Study of Environmental Effects on Cultural Property

Project Findings and Recommendations

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United Nations Development Programme

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Study of Environmental Effects on Cultural Property

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United Nations Educational, Scientific and Cultural Organization

United Nations Development Programme
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I. INTRODUCTION

1. Indian cultural property is varied and vast. Museums, archives and other cultural institutions contain immovable art objects such as stone sculptures, bronze images, textiles, paper manuscripts, paintings, etc. There are also innumerable monuments and historic buildings constructed of various types of stone and other materials. It has been shown that atmospheric pollution can have a tremendous harmful effect on monuments, as well as on the objects housed inside the buildings. In India, the setting up of the Oil Refinery close to Agra where the Taj Mahal is situated drew particular attention to the pollution threat. In that context, some studies were undertaken by some of the Indian institutions. The level of atmospheric pollution is bound to rise at the same rapid rate as the increase in development and industrial programmes. Even though the threat to cultural property is increasing in India because of atmospheric pollution, there have not been many studies made to better understand the process of deterioration caused by pollution, for example, the type of deterioration and the methods used to combat it. It is obvious that such studies will be extremely important in the wider context of conservation of cultural wealth, not only for India but for other countries as well.

2. There are certain fundamental issues involved in the entire process of the study of the effects of atmospheric pollution on cultural property. First of all, what has to be determined is whether a particular pollution level has been reached or not, and if so, what effect it may have on the cultural heritage. Then the impact rate of the pollutant concentration has to be calculated. Questions such as the permissible limits of pollutants in the atmosphere still remain unanswered. The most important part of the study could be the evaluation of the procedures for minimizing the effect of pollution on the property.

3. Another aspect of the problem needs to be investigated. Objects are treated in the Laboratory but even after they are treated the damage to them continues because of the effect of pollution. Similarly, the monuments - even after treatment, cleaning and repair - continue to deteriorate, possibly because of the polluting gases present in the air.

4. It was therefore considered essential that an intensive study be undertaken to find ways and means of evaluating the extent of pollutants and the extent of the damage to the objects. A project for developing the capabilities of the National Research Laboratory for Conservation of Cultural Property (NRLC) in this area was therefore prepared. UNDP was approached to support the project. The project was considered a mere beginning and was designed to stimulate wider interest for future studies.

5. In 1983 the project for the study of environmental effects on cultural property was approved by the UNDP and the Government of India. Unesco was to act as the International Executing Agency and the Department of Culture, through the NRLC, was to be the Governmental implementing agency.

6. The project document envisaged UNDP inputs amounting to US $ 208,000.
The Government of India was to contribute Rs. 960,000. In practice, however, this expenditure was much higher.

II. OBJECTIVES OF THE PROJECT

7. Project activity began in October 1983. The programme's development objectives were:

a) to minimize damage to cultural property due to atmospheric pollution;

b) to ensure preservation of cultural property of various sorts, including monuments and art objects in museums.

The immediate objectives were:

a) to establish capabilities at the NRLC to undertake studies for evaluating the extent and nature of pollution in the atmosphere and to understand its effect on various types of cultural property;

b) to formulate guidelines for custodians of cultural property.

III. ACTIVITIES AND OUTPUTS

8. In order to implement and develop the immediate and future plans of the project, the following objectives were set down and carried out:

a) Identification of the problems.

b) Selection of equipment for ordering and delivering.

c) Selection of candidates for training under individual fellowships. Selection of places for training, preparation of programmes, etc.

d) Training by international experts and consultants of NRLC scientific staff in corrosion evaluation.

e) Training of a member of the NRLC scientific staff in the testing of change in paper products.

f) Survey of atmospheric parameters in selected areas.

g) Setting up of experiments for testing of samples.

h) Training of NRLC scientists in air monitoring techniques by international consultants.

i) Organization of national workshops and seminars.
9. There was provision in the budget for two consultants from abroad. The two experts, namely Dr. Marisa Tabasso and Dr. Maurizio Marabelli of the Istituto Centrale del Restauro, Rome, visited the NRLC and had intensive discussions with the NRLC scientists in the areas. A project for studies was prepared with their help.

10. Under the auspices of the Project, two NRLC scientists received fellowships and were trained abroad in the following areas of studies:

   a) Effects of atmospheric pollution on cultural property and analysis and examination of altered samples and their testing. The work was done at the Istituto Centrale del Restauro, Rome.

   b) Studies on the alterations in paper at the Istituto Centrale del Patologia del Libro, Rome.

11. The training of these two scientists was useful in understanding the methodology being used abroad for such studies. The knowledge gained has been adopted with suitable modifications for applicability to Indian conditions.

12. The studies of Dr. K.K. Jain at the Istituto Centrale del Restauro, Rome, were carried out mainly in two stages. The first stage covered the following:

   a) The theory of air pollution and its effects on cultural property.

   b) Monitoring of sulphur dioxide and suspended particulate matter.

   c) Analysis of suspended particulate matter for acidity, soluble salts, sulphur dioxide, chlorides and ammonium ions, etc.

13. The studies in the second stage were divided into three main groups:

   a) Analysis of altered samples from monuments. For this exercise samples from Benevento were studied microscopically, chemically and by X-ray diffraction. Porosimeter studies were also carried out.

   b) Testing of unaltered samples. The tests performed included water absorption by capillarity and by total immersion, water permeability, rate of evaporation of water, measurement of contact angle and surface roughness, artificial weathering and consolidation of samples.

   c) Study of deterioration, cleaning and consolidation of some Italian monuments.

14. On his return, Dr. Jain wrote a detailed report entitled "Effect of Environmental Factors on Cultural Property and Analysis/Examination of Altered Samples and Their Testing". The report gives techniques of analysis, pollution monitoring methods, etc. It has been circulated to concerned institutions in
the country and forms a part of the project as well.

15. Mr. D.G. Suryawanshi, who worked at the Istituto Centrale del Patologia del Libro, Rome, conducted studies to learn the methodology to characterize paper by such parameters as physical strength, grammage, tensile strength, stretch strength, folding endurance, air permeability, reserve alkali, degree of polymerization, etc. He also studied the techniques for the determination of functional groups in cellulose as factors for the deterioration of paper. Pollution produces certain types of changes in the physical and chemical properties of paper. Mr. Suryawanshi determined the methodology of the outcome of these changes. He also prepared a detailed report describing the techniques that he learned. This report has also been made available to other institutions.

16. One scientist, Dr. Tej Singh, spent one month in the United States on a study tour. He visited the Materials Testing Laboratory at the Environmental Protection Agency of the United States as well as the Conservation Centre of the Institute of Fine Arts, New York University. He also discussed with American researchers the problems of the Statue of Liberty and paid a visit to the Bell Laboratories where work on the effect of atmospheric pollution on metals was in progress. He worked at the Materials Testing Laboratory to understand the basic techniques of testing materials for understanding the effect of atmospheric pollution.

17. As part of the project activity, the content of the NRLC training courses given to conservators was revised to give more emphasis to the study of the effects of atmospheric pollution on archaeological objects. The aim was to make the trainees aware of basic pollution effects.

18. To ensure that everyone (directors, curators, archaeologists and others) also be aware of the problem, an in-depth discussion on the subject was introduced in workshops held at the Laboratory in 1984, 1985 and 1986.

19. A National Seminar on the "Effects of Atmospheric Pollutants on Monuments" took place from 19-20 April 1986. Several scientists working in the field participated in the seminar and exchanged views. The following papers were presented at the seminar:

a) Background Note on the Effect of Atmospheric Pollution on Monuments, by O.P. Agrawal.

b) Atmospheric Pollution and Conservation of Monuments, by Professor J.M. Dave.

c) Air Pollutants Effects on Historical Monuments, by Dr. P.K. Mair, Madhu Bala, Amita Malik and Umesh Taneja.

d) Studies on Pollution Profile of the Taj Mahal, by Dr. M.C. Ganorkar and M. Bhaskar Reddy.

e) Effect of Atmospheric Pollutants on Monuments, by Dr. B.B. Lal.
f) Monitoring of Atmospheric Pollutants for Monuments, by Dr. Hot Chand.

g) Effects of Atmospheric Pollutants on Monuments, by Dr. K.V. Rao.

20. The Seminar participants made some important recommendations. The proceedings of the Seminar were widely circulated for the benefit of other institutions in the country. The papers presented were grouped together and circulated to all interested parties.

Scientific Research and Study

21. Following the discussions with international experts as well as with national specialists, the main areas of scientific research and studies were defined and implemented successfully as follows:

22. **Study of Copper Corrosion Inhibitors:** Copper and bronze objects continue to deteriorate and tarnish even when displayed or stored in a museum. This type of effect is largely due to the pollution present in the atmosphere. Some studies had been performed previously in this direction. During the project period further studies were undertaken to include an increasing number of chemicals which can have a corrosion inhibiting property on copper and its alloys—bronze and brass—against atmospheric pollution. The results of these studies are available to the other institutions.

23. **Study of the Effect of Sulphur Dioxide on Textile Dyes:** Some of the textile dyes fade very quickly and are affected by light, humidity, etc. It is suspected that pollution, like sulphur dioxide, would play an important role in the fading of dyes. In order to understand this possibility, experiments are under way in the Laboratory to observe the effect of sulphur dioxide on textile dyes. A number of dyes are being tested. As a first step in understanding the nature of dyes used in Indian textiles, samples of dye fibres in the collections of various museums were assembled. The dyes were identified through thin layer chromatography (Kharbade, B.V. and Agrawal, O.P., "Identification of Natural Red Dyes in Old Indian Textiles: Evaluation of Thin Layer Chromatographic Systems", *Journal of Chromatography*, 347, 1985, 447-54). After an extensive literature survey, a list of prominent dyes was prepared. Some reference samples were dyed with the colouring materials acquired by the Laboratory for experimental purposes. A chamber for artificial pollution has been designed in which the textile samples are now being exposed to sulphur dioxide gas. The results should be of considerable interest.

24. **Pollution Levels in Museums:** A project was undertaken to study the effects of pollution on the internationally known stone sculptures in the Government Museum, Mathura. This museum was chosen because of its proximity to the Mathura Oil Refinery. Atmospheric measurements were undertaken. Simultaneously, samples from the sandstone sculptures as well as the dust fallout were taken and chemically analyzed. The idea was to see if there was any formation of sulphates. However, no sulphates were identified in any of the objects. The studies will continue.
Conservation of Stone Sculptures at the Mathura Government Museum:
Stone sculptures at the Mathura Government Museum are made out of spotted red sandstone. This sandstone is rapidly deteriorating. Layers of sandstone are escaping from the sculptures. Similarly, the stone surfaces are eroding. The problem of the conservation of these sculptures was referred to the NRLC which undertook a special project for their conservation.

It was found that one of the causes of deterioration was the presence of soluble salts which seeped up to the stone sculptures from the ground. High humidity prevailing in the atmosphere was another contributory factor. After extensive experimentation, a technique has now been perfected whereby the soluble salts have been removed and the supportive statue reinforcements have been put back into place.

Studies on the Taj Mahal: The concern about the effect of atmospheric pollution on the Taj Mahal is shared by everyone. The NRLC has been named as the coordinator for scientific studies on the Taj Mahal. Studies were undertaken by the NRLC to identify the Taj Mahal marble and the type of pollutant attacking it. Samples from the surface of the marble as well as its surface dust deposits were collected and analyzed. Data about the atmospheric parameters has also been collected. So far the deterioration of the Taj Mahal is attributed mainly to natural causes rather than to atmospheric pollution. However, experiments are still going on and nothing can be said positively unless more work is done.

Training of NRLC Scientific Staff

Some of the NRLC scientific staff to be attached to the pollution studies were trained abroad in highly advanced laboratories. These scientists had already worked for a number of years for the NRLC, thus acquiring useful knowledge of the use of available equipment and a practical understanding of the problem. In order to provide these researchers with other types of investigations required for the study of the effect of environmental pollution on cultural property, they were provided with an opportunity to experiment in laboratories where such testing was in progress. Commandable work on the study of the effect of environmental pollution on stone has been done at the Istituto Centrale del Restauro, Rome, and at the Istituto Centrale del Patologia del Libro, Rome, regarding paper. Therefore, one scientific officer was sent for training at the Istituto Central del Restauro, Rome, and the other at the latter institute. This training provided them with excellent opportunities for understanding and working on some of the most advanced equipment.

On their return, these scientists tried to further develop the techniques for particular use in India. Simultaneously, the equipment required for such work has also been obtained and is now in operation.

One of the senior scientific officers visited the facilities at the Environmental Protection Agency in the United States in order to become familiar with the techniques being used at that institute for the study of the effect of environmental pollution on various types of matter.
Equipment

31. Equipment was procured through funds provided by UNDP and the Government of India. The UNDP project provided for an input of US $150,000 for the purchase of equipment, and was later revised to US $171,597. The main items of equipment procured under the UNDP project are listed in Appendix D.

32. All the equipment was installed and standardized soon after its arrival. No major problems were experienced. One of the important pieces of equipment, namely the X-ray diffractometer, is yet to be received. Some of its accessories have arrived, but not the main element. It is expected soon.

33. Several items of equipment were obtained with Government funds. Appendix E lists the important items of equipment thus acquired. The counterpart staff who worked for the Project is given in Appendix F.

34. Facilities for the studies of the effect of environmental pollution on cultural property developed as a direct result of the UNDP project and include the following items:

35. Air Sampling Equipment: For the collection of different types of pollutants present in the air and their subsequent determination by suitable techniques, the following types of air samplers have been acquired.

   a) Station-type Hi-Vol Air Sampler;

   b) Portable Hi-Vol Air Samplers;

   c) Sequential Air Samplers for gases;

   d) Sequential Air Sampler for particulates.

This equipment is used for the sampling of the air to be analyzed. The flow rate of sequential air samplers can be controlled and thus they can be used inside museums and monuments, etc.

36. Sample Preparation Equipment: The stone cutting machine ('Mottacutta') is used for breaking smaller stone samples into desired shapes and sizes for different types of laboratory studies. The machine has the additional facility of grinding the samples into a final shape for testing.

37. Physical Testing Equipment: The following two items of equipment have been procured for the measurement of physical parameters:

   a) Porosimeter: The porosimeter is used for the measurement of porosity and pore size distribution of porous matter such as stones and bricks. These measurements are made on stone samples before and after weathering. The samples give information on the extent of damage caused to different types of stone by various factors of deterioration.
b) Sonic velocity equipment: Passage of ultrasonic waves through solid material gives information on its physical state of health. The sonic velocity equipment is used for the studies on stone samples and on the monuments in situ as well.

38. **Analytical Equipment:** Analytical facilities of the laboratory have further been increased by acquiring the following equipment:
   a) UV/VIS Spectrophotometer.
   b) Multiple Internal Reflectance Accessory for Infra-Red Spectrometer.

This equipment is useful for the analysis of small amounts of different types of samples - gaseous pollutants, suspended particulate matter in air, particulate matter deposited and the reaction products formed on the surface of monuments and sculptures, etc.

39. **Goniometer:** A Goniometer is very effectively used for the identification of crystalline phases in all kinds of samples. When the equipment is received and installed it will be used for the identification of surface deposits on monuments, etc., and the products formed by the pollutants.

IV. **ACHIEVEMENT OF OBJECTIVES**

40. The immediate objectives of the project were:

To establish facilities at the NRLC at Lucknow, India, for evaluating the extent and nature of pollution in the atmosphere and the effects on various types of cultural wealth.

41. After guidelines for the custodians of cultural property were formulated, and after achieving the immediate objectives, the development objective of the project was to evolve techniques for minimizing damage done to the cultural properties due to atmospheric pollutants.

42. In order to achieve these objectives, various types of activities were carried out. The establishment of facilities at NRLC to undertake research on the subject demanded that:
   a) suitable scientific equipment be made available at NRLC;
   b) the NRLC scientists be properly trained to carry out the research work, and
   c) literature on the subject be compiled.

43. The equipment required for the project included the following:
   a) Air monitoring equipment;
b) Sample preparation equipment;

c) Equipment for simulation studies;

d) Equipment for analysis and evaluation.

44. The High-Volume Air Samplers cannot be used satisfactorily inside museums and monuments. Therefore, low-volume sequential air samplers were obtained. Besides these, other analytical equipment such as an X-ray fluorescence spectrometer were acquired. Atomic absorption spectrophotometer, X-ray diffraction equipment, infra-red spectrometer and microscopes were already available in the Laboratory. Thus the instrumental facilities to carry out studies on monitoring air pollution and on evaluation of the effects of atmospheric pollutants on cultural property have been fully developed at NRLC.

45. As regards the development of trained manpower to carry out research on the various aspects of the subject, two scientists of the Laboratory were trained abroad under fellowship programmes of four months each. One of the scientists concentrated on the monitoring of air pollution and the evaluation of the effect of air pollutants on stone, including monuments and sculptures. The other scientist received training in the study of the effect of air pollution on celluloid in general and on archives in particular. One senior scientist visited advanced institutions in the United States specialized in the study of atmospheric pollution and learned modern laboratory techniques. He also studied the evaluation of the effect of atmospheric pollutants on various types of materials in the field. The NRLC library has extensive literature on the subject, including several scientific journals. All this information has been put on a computer database.

46. Thus the facilities for studying atmospheric pollution have been fully established at NRLC. As a result of the project, field studies have begun. Various short-term and long-term research programmes have been undertaken. The results of the research will be made available to the custodians of Indian cultural property.

47. The Laboratory conducts annually a six-month training course for conservators and an Orientation Workshop for curators and directors of museums, archives and archaeology departments. These courses deal with the effects of atmospheric pollution on cultural properties. They include detailed discussions on the techniques used to minimize subsequent effects. The participants are also provided with extensive literature on the subject. During the last few years, representatives of several museums, archives and archaeology departments have profited from the programme. This forum will continue to be used extensively in the future to spread the knowledge on the subject.

48. The studies at the Mathura Government Museum indicated that there was virtually no effect of atmospheric pollution on the museum's collections. This was very significant and reassuring because it was feared that the marness to the Mathura Oil Refinery endangered the sandstone sculptures.

49. Another important area of study has taken place at the Taj Mahal. In fact the pollution effects on the Taj Mahal have been very controversial and
have been debated in scientific circles as well as by the public. For the Taj Mahal, extensive long-term studies have been carried out. The effect of environmental pollution is an important component of this study. This has been possible because of the project now under review.

50. More important than anything else is the establishment of facilities for undertaking studies on pollution and its effect on materials. Thus a project for the survey of pollutants inside the museum galleries and storage areas has been planned for the future. This programme will enable guidelines for saving the objects on display to be drawn up. So far the attention of pollution scientists has been drawn towards the study of the effect of pollution on monuments. Very little, or hardly any interest has been displayed towards the moveable art objects. In India, and in fact in the entire region of South and South East Asia, where museums are hardly ever air-conditioned, the problem could become acute. Even where the galleries are air-conditioned, the normal precautions for the control of environmental pollution are ignored. This is probably due to the mistaken impression that once the object is housed inside a building it is automatically protected from pollution. However, studies indicate that the pollution level inside a gallery can be as high as it is outside.

51. Very useful recommendations were made by the participants of the National Seminar on the Effects of Environmental Pollution held at the NRLC, Lucknow. As a result of this seminar which was a part of the project, two committees were formed to look into the questions of standardizing techniques of studying the effects of atmospheric pollution on different types of stone and for coordinating parameters for quantifying the extent of damage to stone.

52. The aim of the second committee is to help prepare a stone conservation index and case history of monuments.

53. Help to other institutions will also be provided by the NRLC Library which made special efforts to collect as much material as it could on environmental pollution and its relationship to cultural property. Now that the Library possessions are being registered on a computer, the task of preparing bibliographies of sub-sectors of pollution effects will be much easier.

V. FINDINGS

54. The effects of environmental pollution on monuments and art objects has become of paramount importance because of the rapid development taking place everywhere. This project was a serious attempt to acquire the technical know-how for research and studies on the subject.

55. The project was completed successfully, to the general satisfaction of all concerned. All the immediate as well as development objectives have been achieved. Studies for understanding the effects of pollution on various types of cultural property have started. It is also noteworthy that there are plans to intensify these study programmes to cover not only the monuments but also museums or galleries and libraries.
56. There has also been a serious effort to standardize techniques so that the result obtained by the NRLC and other institutions can be compared.

57. It is important that efforts be made to involve several institutions in the programme and that they be alerted to the dangers of pollution.

VI. CONCLUSIONS AND RECOMMENDATIONS

58. Thanks to the initiative of the NRLC, it is now possible to conduct pollution studies on the effects atmospheric pollutants have on India's cultural property. This was the most immediate objective of the project. NRLC is now in a position to promote further studies for tackling the problem. It would be desirable to intensify the research activities already under way so that further concrete results be obtained. These studies should be aimed not only at surveying or monitoring pollution but also at devising new techniques for controlling it.

59. Because of the importance of the subject, it would be advantageous to form a NRLC unit with the well-defined title of "Environmental Pollution Studies".

60. Involvement of other cultural and scientific institutions in this type of programme seems important. Their collaboration could be ensured by formulating multi-institutional projects. The formation of the committees referred to above is an example of such a cooperative project.

61. Because so little is known and understood about the effects of atmospheric pollution, it is essential that the custodians of cultural property be made aware of this danger, which can never be stressed enough. More publications should also be printed and distributed as another means of achieving the goal of averting the ravages that can be wrought on India's cultural heritage by environmental pollution.
## APPENDIX A

**Unesco Consultants**

<table>
<thead>
<tr>
<th>Name of Consultant</th>
<th>Country of Origin</th>
<th>Field of Specialization</th>
<th>Duration of Contract</th>
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<tbody>
<tr>
<td>Dr. M. Marabelli</td>
<td>Italy</td>
<td>Air monitoring</td>
<td>23.02.85</td>
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<td></td>
<td></td>
<td></td>
<td>16.03.85</td>
</tr>
<tr>
<td>Dr. M. Tabasso</td>
<td>Italy</td>
<td>Corrosion evaluation</td>
<td>23.02.85</td>
</tr>
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<td>16.03.85</td>
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## Unesco Fellowship/Study Tour

<table>
<thead>
<tr>
<th>Name of Fellow</th>
<th>Field of Study</th>
<th>Place of Study</th>
<th>Period of Study</th>
<th>Position on Return</th>
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</thead>
<tbody>
<tr>
<td>JAIN, K.K.</td>
<td>Analysis of altered samples and their testing</td>
<td>Istituto Centrale del Restauro, Rome, Italy</td>
<td>17.09.84 - 12.01.85</td>
<td>Junior Scientific Officer (as before)</td>
</tr>
<tr>
<td>SINGH, Tej</td>
<td>Effect of Environmental Protection on different types of material</td>
<td>Environmental Agency, USA and Conservation Centre of the Institute of Fine Arts, New York University</td>
<td>24.07.85 - 22.08.85</td>
<td>Senior Scientific Officer (as before)</td>
</tr>
<tr>
<td>SURYAWANSHI, D.G.</td>
<td>Effects of Environment on paper</td>
<td>Istituto Centrale del Patologia del Libro, Rome, Italy</td>
<td>09.09.85 - 08.01.86</td>
<td>Junior Scientific Officer (as before)</td>
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APPENDIX C

RECOMMENDATIONS MADE AT THE NATIONAL SEMINAR ON THE "EFFECT OF ATMOSPHERIC POLLUTANTS ON MONUMENTS" HELD FROM 19-20 APRIL 1986

1. Two committees were formed to detail:
   a) standardization of techniques for laboratory and field studies on the effect of atmospheric pollutants on different types of stone, and
   b) selection of parameters to quantify the extent of damage to stone for the purpose of preparing a stone corrosion index and establish case histories of the monuments concerned.

   **Action taken:** Two committees, under the chairmanship of Professor J.M. Dave and Dr. B.B. Lal were formed. The committees were expected to submit their reports within six months.

2. Regarding the identification of monuments chosen for detailed scientific studies, it was recommended that monuments selected should represent each type of stone situated in zones of different RH and temperature.

3. Studies should be undertaken to correlate the damage rate of monuments to the quality of air to which they are exposed.

4. An inventory of monuments in the country should be prepared to include the type of construction material used, their state of preservation and a brief history of each.

5. A case history of monuments regarding their state of preservation should be prepared and updated at regular intervals for possible correlation of the damage to the quality of air at a later date.

6. More air quality monitoring stations should be established throughout the country, particularly in the areas where monuments are situated.
APPENDIX D

MAIN ITEMS OF EQUIPMENT PURCHASED FROM UNDP INPUTS

Station type High-Volume Air Sampler, GMW, USA
Portable High-Volume Air Samplers (4), GMW, USA
Sequential Air Sampler for Gases, Anderson, USA
Sequential Air Sampler for Particulates, Terzano, Italy
Mottacutta, ELE, United Kingdom
Porosimeter, Carlo Erba, Italy
Sonic Velocity Equipment, Terrametrics, USA
UV/VIS Spectrophotometer, Beckman, USA
Graphite Furnace for Atomic Absorption Spectrophotometer; Perkin-Elmer, USA
Multiple Internal Reflectance Accessory for Infra-Red Spectrometer, Perkin-Elmer, USA
Goniometer, Philips, Netherlands (to be received)
APPENDIX E

Main Items of Equipment Purchased from Government of India Inputs

Multigas Sampling Unit, Micro Metal
High-Volume Air Sampler, Micro Metal
Environmental Chambers, Remi
Forced Air Circulation Oven, SICO
Stone Slab Cutting Machine, Macut
Stereomicroscopes, Olympus
Clean Air System, Klenzaids
Computer System S-850, Uptron
## APPENDIX F

### Counterpart Staff

<table>
<thead>
<tr>
<th>Name</th>
<th>Position Held</th>
<th>Qualifications</th>
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<tbody>
<tr>
<td>AGRAWAL, O.P.</td>
<td>Project Director</td>
<td>M.Sc.</td>
</tr>
<tr>
<td>BHATNAGAR, I.K.</td>
<td>Senior Scientific Officer</td>
<td>M.Sc., Ph.D.</td>
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<tr>
<td>JAIN, K.K.</td>
<td>Junior Scientific Officer</td>
<td>M.Sc., Ph.D.</td>
</tr>
<tr>
<td>KHARBDAE, B.V.</td>
<td>Senior Scientific Officer</td>
<td>M.Sc.</td>
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<tr>
<td>SINGH, A.R.</td>
<td>Photographer</td>
<td>B.Sc.</td>
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<tr>
<td>SINGH, T.</td>
<td>Senior Scientific Officer</td>
<td>M.Sc., Ph.D.</td>
</tr>
<tr>
<td>SURYAWANSHI, D.G.</td>
<td>Junior Scientific Officer</td>
<td>M.Sc.</td>
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