SUMMARY AND CONCLUSION

Coal mining is one of the core industries in India and plays a positive role in the economic development of the country. Its environmental impact cannot be ignored but, to some extent in unavoidable. Most major mining activities contribute directly or indirectly air pollution. One of the important issues of global concern in the problem related to the changes in environmental quality. Air environment is one of the vital components of environment on which the life depends alone and with combination to the other component of environment, air quality is critical to plant and human health alike. Coal being a primary source of energy plays a vital role in energy – intensive economy such as India. Many developing countries, especially those dependent on oil imports to meet their energy requirement, lay great emphasis on the production and development of coal in order to fulfill their demand for energy. This has resulted in a considerable growth in coal mining in the recent decades. Exploration, Mining and benefaction of coal are associated with variety of environmental hazards. Coal mining especially opencast mining has substantial effect on environment. Research interest in environmental impact assessment around source of pollution has been consistent due to continued increasing rate of industrialization in the country.

The present study was conducted around Jayant open cast coal mine situated at Jayant in sidhi district of Madhya Pradesh India, from Jan. 2007 to Dec. 2008. The study aimed at evaluating the impact of air pollution an ambient air quality, soil characteristics and performance of plants in area receiving different level of pollution load Performance of plants was evaluated on selected tree species which due to perennial nature show cumulative impacts of emission from pollution sources. In the Jayant coal mine area the concentration of So$_2$ and No$_2$ (Gaseous pollutant) and below the NAAQS, CPCB India at all the monitoring station but TSP and settled dust concentration were compound with National ambient air quality standards of the USA (USEPA) (U S Environmental protection Agency 1992 CPCB India) were well above the limit

**Pollutant concentration showed characteristics seasonal and diurnal variance.**

1. Site S1 and S2 and situated in mining complex along major a minor road side, respectively, mining activity such as, drilling blasting movement of heavy duty
vehicles and light vehicle, contribute more pollutant load around the sites. Site S3, S4 and S5 are far from mining complex therefore less affected. The presence of patches of green belt further minimized the pollutant load at the sites.

2. Concentration of gaseous pollutants were high during winter which may be due to frequent temperature inversions, specially during night and early morning hours, restrict pollutant dispersion and them increase the pollutants at ground level. Low wind velocity during winter further reduces the pollutant dispersion in a wider area. Particulate pollutants. Both TSP and settled dust showed maximum concentration during summer. This may be due to high wind velocity and low relative humidity during summer season which also bring surface soil from bare areas and loose overburden along with particulate generated during mining activities and thus increase particulate load.

3. Zinc and Manganese are present in highest quantities in both TSP and settled dust. There are the constituent of the parent rocks and are commonly present in soil dust combustion of oil, coal and refuse also emit these metals in the environment.

Air quality monitoring was done at each site to characterize the ambient concentration and diurnal variations of important air pollutants.

Air quality data at Jayant coal mine have indicated that the concentration of $\text{SO}_2$, $\text{NO}_2$, TSP, dust fall rate and air borne trace metals were highest at S2 sites, although it vary in few cases S1 site also showed highest concentration of pollutant. In general the pattern of followed the sequence of pollution rate S1 followed by S2, S3, S4 and then S5 (Control site). In general, concentration of $\text{SO}_2$ and $\text{NO}_2$ were high during winter season and minimum during rainy season. The particulates (TSP and dust fall rate) were found to be maximum in summer season. Diurnal pattern of gaseous pollutant showed peace during winter. First was recorded between 4 to 8 AM and second between 4 to 8 PM Total suspended particulate showed maximum concentration between 8 AM to 4 PM in a diurnal cycle during summer. In settled dust Zn showed maximum concentration followed by Mn, Pb, Cd, Ni and minimum of Cr, however, in TSP Zn in followed by Mn, Pb, Cr, Ni and minimum Cd.
Variation is pollutant concentration around Jayant opencast coal mine may be attributed to the following reason.

1. Higher concentration of TSP and dust fall rate have been found in zone S1 and S2 (Mining area) in comparison to green belt site S3, residential site S4 and control site S5. Study also reveals higher percentage of dust fall rate in the range of (60 to 80%) of TSP in the mine atmosphere.

2. Studies indicate lower TSP concentration in winter season in comparison to summer season but the trend is not maintained at all the sampling stations. This is probably due to the fact that the concentration levels observed at a particular monitoring station are also influenced by its location and atmosphere stability prevailing at the time of monitoring.

3. Meteorological survey reveals that monitoring station localised towards west and east of the generating source will be polluted maximum in summer season. Similarly, in winter season the monitoring site located towards west and south direction of the generating sources will be affected maximum. Hence most of the monitoring station in residential sites are not only influenced by the mining activities of the project where they are actually located but are also influenced by the activities of the adjoining mining projects and coal based industries due to wind prevailing direction.

4. The concentration of particulate matter (figure no. 3.3) at most of the monitoring station reached a maximum during winter and was at its minimum in the rainy season. This is similar to the reports of soni & Agarwal (1997), CMRI (1999), Ghose and Majee (2000) and Nanda and Tiwari (2001), chaulya (2003) for Indian coal mining areas and karika et al (1995), and Tayanc (2000) for Instanbul in Turkey.

5. The strong correlation between TSP and dust fall rate indication that the concentration of settled dust, which is the main concern for human health effect (Wheeler et al 2000; Baldauf et al 2001), would be well estimated for any open cast coal mining area with similar condition. Coal transportation was the main
source of TSP generation (as reported by Sinha & Banarjee 1994; Sinha 1995, Soni & Agrawal 1997; Ghose and Majee 2000)

6. Ample evidence is now available indicating that air pollutants are damaging the plant growth and productivity. During recent year, factors affecting plant – pollutant interaction under natural condition have received global attention.

7. More recent studies, however, have suggested that exposure to peak concentration are more important than to average value in causing significant vegetation damage (Pandey & Pandey, 1996; Fuhrer et al 1999; Fowler et al 1997).

8. The occasional exposure to extremely high concentration of air pollutant may cause severe biological effects than continuous long-term exposure to low concentration.

9. In addition, the presence of more than one pollutant together under natural condition of mining areas play significant role in modifying plant responses to a singh pollutant either through synergist addition or antegonished effect (Pandey and Agarwal 1994).

10. In the present study, both these aspects bear special significance since the peak and Co-occurrence of pollutant pairs were observed frequently. In the present study most of it 2-h peak of No₂ remained well below the photo toxic limits. Since a low concentration of So₂ and No₂, fertilize the plants stimulating plant growth, their peak concentration and simultaneous occurrence bear great significant in assessing vegetation injury.

11. Maximum concentration of TSP and settled dust found in the mining area, and levels gradually diminished with increasing distance due to transportation, deposition and dispersion of particles. The dispersion of particulate matter attendant to be towards the south west which followed the annual predominant wind direction of the area (Chaulya et al 1998; Corti & senatore 2000; Baldauf et al) concentration of So₂ and No₂ were far below the NAAQS at all the monitoring station
SUGGESTION

Few plant species can be grown around highly polluting source is area when TSP and dust in the main pollutant, it not only reduces air pollution, but also related water and soil contamination. The green belt can help to control and check the dust on the surface, the leaves and bark and can also tolerate $\text{SO}_2$ and $\text{NO}_2$ (Gaseous polluted effectively) Sikarwar et al 1998. India has lots of varieties of plant species that is planted would probably serve locally to lower atmospheric TSP, $\text{SO}_2$ and $\text{NO}_2$. Dust attending plant species should be used to develop green belt (Chaulaya et al 2001).

Diurnal variation in the concentration of $\text{SO}_2$ and $\text{NO}_2$ was more associated with source oriented variation. Two peak hours during pre office time – and post office hour, both the traffic density and domestic heating increase the concentration of $\text{SO}_2$ and $\text{NO}_2$. This results in two peaks of these pollutants in the ambient air. Relative high pressure and humidity during morning and evening hours restricts the dispersion of pollutants, Furthermore, the concentration of heavy metals in the atmosphere were closely associated with the variation in emission source.

Both $\text{SO}_2$ and $\text{NO}_2$ are acidic pollutants, participate in acid rain, and hence can alter soil properties specially microbial medicated nutrient conservation, release and nutrient loss. However, since the buffering capacity of the soil of dry tropics is high, chances of Nutrient loss from soil due acidic deposition in minimum.

Along with the gaseous pollutants a number of trace metals an also observe in the air environment (Soloman and Hartford 1976; Tyell et al, 1979; Voutsa and Sharma 2002, Singh 2002 of meter politan area, and mining area.

High concentration of heavy metal such as Zn, Pb, Ni, Cd and Cr were observed in the mining area of Jayant (Singrauli coal field). Metal particulates remain suspended in air are taken up by plants directly through stomata. Settleable particulate are also taken up through plant roots. Soil deposition of acidic pollutants increase the root uptake of heavy metals.
ATMOSPHERIC DEPOSITION HAS ALTERED THE SOIL CHARACTERISTICS

In addition to the direct damage from pollutants through aerial environment, plants are also damaged through pollution induced changes in the soil properties.

Soil Physico Chemical properties were examined to understand the effects of atmospheric deposition and accumulation of gaseous and particulate pollutants. Deposition of pollution and accumulation of gaseous and particulate pollutant. Deposition of pollutants especially particulate reduces moisture content and water holding capacity of soil. Increased compactness new could lower soil aeration and root growth.

Atmospheric deposition contain toxic metals also reduce decomposition causing accumulation of organic matter at polluted zones. Smith (1991) has suggested that heavy metal binds with colloidal organic matter in soil and increase its resistance be decomposition.

Soils at polluted sites were poor in nitrogen phosphorus, available nutrients and rich in sulphate-sulphur exchangeable calcium and sodium contents. The entire soil sample showed some degree of contamination of heavy metals with minimum at residential localizes S4 as compared to the control site S5.

Sustained productivity of the ecosystem can only be maintained through efficient nutrient cycling. Available evidences indicate that altered soil physico – chemical feature have the potential to interfere with nutrient cycling. Mining activity causes disruption in ecosystem functioning (Stark, 1977) and depletion in soil carbon pool. Mining activity also causes loss of litter layer which is an integral storage and exchange site for nutrients increase in soil exchangeable Ca and Na in mining area in due to the high atmosphere deposition as well as higher concentration of the parent rock.

Reduction in N and P concentration in soils at sites situated in mining complex may be related to low organic matter soils in the mining area contained higher concentration of toxic metals, which may also have adverse effect on the soil biological activity. Decreases in total – N and available with increasing concentration of pollutants could be due to two basic reasons. First, soil deposition of pollutants reduces the process
of decomposition and nutrient release. High C:N ratio observed in polluted zones reflect slow decomposition at there sites. Secondly when C: N ratio in high, microorganism utilize N and P more effectively for their growth and proliferation (Yagoding 1982). Furthermore, increased atmospheric deposition increases the soil compact ness which intern lowers the soil aeration and consequently nitrification. All these factors together may be responsible for nutrient pool soil at polluted sites. In addition, declining concentration of available – P may also be due to formation of unavailable calcium tri-phosphate complex at polluted sites (Devlin 1975).

Nitrogen accumulation in soils depends on precipitation and biological fixation. Since mining activity disturb both the vegetation and soil structure, reduction in mineral nitrogen (NH$_4^+$ - N and NH$_3^-$ - N) and available in P soil may be attributed to lower decomposition rate. Nitrification and ammonification are important microbiological processes by which soil accumulate large amount of mineral nitrogen that can be absorbed by the plants for their metabolism.

The process of nitrification and ammonification are promoted by favourable water regime is adequately aerated soils reduced water holding capacity reduces microbial activity. High concentration of heavy metals have been found to inhibit the activity of acid phosphotase enzyme (Tyler 1976), leading to the reduced decomposition of organic phosphorous. Atmospheric sulphur has been shown to increase the sulphate-sulphur content of the soil due to atmospheric deposition and subsequent accumulation in soil of the mining area.

Microbial immobilization of nutrients in an important mechanism of nutrient conservation and mineralization (Singh et al 1989). Existing evidence support nutrients deficiency in soils but does not support soil acidification in India soils. Neve the less, decreased microbial immobilization of nutrients and consequent acceleration of nutrients and consequent acceleration of nutrient leaching in their nutrient poor system and due to atmospheric deposition could be determined to trees and other plants in long run thus, soil mediated long term effect could become a severe problem ever more than the direct effects of air pollutant through the atmosphere. This may have severe ecological implication in long run with respect to phytotoxicity and ecosystem degradation.
It is clear from the above discussion that atmospheric deposition interacts directly or indirectly with a number of processes related to the soil fertility and nutrient cycling. This may lead to a long term problem to the soil fertility and hence the growth of the plant in the mining area.

Heavy metals are one of the most detrimental fractions of mining effluent, being persistent accumulates in water soil, sediment and living organism (miretsky et al 2004). Then heavy metals can be incorporated into food chain and their level case increase through biological magnification (Card well et al 2002)

* Open cast coal mining in relation to biological life form is not favourable. It destroys the forest as well as ground vegetation in one hand while in another it alter the physico-chemical and biological properties of the soil Dutta & Agrawal 2001)

* G. Pteridofolia was reported to be one of the most successful plants helping in soil formation a mine spoil dumps in Australia.

Dutta & Agrawal (2003) reported than among the tree species E. hydrid, A. auriculiformis and C. equestifolia were most suitable for the modification of spoil characteristics. Dutta and Agrawal (2003) reported maximum available P, available N (NH₄ – N and No₃ – N) in the E. hydrid.

* There are many limiting factors on mine area soil, which are responsible for the lower biomass accumulations.

**UNFAVOURABLE AFFECTS OF THE MINING POLLUTION ARE DEPENDENT ON PLANT SPECIES AND MEASURED RESPONSE VARIABLES.**

Effects of mining pollutant are studied was four exotic plant species namely (White gum) Eucalyplus hydrid pryor and Johnson Cassia siamea Lamk. (Yellow cassia) Gravellia pteridofolia R. Br. (Silver oak) and cassia fistula and the three native plants mangifera indica mango) Dalbergia sissoo Roxb. And Albizia proccera commonly growing in the area. Foliar dust load was very high at the sites situated in mining area for all the plant species C. Siamea, M.Inidica, A. proccera, C. fistula and D. Sissoo were found best dust collector in the area.
It is well established that pollutants alter the growth performance and physiological status of the plants (Malhotra and Khan 1984). Reduction in the leaf area due to leaf injury and reduced leaf expansion reduce the photosynthesis capacity of the plant (Byres et al, 1992, Pandey and Pandey, 1994) particulates on leaf surfaces also reduce in leave. Attend physiological and metabolic processes in plant may alter the dry matter accumulation. Rao and Dubey (1988) observed significant reduction in foliar dry wt due to SO₂ pollution. It was found that all the plant species showed reduction in their content of chlorophylls, ascorbic acid and starch, leaf area, specific leaf weight, photosynthetic rate and transpiration rate and increase in phenol, reducing sugar and total soluble sugar contents and peroxidanactivity growing in the mining area contains pollutants at phytoxic level. Chlorophyl in a sensitive indicator of air pollution (Daral and Jagar 1984). It is suggested that gaseous pollutants produce oxy radicals which damage plant all membrane and other molecules including chlorophyll pigments (Wolfender et al 1992). A number of investigations have established direct relationship between foliar concentration of ascorbic acid and plant susceptibility to air pollutants (Lee et al, 1984; Chen et al 1990). Ascorbic acid is natural antioxidant which maintains the stability of the plant cells membrane and scavenger cytotoxic free radicals loss of ascorbic acid remains generally greater in sensitive species.

Vegetation damage in a polluted atmosphere in an integrate response to various pollutants and a number of environmental factors. The results demonstrate that there is a wide range of variability in the responses of plant to mining air pollutants. Response pattern was dependent on species and measured response variable.

The pattern of change observed in plant parameters may be related to varying levels of their susceptibility.

The magnitude of reduction in different parameter was not identical and therefore, a clear cut susceptibility index cannot be suggested. However, after a critical analysis of all the parameters, a broad generalization can be made about the relative susceptibility of plants to the air pollution status in the area. Mangifera indica showed relatively, lower reduction in total chlorophyll and starch contents, photosynthetic rate and specific leaf wt compared to then plant species. Cassia siamea appeared to be the most sensitive in the
coal mine area as the leaf area, specific leaf weight, and total chlorophyll content declined maximally in the plant species. On the basis of dry matter accumulation per unit leaf area *C. siamea* was found to be the most sensitivity to air pollution in coal mine area followed by *G. pteridofolia, C. fistula, E. hydrid, D. sissoo, A. proccera* and *M. indica* in decreasing order of sensitivity. It is interesting to note that *M. Indica, A. procera* and *D. sissoo* are native species of the area. Where as the other four species are exotic in nature. This clearly shows that indigenous species of the area showed more tolerance be stress in air environment compared to fast growing exotic species.

Higher growth rate of exotic species during initial years of establishment has probably made the vulnerable to air pollutants. The difference in plant ability to avoid the entry of pollutants and/or the physiological and biochemical differences between species have been suggested as important factors contributing to differential susceptibility of species. The level of ascorbic acid does not seen to play an important role in deciding susceptibility level in plant species except in *D. sissoo* and lower in the case of *G. pteridofolia* in all the season.

This insitu experiment in the field clearly demonstrates that the air quality S1 and S2 mining are infurious to the plants plantation developed in the S3 (green belt area) and S4 residential area further away from the mining area have shown decreasing trend of adverse efrection various parameteri which suggest that air pollution problem in relatively localized in the area.

It may be suggested that green belt may bee extended in the area so that the residential localities may be completely free form the adverse impacts of pollution. *Mangifera indica, A. proccera* and *D. sissoo* plants are recommend to be grown in green belts. *Cassia siamea* however, can be used as a bioindicatior plant to monitor the pollution. *G. pterdofolia, C. fistula* for the litter foramation is the mining area.

**LONG TERM EMISSION OF PARTICULATES HAS ALTERED THE NUTRIENT AND HEAVY METALS STATUS IN THE FOLIAGE**

In this study an attempt has been made to determine the concentration of selected major nutrient (So₄²⁻, Ca, Mg, K, N, P etc.) and selected trace metals (Cd, Cr, Ni, Pb, Mn, Zn) in sever plant species commonly growing in the plantation around Jayant open cast
coal mine. The concentration of nutrient as well as trace elements varied in different plant species at different site and during different season.

Plant accumulated high level of sulphate sulphur and different trace metals, where as total Nitrogen, Phosphorus, Magnesium and Potassium level were lower at site receiving higher pollution load. D. sissoo and E. hybrid were found to be the most efficient accumulators of all the trace metals. The concentration of trace metals was highest during summer followed by winter then in rainy season in all the plant species. Higher biomass during rainy season may account for lower level of trace metals in foliage during the season. Further frequent washing of the dust deposition on the leaf surface and the dilution of these elements in air and soil also contribute to the lower level of these metals in the plant species during rainy season. Sulphate sulphur content increased maximally in C. siamea which also showed maximum reduction in most of the study parameter.

Among trace metals, Zn and Cr, accumulated in higher conentration in C. siamea plant compared to the G. pteridofolia, M. indica, A. procerra and C. fistula. No significant correlation was found between the dust deposition and heavy metal accumulation in the leaf because C. siamea was found to accumulate maximum dust or their foliar surface but was not found to have maximum concentration of heavy metals. This shows that C. siamea plant is most sensitive among the studied plant species.

Site wise variation in trace metal concentration showed direct relation with the activity in and around the sites. Soil levels of trace metals and nutrient also correspond directly to the status in the foliage. The interference of there trace metal with the plant metabolism has led to various physiological and biochemical changes leading to reduced growth and dry matter accumulation. This adverse effect on plant metabolism may also alter the major nutrient in the plant foliage. Accumulation of $\text{SO}_4^{2-}$ - S in plant leaves around coal mine area clearly indicates significant sulphur deposition in area.

*Dalbergia sissoo* and *M. indica* recomended to grow in green belt plantation around mine areas as this species is not only efficient bio accumulator but also showed relatively less effects on plant.
CONCLUSION

1. The present field study led to the following conclusion.

2. Jayant open cast coal mining area in Singrauli have adversely affected the air quality, physico–chemical characteristics of soil and plant function within 12 – 15 km in prevailing wind and 4 – 6 km in other direction from the source of emission.

3. Marked spatial and temporal variation in gaseous and particulate pollutants was observed.

4. The highest concentration of So$_2$ and No$_2$ were observed in winter while the dust falls rate and levels of TSP were recorded maximum during summer season. Lowest concentration of all the pollutants were recorded during rainy season, which indicated the influence of rain in diluting the pollutants year to year variability in pollutants concentration, was found to be insignificant.

5. A biomodal pattern for So$_2$ and No$_2$ were recorded in diurnal cycle.

6. TSP concentration exceeded the prescribed limit set by NAAQS (USA) and by CPCB board India during winter and summer season gaseous pollutants were, however, within the limit.

7. The air quality data around Jayant open cast coal mine show that the concentrations of pollutants were highest at site S1 and S2 and considerably low in the residential site S3, S4, S5. The area studied can be ranked from maximum pollution load to a minimum at S1 > S2 > S3 > S4 > S5.

8. The study indicates that the soil physico chemical characterstics have altered unfavourably done to the deposition and accumulation of gaseous and particulate pollutants. Maximum adverse effect was recorded at S1 site followed by S2, S3 and the S4.

9. Soils at sites receiving higher pollution load has lower levels of No$_3^-$ - N, Nh$_4^+$ - N, total N, available P and exchangeable Mg$^{2+}$ and K$^{+}$ and higher levels of So$_4^{2-}$ - S exchangeble Ca$^{2+}$ and Na$^{+}$ and trace elements (Ni, Cr, Cd, Pb, Mn, Zn)

10. Soil processes such as Nand P mineralization rates declined significantly at sites receiving higher pollution load.
11. Dust capturing was found maximum for C. siamea followed by \textit{D. sissoo}, \textit{A. proccera}, \textit{M. indica}, \textit{G. pteridofolia}, \textit{E. hybrid} and \textit{C. fistula}.

12. The adverse effects of air pollution and plants were greater in the areas receiving higher pollution load and vise – versa.

13. Photosynthesis & transpiration rates, total chlorophyll, ascorbic acid and starch content were reduced, while reducing sugar and phenols contents and peroxidase activity increased at site closer to the mining area.

14. Response varied with plant species, site, season and measured response variable.

15. On the basis as most of the studied parameters the plant showed relative susceptibility as \textit{C. siamea} > \textit{G. pteridofolia} > \textit{C. fistula} > \textit{E. hybrid} > \textit{D. sissoo} > \textit{A. proccera} > \textit{M. indica}.

16. \textit{Dalbergia sissoo}, \textit{E. hybrid}, \textit{C. siamea} and \textit{G. pteridofolia} area found to be efficient accumulator of trace element plantation of such species may help in removal of these contaminants from mining environment.

*******