AIR POLLUTION AND OCCUPATIONAL DISEASES IN THE CEMENT FACTORY AT WALAYAR

By

MANJUSHA K. GOPAL

Reg. No. 95 PLS 06

A THESIS 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 LIFE SCIENCES

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CERTIFIED AS BONAFIDE RESEARCH WORK

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Faculty

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the Guide

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Contents

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

INTRODUCTION

Environmental management is relatively a new concept which has evolved partly in response to problems of unbalanced economic development and in particular of the pollution which has resulted due to unregulated industrialization & urbanisation. Establishment of new industries and factories have resulted in widespread pollution especially pollution of air over cities and industrial areas.

Air pollution is defined as the presence in the out door atmosphere of one or more contaminants such as dust, fume, gas, mist, odour, smoke or vapours in quantities of characteristics and of duration such as to be injurious to property or to interfere unreasonably with the comfortable enjoyment of life and property (Varadarajan and Subramanian, 1993). The term air pollution is capable of two interpretation,. To the public at large it means probably the limitation or prohibition of emissions by force of law. Inherent in this interpretation is the determination of which substances should be limited, which requires determination of the effects of each substance on health damage to property and aesthetic values.

The prime sources of air pollution are industries power plants, smelters, mines and refineries and automobiles. Gaseous or particulate by products of manufacturing process, products of fuel burnt for energy, chemicals used in warfare and accidental leakages get into atmosphere. According to an estimate currently approximately more than 200 million tons of carbonmonoxide, 146 million tons of sulphur dioxide and 53 million tons of nitric oxides are discharged into the atmosphere each year (Saxena, 1990). The major pollutants of air include oxides of carbon, sulphur and nitrogen, hydrocarbons, particulate matter and photochemical smog. The particulate matter is usually soot and dust. Usually the particles tend to settle out of the air and land on trees, buildings and houses.

Among the industries, cement industry is one of the main factors causing air pollution. The major type of pollutants from cement factory is cement dust which makes up the particulate matter and oxides of sulphur and nitrogen. Cement dust is chemically a mixture of oxides of calcium, potassium, aluminium, silica and sodium which sets into a hardness when in contact with water (Air Pollution Control, Part III)

Cement is manufactured from a suitable mixture of limestone and clay which are crushed first and then ground either in the dry state or with water. The raw mixture is thereafter burnt at a sintering temperature and the clinter thus obtained is ground to a fine powder with the addition of gypsum, to give cement. Cement is then packed in jute bags and despatched in this form.Thus by the very nature of the processing of cement, there is considerable generation of dust which needs to be contained at all stages.

The size of these dust particles is very small ranging from as low as 1u to as high as 100u above. The concentration of airborne dust was found to be higher in areas of limestone crushing plants, cement packing machines., loading centres and at coal grinding areas whereas it was low around the kiln firing end, clinker cooler and cement mills and the concentration varies with factors such as material input, standards of plant maintenance, limitations in accuracy of measurement etc.

The particulate matter from the cement industries are found to have effects on plants and animals. Investigations have shown the effect of particulate matter on animals and plants. The other pollutants like sulphur dioxide and oxides of nitrogen are also found to have its own effects on the environment.

As already stated the particulate matter in cement industry mainly consists of cement dust. Coal is an important raw material in cement industry used for burning process. The burning of coal produces oxides of sulphur and nitrogen.

These pollute the atmosphere by producing acid rain and carbon smog.

Air pollution is one of the greatest environmental evils. Breathing air has not only life-supporting properties but also life damaging properties. Under ideal condition the inhaled air has a qualitative and quantitative balance that maintain the well being of man. But when the balance among the air components is disturbed or in other words, if it is polluted, it may affect human health.

In general susceptibility to the effects of air pollution is great among infants, the elderly and the infirm. An objectionable odour, visibility reduction, eye irritation or vegetation damage are useful guides to the likelihood or severity of health effects.

Numerous studies have observed health effects of particulate air pollution and have shown that particulate air pollution is an important contributing factor to respiratory disease. Observed health effects include increased respiratory symptoms, decreased lung function, increased hospitalizations and other health care visits for respiratory and cardiovascular disease, increased respiratory morbidity and increased cardiopulmonary disease mortality (Pope, Bates and Raizenne, 1995).

The suspended particulate matter are of different sizes and shapes. The particles of importance in air pollution are those with a size between 0.1 - 10 um. It is only the particles within this size range which remain suspended in the atmosphere, whereas particles larger than this size settle down.

The human body has got its own mechanism for the removal of the particulate matter from the body. Large particles of size 10 micro meters entering the respiratory system are trapped by the hairs and lining of the nose. These trapped particles are removed when we cough or sneeze.Smaller particles are trapped by the mucous and removed. Only particles of the size 2-4 um enter the lungs. The delicate walls of the air sacs do not have any protective mucus and cilia. The air sacs are thus easily damaged by polluted air that reaches them.

Exposure to heavy dust concentration, without any control measures may produce several diseases, chief among them being pneumoconicsis. Silicosis is an important form of this disease caused by inhalation of dust containing crystalline silica.

SO_2 is the most important air pollutant throughout the world due to its serious involvement in causing respiratory tract diseases, extensive and lasting damage to vegetation and to form secondary pollutants in the air like sulphuric acid when it reacts with water. SO_2 is the best known and most widespread man-made pollutant. Sulphur dioxide is produced in cement factories during the burning of coal because of the impurities of sulphur in coal. Sulphur dioxide has been recognised as a major air pollutant in India (Yenwar et al., 1970 ; Kumar and Sharma, 1981).

Sulphur dioxide is an irritant which affects the mucous membrane when inhaled. Sulphur dioxide under environmental conditions can get oxidised to SO_3 and in presence of water vapour or water, SO_2 and SO_3 is a strong irritant and when inhaled can cause severe bronchospasms at relatively lower levels.

The main damage to inert materials due to air pollution is due to corrosion caused by acidic compounds in the atmosphere. The most important acid forming pollutant being SO_2 released during the combustion of sulphur burning fuels. In presence of oxygen the SO_2 slowly gets converted to SO_3 and sulphuric acid. Deposition of this acid on metal parts, building roofs and other metallic equipment results in corrosion.

Air pollution is also posing a great threat to the vegetation in and around the factories and also in urban cities. Industrial dust is a mixture of organic and inorganic chemicals which damage the leaves. Plant needs elements for their healthy growth. The essential elements such as carbon, hydrogen, oxygen, phosphorus, potassium, nitrogen, sulphur, calcium, iron, magnesium and trace elements are needed for better growth of plants. Any soil which lack these nutrients will lead to nutritional deficiency caused due to environmental pollution or environmental degradation. Deposition of airborne cations and anions causes environmental pollution leading to soil pollution. Among these dust particles, cement dust is the major one for soil pollution.

Cement dust is reported to be harmful to vegetation, causing considerable reduction in agricultural production, primarily affecting fertilization and starch production. The dust falling on the leaves may cause foliar injuries, reduction in yield etc. Cement kiln dust is also found to be affecting the yield of agricultural products.

Plant growth is the outcome of many factors among which pollutants must clearly be counted. Atmospheric pollutants bring about various changes in plants and many reports are available on this subject. Work have been carried out by several workers to find out the effect of pollutants in plants and the effect of pollutants in plant growth. Many plant species are found to be easily attacked by the pollutants and these are easily attacked by the pollutants and these are easily destroyed whereas several other species of plants are tolerant to dust particles and SO_2. The easily detroyed plant species can be considered as indicators of pollution. The plants which are tolerant to pollutants can be considered as pollution resistant and they can also be used to control air pollution. Such plants can be planted along the industries to form a green belt. Green belts are often recommended for controlling air pollution in urban industrial areas (Sagar, 1996). The term green belt refers to a patch of vegetation trees, shrubs and herbs around an industrial environment which helps to check and monitor air pollution. Plants by large, absorb low levels of air pollutants from the atmosphere. Plants even act as scavenger. Green belt can be treated as oxygen producing zones amidst industrial environment, thus checking the imbalances.

Many methods are involved in the measurement of air pollution. Air pollution monitoring is a vast discipline and considerable advances are being made in this field. The most standard methods for air monitoring is available in the methods of air Sampling and Analyses (APHA), intersociety committee American Public Health Association. Suspended particulate matter (SPIT) can be monitored by using high volume sampler. Concentration of sulphur dioxide can be measured by using impingers containing hydrogen per oxide which results in the formation of sulphuric acid. The resulting sulphuric acid is titrated using specific solution and from the titre values the concentration of SO_2 is calculated.

Among the most complex problems to be faced by industry during the remaining of this century are the proper control and use of the natural environment. It is practically impossible to treat the polluted air to make it free from contaminants, therefore, pollutants are to be controlled right at the place of their origin or emission. Air pollution abatement is possible through improving the quality of emission from industrial stacks and exhaust pipes of vehicles.

Although most of the pollution control equipments used in industries are not cent per cent efficient in removing the contaminants, yet modern research and development in this field has made it possible to significantly reduce emission level. Many equipments like electrostatic precipitator (E.S.P) fabric fitter, wet scrubber & cyclone filter are used for controlling particulate air pollution.

For the removal of obnoxious gases equipment like vapour conservators, after burners and devices involving absorbtion and condensation are used. Dolamite lime and limestone are placed in the path of gas flow so that contaminants like SO_2 are precipitated. Charcoal is often used as a good absorbent for certain compounds.

Other important methods of controlling air pollution is to plant green trees along the industrial area because plants act as dust collectors & absorber of some pollutants. Planning of industry away from human inhabitation and provision of tall chimneys also regulate pollution. Regular monitoring of air quality over industrial areas is equally important in pollution abatement strategy.

The main objective of the present studies are:

1. to detect the source of air pollution in the cement factory at Walayar
2. to calculate the extent of air pollution caused by the factory.
3. to determine the hazardous effect of cement dust on the water.
4. to adopt various control measures for air pollution and
5. to create an eco friendly industrial area by planning pollutant resistant plants.

Review of Literature

REVIEW OF LITERATURE

Short term air quality survey in four major cities in India at Calcutta, Bombay, Delhi and Kanpur was conducted by Yenwar et al., (1970). Zutshi et al., (1973) conducted an air pollution assessment in Bombay. A sensitive instrument based on coloumetry for the continuous monitoring of SO_2 was developed by Nair et al., (1981).

Sharma and Sharma (1982) carried out a study on the atmospheric contamination of archaeological monuments in the Agra region. The annual average existing level of SO_2 ranges from 16 to 20 micrograms/m^3. The seasonal distribution of SO_2 and SPM in the air at Taj Mahal, Red fort and Sikandra have been studied. It has been observed that there is substantial SO_2 contamination existing in Agra.

Simpon et al., (1985) studied the relationship between air pollution and windspeed data by using the ATDL mode of Giffordad Hanna. His results demonstrated, why the ATDL model often works between air pollution data and wind speed collected at different sites.

Ambient air quality monitoring studies were undertaken at Vishakapatanam by Mudri, et al., (1986). Being a major port, industrial developments have taken place here. The parameters considered were SPM, SO_2, NO_2, sulphation rate and dust fall.

A study of air quality at Kanpur was done by Gupta et al., (1987) Pachma et al., (1987) demonstrated that cement kiln dust released into the atmosphere, along with smoke contains several heavy metals.

With reference to cement dust pollution at Kymore a work was undertaken by Sasi et al., (1987). The effect of cement dust on biotic and abiotic components of the ecosystem were combined into an index of peralization measuring the net damage to the total system at any given place along the pollution gradient. This was found to be convenient.

A 3 stage dust measuring instrument was presented by Vekeny (1988), which was particularly used in mining industry. The instrument was capable of measuring concentration of dust particles upto 0.1 mg/m^3 deposited in lower respiratory duct.

Zaferigbal (1988) studied deposition of air borne cations and anions in the vicinity of a polluted area. Among these dust particles cement dust was the major one for soil pollution.

Sadasivan and Negi (1990) carried out frequency distribution of total suspended particulate matter SPM and trace elements in air.

Joshi et al., (1991) studied a few measurements on ambient air pollutants of Udaipur city. They studied the concentration of sulphur dioxide to their respective sulphates, nitrates, etc. Future directions in photochemical air quality modelling were done by Russel and odman (1991).

Ambient air quality monitoring for SPM, SO_2 & NO_x were assessed for a period of one year in coal mining areas of Raniganj coal fields by Gurdeep et al., (1992) to study diurnal, seasonal variations and spatial distribution of pollutants. Dust fall rate measurements were carried out for a period of one month for each season.

Berndtsson (1993) carried out a work on the spatial patterns of bulk atmospheric deposition. The work was carried out as factors like type of source, type of pollutants and meteorological conditions.

Joshi et al., (1993) carried out air quality monitoring at Indore city with special reference to SO_2 and tree bark pH. Ambient SO_2 concentration were computed on the basis of sulphation rate at 12 sampling stations for successive three years.

Studies on cement dust pollution have been studied in Baghwar region of Rewa (Madhya Pradesh) by Mishra et al., (1993). Assessment have been made on dust deposition, soil characters etc. Samples were collected from each four directions at every 100 mts. distance upto one km.

Ambient air quality of Shimla town with reference to suspended particulate matter was carried out by Gupta and Vidya (1994). Air borne suspended particulate matter were measured using high volume sampler in which air was drawn into a covered housing and through a high efficiency glass micro fibre filter paper. The mass concentration (ug/m^3) of SPM in the ambient air was computed by measuring the mass of collected particulates, volume of air sampled.

Kannan et al., (1994) worked on the extent of pollution by studying the air borne mycoflora as a tool for pollution studies. The presence of mycoflora in the environment is an indication of the extent of atmospheric pollution. The study was carried out at certain areas in Tamil Nadu.

Characterisation of trace elements in suspended particulate matter was done by Wachasunder et al., (1995) by instrumental neutron activation analysis. According to them SPM is an extensively used for parameter for determining the air quality.

Dash and Panda (1996), conducted ambient air quality monitoring around the refractory as Belpabar.

Ambient air quality in Madras city was carried out by Krishnamohan and Muthukrishnan (1996). Sampling was carried out in different areas like industrial areas, residential areas.

Effect of dust on vegetation

Edward (1972) reported that toxic gaseous pollutants are capable of reducing productivity of grain crops. Rao (1972) reports that gaseous pollutants can reduce productivity of fruit trees. Stern (1973) reported that SO_2 and NO_2 are universally occuring pollutants as they are the important constituents of industrial emission and these SO_2 and NO_2 even in lower concentration is toxic to vegetation.

Effect of dust on photosynthesis especially, cement dust, coal dust on the photosynthesis of Picea abies was conducted by Auclair (1976). In his experiment he covered the plants with cement and coal dust and keptsome as control. The different parameters analysed were photosynthesis and transpiration.

Klincsek (1976) conducted a study on the effect of cement dust on seven common trees, shrubs around a cement factory at Hungary.

Effect of cement dust on soil properties and wheat plants were carried out by Singh and Roa (1978).

A case study was conducted by Zutshi *et al* ., (1978) on SO_2, other pollutants in air and in rain water.

The effect of industrial air pollution on the health of a forest plantation in the Carpathian foothills was assessed by Voron (1979). The effects were studied on the emissions from (a) potash factory (b) activated carbon factory and (c) cement factory.

Bechulal and Ambasht (1980) carried out a work on the effect of cement dust pollution on plants of *Psidium guajava* around the Churk cement factory in Mirzapur (UP).

Studies on the effect of SO_2 on protein SH in needles of *Picea abies* were done by Grill *et al*., (1980).

Heath (1980) conducted a survey on the injury to plants by air pollutants. Last (1982) also found the same effects on his experiment on the effect of atmospheric sulphur compounds on natural, man made terrestrial and aquatic ecosystems.

Puri *et al* .,(1982) conducted a survey on the effect of cement kiln dust on Sal (*Shorea robusta)* forest around a cement factory in Himachal Pradesh.

Ninova and Gancheva (1984) conducted a study on morphological and anatomical changes in plants under the influence of pollution from cement production. Studies were made on leaf morphology and anatomy of Prunus domestica, Betula alba, Spiraea vanhouttei and Syringa vulgaris in Bulgaria.

Khosla and Puri (1984) conducted a work on the effect of cement kiln dust on soil nutrients of Sal (Shorea robusta) forest ecosystem.

Effect of air pollution on leaf epidermis and architecture of Lycopersican lycopersicum was carried out by Chandari et al., (1984). The work describes leaf architecture and light, scanning electron microscope (SEM) study of leaf epidermis in plants from polluted and apparently non-polluted environments.

Voron (1984) conducted an experiment on the pollution of grey forest soils with alkali and alkaline earth metals in an area affected by cement dust pollution.

A relationship between agricultural ammonia emissions and the atmospheric SO_2 content over industrial area in GDR was carried out by Moller and Schieferdecker (1985).

Studies of the effect of cement dust on woody vegetation was found by Voron (1986). Agrawal et al., (1987) conducted a survey on the effect of SO2 and quinalphes singly and in combination on the metabolic functions and growth of *Oryza sativa*.

The effect of SO2, Ekalux and SO2 Ekalux on chlorophyll and carotenoid pigments of *Oryza sativa* were investigated by Agrawal *et al*., (1987).

A comparative study of dust fall on the leaves in high pollution and low pollution area of Ahmedabad causing foliary injury was done by Vora and Bhatnagar, (1987).

Braniewski and Chrzanawska (1988) carried out a work on the effect of dusts from electro filters of different industrial works on the vegetation.

Studies by Pandey and Sinbahk (1989) have showed that cement kiln dust have an effect on crop yield, morphological, anatomical and biochemical changes in plants especially in gram leaves.

Kartesharju and Kartesharju, (1989) conducted a work on epiphytic lichens and pine bark in the vicinity of a cement plant in northern Finland. The chemical content of Pine bark and Bryoria lichens were analysed.

Tripathi, *et al*., (1990) carried out a work on the studies on tissue permeability of rice and bean plants to air pollutants.

Pane and Zamora (1991) studied on leaf epidermal features of 4 Phillipine plants as indicators of cement dust pollution. Leaves of *Bougainvillea spectabilis, Hibiscus rosasinensis*, mango and guava were sampled from the vicinity of 3 cement factories. The parameters studied were stomatal density, stomatal size, trichome density and trichome length.

Effect of cement kiln dust on *Cajanus cajan* was assessed by Prasad *et al*., (1991). Prasad and Inamdar (1991) showed the effect of cement kiln dust on the growth and yield of *Vigna* species.

Bansal *et al*., (1991) carried out an experiment on the phytotoxicological response of *Ficus religiosa* to SO2 exposures". Healthy one year old saplings of *F. religiosa* were exposed to different concentration of SO2 for 4 hours every day for three months, to observe their morphological and biological chemical responses.

An experiment on the effect of cement kiln dust deposit on the flora present in the vicinity of a cement factory was conducted by Gunamani *et al*., (1991). Another study on the effect of cement kiln dust in timber yielding plants was carried out by Gunamani and Arjunan (1991).

A study on the response of soils of agro-ecosystem to coal dust pollution was done by Pandey *et al*., (1992). The study was carried out in Dhanbad of Bihar especially in the Jharia coal field to know the responses of physical and chemical parameter of soil agro ecosystem to coal dust pollution. The texture, bulk density, water holding capacity, organic carbon total nitrogen carbon nitrogen ratio and pH were determined. Impact of coal dust pollution on biomass, chlorophyll nutrients and grain characteristics of wheat was done by Pandey et al., (1991).

Impact of coal dust pollution on the biomas, chlorophyll nutrients and grain characteristics of wheat were studied by Pandey et al., (1992). Impact of the Kunda cement plant emission on the distribution of epiphytic lichens were studied by Martin. and Nilson (1992). Effect of cement dust on the condition of woody plants was carried out by Gigauri et al., (1992). The effect of prolonged emission of cement dust from the Kunda plant in NE Estonia on chlorophyll and carotenoid contents was studied on Picea abies and Pinus sylvestris needles (Mandre et al., (1992).

Bawal (1993) conducted a work on the effects of SO_2 in tomato by isolating certain enzymes from diseased tissues of tomato infected by Alternaria alternata exposed to SO_2. The physical and chemical characteristics of a range of dust types on vegetation was done by Farmer (1993). Changes in the macro and micro element content and pH of gleyed sandy podozols and in the species composition of the forest floor under the influence of emission from a cement plant in Northern Estonia was assessed by Annuka (1994).

Ignacimuthu and Muraleytharan (1994) studied on the effect of cement kiln dust on root top cells of *Allium cepa*. Effect of air pollution on some bund trees of the agricultural lands were assessed by Krishnamurthy *et al*., (1994). Mandre *et al*., (1994) studied on the response reaction of conifers to alkaline dust pollution from a cement factory in N.E. Estonia.

Effect of cement pollution on soil fertility was carried out by Sivakumar and Britto (1995). Rath *et al*., (1996) studied on the effect of SO_2 on Bell pepper. A work was carried out around the refractory at Belpahar by Dash and Antarjyamipanda (1996) on the effect of the refractory on vegetation.

Cytotoxicity of cement kiln dust on the mitosis of root tip cells in *Vicia faba* was studied by Kaushik (1996).

Effect of dust on animals:

Sulphur dioxide is found to be one of the harmful pollutants. It causes a lot of harmful effects in animals (Snodderly, 1974).

Oleru (1984) conducted a study on the pulmonary function and symptoms of Nigerian workers exposed to cement dust. The pulmonary and non-pulmonary effects of cement dust exposure in 52 randomly selected directly exposed cement workers and 24 maintenance workers were investigated. Hackney et al., (1984) conducted a work on the assessment of health effects of air pollution. Emphasis was done on respiratory irritation, common in ambient air, specially photochemical oxidants and SO_2. A work was done in estimating the heavy metals in excreted urine of cement. workers by Tandan et al., (1984). A survey has shown enhanced urinary excretions of Mn, Cr, Pb in majority of cement workers and on enhanced urinary excretion of cadmium, in those involved in profession for over 10 years.

Influenza virus infection in mice after exposure to coal dust and diesel engine emissions were conducted by Mohan et al., (1985). Graham and Miller (1985) studied on the inhalation studies of Mt.St. Helens volcanic ash in animals and its potential interaction with SO2. The effects of inhalation exposure of mice to volcanic ash were assessed. Grose and Grady (1985) carried out another experiment on the effect of volcanic ash of Mt.St. Helens on rats.

Synergestic effect of coal dust and diesel emission on various properties of alveolar macrophagaes were investigated by Castranova et al., (1985). Bulankova (1988) studied on the effect of emissions from cement works on the structure of the community of Nabidae (Heteroptera). In connection with research on the productivity of insect communities in woodland ecosystems in Czechoslovakia, the effects of emissions from a cement plant was studied.

Studies on fugitive dust emissions from stone crushers were assessed by Aslam et al., (1992). Exposure to heavy dust concentration as is obtained in stone crushers may produce several diseases.

Bagchi (1992) conducted an experiment on knowing the reason for toxicity of silica. Pope et al., (1995) identified the health effects of particulate air pollution. The studies are to understand the health effects of pollution at levels common to contemporary cities. Epidemiologic studies on short term effects of low levels of major ambient air pollution components was studied by Brunekreef et al., (1995).

The effects of air pollution on children was studied by Bates (1995). Air pollutants have been documented to be associated with a wide variety of adverse health impacts in children. Brauer et al., (1995) conducted a work on the measurement of acidic aerosol species in Eastern

Europe identification of casual constituents of inhalable particulate matter has been elusive.

A paper on epidemologic evidence regarding health effects of poor air quality in central and Eastern Europe was done by Jedrey (1995).

Air pollution control

Pasternak (1981) suggested that forests can be used as a means of environmental protection. The forests can capture various obnoxious gases and also filter many dust particles and thus act as a environmental protecting agency.

A study was made on the causes, effects, main sources and control of air pollution in Singapore (Linn, 1984). Control of these emissions was necessary to protect the future generation. Installation of appropriate cosntrol equipment, proper situation of facatories, inspection of source emission tests were some of the precautionary steps diagonised.

Reduction of sulphur compounds that emit, SO2, the main pollutant can be accomplished by two methods 1) by using DCDA proces which could bring down the SO_2 emission to about 300 - 500 ppm and by absorbing the tail gases in a aqueous solution. One of the most widely known process for controlling SO_2 is scrubbing with ammonia (Manthapurwar et al., (1987).

Jain (1993) carried out a study on the main methods of air pollution control in India. Studies at the University of California at Berkeley in the U.S. have developed a method that cuts 1/10th the cost of cleaning up NO_2 produced when fossil fuels are burned. The new technique is also environmentally less harmful than the techniques currently used by power plants and fossil fuels intensive industries .

The aim of pollution control when dealing with air pollutants is to keep the level of pollutants below the absorptive capacity of the environment. The criteria used in selecting the appropriate policy instruments are efficiency, acceptability, equity and flexibility. Based on these criteria the author is of the view that marketable pollution permits stand well above other policy instruments in controlling industrial air pollution in both developed and developing countries (Sathiendrakumar, 1995).

Methodology

MATERIAL AND METHODS

The present work on air pollution and occupational hazards were carried out at Malabar Cements Limited which is a public sector company, owned by the Government of Kerala. Malabar Cements Limited is located in Walayar, the boundary between Kerala and Tamil Nadu (Fig.1). It is located nearly 23 Km away from Coimbatore City. The cement manufacturing plant is situated 5000 mts away from the National Highway (NH 47) and the mine is 10 Kms away from NH47. Since the plant is situated in the boundary, it can pose threat to both the states, Kerala and Tamil Nadu.

The parameters involved in the study are:

(a) **Physical Parameters**

i) Concentration of suspended particulate matter (SPM) in the different stacks.

ii) Concentration of sulphur dioxide (SO_2) in the stacks.

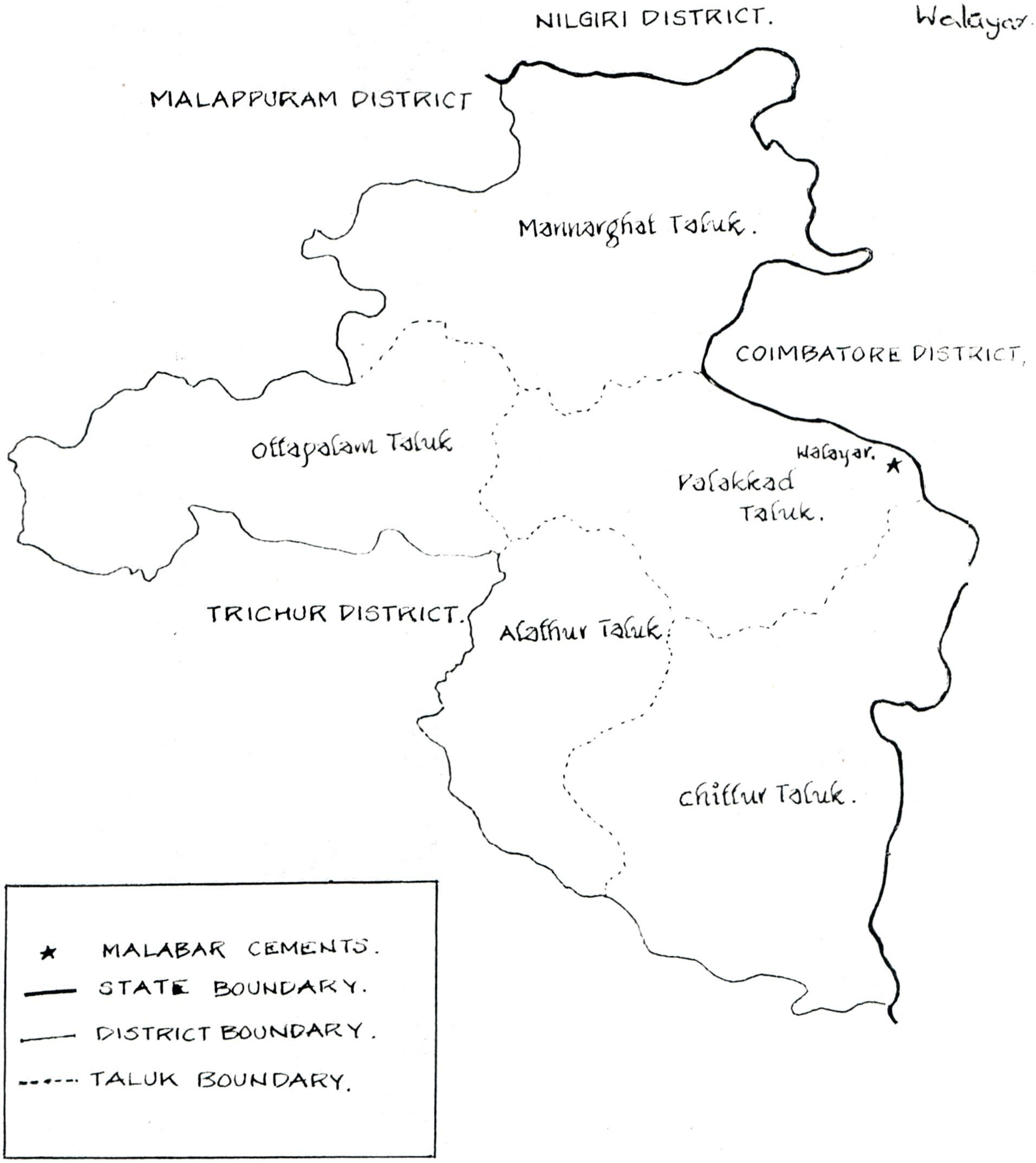
iii) Concentration of suspended particulate in different locations around the cement plant.

iv) Effect of cement dust on male workers of the age group 30 to 50.

v) To identify pollution resistant plants for distribution to the cement factory.

Figure 1

Map showing the location of Malabar Cements, Walayar.



Malabar Cements Ltd. has adopted modern cement processing technology. This is a dry process cement plant (Fig.2) Limestone, the principal raw material, is mined mechanically from the captive mine at Pandarathu in the Walayar hills, about 10 Km from the plant. Material is crushed in two stage crushing system at the mines and is conveyed to the plant site by a 6.2 Km monocable aerial ropeway. In the plant, limestone is blended with additives (laterite) and is ground in closed circuit raw mill. The raw meal thus prepared is blended in huge blending silos and fed to a four stage cyclone preheater kiln system. Raw meal is burnt into clinker in a coal fired roatary kiln and is cooled down ingrate cooler - clinker thus produced is ground along with gypsum and thus cement is produced.

The cement is stored in cement silos having capacity of 4500 tonnes each (2 Nos). The cement is then packed using spout rotary packer and a set of conveyors to transport the bag from packer to trucks. Plant is centrally controlled with programmable logic control. Electrostatic precipitators (ESPS) and bag filters are installed to arrest dust emission.

The company has adopted dry process with suspension preheater system for cement manufacture. Therefore, there is no industrial liquid effluent from the plant. The exhaust is dust-laden air pumped in the system for combustion as well as for pneumatic conveying/classification of finely powdered materials. There are 11 exhaust points through which dust laden air is vented to the atmosphere. At each point pollution control equipments has been installed. They are

Stock No.	Location	Equipment installed
1	Raw mill	Electrostatic precipitator(ESP)
	Clinkerisation	
2	(a) Kiln	ESP
3	(b) Kiln-feed	Bag filter
4	(c) Blending and storage silo I	Bag filter
5	(d) Blending and storage silo II	Bag filter
6	(e) Cooler	Multicyclone
7	Coal mill	Bag filter
8	Cement mill	ESP
	Packing	
9	(a) Storage silo	Bag filter
10	(b) Packer I	Bag filter
11	(c) Packer II	Bag filter

Description of the various pollution control equipments

(1) Electrosatic preciciptator (ESP) (Fig 3)

The main parts of an ESP are

(a) ESP casing
(b) Emitting electrode system
(c) Collecting electrode System
(d) Gas distribution Screen
(e) Emitting Rapping System
(f) Collection Rapping System
(g) Gas distribution Screen Rapping.

The ESP consists of an outside steel casing, enclosing alternate rows of collecting plate electrodes and high voltage emitting electrodes. The casing and the collecting electrodes are kept at ground potential by being permanently connected to the ground and supporting steel frame work. The emitting electrodes frame work is suspended inside through insulators which is negatively charged at around 60KV. The great difference in voltage between the collecting and emitting electrodes set up a powerful electric field between them.

As the dust laden gas passes between rows of collecting plataes and emitting electrodes high unidirectional voltage applied between these electrodes induces ionization of the gas molecules adjacent to the high voltage emitting electrodes. The positive ions migrate towards the emitting electrodes and the negative electrodes and ions towards the collecting electrodes.

On their way to the collecting electrodes these negative electrons, and ions further charge the dust particles and the high voltage electrical field between the electrodes cause the particles to move towards the collecting electrodes, where they get departed and lose their charge. The deposit is periodically rapped off the electrodes using rapping mechanism, and the dust is collected in the bottom hopper which is removed using a set of rotary air lock and screw conveyors.

The ESP being an electric device, the efficiency depends on the power input i.e. the amount of voltage and current that is usefully employed for the collection of the dust.

Gas conditioning tower (GCT) (Fig.4)

The main parats of GCT are

a) GCT shell with hopper

b) The spray lance system

c) High pressure pump with auxiliaries

The kiln exhaust gas enters at the top where water is sprayed by means of return water type nozzles. The water is pressurised by a feed pump and after passing through the nozzles is atomised, which when comes in contact with the hot gas is vapourised,. Usually the temperature of the conditioned gas at the outlet of the GCT is kept between 155|C - 200|C depending on the process requirements.

Cyclone separators

The simple cyclone collector consists of the following parts (Fig.5)

a) Cylinder with a tangential inlet and

b) Inverted cone attached to the base

Gas enters the cyclone through the tangential inlet, which imparts a whirling motion of the gas. Suspended particles are thrown toward the wall on which they collect and slide down into the conical collector. Near the bottom of the cone, the gas turns abruptly upward and forms an inner spiral, which leaves through the pipe or duct extending into the center of the cyclone body. In a multicyclone, a large number of cyclones are arranged parallely with a single header and a single dust hopper. The individual cylinder diameter varies from 6 to 24 inches. Thus, the advantage of the short path for the "settling" particle, inherent in cyclones of small diameter is provided with a single unit.

Bag filter

The main parts of the bag filter are (Figure 6)

a) Filter casing with hopper

b) Filter bags with cages

c) Pulse valves and nozzle pipes.

The dust laden gas is admitted through the inlet branch where the coarsest particles are separated out and dropped down into the dust hopper. The gas flows through the distribution arrangement and is directed onto the bags. The gas is drawn through the filter material and the fine dust is collected onto the outside of the bags. Heavier particles fall directly into the hopper. The clean gas flows through the inside of the filter bags to the outlet.

The dust deposit on the outside of the filter bags is removed by means of compressed air which is admitted as short pulses into the bags. The pressure pulse cause the filter materials to stretch quickly and then immediately regains its original shape. The dust deposit thus falls off the surface of the bags and drops into the hopper.

The bags are grouped in rows with one pulse valve and one nozzle pipe for each row. The pulse valve is a solenoid operated diaphram valve which admits compressed air into the nozzle pipes during purging (cleaning). The compressed air is drawn from a receiver on the side of the nozzle housing. The holes of the nozzle pipe are located above the mouth of the filter bags.

The control unit opens and closes the solenoid valves in accordance with a programmed pattern.

The main aim of the study is to calculate the concentration of suspended particulate matter (SPM) from the 11 stacks equipped with the control equipments.

Estimation of suspended particulate matter (SPM)

Suspended particulate matter (SPM) was monitored using stack monitoring kit. It is designed to measure the total volumetric discharge of particulate matter and gaseous pollutants from the stacks (Fig.7). It takes accurate iso-kinetic samples of the effluents in the emissions from the chemical and combustion process.

Principle of operation

The purpose of stack monitoring (also called source monitoring) is to extract from the stack a sample that is representative of emissions from that source during a time period in which the process is under a desired operating condition. The scope of stack monitoring involves

a) Determination of stack gas velocity and volumetric flow rate.

b) Determination of moisture content in stack gases

c) Determination of particulate matter in stack gas

d) Determination of gaseous pollutants such as SO_2, SO_3, Nox etc.

Description of the apparatus

The stack monitoring kit consists of control module, dry gas meter module, impinger module with standard glass ware set, probe assembly with hoses and pump.

Calculation of suspended particulate matter (SPM) and Sulphur dioxide (SO_2)

Concentration of suspended particulate matter was monitored from all the eleven stacks. Estimation of sulphur dioxide was also calculated from stack no.2 and 7. Emission of sulphur dioxide (SO_2) from stack No.2 is because of the burning of the raw materials which contain sulphur content. Stack No.8 (coal mill) emits SO_2 because of the burning of coal. Coal contains large amounts of sulphur and during burning causes the emission of sulphur dioxide.

Selection of sampling site:

Emission testing is based on the assumption that the sample obtained at a given point is representative of the concentration at that point. For this good sampling site is selected in the stacks.

Procedure

a. Determination of stack gas velocity and volumetric flow rate (Type S Pitot tube)

The average gas velocity in a stack was determined from the gas density and from measurement of average velocity head with a type S pilot tube.

Air was blown through the pitot impact opening until at 1 inch of velocity pressure was registered on the manometer. The impact opening was then closed off. The same method was adopted for the static pressure side.The manometer was then levelled to zero. The velocity head on the inclined manometer was then measured. The atmospheric pressure was also measured using a barometer.

b. Determination of moisture in gas stream:

For determination of moisture, the condenser method was applied, which involves extracting a sample of the stack gases through a filter for the removal of the particulate matter, then through a condenser, accumulating the condensate formed in process and finally through a gas meter.

c. Determination of temperature:

For determination of temperature, the thermocouple was connected to the pilot tube and was then connected to the control module. The thermo couple was inserted into the test part of sampling site. The main switch was put 'ON' and the temperature value was read out in a 3 digit liquid crystal display system.

d. Determination of pressure

For determination of pressure, the inclined manometer was used and the pilot tube was inserted into the test part the manometer reading noted (Fig. 8)

e. Filter holder assembly

Small thimble assembly used for glass fibre thimble of 19mm OD is used. The thimble was placed appropriately on the outer taper ring and was brought upto the open end. Now the thimble along with the outer ring was put on the tapered cone. This was then slowly pressed. Now the assembly was treated into the holder cover and the silicone 'O' ring was inserted for leak tight connection.

The thimbles were prepared by drying in oven at 120|C for 2 hours and then dessicated for 2 hours. This is then weighed.

f. Determination of particulate matter:

Determination of particulate concentration consists of sampling isokinetically a measured amount of gas from the flue and separating the particles from the gas and hence determining the particulate concentration.

The whole of the apparatus was made ready, the initial dry gas meter reading is recorded and the sampling probe was carefully pushed into the duct to the point nearest to the back wall. This allows the probe to cool in hot stack as it comes out, shortening the time required for cooling after the sample is taken. The nozzle and filter holder was preheated so that the moisture present in the gases do not condense in the filter during initial part of the sampling.

During the first part of the experiment, the nozzle should be facing in the upstream direction, the suction source was operated and the control valve opened. The time was then noted. The flow rate was adjusted with the help of the rotameter and control valve until the desired flow rate for isokinetic condition was obtained. As the test proceeds, dust build up in the thimble will increase the amount of suction required to maintain the proper meter rate and the valve was then adjusted. At the end of the test, the control valve was closed. The direction of the probe was turned so that the sampling nozzle faces down stream. The final gas volume and time was noted.

The samples were then carefully removed from the flue and plugged the nozzle to prevent the loss of sample.

g. Sample recovery:

After the samples has cooled the dust on the inside of the nozzle was carefully brushed into the thimble and the thimble was removed. The thimble was then weighed again. The mass of dust collected was determined by the difference in the thimble weight. After sampling, the thimble was again cooled, dried and weighed along with the dust to maintain the same conditions prior to sampling.

Calculation:

The velocity was calculated using the following formula.

Velocity (V) = 0.19 Pd x Ts
where Pd = Pressure difference
Ts = Stack temperature

The volume was calculated using the equation

$$\text{Volume} = V \times r2 \times 3600 \times \frac{298}{Ts}$$

where V = Velocity
r = radius of stack
298 = Ambient temperature
Ts = Stack temperature

Concentration of SPM was calculated using the formula

$$\text{SPM} = \frac{\text{Wt} \times 10_6}{\text{Volume of gas collected}}$$

where Wt = Wt. difference of the thimble (Weight of dust collected)

Determination of sulphur dioxide emission (SO_2) from stack No. 2 & 7.

For the determination of SO_2 also stack monitoring kit was used (Fig.9).

Principle: A gas sample is extracted from the sampling point in the stack. The sulphuric acid mist (including sulphur dioxide) and SO_2 are separated. The sulphur dioxide fraction is measured by the barium thorin titration method.

Apparatus:

The stack monitoring kit used for SO_2 estimation consists of a set of Bubbler and Impinger, temperature gauge, drying tube, control valve, vacuum pump, a rotameter, dry gasmeter, barometer and a filter probe.

Reagents:

a) Water : Deionized water

b) Isopropanol, 80 per cent: Mix 80ml of isopropanol with 20ml of deionized, distilled water.

c) Hydrogen peroxide - 3 per cent: Dilute 30 per cent hydrogen peroxide with deionized distilled water (1:9). 30ml of 3% of hydrogen peroxide is needed for each sample. Hydrogen peroxide 3% should be freshly prepared.

d) Potassium iodide (KI) solution : 10 per cent : Dissolve 10gm of KI in deionized distilled water and diluted to 100ml.

Procedure:

1. Sampling: Measured 15ml of 80% isopropanol into the midget bubbler and 15 ml of 3% hydrogen peroxide into each of the first 2 midget impingers. The final midget impinger was left dry. The probe heater is adjusted to a temperature sufficient to prevent water condensation. Crushed ice and water was placed around the impingers and bubblers.

2. A leak check was done prior to the sampling.

3. Sample collection:

The initial dry gas meter reading and barometric pressure was recorded. The tip of the probe was kept at the sampling point. The sample flow rate was adjusted to a constant rate as indicated by the rotameter. This constant rate was maintained throughout the sampling period. Readings were taken at every 5 minutes. Ice was added periodically to keep the temperature of the gases leaving the last impinger at 20°C . At the end of the run, the pump was turned off and the probe removed from the stack and the final readings were recorded.

4. Sample recovery:

The impingers were disconnected. The contents of the midget bubbler were also discarded. The contents of the midget impingers were transferred to a leak free polyethylene bottle. The midget impingers and the connecting tubes were then rinsed using deionized distilled water.

5. Sample analysis

The contents of the storage container was transferred to a 100 ml flask. 20ml of the aliquot of this solution was pipetted into a 250ml Erlenmeyer flask. To this was added 80ml of 100% isopropanol and 2 to 4 drops of thorin indicator and it was titrated to a pink point using 0.0100 N barium per chlorate. Repeated the titration and the average was taken.

Calculation:

The concentration of SO_2 is calculated using the formula

$$C_{SO_2} = \frac{K2\ (Vt - Vt_b)\ N\ \left(\frac{Vsoln.}{Va}\right)}{Vm\ (std)}$$

where

K = 32.03 mg/meq

Vt = Volume of barium perchlorate titrate used for the sample, ml (average of the titration)

Vtb = Volume of barium perchlorate titrant used for the blank ml

N = Normality of barium perchlorate titrant mill equivalents/ml

Vsoln. = Total volume of solution in which the SO2 sample is contained, 100 ml.

Va = Volume of sample aliquot, titrated, ml.

Vm(std) = Dry gas volume measured by the dry gas meter, corrected to standard conditions, meter cube (at NTP)

Determination of suspended particulate matter (SPM) in three different locations around the cement factory:

The concentration of suspended particulate matter (SPM) was calculated at 3 different regions around the factory. They are:

a) Loading centre - I (LC-I)

b) Packing plant and

c) Township, the residential area

For ambient air quality monitoring, high volume air sampler (Fig.10) was used.

The "high volume air sampler" is divided into 4 compartments as 1) Power module 1, 2) Power module No.2 3) Power pack and 4) Flow measurement device.

Procedure of sample collection:

The unit "high volume air sampler" was kept on level ground. The shelter roof was opened and the stainless steel screen on top of the filter holder cleaned. The filter paper was dried at 105|C for 2 hours and cooled in a desicator and weighed. A teared filter paper was placed on the cutout provided on the filter holder. The aluminium frame with foam rubber was clamped to the filter holder by means of a swing, bolt and fly net. The roof was then closed for SPM calculation. The roof was designed in such a way that air is allowed to enter in a zig-zag path, so that heavy particles separate out easily. This also prevents freedust fall. The timer of the power module No.2 was set for a desired period (8 hours).

The ambient temperature was noted. The manometer reading was then set at 'O' by moving the scale up and down through the screw provided. The power module No.2 was then switched `ON' and pump connected to it was put into operation. The manometer reading was checked at regular intervals. The total flow at STP was also calculated. The concentration of particulate matter was calculated by the difference of the final and initial weight of the filter paper.

Calculation:

The concentration of suspended particulate matter in ambient air was calculated using the formula.

$$SPM = \frac{D}{C} \times 10^6$$

where C = Total volume sampled at NTP, m

D = Mass of dust collected/g.

Determination of the hazardous effect of cement dust on workers

For the determination of hazardous effect of cement dust on workers a survey was carried out on 100 male workers of the age group 30-50. A medial checkup was done with the help of medical officer and a medical survey evaluation sheet (Fig. 20) was made. The medical survey evaluation sheet consisted of any specific allergies on any other symptoms due to cement pollution. Medical check up was carried out by using E.C.G medispiror etc to calculate the heart and lung efficiency (Fig. 11, 12, and 13).

Identification of pollution resistant plants

For the identification of pollution resistant plants, help was sought from Tamil Nadu Agricultural University (TNAU) and Institute of Forest Genetics and Tree Breeding (IFGTB) Coimbatore. References were also carried out from journals and a variety of pollution resistant plants were determined.

TABLE - I

STANDARD LIMITED EMISION VALUES PRESCRIBED BY KERALA POLLUTION CONTROL BOARD

Source of emission	Parameter studied	Standard limit
Stack	S P M	250 Mg/Nm^3
Stack	SO_2	1200 Mg/Nm^3
Ambient air	S P M	500 ug/Nm^3

TABLE - II

VALUE OF SUSPENDED PARTICULATE MATTER (SPM) FROM STACK NO.I - RAW MILL E.S.P

Source of emission	Month	Standard limit	S P M	Mean
Raw mill E.S.P.	Aug. 96	250	128.60	
-do-	Sep. 96	250	67.99	
-do-	Oct. 96	250	112.62	102.17 ± 18.51
-do-	Nov. 96	250	107.06	
-do-	Dec. 96	250	102.19	
-do-	Jan. 97	250	94.58	

Unit : Mg/Nm^3.

TABLE - III

SUSPENDED PARTICULATE MATTER (SPM) FROM STACK NO.II KILN E.S.P

Source of emission	Month	Standard limit	SPM	Mean average
Kiln ESP	Aug. 96	250	93.71	
	Sept. 96	250	100.85	
	Oct. 96	250	78.49	95.25 ± 3.44
	Nov. 96	250	91.80	
	Dec. 96	250	96.74	
	Jan. 97	250	109.88	

Unit : Mg/Nm^3

TABLE - IV

Sulphur dioxide emission (SO2) in stack No.II Klin E.S.P

Source of emission	Month	Standard limit	SO_2	Mean
Kiln ESP	Aug. 96	1200	76.44	
	Sept. 96	1200	58.17	
	Oct. 96	1200	41.62	36.47 ± 15.17
	Nov. 96	1200	30.93	
	Dec. 96	1200	36.51	
	Jan.96	1200	51.58	

Unit Mg/Nm^3

TABLE - V

SUSPENDED PARTICULATE MATTER (SPM) FROM STACK NO.III - RAW MILL SILO - KILN SIDE

Source of emission	Month	Standard limit	S P M	Mean
Raw mill Silo	Aug. 96	250	109.05	
-do-	Sep. 96	250	126.15	
-do-	Oct. 96	250	94.51	96.09 ± 16.76
-do-	Nov. 96	250	86.81	
-do-	Dec. 96	250	81.95	
-do-	Jan. 97	250	78.04	

Unit : Mg/Nm^3.

TABLE VI

SUSPENDED PARTICULATE MATTER (SPM) FROM STACK NO.IV RAW MILL SILO - WORKSHOP SIDE

Source of emission	Month	Standard limit	S P M	Mean
Raw mill E.S.P.	Aug. 96	250	86.39	
-do-	Sep. 96	250	93.68	
-do-	Oct. 96	250	73.09	85.00 ± 6.82
-do-	Nov. 96	250	78.45	
-do-	Dec. 96	250	89.64	
-do-	Jan. 97	250	88.75	

Unit : Mg/Nm^3.

TABLE - VII

SUSPENDED PARTICULATE MATTER (SPM) FROM STACK NO.V KILN FEED DUST COLLECTOR

Source of emission	Month	Standard limit	S P M	Mean
Kiln feed dust collector	Aug. 96	250	152.16	
-do-	Sep. 96	250	135.50	
-do-	Oct. 96	250	126.01	130.11 ± 12.77
-do-	Nov. 96	250	119.62	
-do-	Dec. 96	250	112.41	
-do-	Jan. 97	250	134.97	

Unit : Mg/Nm^3.

TABLE VIII

SUSPENDED PARTICULATE MATTER (SPM) FROM STACK NO.VI COOLER MULTI CYCLONE

Source of emission	Month	Standard limit	S P M	Mean
Cooler multi cyclone	Aug. 96	250	163.04	
-do-	Sep. 96	250	173.93	
-do-	Oct. 96	250	144.90	157.98 ± 23.62
-do-	Nov. 96	250	157.60	
-do-	Dec. 96	250	192.08	
-do-	Jan. 97	250	116.33	

Unit : Mg/Nm^3.

TABLE - IX

SUSPENDED PARTICULATE MATTER (SPM) FROM STACK NO.VII COAL MILL

Source of emission	Month	Standard limit	S P M	Mean
Coal mill	Aug. 96	250	137.93	
-do-	Sep. 96	250	158.22	
-do-	Oct. 96	250	182.15	159.44 ± 17.04
-do-	Nov. 96	250	179.66	
-do-	Dec. 96	250	140.72	
	Jan. '97	250	157.94	

Unit : Mg/Nm^3.

TABLE X

SULPHUR DIOXIDE (SO_2) EMISSION FROM STACK NO. VIII COAL MILL

Source of emission	Month	Standard limit	S P M	Mean
Coal mill	Aug. 96	1200	86.44	
-do-	Sep. 96	250	43.58	
-do-	Oct. 96	250	58.27	51.44 ± 14.72
-do-	Nov. 96	250	69.49	
-do-	Dec. 96	250	49.83	
-do-	Jan. 97	250	68.27	

Unit : Mg/Nm^3.

TABLE - XI

SUSPENDED PARTICULATE MATTER (SPM) FROM STACK NO.VIII CEMENT MILL E.S.P.

Source of emission	Month	Standard limit	S P M	Mean
Cement mill E.S.P	Aug. 96	250	172.88	
-do-	Sep. 96	250	234.59	
-do-	Oct. 96	250	190.88	176.40 ± 34.26
-do-	Nov. 96	250	142.84	
-do-	Dec. 96	250	187.54	
-do-	Jan. 97	250	129.67	

Unit : Mg/Nm^3.

TABLE XII

SUSPENDED PARTICULATE MATTER (SPM) FROM STACK NO.IX CEMENT MILL SILO

Source of emission	Month	Standard limit	S P M	Mean
Cement mill silo	Aug. 96	250	124.33	
-do-	Sep. 96	250	188.09	
-do-	Oct. 96	250	163.69	142.47 ± 33.45
-do-	Nov. 96	250	118.56	
-do-	Dec. 96	250	168.66	
-do-	Jan. 97	250	91.51	

Unit : Mg/Nm^3.

TABLE - XIII

SUSPENDED PARTICULATE MATTER (SPM) FROM STACK NO.X PACKER I - NORTH

Source of emission	Month	Standard limit	S P M	Mean
Packer I North	Aug. 96	250	29.30	
-do-	Sep. 96	250	69.26	
-do-	Oct. 96	250	41.08	40.38 ± 14.86
-do-	Nov. 96	250	21.53	
-do-	Dec. 96	250	42.95	
-do-	Jan. 97	250	38.15	

Unit : Mg/Nm^3.

TABLE XIV

SUSPENDED PARTICULATE MATTER (SPM) FROM STACK NO.XI PACKER II - SOUTH

Source of emission	Month	Standard limit	S P M	Mean
Packer II - South	Aug. 96	250	37.49	
-do-	Sep. 96	250	54.02	
-do-	Oct. 96	250	53.59	45.23 ± 7.83
-do-	Nov. 96	250	38.67	
-do-	Dec. 96	250	36.28	
-do-	Jan. 97	250	51.35	

Unit : Mg/Nm^3.

TABLE XV

MEAN OF THE SPM FROM STACK EMISSION

Source of emission	Standard limit	SPM	Mean average
Raw mill E.S.P	250	102.17	
Kiln E.S.P	250	95.25	
Raw mill silo kiln side	250	96.09	
Raw mill silo - workshop side	250	85.00	
Kiln feed dust collector	250	130.11	111.87 ± 14.27
Cooler multi cyclone	250	157.98	
Coal mill	250	159.44	
Cement mill E.S.P	250	176.40	
Cement mill Silo	250	142.47	
Packer I - North	250	40.38	
Packer II - South	250	45.23	

Unit : Mg/Nm^3

TABLE - XVI

SUSPENDED PARTICULATE MATTER (SPM) AT LCI

Source of emission	Month	Standard limit	S P M	Mean
LCI	Aug. 96	500	77.08	
-do-	Sep. 96	500	74.56	
-do-	Oct. 96	500	108.71	112.12
-do-	Nov. 96	500	89.60	± 36.88
-do-	Dec. 96	500	152.66	
-do-	Jan. 97	500	170.10	

Unit : ug/Nm^3.

TABLE XVII

SUSPENDED PARTICULAT MATTER (SPM) AT PACKING PLANT

Source of emission	Month	Standard limit	S P M	Mean
Packing plant	Aug. 96	500	58.10	
-do-	Sep. 96	500	66.29	
-do-	Oct. 96	500	171.63	197.70
-do-	Nov. 96	250	258.47	± 116.07
-do-	Dec. 96	250	239.11	
-do-	Jan. 97	250	392.61	

Unit : ug/Nm^3.

TABLE - XVIII

SUSPENDED PARTICULATE MATTER (SPM) AT TOWN SHIP

Source of emission	Month	Standard limit	S P M	Mean
Township	Aug. 96	500	46.22	
-do-	Sep. 96	500	80.38	
-do-	Oct. 96	500	101.84	100.42
-do-	Nov. 96	250	118.85	± 28.58
-do-	Dec. 96	250	134.33	
-do-	Jan. 97	250	120.95	

Unit : ug/Nm^3.

TABLE XIX

MEAN SUSPENDED PARTICULATE MATTER (SPM) OF AMBIENT AIR AROUND THE FACTORY

Source of emission	Standard limit	S P M	Mean
LCI	500	112.12	
Packing plant	500	197.70	136.75
Township	500	100.42	± 48.33

Unit : ug/Nm^3.

FIGURE 2

AERIAL VIEW OF MALABAR CEMENTS LIMITED, WALAYAR

FIGURE 3

KILN E.S.P

FIGURE 4

GAS CONDITIONING TOWER

FIGURE 5

FIGURE 6

COAL MILL BAG FILTER

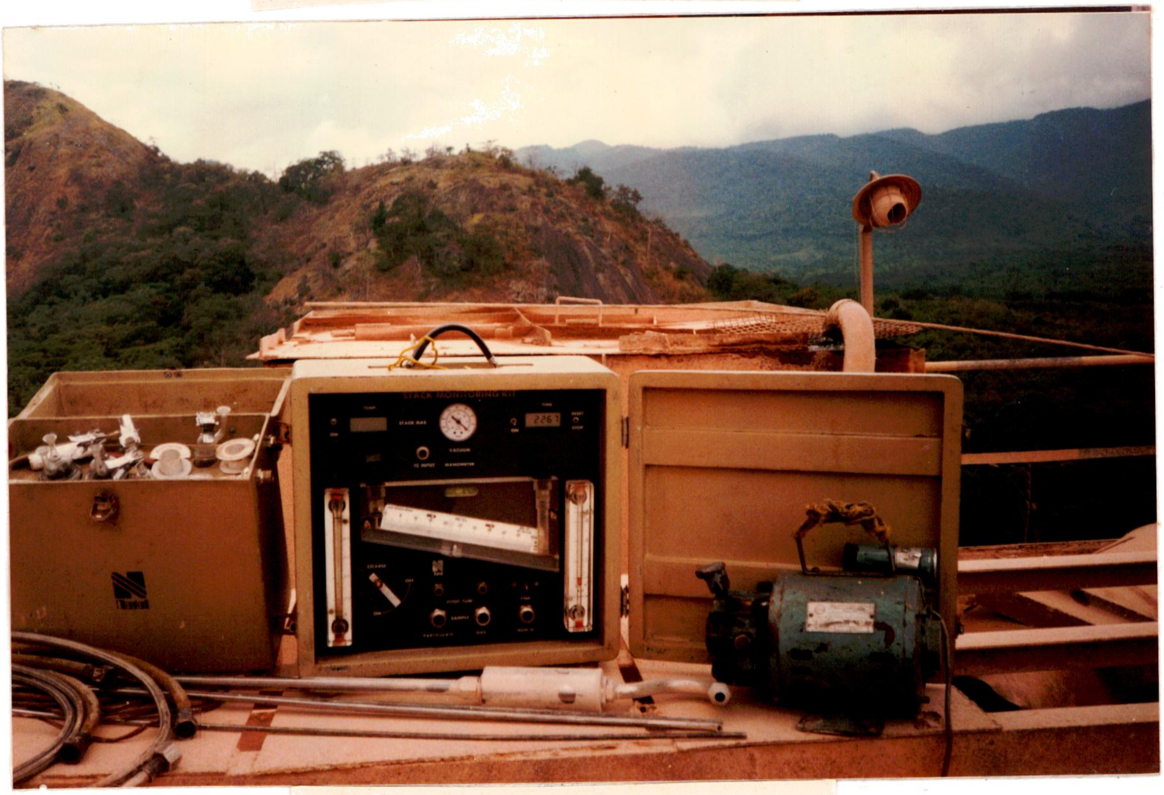


FIGURE 7

STACK MONITORING KIT

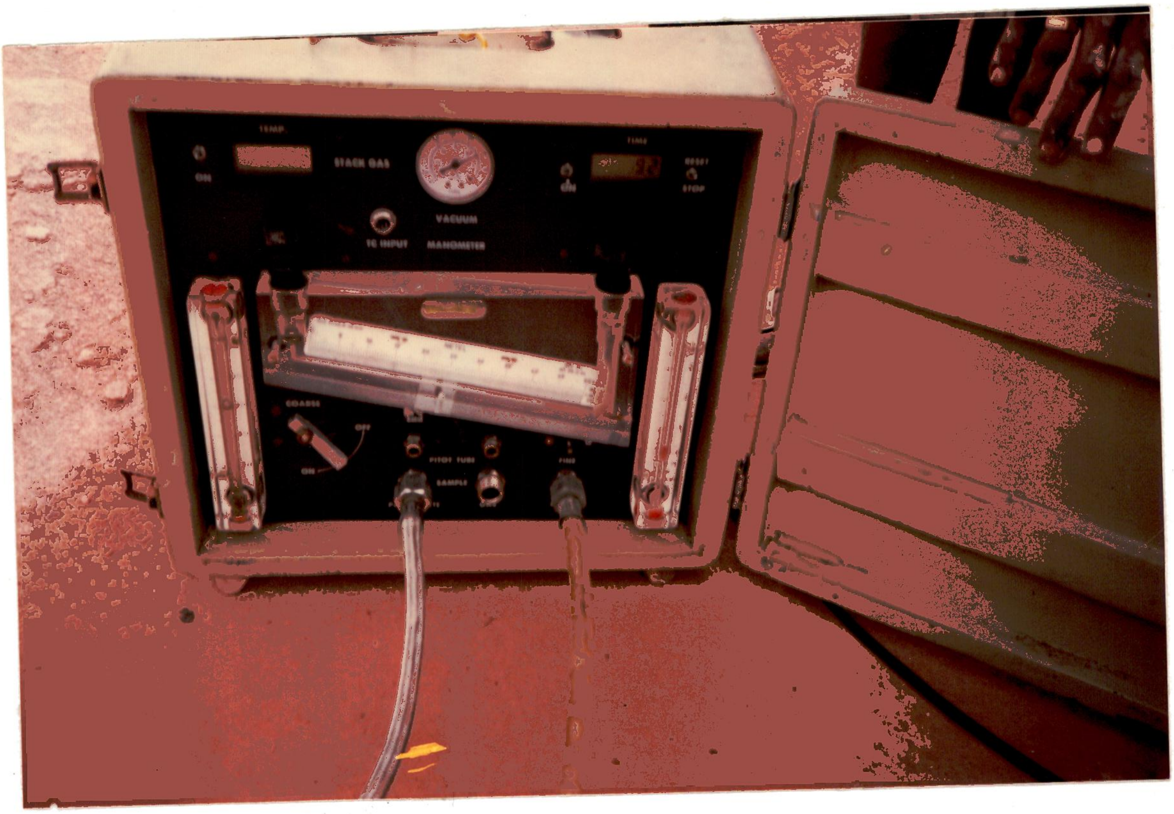


FIGURE 8

STACK MONITORING KIT

FIGURE 9

STACK MONITORING KIT

FIGURE 10

HIGH VOLUME AIR SAMPLER

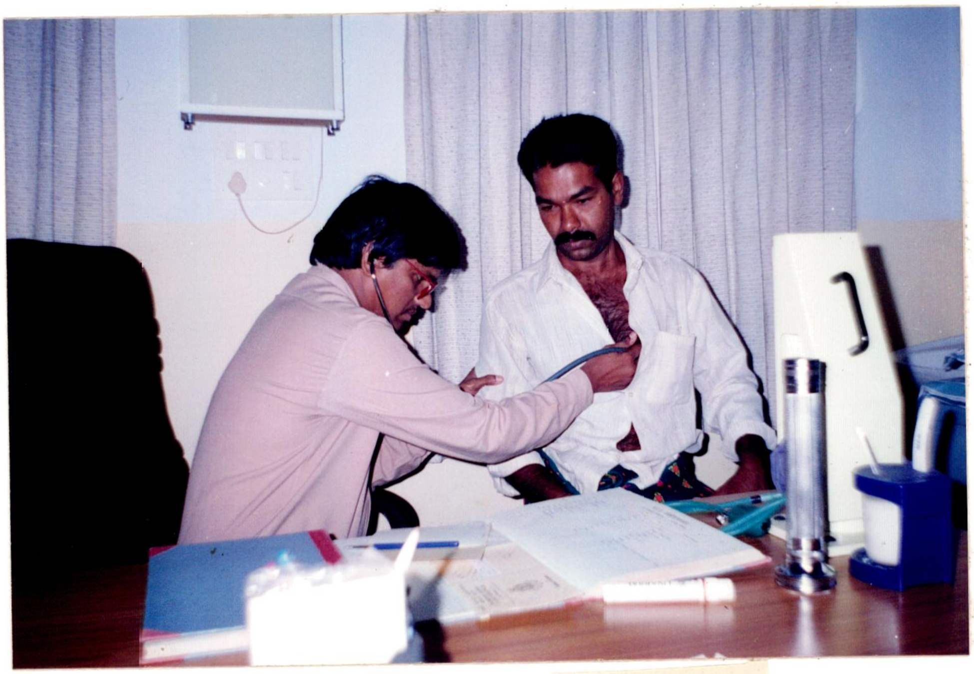


FIGURE 11

MEDICAL OFFICER CARRYING OUT A MEDICAL CHECKUP

FIGURE 12

E.C.G. TEST CARRYING OUT FOR A PATIENT

FIGURE 13

MEDSPIROR USED TO TEST LUNG EFFICIENCY

FIGURE 14

ROTARY KILN

FIGURE 15

CEMENT MILL E.S.P

FIGURE 16

POLLUTION RESISTANT PLANTS

Fig. 17

FIGURE : 17

CONCENTRATION OF SUSPENDED PARTICULATE MATTER FROM ELEVEN STACKS

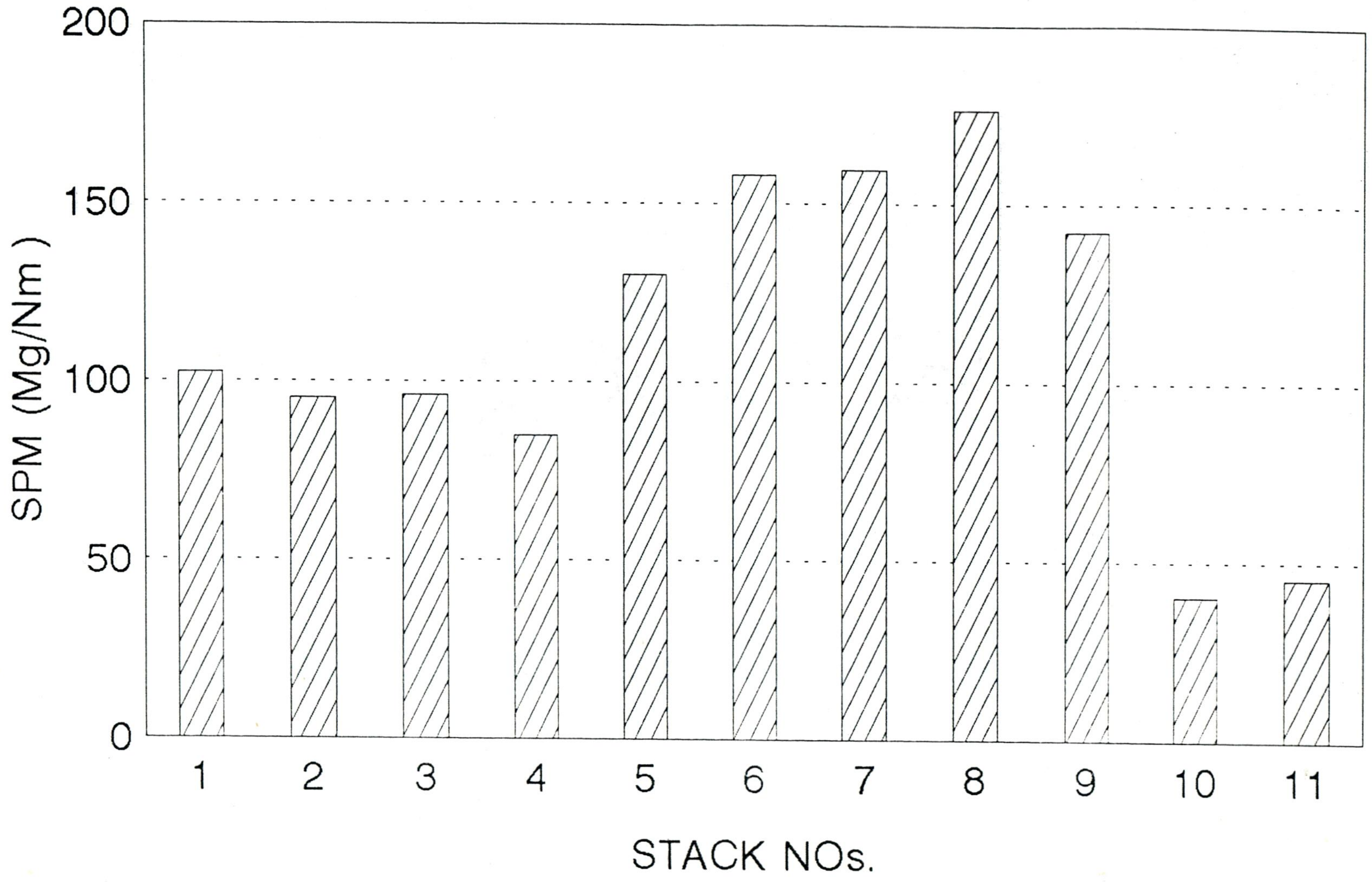
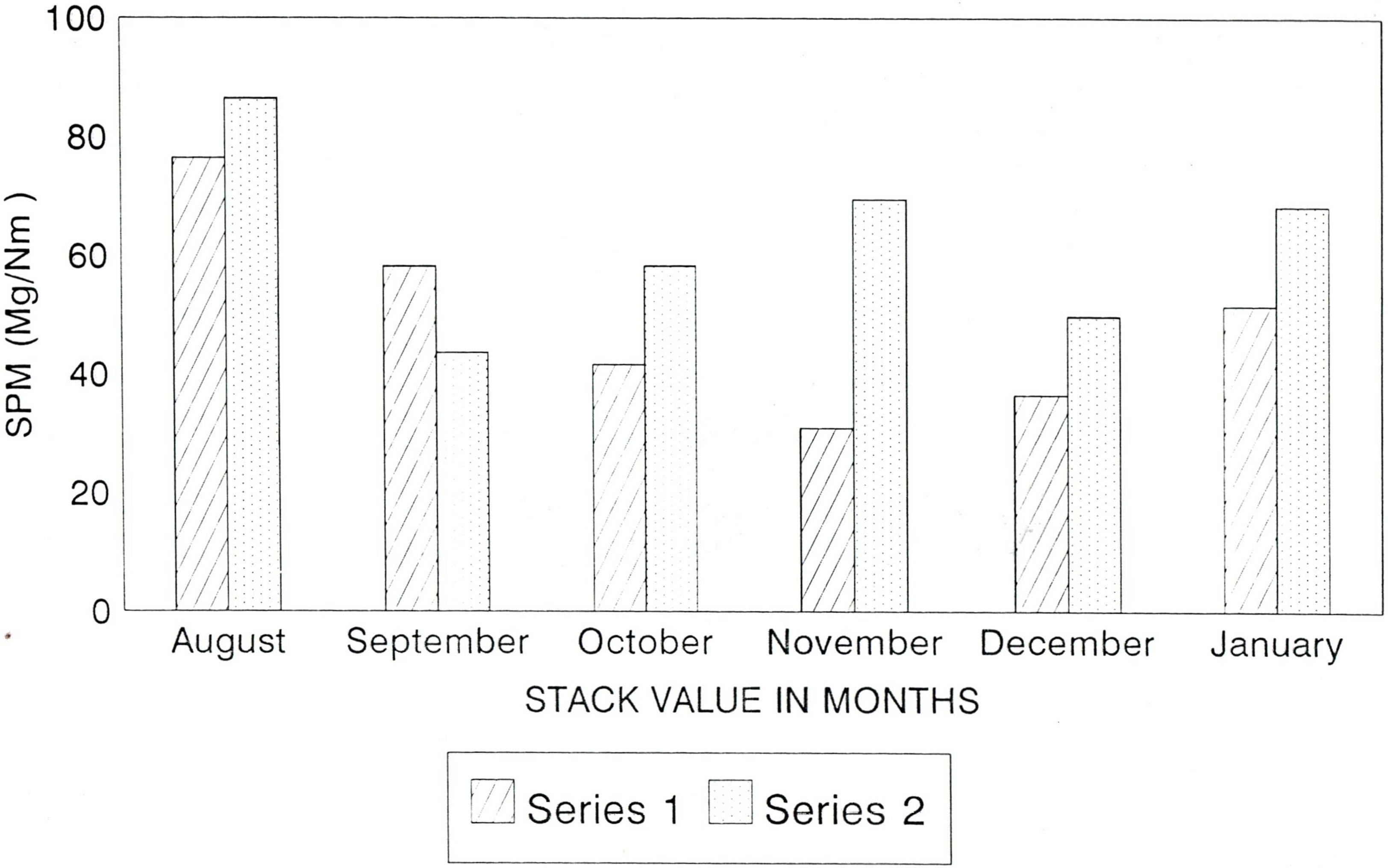


Fig. 18

FIGURE: 18

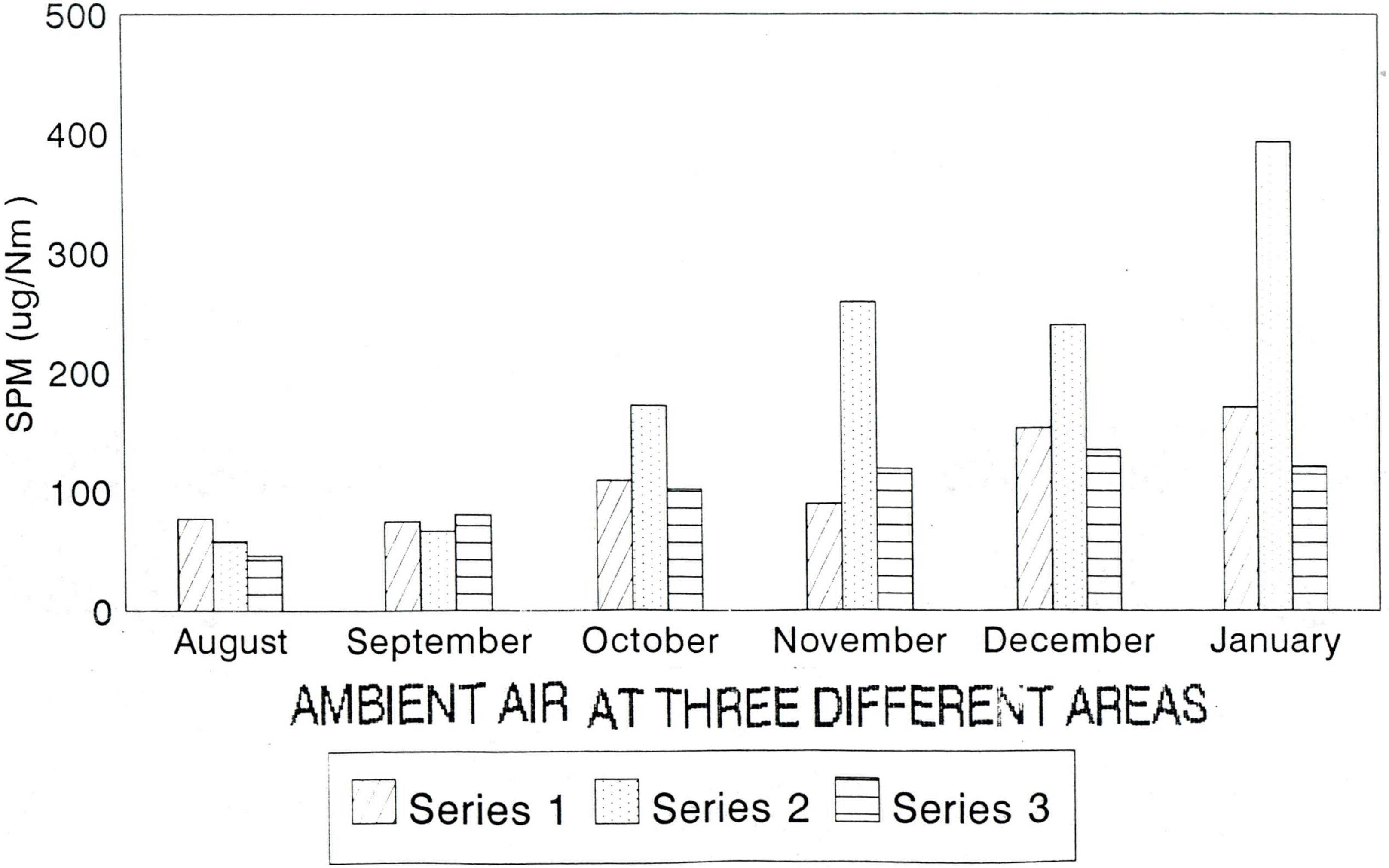
SO2 EMISSION FROM TWO STACKS DURING THE MONTHS OF AUG'96 - JAN'97



STACK 2 (SERIES 1) STACK 7 (SERIES 2)

FIGURE: 19

SPM AT THREE DIFFERENT AREAS FOR AMBIENT AIR MONITORING AUG'96 - JAN'97



LC1 (SERIES 1) PACKING PLANT (SERIES 2) TOWNSHIP (SERIES 3)

Figure: 20

MEDICAL SURVEY – EVALUATION FORM

Name :

Age : Sex : Blood Group :

Occupation / Department :

Years of Service in the factory :

Food Habit :

Other Habit :

Specific ailments :

Known Allergies :

Family Medical History :

Results and Discussion

RESULTS AND DISCUSSION

Cement industry is one of the major contributors of air pollution in our country. The main source of pollution from such industries is due to the combustion of raw materials like limestone, laterite, gypsum, coal etc. Pollution is also caused due to the emission of sulphur dioxide (SO_2) during coal combustion.

The present work was undertaken at Malabar Cements Limited, Walayar, to calculate the concentration of suspended particulate matter (SPM) and sulphur dioxide (SO_2) from the different stacks and also to measure the SPM of ambient air.

Table I shows the air quality standards prescribed by the Kerala Pollution Control Board (KPCB).

Suspended Particulate Matter (SPM) concentration from the different stacks

Concentration of suspended particulate matter was ascertained from the eleven stacks by using stack monitoring kit for a period of six months.

a) SPM concentration in Raw mill ESP

The SPM concentration in raw mill ESP was found out during a period of six months ranging from Aug.'96 to Jan'97 (Table II). The SPM concentration ranged from 67.99

mg/Nm^3 in September to 128.60 mg/Nm^3 in August. The mean concentration was found to be 102.17 + 18.51. This value was found to be below the standard limit (250). Mathur et al., (1985) calculated SPM concentration in a cement plant before and after electrostatic precipitation. The results showed that SPM concentration was very much lowered after using E.S.P. Bhattacharya (1987) also suggested that the SPM concentration from the stacks of cement plant may be controlled and reduced to 99 per cent by the installation of pollution control equipments like E.S.P.

b) SPM and SO_2 concentration in Kiln E.S.P. (Fig.1)

The SPM concentration in kiln E.S.P. ranged from a minimum of 78.49 mg/Nm^3 during October '96 to a maximum of 109.88 Mg/Nm during January '97. The mean SPM average was calculated to 95.25 + 3.44 (Table III). This average was found to be within the permissible limits (250) sulphur dioxide concentration was also calculated from this stack. The value ranged from 30.93 mg/Nm^3 during November to 76.44 Mg/Nm in August. The mean SO_2 concentration was found to be 36.47 + 15.17 mg/Nm^3 (Table IV). This value also lies within the standard limit (1200). The difference in SPM concentration is due to the variation in cement production for each month. Pandey et al., (1981) and Prasad et al., (1991) has undertaken similar study and inferred that the emissions from cement kiln if not controlled is harmful for the vegetation.

c) SPM concentration in Raw mill silo-kiln side (Fig. 14)

SPM in stack No.3 during the study period (Aug'96-Jan'97) revealed that variation of SPM concentration from 81.95 mg/Nm^3 in December to 126.15 mg/Nm^3 in September. The mean average SPM concentration was 96.09 + 16.76 mg/Nm^3 (Table V). This value lies well below the standard permissible limits (250). The uncontrolled emission from the cement kiln causes soil pollution which results in the depletion of soil nutrients. (Khosla and Puri, 1984).

d) SPM concentration in Raw mill silo-workshop side

The SPM concentration in raw mill silo was found to be varying from a minimum of 73.09 mg/Nm^3 in October to a maximum of 93.68 Mg/Nm . The mean average concentration was found to be 85 + 6.82 mg/Nm^3 (Table 6). The value was found to be below the standard limit (250). Puri *et al.*, (1982) carried out a study on the emission from the cement mill and inferred that uncontrolled emission causes harm to the vegetation.

e) SPM concentration in kiln feed dust collector

The SPM concentration in kiln feed dust collector ranged from a minimum of 112.41 mg/Nm^3 during December to a maximum of 152.16 mg/Nm^3 during August. The mean average concentration was calculated to be 30.11 + 12.77 mg/Nm^3. This value lies well below the standard limits (250) (Table VII). Prasad and Inamdar (1991) analysed the effect of cement dust on Vigna species and found out that cement dust affect the growth and yield of Vigna sp.

f) SPM concentration in Cooler multicyclone (Fig. 5)

SPM concentration in cooler multicyclone ranged from 116.33 mg/Nm^3 during January '97 to 192.08 during December. The average concentration was 157.98 + 23.62 mg/Nm^3 which is well below the standard limits (250) (Table VIII).

g) SPM and SO_2 concentration in coal mill

The SPM concentration in coal mill ranged from 137.93 mg/Nm^3 during August to 182.15 mg/Nm^3 during October. The mean average concentration was calculated to be 159.44 + 17.04 mg/Nm^3 (Table IX). This value though a little higher lies well within the standard prescribed limits (250). SO_2 concentration was also calculated from coal mill. The concentration ranged from 43.58 mg/Nm^3 during September to 86.44 mg/Nm^3 during August with a mean value of 51.44 + 14.72 mg/Nm^3 (Table X). This value is also within the limited values (1200). Pandey et al., (1992) undertook a similar study on the emission of dust from coal mill. The studies revealed that high values of the dust is harmful to both animals and plants.

h) Concentration of SPM in cement mill E.S.P.

The concentration of SPM ranged from a minimum of 129.67 mg/Nm^3 during January '97 to a maximum of 234.59 mg/Nm^3 during September '96. The average value was calculated to be 176.4 + 34.26 mg/Nm^3 (Table XI). This value is found to be the highest among all the stacks, but still it lies within the standard limit (250). Previous studies of Westman (1989) have shown that the noticeable increase of pollutant concentration in air is due to the process adopted and also running hours of major operations and control equipments (Mathur and Pal, 1984).

i) SPM concentration in cement mill silo

A six month study on the concentration of SPM shows a range of 91.51 mg/Nm^3 during January '97 to 188.09 mg/Nm^3 during September '96. The average value was calculated to be 142.47 + 33.45 mg/Nm^3 which was well below the standard limits (250) (Table XII). The fluctuation in the values is due to the breakdown of major operations and due to non-functioning of pollution control equipments (Mathur et al., 1986).

j) SPM concentration in Packers I and II

The SPM concentration in packer I lies within a range of 21.53 mg/Nm^3 during November and 69.26 mg/Nm^3 during August. The mean value was 40.38 + 14.86 mg/Nm^3 (Table XIII).

The concentration in Packer II ranged from 36.28 mg/Nm^3 during December to 54.02 mg/Nm^3 during September with a mean average of 45.23 ± 7.83 mg/Nm^3 (Table XIV). The value showed that the SPM concentration in the packers were very low and below the standard prescribed limits (250).

Kamal and Ahmed (1993) studied on the effect of fabric filter on metal content in controlled cement dust. They found out that the average depleted metal concentrations were due to collection by fabric filter and E.S.P.. The lower SPM concentration in the packers was due to the installation of fabric filter. SPM concentration from the stacks of cement plant can be controlled and reduced to 99 per cent by the installation of pollution control equipments like E.S.P. and fabric filter (Bhattacharya, 1987).

Mean SPM concentration

The mean SPM concentration for all the eleven stacks was calculated. The average mean was found to be 118.87 ± 14.27 mg/Nm^3 (Table XV and fig. 17). This was found to be well below the permissible limits (250).

The values of the SPM concentration revealed that the SPM concentration was found to be higher in stack No. 8, cement mill E.S.P. with an average of 176.40 ± 34.26 mg/Nm^3. SPM concentration was found to be lower in stack no.X. Packer I North with an average of 40.38 ± 14.86 mg/Nm^3. The high level of SPM in stack no. 8 can be due to the process adopted, cement processing due to which high quantities of cement dust is given out and also due to some repairable works in the E.S.P. The low level of SPM concentration in stack no. 10 may be due to the high efficiency of the pollution control equipment, i.e. bag filter which can capture 99 per cent of the dust given out. This shows that the pollution control equipments when installed are highly efficient and cuts the emission of dust from the stacks.

Average SO_2 emission was also calculated for the stack no. 2 and 7 (Fig. 18). The average mean in stack no. 2 was 36.47 ± 15.17 and for stack no. 7 was 51.44 ± 14.72. The high SO_2 value in stack no. 7 is probably due to the high volume of SO_2 emitted during coal combustion.

Ambient air quality monitoring

The dust discharged from the cement factory is then carried out to the surroundings and thus causes a high level of SPM in the ambient air. The determination of SPM in the ambient air was very important because the extent of pollution can be ascertained and can be prevented to protect the environment.

Ambient air quality monitoring was carried out at 3 places i.e. Loading Centre I, Packing Plant and Township. The SPM concentration was calculated using High volume air sampler, for a period of 6 months ranging from August '96 to January '97.

a) Ambient air quality at LC-I

Ambient air quality was carried out at LC-I for measuring the concentration of SPM. The value ranges from 74.56 ug/Nm^3 during September to 170.10 ug/Nm^3 during January. The mean average was calculated to be 112.12 ± 36.88 ug/Nm^3. This value lies within the standard limits (500) (Table XVI).

The high level in the SPM concentration at LC-I was due to its location. LC-I was located very nearer to the factory near the packing plant, where packing is carried out. The dust is carried out from the factory and the plant. Moreover, the continuous movement of vehicles results in the increase of higher SPM concentration near the Loading Centre.

Furthermore during the loading of cement baggage also a large a quantity of cement dust is given out which can also be added to high SPM concentration. The unloading of raw materials also adds to it.

b) Ambient air quality at packing plant

The concentration of SPM in the packing plant varies from 58.10 ug/Nm^3 during August '96 to 392.61 ug/Nm^3 during January '97. The average mean concentration was calculated to be 197.70 ± 116.07 ug/Nm^3 (Table XVII).

The results showed that the SPM concentration in the packing plant was slightly higher. During bagging operation of cement (Cement Packing), dust is deposited in large amounts. The packing of cement leads to high discharge of cement dust. The blowing of wind also added to this.

The packing plant is also situated nearer to the cement mill which also emits high amounts of dust. The loading of cement bags at this place also adds to the high level of SPM.

c) Ambient air monitoring at Township

The SPM concentration was calculated at the township. The values show that the SPM lie within a minimum of 46.22 ug/Nm^3 during August to a maximum of 134.33 ug/Nm^3 during December. The mean average value was found to be 100.42 ± 28.58 ug/Nm^3. This value lies within the standard permissible limits (500) (Table XVIII).

The values of SPM at the township shows that the SPM concentration is comparatively lower when compared to the other two sites. The reason for this can be due to the fact that the sampling site is located away from the factory. But still the reason for the level of SPM may be due to the carrying of dust by the wind. The continuous passage of vehicles at the township can also be a reason for the SPM concentration.

The mean average value of ambient air was calculated to be 136.75 ± 48.33 ug/Nm^3. This value lies below the standard prescribed limits (500) (Table XIX and figure 19). Among the 3 sampling sites, SPM concentration was found to be higher at packing plant and lower at the township. The high concentration at packing plant is due to bagging operation and also due to location and vehicular transport. The lower concentration at the township can be related to the location of the township away from the factory and also due to the vast amount of trees around it.

Statistical analysis

Statistical analysis was done for calculating the concentration of SPM for both stack emission and ambient air using Analysis of variation (ANOVA) method.

For stack emission, the variance between the sample was 2071.52 and variance within the sample was 466.76. The F value (24.40) was higher than the test value (1.9926) this shows the significance of the test.

For ambient air monitoring the ANOVA test was found to be non-significant because the F value (3.37) was below the test value (3.68). The value of variance within the sample was 6283.26 and variance between the sample was 2820.705.

Medical Survey

A large number of studies have indicated association between particulate air pollution and adverse health outcome. Relatively low levels of pollution are responsible for increased morbidity and even mortality observed health effects of respirable particulate pollution include increased incidence of respiratory symptoms, decreased lung function, increased hospitalizations and other health care visits for cardiopulmonary diseases.

To evaluate the hazardous effect of cement dust on workers a medical survey was conducted among hundred male workers of the age group 30-50. Medical checkup was carried out with the help of medical officer. A medical evaluation form (fig.20) was maintained to know various medical aspects of the workers. Electrocardiogram for cardiovascular function and medispiror for knowing the lung efficiency of the workers were also undertaken (fig. 11, 12 and 13).

Among the 100 workers, 18 persons (18 per cent) showed allergy to dust, 4 per cent to sulphur and less than 2 per cent to other substances. Four per cent of the workers had bronchial asthma. Lung functioning and cardiovascular function was found to be normal for all the patients.

From the above data it was clear that only a minor percentage of the people have any common symptoms or allergies to any specific compound. A minor population also had any specific ailments like asthma. So it could be ascertained that there is no hazardous effect of cement dust on the workers.

A medical survey on the cement workers were carried out by Rowe _et_ _al_., (1983). The experiments showed that uncareful handling of portland cement may produce skin eruption among the workers. The major symptoms presented by the cement workers due to cement inhalation are cough, phlegm production, skin irritation, chest tightness, conjuctivitis, catarrh, stomach ache and boils (Oleru, 1984).

Pollution resistant plants

In order to find out pollution resistant plants, references were made from various journals and help was sought from the Institute of forest genetics and tree breeding (IFGTB) and Tamil Nadu Agricultural University (TNAU). A number of dust tolerant and SO_2 tolerant plants and trees were identified (Fig. 16). Some of the these plants are:

SO_2 tolerant plants

Azadiracta _indica_

Ficus _religiosa_

Pithecolobium _dulce_

Syzygium _cumini_

Dust tolerant plants

Mangifera indica, *Terminalia arjuna*, *Ficus benghalenses*, *Acacia arabica*, *Achrasapota*, *Tectona grandis*, *Hibiscus rosasinesis* *Delonix regia*, *Eucalyptus globulus*, *Euphorbia hirta*, *Punica granata*, *Achyranthus aspera*, *Amaranthus spinosa*, *Capcium annum*, *Cassia auriculata*, *Gopmpherena*, *Phyllanthus niruri*.

Most of these plants/trees are seen commonly growing in India and 20 saplings collected from forest college were distributed to Malabar Cements Limited inorder to reduce environmental pollution. These plants absorb obnoxious gases, they purify small doses of pollutants. These plants can be treated as oxygen producing zones amidst industrial environment, thus checking the imbalance of the environment.

Summary and Conclusion

V SUMMARY AND CONCLUSION

The present study was carried out in Malabar Cements Limited, Walayar to find out the extent of air pollution caused by the factory and the hazardous effect of cement dust on the workers.

1. Air quality measurements with special reference to suspended particulate matter from the different stacks and ambient air was studied.

2. The emission of sulphur dioxide (SO_2) from stack No.2 and Stack No.7 were also analysed.

3. SPM in the different stacks showed fluctuations due to the variety of pollution control equipments used.

4. SPM fluctuations were also noticed in different months due to some climatic conditions and also due to the difference in cement productivity in different months.

5. SO_2 emission was analysed at stack No.2 and 7 and revealed to be under the standard limited value (1200 ug/Nm).

6. SPM in ambient air was found to be varying in different months.

7. All the observations made were found to be within the permissible limits prescribed by the pollution control board (Table I).

8. The study also emphasised on the working of the pollution control equipments like Electrostatic precipitator, Multicyclone cooler, gas conditioning tower and the bag filters which helped in the regulation of dust emission thus reducing air pollution from the factory.

9. The hazardous effect of the cement dust on the workers revealed that only a very few people have any common respiratory or allergic problems that can be attributed to air pollution. The management is also providing various facilities to the workers. Thus the effect of cement dust on the workers can be considered to be very low.

10. A number of pollution resistant plants had been identified and these were supplied to the factory to plant them along the industrial area, thus reducing the extent of air pollution.

Thus, the present study, was focussed on monitoring the SPM in and around the factory, on the various pollution control equipments that helped in dust regulation, on the hazardous effect of cement dust on workers and also in the identification of pollution resistant plants. Further studies on the effect of cement dust on soil and on the vegetation around the factory can be carried out.

Bibliography

BIBLIOGRAPHY

Agrawal, S.B., Agrawal, M.A., Nandi, P.K., and Rao, D.N., 1987, "Effect of SO2 and Ekalux (EC25) singly and in combination on the photosynthetic pigments of O. Sativa plants", J. Environ. Biol 8 (4) P. 315.321.

Agrawal, S.B., Agrawal, M., Nandi, P.K., and Rao, D.N. 1987, "Effect of SO2 and quinalphes singly and in combination on the metabolic functions and growth of oryza sativa". Proc Indian - National Sc. Azad, B53 (2) P. 169-172.

Annuka, E., 1994, "The impact of emission from a cement plant on forest landscape", Eesti Teaduste Akademia Toimetised, Okoloogia, 4:3, Pp.118-127.

Aslam, M., Manocha A.K., Kalra, P.D., and Srivastava, R.S., 1992, "Fugitive dust emissions from stone crushers", Indian J. Environ. Health, 34(3) Pp. 186-191.
Atkisson, Jr.A., and Faith, W.L., 1988, "Air pollution", Willey Inter Science Publications, New York, Pp. 380-394.

Auclair, D. 1976, "Effects of dust on photosynthesis, I Effects of cement dust and coal dust on the photosynthesis of spruce", Annales des Sciences Forestieres, 33:4, Pp. 247-255.

Bagchi, N., 1992, "What makes silica toxic?", British J. Indl, Med , 49 (2) Pp. 163-166.

Bansal, S., 1993, "Certain enzymes isolated from diseased tissue of tomato fruits infected by alternaria altermater and exposed to SO2, J. Ecotoxical environ Monit, 3(2), Pp.111-115.

Bansal, S., Tiwari, S., and Rai, S., 1991, "Phytotoxicological response of ficus religiosa to SO2 exposures", Indian J.Enviran Hlth, 33 (3), Pp. 366-373.

Bates,D.V., 1995, "The effects of air pollution on children", Envtl. Hlth, persp. 103 (6), 49-53.

Bechulal and Ambasht, R.S., 1980, "Effect of cement dust pollution on plants of psidium guajava", Indian J. Envt. Hlth, 22 (3), Pp.231-237.

Bharanisagar, V., 1996, "Green helt", Econews, Envt quarterly Jan-March, 2 (1) Pp 19-20.

Braniewski, S., and Chrzanowska, E., 1983, "Effect of dusts from electro filters of different industrial works on the vegetation", Zeszyty Naukowe Akademii Rolnizcej H.Kollataja-w-krakowie-Lesnietwo, No.18, Pp 146-166.

Brauer,M., Dumyahn,T.S., Spengler,J.D., Gutschmidlt,K., Heinrich,J and Wichmann,H.E., 1995, "Measurement of acidic aerosol species in easter Europe Implications for air pollution epidemiology", Envtl. Hlth, Persp, 103 (5), 482-488.

Brunekreef, Bert,D., Dackery,D.W., Kryzanowski, and Michael 1995, "Epidemiologic studies on short term effects of low levels of major ambient air pollution components", Envtl.Hlth. Perspectives, 103 (2), 3-11.

Bulankova, E., 1988, "The effects of emissions from cement works on the structure of the community of Nabidae (Heteroptera)", Acta Facultatis Rerum Alaturatium Universitatis, Comeniane-Zoolagia, No.33, Pp. 61-69).

Castranova, V., Baimer,L., Reasar, M.J., Herviest, Tucker J and Milo P.R., 1985, "The response of rat alveolar macrophages to chronic inhalation of coal dust and or diesel exhaust", Environ Res. 36(2), Pp. 405-415.

Chaudari,G.S., Rao, N.V., and Inamdar, J.A., 1984, "Effects of air pollution on leaf epidermis and architecture of Lycopersicon lycopersicum L.Kaust, Varangurtala", Indian.J. Environ. Hlth, 26 (3), Pp. 238-243.

Crawford,M., 1976, "Air pollution control theory", McGraw Hill Inc.,

Dash,T., and Panda,A., 1996, "Ambient air quality around the refractory at Belpahar", J.Ecotoxicol Env. 6 (4), 269-272.

Day,G.D., Virant,A.C., Harvey,D.L., Hoesman,T.R. Pegler,D.G., Hololanko,P., and Fena, E.J. 1976, "You and the environment an investigative approach", Ednl. research councilof America, 223-236.

David V. Bates, 1995, "The effefts of air pollution as children", Envtl. Hlth persp. 103 (6), Pp. 49-53.

Dreisigner, M.F., and McGovern, P.C., 1970, "Conference on impact of air pollution and vegetation", Toronte , Canada.

Edward, W., 1972, "Pollution", Oxford Univ. Press, London, 31, (72).

Farmer,A.M., 1993, "The effects of dust on vegetation - A review", Environmental pollution, 79:1, Pp..63-75.

Gary,D. Day, Anne C.Viront, Dennis, L. Hawes, Thomas, R. Hoesman, Donald G. Pegler, Paul Hololaiho, Erniest J. and Fena, 1976, "You and the environment an investigative approach", Elnl. research council of America, Pp. 223-236.

Gigauri, G.N., Devdarian, T.V., Ratman, P.A., Ramishvili, I.A., Kvadchadze, N.K., Maglashvili, N.T., and Dzhokhadze, G.K., 1992, "Effect of cement dust on the conditon of woody plants", Lesovadenie, No.6, Pp..65-73.

Graham,J.A., and Miller,F.J., 1985, "Inhalation studies of Mt.St. Helen Volcanic ash in animals", Environ. Res. 37 (1), 61-71.

Grose, E.C., and Grady, M.A., 1985, "Inhalation studies of Mt. St. Helens, Volcanic ash in animals, III host defense mechanism". Environ. Res. 37(1), 84-92.

Gunamani, T., and Arjunan, M.C., 1991, "Studies on the cement dust induced abnormalities in some timber yielding plants", J. Swamy Botl Club, 8 (3f 4) 87-96.

Gunamani, T., Guruswamy,R., and Swaminathan, K., 1991, "Effect of dust pollution on the dermal appendages and anatomy of leaes in some herbaceous plants", J. Swamy Botl club 8 (3 and 4) (79-55).

Gupta,D., and Vidya, A., 1994, "Ambient air quality of shimal town with reference to SPM", Indian J. Environ. Hlth, 36 (1), 40-42.

Gupta,R.K., Sharma, V.P., and Arora, H.C., 1987, "A study of air quality of Kanpur", Indian. . Environ. Hlth 29 (2), 180-182.

Gurdeep, S., and Parveen kumar, S., 1992, "A study of spatial distribution of air pollutants in some coal mining areas of Raniganj Coal Field, India", Envt. Int. 18 (2), (191-200).

Hackney,T.D., Linn, W.S., and Avol,E.L., 1984, "Assessing health effects of air pollution", Environ, Sci & Techno, 18 (4), 1154-1224.

Hahan, N., Booth, J.A., and Green, F., 1985, "Influenza virus infection in mice after exposure to coal dust and diesel engine emission", Environ. Res. 37 (1) 44-60.

Heath, R.L., 1980, "initial events in injury to plants by air pollutants", Ann. Re. Pl. Physiol. 31 (395-431).

Hunt, G.T., 1988, "Measurement of PCDDS/PCDFS in ambient air", Air waste management Assoc. 39 (3), (330-331).

Ignacimuthu,S., and Muraleytharan,V., 1994, "Effect of cement kiln dust on root tip cells of Allium cepa", J. Ecotoxicol Environ. Manit 4 (4), 263-265.

Jain,S.K., 1993, "Air pollution Control in India", J. Environ. Prot. 13 (7), 521-527.

Jedrychowski,W., 1995, "Review of recent studies fromcentral and eastern e\Europe associating respiratory health effects with high levels of exposure to traditional air pollutants", Envt. Hlth perspective, 103 (2), 15-21.

Joshi, O.P., Pawar, K., and Wagela, D.K., 1993, "Air quality monitoring at Indore city with special reference to sulphur dioxide and tree bark pH", J. Environ, Bio, 14 (2), 157-162.

Joshi, S.D., Phadke, K.M., Gajran, C.P., Kothari, J.V., Seth, A.K., Bhadar, L.M., and Aggarwal, A.L., 1991, "A few measurements an ambient air pollutants of Udaipur city", Indian.J. Environ. Hlth, 33 (1), 31-39.

Kamal, Hindi, T., and Attia, A.T., 1993, "Effect of ESPN and FFN and FFN on metal content in controlled cement dust, International J. of envtl.edu and information, Envtal. resoruce unit, 12 (1), 35-41.

Kannan, V., Abubacker, M.N., Srinivasan, S., and Muthukumar, B. 1994, "Air borne mycoflora as a tool for pollution studies:, J. Ecobiol, 6 (2), 131-134.

Kaushik, G.C., 1996, "Cytotoxicity of cement kiln dust on mitosis of root tip cells in viciafaba", J. Ecotoxicol Envt, 6 (1), 053-057.

Khosla, P.K., and Puri, S., 1984, "Effect of cement kiln dust on soil nutrients of sal (Shorea robuta) forest ecosystem:, Journal of Tree Sciences, 3:1:2, 73-79.

Klincsek, P., 1976, "Investigations on the effect of cement dust on some common trees and shrubs", Kertgazdosag, 8:3, 71-76.

Kartesharju, M., and Kartesharju, J., 1989, "Studies on epiphytic lichens and pine bark in the vicinity of a cement works in Northern Finland", Silva, Fennica, 23:4 (301-310).

Krishnamohan, K., and Muthukrishnan, N., 1996, "Ambient air quality in Madras City", Eco News, A. Envt. quarterly Oct-Dec 2 (3), 10-23.

Krishnamoorthy, M.S. 1984, "Proceedings of the fourth Annual conference of Society of Toxicology (STOX), India.

Krishnamoothy, R., Srinivas, T., and Bhagwat, K.A., 1994, "Effect of air pollution on some bund trees of the agricultural lands, J. Environ, Biol. 15 (2), 97-106.

Last,F.J., 1982, "Effects of atmospheric sulphur compounds on natural and man-made terrestrial and aquatic ecosystems", Agri., Environ. 7 (299-287).

Linn, H.S., 1984, "Air pollution control in Singapore", Asian Environment, 6 (2), 10-14.

Lultag, U., Osmond,C.B., Ball,E., Brinckmann E and Kinze, G., 1972, "Bisulphite compounds as metabolic inhibitors: non specific elements on membranes:, Plant cell physical, 13, 505-514.

Madavendra, S.S., Satyakala, G., and Kaiser Jamil, 1990, "Survey of vegetation in an industrial area", Indian.J.Environ, Hlth 32 (2), 113-123.

Mandre, M., Annuka, E., and Tuutmets,L., 1992, "Response reactions of conifers to alkaline dust polluton, Changes in the pigment system", Eesti Teaduste, Akadeemia, Toimetised, Okoloogia, 2:4, 156-173.

Madre,M., Tuulmets L., Rank, J., Ots, K., and OPkasmets, M., 1994, "Response reaction of conifers to alkaline dust pollution, Changes in growth", Eesti Teadusts Akadeemia Toimetised Okoloogia, 4:2, 79-95.

Manthapurwar, N.S., Reddy, M.K., Parvez, M.J., and Swaminathan, R., 1987, "Sulphuric acid plant with ammonia scrubbing and related air pollution problem", Indian.J. Environ,Hlth 29 (3) (221-226).

Martin, L., and Nilson,E., 1992, "Impact of the Kunda Cement Plant (North-East Estonia) emission on the distribution of epiphytic lichens", Eesti. Teaduste-Akadeemia-Toimetised, Okoloogia, Vol.2, No.4, 181-185.

Meagher, J.F., Olszyma, K.J., and Luria,M, 1984, "The effect of SO_2 gas phase oxidation on hydroxyl smog chemistry", Atm.Env. 18 (10), 2095-2104.

Mishra,R.M., Gupta,A.K., and Ashok,P., 1993, "Observations on cement dust pollution in Baghwar region, Rewa (M.P.), Bionature, 13 (1) 49-59.

Moller,D and Schieferdecker,H., 1985, " A relationship between agricultural ammonia emissions and the atmospheric SO_2 content over industrial area" Atm. Env. 19 (5), (695-700).

Mudri,S.S., Venkat Rao, D., Prasad, V., Rana Rao, K.G., Rane, R.V., Ravikishan,V., Pumpattina,V.L., Aggarwal, A.L., and Murty, Y.S., 1986, "Ambient air quality at Vishakapatnam - a Case Study", Indian J.Environ.Hlth, 28 (4), 284-295.

Nair, C.K.G., Varma, B.K., and Mishra, U.C., 1981, "Continuous SO_2 monitoring ambient air", Indian J. Environ. Hlth 23 (3), 179-186.

Ninova,D., and Gancheva,E., 1984, "Morphological and anatomical changes in plants under the influence of pollution from cement production", Gorskostopanska - Nauka, 21:3, (3-14).

Oleru,U.G., 1984, "Pulmonary function and symptoms of Nigerian workers exposed to cement dust", Environ. Resources 33 (2), 379-385.

Pachma, M.J., 1987, "Sources of air pollution", Atm. Polln.Edsc.Pickett,EE., 41-43.

Pandey, D.D. and Sinbahk, 1989, "Effect of cement kiln dust on chlorophyll in gram leaves ", Indian.J.Ecol 16 (7), 178-179.

Pandey,D.D., Sinha,C.S., Mishra,C.P., and Natha,R., 1992, "Response of soils of agro ecosystem to coal dust pollution", Env.Eco 10 (2), 389-390.

Pandey,D.D., Sinha,C.S., and Tiwari,M.G., 1992, "Impact of coal dust pollution on biomass, chlorophyll nutrients and grain characteristics of wheat", J. Ecobiol, 4 (1), 19-22.

Pane,V.A., and Zamora,P.M., 1991, "Leaf epidermal features of four philippine plants as indicators of cement dust pollution", Philippine Journal of Science, 120:3, 249-267.

Pastermak,P.S., 1981, "Using forests as a mean of environmental protection", Lesovodstvo-i- Agrolesomelioratisya, No:60 (7-11).

Pope,A III, Bates,D.V., and Raizenne, M.E., 1995, "Health effects of particulate air pollution: Time for reassessment", Envt.Hlth.Perspectives 103 (5), 472-480.

Prasad,M.S.V., and Inamdar,J.A., 1991, "Effect of cement kiln dust pollution on growth and yield of vigna sp", Indian.J.Ecol. 18 (2), 91-94.

Prasad,M.S.V., Subramanian,R.B., and Imamdar,J.A., 1991, "Effect of Cement kilm dust on Cajanus cajan", Indian J. Environ,Hlth, 33 (1), 11-21.

Puri,S., Singh,B., and Khosla,P.K., 1982, "Effect of cement kiln dust on sal (Shorea robusta) forest, Journal of Tree Sciences, 1:1:2, 123-127.

Rao,M.N., and Rao H.N.V., 1989, "Air Pollution", Tata McGraw Hill Publ.Co.Ltd., New Delhi, 1-315.

Rath,S., Padhi,S.K and Khar, M.R., 1996, "Effect of SO_2 exposure on bell pepper", J. Ecobiol, 8 (1), 037-040.

Sadasivan,S., and Negi,B.S., 1990, "Frequency distribution of total SPM & trace elements in air", Indian J. Environ,Hlth, 32 (3), 219-224.

Sahoo,B.N., 1991, "Occurence of trace elements in respirable coal dust", Proc.Int.Conf.Environ. Impact coal utilization, IIT, Bombay, (85-95).

Sasi,V.S., Mishra,M.P., and Mishra,G.P. 1987, "An index for the measurement of penalization of environment by pollution", Environ.Ecol. 5 (4), 798-801.

Sathiendrakumar,K., 1995, "An economic evaluation of policy options available to control industrial air pollutants", Indian.J.Env.Educ.Inf., 14 (3), 245-258.

Saxena,M.M., 1990, "Applied environmental biology 1-Resources and management", Agro botanical publishers (India), 43-51.

Sharma,J.S., and Sharma,D.N., 1982, "Atmospheric contamination of archaeological monuments in the Agra region (India)", The Sc of the total Envt., 23 (31-40).

Simpon,R.W., Jakeman,A.J., and Daly,N.J., 1985, "The relationship between the ATDL model and the statistical distribution of wind speed and pollution data", Atm.Env, 19(1), 75-82.

Singh,S.N., and Rao,D.N., 1978, "Effect of cement dust pollution onsoil properties and on wheat plants" Indian J.Environ.Hlth, 3 (20), 258-267.

Sivakumar,S., and Britto,J.D., 1995, "Effect of cement pollution on soil fertility", J.Ecotoxicol Environ. Monit, 7(2), 147-149.

Snodderly, M.Jr. 1974, "Biomedical and social aspects of air pollution in advances", Envt.Sc & Tech., Vol.3, 157.

Stern,A.C., Wholass,H.C., Bobbel,R.W. and Lowry, W.P., 1973, "Fundamentals of air pollution", Academic Press New York (53-66).

Tandan,S.K., Khadelwal,S., Jain,V.K. and Flora,S.S., 1984, "urinary Excretion of heavy metals in cement workers", Indian. J. Env. Hlth, 26 (3), 181-186.

Theodore, L., and Buonicore,A.J., 1988, Air pollution control equipment, Volume I - Particulates, CRC Press Inc., Boca Raton Florida, (1-163).

Tripathi,B.D., Tripathi, A.J., and Srivastava,J., 1990, "Studies or tissue permeability of rice and bean plants to some air pollutants", Indian J. Environ.Hlth, 32 (4), 377-382.

Trivedy,R.K., Goel P.K., and Trisal,C.L., 1987, "Practical methods in ecology and environmental Science", Environmental publications, Karad, India, (179-195).

Vekeny,H., 1988, "Three stage measuring instrument for dust measurements in the mining industry", Staub Reinhalt Luft, 48 (12), 459-462.

Vora,A.B., and Bhatnagar,A.R., 1987, "Comparitive study of dust fall on the leaes in high pollution and low pollution area of Ahmedabad cause foliar injury", J. Environ. Biol, 8 (4), 339-346.

Voron,V.P., 1986, "Effect sof cement dust on woody vegetation", Lesovodstvo-i-Agrolesomelioratsiya, 72, 41-45.

Voron,V.P., 1984, "Pollution of grey forest soils with alkali and alkaline - earth metals in an area affected by cement dust emissions", Lesovodstvo-i-Agralesomelioratsiya, 68, 27-31.

Voron,V.P., 1979, "The effect of industrial air, pollution on the health of forest plantations in the carpathian foot hills", Lesovodstvo-i-Agrolesomelioratsiya, No.53, 53-57.

Wachasunder,S.D., Pawar,M.B., Pandya,G.H., Dhagess, Dolas,P.G., and Iyer, M.G., 1995, "Characterisation of trace elements in SPM by instrumental neutron activation analysis", Indian J.Environ Hlth, 37 (3), 166-171.

Werner Strauss, 1978, "Air pollution control part III", Measuring and monitoring air pollutants", Wiely Inter Science Publication, vii-viii (1-519).

Westman,W.E., 1985, Eco-impact assessment and environ. planning, John Wiley and Sons, New York, 532.

Yenwar,P.K., Dixit,S.N., Pampattiwar,V.K., Dave,J.M. and Araievella,S.J., 1970, "Short term air quality surveys in four major cities in India", J.Environ.Hlth, 12 (355-383).

Zaferigbal,M., 1988, "Deposition of airborne cations and anions in the vicinity of polluted area", Indian.J.Ecol, 15 (1-6).

Zutshi,P.K., Mahadevan, J.N., Vaidyanathan, M and Sathe,A.P., 1978, "Studies on SO_2 and a few other pollutants in air and in rain water", Indian J. Environ. Hlth, 20 (1), 14-28.