

Students and Scientists Take a “Lichen” to Air Quality Assessment in Ireland

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During the eighties second level students in Ireland were involved in the primary acquisition of data for scientists assessing air quality. The techniques and methodology devised by the scientists were pilot tested in Cork city in 1982. These included mapping lichen and leaf yeast distributions, and measuring acidity of precipitation. Local teachers were contacted about participating in the project. The teachers attended seminars on the techniques to be used, were supplied with background information, and were provided with the scientific equipment to conduct the survey. Following the success of the pilot project, other areas in the country were surveyed for air quality with the cooperation of students and teachers. In 1988, the research team from An Foras Forbartha and Trinity College Dublin collaborated with over 100 secondary science teachers and their students to assess the air quality of the Greater Dublin area. After the completion of each survey members of the team visited the schools, discussed the results with the teachers and students, and presented them with a copy of the final report. For various reasons the research team could not conduct further studies. However, some students in the cooperating schools did continue and have presented their findings over a number of years at a national student science competition. In addition, the survey methodologies are expected to reappear as part of a new second level curricular reform in Ireland.

KEY WORDS: Scientist/Student partnership; air quality assessment, lichen distribution.

INTRODUCTION

When one envisions Ireland the images that often come to mind include an unpolluted landscape of green fields, a battered western coastline, church and castle ruins, and small villages. However, Ireland as a member of the European Community and with one of the fastest growing young populations in Europe faces many environmental challenges. One of these is air quality. In Dublin, like other urban areas in Europe and the U.S., air quality has been of major concern. The Greater Dublin metropolitan area is now inhabited by over one million people. Maintaining an adequate and safe air quality for this popula-

tion is important for health and consequently economic reasons.

One of the techniques frequently used to monitor and assess air quality by professional botanists in an area is the distribution of lichen species and the examination of lichen growth. In the past, this method had been used in Scandinavia, France, Germany, and the British Isles (Henderson, 1982). In 1972, the first complete air quality survey of Britain was conducted with the assistance of students (Mabey, 1974). Following this study and as a result of the continuing air quality research based on lichens, more materials were developed for use in further studies involving students. These included an ‘Air Pollution and Lichens’ Wall Chart developed by the Natural History Museum, London and simple lichen identification guides complete with color plates (Dobson, 1979). In the Irish study, in addition to the lichen survey, leaf yeasts were to be used as an as-

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assessment of air quality. Acid precipitation was the final parameter measured in the survey.

During the summer of 1982, a pilot project to study the feasibility of students assessing air quality with the assistance of their teachers was proposed for Cork city, Ireland. This area was selected for two main reasons: 1) the enthusiasm of the science teachers in the area, and 2) it is the second largest urban area in the country. In addition, the material to be taught in the survey was relevant to the ecology, applied ecology, and microbiology sections of the Leaving Certificate Biology curriculum and created greater receptivity among the teachers for the project. (This is equivalent to the curriculum for junior and senior high school students in the U.S.) Because of the previous research in other countries, it was decided to employ more sophisticated procedures in the study and determine if students could follow these more detailed instructions. Depending on the success of this pilot project, it was envisioned that the procedures could be modified, if necessary, for use in subsequent surveys that would eventually produce detailed information for the whole country. Based on the successful results of this pilot project, the research was extended in subsequent years to other areas of the country (Shannon Estuary, south coast east of Cork city, east coast of Ireland, and finally the Greater Dublin area). This paper details the methods and techniques used, reports the results of the final survey for the Great Dublin area, and examines the success of the students in the collection of the primary data.

BACKGROUND

Lichens have been traditionally used by scientists to assess air quality. While it is known that they are extremely sensitive to deteriorating air quality, the reasons behind this sensitivity are complex. Even though the sensitivity of specific species over others is well documented it is not greatly understood, however certain generalizations can be stated. Lichens absorb substances from liquid precipitation and consequently are particularly susceptible and sensitive to airborne toxic compounds such as sulfur dioxide (SO_2). Because of their biological structure, crust lichens such as the script lichen (*Graphis scripta*) are more tolerant of poor air quality than leafy species such as oak moss (*Evernia prunastri*). The least tolerant or most sensitive species to air pollution is the

shrubby form of lichen such as old man's beard (*Usnea subfloridana*). Because of the moderate temperate climate, over 1,400 species of lichens are recorded in Ireland making the country one of the richest sources of lichens in Europe and an ideal location for such scientific research.

Leaf yeasts are small fungi that thrive on exudates from the leaf surface on which they grow. They are not harmful to the host, but because they live in exposed conditions and have efficient absorption mechanisms they are especially susceptible to inhibition by airborne toxins. As a result, certain species such as the pink colored leaf yeast (*Sporobolomyces roseus*) are greatly reduced in urban environments (Dowding and Carvill, 1980).

Acid precipitation, either liquid or solid, can be detrimental to environments and particular plant species in an area. During the late seventies and early eighties, this phenomenon was recognized as having a major impact on biological systems (Harvey *et al.*, 1981; Pearce, 1982). Because both lichens and leaf yeasts absorb nutrients from precipitation they are particularly susceptible to phytotoxic substances such as SO_2 .

METHODOLOGY

The basis scientific methods followed in this project were first developed in 1982 for the Cork city pilot project. They were adjusted as a result of some of the findings in the Cork survey for the subsequent projects. Students, as in all the studies, were involved in the primary data acquisition. The health of the corticolous community (i.e., lichens living as epiphytes on trees) in an area was to be reported to the scientists. The methodology as outlined here was followed for the Greater Dublin area survey conducted in 1987. The area used in the study "extended from Bray to Malahide and as far inland as Maynooth. This included Dublin City and its suburbs—the Greater Dublin area, extending into County Kildare on the western side" (Ni Lamhna *et al.*, 1988). To perform the survey, the area was divided into 36 five km squares while the city was divided into 257 one km square blocks. One hundred of the 180 secondary schools in the study area were required to complete the survey. All the schools were contacted and given the opportunity to participate in the survey. Members of the research team also visited the schools.

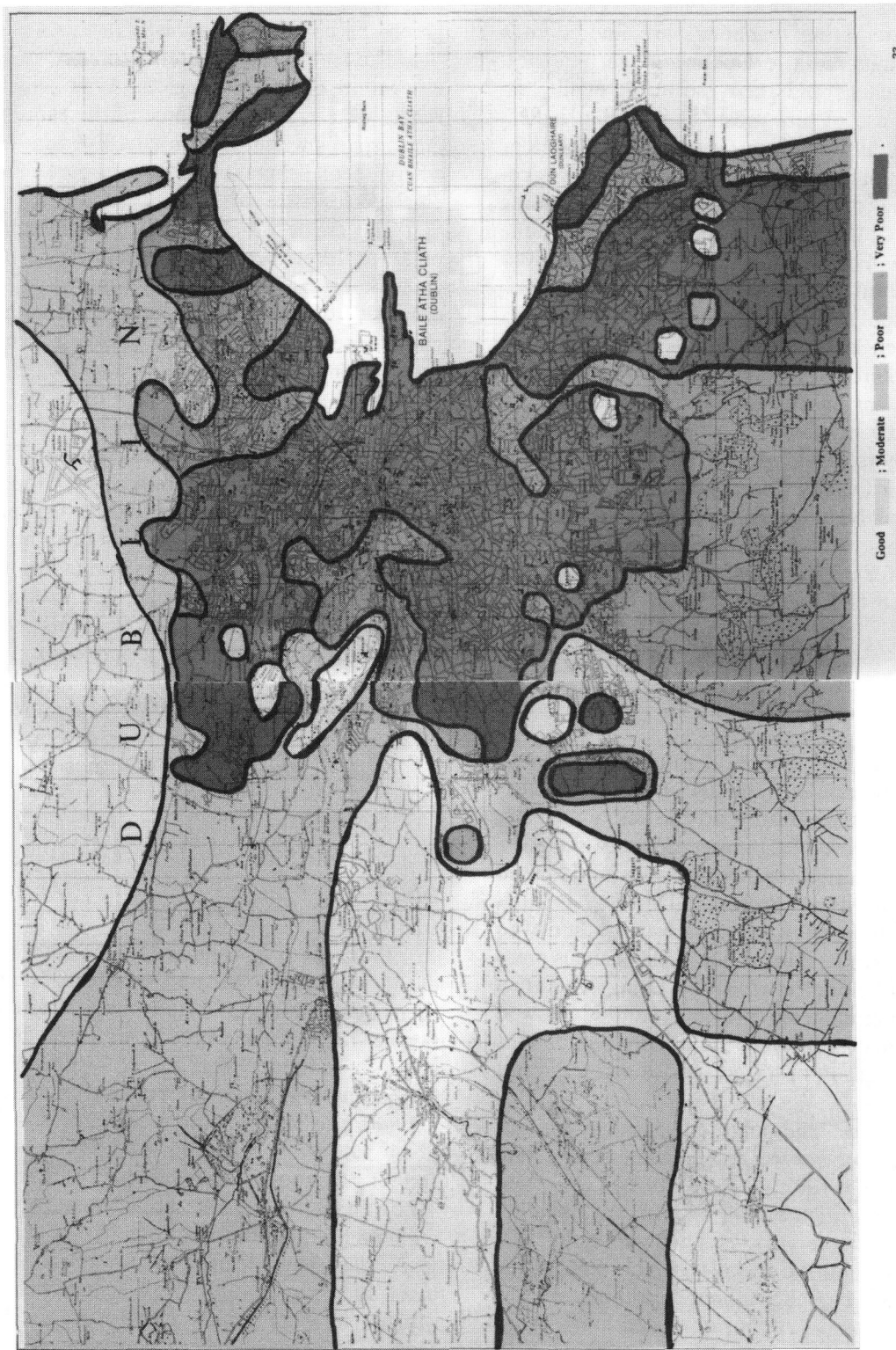


Fig. 1. Air quality zones within the Greater Dublin area created from the leaf yeast data acquired by the students. Light areas have good air quality, dark areas have poor air quality (Ni Lamhna *et al.*, 1988, 22-23).

areas, often for many years, unless the pollution levels are extremely toxic. In contrast, leaf yeasts respond more quickly to pollution, within 48 hours to changes in SO₂ levels. Therefore, in this survey, the data confirmed that the "lichen results reflect the condition of Dublin's air as a result of the last few years of pollution while the leaf yeasts indicate the pollution problem for September" (ibid., 30).

Figure 2 represents the air quality map produced from local authority monitors. Note the correlation between the map produced from the student acquired data which were analyzed by the research team and the monitor map. This again reinforced the validity and reliability of the data acquired by the students. Student data were also probably more accurate because they were acquired over a large area.

Acid precipitation, while a valuable measurement, did not provide information on the relative amounts of ions dissolved in the liquid. These solutes, such as sulfate, sulfite, chloride, nitrate, nitrite or ammonium ions, may be important to phytotoxic effects. However, measurement of these ions was costly in terms of equipment, time and personnel (Ni Lamhna *et al.*, 1983) and therefore were not utilized as part of the survey.

CONCLUSIONS

From the results of this and the previous surveys, it was concluded that both lichens and leaf yeasts could be used as an assessment of, and as a method to maintain, air quality. However, because of differences in their response time to pollution, the two techniques did not correlate. In addition, while the "techniques and value of lichens studies are well established....the leaf yeast method" (ibid.) required further refinement. The data acquired by the students also corresponded with and validated that of the pollution monitors.

Once the survey data were fully analyzed and the final report completed, the research team visited each of the participating schools and discussed the results of the project with the students and teachers. Each one of the schools also received a copy of the final report.

A report "An Air Quality Survey of the Greater Dublin Area carried out by Second Level Students" was published in 1988. Later that same year, the sale of bituminous coal was banned in the city. Previous attempts by the government to improve air quality in

the capitol by banning the burning of coal had met with opposition from residents. Calls for compensation from the government by the people in the area would result in large federal expenditures. However, the legislation which banned the sale of coal in Dublin nullified the claims for compensation from residents but more importantly has proved successful in improving the air quality in areas of the city. Improved air quality should result in growth of lichens and this has been confirmed by one of the research team. "Lichens are now appearing in areas where they were absent during the survey" (Lamhna, pers comm).

The Success of Air Quality Surveys in Ireland as an Example of Scientist/Student Partnerships

The success of this program relied on many different features. From the first pilot survey in Cork local scientists, as well as scientists from Trinity College Dublin and personnel from An Foras Forbartha, were involved in the program. The pilot survey also illustrated that the "three methods for assessing air quality that were used....are sufficiently robust to be used by schoolchildren. Furthermore, they are reasonably inexpensive to perform, do not require expensive capital equipment, and provide valuable and complementary data on air quality which could not be readily obtained by other means" (Ni Lamhna *et al.*, 1983, 14). All of these points were important features of the survey and helped it succeed.

From the teacher's viewpoint, certain concepts from the ecology and applied ecology sections of the biology curriculum were taught through the survey methodology. In addition, microbial techniques and concepts from the microbiology section of the biology curriculum were also an important part of the survey. This innovative approach to teaching such concepts and techniques was motivating and exciting to the teachers and students. It also met the requirements for the Leaving Certificate (high school) Biology examination. The teachers also received all the necessary background materials including the scientific instructions for the survey, as well as the equipment required to grow the leaf yeasts. This reduced the time commitment of the teachers and concentrated their time on the more important aspects of the survey, i.e. teaching the students the necessary scientific skills.

The visits of the research team to the participating schools before the survey highlighted the sig-

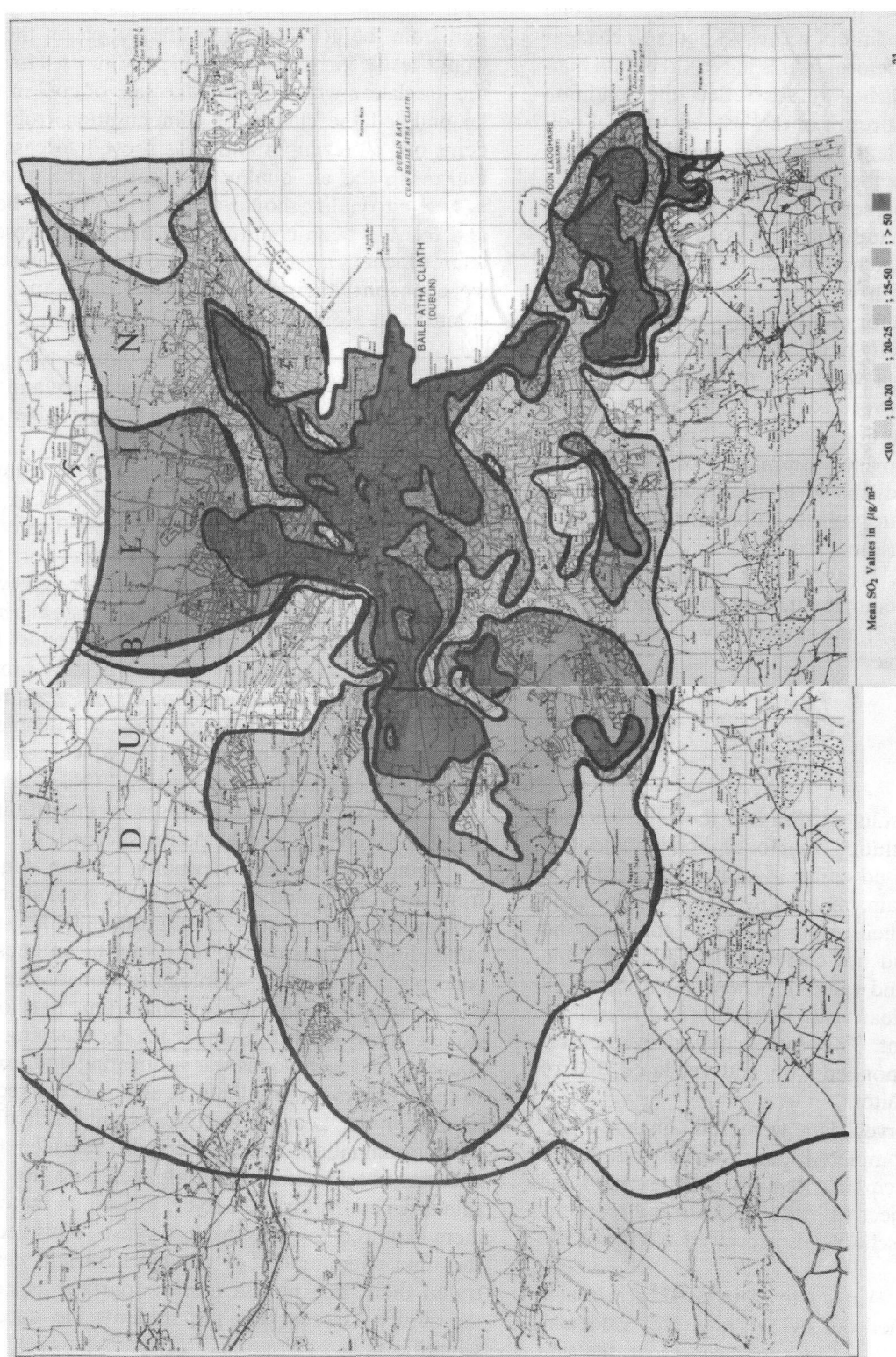


Fig. 2. Air quality zones as delineated by Dublin city (local authority) monitors. Mean SO_2 values are lower in lighter areas (less than $20 \mu\text{g}/\text{m}^3$) greater than $50 \mu\text{g}/\text{m}^3$ in dark areas (Ni Lamhna *et al.*, 1988, 20-21).

nificance of the project to the students and teachers. The students and teachers were enthused by their involvement in current scientific research on a topic which had significance to them. In addition, on completion of each survey report all the participating schools were again visited by members of the research team and provided with a copy of the final report.

The benefits of creating local archives on such information has been highlighted as an educational and scientific tool. In the past few years, some students in the participating schools have used the historical records on lichen distribution as well as the other aspects of the survey in their own school research projects. These projects have been entered in the premier national student science competition in Ireland, the Aer Lingus Young Scientists Project. Many of the winners of this competition proceed to European and world science competitions.

The final air quality survey was performed in 1988. Funding for the project was discontinued, largely as a result of the abolition of the agency involved, An Foras Forbartha, and the disintegration of the research team. However, the survey will soon reappear in a new form. Post primary curriculum in Ireland has been reformed over the last decade. A new addition to the curriculum is the Transition Year, located roughly between the U.S. middle and high school years. In this year, students are encouraged to become involved in projects that may not be possible in the usual curricular framework. One of the original research team, Ni Lamhna, is currently documenting the scientific instructions or protocols

required for this survey and these will reappear in a new publication (Ni Lamhna, pers comm) aimed at transition year students.

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