EFFECTS OF AIR POLLUTION ON DEVELOPMENT OF AGRA SUB-REGION

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MASTER OF URBAN AND RURAL PLANNING

By

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CERTIFICATE

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Dated: 14th Oct. 1980.

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PREFACE

The pollution problem, which is causing considerable concern in developed countries is now making its presence felt in various parts of our country. Pollution issues have been created newspaper headlines, prompted by public awareness and concern, followed by political response. Industrial development, with population expansion and change in living habits, has had many unplanned and unwanted side effects on our health and welfare. Air Pollution is one such side effect whose presence is now felt by millions of Indians in all parts of the country. Efficient and effective management of urban environment, especially from pollution point of view, is essential for the physical and social well being of all our citizens.

In response to people's needs, the planner and scientis are obliged to reduce and prevent pollution of which air pollution is a part. Today's reduction and prevention programs, however present challenges to the planner and scientist that were not evident a few years ago.

This work is therefore developed to the study of the problem of air pollution and to the programs of its reduction and prevention. Thus the whole study is divided into different chapters on the above theme. In chapter one the author has tried to give general information about air pollution. Chapter Two approaches the problem with a planning bias, defining the Scope of the Study, etc. Chapter three deals with information about the subregion selected for the study, whith includes all basic information necessary for the analysis of the subregion. Chapter four includes, the method of analysing the problem i.e. methods of calculation of concentration due to a particular pollutant in the subregion. Findings of the analysis are also given in this chapter. Chapter five is on the pollution abatement methods, in the form of air pollution strategy and tactics. In chapter six the author has given his conclusions arrived at after scientific analyses and recommendations have been drawn here on the basis of the above conclusions.

I hope that this work will help planners, scientists and decision-makers in this direction and will also encourage them to do further work in this field.

Shyam.
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Dated: 14th Oct. 1980.

1

INTRODUCTION

It is axiomatic that the more advanced a civilization becomes, the more complex are the problems related to man's environment, namely; congestion, housing, traffic, noise, crime, etc. In recent years, it has become increasingly obvious that the improper disposal of solid, liquid and gaseous wastes is creating a burgeoning problem of environmental pollution. The resulting alteration of man's natural environment has reached the point where the environment is now beginning to exert effects on man.

1.1 DEFINITIONS AND TYPES OF AIR POLLUTION

In its policy statement on Air Pollution and its Control, proposed by its Air Pollution Committee (Report Number 107), the Engineers Joint Council provides us with an excellent definition of the term as follows:

> Air Pollution means the presence in the outdoor atmosphere of one and more contaminants, such as dust, fumes, gas, mist, odour, smoke or vapour, in quantities, of characteristics, and of duration such as to be injurious to human, plant or animal life or to property, or which unreasonably interferes with the comfortable enjoyment of life and property[7].

In its broadest context, air pollution can exist in three distinct categories.

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7 Faith, W.L. and Atkinson, Aurthur A., Jr., Air Pollution Wiley Interscience, New York, 1972.

1.1.1 Personal Air Pollution

This refers to exposure to dust, fumes and gases to which an individual exposes himself when he indulges in cigarette, cigar or pipe smoking or sits in the company of smokers.

1.1.2 Occupational Air Pollution

This represents the type of exposure ofindividuals to potential harmful concentrations of aerosols, vapours and gases in their working environment.

1.1.3 Community Air Pollution

It represents the most complex of the three varieties since it involves a varied assortment of pollution sources and contaminants, meteorologic factors, and diversity of adverse social, economic and health effects.

1.2 FACTORS RESPONSIBLE FOR THE BURGEONING AIR POLLUTION PROBLEM

Air pollution is not a new phenomenon, it is now apparent that it is one of our most rapidly growing environmental problems. What are the factors contributing to this rather recent trend towards deterioration of the atmosphere? There are three major underlying factors which have brought about this condition.

1.2.1 Population Growth

The upward trend in population in India, has, indeed, been explosive. More people mean more manufactured goods, more wastes and services.

1.2.2 Expansion in Industry and Technology

The growth of industrial activity, has been remarkable in terms of expansion of existing plant capacity, and the increase in number of new manufacturing establishments. In additions, there has been the introduction of many new processes, methods and products. The nature of the airborne waste from some of these new technologies was completely unknown until the adverse effects on man and his environment, suddenly, became manifest.

1.2.3 Social Changes

Two important social changes served to accelerate the trend of burgeoning air pollution.

A. Urbanization. The unrelenting movement of people from rural areas into urban centers has led to the rapid transformation of cities in to large metropolitan complexes.

B. The other social factor which has indirectly contributed to the intensification of air pollution, over relatively recent years, has been the rising standard of living which has prevailed during this period. Large segments of the population have been economically able to enjoy a better life, including higher quality of nutrition, housing transportation, and a variety of labour saving devices.

The combined impact of population, expansion in industry/technology, and social changes operating in our contemporary society, can be regarded as the compounding factors which have resulted in serious degradion of the urban atmosphere within relatively recent years.

1.3 METEOROLOGICAL ASPECTS OF AIR POLLUTION

Meteorology is the science of atmosphere with particular reference to the study of those elements which are characteristics of weather(14). The meteorological parameters important to the problem of air pollution are those governing the transport and diffusion of airborne effluents in the atmosphere (Fig. 1.1). These can be classified basically in the following categories:

1. Vertical Temperature Structure,
2. Wind Structure,
3. Topographic Effects,
4. Scrubbing Process,
5. Application of Meteorology in dispersion of air pollutant.

Before discussing about meteorological aspects of air pollution, it is desirable to know something about the atmosphere.

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14 Mittal, A.K., Seminar on Micro Meteorological Aspects of Air Pollution, Department of Civil Engineering, University of Roorkee, Roorkee, 1978.

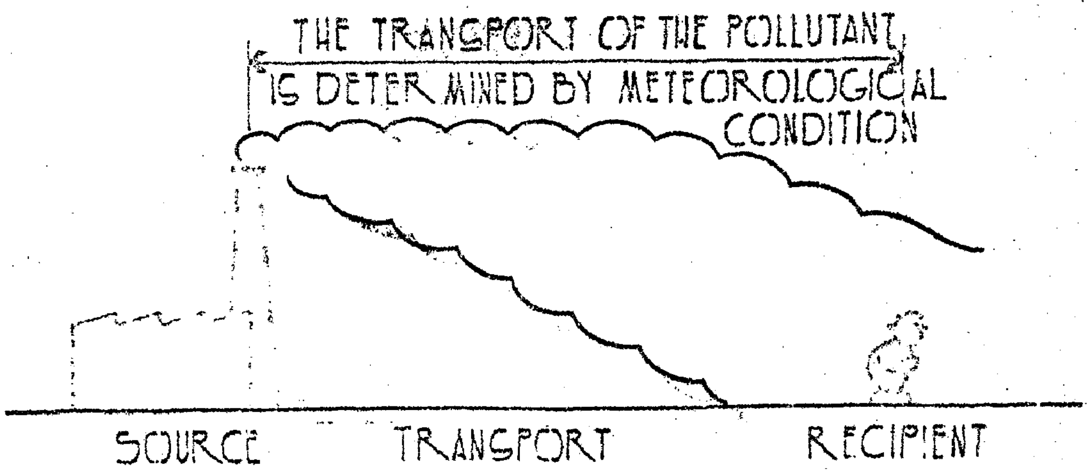

FIG.1.1 METEOROLOGY AND AIR POLLUTION

EFFECTS OF AIR POLLUTION ON DEVELOPMENT OF AGRA SUBREGION

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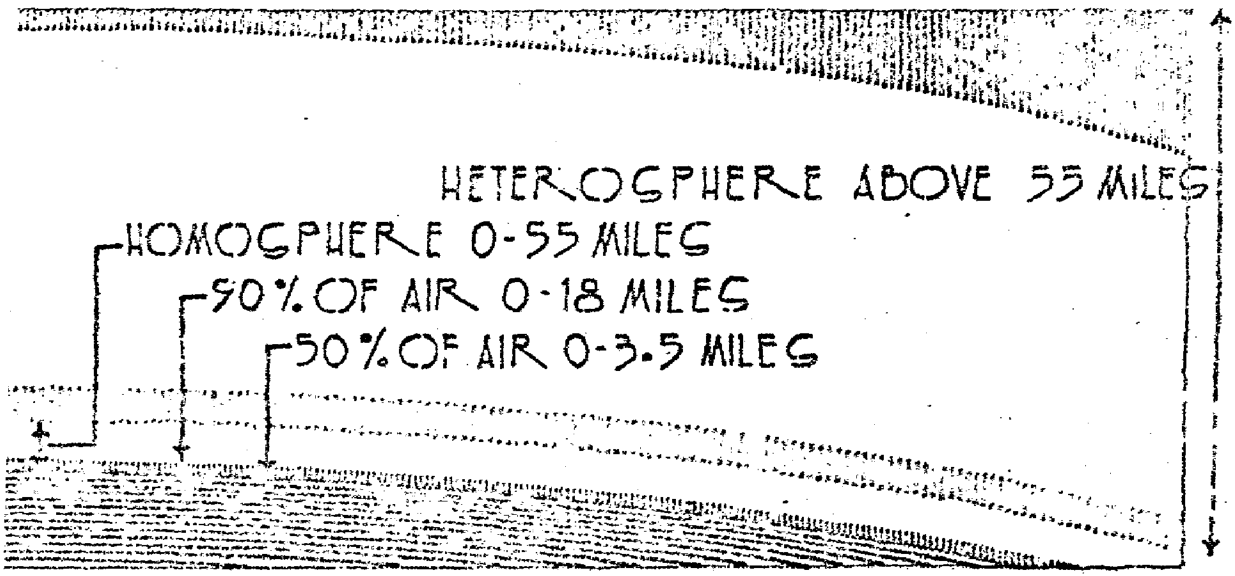
The Atmosphere. The earth is completely enveloped in a layer of a gaseous mixture composed largely of nitrogen and oxygen and called the atmosphere. More than half ofthe mass of the atmosphere lies below 5.6 km and 99 percent below 29 km; a very thin layer when compared to the earth's diameter (Fig. 1.2)

Based on molecular composition, the atmosphere is divided in to two general regions: the homosphere and the heterosphere. The atmosphere is also classified in to four characteristic temperature regions, called the troposphere, the stratosphere, the mesosphere, and the thermosphere. Figure 1.3 graphically portrays the volume percent composition of the air in the homosphere on dry basis.

1.3.1 Vertical Temperature Structure

A. Dry Adiabatic Lapse Rate. Theoretically, when small volume of air is porced upward in the atmosphere it will encounter lower pressure expand and cool. If we assume adiabatic conditions i.e. no exchange of heat between the environment and small volume, we can define a rate at which cooling occurs during the ascent as the Dry adiabatic lapse rate. It is normally 0.98^{o}C/100 m. (Fig. 1.4).

B. Environmental Lapse Rate. The actual distribution of temperature in the vertical is known as the 'environmet lapse rate', and is seldom equals the DALR in the lowest 100 meters over any extended time period. In Fig. 1.5, examples of typical environmentallapse rate are shown.



EARTH RADIUS = 4000 MILES

FIGURE 1.2 THE HOMOSPHERE AND HETROSPHERE RELATIVE TO EARTH SURFACE

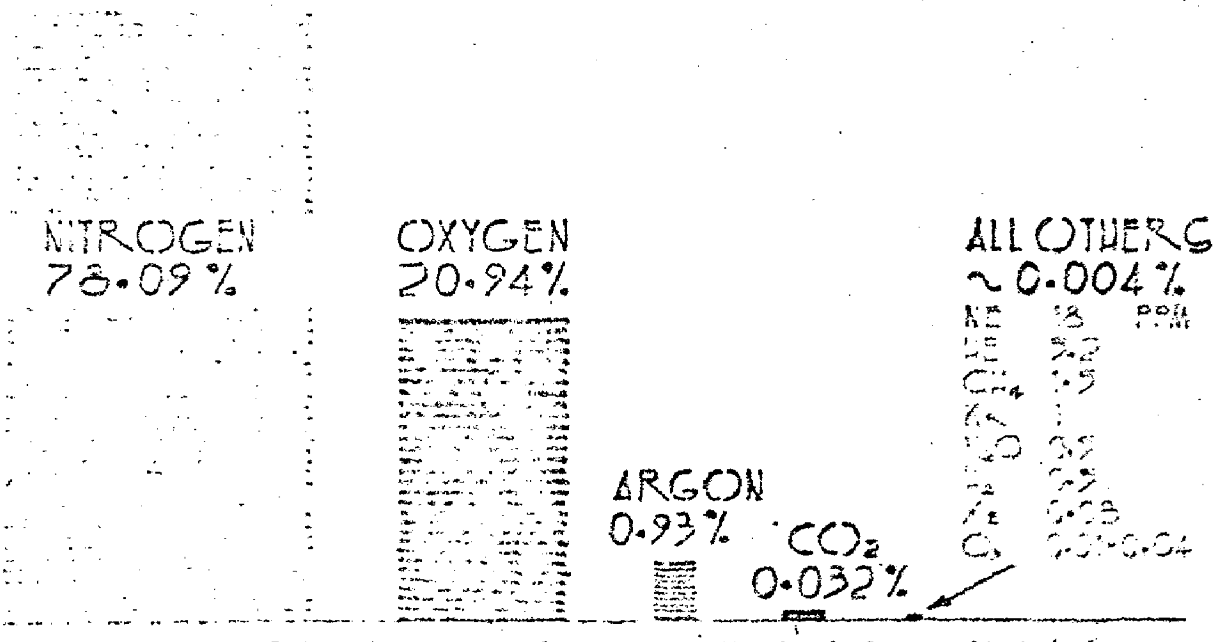


FIGURE 1.3 COMPOSITION OF DRY AIR (% V/V)

EFFECTS OF AIRPOLLUTION ON DEVELOPMENT OF AGRASUBREGION

(i) Super-adiabatic. On days when strong solar heating is occuring or when cold air is being transported over a much warmer surface, the rate of decrease in temperature with height usually exceeds $1^{o}C/100$ m. That would mean that any small volume displaced upward would become less dense than its surroundings and tends to combine its upward motion. A super - adiabatic conditions favours strong convection, instability, and turbulence and usually confined to lowest 200 m of the atmosphere.

(ii) Neutral. A neutral condition, is that in which the environmental lapse rate is nearly identical to DLAR, implies no tendancy for a displaced parcel to gain or lose buoyancy.

(iii) Sub-adiabatic. It is the condition in which the temperature decreases more gradually than DALR. It is actually stable since a small parcel displaced will become more dense than its surroundings and tend to descend to its original position, whereas a parcel displaced downward will become warmer and rise to its original position.

(iv) Inversion. It is a stable atmospheric layer in which temperature increases with height and strongly resists vertical motion and tends to supress turbulence. It is, therefore of particular interest in air pollution. Different types of temperature inversions occurs are discussed below.

(a) Surface or Radiation Inversion. The inversion as shown in Fig. 1.6 is usually found at night with light winds and clear skies, when the loss of heat by long wave radiation from the ground surface cools the surface and subsequently the air adjacent to it. The condition usually found in open country

(b) Elevated Inversion. In Fig. 1.6 the temperature decreases with height upto 600 m and then is capped by an inversion layer. Above the inversion there is a normal decrease of temperature with height.

The key point is that vertical motion is inhibited in the inversion layer. If it exists aloft, it tends to act as a 'lid'; if it developes near the ground it inhibits upward dispersion of low level pollutants released above it.

(v) Mixing Layers. Mixing layer is considered to be that in which the potential temperature between the surface and a capping inversion aloft decreases with height. In a sense the troposphere is a mixing layer, since tropopause is a virtually permanent inversion lid; but frequently lower transient inversion confine the mixing to much shallower layers.

1.3.2 Wind Structure

The fundamental parameter in the movement of contaminants by the atmosphere is the wind, its speed and direction, which in turn are inter related with the temperature gradient in the atmosphere. Essentially, the greater

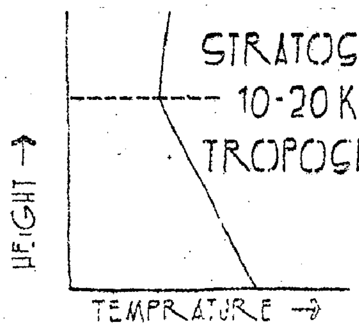


FIG 1.4 TEMP. CHANGE WITH HEIGHT POSITIVE LAPSE RATE

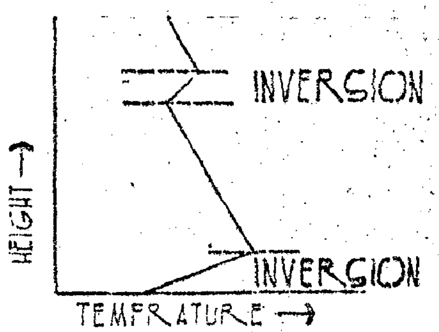


FIG 1.6 SURFACE INVERSION AND INVERSION ALOFT

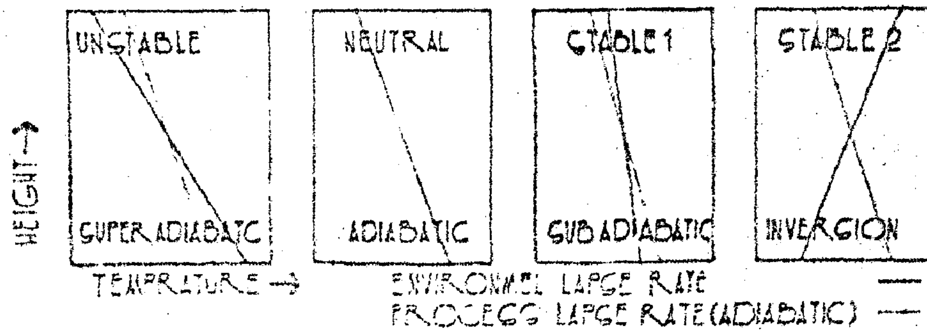


FIG. 1.5 STABILITY OF AN AIR PARCEL
DETERMINED BY THE ENVIRONMENTAL LAPSE RATE

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the wind speed, the greater is the turbulence and more rapid and complete is the dispersion of the contaminants in the atmosphere. In addition to the seasonal changes, in many locations there is a diurnal change in wind flow which may be even more marked. At most continental locations, it is usual that the night hours are periods of low level stability. In contrast, the daytime winds are apt to be more turbulent, of higher speeds, and the vertical motions are enhanced, so maximum dilution of material occurs on clear, sunny days.

In addition to the variation of wind flow in horizontal and with time, there is usually a marked difference in wind flow in the vertical. The roughness of earth surface, whether natural or manmade, induce mechanical turbulence, which decreases with altitude. Turbulence, or eddy motion, is the mechanism by which effective atmospheric diffusion is achieved.

The changes of wind direction and speed with time at a particular site can be presented dia-gramatically in the form of wind rose, showing cli-matological statistics of great importance in air pollution studies.

1.3.3 Topographic Effects

The topography of an area, either that of the pollution source or that of targets, may be extremely important. It should be noted that restrictive topography is not a necessary condition for extreme pollution levels if the source strength is sufficiently high.

A. Sea land breezes. The difference in the air temperature over land and water caused by difference in the heating and cooling, result in pressure gradient and accompanying air flow. On clear days the land surface heats to a higher temperature than the water surface, because of higher pressure of the cold air over water, the air flows from the water towards the land. At night radiation cooling of the land causes lower temperature over the land surface than over the water, resulting in a flow from the land towards the water. These sea land breezes are some what light and generally overshadowed when large scale pressure gradients are present.

B. Mountain Valley. The differences in heating and cooling rates between the valley floor and sides can cause a variation, in the air density and pressure resulting in air flow. This down flow of cold air tends to severely limit the upward motion of emitted pollutants.

1.3.4 Scrubbing Processes

A. For the removal of particles from the troposphere, the important processes are

i) Wet removal by precipitation

ii) Dry removal by sedimentation

iii) Dry removal by impaction on vegetation

B. For the removal of gases from the troposphere, the important one's are :

i) Wet removal by precipitation

ii) Absorption or reaction at the earth surface

iii) Conversion in to other gases or particulates by chemical reaction within the atmosphere

iv) Transport in to stratosphere

Wet removal by precipitation, or precipitation scavenging, is one of the most effective atmospheric cleansing mechanisms for both particles and gases. The removal of particles by gravitational sedimentation is an effective process only for particles of radius larger than 10 mm. Impactation on vegetation can be an effective removal process near the ground. The removal of gaseous pollutants by absorption or reaction at the surface of the earth is a removal process about which little is known for many substances.

1.3.5 Application of Meteorology in Dispersion of Air Pollutant

Gaseous and particulate waste products are commonly discharged to the atmosphere through the stacks of some form. These may range from short ventilation stacks on a small building to very tall ground based stacks for a large power plant or smelter. Stack effluents vary widely in their physical and chemical characteristics as well as in their degree of undesirability. The environment into which a stack discharges its effluent is another factor of wide variability. Meteorological characteristics play an important role. The location of stack in relation to obstruction to air motion whether a building or a mountain range may have an important effect. These characteristics are significant to stack design.

Behaviour of Stack Effluents in Atmosphere - Single Source. A careful observation of chimney smoke shows that initially the effluent rises while undergoing fast whirling motion (Fig. 1.7). During this rise, winds carry the effluent smoke horizontally. After some time the vertical rise reaches its maximum and the effluent travels horizontally, in the direction of the wind. During all these processes, the effluent also spreads laterally. From a distance, the smoke looks like a bent feather and hence it is usually called plume. Invisible plumes such as that of Sulfur dioxide are also included in the term.

The initial rise is called plume rise. It occurs under the combined effect of the initial discharge velocity of the affluent and its initial temperature excess above that of the ambient air.

Church classified the smoke plumes into five types and sixth type was added by Hewson. The plume types are illustraded in Figure 1.8.

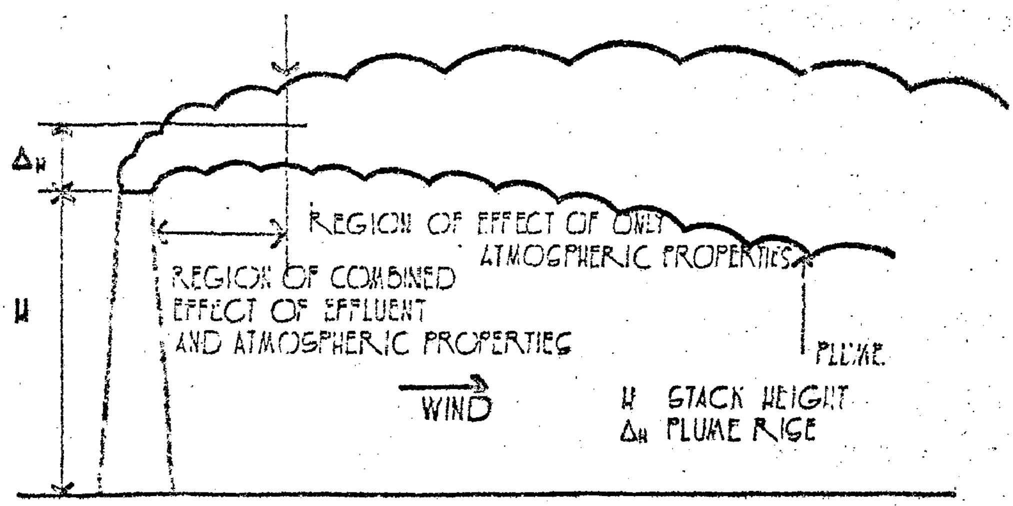

FIG1.7 INITIAL BEHAVIOUR OF PLUME

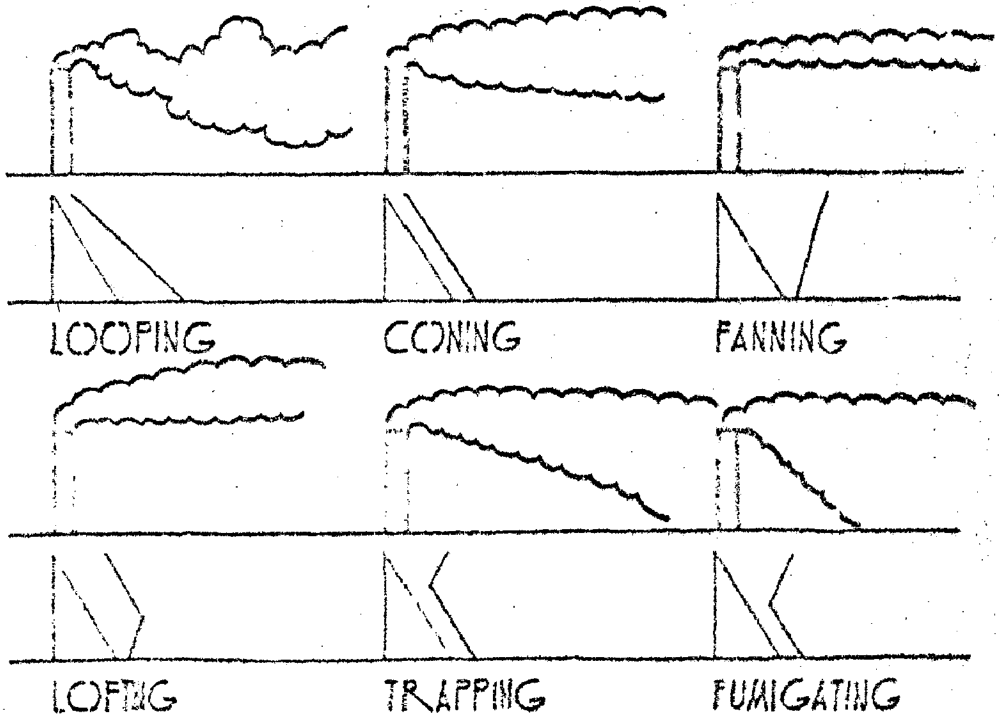

FIG1.8 BEHAVIOR OF PLUMES UNDER VARIOUS STABILITY CONDITIONS

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Looping plumes occurs when there is a super-adiabatic lapse rate and solar heating. The large thermal eddies in the unstable air may bring the plume to the ground level periodically. In general, however, the dilution of the plume with the surrounding air occurs rather rapidly.

A coning plume results when the vertical air being slightly unstable with some horizontal and vertical mixing occurring. Coning is most likely to occur during cloudy or windy periods.

Fanning plumes spred out horizontally but do not mix vertically. Fanning plumes occur when the air temperature increases with altitude (inversion). The plume rarely reaches the ground level unless the inversion is broken by surface heating or plume encounters a hill. At night, with light winds and clear skies, fanning plumes are most probable.

Lofting plumes diffuse upwards but not downwards and occur when there is a super-adiabatic layer above an inversion. A lofting plume will generally not reach the ground surface.

Fumigation results in the high pollutant concentration, plume reaching the ground level along the full length of the plume and is caused by superadiabatic lapse rate beneath an inversion. The superadiabatic lapse rate at the ground level occurs due to solar heating. This condition is favoured by clear skies and light winds.

Trapping is similar to fumigation in that the plume is below an inversion, however, the plume does not reach the ground level along the plume length[31].

B. Multiple Source. When two or more stacks are closely grouped they have mutual influence. The plumes tend to merge into one. Bosanquet[30] states that plumes from multiple stacks will rise higher than that from one of them but not as high as that of a plume from one stack replacing all of them. In practice multiple stacks are often in line, and it is common experience to note that when the wind direction is in line with the stacks, the plumes rise higher, than for other directions.

1.4 AIR POLLUTION AND URBAN FORM

Evidence is mounting that urban air pollution problems are caused not only by the presence of such things as smoke stacks and automobiles, but by the overall spatial arrangement of these urban elements - in short, by urban form. Once pollutants are released in the atmosphere their dispersion and

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31 Vesilind, P. Aarne, Environmental Pollution and Control Ann Arbor Science Publishers Inc., Michigan, 1975.
30 Verma Manju, Air Pollution and Human Environment, Dept. of Civil Engineering, University of Roorkee, Roorkee, 1977.

transportation is caused by the urban microclimate, in particular, the wind speed and the vertical temperature gradient. However, it is incorrect to conclude that pollution distribution is therefore beyond human control. The city's profile can cause a significant reduction in wind speed relative to the surrounding rural areas, permitting air pollutants to accumulate. There is the heat island whereby circulating air that rises over the hot centre of a city and falls. Upon cooler edges, traps pollutants, and produces the familiar dust domes or haze hood (Fig. 1.9 and 1.10).

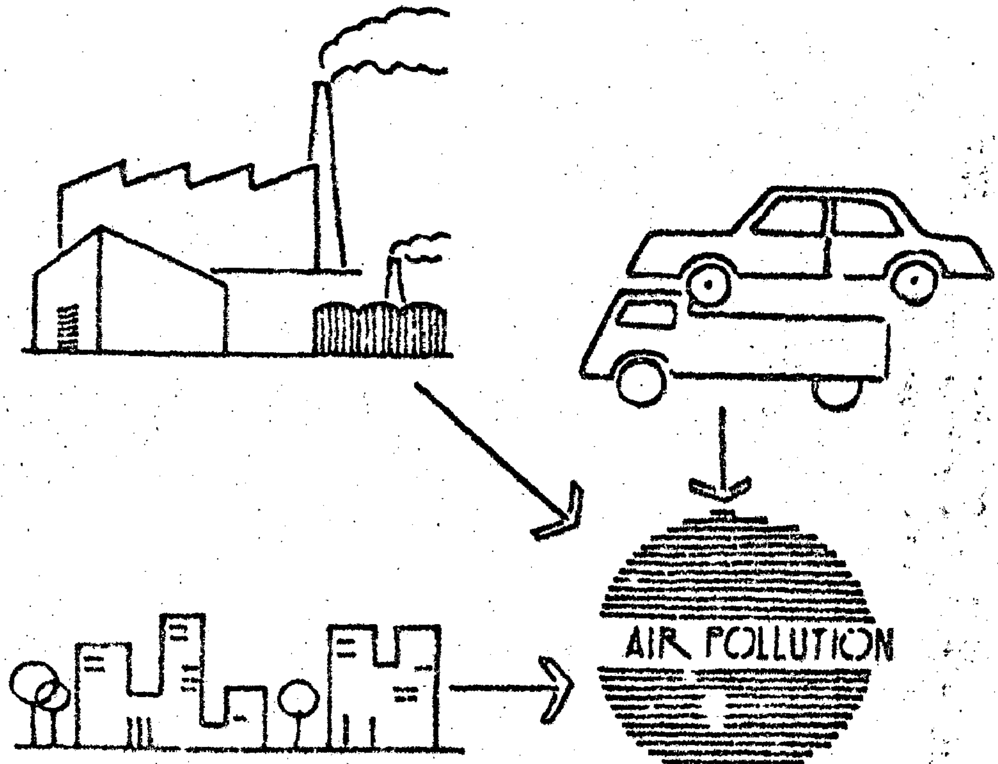


FIG 1.9 AIR POLLUTION AND URBAN FORM

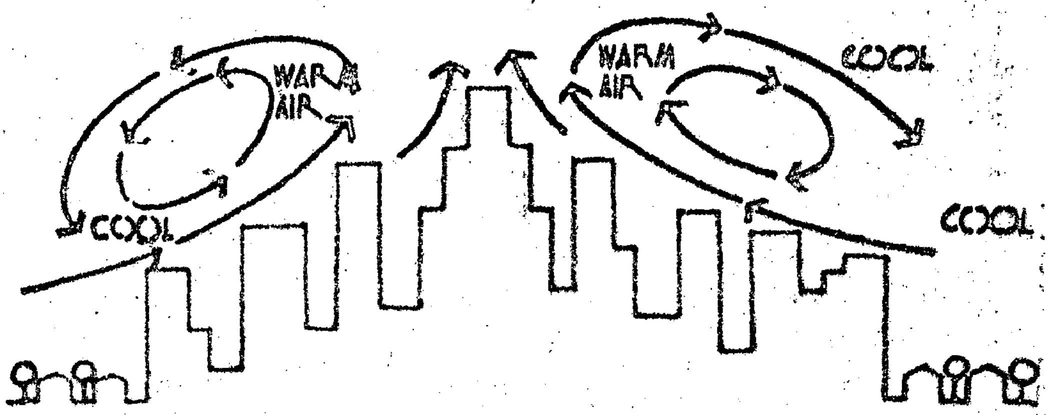


FIG 1.10 AIR CIRCULATION IN A CITY

EFFECTS OF AIRPOLLUTION ON DEVELOPMENT OF AGRA SUBREGION

AN APPROACH TO THE PROBLEM

2.1 IDENTIFICATION OF PROBLEM

There are many reasons for the interest that has developd during the past few years in the various aspects of air pollution, but foremost among them are the incidents in which fatalities have occurred; public concern with the chronic effects of air pollution; the development of industry and growth of communities, which produce more air borne wastes; contaminants released in new places; wide spread rebuilding of blighted city areas; better science and engineering and improved control equipment.

When we think of the air pollution problem, we associate its source with some activity of man, whether it be farming, manufacturing, or just moving about in this world of ours. Although generally recognized by public as a critical problem literally hanging over many municipalities and metropolitan regions, air pollution has been almost entirely ignored in Indian cities by city planning agencies.

2.2 SCOPE OF THE STUDY

Much of this is the task of a planner, yet it is a new field for him, and he may not be familiar with the technical information, or even have a method of approach and procedure defined that would introduces pollution consideration in routine planning works.

The purpose of this investigation is to serve as an aid to the planner by offering a discussion of the various techniques and methods currently available in air pollution control. The discussions are general in nature related to air pollution problem and control but analysis is limited strictly to Sulfur dioxide pollutant emitted by Mathura Oil Refinery, because

2.2.1 Detailed data of other pollutents is not available.

2.2.2 Sulfur dioxide is highly toxic even in minor concentration.

2.2.3 The contreversial Mathura Oil Refinery brought this region into lime-light.

2.3 GOALS AND OBJECTIVES OF THE STUDY

2.3.1 Goals

The goals of the study are

A. To achieve a physically and socially healthy urban environment from air pollution point of view. The impact of pollution may range over a wide scale. Since perfect purity of the environment is not possible nor necessary, a level of tolerance has to be established for various areas depending upon local circumstances.

B. To stimulate our awareness of the problem of pollution and to ensure that in the future, the government will throughly study the environmental impact of large scale industries before setting them up.

2.3.2 Objectives

Thus goals have set the direction towards which planning objectives are oriented. The objectives of the study are:

A. To identify the different, present and future, sources of air pollution in the region.

B. To identify different pollutants from these sources of pollution and their concentration.

C. To establish a level of tolerance for different pollutants.

D. To summarize basic meteorological data for the area.

E. To determine the effects of pollutants.

F. To identify different strategies for improving the quality of air.

G. To develop a conceptual plan keeping in view the magnitude and distribution of the pollutants.

2.4 RELEVANCE TO THE PLANNING FIELD

During the last few years, urban and regional planners have opined that in addition to the standard considerations in the preparation of plans, another element has to be included namely, environment pollution control, of which air pollution is one part.

This is not, of course, a new urban problem, yet it has emerged recently as a basic and of vital concern not only in the public health area, but also in the structuring and organization of city. It enters thus within the province of planners.

2.5 SELECTION AND SCALE OF CASE STUDY AREA

For study purposes Agra Subregion, including Agra city, part of Mathura and Bharatpur has been selected as per figure. This region has been selected for study because:

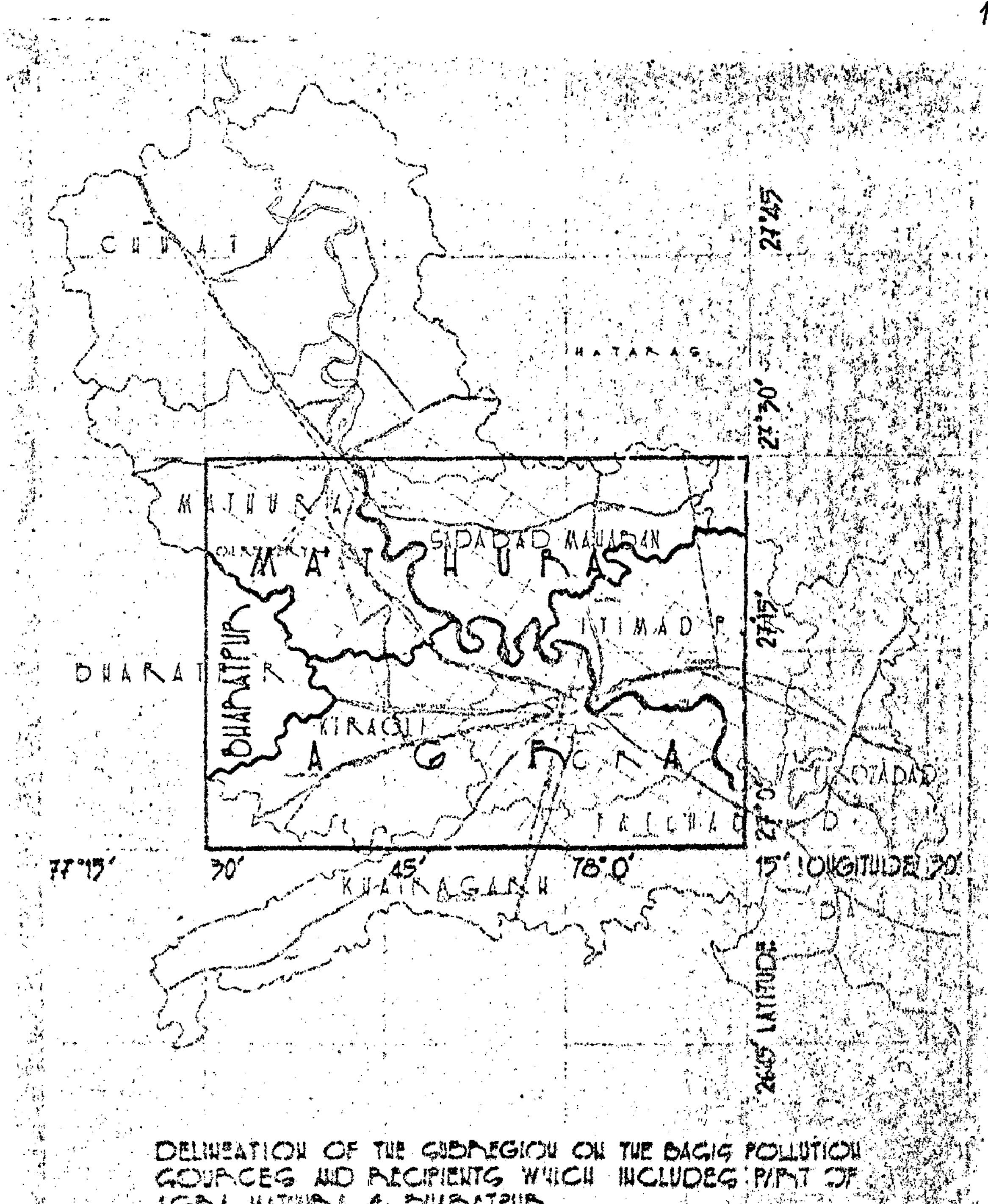
2.5.1 It is an internationally important region due to the indusion of a number of tourist attractions which include the Taj Mahal Agra Fort and Bharatpur Bird Sanctuary etc.

2.5.2 This region came into lime light very recently, with the establishment of an oil refinery.

2.5.3 Whatever studies have been done in this region, in relation to pollution, were with respect to the threat to the Taj Mahal in particular.

2.5.4 It's importance from Meteorological point of view.

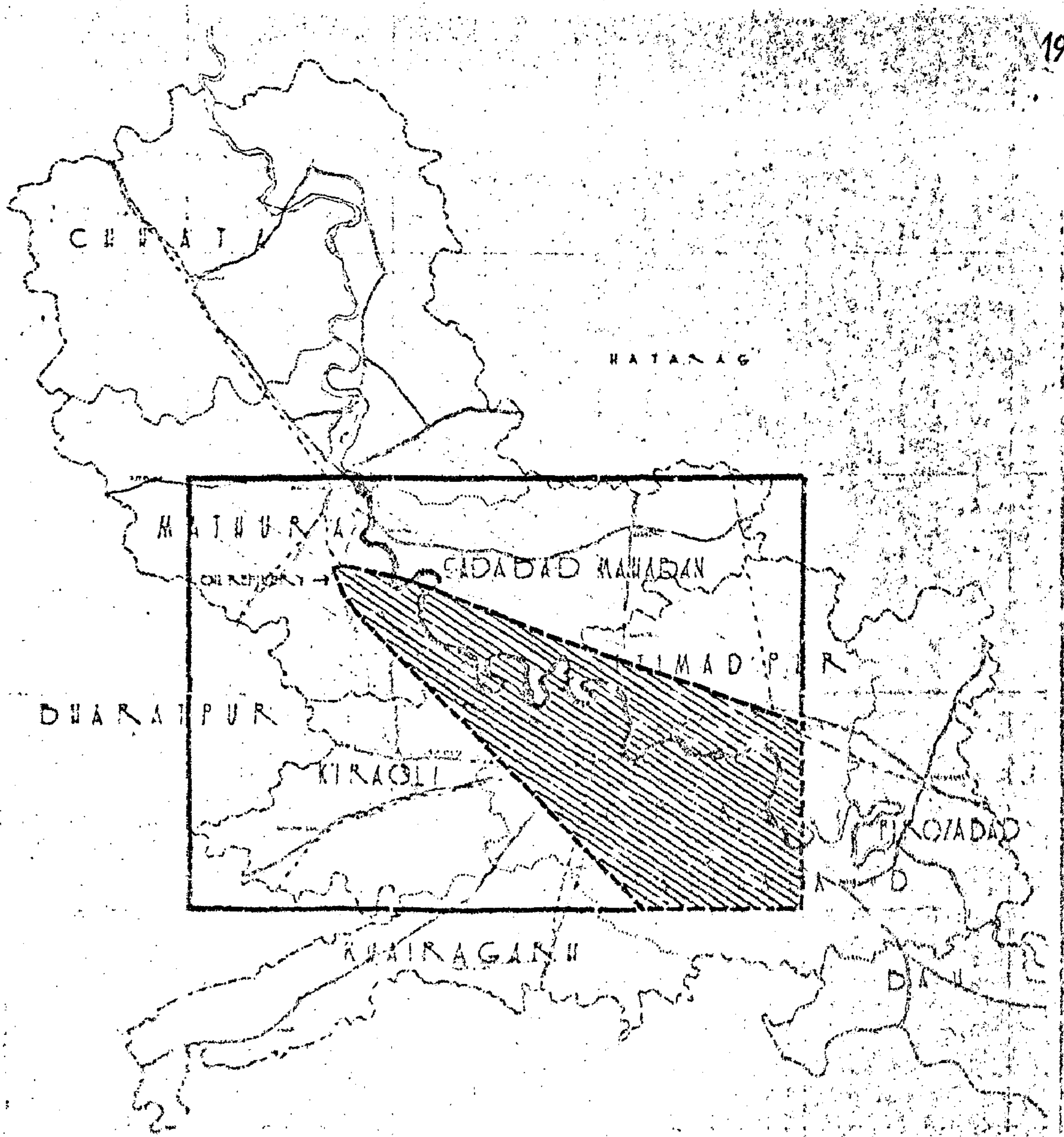
Initially Agra Subregion had been selected on the basis of the Inter relationship of different places in terms of pollution sources and recipients. Further, refinement on the basis of concentration contours, knownas isopleths, and the detailed discussion is focussed on Agra city only because Town Planning authorities have prepared a Master Plan in this region for Agra only. The Master Plan needs to be modified taking in to consideration the air pollution aspects (Fig. 2.1, 2.2, 2.3 and 2.4).



DELINEATION OF THE SUBREGION ON THE BASIS POLLUTION SOURCES AND RECIPIENTS WHICH INCLUDES PART OF AGRA, MATHURA & BHARATPUR

FIG 2.1 SELECTION & SCALE OF THE SUBREGION

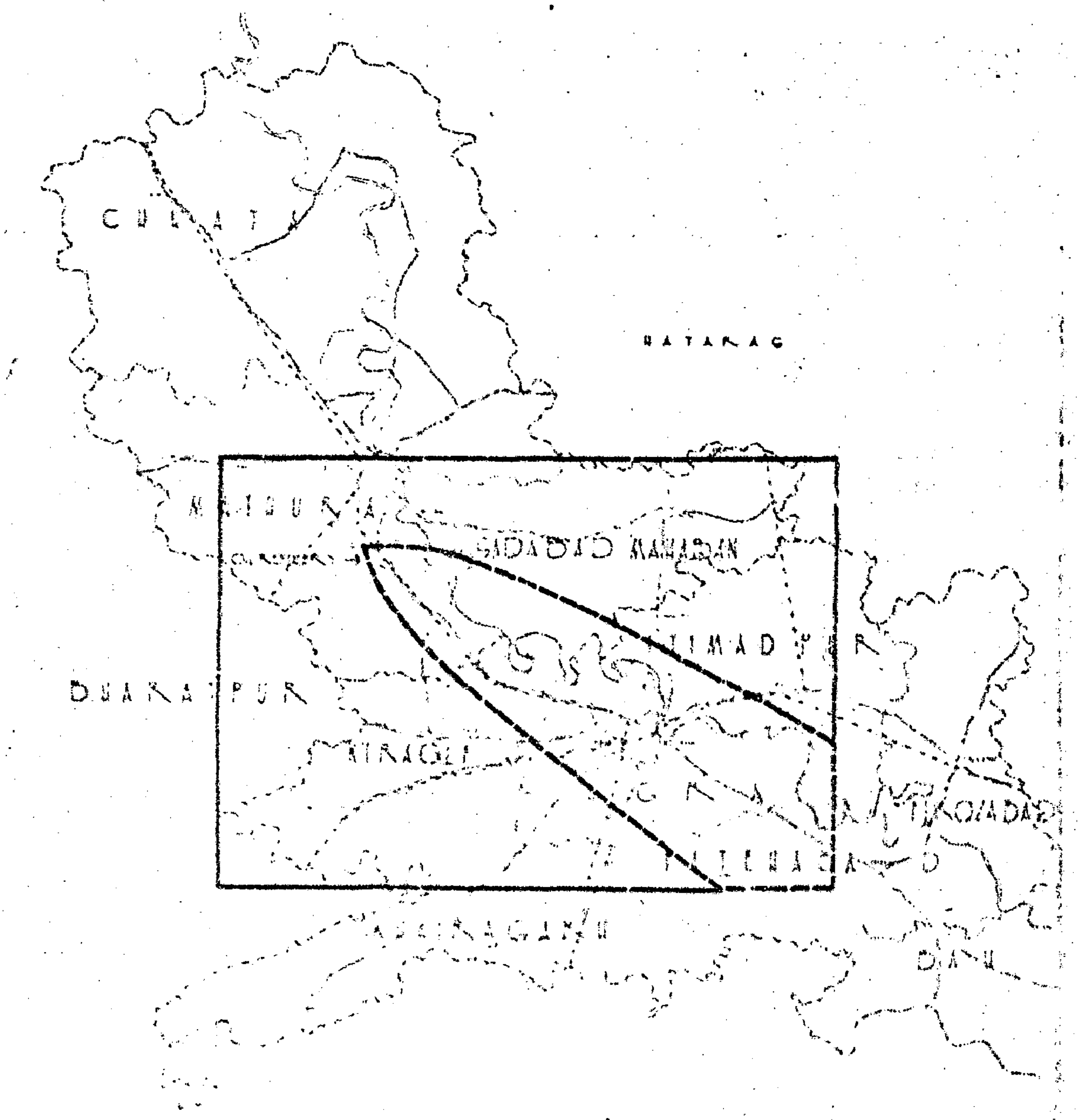
EFFECTS OF AIR POLLUTION ON DEVELOPMENT OF AGRA SUBREGION



REGION WHICH IS AFFECTED BY AIR POLLUTION IS DELINEATED ON THE BASIS OF ISOPLETH VALUE OF ·01 μg/m³ AND STABILITY CLASS 'C'. (BEYOND WHICH THE POLLUTION EFFECTS CAN BE CONSIDERED NEGLIGEBLE)

FIG. 2.2 SELECTION & SCALE OF THE SUBREGION

EFFECTS OF AIR POLLUTION ON DEVELOPMENT OF AGRA SUBREGION

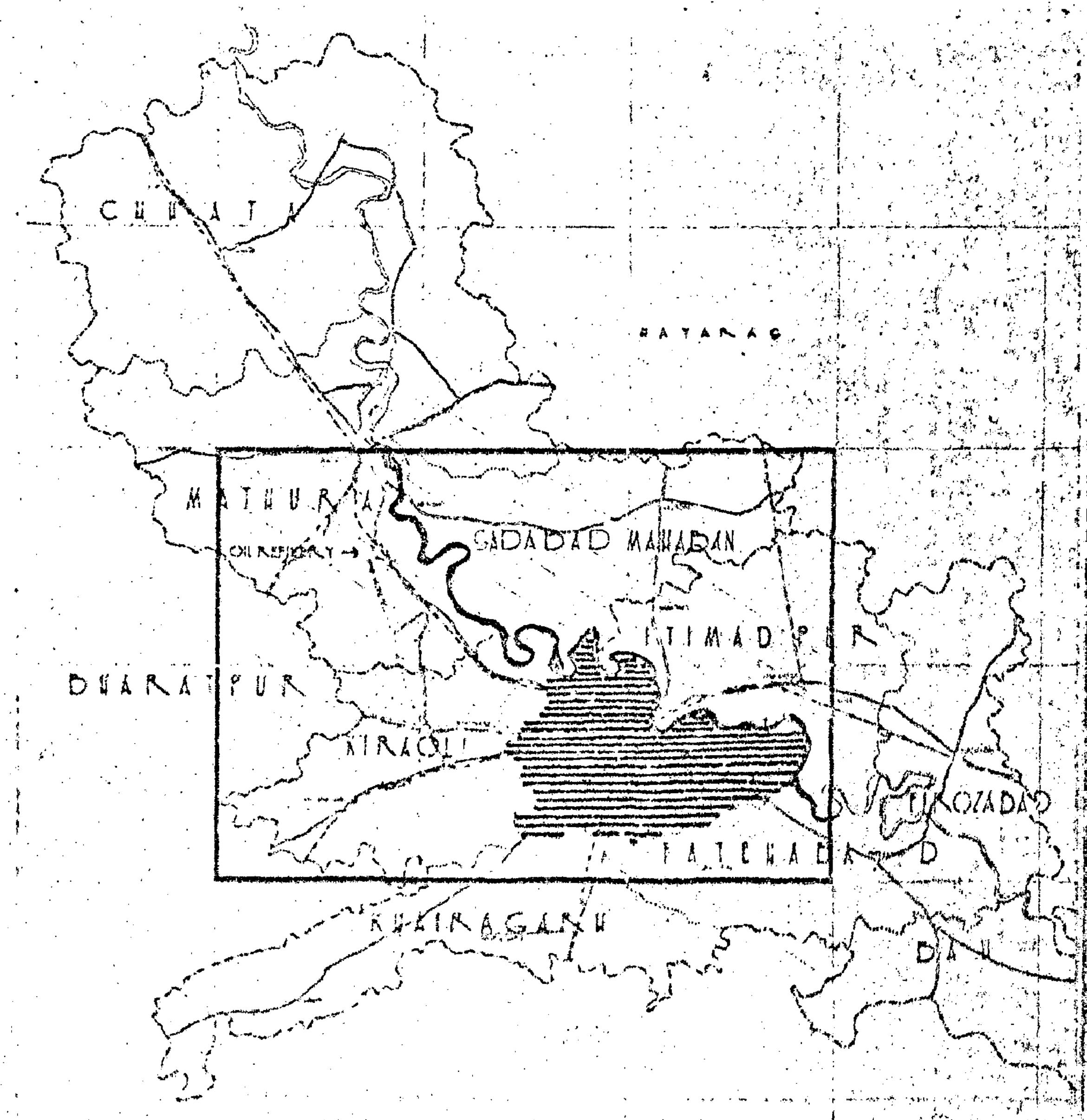


REGION WHICH IS AFFECTED BY AIR POLLUTION IS DELINEATED ON THE BASIS OF ISOPLETH VALUE OF ·01 $\mu g/m^3$ AND STABILITY CLASS 'B'

NOTE - THIS IS NOT THE CRITICAL CASE DUE TO THE RESTRICTED REGION OF INFLUENCE AS CAN BE SEEN ON COMPARISON WITH FIG. 2.2

FIG 2.7 SELECTION & SCALE OF THE SUBREGION

EFFECTS OF AIR POLLUTION ON DEVELOPMENT OF AGRA SUBREGION



FOR THE DETAILED STUDY AGRA CITY HAS BEEN SELECTED.

FIG. 2.4 SELECTION & SCALE OF THE SUBREGION

EFFECTS OF AIRPOLLUTION ON
DEVELOPMENT OF AGRASUBREGION

3

ANALYSIS OF CURRENT AND PROJECTED SITUATION

3.1 BASIC ANALYSIS

The city of Agra is situated in 27°12' North latitude and 78°17' East longitude on the west and right bank of river Yamuna. It is situated at a height of 169 mts (515 ft) above the mean sea level and 63.3 sq. kms. (24.51 sq. miles) in area. It is 198 km (124 miles) south east of Delhi, 320 km (200 miles) west of Kanpur, 104 km (65 miles) north of Gwalior and 240 km (150 miles) east of Jaipur. Agra is well connected by road, rail and air. Its metalled roads radiate in all directions leading to the surrounding regional centres such as Hathras and Aligarh on the north, Firozabad and Mainpuri on the east, Fatehabad and Bah on the south east, Dholpur and Gwalior on the south, Bharatpur on west and Mathura on the north west. Several railway lines also converge at Agra. The most significant fact about its location which has played and still plays a very important role in the historical development and life of the city, is its situation on the confluence of three different states viz., Uttar Pradesh, Rajasthan and Madhya Pradesh. Climatically the year, in the region, can be divided into three seasons.

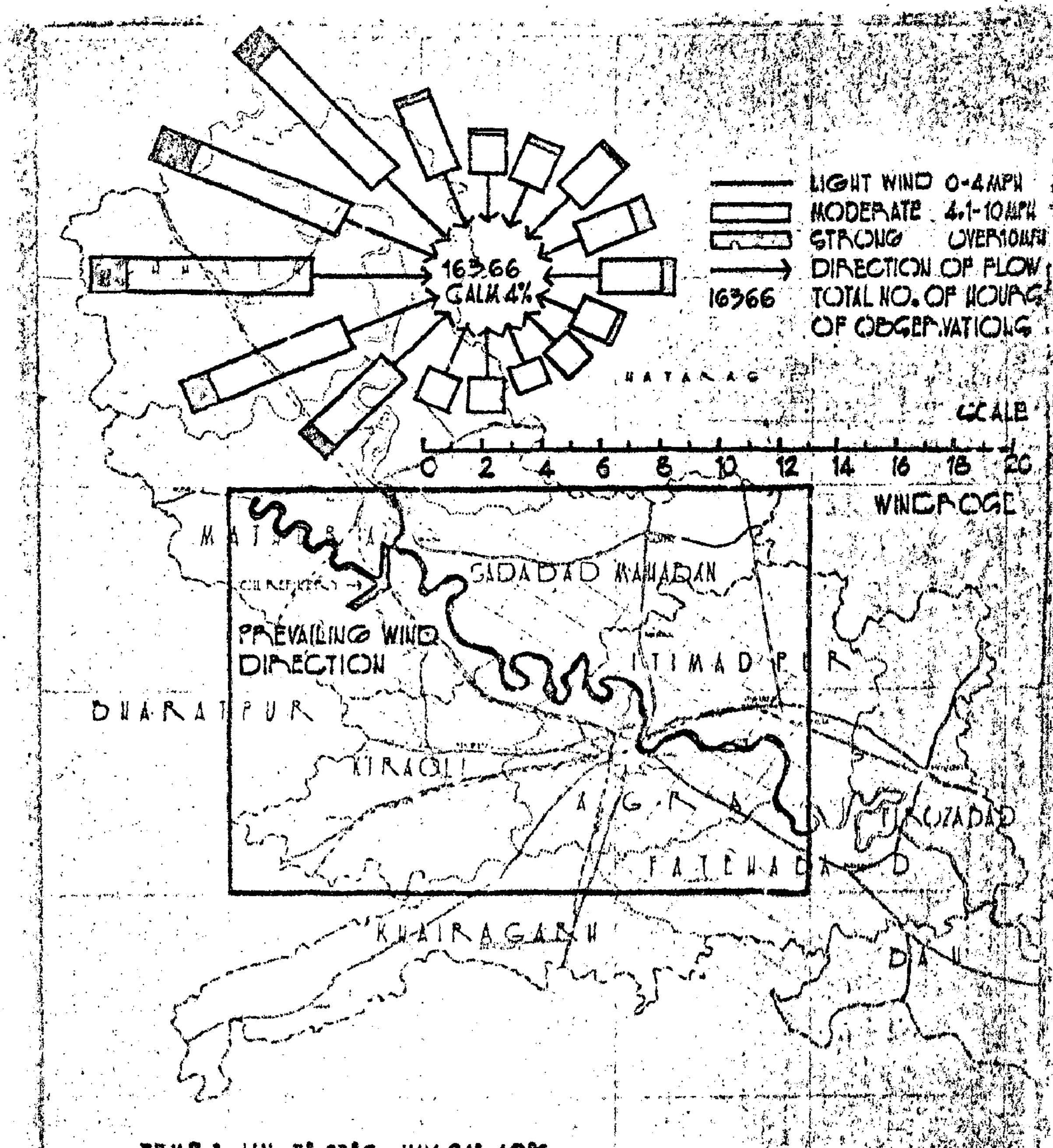
3.1.1 Winter, the cool dry season, October to February.

3.1.2 Summer, the hot dry season, March to May

3.1.3 Monsoon, the wet season, June to September.

June and October are transitional months between the seasons. The predominant wind-direction for the first two seasons is North-Westerly and for the rest of the year it varies as indicated by the annual wind rose for Agra. On the annual average, the wind direction for Agra is N-W and W. During winter, the surface air movement over Agra forms part of anticyclonic lower air movement over Northern India and this tends to bring down the pollutant along the Yamuna River Valley. Even the meteorological data for Mathur Refinery site confirms that wind direction is mainly from West to North from November to April. Occurrance of wind from WNW sector and speeds exceeding 6 knots are present in all months except the monsoon, under stable and unstable conditions; such conditions are of great significance for the transport of pollutants over long distance. The temperatures vary from a minimum mean of 7°C to maximum mean of 23°C for January and from 24°C to 40°C for May. The relative humidity at 08-30 hours is around 60 percent in summer and 80 percent during the other seasons. The region experiences rain fall of 89 cm for 70 days throughout the year (Figure 3.1).

The wind - rose for Agra can be considered to be fairly representative of the wind pattern for the Mathura-Agra region.



TEMP : JAN 7°-23°C, MAY 24°-40°C
RELATIVE HUMIDITY : 60% SUMMER, 80 WINTER
RAINFALL : 69 CM - 70 DAYS
SEASONS : WINTER - COOL DRY - OCT. TO FEBRUARY
SUMMER - HOT DRY - MARCH TO MAY
MONSOON - WET - JUNE TO SEPTEMBER

FIG 3.1 BASIC INFORMATION ABOUT AGRASUBREGION

EFFECTS OF AIRPOLLUTION ON DEVELOPMENT OF AGRASUBREGION

The total population of Agra - Town group (Agra city, cantonment, Dayal Bagh and Swami Bagh is 6,37,785 in 1971, which will increase to 12,00,000 in 2001 that is in 30 years.

TABLE 3.1 - TYPES OF MANUFACTURING INDUSTRIES IN AGRA IN 1969 [28]

INDUSTRIAL GROUP	TOTAL FIRMS No.	PERCENTAGE OF THE TOTAL
Food	30	10.0
Textile	21	6.8
Wood and Wood Product	1	0.3
Paper and Paper product	6	1.0
Printing and publishing	19	6.3
Leather and Leather products	44	14.7
Chemicals	11	3.5
Stone, Clay and glass products	6	1.9
Metal and Metal products	140	45.5
Mechineries	13	4.2
Transport	12	4.0
Service	4	1.5

The total number of household industries in 1969 was 741 units. Out of these units 70 percent were of leather, 18 percent of stone, 4 percent of dari making, 4 percent of metal, 3 percent of wood and one percent miscellaneous.

28 Town and Country Planning Department, U.P., Agra Draft Master Plan, Controlling Authority Regulated Area, Agra, 1971.

It is expected that these industries with manufacturing industries will develop in future. The total working force under industrial sector was 31.5 percent as per 1961 census and it is expected that it will increase to 37 percent by 2001.

3.2 SOURCES OF POLLUTION

Air pollution sources in the region can be grouped in three major categories:

3.2.1 Single or Point Source. These are the rather large readily identifiable sources as power plants, petroleum refinery. It includes two thermal power plants in Agra and one refinery coming up at Mathura.

3.2.2 Area-Wide or Multiple Source. These represent collectively, a large number of smaller sources distributed over a well defined area. It includes different industries and domestic sources.

3.2.3 Line Source. Free ways, highways and arterials carrying a steady steam of moving vehicles contribute line source of pollution. It also includes railway yards.

3.2.4 Natural Versus Man-Made Source

A. Natural Air Pollution includes Wind blown dust, Pollen and other aero-allergens, Smoke, Flyash and gases from forest fires, Microrganism, Gases and odours from Swamps and marshes, Fog, and Ozone from lighting.

B. Man Made Sources. The sources of man-made pollution cover a wide spectrum types. The accompany table includes a classification of major types, categories and examples of air pollution sources and their characteristics pollutant emission.

TABLE 3.2 - CLASSIFICATION OF AIR POLLUTION SOURCES AND EMISSIONS (30)

TYPE	CATEGORY	EXAMPLES	IMPORTANT POLLUTANTS
1. Combustion	Fuel burning	Domestic burning Thermal Power Plants	Oxides of Carbo Sulfur and Nitrogen
	Transportation	Cars, Trucks and railways	Oxides of Carbo and nitrogen, lead, smoke, unburnt hydrocarbon
	Refuse burning	Open burning	Flyash and particulates
2. Manufacturing Process	Chemical Plant	Petroleum refineries, paper plants, ceremic clay products and glass manufacture	Hydrogen sulphi Sulfur oxide, fluorides, odou organic vapours and dusts
	Metallurgical Plants	Steel Plants	Metal fumes (Pb and Zn) Fluoric and particulate

30 Verma Manju, Air Pollution and Human Environment, Department of Civil Engineering, University of Roorkee, Roorkee, 1977.

3. Agricultural activities	Crop spraying	Pest and Wood control	Organic phosphates, cl rinated hydrocarbons, Pb, As
	Field Burning	Burning of refuse fire wood and dry cattle dung	Smoke, Flyash, soot, Sulfur oxide, particulate and organic vapours
4. Solvent Usage	Spray painting inks, Solvent extraction and Solvent cleaning	Furniture and appliances, dyeing, printing, drycleaning etc.	Hydrocarbon and other organic vapours

In Figure 3.1 different sources and recipents of pollutants in Ag are shown through photographs.

TABLE 3.3 - DATA OF SULFUR DIOXIDE EMISSION IN THE SUBREGION[20]

EMISSION RATE	MATHURA REFINERY	AGRA POWER HOUSE I	AGRA POWER HOUSE II	CITY AREA SOURCE
kg/h	5000	125	125	137.5
T/day	120	3	3	3.3
Stack height, m	100	50	50	8.0

3.3 THE POLLUTION COMPONENT OF THE GLOBAL SULFUR CYCLE

Any excess quantities of sulfur mobilized by human activities must follow certain of the established pathways of the sulfur cycle, depending upon its occurrence and form at the time of mobilization. It is possible to abstract a 'pollution component' of the total cycle as shown in Fig. 3.2.

3.4 STANDARD FOR AIR POLLUTANTS

In the following table 3.4 standards for air pollutants are given so that the status of ambient air quality can be established.

20 Rao T. Sivaji, Save Taj Mahal and People of Brij Mandal, Mrs. T. Lawanya Lata, Waltair, 1970.

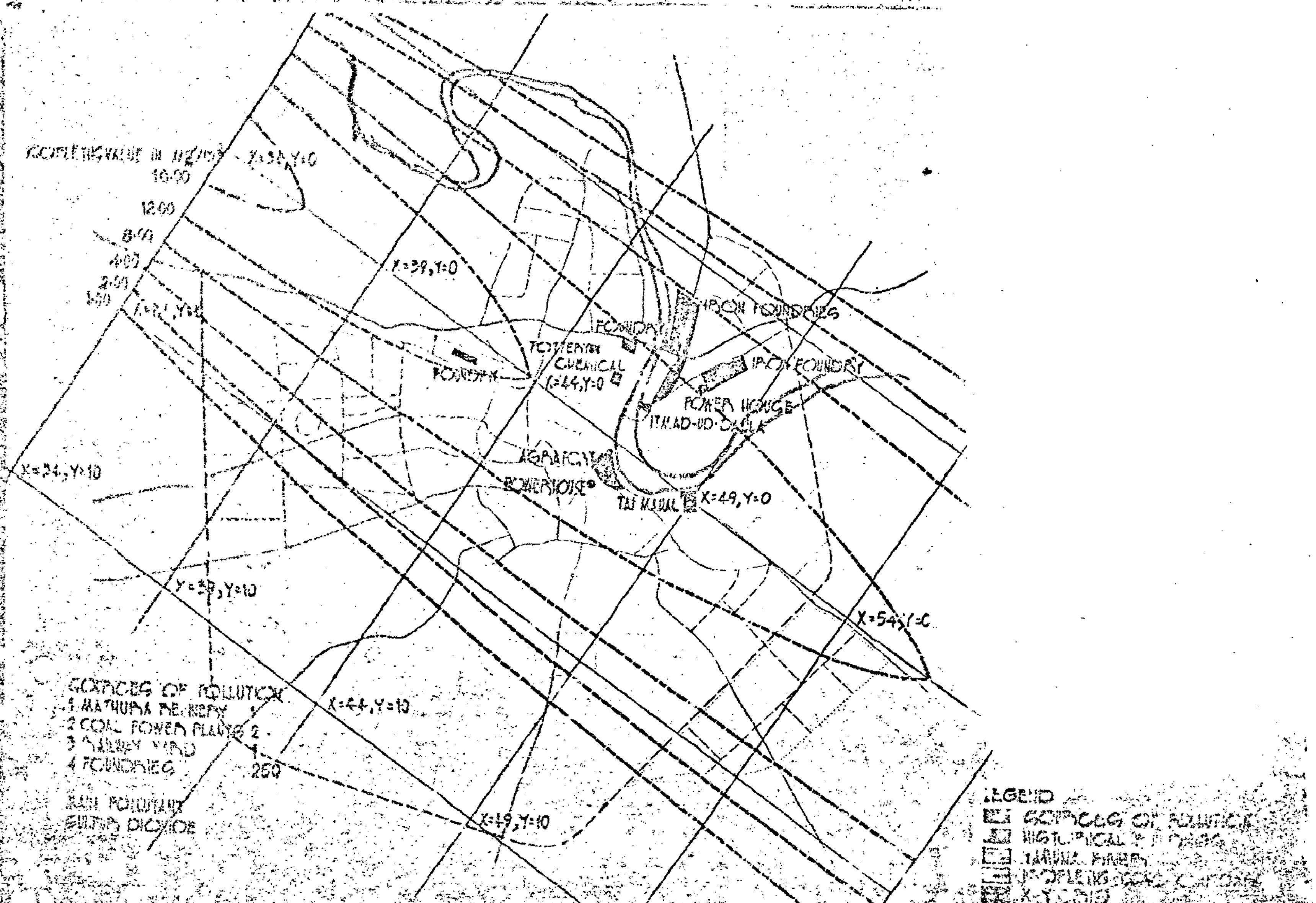
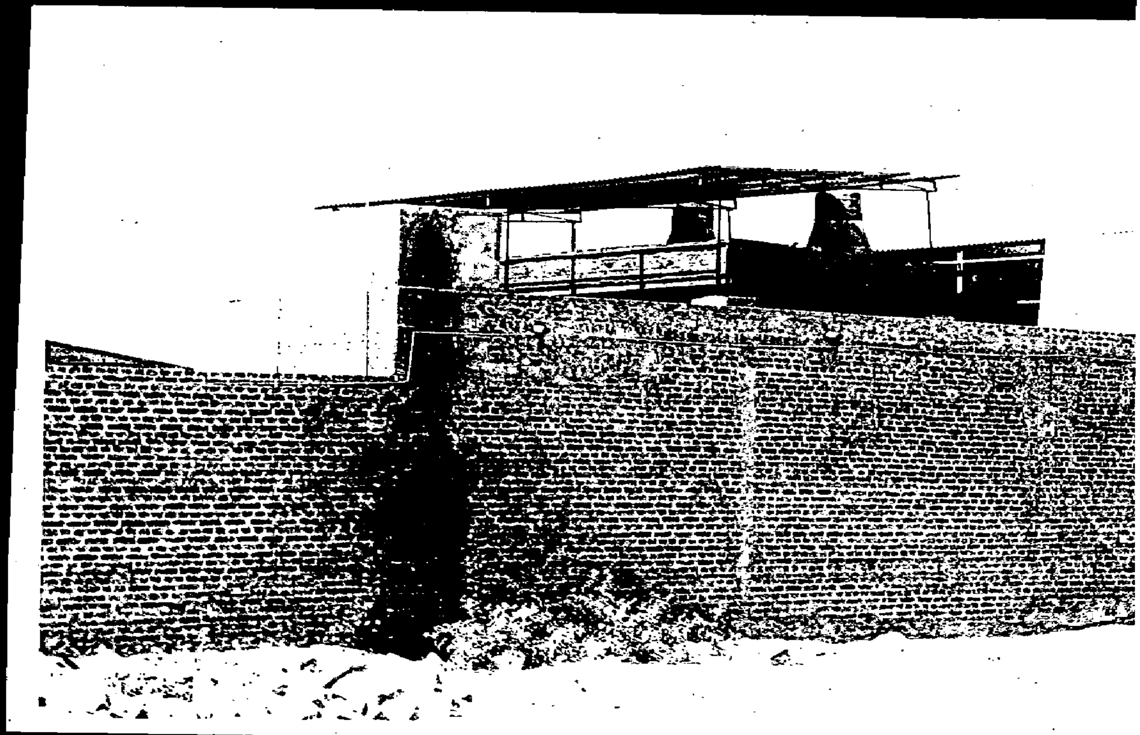


FIG 3.2 SOURCES OF POLLUTION

... OF AIR POLLUTION ON DEVELOPMENT OF ...

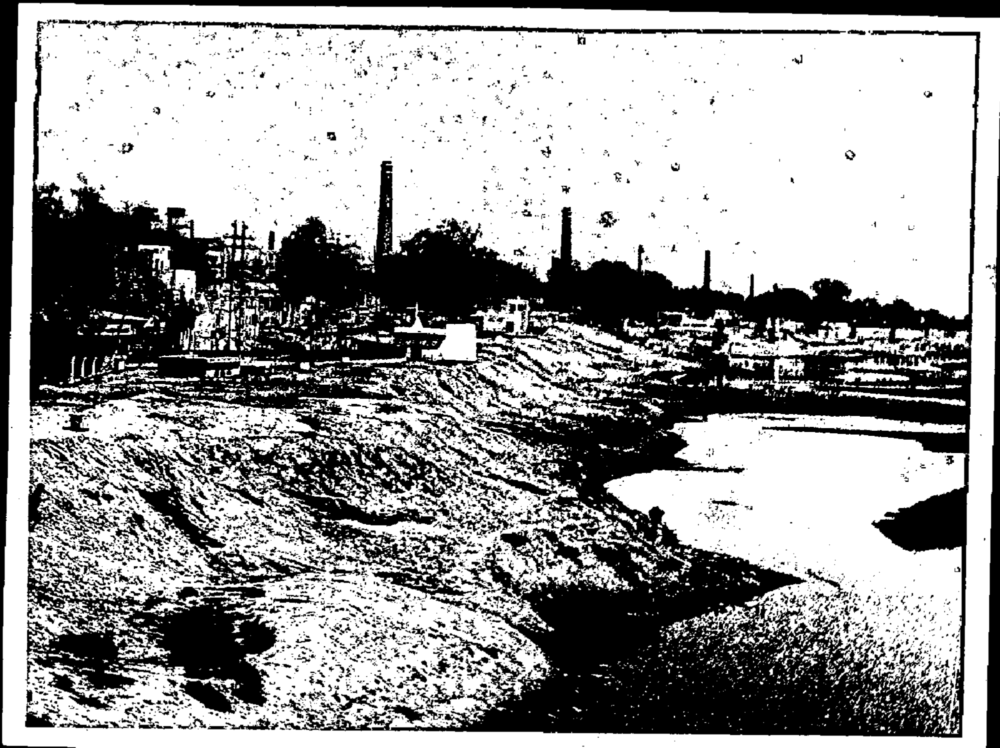
POLLUTION SOURCES - THERMAL POWER PLANT -I

POLLUTION SOURCES - THERMAL POWER PLANT-II

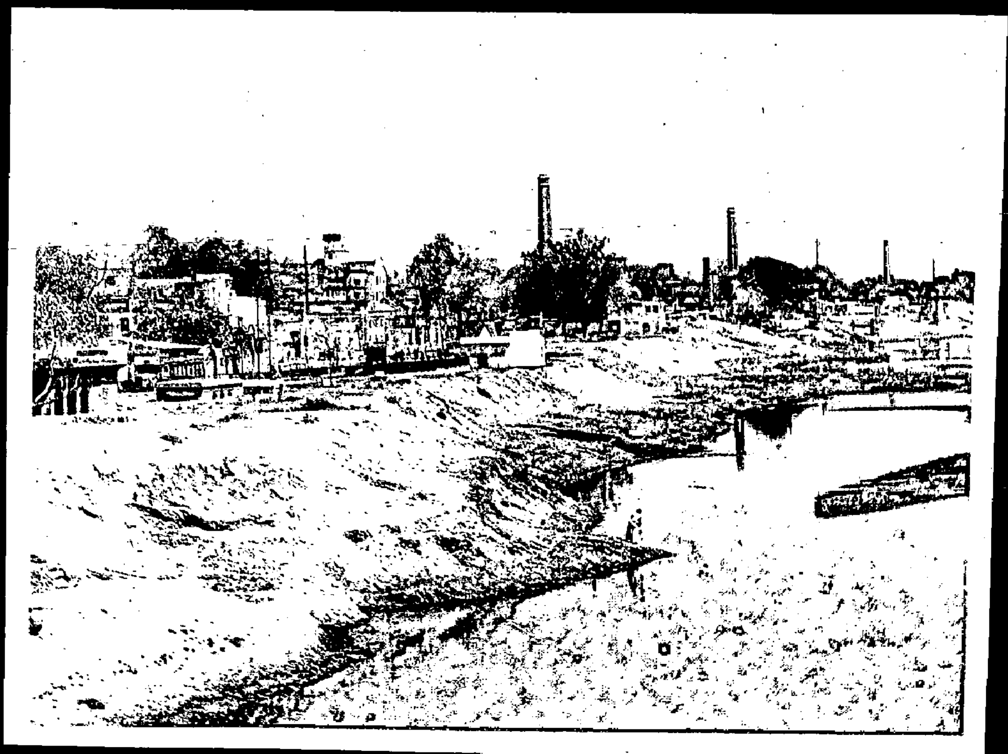


POLLUTION SOURCES - FOUNDRY SHOP

POLLUTION SOURCES - FOUNDRY SHOPS

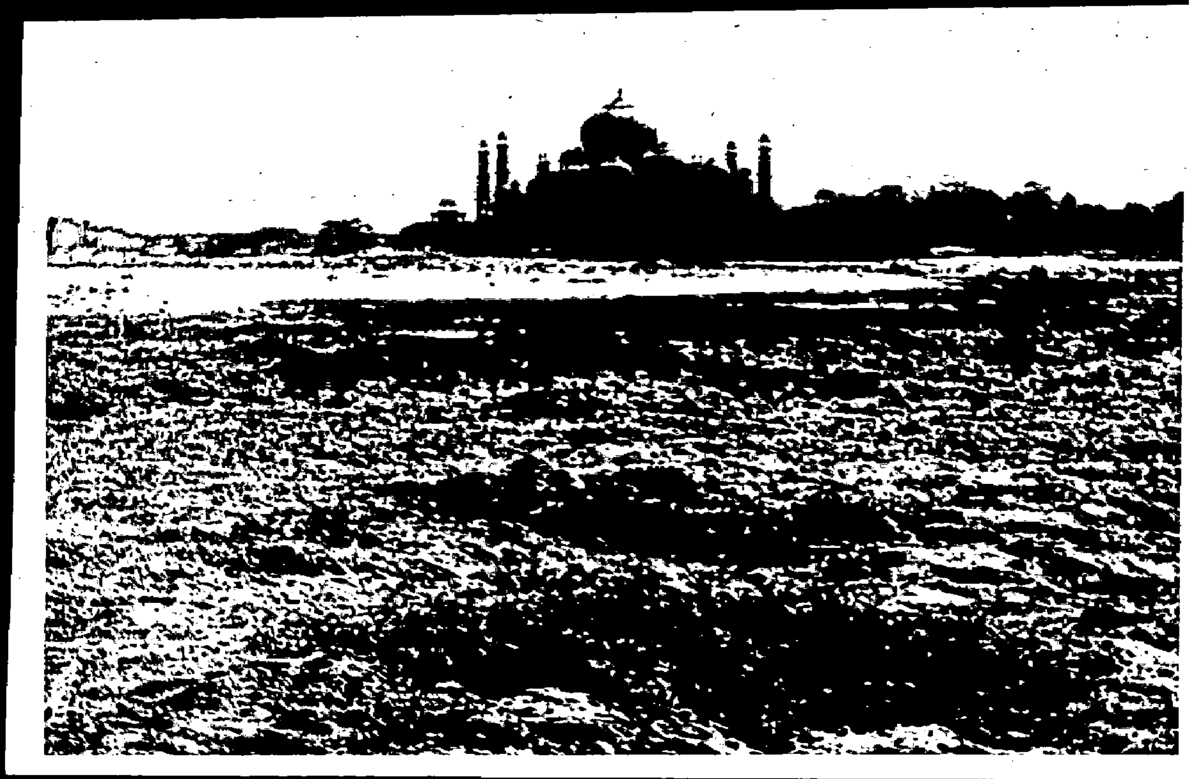


POLLUTION SOURCES - CHEMICAL AND OTHER INDUSTRIES

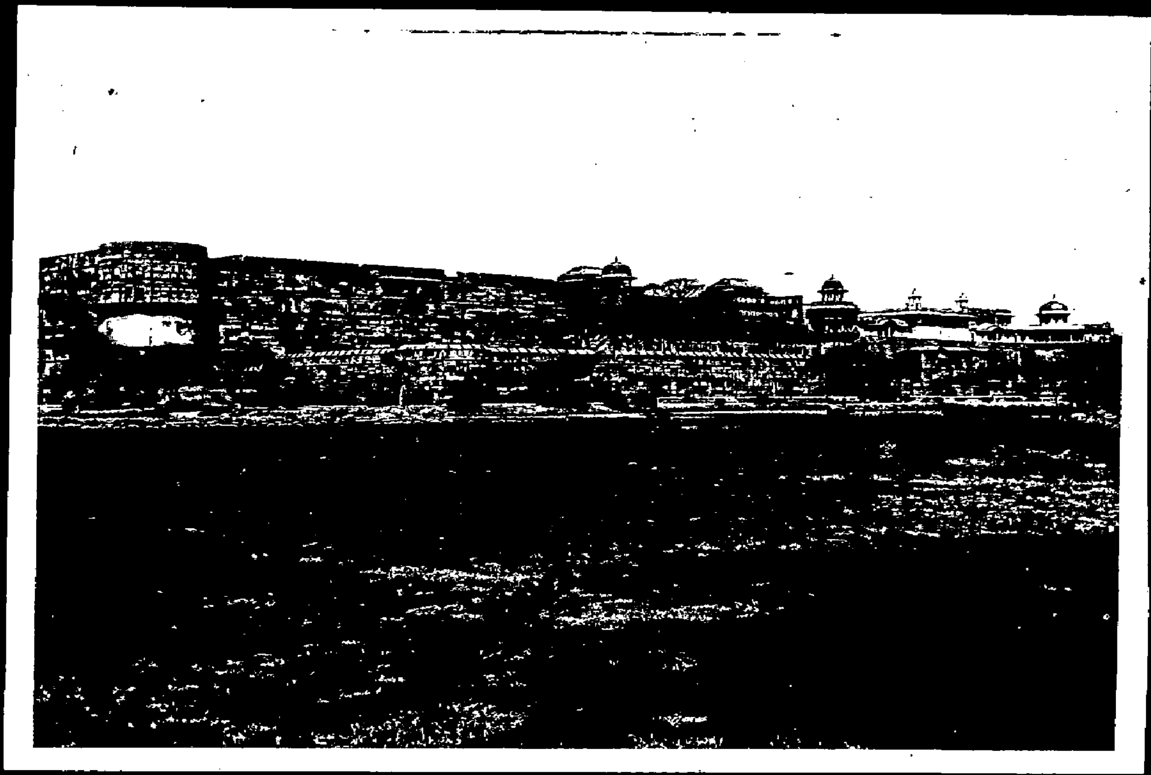


POLLUTION SOURCES - CHEMICAL ANDOTHER INDUSTRIES

POLLUTION RECIPIENTS - PEOPLE, PLANTS AND BUILDINGS

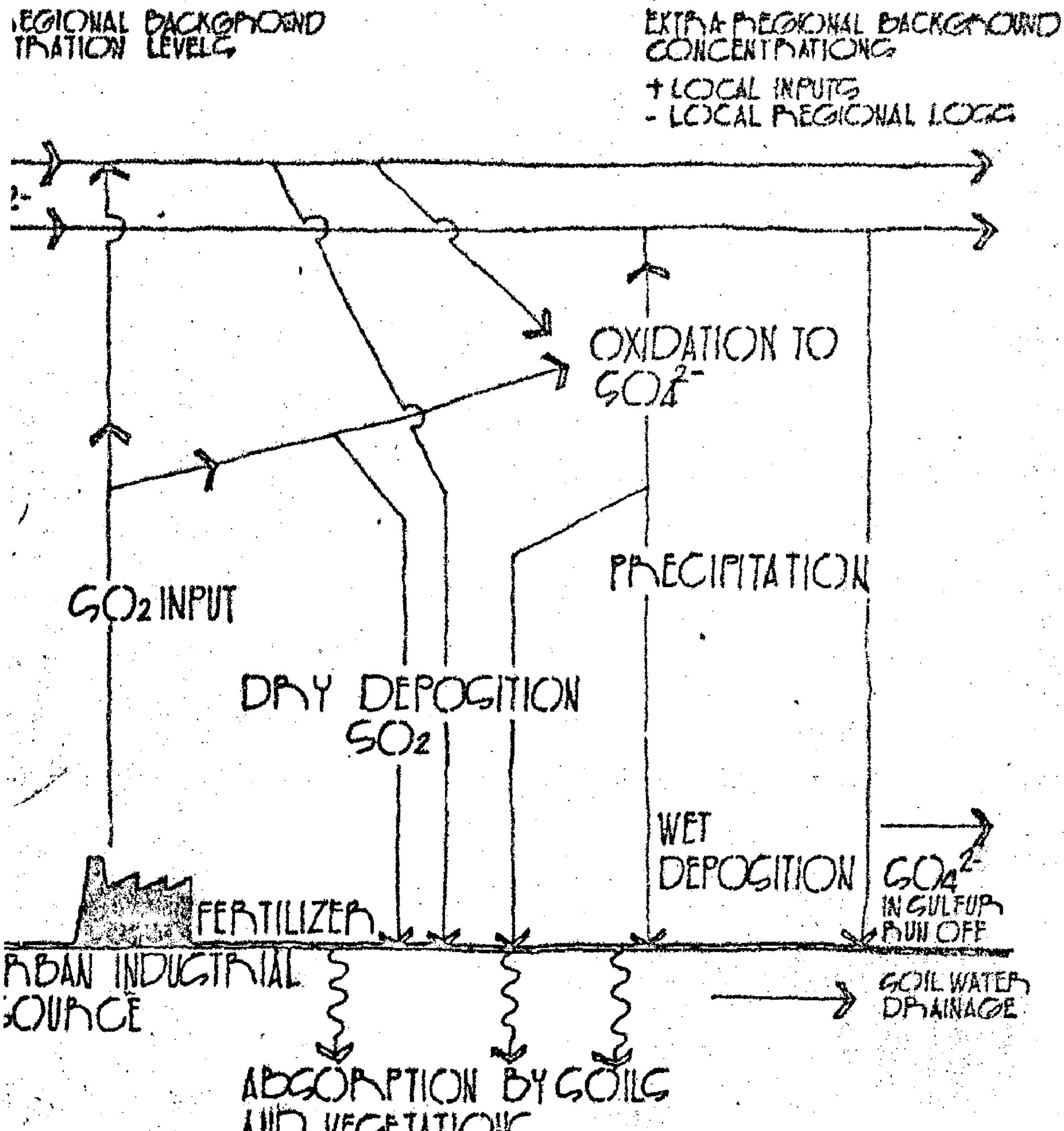


POLLUTION RECIPIENT - SOIL, WATER & BUILDINGS



IMPORTANT POLLUTION RECIPIENT - AGRA FORT

IMPORTANT POLLUTION RECIPIENT - TAJ MAHAL



3 POLLUTION COMPONENT OF GLOBAL SULFUR CYCLE

TABLE 3.4 - STANDARDS FOR AIR POLLUTANTS[20]

AIR POLLUTANT	AVERAGING TIME	STANDARD PRIMARY	SECONDARY
1. Particulate	A.G. Mean 24 hrs	75 ug/m^3	60 ug/m
	24 hours	260 ug/m^3	150 ug/m
2. Sulfur Oxide	Annual Mean	80 ug/m^3	60 ug/m
	24 hours	350 ug/m^3	260 ug/m
	3 hours	-	1300 ug/m
3. Carbon mono-oxide	8 hours	10000 ug/m^3	10000 ug/m
	1 hour	40000 ug/m^3	40000 ug/m
4. Nitrogen oxides	Annual Mean	100 ug/m^3	100 ug/m
5. Photo Chemi-cals Oxidants	1 hour	160 ug/m^3	160 ug/m
6. Hydrocarbons	3 hours	160 ug/m^3	160 ug/m

The criterion for establishing an air quality standard is every changing with the increasing knowledge about the pollutant and its interaction with the environment.

3.5 EFFECTS OF AIR POLLUTION

Air pollution has been defined as a condition which is likely to cause adverse effects in man or his possessions. The untoward consequences of atmospheric pollution cover a very wide spectrum ranging from material damage to personal dis-comfort and illness. The effects of air pollutants may be divided into following categories.

20 Rao T. Sivaji, Save Taj Mahal and People of Brij Mandal, Mrs. T. Lawanya Lata, Waltair, 1978.

3.5.1 Material Damage

Direct damage to structural metals, surface coatings, fabrics, and other materials of commerce is a frequent and widespread effect of air pollution.

3.5.2 Effects on Vegetation

A large number of food, forage, and ornamental crops have been shown to be damaged by air pollutants; curtailed value results from various types of leaf damage, stunting of growth, decreased size and yield fruits and destruction of flowers. Some plant species are so sensitive to specific pollutants as to be useful in monitoring air quality.

3.5.3Effects on Animals

The effects of air pollution on domestic animals are similar to those observed in man. This was shown to be the case in some of the severe air pollution episodes that have been documented. Though the effects on animals in some circumstances are of economic importance, they are possibly of greater importance in indicating where to search for human effect.

3.5.4 Economic, Sociological and Psychological Effects

Economic losses due to air pollution includes.

A. Increase of travel costs and time to travel due to reduce visibility, together with increased risk of accidents. Injury in travel due to decrease in visibility.

B. Increase of cost of artificial illumination.

C. Repair of damage to building and other structures.

D. Increased cost of cleaning.

E. Losses due to damage to crop and ornamental vegetation.

F. Losses due to injury to animals of economic importance.

G. Decrease of real estate values.

H. Extra cost of manufacture because pollution from outside source.

The sociological importance of air pollution results largely in individual economic losses. If the economic damage were reduced, the sociological gains would be significant.

Since fear is a recognizable element in public reactions to air pollution, the psychological aspect of phenomenon can not be ignored.

3.5.5 Effect on Man

The effects upon animals and vegetation and economic, sociological and psychological effects due to atmospheric pollution are more or less directly or indirectly connected to humans. So the overall effects of atmospheric pollution are felt by mankind. Human health is also affected by the air pollution.

TABLE 3.5 - EFFECTS OFAIR POLLUTANTS[30]

AIR POLLUTANTS	EFFECTS
1. Particulate	Speed chemical reactions, obscure vision, corroding and soiling structures, aggravate respiratory disorder, pneumoconiosis.
2. Sulfur oxides	Suffocation, irritation of throat, watering of eyes, respiratory diseases, damage crops, corrode metals and structure; harms textile and paper.
3. Carbon Monoxide	Head-aches, dizziness, Nausea, and other poisening effects. Increased accident liability.
4. Nitrogenoxides	Irritate eyes and nose, bronchitis, corrode metals, damage vegetation.
5. Photochemicals exidants	Irritate eyes, nose, throat and lungs, damage vegation and textile.
6. Hydrocarbons	Suspected to Produce cancer in man; damage leaft and vegetation.

In Figure 3.2 particularly the effects of Sulfur Dioxide is shown [17].

30 Verma Manju: Air Pollution and Human Environment, Department of Civil Engineering, University of Roorkee, Roorkee, 1977.

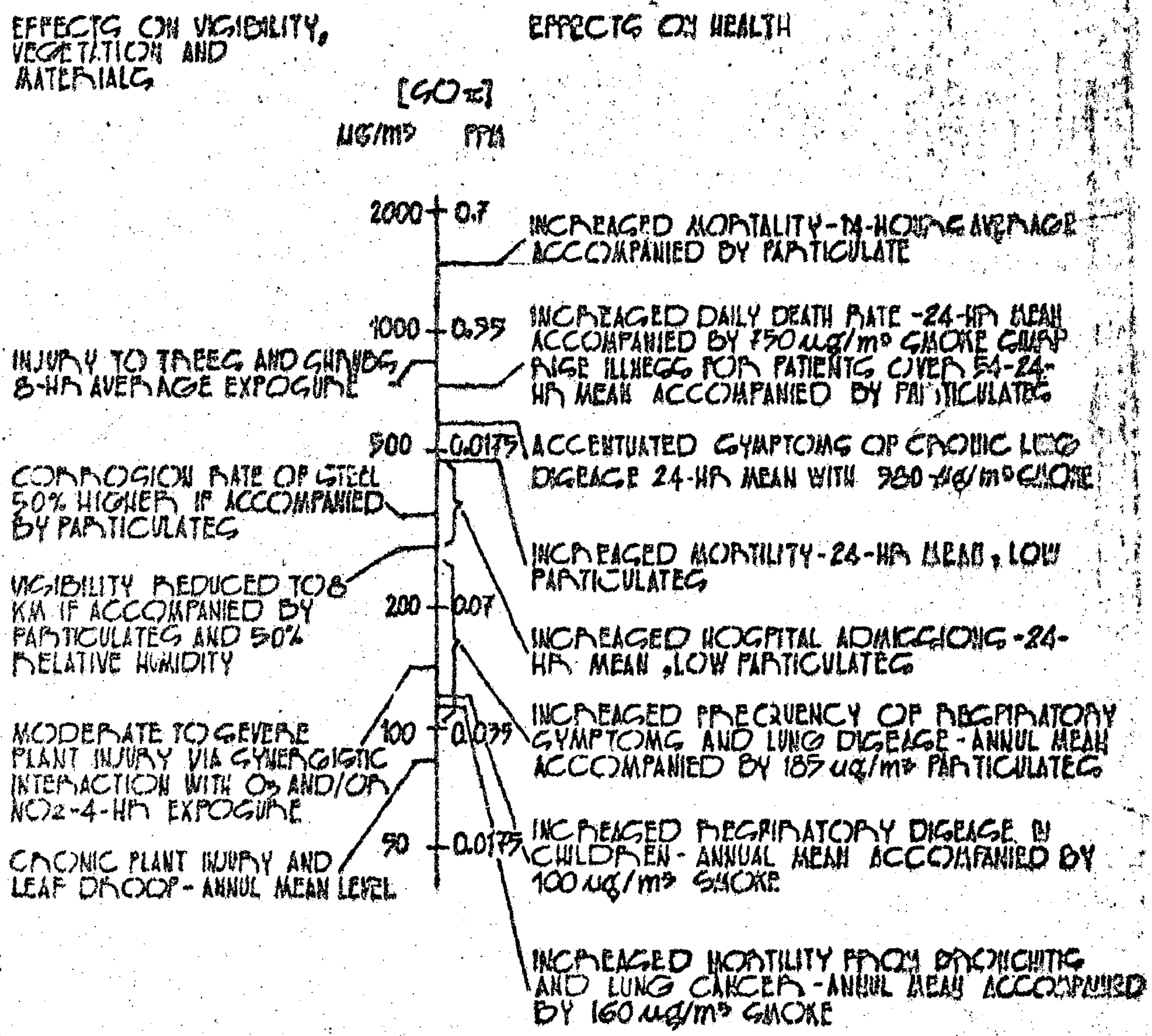


FIGURE 3.4 EFFECTS OF SULFUR DI OXIDE

4.1 THEORETICAL BACKGROUND

The atmospheric dispersion of effluents from vents and stacks depends upon many interrelated factors for example, the physical and chemical nature of the effluents, the meteorological characteristics of the environment, the location of the stack with relation to obstructions to air motion, and the nature of the terrain downwind from the stack.

The ability to predict ambient concentrations of pollutants in urban areas on the basis of dispersion from sources within the region is essential if ambient air quality standards are to be attained and maintained, inspite of future industrial and residential growth. Thus mathematical models for estimating the dispersion of pollutants from ground and elevated sourdes, whether single or grouped, must be developed to simulate the atmospheric process.

For localized point sources such as stack, the general appearance of the plume might be represented by the schematic shown in Fig. 4.1. Although the plume originate at a stack height h, it rises an additional Δh, owing to the buoyancy of the hot gases and the mommentum of the gases leaving the stack vertically with a velocity vs. consequently, for practical purposes the plume appears as a point source at an equivalent stack height $H = h + \Delta h$.

The point source also lies somewhat back along the center line from the stack position at $x = 0$.

The mass diffusion of pollutant in the y- and z-direction i.e., cross wind and vertical directions, as a fluid element is carried downwind in the x-direction with wind speed u. The necessary assumptions for the model in summary, include steady - state, negligible mass diffusion in the x-direction, a constant wind speed u at all positions, and constant mass diffusivities Dx, Dy, and Dz in the respective cordinate directions. It is also common to neglect the distance from the equivalent or virtual source to the actual stack position. Hence the point source appears to be situated at $x = 0$ and at a height H.

One appropriate representation of the concentration profile downwind from a point source is given by the general equation

$$C = Kx^{-1} \exp - \left(\frac{y^2}{D_y} + \frac{z^2}{Dz} \right) \frac{u}{4x} \qquad \ldots (4.1)$$

where K is an arbitrary constant whose values is determined by the boundary conditions on the specific atmospheric problem. For a point source at ground level the proper expression for K is

$$K = \frac{Q}{2\pi (Dy.Dz)^{1/2}} \qquad \ldots (4.2)$$

where Q is the strength of the emission source, that is, mass emitted per unit time. By substitution of Equation (4.2) into Equation (4.1) we find that the concentration of a pollutant emitted from a point source at a ground level is modelled by the expression

$$C(x,y,z) = \frac{Q}{2 \quad x(DyDz)^{1/2}} \exp\left[\left(-\frac{y^2}{Dy} + \frac{z^2}{Dz}\right)\frac{u}{4x}\right] \quad \ldots(4.3)$$

This equation has the format of the double Gaussian or normal distribution as expressed by following equation,

$$f(y,z) = \frac{1}{2 \quad y \quad z} \exp\left[\frac{-(y-\mu y)^2}{2 \quad y^2} + \frac{-(z-\mu z)^2}{2 \quad z^2}\right] \ldots(4.4)$$

Since for a ground level source the maximum concentration in the y and z directions should occur along the center line at ground level, the values of μy and μz in Equation (4.4) are zero for this physical situation. Hence Equation (4.4) reduce to the form

$$f(y,z) = \frac{1}{2\pi\sigma_y\sigma_z} \exp\left(-\frac{y^2}{2\sigma_y^2} + \frac{-z^2}{2\sigma_z^2}\right) \quad \ldots(4.5)$$

It has been found convenient to reorganize Equation (4.4) into a form similar to the above expression. In order to do this we make the following definitions.

$$\sigma_y^2 = \frac{2D_y x}{u} \text{ and } \sigma_z^2 = \frac{2D_z x}{u} \quad \ldots(4.6)$$

Substitution of these two definitions into Equation (4.4) leads to the following relationship for the concentration downwind from a ground level point source.

$$C(x,y,z) = \frac{Q}{\pi u \sigma_y \sigma_z} \exp - \frac{1}{2}\left(\frac{Y^2}{y^2} + \frac{z^2}{z^2}\right) \quad \ldots (4.7)$$

For emission from a stack with effective height H, Z = (z-H), and

$$K = \frac{Q}{4\pi\,(Dy.Dz)^{1/2}}$$

Concentration for an elevated point source or a gaseous pollutant, without reflection,

$$C = \frac{Q}{2\pi u \sigma_y \sigma_z} \exp\left\{- \frac{1}{2}\left[Y^2/\sigma_y^2 + \frac{(Z-H)^2}{\sigma_z^2}\right]\right\} \quad \ldots (4.8)$$

The restriction 'without reflection' is extremely important. The above equation is an appropriate expression for concentration in the downwind direction upto the point in the X-direction where the concentration at ground level (z=0) is significant. Then appreciable reflection of the gaseous pollutant will occur by diffusion back into the atmosphere from ground level. Such a model assumes that the earth's surface is not sink for a pollutant.

It is relatively simple task to modify the preceeding equation to account for reflection of a gaseous pollutant back into the atmosphere, once it reached ground level. By refrence to Fig. 4.2, we see that reflection at same distance X is mathematically equivalent to having a mirror image of the source at -H. The shaded area beyond position

I on the diagram indicates the region of the atmosphere in which the concentration will increase over that normally supplied by the source at H. This increased concentration is determined mathematically by linear superposition of two Gaussian-type concentration curves, one centered at H and the other at -H. This is equivalent to adding together two Equation (4.8). However, one equation contains a(z+H) term, rather than a(z-H). As a result, the concentration equation for an elevated source with reflection becomes

$$C(x,y,z) = \frac{Q}{2\pi \sigma_y \sigma_z u}\left[\exp - \left(\frac{y^2}{2\sigma_y^2}\right)\right]\left\{\exp\left[-\frac{(z-H)^2}{2\sigma_z^2}\right] + \exp\left[-\frac{(z+H)^2}{2\sigma_z^2}\right]\right\} \quad \ldots (4.9)$$

The effect of ground reflection on pollutant concentration above ground level is shown in Figure 4.3. At position I the two Gaussian type curves predict essentially no overlap in concentration, but at position downwind from I the overlap will become significant and increase as x increases. At position J downwind overlap is appreciable. By adding that portion of the lower curve which extend above ground (z = 0) to the original upper curve, we find that the upper concentration curves is altered by the addition of the shaded area shown. At some distance K further downwind from J, the shaded contribution due to reflection might lead to the profile show at K in Figure 4.3. Obviously the effect of

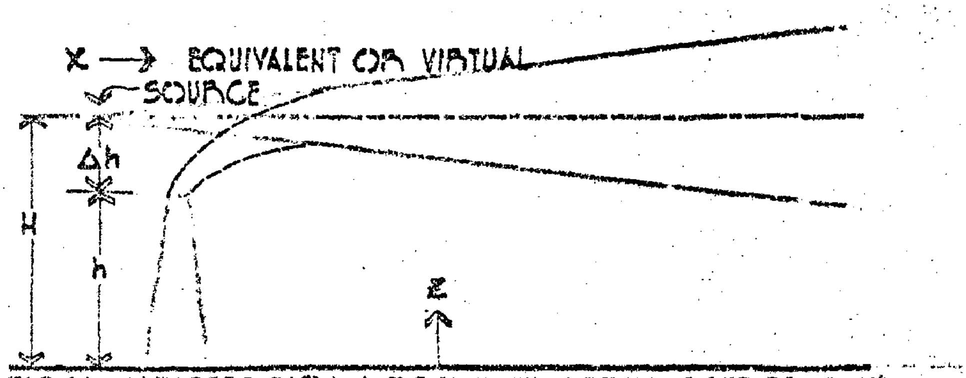


FIG 4.1 A DISPERSION MODEL WITH VIRTUAL SOURCE AT AN EFFECTIVE STACK HEIGHT H

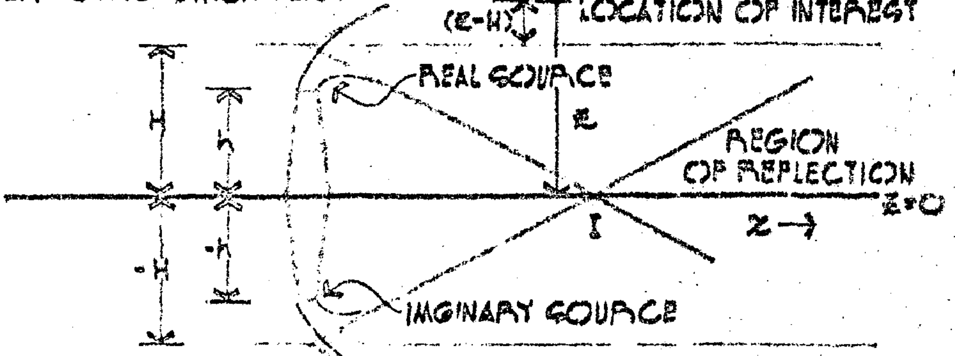


FIG 4.2 USE OF AN IMGINARY SOURCE TO DESCIBE MATHEMATICALLY GASEOUS REFLECTION AT SURFACE OF EARTH

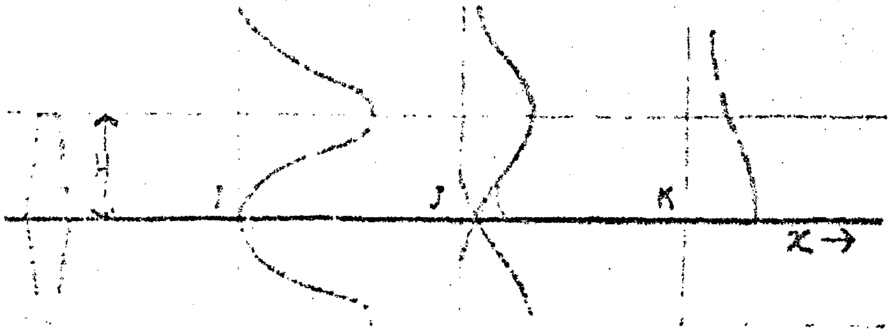


FIG 4.3 EFFECT OF GROUND REFLECTION ON POLLUTANTS

FIG 4.1, 4.2, 4.3 DISPERSION MODEL

EFFECTS OF AIR POLLUTION ON DEVELOPMENT OF AGRA SUBREGION

ground-level reflection is to increase the ground-level concentration well above that anticipated with out reflection.

Evaluation of the Standard Deviations. Besides physical data such as the coordinates x, y, and z, the emission strength Q, and the effective height H of the plume center line, it is necessary to have values u, σ_y, and σ_z. The wind speed, u is a function of height Z. Meteorological values at 10 m is used to estimate the wind speed at stack height.

The values of σ_y and σ_z to be related to the diffusion coefficients or mass diffusivities of a gas through another media in the Y- and z-directions. The horizontal and vertical deviations, σ_y and σ_z are a function of downwind position x as well as atmospheric stability conditions. Many experimental measurements in the atmosphere have led to an evaluation and correlation of σ_y- and σ_z- values. There are several sets of charts for these two parameters, and the range of stability conditions covered in the different sets do not normally coincide. One widely accepted set of charts is presented as Fig. 4.4 and 4.5 as prepared by Turner[32].

Turner has also prepared a listing of atmospheric conditions which aid in determining which of the six stability

32 Wark, Kenneth and Warner, F. Cecil, Air Pollution and its Origin and Control, Dun Donneley Publisher, New York, 1976.

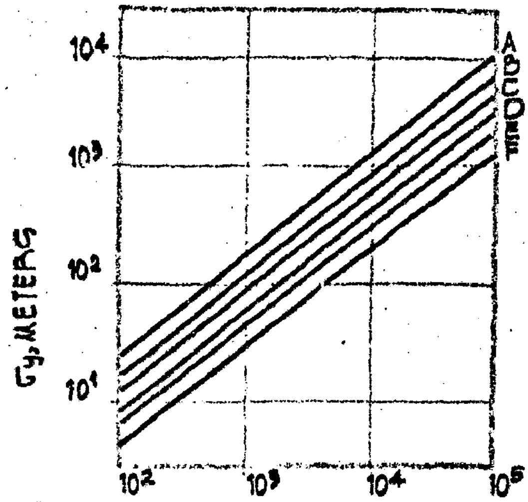


FIG.4.4 STANDARD DEVIATION, σ_y IN THE CROSSWIND DIRECTION DIRECTION AS A FUNCTION OF DISTANCE DOWNWIND

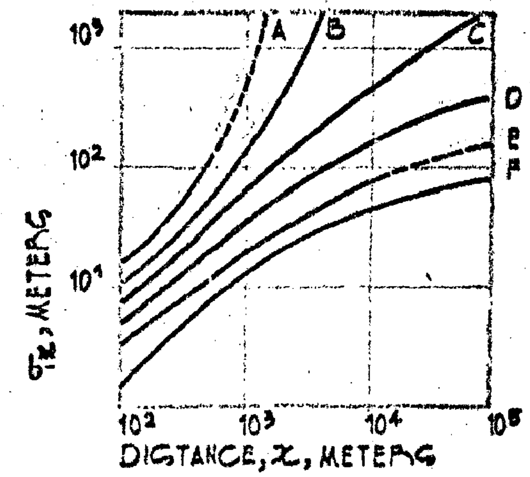


FIG.4.5 STANDARD DEVIATION, σ_z, IN THE VERTICAL DIRECTION AS A FUNCTION OF DISTANCE DOWNWIND

FIG.4.4-4.5 STANDARD DEVIATION

When estimating gaseous dispersion from a given source, we normally would chose that stability class typical of the region which would lead to the worst pollution episode.

4.2 ANALYSIS

In order to analyse the effect of the Mathura Refinery on the Agra subregion and its environs according to the formulation described in the preceding section 4.1 it is necessary to adopt specific points at which the concentration of the pollutants be studied and the data pertaining to the analysis be finalized.

4.2.1 Discretisation of the Region

Discretisation of the subregion in essence means the generation of specific sampling points, for the variables involved, in the region. Relevant to this problem, it was felt that the conditions which would be responsible for the probable worst distribution of pollution effluent be considered. Subsequently the direction of effluent flow i.e. along the flow of wind, be such as to be directed from the refinery to the Taj, as the crow flies.

The orientation of the coordinate axis is such that the origin lies at the Mathura Refinery at ground level. The adopted mesh is such that the X-axis is oriented along the line joining the Mathura Refinery to the Taj. The Y-axis is classes (A through F) appearing on the σ charts is appropriate. Table 4.1 shows the key to the various stability categories which is given on the next page.

TABLE 4.1 - KEY TO STABILITY CATEGORIES

Surface Wind Speed at 10 m (m/s)	Day Incoming Solar Radiation			Night Cloud Cover	
	Strong	Moderate	Slight	Mostly Overcast	Mostly clear
Class	(1)	(2)	(3)	(4)	(5)
2	A	A-B	B	E	F
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
6	C	D	D	D	D

The following items refer to the classes numbered in Table 4.1.

1. Clear skies, solar altitude greater than 60 degrees above the horizontal, typical of a sunny summer afteroon. Very convective atmosphere.

2. Summer day with a few broken clouds.

3. Typical of a sunny fall afternoon, summer day with broken low clouds, or summer day with clear skies and solar altitude from only 15 to 35 degrees above horizontal.

4. Can also be used for a winter day.

perpendicular to the X-axis and is such that X-Y plane is horizontal. The Z-axis is directed vertically upward.

The mesh extends from X= 29 kms to X = 64 kms with subdivisions at increments of 5 kms (approximately). The subdivisions in the Y-direction has been done at the interval of 5 kms so as to establish a square grid over the region of interest. The grid extends upto a distance of 20 kms on either side of the X-axis (Mesh I, Figure 4.6). Subsequent to the preliminary studies from Mesh I, which established a distance of 10 kms on either side of X-axis as sufficient for evaluation of concentration of pollutants of appreciable magnitude, the mesh points were placed 1 km apart in the Y-direction (Mesh II, Figure 4.7).

4.2.2 Data for Analysis

The characteristics of the Mathura Refinery used for the purpose of study, along with the wind velocity are as follows.

Emission rate of sulfur dioxide	=	5000 kg/hrs (17)
Stack height	=	100 mts (17)
Wind velocity	=	6 mts/sec

The constants σ_y and σ_z are calculated from Chart for various values of X and the relevant class of atmospheric conditions. The studies conducted on Mesh I were carried out for values of Z = 0.00 mts, 1.5 mts, 4.0 mts, 12 mts and 100 mts. This variation of Z was adopted to similate the ground level, the average height of man, the average height of single storeyed buildings, the average height of three storeyed building, and the stack height. Subsequently in Mesh II Z = 0.0 mts only was adopted.

4.3 FINDINGS

4.3.1 General

A. In selecting the site for an industry, factors like soil conditions, drainage, access to water, power, transportation and utilities are seriously considered. Unfortunatley, the more important topographical, meteorological and other ecological factors and the overall land use plan for the region are generally ignored.

B. The location of a major industry i.e. oil refinery in river valleys, along the water frontage and areas subjected to frequent atmospheric inversion is bound to create a more adverse impact on the local environment than would be the case if the industry were located elesewhere.

C. In hot dry and monsoon seasons the pollutant are well dispersed causing low pollution level as compared to cool dry season. In monsoon months wind is gusty and in

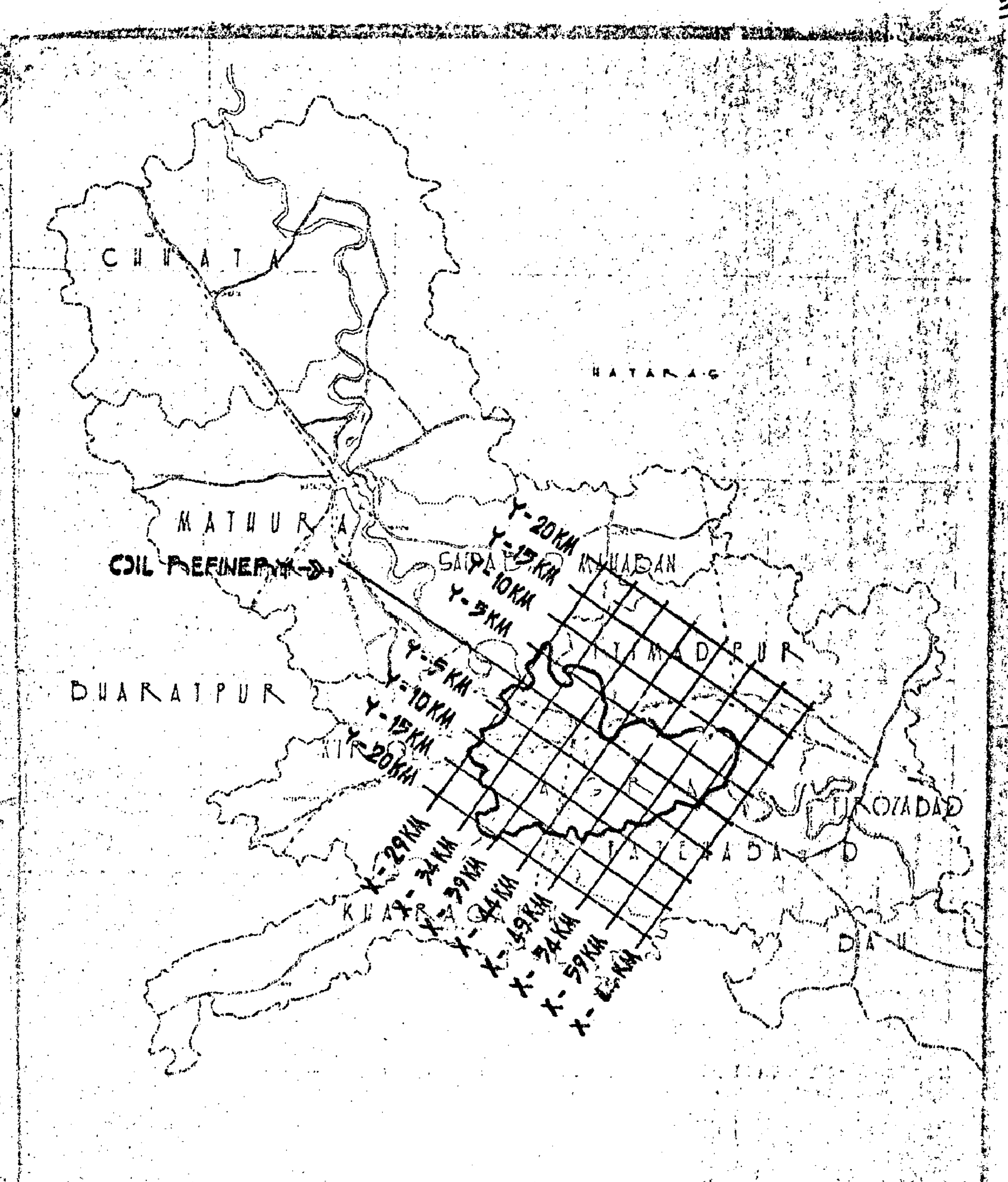


FIGURE 4.6 MESH I

EFFECTS OF AIR POLLUTION ON DEVELOPMENT OF AGRA SUBREGION

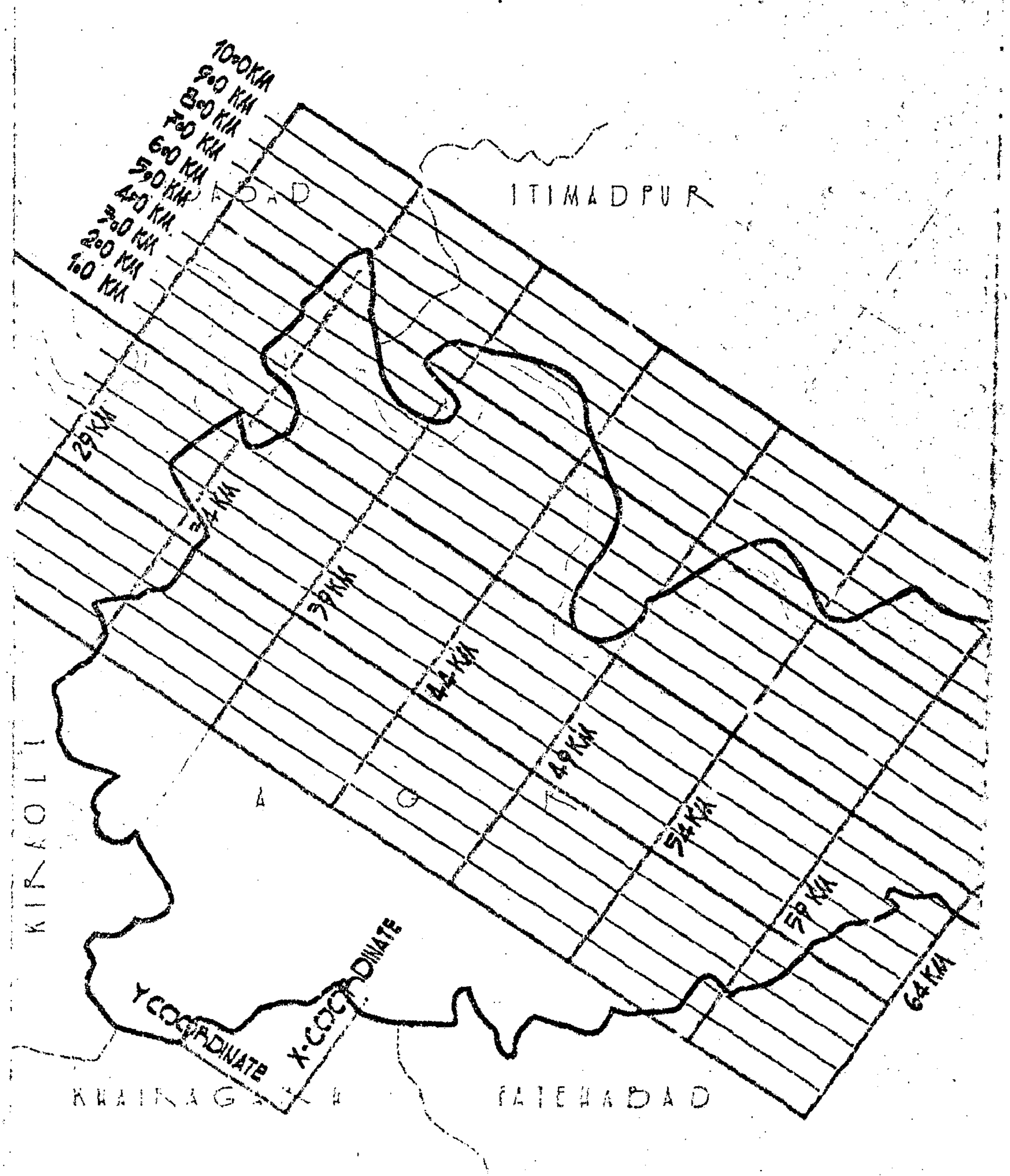


FIGURE 47 MESH II

EFFECTS OF AIRPOLLUTION ON DEVELOPMENT OF AGRASUBREGION

hot dry season the stability ranges mostly from 1 to 3, which are favourable for the dispersion of Sulfur dioxide. This is not so in cool dry season when wind velocities are low and wind is less gusty. The air movement in this season is anticyclonic, which tends to bring down the pollutants. These conditions are unfavourable for dispersion.

D. The geography and meteorology which are characteristic of the Agra Subregion add to the severity of air pollution and the area east and south-east of the Mathura Refinery is subjected to high level of pollutant.

E. Authorities have also ignored the multiplier effects of the location of the refinery, leading to increased traffic and urbanization with the consequential solid, liquid and air pollution load in the upwind direction of Agra.

F. Surveys show that a large majority of the people living in the subregion consider air pollution serious problem.

G. As in the case with many other regional problems; air pollution within one local jurisdication must be related to the larger air system of which it is a part, and this relationship is missing here.

H. Although more and better data are needed relating to several aspects of air pollution, particularly its effect on human health, existing information is sufficient to support the major decisions in planning air pollution control.

I. The principal sources of pollution, apart from the Mathura refinery itself, are two ancient coal power plants, a railway yard with steam locomotives, and about 250 small iron foundries. The main poision they emit is sulfur dioxide, an acrid gas which, when dissolved in water forms an acid.

J. The emission rate for Mathura Refinery, 13 MW Agra Power Plants and Area source are 5000, 250, and 137.5 kg/hour respectively.

K. Recent U.S. investigations indicate that little oxidation of Sulfur dioxide occurs during first 16 to 32 km, the conversion rate gets highly accelerated by several per-cent per hour after the first 50 km of plume travel downwind. In such a case the low level of sulfur dioxide expected at Agra should make realize that high acidic radicals resulting from long distance travel and transformation of different pollutants from the refinery can become alarming signals to the safety of plants, animals and buildings.

L. The expected air pollution levels inthe study area will be higher than the level judged safe for human health by medical authorities, because, theoretically, any increase in air pollution even at one microgram per cubic metre is not good. Dr. Michael Royston of the Centre for Environmental Education, Geneva, has warned that the refinery emissions could cause cancer not only to the monuments but also to people of the region.

M. At present Town Planning Departments do not consider and discuss air pollution in analysis and preparation of Master Plan.

N. City and Regional Planning as presently practiced have neither the analytical knowledge nor institutional position to direct development towards more rapid attainment of air quality objectives.

O. There is no cooperation between different agencies.

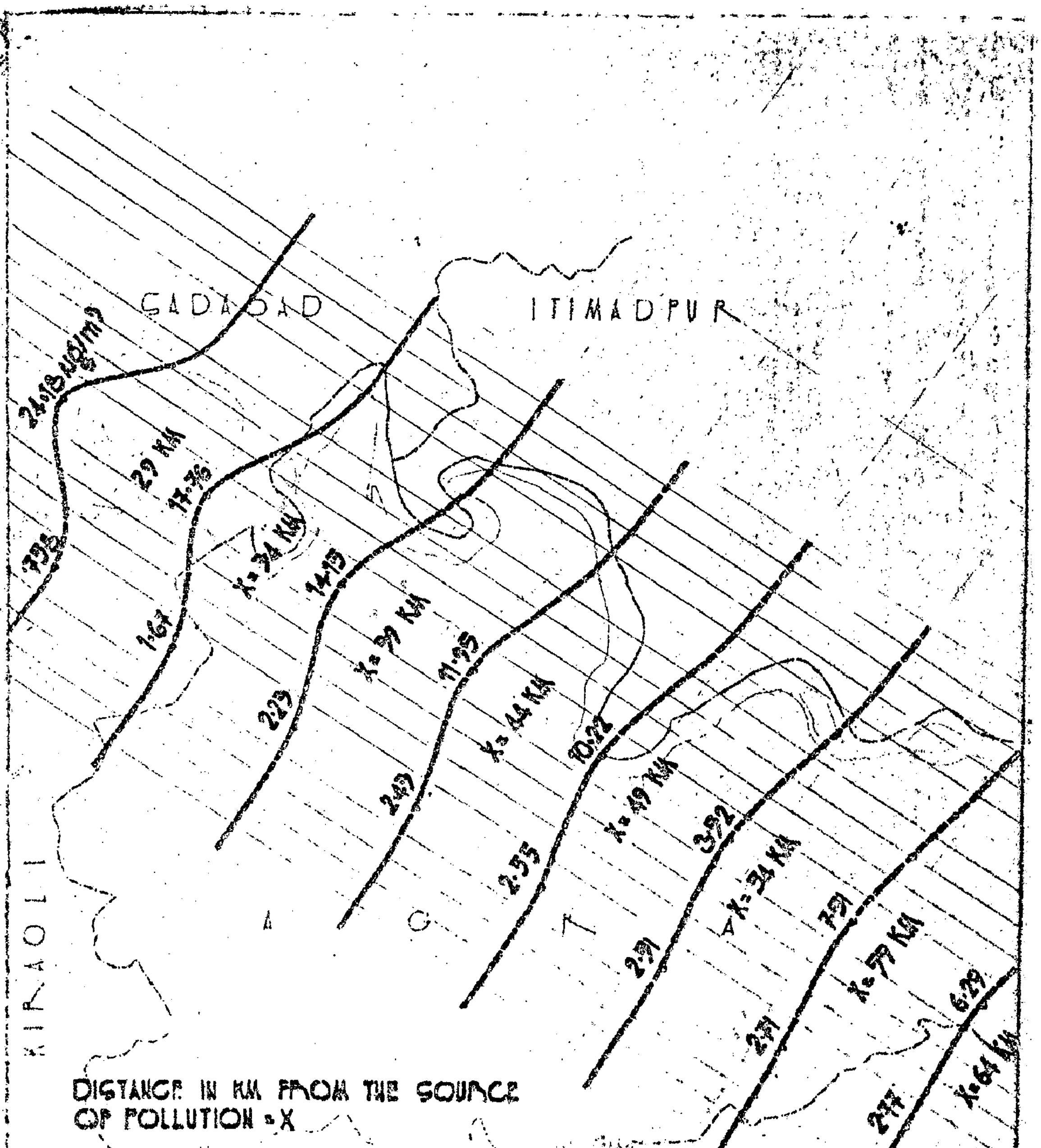
P. At present the persons, who are polluting the atmosphere, are rarely bothered about the rational way of controlling urban air pollution by curbing and substantially reducing pollution at the source.

4.3.2 From Analytical Studies

A. Results. The results obtained from a computer programm (See Table 1 and 2) developed specifically for the study (appendix 1) are presented in figures as mentioned below.

Figure No. 4.6. Variation of Sulfur dioxide concentration for different values of X.

This figure indicates clearly the Gaussian nature of the distribution of Sulfur-dioxide emitted from the Mathura refinery. It is also possible to reconstruct or to visualize the specific Gaussian surface generated by the distribution of effluents emitted from a polluting source.



THIS FIGURE INDICATES CLEARLY THE GAUSSION NATURE OF THE DISTRIBUTION OF SULPUR DIOXIDE EMITTED FROM THE MATHURA REFINERY. IT IS ALSO POSSIBLE TO CONSTRUCT OR TO VISUALIZE THE SPECIFIC GAUSSIAN SURFACE

FIG48 VARIATION OF SULFUR DIOXIDE CONCENTRATION FOR DIFFERENT VALUES OF X

EFFECTS OF AIRPOLLUTION ON DEVELOPMENT OF AGRASUBREGION

Figure No. 4.9. Variation of Sulfur dioxide concentration for different values of Y.

This figure indicates, in conjunction with Figure No. 4.8, the Gaussian nature of the distribution of Sulfur dioxide concentration. It is also possible to see the reflection effect.

Figure No. 4.10. Variation of Sulfur dioxide concentration fof different values of Y and Z.

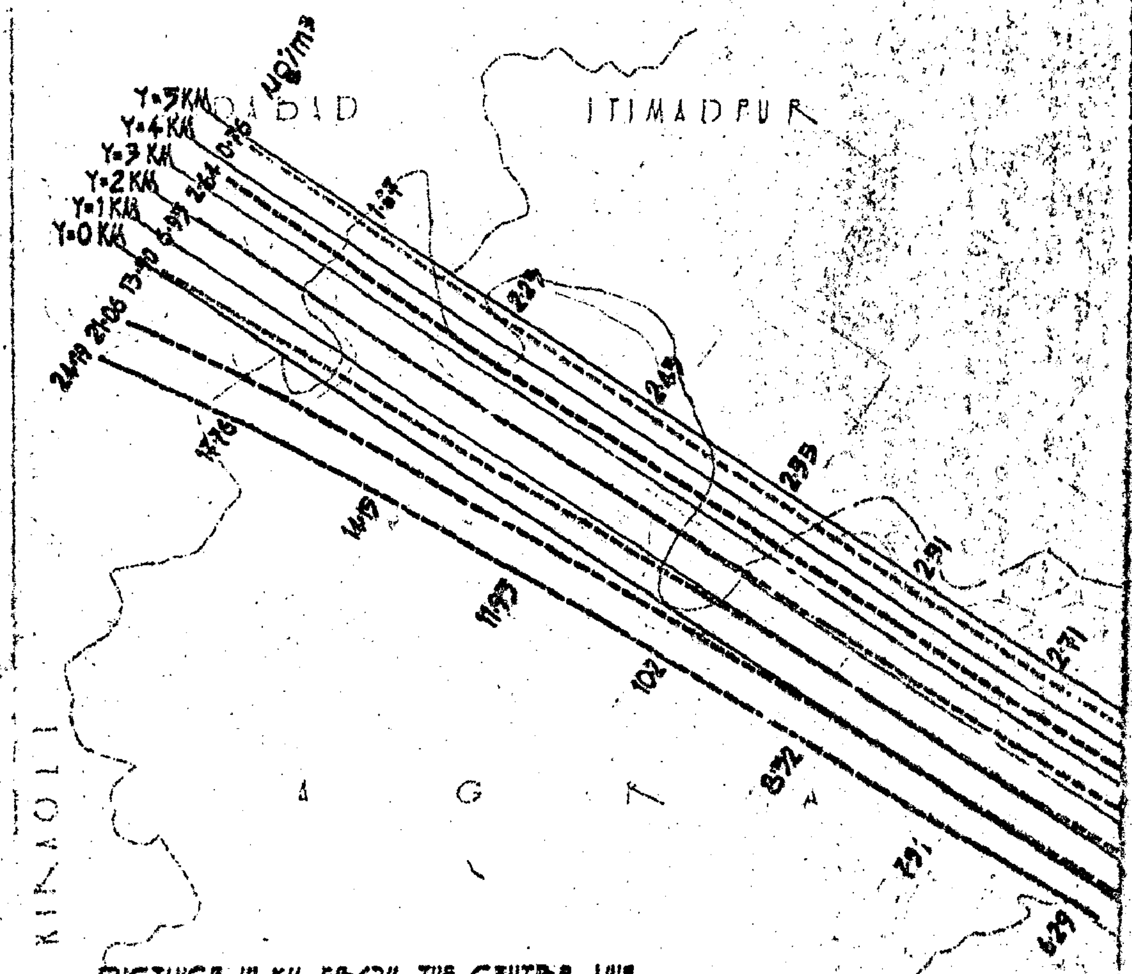
As mentioned in the discription of Figure No. 4.9 the reflection effect is clearly visible at Y = 5 km for each of the cases i.e. z = 0, 1.5 and, 4 mts.

Figure No. 4.11. Variation of Sulfur dioxide concentration for different values of X and Y.

This figure representing the histograms which depicts the distribution of Sulfur dioxide concentrations at some locations of X (29 kms, 34 kms, 39 kms) and Y (0 km and 5 kms) for the various values of Z adopted for this study.

Figure No. 4.12. Sulfur dioxide concentration contours for Agra Subregion.

This figure indicates the Sulfur dioxide concentration at ground level for the parameters adopted for this study.

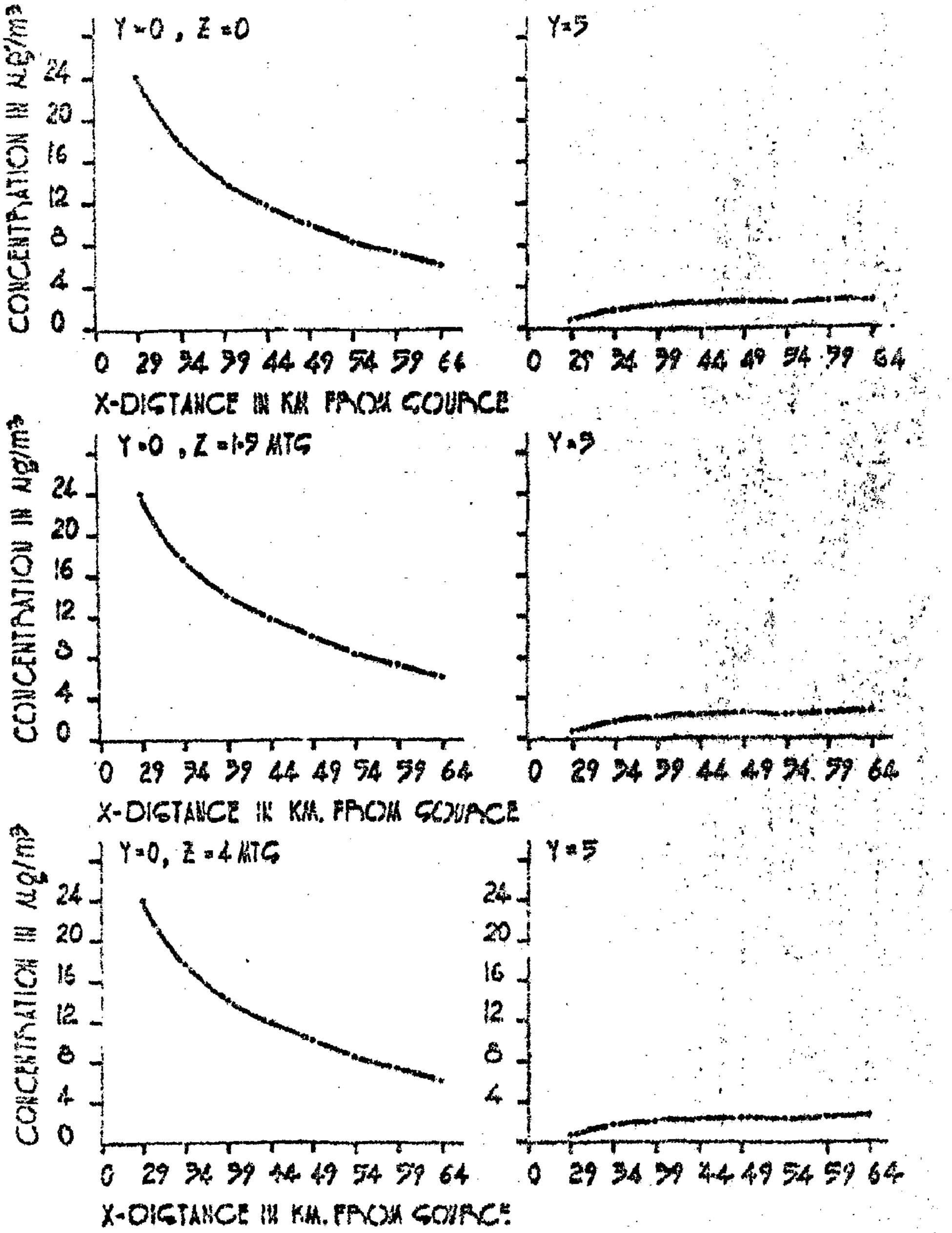


DISTANCE IN KM FROM THE CENTRE LINE OF PLUME = Y

THIS FIGURE INDICATES , IN CONJUNCTION WITH FIG. , THE GAUSSIAN NATURE OF THE DISTRIBUTION OF SULFUR DIOXIDE CONCENTRATION . IT IS ALSO POSSIBLE TO SEE THE 'REFLECTION EFFECT'

FIG 4.9 VARIATION OF SULFUR DIOXIDE CONCENTRATION FOR DIFFRENT VALUES OF Y

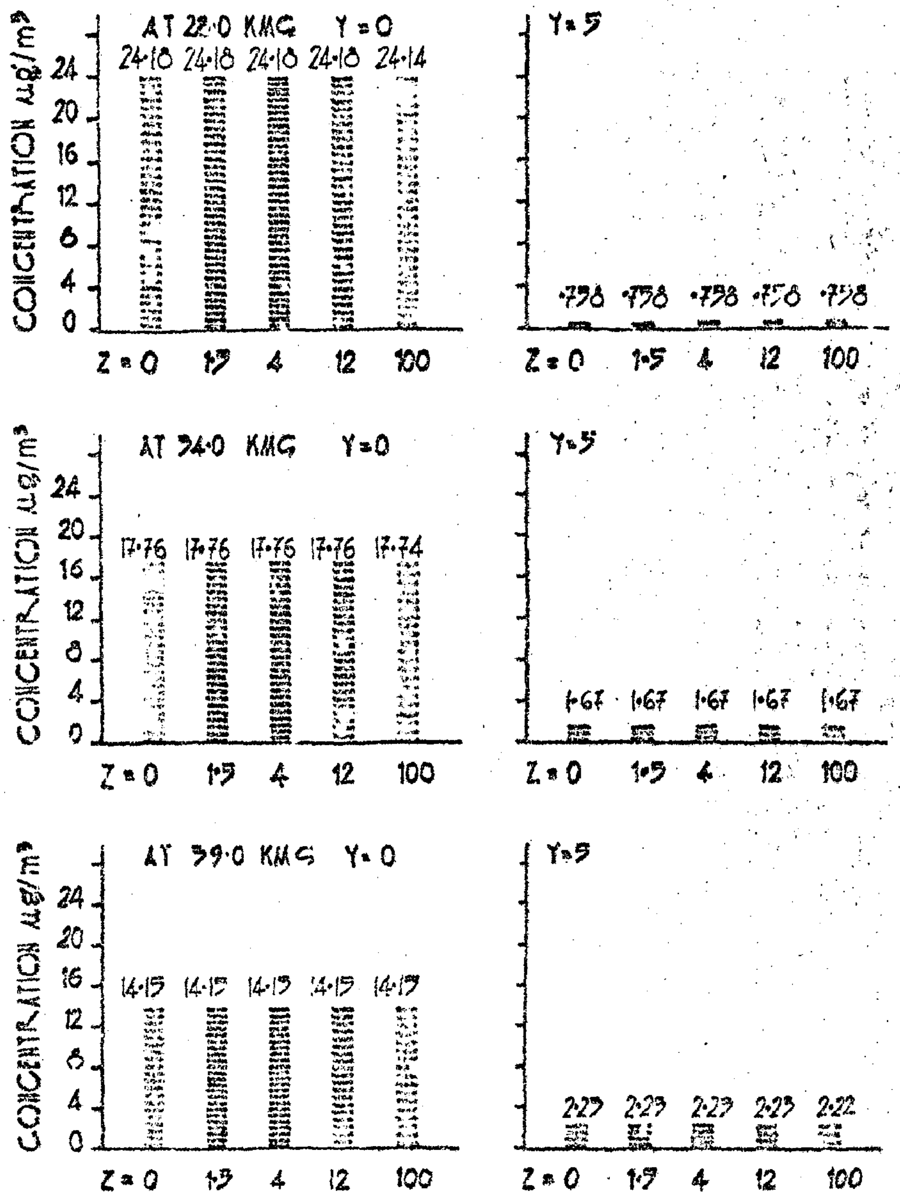
EFFECTS OF AIR POLLUTION ON THE DEVELOPMENT OF AGRA SUBREGION



AS MENTIONED IN THE DESCRIPTION OF FIG. THE REFLECTION IS CLEARLY VISIBLE AT Y=5 KM FOR EACH OF THE CASES I.E. Z=0 1.5 AND, 4 MTS

FIG.4.10 VARIATION OF SO_2 CONC. FOR DIFF. VALUES OF Y AND Z

EFFECTS OF AIRPOLLUTION ON DEVELOPMENT OF AGRASUBREGION

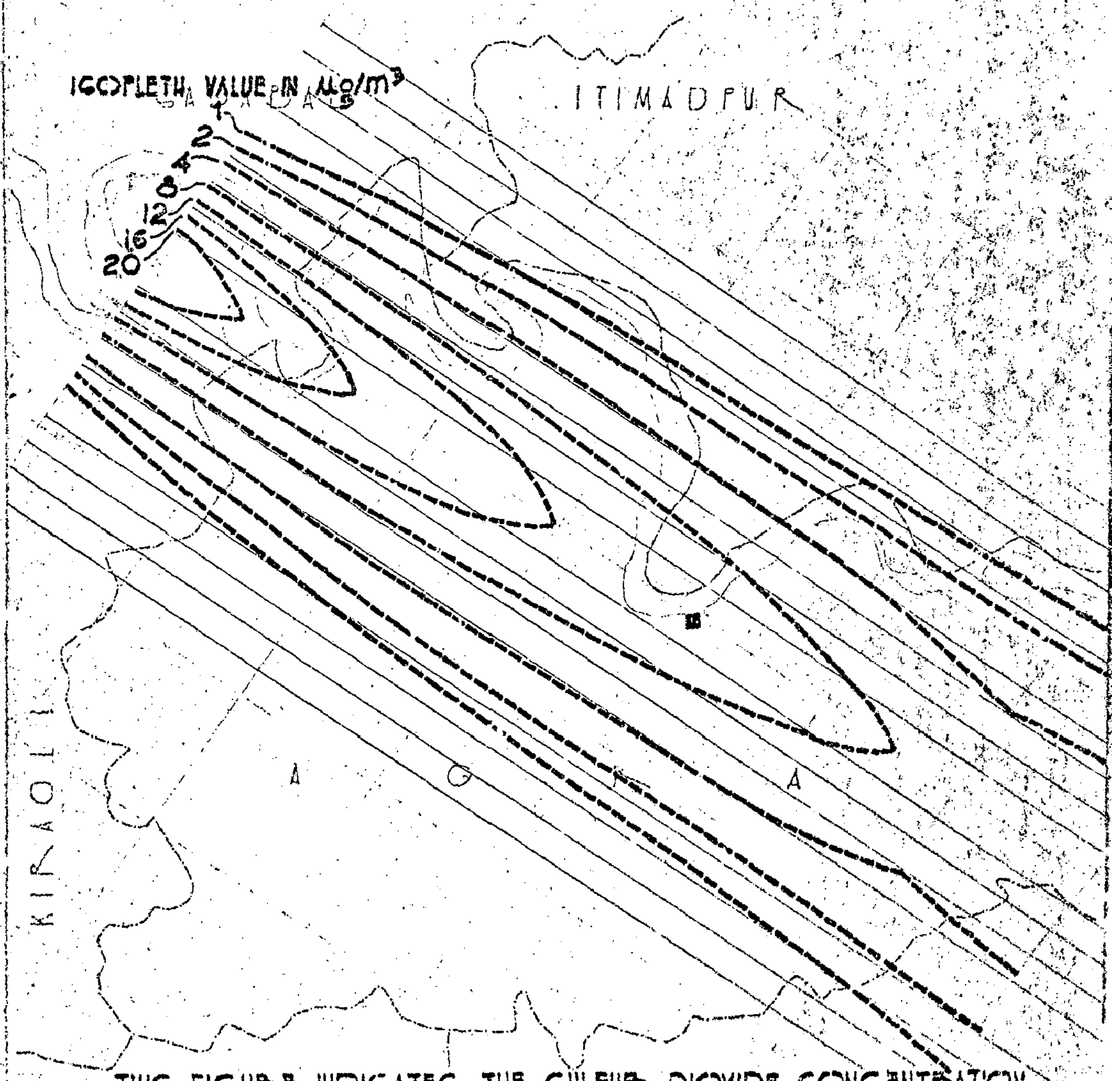


THIS FIGURE PRESENTING THE HISTOGRAMS WHICH DEPICTS THE DISTRIBUTION OF SO_2 CONCENTRATIONS AT SOME LOCATIONS OF X (29, 34, 39 KMS) AND Y (0, 5 KMS) FOR THE VARIOUS VALUES OF Z

FIG 4.1 VARIATION OF SO_2 CONC. FOR DIFF. VALUES X AND Y

EFFECTS OF AIRPOLLUTION ON DEVELOPMENT OF AGRASUBREGION

MADHUKAR GAYAN



THIS FIGURE INDICATES THE SULFUR DIOXIDE CONCENTRATION AT GROUND LEVEL FOR THE PARAMETERS ADOPTED FOR THIS STUDY

FIG4.12 SULFUR DIOXIDE CONCENTRATION CONTOURS FOR AGRA SUBREGION

EFFECTS OF AIRPOLLUTION ON DEVELOPMENT OF AGRASUBREGION

MADHUKAR GHYAM

B. Specific Findings.

(i) The bidirectional Gaussian distribution of pollutants essentially represents a Gaussian surface.

(ii) The effect of height on the concentration of Sulfur dioxide is negligible in the subregion considered. The emission of Sulfur dioxide from the Mathura Refinery has a tendency to cause uniform concentration throughout the height in the city of Agra and its suburbs.

(iii) The effect of reflection is not so pronounced so as to cause any appreciable effect in the concentration of Sulfur dioxide in the region under consideratioh.

(iv) The concentration of Sulfur dioxide in the major part of the region lies below 16 ug/m^3 due to the Mathura Refinery only.

(v) The Mathura Refinery causes a concentration of 10 ug/m^3 of Sulfur dioxide at the location of the Taj and its immediate vicinity. The total concentration is however of the order of 30 ug/m^3.

STABILITY CLASS 'C'

VALUES OF X IN KMS	VALUES OF Y IN KMS 0	1	2	3	4	5	6	7	8	9	10
4	910.03	1.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	189.24	55.83	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	83.08	54.96	15.91	2.02	0.11	0.00	0.00	0.00	0.00	0.00	0.00
19	43.71	33.87	15.75	4.40	0.74	0.07	0.00	0.00	0.00	0.00	0.00
24	30.88	25.97	15.46	6.51	1.94	0.41	0.06	0.01	0.00	0.00	0.00
29	24.19	21.06	13.90	6.95	2.64	0.76	0.17	0.03	0.00	0.00	0.00
34	17.77	-16.17	12.18	7.59	3.92	1.67	0.59	0.17	0.04	0.01	0.00
39	14.15	13.14	10.53	7.27	4.33	2.23	0.99	0.38	0.12	0.04	0.01
44	11.95	11.21	9.26	6.73	4.31	2.43	1.20	0.53	0.20	0.07	0.02
49	10.22	9.67	8.19	6.20	4.20	2.55	1.38	0.67	0.29	0.11	0.04
54	8.52	8.12	7.01	5.49	3.90	2.51	1.47	0.78	0.37	0.16	0.06
59	7.51	7.21	6.38	5.20	3.91	2.71	1.73	1.02	0.55	0.28	0.13
64	6.29	6.09	5.52	4.68	3.72	2.77	1.93	1.26	0.77	0.44	0.24

TABLE 4.2 - CONCENTRATION OF SULFURDIOXIDE POLLUTANT IN UG/M^3 IN THE AGRA SUBREGION FOR STABILITY CLASS 'B'

VALUES OF X IN KMS	VALUES OF Y IN KMS: 0	1	2	3	4	5	6	7	8	9	10
4	535.62	72.49	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	96.61	55.52	10.53	0.66	0.01	0.00	0.00	0.00	0.00	0.00	0.00
14	46.87	32.73	16.80	5.53	1.17	0.16	0.01	0.00	0.00	0.00	0.00
19	19.18	16.44	10.35	4.78	1.62	0.40	0.07	0.01	0.00	0.00	0.00
24	11.16	10.07	7.38	4.40	2.14	0.84	0.27	0.07	0.02	0.00	0.00
29	7.37	6.80	5.35	3.59	2.05	1.00	0.41	0.15	0.04	0.01	0.00
34	3.72	3.47	2.83	2.01	1.24	0.67	0.32	0.13	0.05	0.01	0.00
39	2.72	2.57	2.15	1.59	1.05	0.62	0.32	0.15	0.06	0.02	0.01
44	2.23	2.12	1.81	1.40	0.97	0.61	0.34	0.17	0.08	0.03	0.01
49	1.91	1.83	1.61	1.30	0.96	0.65	0.40	0.23	0.12	0.06	0.03
54	1.57	1.52	1.37	1.15	0.90	0.66	0.45	0.29	0.17	0.10	0.05
59	1.46	1.41	1.29	1.11	0.91	0.69	0.50	0.34	0.22	0.13	0.07

5

AIR POLLUTION STRATEGIES AND TECTICS

An air pollution strategy is a master plan that provides a solution to a municipal, state or provincial, air pollution problem. Air pollution tectics are detailed procedures for carrying out this master plan. Tactics may be of broad scale, involving the control of air pollution in a city, or of a more limited nature, e.g., determining type of control equipment to install on a specific emission source.

5.1 LIMITS OF POLLUTION CONTROL STRATEGY

It is the desire of all to have a totally pollution - free environment at no cost. That is only possible if one can repeal the laws of nature. Since the laws of nature can not be repealed, a rational goal must be try to limit air pollution to an appropriate level, by appropriate expenditure of pollution control resources.

The ultimate goal of any air pollution strategy is the reduction or reapportionment of pollutant emissions. Thus, the a strategy must be worked out such that it regulated various emission sources.

5.2 QUALITY OF POLLUTION CONTROL STRATEGY

The peffect strategy and resulting tactics for carrying it out would have the following qualities:

5.2.1 It would be cost effective and fair, gaining the maximum benefit for the resources (financial and social) expended and distributing costs and benefits equitably.

5.2.2 It would be simple and understandable to all concerned.

5.2.3 It would be easily enforceable.

5.2.4 It would be flexible, allowing some reasonable method for dealing with special situations, problems, and hardship cases without resource to extensive litigation.

5.2.5 It would be evolutionary, allowing new data on pollution effects and new advances in control technology to be incorporated rapidly.

No air pollution control strategy possesses all of these virtues.

5.3 AVAILABLE ALTERNATIVE STRATEGIES

The four p air pollution control strategies which have received the greatest public attention to date are air quality management, emission standards, emission taxes, and cost-benefit strategies.

5.3.1 Air Quality Management Strategy

The air quality management approach specifies a set of ambient air quality standards. Once they have been develope and adopted, the quality of air is managed to meet these standards. This management takes place through regulation of the amount, location, and time of pollutant emissions.

5.3.2 Emission Standards

An emission standard strategy establishes permitted emission levels for specific group of emitters and requires that all, members of these groups emit no more than these permitted emission levels. These standards can be applicable to any selected group of emitters and can be local, regional or national in application.

5.3.3 Emission Taxes

An emission tax strategy would tax each emitter of major pollutants, according to some published scale related to its emission rate. The tax rate is set such that major emittes would find it economical to instal control equipment rather than pay the taxes. In its "pure form" there would be no legal or moral section against an emitter who elected to pay the tax and not control his emission.

5.3.4 Cost Benefit Strategies

Cost benefit strategies attempt to quantify the damages from various pollutants and cost of controlling these pollutants, and then select those pollution control alternatives which lead to a minimum in the sum of pollution damage and pollution control cost.

5.4 AIR QUALITY MANAGEMENT

5.4.1 Definition

Of the various definitions now in vogue for air quality management strategy is the regulation of the amount, location, and time of pollutant emissions to achieve some clearly defined set of ambient air quality standards or goals. It includes the evaluation of various sets of emission control schedules to determine the consequencies to air quality and the formulation of alternative emission control schedules to meet air quality goals subject to some other constraint, e.g., technological feasibility or minimum cost.

5.4.2 Information Inputs

From the definition, it follows that to practice air quality management in a city, state, or region the air quality manager requires the following:

A. A set of air quality standards or goals to be achieved. These can be locally or, nationally determined. They may relate to long or short term, measurable concentrations of various pollutants.

B. An inventory of the emission from various sources in the region including man made (anthropogenic) emission as well as emission from natural sources (biogenic). Ideally, the emission inventory would indicate not only the location of the source (grid coordinates and stack height), but also the emission schedule.

C. Predictive methodology to relate air quality to emission. It would provide both short term and long term average predictions and show the impact of each emission source on air quality at each location.

D. Monitoring data to determine the status of ambient air quality. Since the ultimate goal of air quality management is to regulate emissions to meet a clearly defined air quality standard, the air quality manager must test this performance by measuring ambient air quality.

E. Plausible sets of emission control tactics which can be evaluated to see if they will allow the standards to be met, subject to constraints of technical and economic feasibility, enforcibility, etc.

F. Data on the cost and efficacy of control devices and options. In evaluating the emission tactics (item D above), the air quality manager must estimate the cost of each set of tactics, including both capital expenditure for control equipment and operating cost to meet the ambient air quality standards.

G. An enforcement procedure which allow the air quality manager to implement his planned emission control programme.

5.4.3 Tactics

Once the decision has been made to use the air quality management strategy and set of ambient air quality standards have been determined, the air quality manager has numerous tactical options for achieving these standards.

A. Tactic 1 - Land Use Planning. Many issues are now being raised with regards to land use. In the past, environmental problems have been approached independent of interactions instead of recognizing them as insepprable part of entire land use system. They have been considered as unrelated to anything else. The pollution problem is integrated with land use, including concerns such as community planning, highway design, traffic control, mass transportation, demography, topography, economy and social concerns. Population growth and concentration significantly effect planning considerations to minimize environmental hazards.

Consideration of land as a commodity to be exploited for the highest price must be reappraised to consider land as a resource to be used for the benefit of society as a whole. The systems approach to land utilization is necessary if we are to maintain the environmental quality mandated by laws, regulations, and common sense. There is need for institutional reform. Government must decide on how their land will be used within given environmental constraints.

Failure to perceive environmental consequences associated with planning decisions has created many day to day problems. Land use problems associated with urban growth, congestion, sprawl, and unnecessary decay of the central cities have evolved over many years and are in conflict with environmental goals.

These are problems that can not be corrected in a short time. There are many vital issues that planners must consider within a framework for decision making. Air pollution control is but one of them. To legislate the achievement of air quality standards in a very short time imposes severe hardships. Long range programmes will be required to so-lve the basic cause of the problem.

Land use plans are subject to change and in no way bind jurisdictions to their long range goals, which are often subverted for short term gains. Successful maintenance of standards requires that land use, and environmental planning be closely interrelated with common goals clearly defined and vigrously pursued.

In theory there are at least six purposes which might be served through the application of land use controls to the field of air quality management.

(i) To provide complete protection from pollution of all sorts to highly desired environments, such as scenic shorelines recreational areas, or agricultural areas devoted to the growing of highly sensitive crops.

(ii) To prevent entry of a particularly large or noxious source of pollution emissions into certain type of land areas, such as those occupied by metropolitan communities.

(iii) To prevent the development of significant area sources of pollution emission as a consequence of proliferation of controlled sources within a limitedland area.

(iv) To prevent the mixing of incompatible land uses within a limited area, such as intermingling of sensitive air pollution receptors and sources of highly noxious pollutants.

(v) To influence the ultimate design configuration of a community so as to minimize those community conditions which lead to high yields of unwanted pollution emissions, such as the relationship between distance to work and likely exhaust emissions from motor vehicles.

(vi) To provide areas remote from populous or highly valued environmental settings for high environment impacting or hazardous operations.

B. Tactic 2 - Urban Forestry. Efficient, effective management of urban vegetation, especially forests, is essential to the environmental and social well - being of all our citizens. The urban forests includes all woody vegetation within the environs of populated places, from the tiniest villages to the largest cities. In this sense it includes not only trees within city limits but trees on associated lands that contribute to the environment of populated places for example, greenbelts, municipal watersheds, recreation sites, and road sides.

The role of trees in reducing air pollution is not well understood, and there is considerably disagreement as to their effectiveness.

It is well known that plants produce oxygen in the photosynthetic process. Some people have suggested that plants perform an important role in reducing air pollution through the process of oxygenation (the introduction of excess oxygen into the atmosphere) and dilution (the mixing of polluted air with fresh air). (Fig. 5.1 and 5.2).

Certain plants can absorb specific air pollutants, that is, hydrogen fluoride, sulfur dioxide, and nitrogen dioxide. The pollutant least absorbed, however, is carbon monoxide. It has been estimated that approximately 88 percent of the oxygen produced on the earth through photosynthesis originates in the sea. It has also been estimated that the oxygen produced by an acre of forest land per year represents only 0.03 percent of total oxygen found over that acre. Thus oxygenation and dilution by plants are probably

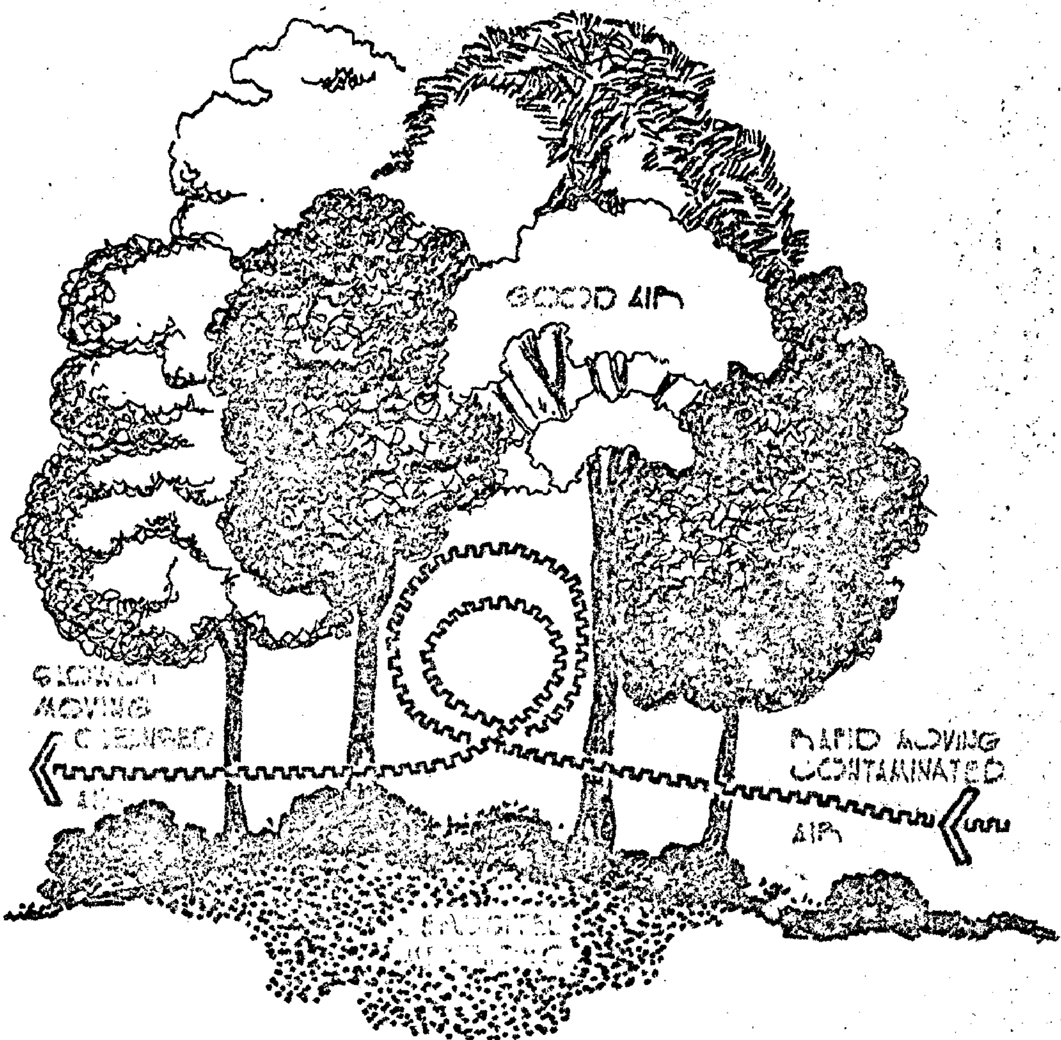
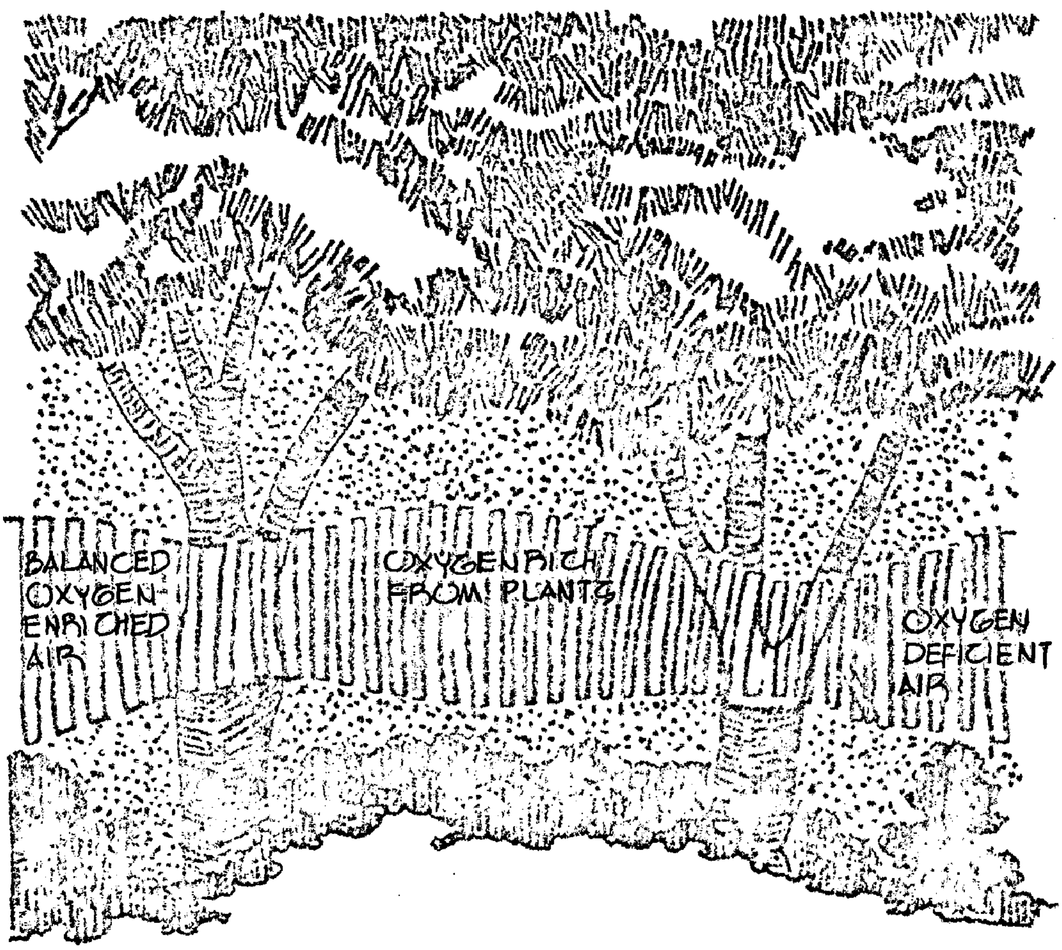


FIG 6.1
DILUTION
PROPOSED SCHEMATIC FOR AIR POLLUTION ABATEMENT BY PLANTS THROUGH THE PROCESS OF OXYGENATION

FIG 5.1 TACTIC II - URBAN FORESTRY

EFFECTS OF AIRPOLLUTION ON DEVELOPMENT OF AGRASUBREGION

MADHUKAR CHYAK



OXYGENATION

PROPOSED SCHEMATIC FOR AIR POLLUTION ABATEMENT, BY PLANTS THROUGH THE PROCESS OF OXYGENATION

FIG 5.2 TACTIC II - URBAN FORESTRY

EFFECTS OF AIR POLLUTION ON DEVELOPMENT OF AGRA SUBREGION

not at all effective in the abatement of gaseous pollutants.

> Trees, however, are effective in reducing gaseous air pollutants through absorbtion. A recent Russian study has shown that a 1640 ft (500 m) wide green area surrounding factories will reduce sulfur dioxide concentrations by 70 percent(9).

Wind turbulenceis a major factor in dispersing gaseous pollutants. As the presence of trees increases wind turbulance, they can be used to aid in the dispersion of gaseous pollutants if located downwind from the source of pollution.

Particulate air pollutants can be reducedby the presence of trees and other plants in several ways. They aid in removal of air borne particulates such as sand, dust, flyash, pollen and smoke. Leaves, branches, stems, and their associated surfaces structures (i.e. pubescence on leaves) tend to trap particles that are later washed off by pecipitation. Trees also aid in the removal of airborne particulate matter by air washing. Evapo-transpiration increases, humidity thus aiding in the settling out of airborne particulates. The results of these processes can be readialy observed on trees adjacent to factories or along gravel roads (Fig. 5.3).

Trees also often mask fumes and disagreeable odors by replacing them with more peasing foliage or floral odours

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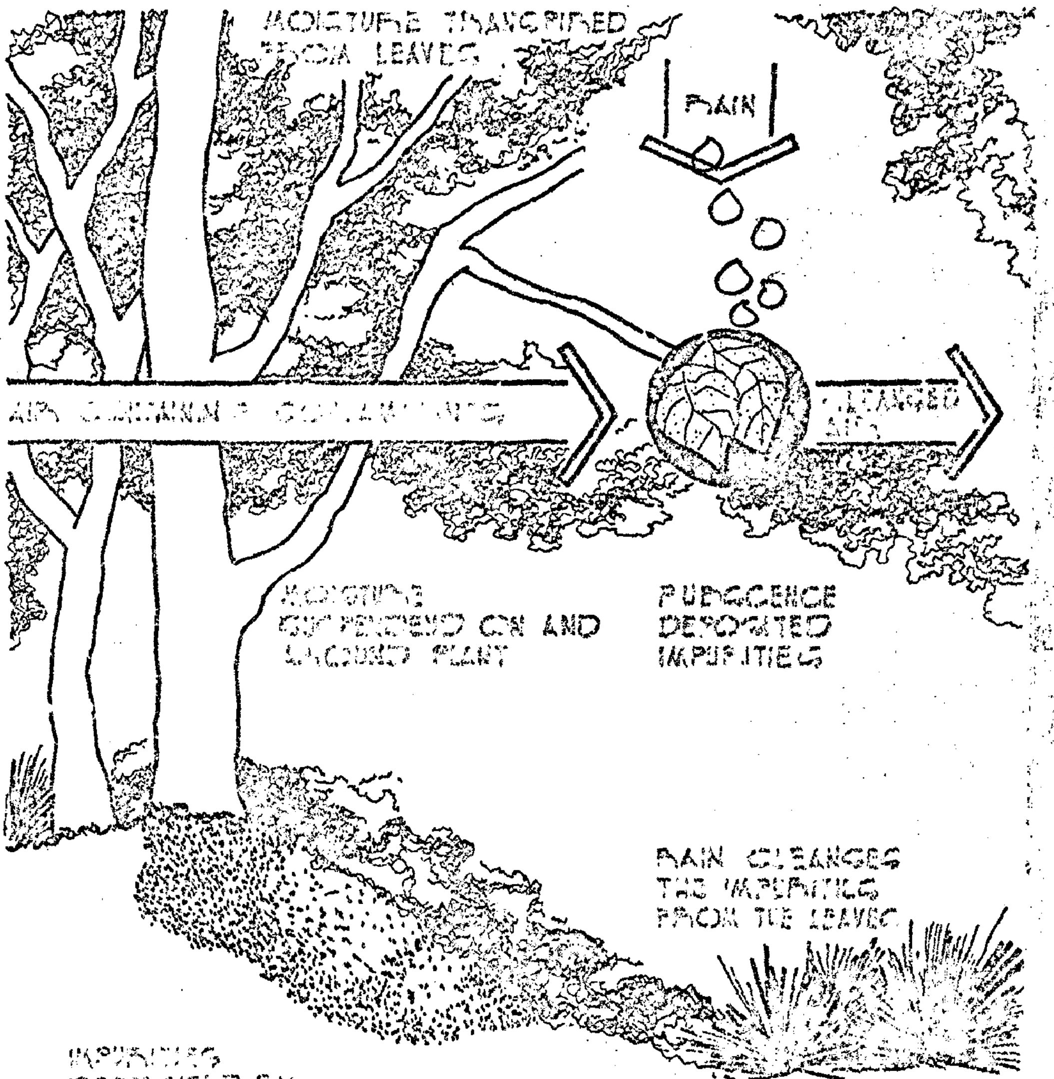
9 Grey, Gene W. and Deneke, Fredrick J., Urban Forestry, John Wiley and Sons., New York, 1978



FILTERATION / AIR WASHER

PLANTS REDUCE AIR-POLLUTANTS THROUGH THE PROCESS OF WASHING

FIG5.3 TACTICII-URBAN FORESTRY

EFFECTS OF AIRPOLLUTION ON DEVELOPMENT OF AGRASUBREGION

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or by actual absorption (Figure 5.4). When trees are planted to aid in air pollution abatement, the following guidelines should be used.

(i) Planting should be perpendicular to the prevailing winds.

(ii) Open and permeable plantings should be combined barrier stands.

(iii) Planting should be concentric around the pollution source.

C. Tactic 3 - Engineering Control. Prevention of air pollution from industrial operations starts within the factory or mill. Even when gas cleaning and atmospheric dispersion must be used at final steps, process, operationa, and system control is a means of minimizing the quantity of substances entering cleanup systems and, ultimately, being discharged to the atmosphere.

Reduction of air polluting emissions by process, operational, and system control is not only an important adjucent to air and gas cleaning technology and to atmospheric dispersion but is a definitive response to the concept of zero emission when it can be employed for total control. This deals with.

(i) Reduction of contaminants discharge by application of control equipments.

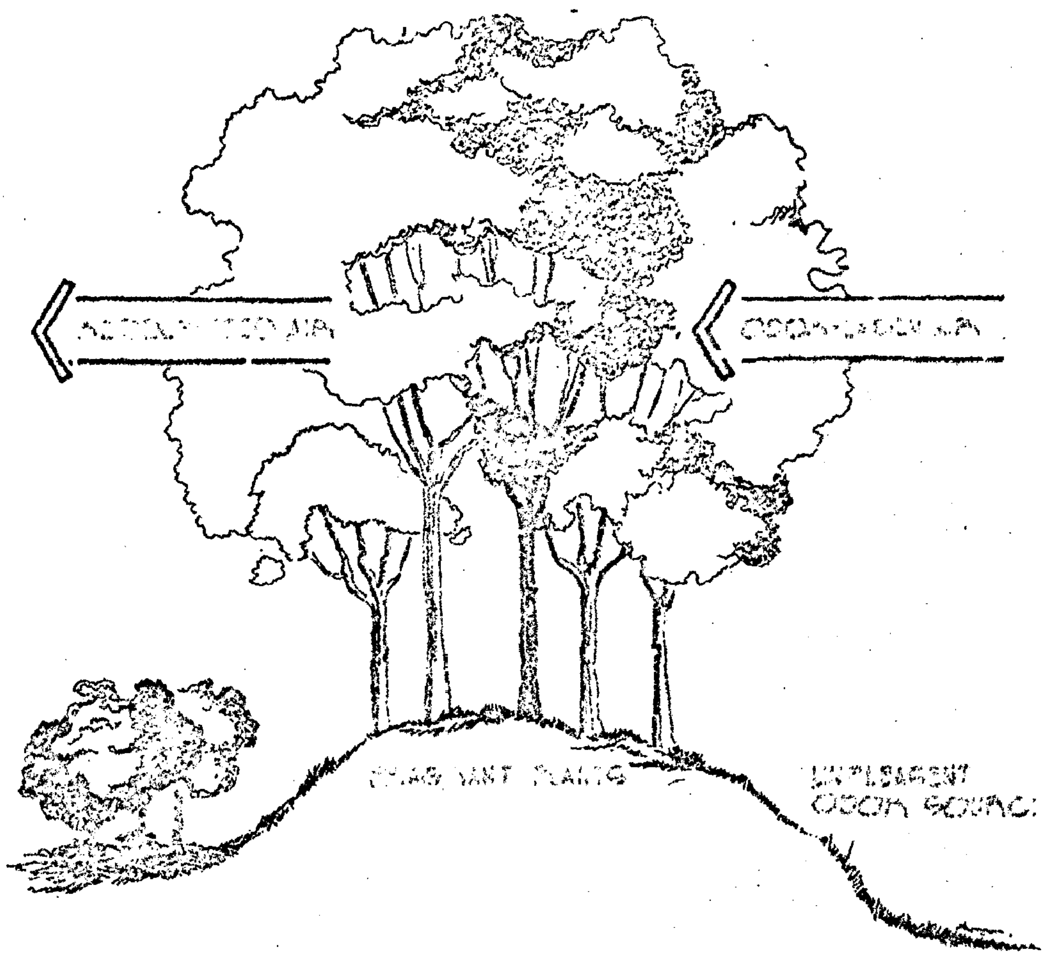

FIG. 6.4
DEODORIZATION
TREES CAN REDUCE UNPLEASANT ODORS EITHER BY ABSORPTION OF GASEOUS POLLUTANTANTS OR BY MASKING THEM WITH THEIR OWN ODORS

FIG.54 TACTIC II - URBAN FORESTRY

EFFECTS OF AIRPOLLUTION ON DEVELOPMENT OF AGRASUBREGION

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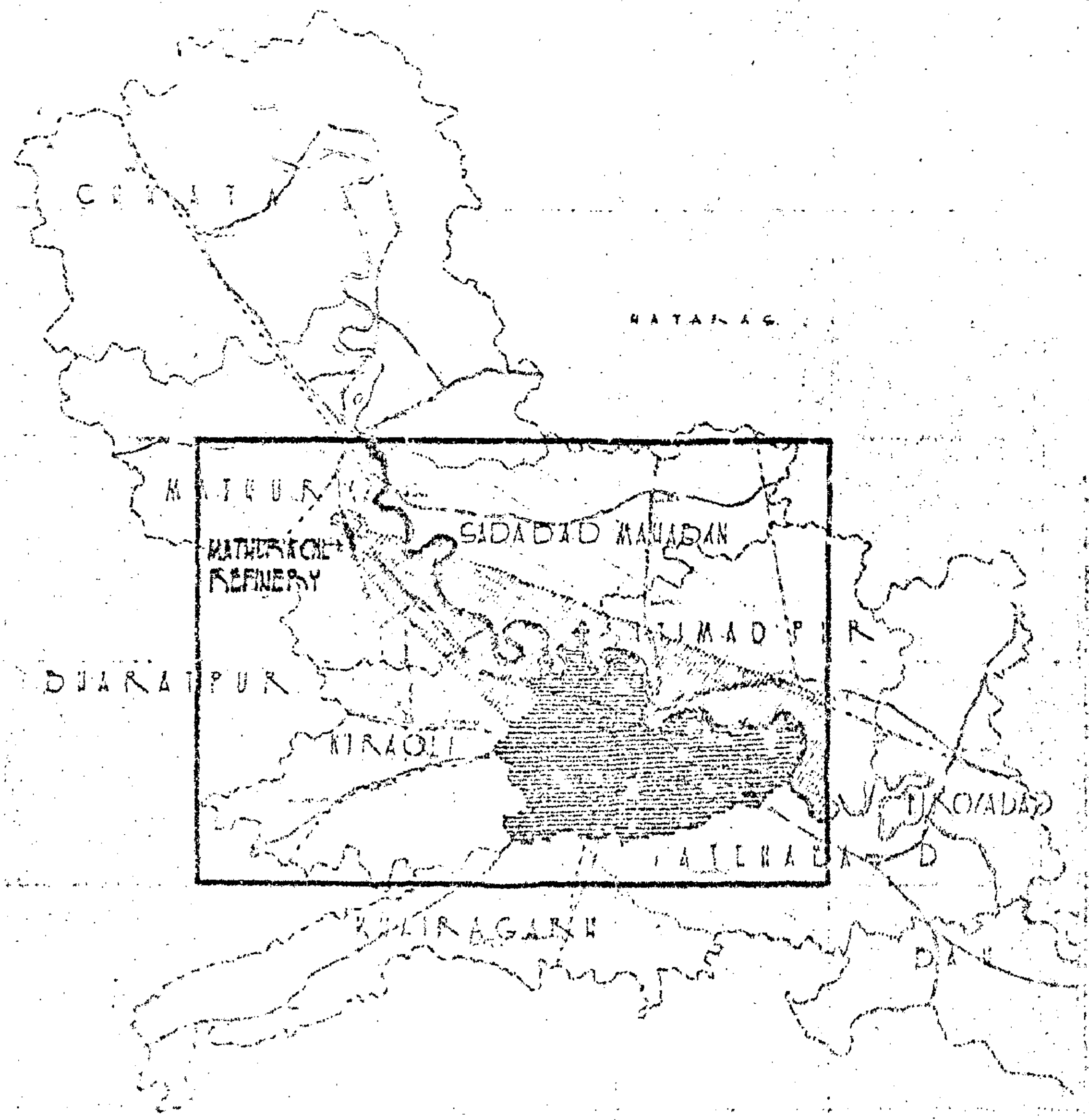
(ii) Reduction at source through raw material change or practices, or modification or replacement of process equipment.

(iii) Dilution of the source discharge by the use of tall stacks.



DEVELOPMENT OF THE AGRA CITY ACCORDING TO THE PROPOSED MASTER PLAN WHICH IS HAVING MODIFICATION ON THE BASIS OF AIRPOLLUTION ASPECT

DEVELOPMENT OF THE AREA WITH HEAVY PLANTATION AND WITHOUT UNPLANNED URBANIZATION

FIG 5.5 PROPOSALS FOR THE DEVELOPMENT OF AFFECTED SUBREGION

EFFECTS OF AIRPOLLUTION ON DEVELOPMENT [illegible] AGRA SUBREGION

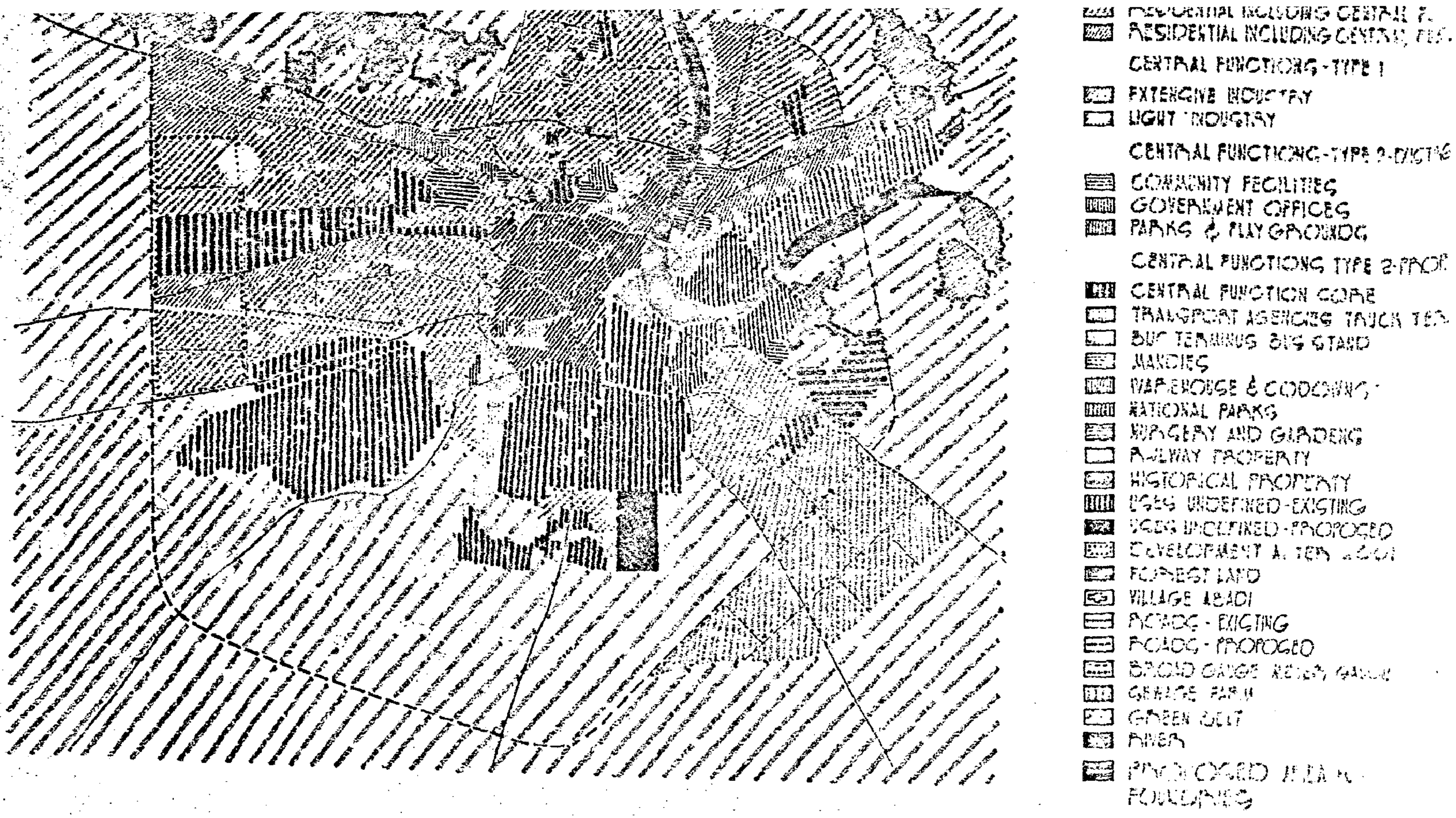


FIG56AGRA MASTER PLAN (1971-2001) EXISTING

EFFECTS OF AIR POLLUTION ON DEVELOPMENT OF AGRA SUBREGION

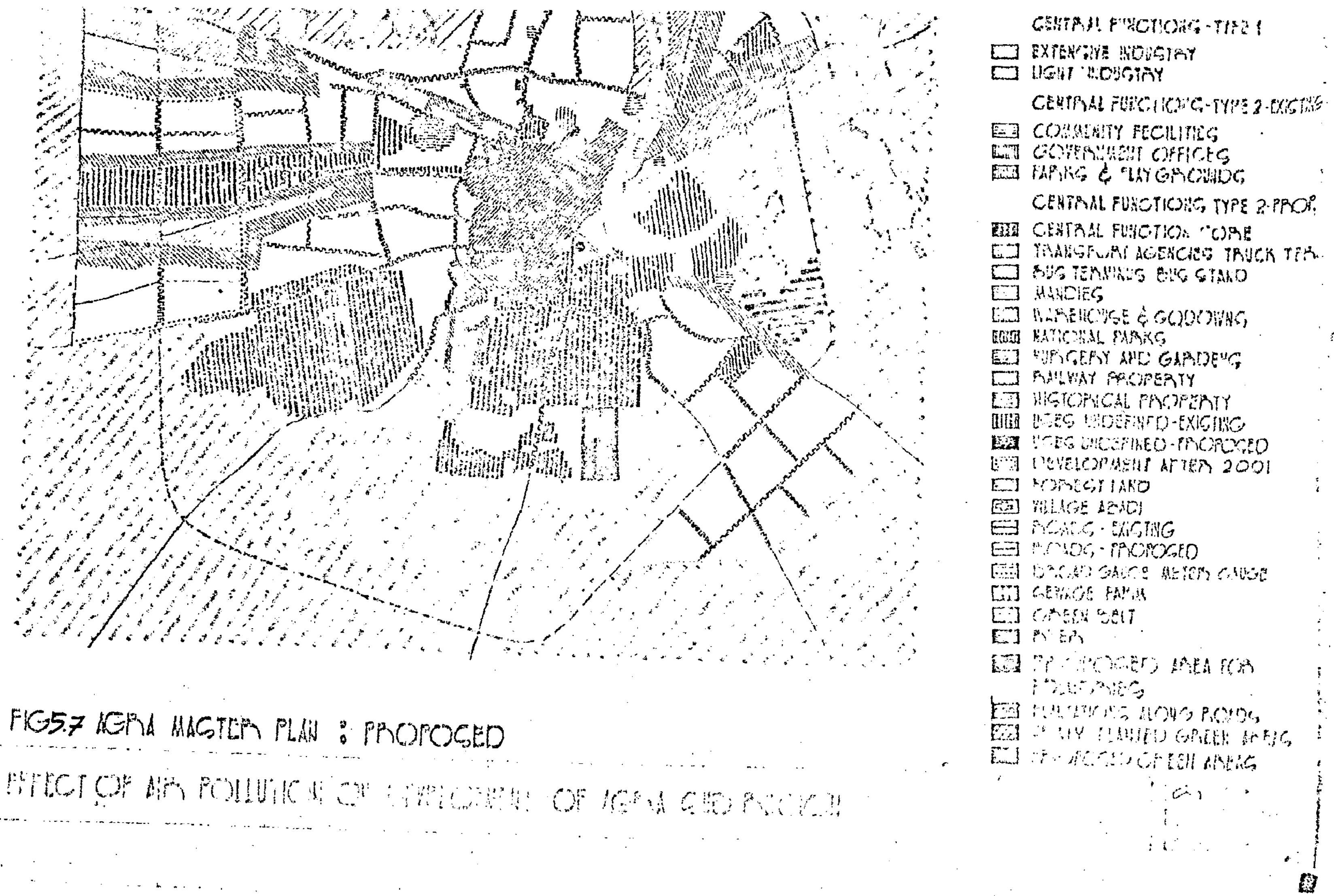


FIG 5.7 AGRA MASTER PLAN : PROPOSED

EFFECT OF AIR POLLUTION ON [illegible] OF AGRA [illegible]

Relatively unpolluted air is no longer a free commodity in our society. It costs money to trap pollutants before they escape into the air, and it costs money to escape to places where the air is relatively clean. Most people probably would be willing to pay for the benefits of increased longevity, decreased morbidity, and decreased nuisance that come with relatively cleaner air.

The singular characteristic of air pollution is its pervasiveness. Unlike water pollution, the extent of air pollution is limited only by the course of prevailing winds. We know that pollution of the atmosphere affects the health of human beings, of animals, and of plants; it causes deterioration in property values and increased costs in a number of production processes; it may substantially reduce agricultural productivity in affected areas. A slow rise inthe temperature of the earth has been attributed to air pollution. It is suspected of altering human genes so that mutations may occur resulting in the transmission of different characteristics to future generations. Almost certainly, the major benefit from air pollution abatement is found in a general improvement in the quality of life rather than in one of the more measureable categories. It is therefore not surprising that there are fundamental problems in measuring the economic costs of air pollution.

Harold Wolozin[27] has proposed an S-shaped functional relationship between the level of pollution and the cost of abatement as is shown in Fig. 6.1.

The horizontal axis on Figure 6.1 measures the various possible levels of pollution on some composite index. The vertical axis measures the total cost of abatement required to achieve each level of air quality measured on the horizontal axis. This static analysis assumes that technology is constant in the short run. The point at which air pollution is just detectable is indicated by r; the saturation point at which pollution is at dangerously high levels, by s. As we move from s towards r, outlays for air pollution abatement increase initial low returns to scale as abatement is initiated at point m, and entry to an area of rapidly diminishing returns to scale as the air becomes cleaner.

Independently of the ability to forecast, general abatement will be more economic than selective abatement where the cost of implementing and supervising selective abatement is very high where sources ofpollution are small and numerous as with residential units, small incinerators, and automobiles..

The most efficient solution will also differ between cities or air sheds, each of which has its own unique

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27 Thompson, Donald N., <u>The Economicsof Environmental Protecti</u> Winthrop Publishers, Inc., Massachusetts, 1973.

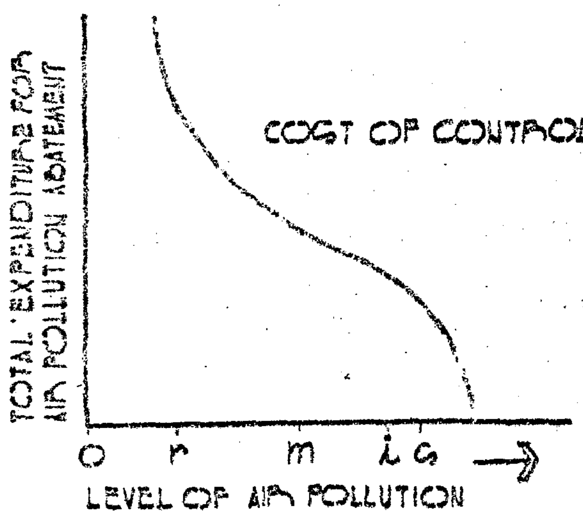

FIG 6.1 FINANCIAL ASPECTS OF AIR POLLUTION

EFFECTS OF AIRPOLLUTION ON DEVELOPMENT OF AGRASUBREGION

MADHUKAR CHYAK

characteristics and problems; each must determine for itself whether constant abatement or some variation of selective abatement is most efficient in meeting specific air quality standards. This means it is probably uneconomic for the government to establish national air quality standards or emissions standards, except perhaps at very minimal levels, or as guidelines.

7

CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

7.1.1 The problem of air pollution of the Agra Subregion, must be envisaged in terms of a regional problem rather than a local problem.

7.1.2 For effective air pollution control there should be collaboration between different concerned authorities.

7.1.3 The socio-economic plans for different polluted areas have to be knitted with an environmental plan based on pollution aspects, for the total and healthy development of the region.

7.1.4 Industrialization for the development of a country is of national and international importance, but before selecting the site for an industry, other factors such as topography, meteorology and ecology of the region have to be considered.

7.1.5 The city and regional planning agencies must acquire detailed knowledge regarding environmental planning aspects of which air pollution is a part.

7.1.6 Where there is conflict between environmental factors and other factors such as landuse, resource availability and cost, the Master Plan seeks to have balance between them.

7.1.7 With the effects of the development of a major industry in a region, the multiplier effects due to that industry must also be taken into account.

7.1.8 Degradation of the region, due to man's indulgence, has to be checked by proper management.

7.2 RECOMMENDATIONS

Based on the above conclusions drawn by the author, the recommendations are as follows.

7.2.1 General Recommendations

A. Town Planning Departments and authorities, together with other units of their respective local governments, should

(i) Accept their share of responsibility for preventing or reducing air pollution, because clean air is a critical requirement for all cities and regions and suggests means of improvements in the subregion.

(ii) Recognise that limiting and programmigg of urban growth may be required to achieve air quality standard necessary for the health of resident population.

(iii) Abandon planning, policies which encourage more and more industries in already industrialized region, causing air pollution.

(iv) Encourage action as needed when air pollution exists or threatens and can not be controlled locally.

B. Meteorological departments and authorities should,

(i) Accept their share of responsibility for preventing or reducing air pollution by acquiring detailed information regarding meteorological aspects of the area, prior to establishing a major industry or any industry of serious polluting nature.

C. Environmental Engineering departments and authorities should,

(i) Accept their share of responsibility for preventing and reducing air pollution by acquiring more information regarding polluting nature of solid, liquid and gaseous wastes and bye products of an industry.

(ii) Inform concerned authorities about the nature of the industry, air pollution conditions and trends within their area of responsibility, & develop data for determining acceptable levels of pollution.

(iii) Inform and educate the concerned industries and government organisations about different abatement measures.

7.2.2 Recommendations Regarding Tactic - 1 Land use Planning

Further industrialization of the Agra Subregion must be curbed and good mass transit system should be developed.

7.2.3 Recommendations Regarding Tactic - 2 Urban Forestry

Where it is necessary buffer zones of heavy plantation should be created and authorities should prohibit cutting of trees.

7.2.4 Recommendations Regarding Tactic 3 - Engineering Control

Prevention of air pollution should start from the source itself through technological means.

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9.1 APPENDIX 1. CASE STUDIES. SHORT TERM AIR QUALITY SURVEYS IN 4 MAJOR CITIES OF INDIA

9.1.1 Introduction

With the rapid growth of industries and urbanization, India has started to experience the effects of air pollution in some cities. The episodes of pollution from industrial emissions are being reported with increasing frequency. The data collected and reported on air quality is fragmented and does not present a systematic picture in India.

The National Environmental Engineering Research Institute Nagpur decided to embark on a programme of air quality survey and monitoring on selected cities of India. As a preliminary step a short term survey was undertaken in 4 major cities.

The short term surveys were undertaken to assess the air quality and determine the level of pollution currently obtaining in 4 major cities of India, with following specific objectives:

A. To have a quick check of levels of various known pollutants in the cities.

B. To obtain data as a first step towards formulating a general plan of air quality studies on long term basis for the country.

c. To draw the attention of the concerned authorities towards the atmospheric pollution in these cities so as to generate interest in control measures.

9.1.2 A General Plan of Survey

The survey was carried out for a period of 1 to 2 months for each city as follows:

City	Period of Survey	Remarks
Bombay	April - May 1968	A coastal city. Centre of textile and other types of industries. Hot and humid period.
Delhi	June - July 1968	Inland city. Not many industries. Hot and dry periods with many dust stroms.
Calcutta	February - March 1969	Located on Hoogly river, 80 miles from the sea. Highly industrialized like Bombay. End of winter periods. Low wind speeds.
Kanpur	January - December 1968	Inland city with concentration of textile andother industries. Climatologically similar to Delhi but more industrialized.

9.1.3 Observations

The short term survey has surved its purpose because it has high lighted the nature of the air pollution problem in the country and has given the scientists of the Institute a field experience which in turn has given insight into the problem. Some salient observations made in the study are given below.

A. This study was scattered over various months of the year in the 4 cities, starting from April 1968 to March 1969.

B. The following parameters of air pollution such as Sulfur dioxide, nitrogen dioxide, hydrogen sulphide, oxidants and suspended particles were studied.

C. The survey was carried out with a limited number of stations selected judiciously in each city to given representative data. The sampling was done by rotation, at intervals of few days at each station, for a period of approximately 1 to 2 months. The samples were collected over 24 hours in 4 hour batches for gaseous pollutants and continuously for 24 hours for particulates. Therefore the values are averaged to give a broad picture of air pollution over the sampling period.

D. BOMBAY CITY has a favourable climatological condition with mild breeze throughout the year with strong winds in monsoon. Stable condition rarely extends beyond a few hours at any time. The city shows fairly high level of air pollution in places like Chembur - Trombay where concentration was 3 to 6 times the average city level. It also had relatively high levels of H_2S compared to other Indian cities. Particulates were significantly high at all stations compared to the levels of other cities of the world as shown in the Table 9.1. The total oxidants levels in Chembur - Trombay area are high probably due to presence of hydrocarbons from patro-chemical operations in the area. No study on automobile gasoline or diesel emission was done in the city in this short term survey, but it is desirable and will be included in subsequent studies.

E. DELHI has hot dry climate with windy conditions in summer and mildly cold dry climate with low-speed winds in winter. Radiation inversion does occur frequently in winter from late evening to early morning, unlike Bombay, resulting in pollution accumulation. Locomotive discharges appear to contribute substantially to SO2 pollution in Delhi. This is also aggravated by domestic emission from use of coal.

Particulate concentrations in Delhi for average dust content recorded was 700 ug/cum. This is extremely high compared to various available data from other countries. During the actual occurrence of dust strom, value exceeded even 10,000 ug/cum. No work on vehicular emission was done in this city. It would be advisable to undertake this important study particularly in Delhi where heavy auto exhaust emissions are visible throughout the year (Table 9.2).

LOCATION	RANGE OF CONCENTRATION OF POLLUTANTS									
	SO_2		NO_2		H_2S		O_3		SUSPENDED DUST	
	AVE.	MAX.	AVE.	MAX.	AVE.	MAX.	AVE	MAX	AVE.	MAX.
	PPM		PPM		PPM		PPM		µg/m³	
WORLI RESIDENTIAL CUM INDUSTRIAL AREA	.014	.03	.011	.024	.023	.082	.005	.031	269	349
	REMARKS: HYDROGEN SULPHIDE IS SIGNIFICANTLY HIGH. PARTICULATE LOAD IS ALSO SIGNIFICANT.									
DADAR RESIDENTIAL CUM INDUSTRIAL	.01	.023	.008	.013	.012	.051	.003	.026	228	333
	REMARKS: MODERATE LEVEL OF ALL POLLUTANTS									
HOSPITAL RESIDENTIAL CUM INDUSTRIAL AREA	.016	.067	.012	.032	.016	.022	NIL	TRACE	215	250
	REMARK: LEVELS OF SULPHUR DIOXIDE, NITROGEN DIOXIDE AND HYDROGEN SULPHIDE ARE RELATIVELY HIGH.									
CHEMBUR-TROMBY ROAD IN THE VICINITY OF REFINERY INDUSTRIAL AREA	.137	.172	.013	.02	.035	.05	.017	.047	223	261
	REMARK: HIGHER VALUES THAN ABOVE THREE STATIONS CAN BE ACCOUNTED FOR BY INDUSTRIAL EMISSIONS FROM REFINERIES AND OTHER PETROCHEMICAL FACTORIES									
CHEMBUR-TROMBY ROAD IN THE VICINITY OF FERTILIZER FACTORY	.031	.116	.033	.05	.004	.01				
	REMARKS: AVERAGE CONCENTRATION OF SO_2 IS ALMOST DOUBLE THAT PREVAILING OTHER RESIDENTIAL AREAS IN THE CITY									

TABLE 31 BOMBAY: AIR SAMPLING STATIONS AND RESPECTIVE POLLUTION LEVELS

LOCATION	RANGE OF CONCENTRATION OF POLLUTANTS									
	SO_2		NO_2		H_2S		O_3		SUSPENDED PARTICLES	
	AVE.	MAX.	AVE.	MAX.	AVE.	MAX.	AVE.	MAX.	AVE.	MAX.
	PPM		PPM		PPM		PPM		µG/M³	
MOTINAGAR INDUSTRIAL CUM RESIDENTIAL	.012	.042	.013	.035	.005	.007	.013	.01	720	2671
KISANGANJ INDUSTRIAL CUM RESIDENTIAL	.030	.03	.012	.026	.004	.012	.006	.012	900	1426
PAHADGANJ RESIDENTIAL	.024	.058	.012	.025	.002	.007	.008	.028	1100	2295
IRWIN HOSP-ITAL RESIDENTIAL	.007	.019	.008	.016	.003	.011	.006	.025	500	10306
TOWN HALL RESIDENTIAL	.008	.020	.011	.027	.002	.004	.011	.021	1225	2541

REMARK: 1. OF THE SELECTED AREAS FOR AIR QUALITY SURVEY, KISHANGANJ AND PAHAR GANJ, AREAS WERE COMPARATIVELY MORE POLLUTED. HIGH LEVELS OF SO_2 IN THESE AREAS ARE ATTRIBUTED TO OVERCROWDING OF POPULATION AND DOMESTIC COAL BURNING. OTHER CAUSES ARE THE RAILWAY MARSHELLING AREA IN THE VICINITY AND TRAFFIC ACTIVITY

2. HIGH PARTICULATE LOAD IN THE ATMOSPHERE IS ATTRIBUTED MAINLY TO OCCURANCE OF NATURAL DUST STORMS DURING THIS PERIOD. PART OF SIGNIFICANT PARTICULATE IS ALSO DUE TO THE HEAVY TRAFFIC ACTIVITY AND AUTO EMISSIONS.

TABLE 9.2 DELHI : AIR SAMPLING STATIONS AND POLLUTION LEVEL

EFFECTS OF AIRPOLLUTION ON DEVELOPMENT OF AGRASUBREGION

MADHURI GUPTA

F. CALCUTTA has significantly lower wind speed particularly in winter months, compared to other cities of this survey. It also has radiation inversions quite frequently. The automobile exhaust pollution level was studied in Calcutta city on four important traffic arteries. The parameter of carbon monoxide was chosen as an index to auto exhaust pollution. Repeated instant samples of carbon monoxide on these streets showed concentration as high as 35 ppm during peak traffic hours which were comparable with the other important cities of the world. With high traffic density Sulfur dioxide levels were uniformly high at all stations in Calcutta. Particulate average value was 530 ug/cum. Peak recorded was 1500 g/cum. Since Calcutta is not subjected to dust storms this could be attributed to traffic or unpaved roads and other emission sources. Nitrogen dioxide levels and oxidant levels in Calcutta were also higher compared to Bombay and Delhi.

G. KANPUR is meteorologically similar to New Delhi. The average concentration values for all pollutants are comparable to other cities. Particulates also show a trend similar to that of Delhi and Calcutta (Table 9.3).

9.1.4 Conclusions

The work was done for about a couple of months in each city but it has given some useful ideas about the air

LOCATION	RANGE OF CONCENTRATION OF POLLUTANTS									
	SO_2		NO_2		H_2S		O_3		SUSPENDED DUST	
	AVE	MAX	AVE	MAX	AVE	MAX	AVE	MAX	AVE	MAX
	PPM		PPM		PPM		PPM		$\mu g/m^3$	
CIVIL LINES INDUSTRIAL CUM RESIDENTIAL	·03	·04	·015	·03			·025	·04		
ANWARGANJ INDUSTRIAL CUM RESIDENTIAL	·08	·11	·025	·13			·10	·135		
SWAROOP NAGAR RESIDENTIAL	·015	·025	·01	·02			·02	·028		
NAZEERABAD RESIDENTIAL									488	770

REMARKS: 1 OLD INDUSTRIES INCLUDING HEAVY CHEMICALS WITH MAJOR EMISSION OF POLLUTANTS. THIS CAUSE A SEVERE POLLUTION IN THE VICINITY

2 SWAROOPNAGAR IS AWAY FROM THE INDUSTRIAL ZONE & SHOWS CLEAR & CLEANER ATMOSPHERE

3 PARTICULATES ARE SIGNIFICANTLY HIGH

TABLE 9.3 KANPUR : AIR SAMPLING STATIONS AND RESPECTIVE POLLUTION LEVEL.

quality in general. The concentration level for all the parameters showed that these four important cities do have a problem of air pollution. The survey was carried out in different seasons in different cities, therefore it would not be correct to interpret this data as valid for all the year round. However, in winter conditions for the northern cities of Delhi and Kanpur, the values may be 2 to 3 times higher than those recorded in this survey due to radiation inversion conditions for limited periods of 12 to 15 hours at a time (Table 9.3).

Though the stations were selected with care it is possible that pockets of even higher concentration exist in the cities. Also automobile exhaust pollution study was limited to only one city of Calcutta. It shows a fairly high level of carbon monoxide in the city. It is possible that similar condition may be existing in the other cities and therefore this aspect should be invariably studied in detail in future surveys.

This survey has revealed peculiar characteristic of air pollution in this country specially with reference to particulate matter. All the cities show 2 to 3 times higher values of average dust concentration when compared to the other cities of the world. This may have to be botne in mind while planning the future studies as well as air quality standard. The overall assessment of the result shows that there appears to be a very strong need to assess the exact status of air pollution in all the cities by a full scale investigation to obtain more detailed information on long term basis. Each city survey will have to be planned individually taking into consideration the findings from this survey beside the standard survey techniques. The collection of such data will be useful to hasten the enactment of control legislation.

9.2 APPENDIX 2

MAIN.   AGRPOL.FOR   FORTRAN V.5A(621) /KI/OPT

```
C  C    AGRAPOL**MADHUKAR**
        DIMENSION X(20), Y(20),Z(5),SY(20),SZ(20),ZC(
        READ 1,NX,NY,NZ,ICON
        PRINT 1,NX,NY,NZ,ICON
        READ 2,(X(I),I=1,NX)
        PRINT 2,(X(I),I=1,NX)
        READ 2,(Y(I),I=1,NY)
        PRINT 2,(Y(I),I=1,NY)
        READ 2,(Z(I),I=1,NZ)
        PRINT 2,(Z(I),I=1,NZ)
        READ 2,Q,H,U
        PRINT 2,Q,H.U
        READ 2,(SY(I),I=1,NX)
        PRINT 2,(SY(I),I=1,NX)
        READ 2,(SZ(I),I=1,NX)
        PRINT 2,(SZ(I),I=1,NX)
        READ 2, (CON(I),I=1,ICON)
        DO 10   I=1,NZ
        ZZ=Z(I)
        ZZP=ZZ+H
        ZZM=ZZ-H
        DO 20   J=1,NX
        SSY=SY(J)
        SSZ=SZ(J)
        ZP=ZZP/SSZ
        ZP=0.5*ZP*ZP
        ZM=ZZM/SSZ
        ZM=0.5*ZM*ZM
        A=EXP(ZM)
        B=EXP(ZP)
        C=1./A+1./B
        C=0.5*C*Q/(3.1416*U*SSY*SSZ)*277777.777777
        CA=0.5/(SSY*SSY)
        DO 30  K=1,NY
        YY=Y(K)
        CB=YY*YY*CA
        CB=EXP(CB)
30      ZC(K)=C/CB
        PRINT 3,(ZC(K),K=1,NY)
20      CONTINUE
C
10      CONTINUE
41      CONTINUE
1       FORMAT (16 I5)
2       FORMAT (10F 8.2)
        STROP
        END
```