tr>
<td>Plymouth 11</td>
<td>$D_1$</td>
<td>1961/62</td>
<td>105</td>
<td>49</td>
<td>56</td>
<td>6.2</td>
</tr>
<tr>
<td>Plymouth 12</td>
<td>$B_3$</td>
<td>1963/64</td>
<td>30</td>
<td>24</td>
<td>6</td>
<td>0.7</td>
</tr>
<tr>
<td>Plymouth 13</td>
<td>$A_1$</td>
<td>1962/63</td>
<td>162</td>
<td>86</td>
<td>76</td>
<td>9.5</td>
</tr>
</tbody>
</table>

### Table 3. Smoke decreases in London

<table>
<thead>
<tr>
<th>Years</th>
<th>Number of stations</th>
<th>Range $\mu g\ m^{-3}$</th>
<th>Decrease $\mu g\ m^{-3}$</th>
<th>Rate of decrease $\mu g\ m^{-3} y^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>London winter and summer mean</td>
<td>?</td>
<td>110–35</td>
<td>75</td>
<td>9.4</td>
</tr>
<tr>
<td>Kew 1</td>
<td>1</td>
<td>148–36</td>
<td>112</td>
<td>14.0</td>
</tr>
<tr>
<td>London winter and summer mean</td>
<td>?</td>
<td>170–45</td>
<td>125</td>
<td>11.4</td>
</tr>
<tr>
<td>Kew 1</td>
<td>1</td>
<td>168–41</td>
<td>127</td>
<td>11.6</td>
</tr>
<tr>
<td>Kew 1</td>
<td>1956/57–1969/70</td>
<td>1</td>
<td>110–36</td>
<td>74</td>
</tr>
</tbody>
</table>
of decline (or even an increase) in other cities where no smoke control programmes have been adopted, or have been adopted only recently.

In seeking cities for comparative examination, relatively isolated or coastal locations were chosen to reduce the likelihood of observations being affected by diffusion of smoke from nearby sources. Norwich, Brighton and Plymouth meet these requirements. The data for these cities are plotted in Fig. 4, showing winter (October–March) levels at each station. In cases when complete data for a particular year are lacking,

Fig. 4. Average winter smoke concentrations in Norwich, Brighton and Plymouth.

Fig. 5. Average winter smoke concentrations in London.

the points are connected by dashed lines. From visual inspection it is clear that considerable smoke reductions have occurred. Some decreases per year are listed in Table 2 and it can be seen that these are comparable in magnitude to the averages for London listed in Table 3.

The curve of winter smoke values for London (Fig. 5) is based on all 18 stations (including Kew 1) in continuous operation since 1961/62 and having no more than 1 y of missing data. The winter and summer mean trend for London is reproduced from Craxford, Gooriah and Weatherley (1970) and shows somewhat lower rates
of smoke reductions since 1961. It is not possible to extend the London average curve back in time any further than 1961/62 with complete reliability.

Norwich is sufficiently removed from London and the midland industrial towns to be little affected by smoke except that originating within the town itself; it has had no smoke control programme in operation prior to 1969. Five monitoring stations have been collecting data continuously since 1961, recording daily levels of smoke pollution. There was little public demand for smoke control in the past since the nature of local light industry precludes heavy air pollution. One designated smoke control zone of 104 acres (Zone 1) became operative in July, 1969. It is in the centre of Norwich and consists of commercial establishments and blocks of flats. This area was in the process of redevelopment prior to 1969, and by the time legislation was introduced, the new premises completed or under construction were already equipped with gas or electric heating systems.

Two other Norwich areas designated as smoke control zones are (a) 727 acres (Zone 2) of open country southwest of the city (1 dwelling), and (b) 604 acres (Zone 3) of land containing an airfield and some light industry on the northern perimeter of the city. These two areas became operative smoke control zones in November 1972. In any case, due to the absence of smoke emissions in (a) and minimal emission in (b), legislation is unlikely to have any effect on smoke levels in these areas. The designation of these zones as areas of control is a foresighted act to anticipate potential industrial or residential growth.

It is clear from Fig. 4 that significant decreases in mean winter smoke concentrations have been occurring in Norwich at least since 1961. This decline cannot be attributed to the smoke control programme which began only in July, 1969, and which in any case applies only to three areas of the city that contain no major sources of pollution.

The record of smoke concentrations examined from Norwich, Brighton and Plymouth (Fig. 4) does not conflict with the implications derived from the long-term data at Kew. It seems likely that in the absence of the Clean Air Act of 1956 substantial improvements in air quality would have occurred anyway as a result of socio-economic factors that have been leading to increased use of oil and fuels other than coal in industry, and a displacement of the coal fire as the normal form of domestic heating. We suspect that the undoubtedly improvements in air quality are a continuation of long-term trends. While the Clean Air Act of 1956 may have hastened this process somewhat and has provided a tool for prevention of detrimental smoke concentration in areas of future development, none of the evidence examined lends support for the strong claims made on behalf of the Act.

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