Ambient Air Quality in The Area Of Associated Cement Companies Limited, Madukkarai, Tamilnadu : A Case Study

By

Savithiri V.

A DISSERTATION SUBMITTED TO THE AVINASHILINGAM INSTITUTE FOR HOME SCIENCE AND HIGHER EDUCATION FOR WOMEN - DEEMED UNIVERSITY, COIMBATORE - 641 043 IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN APPLIED CHEMISTRY

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April 1998

Certified As Bonafide Research Work

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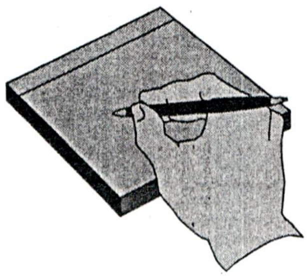

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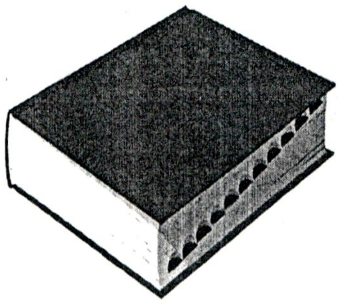

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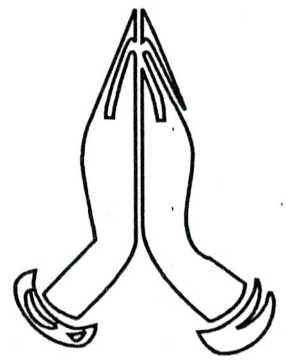


Introduction

INTRODUCTION

"We don't have a society if we destroy the environment"
- Margret Mead

Much in the environment around us is changing and very little of it seems for the better (Power, 1993). In the process of development, man's relationship with the ecosystem has changed gradually and some major modifications have been brought about in the environment which are becoming detrimental to human society. Our industries, agriculture, mining and growth of cities have expanded and this output and wastes are polluting the long unpolluted air, water and soil. (Vyas, **et al**., 1982).

Pollution is not a new phenomena. It is as old as civilization itself. With the advancement of civilization, it also matured and expanded in proportionate dimensions. It is the by-product of development and in fact a price for progress (Peoras, 1973).

Industrial revolution of nineteenth century lead to environmental disaster. The environmental problem assumed colossal importance with the transition from feudal system to industrial capitalism. Pollution has become the first enemy of mankind. Today the whole mankind is more afraid of pollution rather than the nuclear holocaust. (Indian Express, 1985).

Environmental pollution due to rapid industrial expansion is fast becoming a cause of public concern. (Kudesia, 1986). Recent reports assert that environmental problems will increasingly dominate the world in the future and influence the course of global politics.

Among various natural resources, air is an important resource not confined by political or geographical boundaries. (Stern, **et al**, 1984). We can live without food and water for days together but for only five minutes without air. On an average a man needs 30 lbs of air every day (Raja Ram, 1972). So air pollution is indeed of great immediate concern than any other aspect of pollution.

Air pollution is woven throughout the fabric of our modern life (Kenneth wark, 1972). Air pollution is a public health and environmental quality problem. It is also an economic problem, intimately and directly affecting industry and agriculture. It can be a social problem, creating constraints on the nature and direction of urban and regional development and patterns of land use (Tripathy, 1985).

Clean, dry air contains 78.04% nitrogen and 20.94% oxygen by volume. The remaining 0.97% is composed of gaseous mixture of carbon dioxide, helium, argon, krypton, nitrous oxide, and xenon and very small amount of organic and inorganic gases, whose amount in the atmosphere vary with time and place. (Shukla and Srivastava,1975). Various amounts of contaminants that continuously enter the atmosphere and cause toxicity, disease, physiological effects or environment decay, has been labelled by man as a pollutant.

The atmosphere has always transported, diluted and eventually ejected pollutants and has never been clean in the sense of containing only the major gaseous constituents. It carries at least volcanic dust and gas, wind-eroded soil, sea-salt nuclei, methane from marshes, hydrogen sulphide from decaying matter and certain radioactive materials from Radium and Thorium decay and from cosmic - ray production. Air borne pollen, spores, and bacteria are also present in the air (Tripathy, 1985).

These air pollutant also interact with the surface water and soil, through precipitation and dry deposition, they can cause water pollution and soil contamination as well (Trivedi and Raj, 1992).

Air pollution is basically the presence of foreign substances in air.

"Air pollution means the presence in ambient atmosphere of substances generally resulting from the activity of man in sufficient concentration present for sufficient time and under circumstances which interfere significantly with the comfort, health or welfare of persons or with the full use or enjoyment of property" (Varadarajan, and Subramanian, 1993).

According to American Medical Association,
"Air pollution is the excessive concentration of foreign matter in the air which adversely affects the well being of the individual or cause damage to property" (Trivedi and Raj, 1992).

"Air Pollution" means the presence in the atmosphere of any solid, liquid or gaseous substances as may tend to be injurious to human beings or other living creatures or vegetation or property or environment. (Garg and Tiwana, 1995).

Industrialization, no doubt, makes a nation supporting and provides more advances for employment. However, the variety of wastes generated during the process poses numerous environmental problems (Saxena and Frost, 1992). Some critics comment air pollution as the price of industrialization.

Primary cause of pollution is the rapid population growth. As the population increases, the attendant pollution problems also increases proportionately. With the discovery of fire, significant change in man's effect in nature came into existence. In addition, the pollution caused by vehicles, particularly two and three wheelers, has worsened the situation. (Kamat and Mahashur, 1997). Air pollution caused by automobiles have been described as the "Disease of Wealth".

With the advent of industrial revolution, coupled with urbanisation, all kinds of impurities began to be added to the natural air, water, as well as soil causing almost irrepairable damage to environment. The growing population and the massive increase in architecture has led to the increase in cement use.

As far as cement industry is concerned , the pollution are mainly air and noise. Emissions of dust particulates from the stakes at various stages of manufacturing process and fugitive dust emissions are considered to be the only source of air pollution. There are variety of pollutants which are released in air. Among them sulphur dioxide , nitrogen oxides, particulates have been identified as priority pollutants. (Banerjee and Pandey,1987). Water, radiation or soil pollutions are not much relevant to cement industry, in a view of little/no discharge from the plant. (A.C.C. / T.N.P.C.B. Statement, 1997).

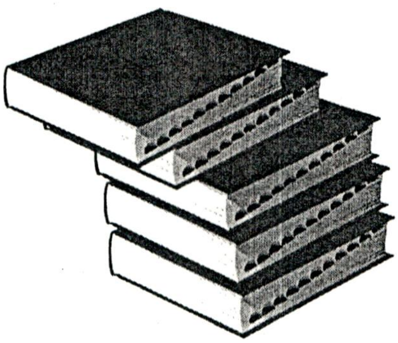
Therefore, air pollution which can be very destructive to rise in the long run, needs to be under check.

The present study has been undertaken to assess the level of air pollution in a highly industrialized area, such as Associated Cement Companies Limited, Madukkarai, Tamilnadu.

The objectives of the present study are

1. To sample and analyse the ambient air quality and compare it with national standards.
2. To identify the maximum and minimum polluted months during the course of study.
3. To locate the most polluted area around A.C.C. Limited.
4. To categorise the different places of study based on Oak Ridge Air Quality Index.
5. To arrive at a conclusion about the quality of the ambient air around Associated Cement Companies, Madukkarai, based on the above studies.

CHAPTER 2



Review of Literature

REVIEW OF LITERATURE

2.1 : INTRODUCTION TO ENVIRONMENTAL POLLUTION

According to scholars, any deterioration in physical, chemical and biological quality of the environment may be regarded as environmental pollution (Gupta, 1991). Today pollution has become a major threat to the existence to the mankind on this earth. The problem of pollution arose with the very civilization of man. As human population increased, there was increase in our working sphere and with this also increased the pollution (Sah, 1984).

More and more demands are made on the limited sources of energy and materials (Ramachandran, 1992). Today environmental degradation has assumed alarming proportions threatening public health. Damage done to the environment is so great that it is approaching a stage where it cannot be undone now. However, with timely intervention, it can surely be prevented or reduced (Joshi, 1996).

2.2 AIR POLLUTION - SOURCES AND EFFECTS

The air pollution is due to a multitude of different sources. In addition to power stations and large industries, come a number of small sources like domestic heating, traffic, numerous small scale industrial activities, waste treatment and solvent evaporation etc., (Shukla and Srivastava, 1975).

Air may be polluted by automobile exhaust and by byproducts of manufacturing and mining operations (WHO, 1974), uncontrolled use of herbicides, pesticides and chemical fertilizers to increase production of certain foods contaminate the ecosystem.

Research in the field automobile pollution has revealed many alarming facts. A report by R.K.Arora revealed that environmental pollution is concentrated primarily around the major metropolitan areas of both developed that the rate of increase in the use of motor vehicles has been even more than the rate of increase in population. A study conducted by the Central Pollution Control Board has also indicated that Indian vehicles are emitting more pollutants than the vehicles in the west. According to a survey conducted by the National Environmental Engineering Research Institute, Nagpur, the pollution levels during peak hours in certain locations in Calcutta exceeds even that of New York.

The growing number of automobiles is posing a serious threat to the air environment. It has been found that the vehicular exhaust accounts for more than 50 percent of the total population from all sources put together in all the major cities in India (Mathur, 1992). The diesel engines of trucks, buses etc., emit carbonaceous particulates, which are mutagenic and possibly carcinogenic (Masters, 1991). The form of nitrogen oxide emitted into the atmosphere from automobile exhaust is almost all nitric oxide. (Chhatwal **et al**., 1989) Quality of lead emission from vehicles to environment depends on various factors such as lead content of petrol, wind speeds, quality of road and speed of vehicles (Gajghate and Hasan, 1997)

Out of air pollution, gaseous pollutants like nitrogen (60-75%), water vapour (7-30%), carbon dioxide (10-30%), carbon monoxide, oxides of sulphur and nitrogen (all in ppm level) etc., are not so hazardous to human health as the nature creates them much higher than human creation, which is clear from the following table (A.C.C. Environmental Statement, 1997).

TABLE I

AMOUNT OF GASEOUS POLLUTANTS

Pollutants	ManMade (Million tons per year)	From natural sources
Particulates	750	Small
CO_2	12,780	50 times
CO	276	10 times
S-Compounds	133	Double
N-Compounds	48	Enormous
Ammonia and Nitrates	4.2	2,000 times
Hydrocarbon and Organic Compounds	80	20 times

Asthana **et al.**, (1986) indicated that a considerable amount of air pollution results from the burning of non-commercial fuels and this far outweighs that resulting from burning of commercial fuels. The combustion of fossil fuels and their products is responsible for a sizable amount of air pollution. Among commercial fuels, coal is the greatest contributor to air pollution followed by fuel oils and mobile sources.

Nationwide studies on air pollutant emission from fuel sources in India have revealed 3.21 million tonnes of particulate matter, 2.15 million tonnes of sulphur dioxide, 0.62 million tonnes of oxides of nitrogen, 1.29 million tonnes of carbon monoxide and 2.80 million tonnes of organics including hydrocarbon from the commercial sources using (coal, petroleum and natural gas). Similarly the emission from non-commercial sources namely firewood, dry cattle dung, vegetable wastes and refuse burning were 7.54 million tonnes of particulate matter, 4.67 million tonnes of sulphur dioxide, 1.97 million tonnes of oxides of nitrogen, 2.05 million tonnes of carbon monoxide and 6.19 million tonnes of organics including hydrocarbon respectively (Katz,1976).

Several studies have been conducted on air quality by many workers in various parts of India. Growing number of automobiles and narrow roads with heavy traffic congestion causes the high levels of air pollution in Tiruchirapalli city. (Ravichandran, **et al**, 1996). About 2,00,000 tonnes of carbon dioxide emission is attributed to the road transport in Bangalore (Chandrasekaran **et al**, 1997).

Afforestation and water sprinkling system are used to reduce dust pollution near coal mines (Sahu and Mohapatra, (1996).

Major sources of atmospheric suspended particulate matter in kanpur were soil dust, coal / refuse burning, auto exhaust emissions and mixed industrial sources (Sengar, **et al**., 1991).

Mohan and Muthukrishnan (1996), reported that the amount of suspended particulate matter has been found to be higher than the permissible limits and the amount of sulphur dioxide and oxides of nitrogen were found to be less than the permissible limits, Automobiles seem to be major contribution to air pollution in and around Madras.

Similar study of air quality in Madras city was studied by Hussain (1971). Karunanidhi (1979) has been conducted the air pollution with respect to sulphur dioxide, suspended particulate matter and oxides of nitrogen in Madras city.

Sankiliraj, (1981), Shenbaganandhan, (1982) and Sivaprakasan, (1984) reported that the air pollution situation in Madras city caused by automobile emissions.

The concentrations of air pollutants were within the limits and the air pollution indices showed that air quality of Neyveli was fit for floral, faunal and human existence (Malathi and Sarojini, 1996).

2.3 POLLUTION BY INDUSTRIES

Industrial development of any country is the foundation stone of its prosperity provided, it is without distruction. Industries constitute a formidable source of pollution with large quantities of waste products in the form of solids, liquids, gases, heat, noise etc., proper treatment becomes an important criterian as a preventive measure to ensure that to the extent possible, the environmental problems are kept at the minimum (Biswas, 1985).

One of the major impact of any industry is on the air quality in its neighbourhood. The construction and operation of an industry cause emissions of gaseous and particulate air pollutants. (Padmanabhamurthy, 1981).

Our industrial chimneys, power houses, burning of fuel and auto-exhaust emit such pollutants into the air as suspended particulate matter, smoke, dust, sulphur dioxide, carbon monoxide, nitrogen oxides, fluorides, silicon, tetra fluorides, mai-odours etc. (Agarwal, 1996)

Thermal power plants emit fly ash, oxides of sulphur and nitrogen and particulates such as soot, carbon monoxide and unburnt coal dust. (Dara, 1992, Kumar and Upadhyay, 1983, Rao, 1992). Many of the thermal power stations used pulverised coal (Sengar **et al.**,1991), the burning of poor quality coal causing an imbalance in the ecosystem (Thomas and Hendricks, 1986). The increasing use of coal certainly increase the amount of fly-ash in ambient air (Dubey **et al.,** 1982 and Deshpande, 1985).

In the mining industry during crushing organic particulates, Sulphur dioxide, oxides of nitrogen and dust are released (Rao, 1992). It produce the particulate pollutants of size from 5 to 500 micron affected a few square kilometers around the mine (Jacobson and Hill, 1990, Banerjee, 1981) it affects the surrounding vegetation (Negi, 1986).

Textile mills in India produce about 30,000 to 35,000 tonnes of cotton dust in the blow rooms (Patle **et al**, 1982).

From pulp and paper industry, particulates, hydrogen sulphide, mercaptans and sulphur dioxide are emitted (Rao, 1992, Dara 1992). The major compound resulting from the combustion is nitrogen oxide (Das, 1984).

Petroleum refinaries constitute a major source of air pollution (Hitchcock, 1955, Blokker, 1970). The common air pollutants released are smoke, particulate matter, hydrocarbons, oxide of sulphur and nitrogen, carbon monoxide and malodorous emissions (Elkin, 1977).

Food processing covers a wide range of activities including drying, preservation of food materials and packaging. These activities produce dust and odours (Rao, 1992).

Cement industry releases cement dust, lime dust, oxides of nitrogen, sulphur dioxide, fly ash and smoke (Rao, 1992 and Dara, 1992). Cement dust is a mixture of calcium, potassium, aluminium and their concentration varies with time and location. (Lerman and Darley, 1975). It is highly alkaline in nature (Pawar, **et al.**, 1982) The emission of cement dust particulate varies in the various activities. Cement dust particle size ranges 0.1 to 100 micron (Faith and Atkisson, 1972).

Agarwal (1996) reported that the dust generating sources in cement industry are crusher, raw mill, coal mill, kiln, cement mill, packing plant and material handling operations.

The suspended carbon particulates were found to be ranging from 3.9 to 12.8 μgm^{-3} in cement plant at Ariyalur. This high concentration could be due to predominant north east wind direction. (Chandrasekaran, **et al**., (1996).

Various methods are used to facilitate the communication of different environmental quality parameters. Quality indices are quite important in general, particularly the air quality index or air pollution index. Prusty and Rout (1993). has described in the general features of the air quality index and a case study of Angul Talcher area for the computation of an air quality index.

Umamaheswari **et al.**, and Balasubramanian (1996) indicated that the ambient air total suspended particulate matter concentration was maximum at coal mill and the least was at ball mill in the A.C.C. Limited, Madukkarai.

Ambient air quality at different locations inside the precints of cement industry has been studied earlier. No attempt was taken to study the ambient air quality around the cement industry. In order to get an idea about the air quality around the cement industry, this study was carried out.

2.4 EFFECT OF AIR POLLUTANTS

The green house effect is caused by the increasing amounts of carbon dioxide found in the atmosphere. Due to this rise, the mean global temperature could rise by 4°C in next five decades. This is a matter of great concern since even an small increase in temperature could cause a partial melting of the ice caps of the earth causing continental flooding.

Human health as a result of these changes, will be affected both physiologically and psychologically. Psychological effects may be more pronounced in cases occuring due to changes in rainfall and temperature patterns, food production amounts, water availability etc. Psychological impact may be more in cases of catastrophes like floods, hurricanes or famine (Singh and Syam, 1997).

Air pollution is reported to cause increased respiratory tract disorder in the old and young, decreased visibility, damage to plants and animals. In several studies of mortality from lung cancer, urban sources had death rates from lung cancer three times that of smokers in non-urban environments (Williamson Samuel, 1973).

2.4.1 Suspended Particulate Matter

Suspended Particulate Matter are a composite group of substances, liquid or solid, dispersed in atmosphere. The most significant fraction of suspended particulate matter is the respirable size, that is larger than about 0.1 micron and smaller than about 5.0 micron. Particles in this size range remain in the atmosphere for a longer duration. They not only affect health but also affect visibility (Pondey, 1993). The suspended particulate matter are of different size and shapes. Particles with a size between 0.1 to 10 micron remain suspended in the atmosphere, whereas particles larger than this size settle down.

Significant increasing volume of particulate matter entering the atmosphere scatters the incoming sunlight. This reduces the amount of heat that reaches the earth, and tends to reduce its temperature (Singh and Syam, 1997).

Effect on Human beings

Particulate matter alone or along with other pollutants constitutes a very serious health hazard. The pollutants enter the human body via the respiratory system (Kenneth wark and Cecil F.Warner 1972). It may enter the blood system or lymph system through the lungs (Tyagi and Mehra, 1990).

Increased particulate matter with oxides of sulphur can cause upper respiratory tract infections, cardiac disorders, bronchitis, asthma, pneumonia, and emphysema (Hodgson, 1976), Some of the particulate matter could also be carcinogenic, like the carbonaceous particles containing Poly Aromatic Hydrocarbons (PAHs). (Masters, 1991). High concentrations of particulate matter could reduce visibility.

Effect on Vegetation

Particulates deposited on leaves reduce photosynthesis. Cement kiln dust in combination with mist or light, rain to form a crust on the leaves of plants resulting in plant damage. Particles containing fluoride also cause some plant damage. Magnesium oxide falling on agricultural soils has resulted in poor plant growth (Kenneth wark and Cecil F.Warner, 1972).

A thick crust of cement dust is found to interfere with light absorption and subsequent starch formation. Lime deposits causes reduction in photosynthesis, vigour and hardiness of plants (Mowli and Subbayya, 1989).

The plants with cement dust deposition show suppression in most of the characters like leaf size, number, size of crops and plant height when compared with plants in unpolluted fields (Parthasarathy, **et al.**, 1975).

Effect on Materials

Air pollutants have damaging effects on many inert materials. Atmospheric particles can accelerate the corrosion of iron, steel and various non -ferrous metals and soil. Particulate pollution affects electrical equipment including transmission lines and contacts increasing the maintenance of the distribution system. It can damage the protective coating and exposing the underlying surface (Mowli, and Subbayya,1989). Building surfaces and materials are soiled, disfigured and damaged by atmospheric particulate matter. Under conditions of high wind speed, larger particles can be disloaded by the wind stream and result in slow erosion of building surfaces (Kenneth wark and Cecil F. Warner, 1972).

2.4.2 Sulphur dioxide

Sulphur dioxide is an irritant which affects the mucous membrane. When inhaled sulphur dioxide under certain environmental conditions can get oxidised to sulphur trioxide and in the presence of water vapour or water, sulphur dioxide and sulphur trioxide can get converted into sulphurous and sulphuric acid, respectively. Sulphur trioxide is a strong irritant and when inhaled can cause severe bronchospasms at relatively lower levels of concentrations (Rao and Rao, 1989).

Effect on Human beings

According to Andrew R.W.Jackson and Julie M. Jackson (1996) 0.2 ppm of sulphur dioxide is the lowest concentration causing a human response, 0.3 ppm is threshold for taste recognition, 0.5 ppm is threshold for odour recognition, 1.6 ppm is threshold for inducing reversible broncho constriction in healthy individuals, 8 to 12 ppm causes immediate throat irritation, 10 ppm causes eye irritation and 20 ppm causes immediate coughing.

Irritation of tissues lining upper respiratory tract resulting in increased resistance to air flow (Mowli and Subbayya, 1989).

Effect on Vegetation

The effect on leaves of excessive sulphur dioxide in the atmosphere causes chlorosis (whitening), leaf necrosis (death), bleaching or yellowing of the normally green portions of the leaf. It causes direct injury to reproductive structures, damage to pollen, damage to the seed and reduced viability of seeds or damage to seedlings, hardening of floral buds, necrosis of fruit tip (Verma and Agarwal 1996).

Agarwal **et al.,** (1982) have been studied that the plants treated with sulphur dioxide showed visible foliar injury symptoms with decreasing levels of chlorophyll and carotenoid pigments and also interveinal chlorosis.

Effect on Materials

Sulphur oxides generally accelerate metal corrosion. Corrosion rate of most metal's and especially iron, steel and zinc are accelerated by sulphur dioxide and also particulate matter. It increases the drying and hardening time of some paints (Tyagi and Mehra, 1990).

Sulphurous and Sulphuric acids are capable of attacking a wide variety of building materials including limestone, marble, roofing slate and mortor (Kenneth wark and Cecil F.Warner, 1972)

The sulphur dioxide exposed paper gets discoloured and become brittle and fragile (Dara, 1992).

2.4.3 Oxides of nitrogen

Of the seven types of oxides of nitrogen known to exist in the ambient air, only two are thought to affect human health. They are nitric oxide (NO) and nitrogen dioxide (NO_2). Nitric oxide can oxidize to nitrogen dioxide which may react with hydrocarbons in the presence of sunlight to form photochemical smog, which could be injurious. Nitrogen dioxide can react with the hydroxyl radical (OH) in the atmosphere to form nitric acid (HNO_3), which is washed out of the atmosphere as acid rain. Acid rain can damage plants and corrode metal surfaces. (Mohan and Muthukrishnan, 1996).

Effect on Human beings

U.S.E.P.A (1971) reported that 0.06 to 0.1 ppm of nitrogen dioxide causes increase in acute respiratory disease, upto 0.1 ppm increases in acute bronchitis in school children, 0.12 ppm causes human olfactory threshold, 5 ppm causes increase in airway resistance and 90 ppm causes pulmonary edema.

The oxides of nitrogen, which inhaled, combined with haemoglobin to result in a condition called methaemoglobinaemia resulting in the depletion of oxygen in individual cells, causing cellular asphyxiation (Mohan and Muthukrishnan, 1996).

Effect on Vegetation

Primary symptoms are collapsed, white to tan, irregular shaped necrotic lesions appearing between the large secondary veins near the leaf margin (Mowly and Subbayya, 1989)

Oxides of nitrogen affects sensitive plants by causing leaf injury, reduction of growth. It causes chlorotic marking, banding and silvering of the underside of the leaf (Dara, 1992) and causes abscission and decreased yield of navel oranges.

Effect on Materials

Nitrate compounds cause corrosion and failure of electrical components with average oxides of nitrogen levels of 125 to 150 μgm-3 (U.S.E.P.A., 1971)

The dyes of acetate rayon, cotton and viscose rayon will fade upon exposure to oxides of nitrogen. It also reduces the fibre strength. Nitrogen dioxide produced acid aerosols which damaged the nylon.

Stress - corrosion failures of nickel - brass wire springs in relays used by telephone companies. It causes discolouration in paints and building materials (Tyagi and Mehra, 1990).

2.5 AIR POLLUTION CONTROL EQUIPMENTS

There are many varieties of dust control equipment which are used in cement industry. Settling chambers, filters, electrostatic precipitators, cyclone collectors, scrubbers are commonly used for the removal of particulate pollutants escaping to the atmosphere are provided between the plant and the stack. Meteorological control of air pollution is achieved by use of tall stacks, by air zoning and by control of process techniques according to meteorological conditions. Gas removal methods including adsorption and condensation. (Parthasarathy **et al.**,1975)

Fabric filters

They are generally known as bag filters, Dust is removed from the bags by isolating portions of filter bags from main gas flow and blowing low pressure air in reverse direction when the bags are mechanically shaken.

Electrostatic precipitators

The collection efficiency of electrostatic precipitator is invariably above 99% and often goes to 99.9% and down to a particle size of one micron. The electrostatic precipitator are generally horizontal type collecting electrodes with horizontal gas flow to achieve maximum collection efficiency. They are generally provided with a pre-collector and one or more fields of treatment zones in series.

The collected dust is returned to the system in case of dry process plants. However where the raw material contains high percentage of alkalies, part of the dust is required to be thrown to reduce the nuisance of higher alkali levels (Das, 1990).

In A.C.C. Limited, Madukkarai, they use water sprays, chemical sprays, electrostatic precipitators, fabric filters, and vacuum cleaners for the removal of particulate pollutants and fugitive dust emission (A.C.C. Environmental Statement, 1997).

CHAPTER 3

Materials and Methods

MATERIALS AND METHODS

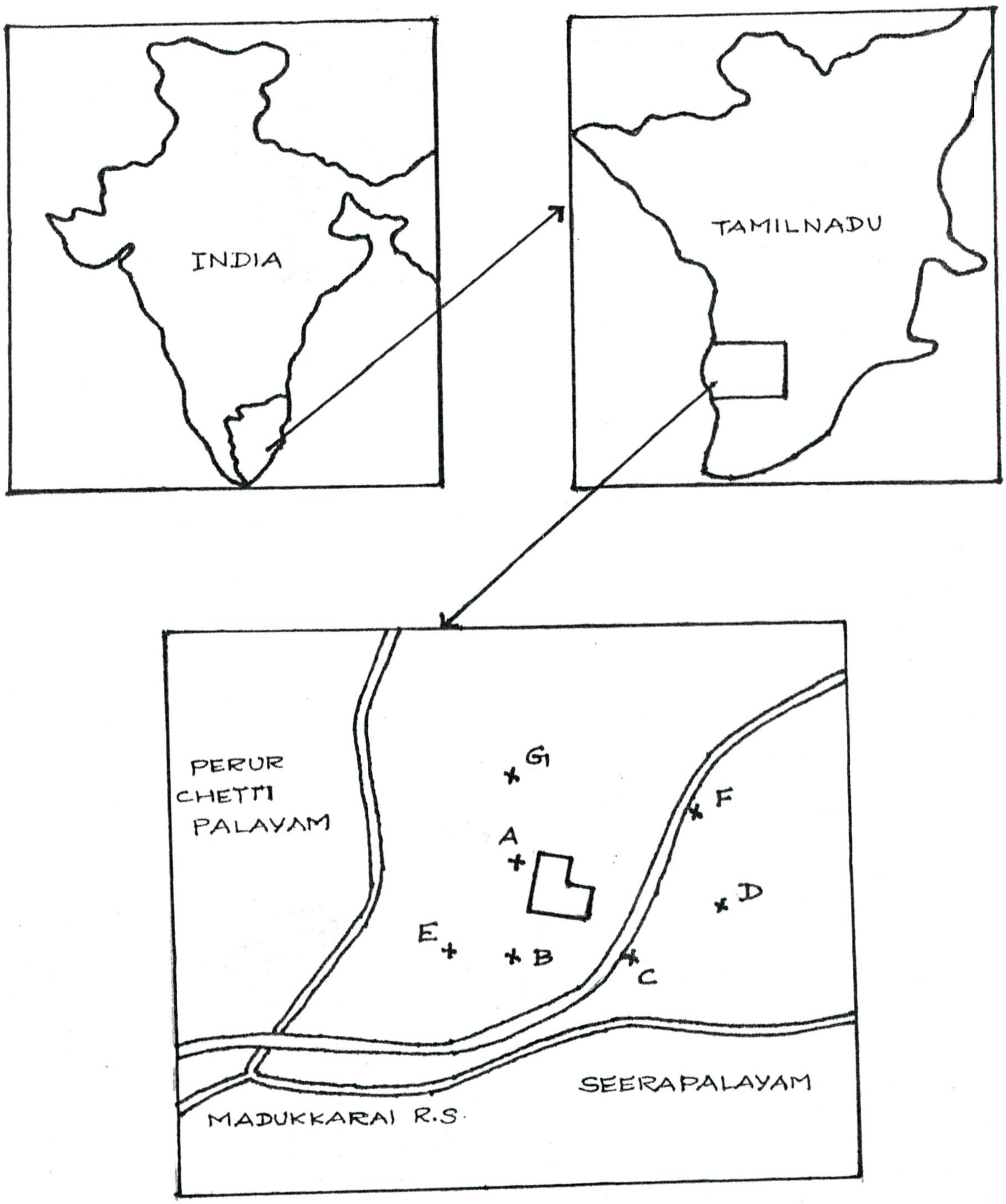
There are variety of pollutants which are released in air. Among the variety of pollutants released, sulphur dioxide, oxides of nitrogen, particulates and carbon monoxide have been identified as priority pollutants. The gaseous emission from cement manufacturing industry has been investigated using high volume air sampler, Envirotech APM 415. The aim of using it to measure the ambient air quality around the cement industry. The experimental procedure has been elaborated as follows:

3.1 SELECTION OF THE CEMENT INDUSTRY

Coimbatore is an industrial city with industries centered in and around it. Cement industry is one among the energy intensive industries. The exit gases of cement kiln consists of nitrogen, carbon dioxide and water vapour. In addition they may contain small amount of sulphur dioxide, oxides of nitrogen, carbon monoxide and hydrogen sulphide. These pollutants may cause severe air pollution problems. However the amount of dust emitted into the atmosphere by cement industry is considerable. Hence a cement industry situated in Coimbatore has been selected for the study.

3.2 SELECTION OF THE SAMPLING SITE

The Madukkarai Cement Industry, M/s The Associated Cement Companies Limited (A.C.C) was selected for impact assessment as one of the up-to-date case study. The industry is located about 14 kilometres away from Coimbatore city at Madukkarai. The cement factory is situated close to the National Highways-47. (NH-47, Coimbatore - Palakkad). This area is developing at a faster rate.



A-G LOCATION OF AIR SAMPLING SITES

Fig. 1 Area Map of Associated Cement Companies, Madukkarai, Showing the location of the seven air sampling stations.

The monitoring unit was located at the following places which are about 250 to 2000 metres from the industry.

A. On the top of A.C.C. Hospital building which is a supporting facility to the industry at 250 metres from the source.

B. On the house top of A.C.C. 'K' type quarters, D.No.3/99. Madukkarai, which is 500 metres from the source.

C. At 600 metres from the source on the top of 'N' type quarters of A.C.C. Limited.

D. House of Mr. Arumugam in Mettangadu village at 750 metres from the source.

E. At 1000 metres on the house top of 'H' type quarters of A.C.C. Limited, D.No.7/73.

F. On the top of Nataraj Hospital, which is again a supporting facility of the industry, which is located at 1500 metres from the source.

G. At 2000 metres on house top of Mr.Shanmugam, D.No.8/114A, Kurumbapalayam village.

3.3 COLLECTION OF AIR SAMPLES

3.3.1 Collection of Suspended Particulate Matter (SPM)

Suspended Particulate Matter is estimated by the well known reference method in United States Environmental Protection Agency literature. The suspended particulate matter was collected using a Whatman glass microfibre filter (GF/A) and estimated gravimetrically.

Sampling procedure

1. The fibre glass filters were checked for any pin holes, particulates or other imperfections. The filter was dried in a hot air oven at 105°C for six hours and cooled. The initial weight of the filter was measured (W_1). The filter was carried in a polythene bag without folding to the sampling site.

2. The filter was fixed on the filter holder in position. The face plate was replaced and the nuts were fastened securely. A very thin application of talcum powder was used on the sponge rubber of the face plate to prevent it from sticking. The instrument was placed approximately 10 metres above and 5 metres away from the road.

3. For every three hours of the sampling period, the flow rates were noted and the average flow rate was calculated. The closing - time was also noted.

4. After the sampling was completed, the face plate was removed and the filter was carefully removed from the holder.

5. The filter was kept in a hot air oven for six hours and then cooled. The filter with sample was weighted. (W_2).

Estimation of Suspended Particulate Matter.

Concentration of suspended particulate matter $= W/V\ \mu g m^{-3}$

Weight of suspended particulate matter (W) $= W_2 - W_1$ g

PLATE I

HIGH VOLUME AIR SAMPLER - ENVIROTECH APM 415

W_2 = Weight of filter paper after sampling (g)

W_1 = Weight of fresh filter paper (g)

Volume of air sampled (V) = QT (cubic metres)

Q = Average sampling rate (m^3/min)

T = Sampling time (minutes)

$Q = (Q_1+Q_2) / 2$

Q_1 = Initial sampling rate

Q_2 = Final sampling rate.

3.3.2 Collection of gaseous pollutants

Collection of sulphur dioxide and oxides of nitrogen

The APM 415 sampler with APM 411 gaseous sampling attachment was used in the monitoring of gaseous pollutants. These samples were collected in duplicate in two impingers containing the appropriate chemical solutions.

Sampling procedure

1. For the collection of gas sample, the gas impinger was checked to make sure, there was no leakage. The gases were absorbed at the rate of 1 litre/minute in the absorbing solution. Different absorbing solutions were used for sulphur dioxide and oxides of nitrogen. The absorption solution used for sulphur dioxide was sodium tetrachloromercurate and sodium hydroxide for oxides of nitrogen. The absorption solutions used were in accordance with the recommendations made by the Bureau of Indian Standards (BIS).

2. After the sampling was completed the impinger was carefully removed. The volume of absorbing reagent was checked in the tube. It was less due to evaporation.

PLATE II
GASEOUS SAMPLER - ENVIROTECH APM 411

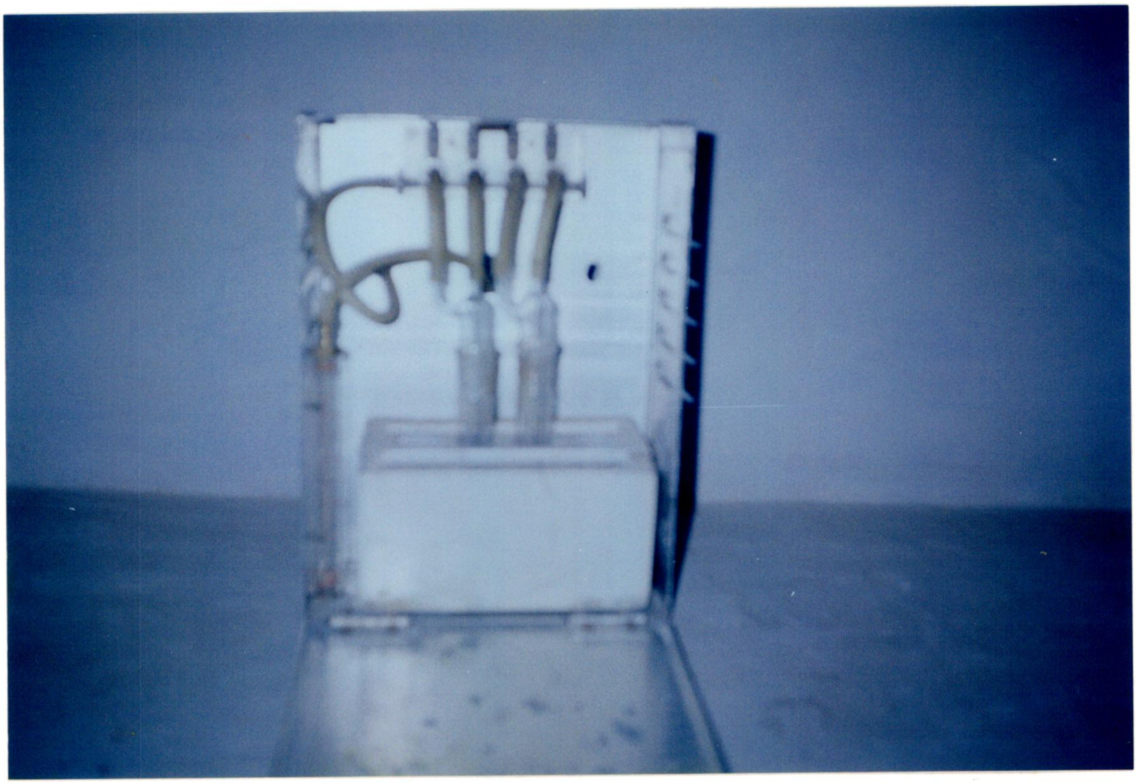


PLATE III
HIGH VOLUME AIR SAMPLER ENVIROTECH APM 415 WITH GASEOUS SAMPLER ENVIROTECH APM 411

3. The solution in the impinger was taken to the laboratory for estimation.

Estimation of sulphur dioxide

Sodium Tetrachloromercurate Method: (West and Gaeke, 1956).

Principle

When sulphur dioxide from the air stream is absorbed in a sodium tetrachloromercurate solution it forms a stable dichloro sulphito mercurate. The amount of sulphur dioxide is then estimated by the colour produced when p-rosaniline hydrochloride is added to the solution. The colour is estimated by a reading from an spectrophotometer at 560 nm for which a calibration curve has already been prepared.

Reagents

Absorbing solution: 0.1 M sodium tetrachloromercurate.

Dissolved 27.2 g (0.1 mole) mercuric chloride and 11.7 g (0.2 mole) sodium chloride in litre of distilled water.

Formaldehyde solution : 0.2 percent

Diluted 5 ml of 40 percent formaldehyde solution to one litre with distilled water.

P-Rosaniline Hydrochloride: 0.04 Percent (W/V) acid bleached.

Dissolved 0.20 g of P-rosaniline hydrochloride in 100 ml of distilled water and filter the solution after 48 hours.

Sulfamic acid solution:

Dissolved 0.6 g in 100 ml of distilled water.

Standard sodium sulphite solution:

Dissolved 640 mg of sodium metabisulphite in 1 litre of distilled water.

Procedure

30 ml of absorbing reagent was taken in the bubbler. The water loss by evaporation during sampling was replaced by adding distilled water upto 30 ml mark. From this, 10 ml was pipetted into a Nessler's tube. 10 ml of standard solution was then added followed by 1 ml of sulfamic acid. After 10 minutes, 2 ml of formaldehyde, 5 ml of p-rosaniline was added and was kept for 30 minutes. Then the optical density was determined spectrophotometrically at 560 nm.

Calculation

Concentration of sulphur dioxide was calculated as follows:

$$= (X \times 30) / \text{Volume of air sampled}$$

$$X = \text{Volume from standard graph in } \mu g/ml$$

The volume of air sampled (V) = sampling rate X sampling time.

The volume of air sampled was adjusted to standard temperature pressure conditions.

$$X.30 / V = \text{Concentration of sulphur dioxide in } \mu g\ m^{-3}.$$

3.3.3 Estimation of oxides of nitrogen

Sodium Hydroxide Method (Jacobs and Hochheiser, 1960).

Principle

Nitrogen oxides as nitrogen dioxide are collected by bubbling air through a sodium hydroxide solution to form a stable solution of sodium nitrate. The nitrite ion produced during sampling is determined colorimetrically by reacting the exposed absorbing reagent with phosphoric acid, sulphanilamide and N(1-naphthyl) ethylene diamine dihydrochloride.

Reagents

Absorbing Reagent

Dissolved 4 g of sodium hydroxide in distilled water, and diluted to 1000 ml.

Sulphanilamide

Dissolved 20 g of sulphanilamide in 700 ml of distilled water. Added with mixing, 50 ml of concentrated phosphoric acid (85 percent) and diluted to 1000 ml.

Hydrogen Peroxide

Diluted 0.2 ml of 30 percent hydrogen peroxide to 250 ml with distilled water.

NEDA Solution

Dissolved 0.5g of N(1-naphthyl) ethylene diamine dihydrochloride in distilled water.

Standard Nitrite Solution

0.765 g sodium nitrite dissolved in 500 ml of distilled water.

Procedure

30 ml of absorbing reagent was taken in the bubbler. The water loss by evaporation during sampling was replaced by adding distilled water upto 30 ml mark. From this, 10 ml was pipetted out into a Nessler's tube. 10 ml of sulphanilamide solution followed by 1 ml of hydrogen peroxide and 1.4 ml of NEDA solution were added. The solution was made upto the mark with distilled water. After 10 minutes, the intensity of colour developed was measured using a

spectrophotometer at 540 nm against the blank. The concentration of nitrogen dioxide in μg/ml was read from the calibration curve.

Calculation

Concentration of nitrogen dioxide in μgm^{-3} was calculated as follows:

(X x 30) / Volume of air sampled

X = Volume from standard graph in μg/ ml

The volume of air sampled (V) = sampling rate x sampling time.

The volume of air sampled was adjusted to standard temperature pressure conditions.

X.30/V = Concentration of nitrogen dioxide in μgm^{-3}.

3.4 CALCULATION OF AIR POLLUTION INDEX (API)

The concept of air pollution index is the result of the acute need to reduce a large quantity of data down to its simplest form while retaining all essential informations. Thom and Ott (1976) define an Air Pollution Index as a scheme which transforms the weighted value of individual air pollution - related parameters into a single number. The fundamental step in forming an index is the calculation of the sub-index for the n pollutant variables ($X_1, X_2, \ldots X_n$) using some sub-index function.

$I_i = f_i (X_i)$ where I - sub-index and i = 1,2,....n.

In the present study, the sub-index was calculated following the linear relationship of pollutant concentration and sub-index I, and I was interpreted as a percentage of the prescribed ambient air quality standard.

$$I = 100\ X / Xs$$

Where X is the observed value of the pollutant.

Xs is the prescribed standard for the pollutant.

Using this method, the sub-indices for all the three major pollutants at all the seven sampling stations for all the six months of study were determined.

Calculation of Aggregated Air Quality Index

Once the sub-indices are formed, they are combined or aggregated in a simple additive form or weighted additive form. The overall Air Quality Index (AQI) was calculated using the Oak Ridge Air Quality Index (ORAQI) method adopted by the National Environmental Engineering Research Institute (NEERI), India and is calculated as follows

$$ORAQI = \left[39.02 \left[\frac{SPM}{200} + \frac{SO_2}{80} + \frac{NO_X}{80} \right] \right]^{0.967}$$

Where 39.02 and 0.967 are constants

200 is standard SPM concentration

80 is standard SO_2 and NO_x concentration

SPM, SO_2 and NO_x are the estimated concentrations of the respective air pollutants.

3.5 SURVEY OF THE AUTOMOBILES ON NATIONAL HIGHWAYS-47 NEAR A.C.C

The factory being located in the National Highways-47 (NH:47), the vehicular movement also accounts for the air quality around A.C.C. Limited. Therefore a survey of the different vehicles which ply on the road was taken on 17.1.98 from 9 a.m to 5 p.m . From the data, the number of vehicles crossing the cement industry per minute was calculated.

CHAPTER 4

Results and Discussion

RESULTS AND DISCUSSION

The monitoring of environmental pollutants is not a new concept. The monitoring of concentrations of different ambient air quality parameters is important in order to determine the status of air quality, so that action may be taken to prevent any adverse health effects.

The present study was carried out on air samples taken from seven different stations in various locations in and around A.C.C. Limited. The results obtained are being discussed below.

Table II, III and IV represent the concentrations of SPM, SO_2 an NOx respectively in air samples of A.C.C. Limited for a period of six months viz., August 1997 to January 1998.

During the period under study, the concentration of SPM was more compared to the concentrations of NOx and SO_2. Most of the time the concentration of SO_2 was below detectable limit (Fig.2-8). Compared to the ambient air quality standard given by State Pollution Control Board (Table V) all the pollutants concentration were within permissible limits.

The average sub-index values for SPM, SO_2 and NOx at different stations are given in Table VII.The maximum average sub-index of SO_2 (6.48) was noted in station B while station E recorded a minimum value (2.58). On the other hand station E has recorded a high sub-index (10.79) of NOx and Station B has recorded a low sub-index (4.81) of NOx. The reason for this observation is not obvious. A more detailed study may be under taken to explain this phenomenon.

TABLE II

SPM CONCENTRATIONS IN AMBIENT AIR OF A.C.C LIMITED FOR THE PERIOD AUGUST 1997 TO JANUARY 1998.

Station No.	Distance from the source(m)	August 1997		September 1997		October 1997		November 1997		December 1997		January 1998	
		Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index
A	250	150	75	110	55	153	76.5	187	93.5	74	37	103	51.5
B	500	153	76.5	133	66.5	75	37.5	135.23	67.615	109	54.5	75	37.5
C	600	114	57	113	56.5	174	87	127.05	63.525	126	63	180	90
D	750	126	98	46	23	103	51.5	187	93.5	163	81.5	129	64.5
E	1000	72	36	66	33	129	64.5	178	89	117	58.5	143	71.5
F	1500	151	15.5	101	50.5	164.5	82.25	141.12	70.56	49	24.5	168	84
G	2000	190	95	177	88.5	180	90	198	99	184	92	188	94

TABLE III

SO_2 CONCENTRATIONS IN AMBIENT AIR OF A.C.C. LIMITED FOR THE PERIOD AUGUST 1997 TO JANUARY 1998.

Station No.	Distance from the source(m)	August 1997		September 1997		October 1997		November 1997		December 1997		January 1998	
		Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index
A	250	BDL	-	BDL	-	3.600	4.5	3.120	3.9	BDL	-	3.2	4.0
B	500	BDL	-	BDL	-	BDL	-	5.18	6.48	BDL	-	BDL	-
C	600	BDL	-	BDL	-	BDL	-	3.91	4.88	BDL	-	BDL	-
D	750	BDL	-	BDL	-	3.2	4.0	3.90	4.87	5.000	6.25	3.2	4.0
E	1000	BDL	-	BDL	-	3.2	4.0	1.3	1.630	1.700	2.13	BDL	-
F	1500	BDL	-	BDL	-	6.2	7.75	6.05	7.52	BDL	-	3.1	3.88
G	2000	BDL	-	BDL	-	BDL	-	2.8	3.500	2.800	3.5	5.1	3.38

* BDL - Below Detectable Limit

Table IV

NO_x CONCENTRATIONS IN AMBIENT AIR OF A.C.C. LIMITED FOR THE PERIOD AUGUST 1997 TO JANUARY 1998.

Station No.	Distance from the source(m)	August 1997		September 1997		October 1997		November 1997		December 1997		January 1998	
		Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index	Concen-tration (μgm^{-3})	Sub Index
A	250	4.7	5.875	9	11.25	6.0	7.500	3.3	4.125	12.900	16.125	0.7	0.875
B	500	7.9	9.875	5	6.25	0.7	0.875	2.6	3.250	6.200	7.750	0.7	0.875
C	600	6.4	8	3	3.75	1.2	1.500	5.9	7.375	11.400	14.250	1.5	1.875
D	750	21.6	27	8	10.00	4.400	5.500	4.100	5.125	8.100	10.125	1.900	2.375
E	1000	21.5	26.875	5	6.25	1.9	2.375	13.2	16.500	9.100	11.375	1.1	1.375
F	1500	2.2	2.750	6	7.50	3.4	4.250	2.0	2.500	16.700	20.875	0.9	1.125
G	2000	2.8	3.500	14	17.50	1.5	1.870	5.4	6.750	7.900	9.875	0.9	1.125

Table V

AMBIENT AIR QUALITY STANDARDS

Category	Area	Concentration (micrograms per meter cube)		
		SPM	SO_2	NO_x
A	Industrial and mixed -use	500	120	120
B	Residential and Rural	200	80	80
C	Sensitive	100	30	30

TABLE : VII

AVERAGE SUB-INDEX VALUES FOR SPM, SO_2 AND NO_X

Station Number	SPM	SO_2	NO_x
A	64.75	4.130	7.63
B	56.690	6.480	4.81
C	69.50	4.890	6.13
D	68.670	4.780	10.020
E	58.750	2.580	10.790
F	64.550	6.390	6.50
G	93.080	4.460	6.77

Fig.2 Monthly Average Air Quality Index
Station-I

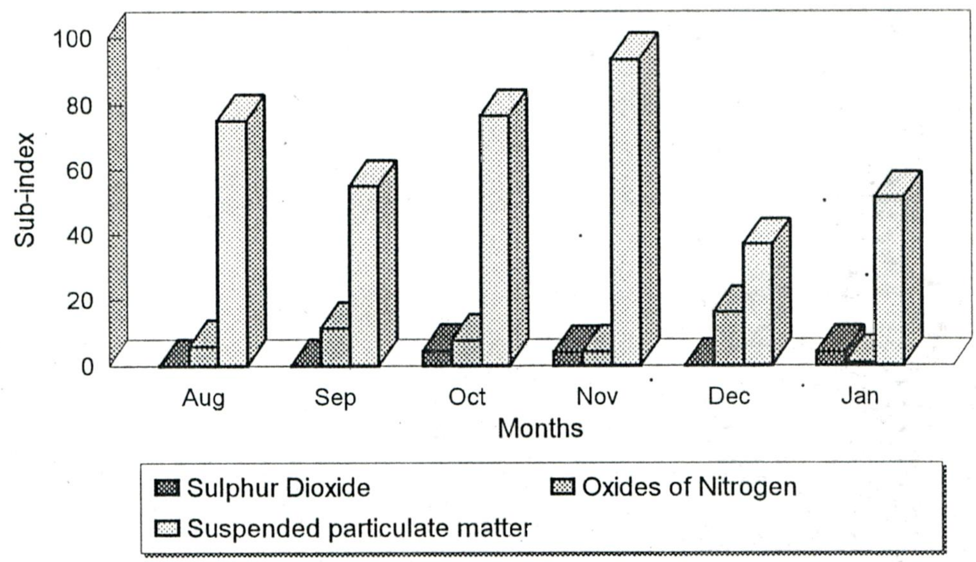


Fig. 3 Monthly Average Air Quality Index
Station-II

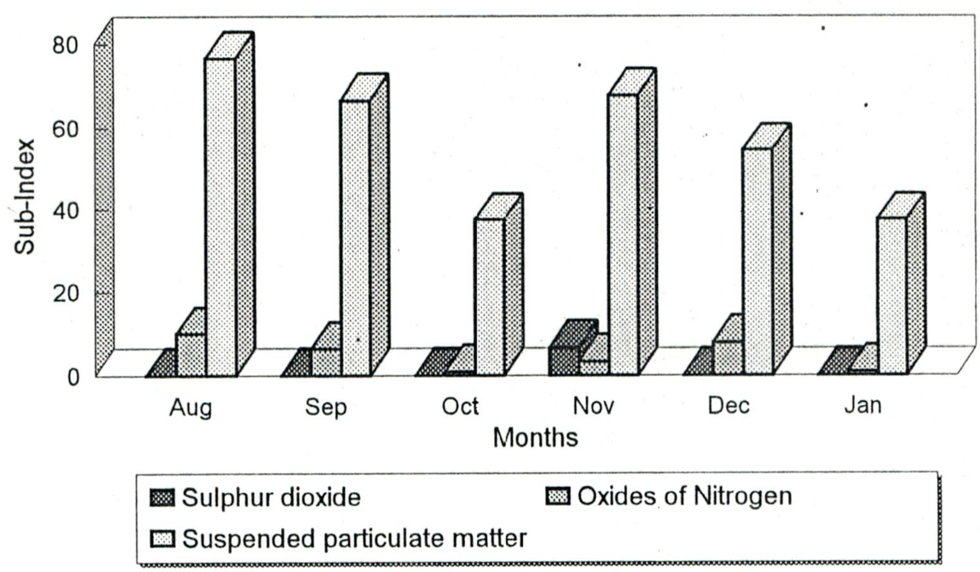


Fig. 4 Monthly Average Air Quality Index
Station- III

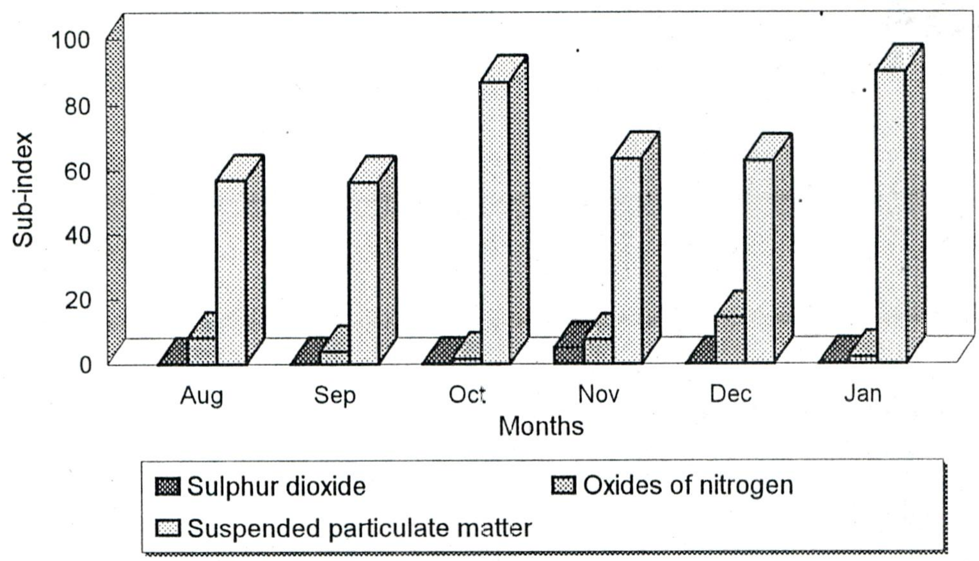
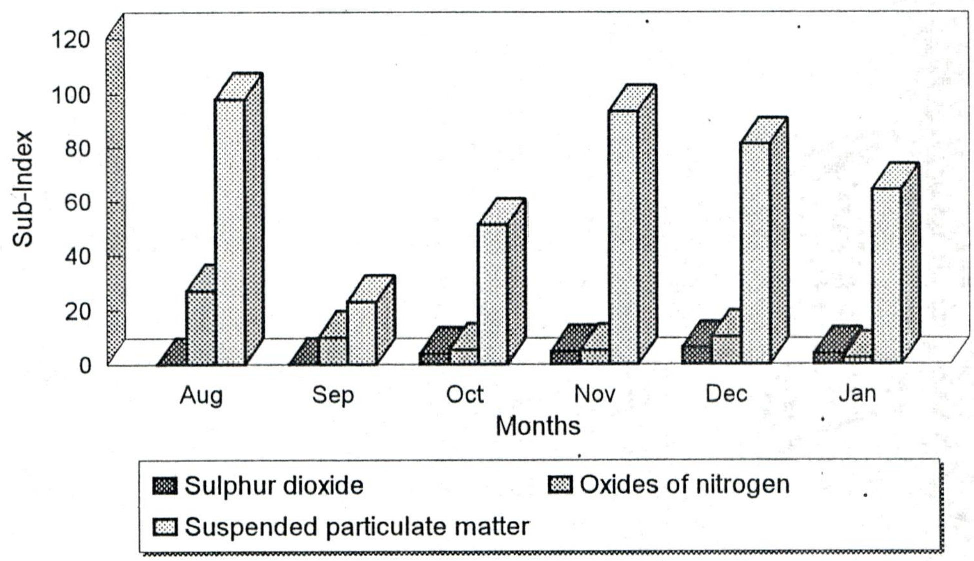


Fig. 5 Monthly Average Air Quality Index
Station-IV



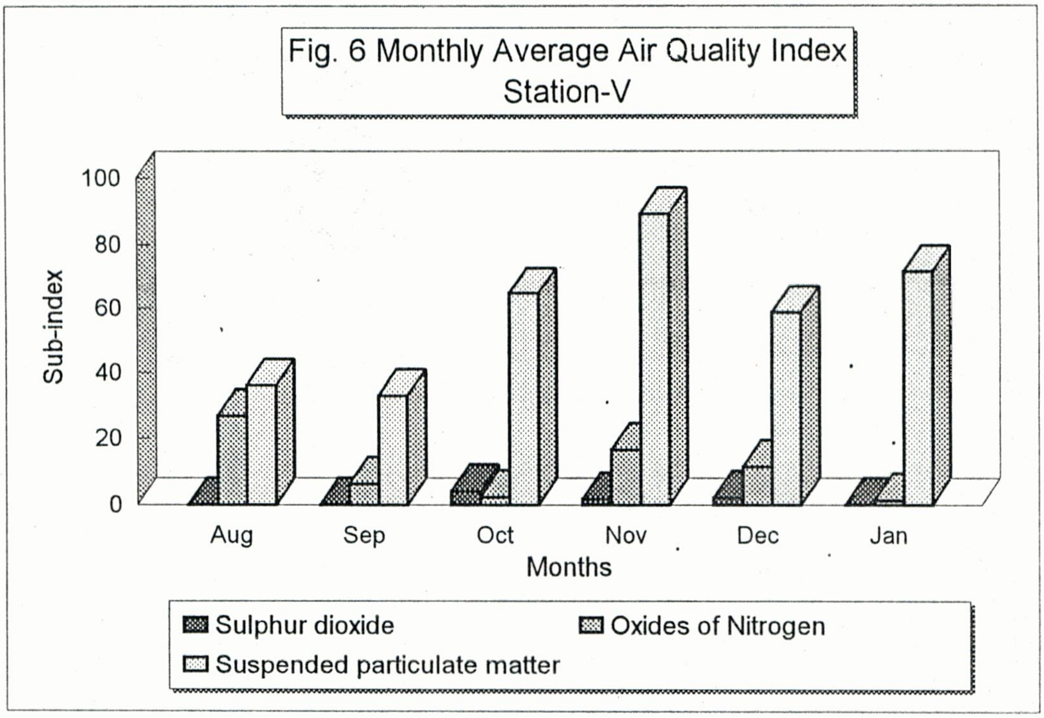


Fig. 6 Monthly Average Air Quality Index
Station-V
100
80
60
40
20
0
Sub-index
Aug
Sep
Oct
Nov
Dec
Jan
Months
Sulphur dioxide
Oxides of Nitrogen
Suspended particulate matter

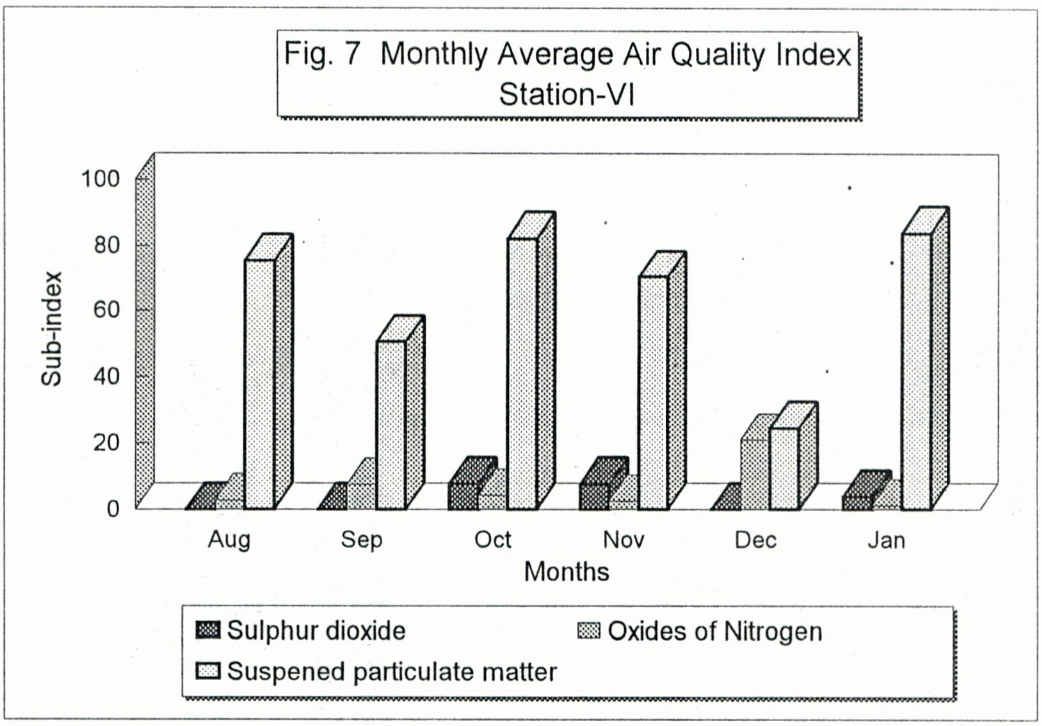


Fig. 7 Monthly Average Air Quality Index
Station-VI
100
80
60
40
20
0
Sub-index
Aug
Sep
Oct
Nov
Dec
Jan
Months
Sulphur dioxide
Oxides of Nitrogen
Suspened particulate matter

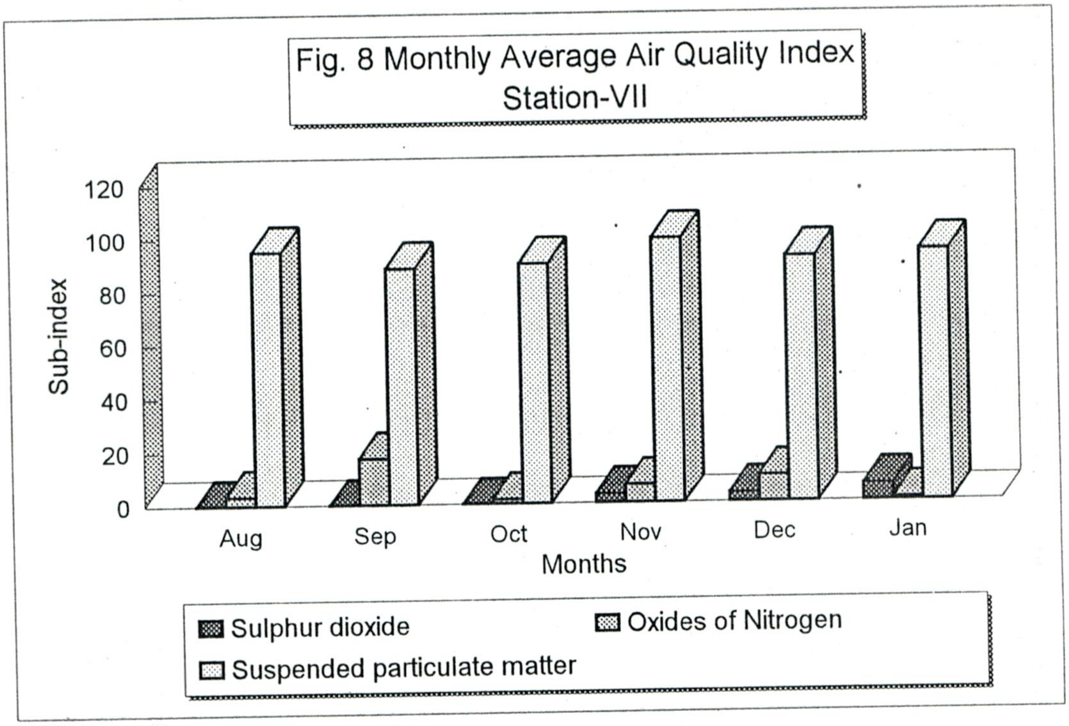


Fig. 8 Monthly Average Air Quality Index
Station-VII
Sub-index
120
100
80
60
40
20
0
Aug
Sep
Oct
Nov
Dec
Jan
Months
Sulphur dioxide
Oxides of Nitrogen
Suspended particulate matter

maximum SPM value (93.08) was recorded at station G and a minimum of (56.69) was recorded at station B. This may be attributed to the fact that the station G is situated on the windward side.

Aggregated air quality Index (AQI) calculated for the seven stations (Table VI) was compared with average AQI for each month and average AQI for each station.

Station wise comparison for a given month.

For August the average Air Quality Index (AQI) was 27.95. The AQI was higher than the average AQI for stations A (28.16), B (30.01), D (31.23) and G (34.07). The AQI for station C (22.79), E (22.08) and F (27.28) were lesser than the average (Fig-9). The co-efficient of variation of AQI for August across the stations was 14.44.

During September the average AQI was 21.81 and was the least for the period studied. A (23.22), B(25.42) and G(36.58) showed higher values than average AQI. Stations C (21.18), D (11.84), E (13.99) and F (20.42) showed lesser values than average AQI (Fig.10). The coefficient of variation for September across the stations are found to be 34.49.

In October the average AQI was 26.55. Stations A (30.72), C (30.72), F (32.65) and G (31.86) had AQI higher than the average AQI for the month. Stations B (13.69), D (21.44) and E (24.79) had lesser than average AQI values.(Fig.11). The co-efficient of variation for October was 24.44.

November recorded the highest average AQI as 32.42. Stations A(35.09), D (35.75), E (36.96) and G (37.66) had higher than average AQI, indicating

TABLE VI

AGGREGATED AIR QUALITY INDEX OF A.C.C. LIMITED (BASED ON OAK RIDGE AIR QUALITY INDEX ADOPTED BY NEERI)

Station No.	Distance from the source(m)	August 1997	September 1997	October 1997	November 1997	December 1997	January 1998	Standard deviation	Arithmetic Average	Coefficient of Variation
A	250	28.1599	23.2199	30.7234	35.0858	18.7559	19.8644	5.8780	25.9680	22.6353
B	500	30.0097	25.4195	13.6946	36.9688	21.8629	13.6946	6.3046	21.9416	28.7335
C	600	22.7962	21.1833	30.7234	26.4451	26.9385	31.8557	3.8120	26.6870	14.2841
D	750	31.2268	11.8353	21.4382	35.7455	33.8653	24.7857	8.222	26.4828	31.0470
E	1000	22.0751	13.9964	24.7857	36.9555	25.1661	25.4617	6.7385	24.7400	27.2372
F	1500	27.2756	20.4178	32.6516	28.0740	16.1034	30.8912	5.818	25.9022	22.4614
G	2000	34.0744	36.5802	31.8557	37.6642	36.3716	35.0774	1.9055	35.2705	5.4025
Standard Deviation		4.0366	7.5219	6.4086	4.6374	6.9417	6.880	*	*	*
Arithmetic Average		27.9453	21.8074	26.5532	32.4198	25.5805	25.9472	*	*	*
Co-efficient of Variation		14.4446	34.4924	24.4362	14.3042	27.1366	26.515	*	*	*

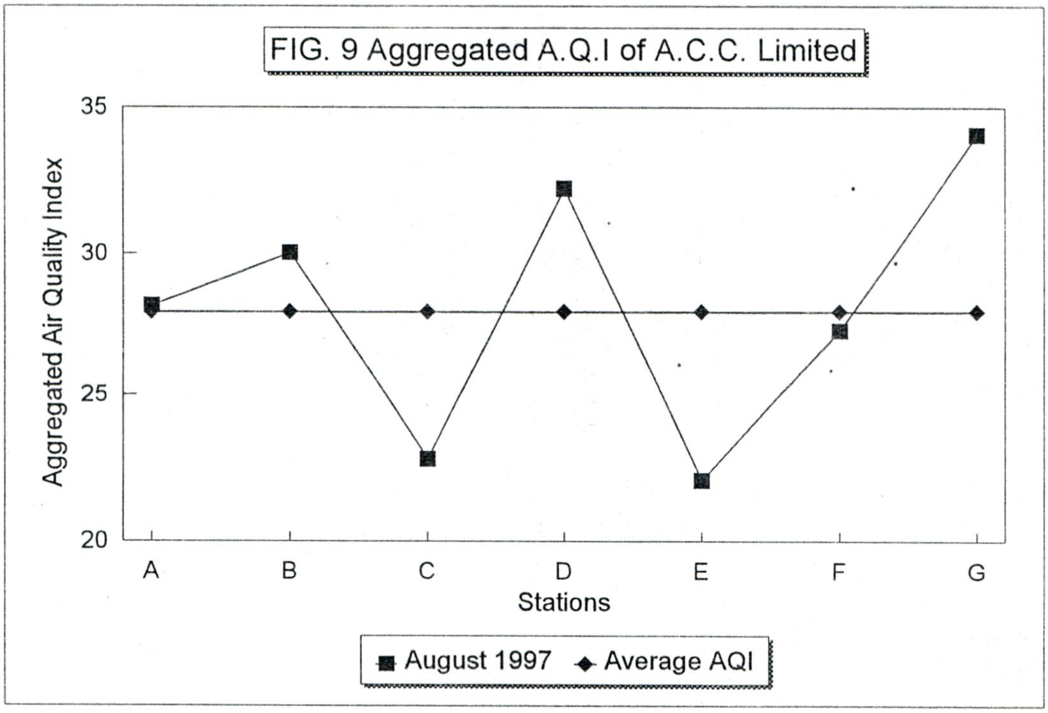


FIG. 9 Aggregated A.Q.I of A.C.C. Limited
Aggregated Air Quality Index
35
30
25
20
A
B
C
D
E
F
G
Stations
August 1997
Average AQI

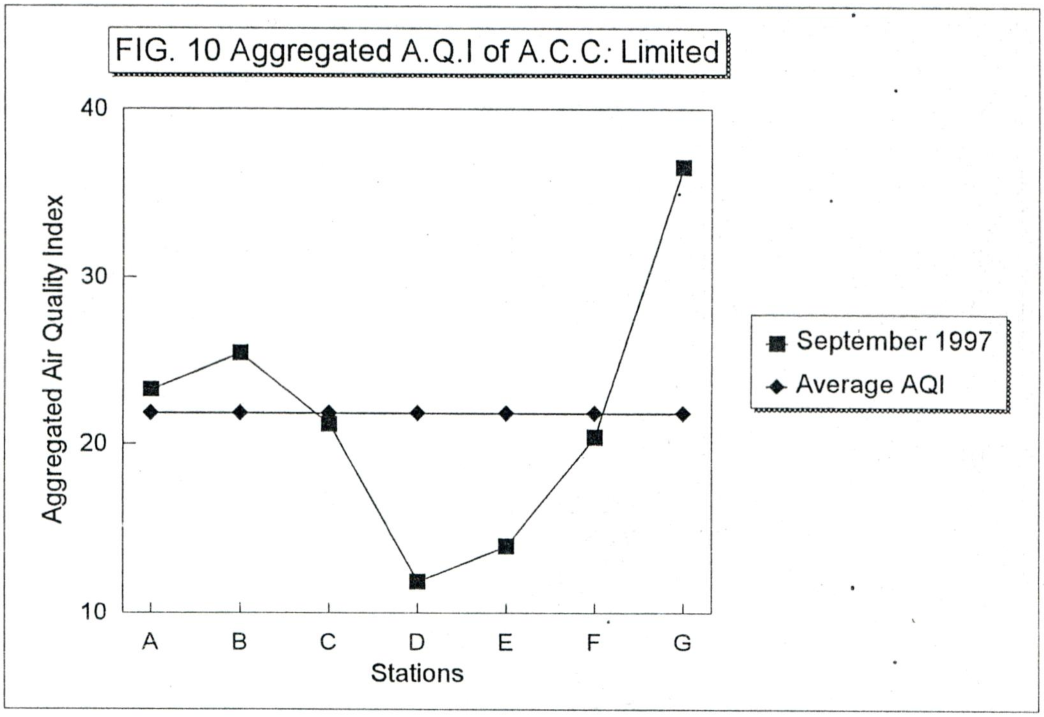


FIG. 10 Aggregated A.Q.I of A.C.C. Limited
Aggregated Air Quality Index
40
30
20
10
A
B
C
D
E
F
G
Stations
September 1997
Average AQI

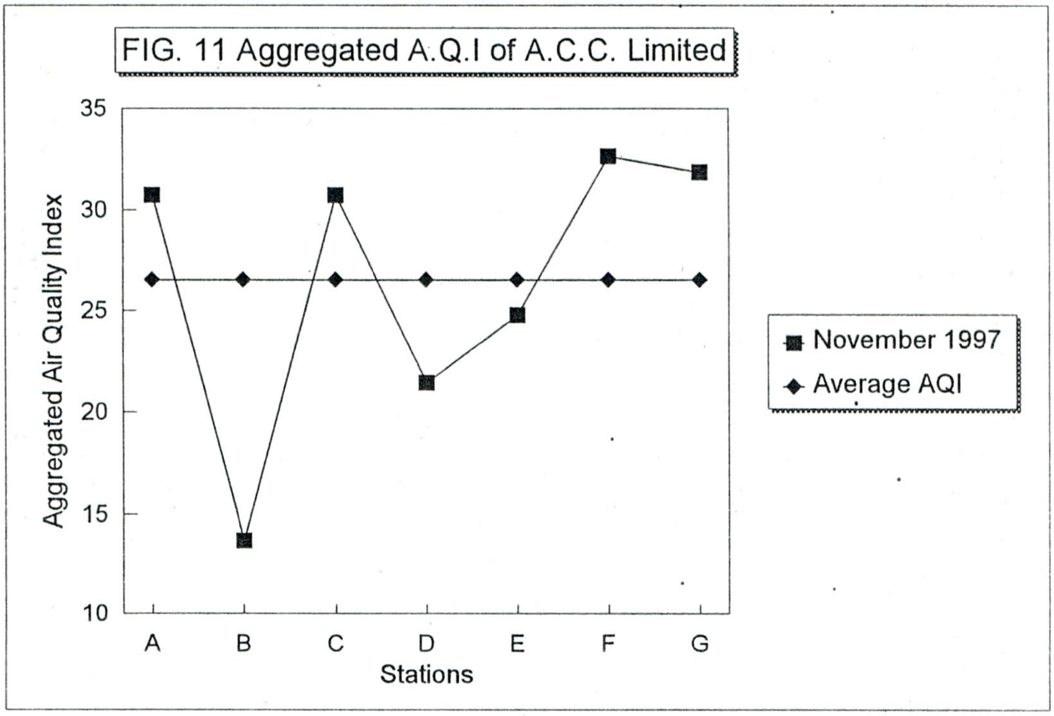


FIG. 11 Aggregated A.Q.I of A.C.C. Limited
Aggregated Air Quality Index
35
30
25
20
15
10
A
B
C
D
E
F
G
Stations
November 1997
Average AQI

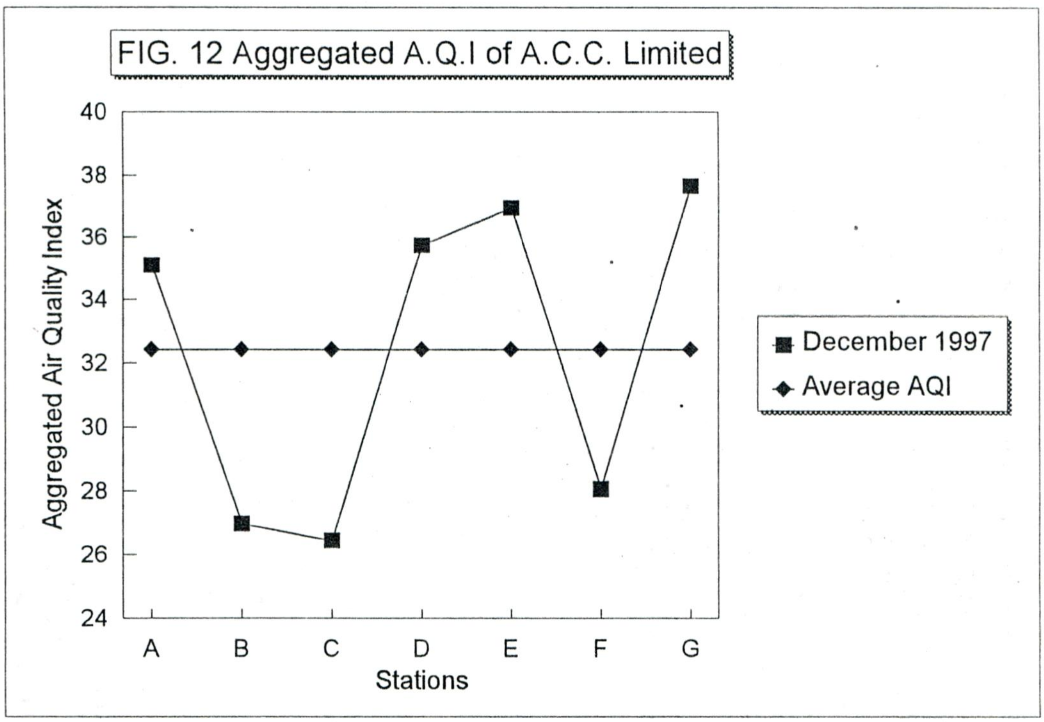


FIG. 12 Aggregated A.Q.I of A.C.C. Limited
Aggregated Air Quality Index
40
38
36
34
32
30
28
26
24
A
B
C
D
E
F
G
Stations
December 1997
Average AQI

comparatively higher pollution levels for the period. Stations B (36.97), C (26.45) and F (28.07) had lesser values than average AQI. However the values for stations B and F were higher than the average value for the station for the period under study, indicating higher levels of pollution for the month (Fig.12). The coefficient of variation for November across station was 14.30.

During December the average AQI was 25.58. Stations C (26.94), D (33.87) and G (36.37), recorded higher values than average AQI. Stations A (18.76), B (21.86), E (25.17) and F (16.10) recorded lower values than average AQI (Fig.13). The coefficient of variation for December was 27.14.

In January the average AQI was 25.95. Stations C (31.86), F (30.89) and G (35.08) reported higher than average AQI values. Stations A(19.86), B(13.69), D (24.79) and E (25.46) recorded lesser than average AQI values (Fig.14). The co-efficient of variation for January was 26.52.

The month wise AQI observations show that station G had constently higher AQI values than the average AQI values in all the months. The higher levels may be due to windward direction of the station clubbed with agricultural activities and voluminous traffic in that region. A sample survey undertaken for a single day showed that an average of 11 vehicles/minute crossed the region (Table VIII) being located in the N.H.- 47.

Station wise comparison for a given station.

For station A, the average AQI for all the six months (August 1997- Jan 1998) was 25.97. The AQI for the station A for August (28.16), October (30.72) and November (35.09), were higher than the average AQI. The AQI for the station

TABLE VIII

SURVEY OF AUTOMOBILE MOVEMENTS

Type of Vehicles	Number of Vehicles				Total
	Time				
	9.A.M. - 10 A.M	11.A.M - 12 NOON	2. P.M - 3 P.M.	4 P.M - 5 P.M	
Scooter / Bike / Moped	247	310	182	201	940
Car/Jeep/Auto	162	203	172	159	696
Tempo/Van/Mini Lorry	74	95	92	79	340
Bus/Lorry	145	190	164	139	638
Trailor	-	18	4	6	28

TABLE IX

ASSESSMENT BASED ON OAK RIDGE AIR QUALITY INDEX (NEERI).

Aggregated Index Value	**Air Quality Category**
<20	Excellent
20-39	Good
40-59	Fair
60-79	Poor
80-99	Bad
100+	Dangerous

FIG. 13 Aggregated A.Q.I of A.C.C. Limited

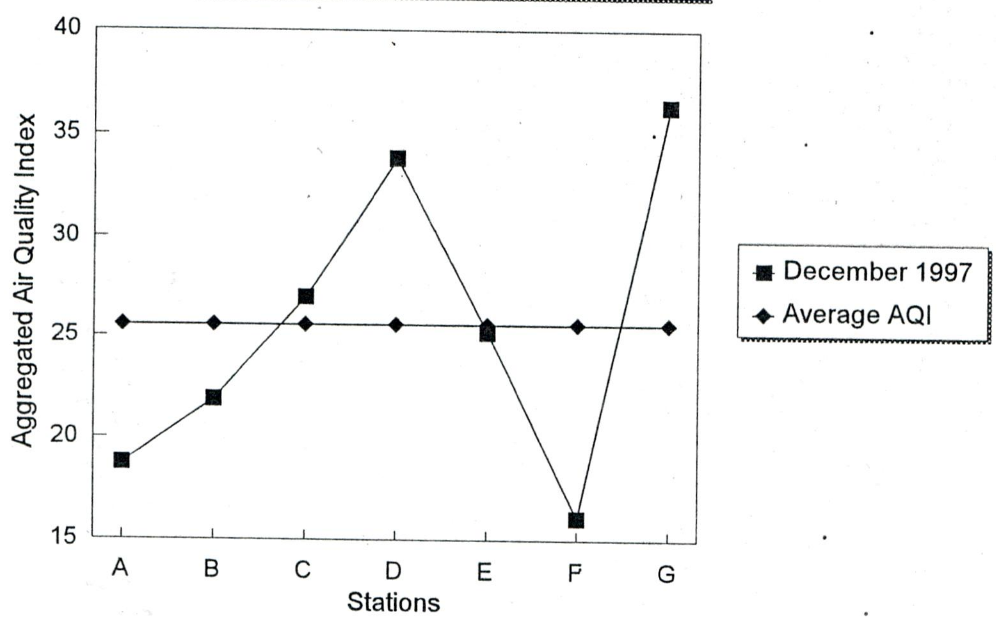
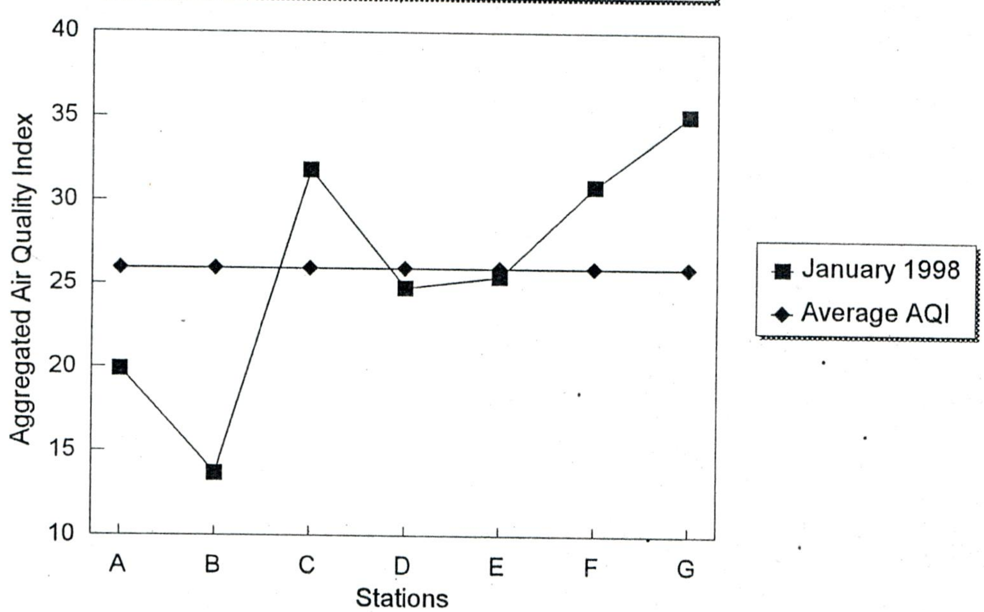


FIG. 14 Aggregated A.Q.I of A.C.C. Limited



for September (23.22), December (18.76) and January (19.86) were lower than the average AQI. The co-efficient of variation was found to be 22.64.

In station B, the average AQI for the station for all the six months (August 1997- January 1998) was 21.94 Which is the least, compared to all the stations. The AQI for August (30.01), September (25.42) and November (36.97) showed higher values than average AQI. The AQI for October (13.69), December (21.86) and January (13.69) showed lesser value than average AQI. The co-efficient of variation for station B was 28.73.

The average AQI for station C was 26.69. The AQI for October (30.72), December (26.94) and January (31.86) was higher than the average. Whereas the AQI for August (22.79) September (21.18) and November (26.45) was lower than the average. The reasons for the AQI for November of this station showing less than average is not clear where as November has been found to be the most polluted month. The co-efficient of variation for this station is found to be 14.28 which is the least co-efficient of variation.

The average AQI for station D was (26.48) the highest for the study period. The AQI for August (31.23), November (35.75) and December (33.87) were higher than the average. The AQI for September (11.84), October (21.44) January (24.79) were below the average. The co-efficient variation was found to be (31.05).

For the station E the AQI for the month of October (24.79) November (36.96), December (25.17) and January (25.46) shown higher. value than the average AQI. The average being 24.74 correspondingly the AQI for August

(22.08) and September (13.99). showed lesser than the average value. The coefficient of variation was found to be 27.24.

At station F average AQI was found to be 25.9022. August (27.28), October (32.65), November (28.07) and January (30.89) showed higher values and September (20.42), December (16.10) showed lower values of AQI than the average AQI. The co-efficient of variation at the station are 22.46.

Station G had the average AQI (35.27). The AQI values of September (36.58), November (37.66), December (36.37) and January (35.08) showed higher and August (34.07) and October (31.86) showed lower AQI than the average AQI.

In November six stations had recorded higher AQI than the average AQI. This may be due to the stable condition of atmosphere during the winter period.

This result is in agreement with the reports of Trivedi and Raj (1992), Priyadarshini **et al.,** (1991) Prusty and Rout (1993) Gupta and Anupvaidya (1994) and Malathi Srinivasan and Sarojini sukumar (1997) according to which high levels of particulates occur during winter months.

Comparison of AQI with standard assessment

The aggregated Air Quality Index Calculated for the seven stations was compared with the standard assessment table (IX) and accordingly categorised.

Station A in the months of December (18.7559) and January (19.8664), station B in the months of October (13.6946) and January (13.6946), station D in the month of September (11.8353) Station E in the month of September (13.9964) and station F in the month of December (16.1034) had AQI less the 20 and they are categorised "excellent". In all the stations for the rest of the months, the aggregated index was in the range of 20-39 and therefore categorised as "good". Thus the air quality prevailing in and around A.C.C. at Madukkarai can be recommended as fit for human existence.

CHAPTER 5

Summary and Conclusion

SUMMARY AND CONCLUSION

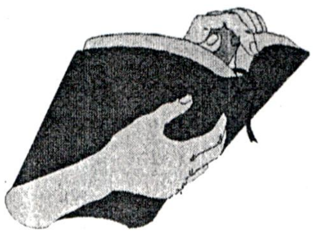
The results obtained from the studies located station G as highly polluted which is at 2000 meters away from the source. The higher level may be due to wind ward direction of the station combined with agricultural activities and the traffic in that region.

November recorded the highest AQI in all the stations. The stagnation of the pollutants near the source is due to the stable condition of the atmosphere during the winter period, may be the reason for this observation.

Although high concentration of pollutants are generally expected in the atmosphere around cement industries, the ambient air at Madukkarai has been found to be harmless with pollutant concentrations within permissible limits.

This may have been due to afforestation and the following control measures taken in the factory. Electrostatic precipitators on stacks attached to kilns, clinker cooler and coal mill. Bag filters are installed on stacks attached to cement mills, cement silos, transfer points and packing plant. Chemical spray arrangement at crushers, water spray system at coal yard and raised curtains at the gantry to suppress the fugitive dust emission. Drill machines are provided with water vaposal system to encourage the wet drilling in order to reduce dust formation & the installation of fly ash handling system with latest pollution control techniques.

An elaborate and intensive study could be undertaken to identify whether the measures undertaken to control air pollution at A.C.C. could be identified as a role model and replicated in other areas.



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