Effect of Smokes of Thermal Power Stations on Terrestrial Plants.

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Abstract

The experiment was conducted to know the effect of smokes of thermal power stations on terrestrial vegetation to adjacent area of KTPS, of Nagpur District(M.S)It was reported that in Azadirachta indica and Dalbergia sissoo, the stomatal index (SI), stomatal frequency (SF) touched the minimum up to the site III. The concentration of total chlorophyll was lowest upto site III and recovered thereafter. Carotenoid content also exhibited a similar trend. The total chlorophyll content was severely affected by air pollutants. But the only genus Prosopis juliflora does not exhibit and prominent effect on stomatal index, stomtatal frequency, total chlorophyll and carotenoid concentration. The results of heavy metal contents indicated a significantly different heavy metal uptake pattern. The plant species P. juliflora showed a significantly higher Fe uptake than that of observed with other two species. The estimated inter plant heavy metal uptake variation between selected plant species was significantly (ANOVA, $P < 0.05$) different. The results obtained during this study showed that P juliflora was higher metal uptake capacity indicating its possible use as a biomarker for early detection of heavy metal pollution due to various industrial activities.

Key words : Environment, effect, Stomatal index, Stomatal frequency, Chlorophyll content and Carotenoids, Azadirachta indica and Dalbergia sissoo, P. juliflora, smokes, Power stations, Terrestrial plants.

Introduction: -

The atmosphere, is a dynamic system that continuously absorbs a wide range of solids, liquids, and gases from both natural and man-made sources. These substances travel through air, disperse, and react with one another and with other substances both physically and chemically. Maximum of these constituents, naturally find their way and deposits in an ocean, or to a receptor such as soil. Some substances such as helium, however, escape from the biosphere. Others such as carbon dioxide may enter the atmosphere faster than they enter in a reservoir and thus gradually accumulate in the air.

A clean, dry air contains 78.09% nitrogen by volume and 20.94% oxygen. The remaining 0.97% is composed of gaseous mixture of carbon dioxide, helium, argon, krypton, nitrous oxide and xenon, as well as very small amounts of some other organic and inorganic gases whose amount in the atmosphere vary with time and place. A variable amount of contaminants continuously enter the atmosphere through both natural and human processes that exist upon the earth. This portion of these substances which interacts with the environment to cause toxicity, disease, discomfort, illness, physiological effects or environmental decay, has been labelled by man as a ‘pollutant’.

In general, the action of people are the primary cause of pollution and as the population increases, proportionate amount of problems also increases. The first significant change in man’s effect on nature came with his discovery of fire. Prehistoric man built a fire in his cave for cooking and heating provides light. The problem of air pollution came in to existence at that time.

The British Parliament passed an act in 1273, forbidding the burning of coal in London because it was beginning to choke the atmosphere. In 1300, King Edward I issued a royal proclamation, "Whosoever shall be found guilty of burning coal shall suffer the loss of his head." In 1306, a man was executed for violating this regulation. Later, the law fell into disuse as the industrial revolution took place in England.

A pollution is basically the presence of foreign substances in air. Some specific definition of air pollution are given below.

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

-Engineers Joint Council (U.S.A.)

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

-Indian Standard Institution-IS 167 (1966).

Air pollution is the excessive concentration of foreign matter in the air which adversely affect the well being of the individual or causes damage to property.''

-American Medical Association

Since air pollution has been mainly caused by rapid industrialization'. In some western countries, some critics comment on air pollution as 'the price of industrialisation'. Air pollution caused by automobiles has been described as the 'disease of wealth'.

Air pollution means different things to different people. To the house holder it may be an eye irritation and soiled clothing, to the farmer damaged vegetation, to the pilot dangerously reduced visibility and to industries problem of process control and public relations.

Further, the problem of air pollution varies from place to place. For example, air pollution in Tokyo is not the same as that in Bombay.

Today, the natural terrain that surrounds large cities is recognised as having a significant bearing on the problem of air pollution. However, this is not an altogether new concept either. Historians tell us that Los Angeles which in recent year has become a national symbol of comparison for excessive smog levels, was known as the 'valley of smokes' when the Spaniards arrived there.

It has been found that a significantly increasing volume of particulate matter entering the atmosphere scatters the incoming sunlight. This reduces the amount of heat that reaches the earth and tends to reduce its temperature. The decreasing mean global temperature of recent years has been attributed to the rising concentration of airborne particles in the atmosphere. A counter acting phenomenon commonly referred to as the "green house effect" is caused by the increasing amount of carbon dioxide found in the atmosphere. It has been estimated that if the carbon dioxide content in the atmosphere generated in combustion processes continues to increase at the present rate, the mean

globle temperature could rise by 4°C in the next five decades. There has been conjecture that this might become a matter of great importance because small temperature increase could cause a partial melting of the ice caps of the earth causing continental flooding and devastating effects on man.

Air pollution can cause death, impair health, reduce visibility, bring about vast economic losses and contribute to the general deterioration of both our cities and countryside. It can also cause intangible losses to historical monuments such as the Taj Mahal which is believed to be badly affected by air pollution.

On account of large scale industrial activities in advanced countries notably the USA, UK, and other European countries, fall of acid rain had been reported in Scandinavia. This has reduced forest growth in Scandinavia. In Canada, thousands of lakes have been destroyed due to acid. Apart from the international issues involved, the basic ecology is affected. Large scale deforestation apart from creating an imbalance in the oxygen proportion of the atmosphere, affects the weather and rain patterns as well. Industrial activity, particularly in thermal power stations, cement plant, oil refineries, petrochemical complexes, metallurgical industries, steel plants and fertilizers complexes, causes major problems in air pollution. The effect of air pollution is felt more by the elderly and chest and respiratory complaints are very common among them. Tragic instances of death have also been reported in air pollution episodes such as London smog of 1952, and the Bhopal gas tragedy of 1984.

The environment commonly means the surrounding but in context of life, it means much more. Life could originate and flourish on earth only because this environment of this planet and provides the necessary conditions for it. All organisms, i.e. microbes, plants and animals including man, depend upon the environment for their sustenance. Thus environment is the sum total of all biotic (living) and abiotic (nonliving) factors that surround and potentially influence an organism. Every organism lives in the midst of various living and non-living objects, events and influences. Some components of the environment act as resource, while others acts as a regulatory factors.

The environment and the organisms are both products of a continuing process of reciprocal change. Each plant or animal species of today is the outcome of millions of years of biological evolution, and any form of life once lost cannot be recreated. Thus, all existing living forms including man are related somehow to one another through common ancestry.

Pollution of our environment has become a serious problem due to rapid rate of increase in the human population, the space on earth available to each man is getting smaller. Needs of a man now increasing day by day and their fulfilment brought about the disaster of natural wealth and it facilitates in the increase the pollution. Pollutions are of various types but among the main are types the air, water and soil. Due to more advancement of industrialisation, the earth is to be more polluted.

Pollution in our world affects two essential aspects of our planet, air and water. Although their pollutants are emitted in completely different ways, they both harm living organisms. Air pollution is predominantly emitted through the exhaust of thermal power plant (coal based), motor vehicles and combustion of fossil fuels. Our society knows that pollution is harmful and a serious problems for the earth but generally peoples do not care. Nevertheless, everybody needs to contribute to prevention and pay attention to government control in the amount of material large industries can emit pollutants into the air or water. Industry gives off a good share of the waste that is polluting our planet, but it is every person is contributes as well. Government involvement is a key to regulating

toxins building waste systems and protecting air and water. Effect of air pollutant on terrestrial vegetation. A large amount of information has been generated about the response of plant to air pollution. Plants are living organisms and hence are prone to suffer toxicity of air pollutants as in other organism. Still, they are expected to scavenge pollutants from the ambient air through the limited capacity they possess for sorption, and neutralize the absorbed pollutants. Major primary pollutants of industrial origin are considered here. To see the environmental impacts on the plants, of air pollutants on from select dominant plants to coal smoke pollution, the present study was undertaken.

Venkataramana et al.,(2011) reported the land degradation problems and may cause potential environmental hazards in spreading diseases and leaching of unwanted chemicals in to ecosystem.

Urone, (1976) reported the level of 1.9ug m^{-3} No_2 that of N_20 may be as 450ug m^{-3} Mudd, (1973); Zeevart, (1976) reported that absorption of N0x across the stomatal apertures reacts on cell walls to form HN_20 and HNO_3. HNO_2 is more phytotoxic. Coal is a primary source of SO_x. About 97 to 99% of SO_x emitted from combustion sources is in the form of sulphur oxide which is a critical pollutant, the remainder is mostly SO_3 which combines with atmospheric water and transform into sulphuric acid, at higher concentrations, produce deleterious effects on the respiratory system. SO_2 is phytotoxicant. Kellogg et al.,(1972) reported the background(0.001) ugL^{-1} level of SO_2 in the atmosphere. Helbwachs,(1983) estimated the 10^9 million metric tonnes(mmt) of SO_2 to be added in the earth's atmosphere every year. Kumar and Upadhyay,(1981) reported the 6.76 mmt of SO emission in 1976 and was expected the 13.19 mmt SO_2 emission by the turn of this century. SO_2 is water soluble gas. It enters in plants mainly through the stomatal apertures, cuticle and was on the leaf epidermis finally it passes into the intercellular spaces of mesophyll cells and it gets absorbed on the wet cell walls and finally diffuse gradually into the cell sap (Katabe, 1976). Winner and Mooney,(1980) shown the absorption of SO_2 by mesophyll tissue of leaf is proportional to the stomatal conductance and diffusion of SO_2 to the cell sap is a function of its water solubility, which is fairly high.

The adverse effect of SO_2 on chlorophyll pigments leads to reduced productivity and may be consider fewer than two cellular pH conditions. At pH 2.2 to 3.5 SO_2 displace the Mg^{2+} from chlorophyll molecule to degrade and from phaeophytin molecule, a non-photosynthetic brown pigment(Rao and Blanc, 1966). Oxidation of carotenoids takes place by SO_2 through generation of O_2 from HSO_3^- above pH 3.5(Pieser and Yang, 1978).

1. $2SO_2 + O_2$ ------ Æ $2 SO_3$
2. $SO_3 + H2O$ --- Æ H_2SO_4

Hydrogen Fluoride :

Combustion of fossil fuels, smelting ores like bauxite and reduction of phosphatic rock release hydrogen fluoride. Fluoride enters leaf through stomata and from the intercellular spaces of mesophyll, diffuses into vascular tissues. It moves along transpiration stream towards leaf tips and margins, where accumulation takes place. Accumulation of HF causes visible injury like chlorosis of leaf tip and veins. Injured, brown or dead areas of leaves become necrotic, leading to premature leaf fall (Weinstein, 1977).

It is, therefore, a matter of great importance that engineers of all disciplines consciously integrate into their designs sufficient constraints and safeguards to ensure that they do not contribute to air pollution. In addition, they must apply their ingenuity and problem-solving abilities to eliminate air pollution where it exists and restoring the natural environment.

There are three methods of identifying air pollution

1. Sensory recognition

2. Physical measurement of pollution

3. Effects on plants, animals, and buildings.

These methods are widely used and they have their merits and demerits.

1. Sensory recognition- Usually the first awareness of an air pollution problem is through some effects on the individual. These are:

(a) Strong or unusual odours

(b) Reduction in visibility

(c) Eye irritation

(d) Acid taste in the mouth

(e) Feel of grit under foot

These are highly subjective phenomena and vary from individual to individual.

2. Physical measurement- While sensory perception may provide the first indication of the presence of most of the contaminants in the air, it is often not possible to detect trace quantities of many harmful toxic substances or the presence of radioactive matter through the senses. Their identification requires physical measurement by standard methods of sampling and analysis.

3. Effect on plant, animals and buildings- Effects of air pollution can be observed on the growth of the plants and health of animals. Similarly, its deleterious effect on buildings can also be observed. Thus plants, animals, and buildings act to some extent as indicators of certain atmospheric impurities. These and other aspects of air pollution are dealt with in detail in the subsequent chapters.

In our study we have employed third method i.e. effect on plant, animals and buildings.

Materials and Methods :

Koradi Thermal Power Station (KTPS)

The study was carried out around the Koradi Thermal Power Plant Station, located on the Nagpur-Chhindwada road, Maharashtra (21°56.51” N;79°05’55.13” E). This power plant consists of 7 power station units (4 units 120 MW each, 2 units 210 MW each and 1 unit 200 MW) having capacity 1100 MW. Outline structure of Koradi Thermal Power Station (KTPS) was shown in figure 4.1 and plate 4.1.A Satelite picture of KTPS, Koradi from Google Earth plate 4.2. Study area experiences a dry tropical monsoon type climate. The year comprises of 3 principal seasons. In winter mean temperature ranges from 8 to 21°C. The mean of RH is 60%. The temperature arose during the

pre monsoon season, the mean minimum and mean maximum being 37.0°C respectively. The temperature decreased whereas the relative humidity increased during the post monsoon period. The soil of the region is sandy loam, fertile and shows a low resistance to erosion.

Sampling Sites :

The fuel mainly used in the KTPS is lignite that is available in the region but that has a low thermal value. The average coal consumption is 15,173 tonnes day-1. To study the target effect of select dominant plant to coal smoke pollution on foliar parameters viz. stomata index, stomata frequency, total Chlorophyll, carotenoid are studied. Study also carry out to assessed accumulation of heavy metals in select plant leaves sampled from the surroundings of Koradi Thermal Power Plant.

Site I :

It is 1.0 Km from southwest direction of the Koradi Thermal Power Station (KTPS). The commonest plant observed was e.g. Acacia leucophloea, Prosopis juliflora, Dalbergia sissoo, Azadirachta indica, Butea monosperma, Acacia nilotica, and Ziziphus mauritiana etc.

Site II :

It is 2 km from the southwest direction of the KTPS. The commonest plant observed was e.g. Mangifera indica, Delonix regia, Prosopis juliflora, Dalbergia sissoo. Azadirachta indica, Butea monosperma, Acacia, nilotica, Pithecellobium dulce, Ziziphus mauritiana, and Peltophorum sp., etc.

Site III :

It is 3.5 Km from southwest direction of the Koradi Thermal Power Station (KTPS). The commonest plant observed was Delonix regia, Pithecellobium dulce, Prosopis juliflora, Dalbergia sissoo, Azadirachta indica , Eucalyptus sp., Cassia fistula, and Syzygium cumini, etc.

Site IV :

It is 5 Km from southwest direction of the Koradi Thermal Power Station (KTPS}. The commonesty plant observed was Prosopis juliflora, Dalbergia sissoo, Azadirachta indica, Cassia siamea, Delonix regia, Butea monosperma, Bauhinia variegate, and Ziziphus mauritiasna, etc.

Site V :

It is 10 Km from southwest direction of the Koradi Thermal Power Station (KTPS). The commonest plant observed was Prosopis juliflora, Dalbergia sissoo, Azadirachta indica, Syzygium cumini, Pithecollobium dulce, Butea monosperma, Delonix regia, Eucalyptus sp., and Acacia nilotica, etc.

A control site was also selected at a distance of 15km south of KTPS is seminary hills and nearby areas. The study being carried out from (April 2006 to October – 2007). Quarterly sampling of leaves were conducted to observe the effect of air pollutant on select dominant plants, Dalbergia sissoo, Azadirachta indica and Prosopis juliflora,.

Sampling Method :

Select dominant plants of almost uniform age leaves samples were randomly collected in time period between 11 A.M – 12 noon O' clock form 5 sites, i.e. (1.0 km away from the

source of emission), II (2 km away), III (3.5 km away), IV (5 km away) and V (10 km away) and control site (unpolluted) were selected at seminary hills and related area (15km away south of KTPS in the opposite direction).

As soon as the plant collected from the site they were examined in the laboratory so also their total chlorophyll content and total carotenoids were also analyse..

Observations :

Description of Select dominant plants :

Azadirachta indica :

Family: Meliaceae

Common name : Neem

Description: An esteemed evergreen plant native to the Indian subcontinent. Neem are very much medicinally important Aqueous of neem seeds, bark or leaves exhibit potent immune stimulant activity through both humeral and cell-mediated response . Neem derivatives are very useful in hyperglycemic, anti-inflammatory, anti-infective, and anti-nematodal effects, Neem contain azadirachtin and nimbicidin like alkaloids.

Dalbergia sissoo

Family: Fabaceae (Leguminosae)

Common name: Indian rosewood or shisham

It is a medium to large deciduous tree. Leaves are leathery, alternate, pinnately compound and about 15cm long Pods are oblong, flat, thin, strap-like 4 – 8cm long, 1cm wide and light brown. The tree has many reputed medicinal properties and have been used culturally for a variety of ailments including skin diseases, syphilis, stomach problems, dysentery, nausea, eye and nose disorders, aphrodisiac, expectorant, among others (Duke, 1983).

Prosopis juliflora :

Family: Leguminosae

Common name : Vilayati Babul

Description :

Prosopis juliflora is a fast growing nitrogen fixing species tolerant to arid conditions and saline soils. It can produce valuable goods including construction materials, charcoal, soil conservation and rehabilitation of degraded and saline soils. It has survived where other trees species have failed and in many cases has become a major nuisance. P. juliflora have several medicinal properties showing improve children weight deficiencies or retardation in motor development. P. juliflora syrup is considered to increase lactation in breast-feeding. P. juliflora syrup is used in preparation of expectoration purpose. Coffee prepared from P. juliflora pods and is considered good for digestive disturbances and skin lesions.

Estimation of Stomata frequency and stomata index.

Stomatal frequency and stomatal index:

For the experimentation epidermal peels were obtained by the method of Ghouse and Yunus,(1972). Pieces of about one cm2 cut out from the region between midrib and leaf margin around the middle part of the leaf lamina were taken with 70% HNO_3 in the test tube and heated gently until the epidermal peels has been separated from the mesophyll tissue. The peels, washed with tap water, were stained with safranin and mounted in Canada balsam for microscopic study. Twenty five randomly selected microscopioc field areas from five leaves were counted per plant to obtain stomatal and epidermal cell frequency.

Stomatal frequency (SF) and stomatal index (SI) were calculated according to the formula of Salisbury (1927).

Stomatal frequency (SF) = $\frac{\text{Number of stomata}}{\text{Number of epidermal cells}} \times 100$ (Timmermann 1927)

Stomotal index (SI)= $\frac{S}{E + S} \times 100$ (Salisbury,1972)

Where,

S= Number of epidermal cells per unit leaf area.

E = Number of epidermal cells per unit leaf area.

Procedure for pH measurement :

pH in soil – water suspension (Jackson, M.L. 1967)

Take 10g of soil sample in 50 or 100 ml beaker. Add 25 ml of distilled water and stir well for about five minutes and keep for half an hour. Again stir just before immersing electrodes and take pH reading by pH meter. In acid soils pH normally ranges from 4 to 5 and in calcareous ones between 6.9 and 7.2. The pH of near neutral soil in CO_2 solution is usually around 6.0.

Electrical conductivity (EC) :

Electrical conductivity of a solution is directly related to its ion content. The measurement of EC gives the concentration of soluble salts in the soil at any particular temperature.

For classification purpose the conductivity of saturation extracts of soil is used however, extraction of solution from a saturated paste is a difficult process. As an approximation, the conductivity of the water extract from a 1:2:5 soil: water suspension is determined, and the conductivity of the saturation is calculated as.

$$\text{E.C (Saturation extract)} = \text{E.C.1:2:5ext} \times \frac{250}{\text{Saturation \%}}$$

The instrument used is conductivity meter and EC is expressed is millimhos or millisiemens (ms) per cm or dsm^{-1}.

Electrical resistance is defined by the equation

E = IR

Where, E is the electrical potential (in volts)

I is thecurrent (in ampheres)

R is resistance (in ohms)

Electrical conductance C, or conductivity of a solution in mhos is the reciprocal of resistance R, in ohms.

C = I/R

Standardization of EC meter :

Conductivity cell shows individual deviation; hence it is necessary to calibrate the conductivity meter before use. The calibration of the conductivity meter is made with 0.01N KCI solution. It is prepared by dissolving 0.7456g of dry potassium chloride (A.R.) grade in distilled water and makeup the volume up to one litre. At 25°c it gives an electrical conductivity of 1.41mmhos/cm or 1.41ds m^{-1}.

Procedure (Jackson, M.L. 1967)

Weigh 20gm soil in to a 100ml beaker add 40ml distilled water and stir at regular interval. Allow it to stand until clear supernatant liquid is obtained. The clear extract after pH measurement can be observed for EC measurement. Calibrate the conductivity bridge with the standard KCI solution and determine the cell constant.

Determine the conductivity of the supernatant liquid with the help of the conductivity bride.

Significance Level :

The significance level was chosen to be 0.05 (or equivalently, 5%) by keeping in view the consequences of such an error. That is, we want to make the significance level as small as is possible order toprotect the null hypothesis and to prevent, as far as possible, from inadvertently arriving at false conclusions.

Observation Table :

Table 1.The composition of lean dry air, and the approximate total mass of different atmospheric constituents

	Concentration (Volume Percent)	Total Mass (Millions of Tons)
Major Components		
Nitrogen (N_2)	78.09	4,22,000,000
Oxygen(O_2)	20.95	1,290,000,000
Argon(Ar)	0.93	72,000,000
Carbon dioxide(CO_2)	0.032	2,700,000
Minor Components		
Neon (Ne)	0.0018	70,000
Helium (He)	0.00052	4,000
Methane(CH_4)	0.00015	4,600
Krypton (Kr)	0.0001	16,200
Hydrogen(H_2)	0.00005	190
Nitrous oxide (N_2O)	0.00002	1,700
Carbon monoxide (CO)	0.00001	540
Xenon(Xe)	0.000008	2,000
Ozone(O_3)	0.000002	190
Ammonia (NH_3)	0.0000006	21
Nitrogen dioxide (NO_2)	0.0000001	9

Nitric oxide(NO) Sulphur dioxide (SO_2) Hydrogen sulfide (H_2S)	0.00000006 0.00000002 0.00000002	3 2 1

(WWW: Wikipedia.com)

Table 2. Air quality in major cities in India.

City (Location)	Concentration (µg/m^3)		
	Sulphur dioxide (SO_2)	Nitrogen dioxide (NO_2)	Respirable Suspended ParticulateMatter(RSPM)
National Standard	80	80	100
Chennai (Adyar)	7	12	94
Delhi (B.S.Z.Marg)	7	70	133
Mumbai (Sion)	35	103	293

Source : CPCB, NEW Delhi , 2007

Table 3. Average Quantities of SO_2 liberated during different types of Industrial activities.

Major Sources	SO_2 emission factor (in Kg)
Combustion of coal	4.536 per 1000 kg coal (Variable)
Combustion of fuel oil	9.9 per 10,000 L oil (Variable)
Municipal incineration	0.544 - 0.907 per 1000 kg refuse
Sulphuric acid manufacture	9.07 - 3.75 per 1000 kg 80% acid
Cu smelting (primary)	635.04 per 1000 kg conc. ore.
Pb smelting(primary)	299.376 per 1000 kg conc. ore.
Zn smelting(primary)	494.424 per 1000 kg conc. ore.

(Source: Kumar and Prakash,1978)

Table 4.Amount of SO_2 emitted by burning different types of fuels

Fuel	SO_2 emission in kg per tones of fuel
Firewood	20
Coal	6 to 15.0
Oil	6 to 7.6
LPG	0.0002 to 0.008
Natural Gas	0.2
Petrol	5.4
Diesel	5 to 6

(Source : Kumar and Prakash,1978.)

Table 5. Fossil fuels share in carbon emission and energy generation.

Fuel	Share of energy generation (%)		Share of carbon emission (%)	
----------	India	World	India	World
Coal	55	20.3	69.78	41.2
Oil	30.5	41.3	26.31	42.65
Natural gas	7.0	21.1	3.9	16.12

Table 6. Solubilities of pollutant gases in water.

Pollutant	Solubility at 20^0 gas ml^{-1} H_2O
CO	0.02
NO	0.05
CO_2	0.88
PAN	-----
O_3	0.26
NO_2	Decomposes
Cl_2	2.30
SO_2	39.40

HF	446

(Source : Hill and Chamberlain, 1974.)

Table 7. Number of mines in India on 2003

Source: http://www.coal.nic.in/welcome.html

STATES	TOTAL
COAL:	
ANDHRA	67
ASSAM	6
CHHATTISGARH	58
J & K	4
JHARKHAND	169
MADHYA PRADESH	75
MAHARASHTRA	50
MEGHALAYA	1
ORISSA	23
WEST BENGAL	100
UP	3
TOTAL COAL	556
LIGNITE:	
GUJARAT	3
TAMIL NADU	2
RAJASTHAN	1
TOTAL LIGNITE	6
TOTAL COAL + LIGNITE	562

Table 8. Coal reserves by category (MT) in India as on 01 January 2001

Coal type	Proved	Indicated	Inferred	Total
Coking				
Prime coking	4614	699	–	5313
Medium coking	11,294	11,296	1036	23,626
Blended/semi-coking	482	907	221	1610
Subtotal	16,390	12,902	1257	30,549
Non-coking[@]	68,024	85,644	36,766	190,434
Total	84,414	98,546	38,023	220,983

Source: Ministry of Coal, India, 2001. includes coal of Northeastern region also.

Table 9: Coal Demand Forecast (Million tonnes)

Sector	Estimated Coal Demand			
	1996-97*	2001-2002	2006-2007	2009-2010

Power	199	285	400	500
Steel	25.53	49	60	68
Consent	11.34	21	30	37
Others	50.57	61	75	85
Total	286.46	416	565	690

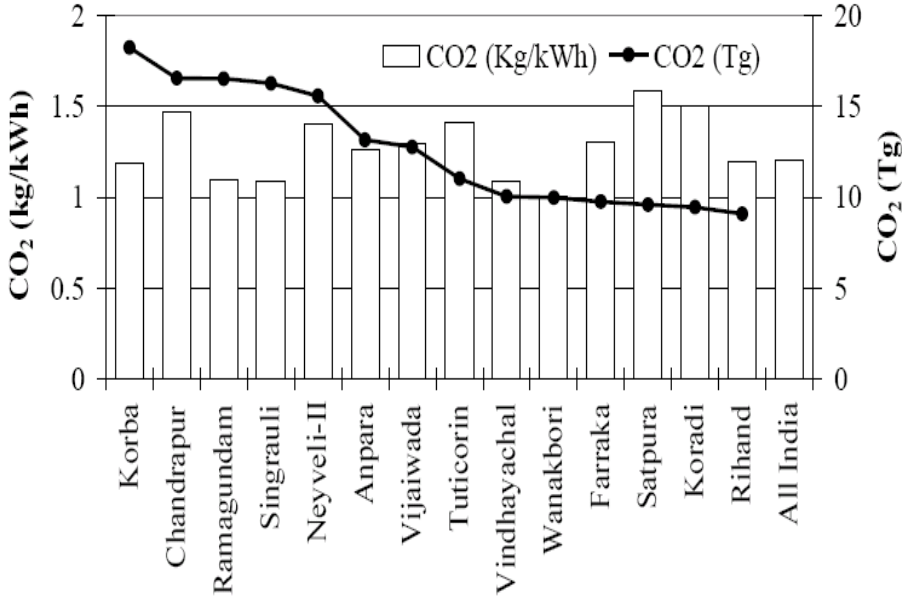
* Actual Coal supplied.

Table 10. Consumption of coal in power sector

Year	**Coal consumption (million tonnes)**	**Electricity installed capacity (MW)**
1995-96	184.52	58675
1996-97	199.00	60,000
1997-98	212.92	63038
1998-99	208	67000

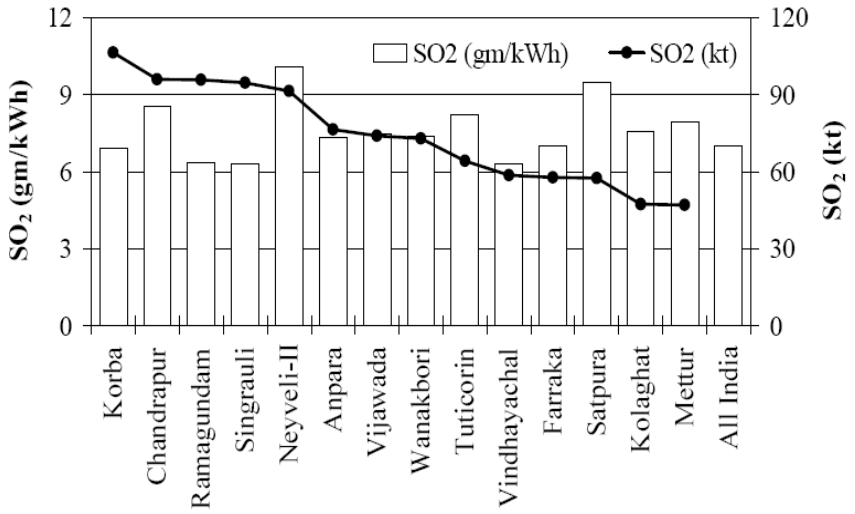
(A newsletter from C.P.C.B. June, 2000)

Table 12. CO2 emissions from largest power plant.



(Source: Indian Institute of Management, Ahmedabad, India)

Table 13. SO2 emissions from largest power plants



(Source: Indian Institute of Management, Ahmedabad, India)

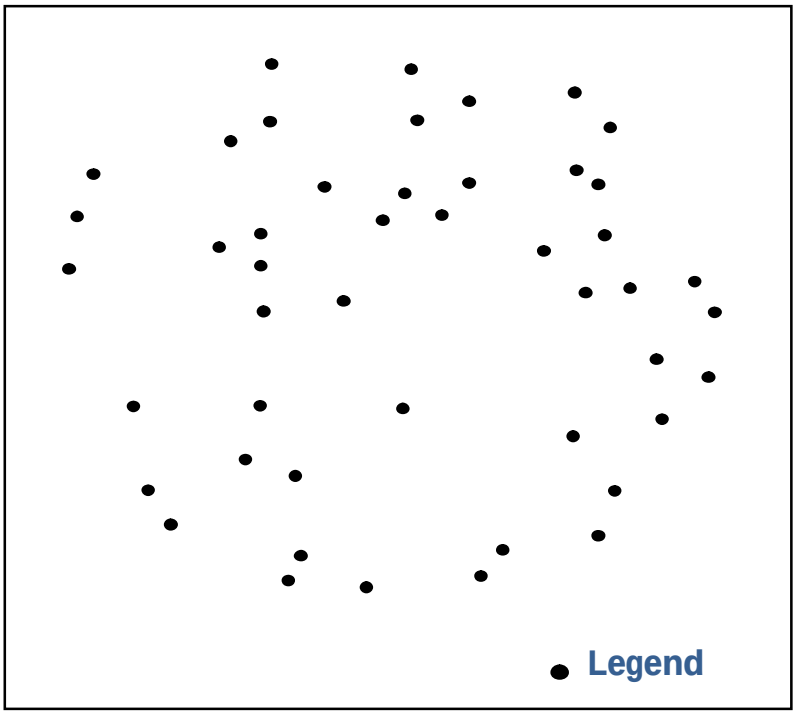


Fig1. An area around Koradi Thermal Power Station (15 km radial distance)

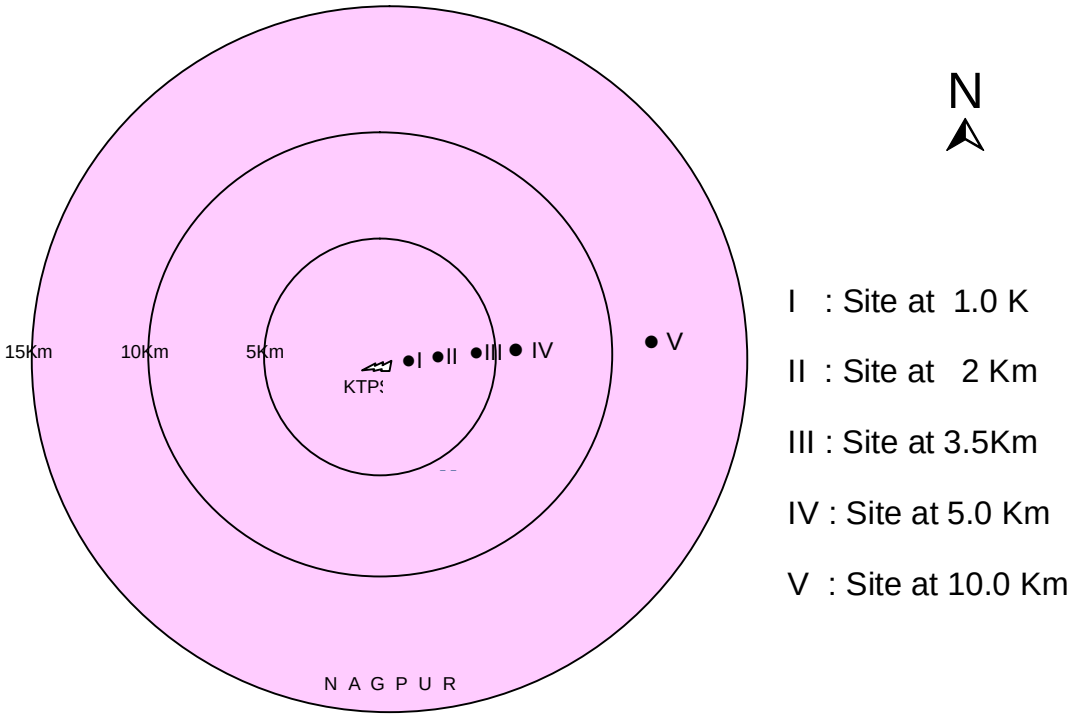


Fig 2.Sampling site around Koradi Thermal Power Station, Koradi .

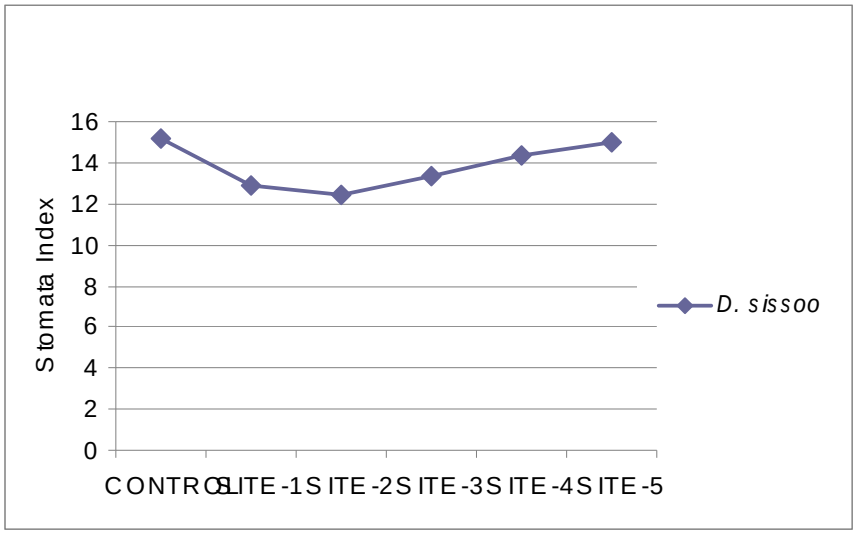


Fig. 3 a. Estimation of Stomatal Index of select Dalbergia sissoo plants at different sites around KTPS and Control site.

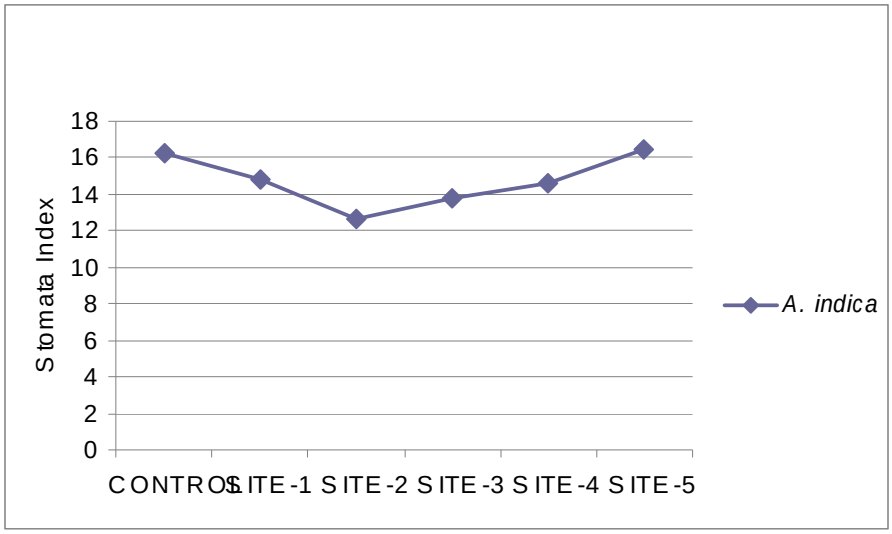


Fig. 3 b. Estimation of Stomatal Index of select Azadirachta indica plants at different sites around KTPS and Control site.

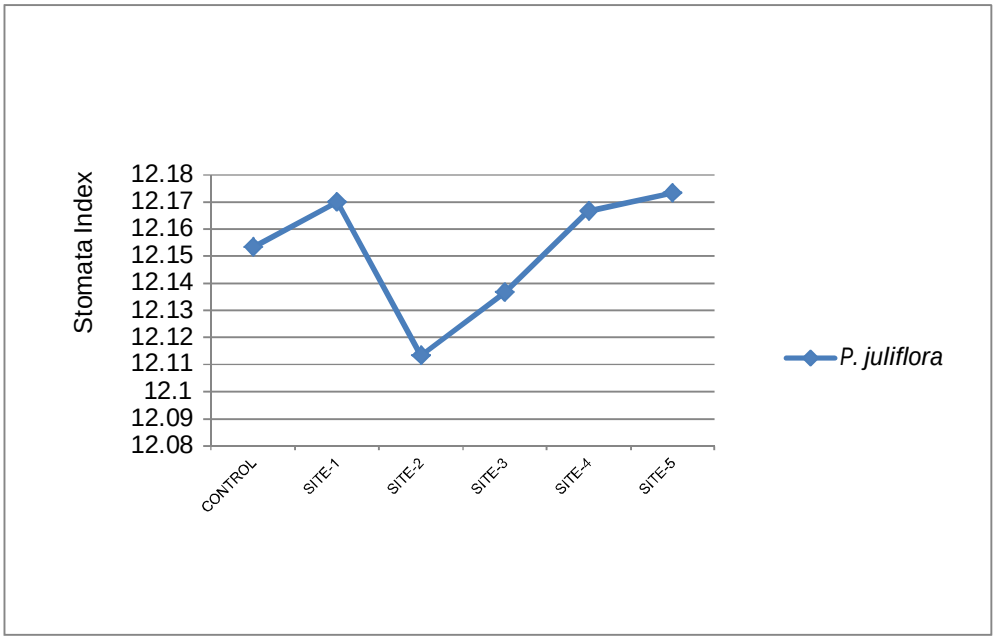


Fig. 3 c. Estimation of Stomatal Index of select Prosopis juliflora plants at different sites around KTPS and Control site.

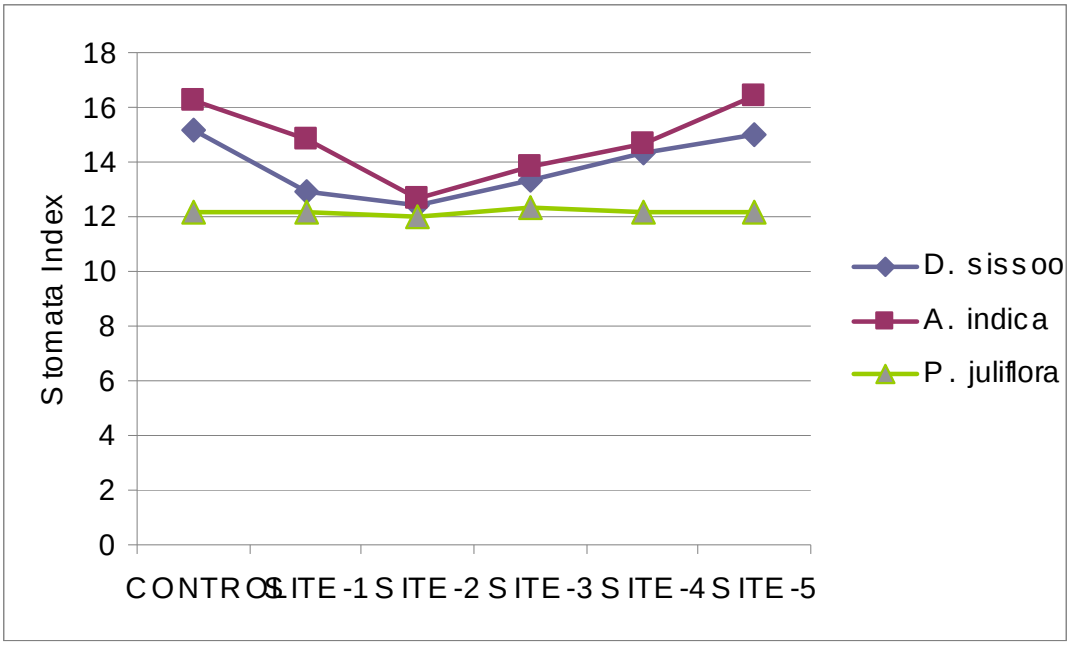


Fig. 3 d. Comparison of Stomatal Index of select dominant plants at different sites around KTPS and Control site.

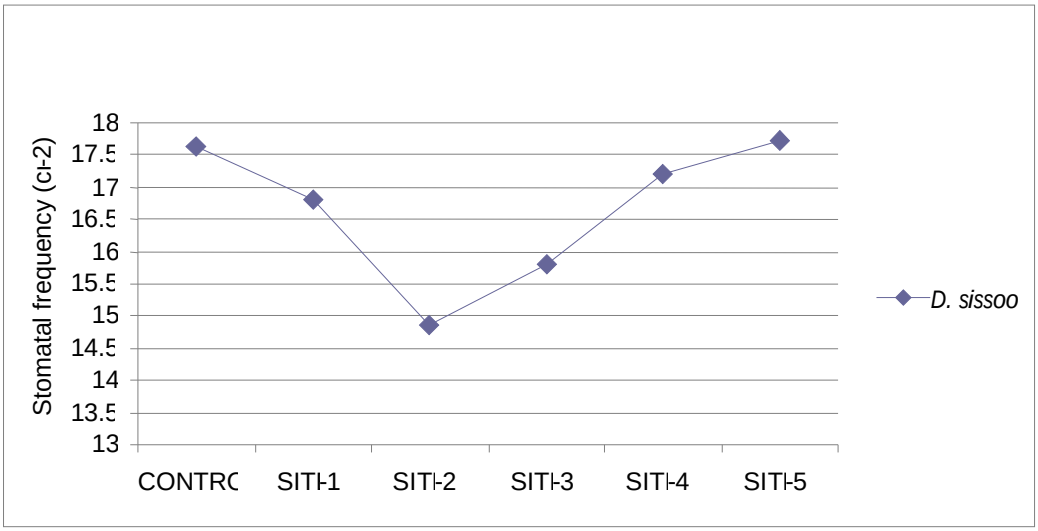


Fig. 4 a. Estimation of Stomatal Frequency of select Dalbergia sissoo plants at different sites around KTPS and Control site.

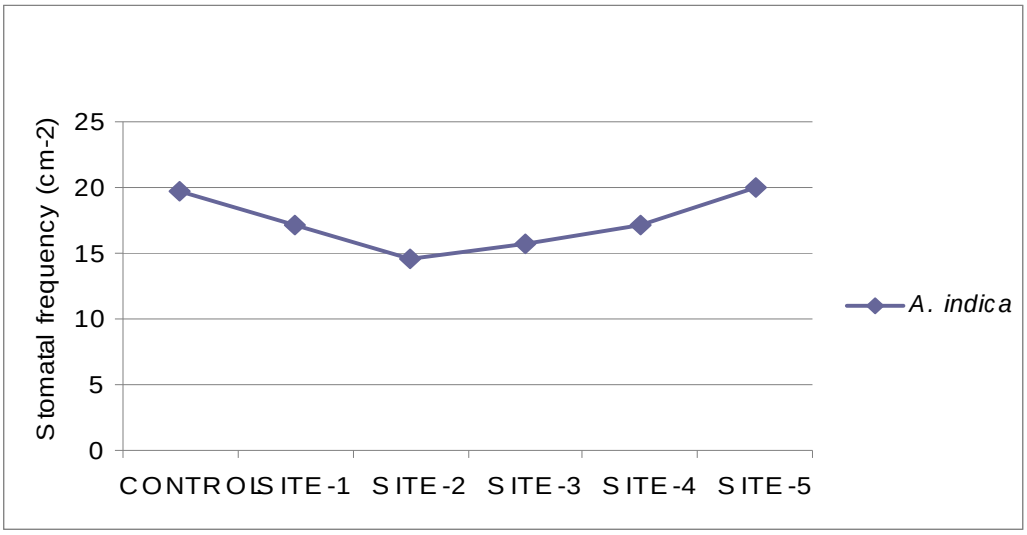


Fig.4 b. Estimation of Stomatal Frequency of select *Azadirachta indica* plants at different sites around KTPS and Control site.

Fig.4 c. Estimation of Stomatal Frequency of select Prosopis juliflora plants at different sites around KTPS and Control site.

Fig.4 d. Comparison of Stomatal Frequency of select plants at different sites around KTPS and Control site.

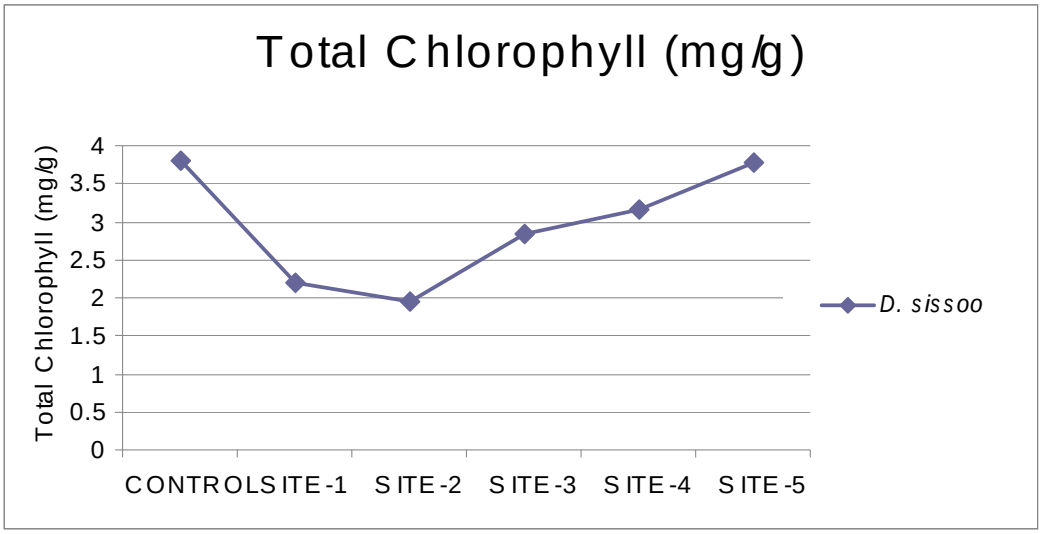


Fig. 5 a. Estimation of Total Chlorophyll of Delbergia sissoo plants at different sites around KTPS and Control site.

Fig. 5 b. Estimation of Total Chlorophyll of *Azadirachta indica* plants at different sites around KTPS and Control site.

Fig. 5 c. Estimation of Total Chlorophyll of *Prosopis juliflora* plants at different sites around KTPS and Control site.

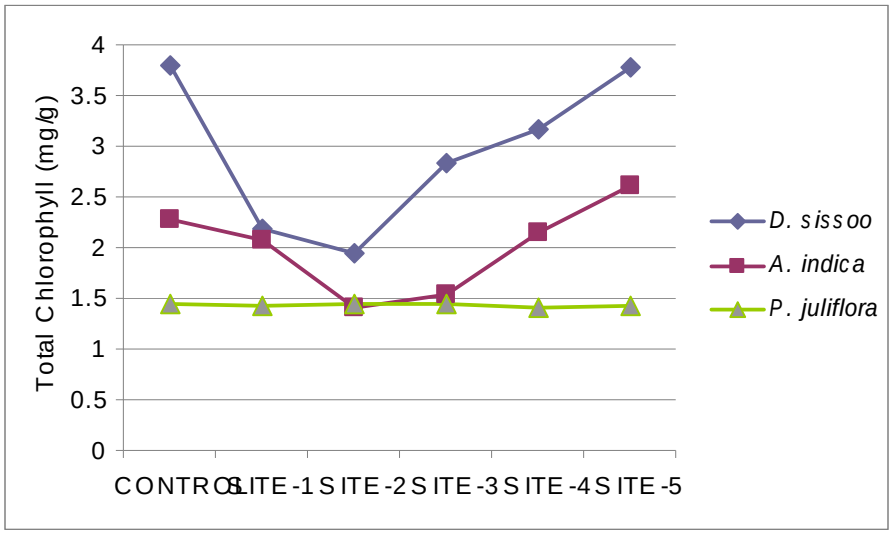


Fig. 5 d. Comparison of Total Chlorophyll of select plants at different sites around KTPS and Control site.

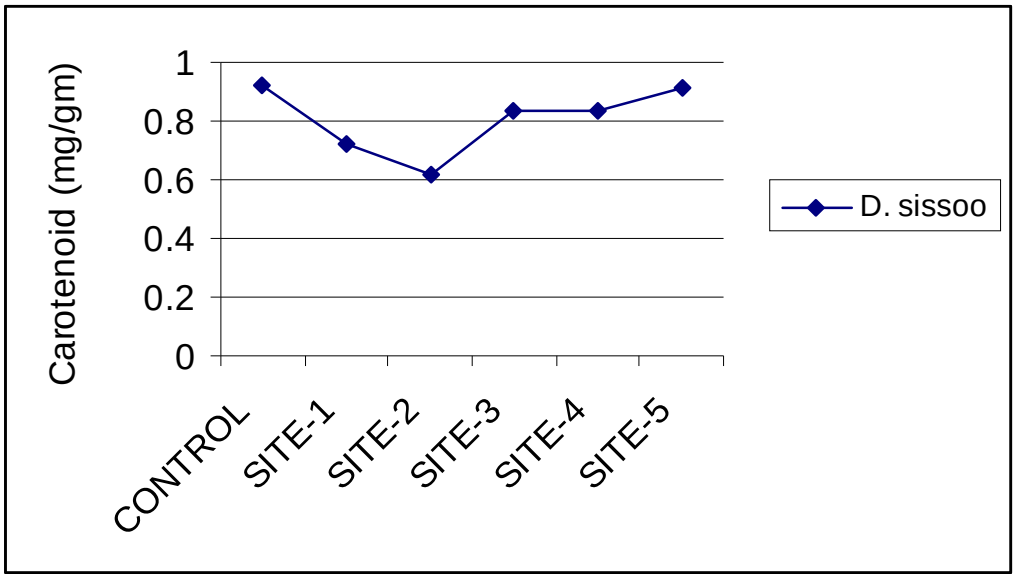


Fig. 6 a. Estimation of Carotenoid of select *Dalbergia sissoo* plants at different sites around KTPS and Control site.

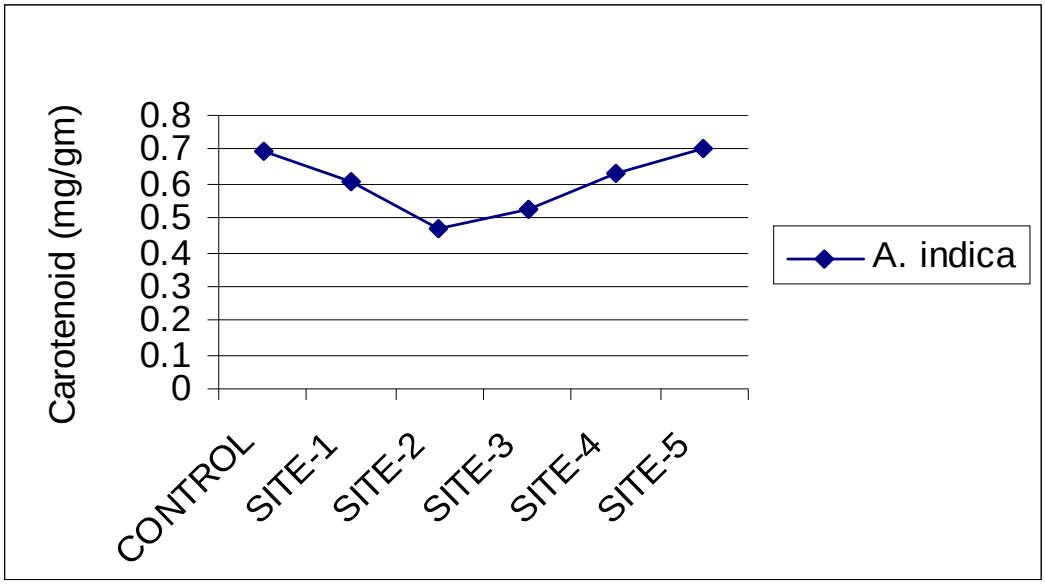


Fig. 6 b. Estimation of Carotenoid of select Azadirachta indica plants at different sites around KTPS and Control site.

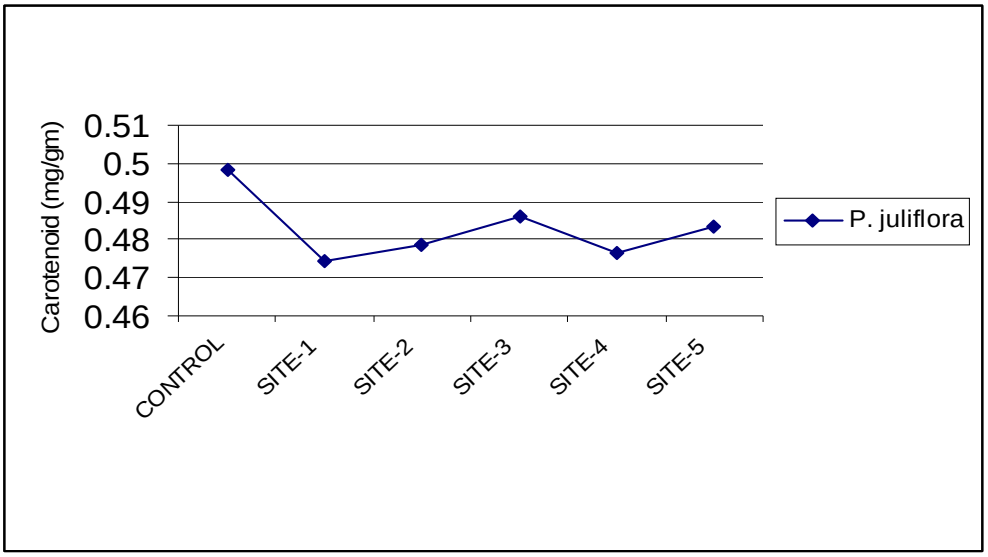


Fig. 6 c. Estimation of Carotenoid of select Prosopis juliflora plants at different sites around KTPS and Control site.

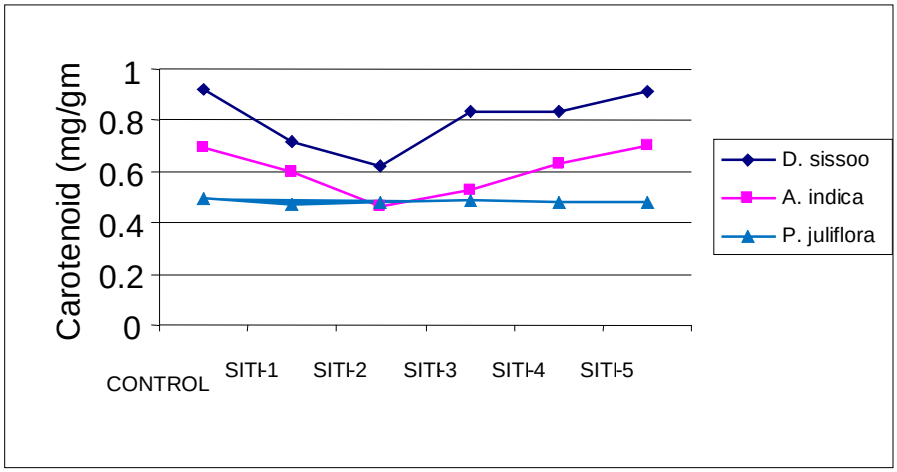


Fig. 6 d. Comparison of Carotenoid of select plants at different sites around KTPS and Control site.

Results and Discussions :

Baseline Status of the location: Figure 2.

Site I : The pH of the soil is 8.48 and electrical conductivity(dSm^{-1}) is 0.60.

Site II : The pH of the soil is 7.84 and electrical conductivity(dSm^{-1}) is 0.44.

Site III : The pH of the soil is 7.56 and electrical conductivity(dSm^{-1}) is 0.54

Site IV : The pH of the soil is 7.91 and electrical conductivity(dSm^{-1}) is 0.33

Site V : The pH of the soil is 8.36 and electrical conductivity(dSm^{-1}) is 0.31.

In the above all site the select dominant species were Dalbergia sissoo Azadirachta indica and Prosopis juliflora. The location site is described in the Figure 1 and Figure 2.

Estimation of Stomatal Index :

Declined values of Stomata index were recorded in select plants at different sites around KTPS. The results were observed and plotted a graph in Figure 3 a,b,c,d)

Estimation of Stomatal Frequency:

Declined values of Stomatal Frequency were recorded in select plants at different sites around KTPS (Figure 4).

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Estimation of Total Chlorophyll:

Declined values of Total Chlorophyll were recorded in select plants at different sites around KTPS. The results were plotted in the graph in Figure 5 a,b,c,d.

Estimation of Carotenoid:

Declined values of Carotenoid were recorded in select plants at different sites around KTPS. The results were plotted in the graph in Figure 6 a,b,c,d.

In preliminary study was conducted at a total of 5- locations (Control and Site I, II, III, IV and V) towards southwest direction (prevalent wind) from the vicinity of KTPS. Where the prevailing winds were directed, the highest level of pollutant concentrations. Leaf samples obtained from southwest at different locations of the KTPS, outside the impact zone of control site, had relatively less S.I., S.F., Total Chlorophyll , Carotenoid.

The magnitudes of changes were maximum in Dalbergia sissoo and Azadirachta indica up to 3.5 Km away from source of KTPS. However, species like Prosopis juliflora showed tolerance to pollution load and it did not show any prominent effect in comparison to the plants at control site.

The plants Dalbergia sissoo, and Azadirachta indica were found to withstand the levels of air pollutants from power plant at a distance of 10 km from the source of pollutants

P. juliflora have higher assimilative capacity than other select dominant plants in the region

These plants can be used as indicators for monitoring the effects of the air pollutants.

Select plants like Dalbergia sissoo and Azadirachta indica were found to withstand the levels of air pollutants from power plant at a 10 km from Koradi thermal power station, Koradi. However Prosopis juliflora did not show any prominent effect

Sensitive plants can be used as indicators for monitoring the effects of the air pollutants

The study suggests differential sensitivity of plants to air pollution around the emission source, which may be considered as bioindicators to air pollutants

The recorded effects of pollution in the morphological, physiological, biochemical characteristic are suitable indicators for biological monitoring. The pollution load alters not only the quantity

Conclusions :

This study was carried out on Azadirachta indica (Neem) , Dalbergia sissoo (Sheesham) and Prosopis juliflora (Devbabul) trees grown abundantly around the vicinityof Koradi Thermal Power Plant, where atmosphere was very much polluted due to coal-smoke pollutants emitted from the stacks of the power plant. The observations were carried out for one and half years period. Plant materials (mature leaves) collected from five selected sites, located at different distances from the pollution source, were studied and analyzed so as to assess the impact of environmental degradation on foliar morphological, anatomical and biochemical traits of the test plants.

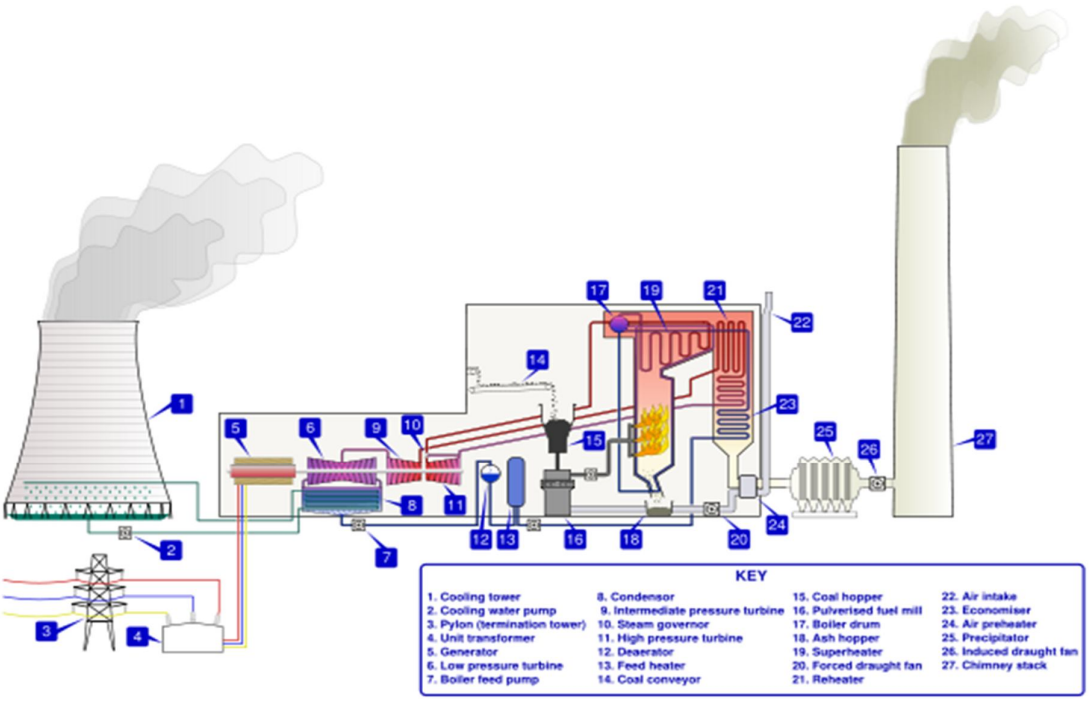
The following conclusions can be drawn from the present investigation regarding the changes in the Azadirachta indica, Dalbergia sissoo and Prosopis juliflora trees experienced due to coal-smoke pollutants present in the air.

In ***Azadirachta indica*** and ***Dalbergia sissoo*** stomatal index (SI) , stomatal frequency (SF) touched the minimum up to the site III.

The concentration of total chlorophyll was lowest upto site III and recovered thereafter.

Carotenoid content also exhibited a similar trend. The total chlorophyll content was severely affected by air pollutants.

But the genus Prosopis juliflora does not exhibit and prominent effect on stomatal index, stomtatal frequency, total chlorophyll and carotenoid concentration.



Schematic representation of Thermal power plant

ABBREVIATION

KTPS – Koradi Thermal Power Station

MW – Megawatt

SI – Stomatal Index

SF – Stomatal Frequency

Chl – Chlorophyll

SO_x – Oxides of Sulphur

NO_x – Oxides of Nitrogen

HF – Hydrogen Fluoride

SPM – Suspended Particulate Matter

RSPM – Repairable Suspended Particulate Matter

LPS – Large Point Sources

MoEF – Ministry of Environment and Forest

EIA – Environmental Impact Assessment

NBRI – National Botanical of Research Institute

USEPA – United State of Environmental Protection Act

HHV – High Heating Value

GEV – Gross Calorific Value

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