SUMMARY AND CONCLUSIONS
Summary of the presented work has been written chapter wise.

• CHAPTER – 1  INTRODUCTION AND DESCRIPTION OF INDUSTRIAL SITE

Chhattisgarh state is rich in mineral resources; therefore, variety of industries established due to availability of raw materials. Cement industry is one of the examples. The cement industry is involved in the development of structures of this advanced and modern world because it is the basic ingredient of concrete use in constructing modern edifices and structures. In fact, life without cement in this 21st century is inconceivable. Cement is a fine, gray or white powder which is largely made up of Cement Kiln Dust (CKD), a by-product of the final cement product, usually stored as wastes in open-pits and landfills.

The cement dust, produced by cement manufacturing units is considered one of the most hazardous pollutants which effect surrounding environment. The cement industry also plays a vital role in the imbalances of the environment and produces air pollution hazards. Different greenhouse gases and solid particles derived from cement industries threaten air, as the time passes, these gases and solid particles gradually condense the environment and can be potential risk for world’s atmosphere, inhabitants and animals. When wastes containing heavy metals are co-processed in cement kilns, almost all non-volatile and semi volatile heavy metals are transferred into the cement minerals during cement clinker formation (distribution rates of As and Cr in the cement clinker are 99.99 and 99.96%, respectively, and those of Cd and Pb are 99.95%). This causes the heavy metal content in the cement clinker to increase significantly as compared with untreated hazardous wastes.

Dust consists of tiny solid particles carried by air currents. These particles are formed by disintegration or fracture processes. Particles that are too large to remain
Summary & Conclusion

airborne settle, while others remain in the air indefinitely. The cement industry also
plays a vital role in the imbalances of the environment and produces air pollution
hazards.

Variation in elemental concentration due to cement dust pollution in the
adjoining areas of a cement plant and the effects on the soil, plant, animal and human
health was the reason of planning proposed study, as very meager information is
available about the pollution caused by the cement dust in the state of Chhattisgarh.
Variation in mass and elemental condition of particulate matter with local climatic
conditions, process mechanism in factories has showed the need of environmental
quality assessment of surrounding environment of single point source. So the main
object of this research is assessment of soil, air and vegetation quality around selected
cement plant.

- **CHAPTER II – REVIEW OF LITERATURE**
In this chapter a brief outline of various types of pollutants releasing from cement
industry and their effects on different environmental media like air, water, land,
vegetation and living beings. Characteristics are presented, along with the reviews of
studies of various investigators. An attempt has been made to include review of recent
literature relevant to the present work.

- **CHAPTER III - AMBIENT AIR CONCENTRATION AROUND THE
CEMENT INDUSTRY AND PHYSICOCHEMICAL NATURE OF CEMENT
DUST**
This chapter describes the nature of cement dust and ambient air quality around the
targeted cement industry, Characterization of settle-able cement dust and
concentration of particulate matters were calculated by following standard procedures
by cooperation with Pollution Control Board Raipur.
Settle-able dust was collected at four sampling sites within a distance of 500m from the cement plant in each direction using deposition gauges. Then digested for the detection of trace metal constituents by (AAS GF VARION 240), and SiO$_2$, Fe$_2$O$_3$, Al$_2$O$_3$, CaO, SO$_3$ were also detected in the dust samples.

Results showed that dust had elevated basic pH, high salinity, and was rich in metal oxides of Ca and Si, whereas, the dust was poorer in the oxides of Al, Fe, K and Mg. The AAS analysis of trace metals showed settle-able dust from cement industry were rich in Pd, Cr, Cd, and Ni heavy metal content with little amount of Zn, Cu, Mn and K metals.

The results of mean concentration of ambient air particulates matters around the cement industry showed that the air quality in the vicinity of the cement plant was deteriorated due to factory emissions and the concentration of particulates were higher than the permissible limits; prescribed by Indian air quality standard (IAQS). Higher concentrations of SPM, RSPM, SO$_2$ and NO$_2$ were observed in winter season than the other seasons.

**CHAPTER IV ANALYTICAL STUDIES FOR DETECTION OF SOIL QUALITY AROUND THE CEMENT INDUSTRY**

This chapter describes the quality of soil around the cement industry, Changes in soil physicochemical properties and nutrient, and heavy metal contents, analysis of soil was done by standard procedures followed by soil water and plant testing laboratories of Department of soil science and Agricultural chemistry Jawaharlal Nehru Agriculture University, Jabalpur.

The soil quality was found depended on the soil structure and their physicochemical properties. Cement kiln dust dispersed on soil and sediment deposited on the top soil as well as inner layer and influenced soil porosity, water
holding capacity, texture, particle size, bulk density, infiltration rate, pH and electrical conductivity.

50 sites were taken as bench marked around cement the industry for the investigation. These sites were monitored for two years. Four consecutive campaigns were performed in these bench marked sites to establish temporal, seasonal trends. Soil samples at the time of harvest were collected from these bench marked sites during two cropping seasons in the months during Kharif (November 2010-2011) and Rabi (April 2011-2012) seasons.

▲ Primary and secondary nutrient content in soil samples collected at varying distance from cement industry - according to analytical results available N, P and S content in soils increased significantly, with the increase in distance from the cement industry from 50 meter to 4500 meter. On the other hand the K, Ca and Mg content around the industry, showed decrease with the increase in the distance from the cement industry. The K content in soil was maximum at 50 meter which decreased significantly with the increased in distance from cement factory and was minimum at 4500 meter. Calcium content in soils decreased significantly from 22.88 meq 100g⁻¹ at 50 meter with the increase in distance to 16.80 meq 100g⁻¹ at 2000 meter. Similarly magnesium content also decreased significantly with the increase in the distance; the values were 12.61 meq 100g⁻¹ at 50 meter, 8.75 meq 100g⁻¹ at 1000 meter and minimum 3.18 meq 100g⁻¹ at 4000 meter distance.

▲ Micronutrients content in soil samples collected at varying distance from cement industry - there was no significant variation observed in the micronutrient content at various distances from 50 meter to 4500 meter in the soil around the cement industry. The content of Zn varied from 0.24 mg kg⁻¹ to 0.41
mg Kg\(^{-1}\), Cu from 0.99 mg kg\(^{-1}\) to 1.55 mg kg\(^{-1}\), Fe from 11.73 mg kg\(^{-1}\) to 13.85 mg kg\(^{-1}\), Mn from 4.46 mg kg\(^{-1}\) to 8.74 mg kg\(^{-1}\) while Boron content varied from 1.24 to 1.90 mg kg\(^{-1}\) in soil.

Toxic metals content of soil samples collected at varying distance from cement industry - according to analytical findings there was significant difference in Pb, Cr, Co and Cd content in the soils around the industry. The Pb, Cd and Cr contents were significantly higher in the vicinity of industry up to 1000m and decreased significantly, with the increase in the distance from the industry. The respective content of Pb, Cd and Cr increased from 2.03 mg kg\(^{-1}\), 0.036 mg kg\(^{-1}\) and 0.0139 mg kg\(^{-1}\) at 4500 meter to 3.18 mg kg\(^{-1}\) at 1000 meter, 0.049 mg kg\(^{-1}\) at 2500 meter and 0.0219 mg kg\(^{-1}\) respectively, and the value was kept on increasing to the maximum value of 3.59 mg kg\(^{-1}\), 0.051 mg kg\(^{-1}\) and 0.0330 mg kg\(^{-1}\) at 50 meter, for Lead, Cadmium and Chromium, respectively. On the other hand the Co content in soil after rice and wheat followed increasing trend with increasing distance from industry. The findings were statistically significant. The cobalt content is a beneficial element for crops growth correlated negatively and significantly in the post harvest soil samples after rice with the soil properties like soil pH, electrical conductivity and Calcium carbonate content, nevertheless the relationship was positive with the organic carbon content in the soil samples.

Chapter V - Chemical analysis of metals in growing crops around the cement industry

This chapter describes the effect of cement manufacturing dust on growing crops around the cement industry; analysis of crops (grain, straw and leaves chlorophyll) were done by following the standard procedures.
Cement dust exhibited adverse effect on the soil environment. Soils around cement industries especially in downwind areas showed elevated pH. The results described of previous chapter showed cement industry deteriorate air quality, because of deposition in long run changed chemical composition of soils at the vicinity of factory.

Uptake of heavy metals from contaminated soils by food and forage plants comprises a prominent path for such elements to enter the food chain and finally be ingested by human and animals. Cd and Pb are potentially hazardous contaminants in the biosphere Cadmium is readily taken up by plant roots and translocated to above ground tissues.

According to findings of previous chapter the soil were found affected by cement dust, changed physicochemical and chemical composition than control soil now it is necessary to investigate the effect on vegetation which grown in surrounding environment of cement industry. The aim of this chapter was to determined nutritional and heavy metal concentration and uptake by rice and wheat crops grown in the vicinity of cement industry and effect of cement dust on yield and chlorophyll content of the leaves.

Estimation of Concentration primary and secondary nutrients in grain and straw samples of rice and wheat crop grown at varying distances (50m, 500m, 1000m, 1500m, 2000m, 2500m, 3000m, 3500m, 4000m, 4500m and 10000m) from cement industry - grain and straw samples of rice and wheat crops grown around the cement industry were taken at the time of harvest of these crops, along with the yield data. These samples were digested in the diacid mixture and analysed for the concentration of primary, secondary, micronutrients and toxic metals.
The concentration of N was increased significantly, from the 0.89% and 0.38% at 50 meter to the maximum of 1.09% and 0.54% at 4500 meter away from the industry for rice grain and straw, respectively, in wheat grain the nitrogen concentration was increased significantly from the 1.43% at 50 meter distance to the maximum of 1.80% at 4500 meter distance. There was no significant variation in phosphorus concentration in wheat as well as in rice grain and straw samples.

Concentration of K in rice as well as wheat showed relatively higher values at nearer surroundings of the industry than those of distantly located field. The concentration of K was found higher in straw than grain in case of wheat, which showed the partial translocation of K to grain in contrast to that of N and P which were found more in wheat grain than straw. The distribution of S concentration either in rice grain or straw was not definite and the values did not differ significantly, at various distances. The S concentration in wheat grain was higher than rice grain because of differences in absorption from soils due to their physiological and anatomical reasons.

Assessment of concentration of micronutrients in grain and straw samples of rice and wheat crops grown at varying distances, from cement industry - micronutrients (Zn, Cu, Fe, Mn, B, Co) are essential for plants in trace level, these stimulate or catalyse cell division, precursors of enzymatic activities, stimulate the stem development, stimulates pigment formation, needed for nitrogen fixation. These metals are beneficial at a trace amount and excess of metal can cause toxicity in plant parts.

The Zn concentration in rice grain and straw was maximum 16.64 and 26.48 mg kg$^{-1}$ at 4500 meter which decreased significantly, at 50 meter distance. According to analytical data Zinc concentration in wheat grain decreased
significantly form 34.8 mg kg\(^{-1}\) at 4500 m to the minimum of 29.7 mg kg\(^{-1}\) at 50 meter distance. In straw Zinc concentration was reduced significantly from 10.2 mg kg\(^{-1}\) at 4500 m to 7.3 mg kg\(^{-1}\) at 50 m distance.

The Cu concentration varied from 2.9 to 3.7 mg kg\(^{-1}\) and 4.4 to 5.9 mg kg\(^{-1}\) in rice grain and straw, respectively. Whereas, in wheat grain decreased significantly from 5.9 mg kg\(^{-1}\) at 4500 meter to the minimum of 4.9 mg kg\(^{-1}\) at 500 meter, similarly, for straw the Copper concentration was 6.2 mg kg\(^{-1}\) at 4500 meter decreased significantly to the minimum of 4.8 mg kg\(^{-1}\) at 50 meter.

Fe concentration in rice grain showed a decreasing trend while reaching closer to the industry. No any definite trend was observed however, the differences were statistically non significant. In wheat the Fe concentration in grain did not differ significantly with each other at various distances.

The Mn concentration in rice grain decreased significantly from 22.7 mg kg\(^{-1}\) at 4000 meter to 18.9 mg kg\(^{-1}\) at 1500 meter and was at par at closer distances. Similarly, in rice straw, values were decreased significantly, from 90.2 mg kg\(^{-1}\) at 4500 meter to the minimum of 68.4 mg kg\(^{-1}\) at 500 meter distance. Similarly, in wheat grain values were decreased significantly, from 35.7 mg kg\(^{-1}\) at 4500 meter to the minimum of 28.3 mg kg\(^{-1}\) at 1000 meter distance from the industry.

The Co concentration in rice grain as well as in straw was increased significantly with the increase in the distance from the cement industry. Overall the concentration of cobalt was higher in rice straw than grain. In wheat also the Cobalt concentration was slightly lower in the closely located fields than the distant ones.

Assessment of concentration of toxic metals in grain and straw samples of rice and wheat crop - the accumulation of heavy metals in agricultural crops
inevitably leads to phyto-toxicity. General toxicity symptoms of Pb include rapid
inhibition of roots, phyto-toxicity results in enzyme inhibition, disturbance of
other mineral nutrients.

The concentration of toxic and heavy metals in grain samples of wheat and
rice were below the toxicity limits given by WHO, Concentration of toxic metals
in plant parts was found in order soil > straw > grain.

The Pb concentration in rice straw was minimum 35.0 mg kg\(^{-1}\) at 4500 meter
which increased significantly to 56.9 and 62.9 mg kg\(^{-1}\) at 500 and 50 meter
distance, respectively. The Pb concentration in wheat straw increased significantly
from 30.5 mg kg\(^{-1}\) at 4500 meter to the maximum of 48.0 mg kg\(^{-1}\) at 50 meter
distance. There was a positive relationship found between concentration of Pb in
soil and concentration found in plant parts. Rice straw Cd was increased
significantly, from 0.59 mg kg\(^{-1}\) at 4500 meter to the maximum of 1.24 mg kg\(^{-1}\) at
50 meter distance from the industry. The Cadmium concentration in wheat straw
was also increased significantly, from 0.40 mg kg\(^{-1}\) at 4500 meter to 1.07 mg kg\(^{-1}\)
at 50 meter distance. The Chromium concentration in rice straw was increased
significantly from 0.13 mg kg\(^{-1}\) at 4500 meter to 0.51 mg kg\(^{-1}\) at 50 meter distance.
Chromium concentration in wheat straw was 0.15 mg kg\(^{-1}\) at 4500 meter
increased significantly, to 0.54 mg kg\(^{-1}\) at 50 meter distance from the industry.

▲ Yield of rice and wheat crop growing around the cement industry- yield of
rice and wheat crops grown around the cement industry were recorded at various
distances. Rice grain yield was maximum 4.90 t ha\(^{-1}\) at 10 km away from the
cement industry which may be taken as the reference sample and 4.64 t ha\(^{-1}\) at
4500m which reduced significantly, to 3.79 t ha\(^{-1}\) at 2000 meter and to the
minimum of 3.49 t ha\(^{-1}\) at 50 meter distance from the cement industry indicated
the significant reduction in yield existed up to 2000 meter, as an adverse effect caused due to pollution. Yield of wheat grain was maximum 3.38 t ha\(^{-1}\) at the reference site located at 10 km away from the cement plant, and 2.99 t ha\(^{-1}\) at 4500m, reduced significantly to 2.48 t ha\(^{-1}\) at 2500m and varied from 2.34 to 2.46 t ha\(^{-1}\) in between 50 to 2000 meter distance being statistically at par.

▲ **Total uptake of nutrients and toxic metals by rice and wheat crops**—nutrient uptake was calculated as the product of concentration of the nutrients in grain and straw of rice with the multiplication of their respective yields, that is uptake by grain and straw separately and summing up to derive at the total uptake of particular nutrients by the rice crop. N uptake was increased significantly with the increase in the distance from the industry, at 50 meter. The N uptake by rice was 51.2 kg ha\(^{-1}\) which increased significantly to 84.5 kg ha\(^{-1}\) at 4000 meter distance and by wheat from 48.1 kg ha\(^{-1}\) to 75.8 kg ha\(^{-1}\).

P uptake was varied from 5.8 kg ha\(^{-1}\) at 500 m to 8.5 kg ha\(^{-1}\)at 4500 meter, irregularly, in the case of rice and from 8.5 kg ha\(^{-1}\) at 50 meter to 12.8 kg ha\(^{-1}\) at 4500 meter in wheat. The uptake of potassium by rice was varied from 147.9 kg ha\(^{-1}\) at 500 m to 172.91 kg ha\(^{-1}\) at 4000 m. Uptake of potassium by wheat was relatively higher in the nearby area up to 1500 m than those located distantly.

The S uptake by rice was varied from 9.10 to 13.03 kg ha\(^{-1}\) and by wheat from 7.8 to 9.5 kg ha\(^{-1}\), at various distances, there was no any definite pattern observed in both the cases.

▲ **Micronutrients uptake by rice and wheat crops**—for uptake of micro nutrients by the rice crop, the Zinc uptake increased significantly from 142.8 g ha\(^{-1}\) at 50 meter to 223.3 g ha\(^{-1}\) at 4000 meter distance. There was no definite pattern of Cu and Fe
uptake by rice, whereas the Manganese uptake was minimum 391.8 g ha\(^{-1}\) at 50 meter increased significantly to 594.4 g ha\(^{-1}\) at 4000 meter distance.

Zn uptake by wheat was decreased significantly from 139.4 g ha\(^{-1}\) at 4500 meter to 93.3 g ha\(^{-1}\) at 500 meter distance. Just like Zn uptake the Copper uptake by wheat was also reduced significantly from 39.4 g ha\(^{-1}\) at 4500 meter to 25.3 g ha\(^{-1}\) at 500 meter. Iron Uptake was maximum 935.7 g ha\(^{-1}\) at 4500 meter which reduced significantly to 638.2 g ha\(^{-1}\) at 50 meter distance from the industry. Mn uptake by wheat was also reduced significantly from 190.3 g ha\(^{-1}\) at 4500 meter to 132.3 g ha\(^{-1}\) at 1000 meter. The Co uptake by rice varied from 2.06 g ha\(^{-1}\) to 2.63 g ha\(^{-1}\) at various distances. Co uptake by wheat increased significantly from 1.11 g ha\(^{-1}\) at 50 meter to 1.90 g ha\(^{-1}\) at 4500 meter distance.

### Toxic metals uptake by rice and wheat crops
- The Pb uptake by rice was increased significantly from 194.6 g ha\(^{-1}\) at 4500 meter to 296.0 g ha\(^{-1}\) at 500 meter distance. The uptake of Cd by rice crop varied from 3.77 to 6.19 g ha\(^{-1}\) at various distances. The Cr uptake was increased significantly from 0.71 g ha\(^{-1}\) at 4500 meter to 2.49 g ha\(^{-1}\) at 500 meter. Amongst the heavy metals uptake a significant higher accumulation of Pd, Cd and Cr were observed in the vicinity and nearby located fields around the cement industry. The Lead uptake by wheat, increased significantly from 104.71 at 4500 meter to 129.83 g ha\(^{-1}\) at 50 meter. Similarly the uptake of Cadmium was 1.35 and 2.90 g ha\(^{-1}\) at these distances, respectively. The Chromium uptake by wheat crop was minimum 0.05 g ha\(^{-1}\) at 4500 meter and increased significantly with the decrease in distance from industry to 0.146 g ha\(^{-1}\) at 50 meter distance.

### Chlorophyll content in fresh leaves of rice and wheat plants
- Fresh leaves of rice and wheat crops during the kharif and rabi season were collected in the first
week of September and April at vegetative growth stage and analyzed for Chlorophyll (chl 'a', chl 'b' and total chlorophyll).

▲ **Chlorophyll content in fresh leaves of rice** - Chlorophyll 'a' was maximum 0.90 mg g\(^{-1}\) at 4500 meter reduced significantly to 0.54 mg g\(^{-1}\) in the vicinity of the industry up to 50 meter distance. Similarly the normal content of Chlorophyll 'b' 0.85 mg g\(^{-1}\) was reduced significantly to 0.53 mg g\(^{-1}\) at 1000 meter distance. Collectively, the total content of Chlorophyll was reduced significantly from 1.76 mg g\(^{-1}\) at 4500 meter to 1.11 at 500 meter distance; it was obvious from the data that the adverse effect of cement industry was more up to 1000 meter distance.

▲ **Chlorophyll content in fresh leaves of wheat** - In wheat leaves the chlorophyll 'a' was reduced significantly, from 0.88 mg g\(^{-1}\) at 4500 meter to 0.48 mg g\(^{-1}\) at 50 meter distance. Similarly, the chlorophyll 'b' reduced significantly from 0.84 mg g\(^{-1}\) at 4500 to 0.53 mg g\(^{-1}\) at 1000 meter distance, the chlorophyll 'b' content at 50, 500, 1000 and 1500 meter distance from the factory, were statistically at par. The total chlorophyll content was varied in the normal range of 1.62 to 1.72 mg g\(^{-1}\) at 3500 to 4500 meter distance medium 1.35 to 1.48 mg g\(^{-1}\) at 2000 to 2500 meter and lower range varied from 1.01 at 50 meter to 1.17 mg g\(^{-1}\) at 1500 meter distance.

- **CHAPTER VI - CORRELATION STUDIES BETWEEN SOIL AND PLANT PHYSICOCHEMICAL AND CHEMICAL PARAMETERS**

Cement Dust influenced chemical composition of soil and plant which affect the quantity and quality of food products. Physical and chemical changes in soil ultimately affect the physical and chemical properties of plants. The availability of various essential and beneficial nutrients is influenced by the soil properties. The effect of the properties may either be positive or negative on the nutrient availability.
in the soil to the crops, their absorption by roots, translocation to shoots and leaves, ultimately uptake of these nutrients, influences the yield and quality of crops. In light of above view the relationship of these soil properties with various nutrients availability and their uptake by crops were worked out by calculating the correlation coefficient.

**Correlation between Physicochemical properties and major nutrient content in post harvest soil samples** - N, P and K content in soil samples were taken after the harvest of rice and wheat crops, correlated significantly with all the soil properties. A significant negative correlation existed between N content and soil pH $r = -0.871^{**}$, $-0.977^{**}$, Electrical conductivity $-0.772^{**}$, $-0.971^{**}$, and CaCO$_3$ content $r = -0.884^{*}$, $-0.952^{**}$ for rice and wheat crops, respectively. On the other hand a significant positive relationship existed with organic carbon content in the soil and soil N content $r = 0.786^{**}$ after harvest of rice and $0.813^{**}$ after wheat.

Similar observations were recorded in case of phosphorus content whereas the potassium, had reverse trend than the N and P content, as the K content correlated positively with the soil pH, EC and CaCO$_3$ content and with the increase in organic carbon content the K content was decreased significantly $r = -0.853^{**}$ after harvest of rice and $-0.803^{**}$ after wheat. Overall the values of correlation coefficient were slightly higher; in case of the soil samples taken after the harvest of wheat crop than those of after rice.

**Correlation between Physicochemical properties and Secondary nutrient content in Post harvest soil sample** - the calcium and magnesium content in the post harvest soil samples taken after harvest of rice and wheat crops was increased with the increase in soil pH, electrical conductivity and calcium carbonate content in soil. The correlation coefficient was more in case of soil samples taken after harvest of rice than wheat. In contrast to these properties a significant negative
correlation existed in case of organic carbon content. The status of sulphur content in soil samples taken after the harvest of either rice or wheat crop did not correlate, significantly, with the soil properties.

**Correlation between physicochemical properties and Micronutrient content in Post harvest soil samples** - copper content was correlated significantly and negatively with soil pH -0.837**, E.C. -0.847** and CaCO₃ -0.925** that is available copper content decreased with the increase in these soil properties, whereas, it has a significant positive correlation with organic carbon content in soil. The Zn and Fe content did not correlate significantly, with any of the soil properties. Highly significant negative correlation was existed between the soil pH, E.C. and Calcium carbonate content in the post harvest soil and Mn content in soil, while, the Mn content increased with the increase in the organic carbon content r = 0.698*. The cobalt content is a beneficial element for crop growth correlated negatively and significantly with the soil properties like soil pH, electrical conductivity and Calcium carbonate content however, the relationship was positive with the organic carbon content.

**Correlation between physicochemical properties and heavy metals content in post harvest soil samples** - Pollutant elements (heavy metals) like lead, cadmium and chromium content in the soil samples were collected after the harvest of rice and wheat crop increased significantly, with the increase in soil pH, as evidenced by the r values, 0.863**, 0.961** in case Pb, 0.843**, 0.900** in case of Cd and 0.936**, 0.964** in case of Cr, respectively. Similarly, the highly significant positive correlation was found between the electrical conductivity and calcium carbonate content in soils with these heavy metals (Pb, Cd and Cr content). On the contrast, the rise in the organic carbon content in soils decreased the Pb
content r = -0.876**, -0.876**, Cd content r = -0.855**, -0.843** and Cr content r = -0.937**, -0.827** in soils after harvest of rice and wheat crops, respectively.

**Correlation between Physicochemical properties and concentration of primary nutrients in rice and wheat crops** - concentration of N in rice and wheat crops correlated significantly, with the soil properties. As a negative relationship, the N concentration decreased with the increase in soil pH, EC and CaCO$_3$ content, whereas, it increased with the increase in the organic carbon content of soil. The values of ‘r’ were more in grain N than straw of rice and the reverse was observed in case of wheat, where, the ‘r’ values were more in case straw N than the grain N.

The P concentration in wheat grain as well as straw was decreased with the increase in soil pH electrical conductivity and CaCO$_3$ content in soil samples collected after the harvest of wheat crop, however P concentration in wheat grain increased with the increase in organic carbon content of soil r = 0.703**.

The K concentration in the grain and straw of rice as well as wheat, correlated significantly and positively, with the soil pH, electrical conductivity and CaCO$_3$ content of soils and the ‘r’ values were more in case of grain than the straw. The K concentration increased with the increase in these soil properties but decreased with the increase in the organic carbon content in case of both crops as indicated by the significant negative ‘r’ values. The S concentration in rice straw and wheat grain increased with the increase in the soil pH, EC and CaCO$_3$ content of soil, but decreased, with the increase in the organic carbon content in soil r = - 0.688* in case of rice straw S and r = - 0.623* in case wheat grain S.

**Correlation between Physicochemical properties and micronutrients concentration in rice and wheat crop** - The Zn and Cu concentrations were decreased with the increase in soil pH, EC and CaCO$_3$ content of soils, whereas, it
increased with the increase in the organic carbon content. The concentration of Fe in rice grain and wheat grain as well as straw correlated significantly and negatively with the soil pH $r = -0.908^{**}$, $-0.832^{**}$ and $-0.936^{**}$ E.C. $r = -0.909^{**}$, $-0.849^{**}$ and $-0.893^{**}$ and CaCO$_3$ content $'r' = -0.944^{**}$, $-0.828^{*}$ and $-0.891^{**}$, respectively, while, positive significant correlation existed with the organic carbon content $r = 0.861^{**}$, $0.733^{*}$, $0.624^{*}$ in case of rice grain Fe, wheat grain and straw Fe concentration, respectively. Similarly, Mn concentration in grain and straw of rice and wheat grain correlated significantly and negatively, with soil pH, E.C. and CaCO$_3$ content of soil indicated that Mn concentration decreased with the increase in these soil properties, and increased with the increase in the organic carbon content of soil.

**Correlation between Physicochemical properties and Pb, Cd and Cr concentration in rice and wheat crops** - all of the pollutant elements that is Pb, Cd and Cr concentration in rice and wheat straw correlated significantly and positively with the soil properties pH, electrical conductivity and CaCO$_3$ content in soil and increased with the increase in these properties, whereas, correlated, negatively, with the organic carbon content in soil.

**Correlation between physicochemical properties and yield of rice and wheat** - significant negative correlation was found between the soil properties like pH, E.C. and calcium carbonate content of soil and yield of rice and wheat crops, whereas the organic carbon content of soil exerted a positive effect on increasing the yield of rice grain $r = 0.791^{**}$, straw $r = 0.661^{**}$ wheat grain $r = 0.658^{*}$ and straw $r = 0.662^{*}$

**Correlation between physicochemical properties and nutrient uptake by rice and wheat crops** - the N and P uptake by the rice crop correlated significantly and negatively with soil pH $r = -0.861^{**}$ and $-0.746^{**}$, E.C. $r = -0.846^{**}$ and -
0.653* and CaCO$_3$ content in soil $r = -0.938^{**}$ and $-0.665^*$, respectively, however with the organic carbon content, significant positive correlations were found as $r = 0.812^{**}$ and $0.611^*$, in case of N and P uptake, respectively. The N and P uptake by wheat also correlated significantly and negatively, with soil pH, E.C. and CaCO$_3$ content and positively, with the organic carbon content in soil $r = 0.791^{**}$ and $0.682^*$ in case of N and P uptake respectively. The correlation coefficient values were higher in case of wheat than that of rice.

▲ Correlation between physicochemical properties and micronutrients uptake by rice and wheat crops - the highly significant negative, relationship of the soil properties like pH, electrical conductivity and calcium carbonate content in the post harvest samples after harvest of rice with micronutrients uptake that is Zn, Cu, Fe and Mn by the rice crop reflecting the decrease in their uptake with the increase in these soil properties, whereas, the organic carbon content had a positive significant correlation with the uptake of Zn $0.837^{**}$, Cu $0.651^*$, Fe 0.514 and Mn $0.790^{**}$ thus the uptake of these nutrients increased with the increase in the Organic Carbon content in soil. Uptake of micronutrients by wheat also decreased with the increase in the soil properties like soil pH the significant negative correlations were observed as Zn $r = -0.958^{**}$, Cu $r = -0.949^{**}$, Fe $r = -0.941^{**}$ and Mn $r = -0.951^{**}$, with E.C., Zn $r = -0.978^{**}$, Cu $r = -0.959^{**}$, Fe $r = -0.961^{**}$ and Mn $r = -0.979^{**}$ and with CaCO$_3$ Zn $r = -0.986^{**}$, Cu $r = -0.993^{**}$, Fe $r = -0.983^{**}$ and Mn $r = -0.966^{**}$. On the other hand, a significant positive relationship existed between the organic carbon content and uptake of Zn, $r = 0.717^*$, Cu $0.761^{**}$, Fe, $r = 0.743^{**}$ and Mn $r = 0.711^*$. Cobalt uptake correlated negatively and significantly, with soil pH, EC and CaCO$_3$ but positively with the organic carbon content.
Correlation between physicochemical properties and heavy metals uptake by rice and wheat crops - The soil pH, E.C. and CaCO$_3$ content in the soil exerted a positive effect on the uptake of Pb, Cd and Cr by rice crop, while, the organic carbon content decreased the uptake of these pollutant metals. Significant positive correlations were observed with the pH, EC and CaCO$_3$ content in soil and Pb, Cd and Cr uptake by rice but r values were negative and significant in case of organic carbon content. The uptake of Pb, Cd and Cr by wheat also correlated significantly and positively with soil pH, E.C. and CaCO$_3$ content in soil and negatively, with the organic carbon. Content thus the uptake of these pollutant elements increased with the increase in soil pH, E.C. and CaCO$_3$ content in soil, whereas, decreased with the increase in the organic carbon content.

Correlation between chlorophyll concentration in leaves and yield of rice and wheat crop - highly significant positive correlation existed between the chlorophyll content in the leaves of rice and wheat crop and their yields. Correlation coefficients were higher in case of grain yield than the straw yield and amongst the two crops values were more in case of rice than wheat. Comparison of the effect of chlorophyll ‘a’ and ‘b’ indicated that the ‘r’ values were similar in case of rice grain yield where as the effect of chl 'b' was more than the chl 'a' in case yield of rice straw and grain and straw yield of wheat.

Correlation between major nutrients content in soil and rice and wheat crops - The Nitrogen Content in soil correlated significantly with the N concentration in the rice grain and in grain and straw of wheat. The soil potassium content, correlated significantly with the K concentration in both grain and straw of rice and the ‘r’ values were rather more in case of the K concentration in the wheat grain and straw as well.
Correlation between heavy metals content in soil & rice and wheat crops - the cobalt content in rice grain and straw and wheat grain were increased with the increase in cobalt content in soils. Similarly, significant correlation existed between the lead content in soil with its concentration in rice and wheat straw \( r = 0.860^{**} \) and \( 0.970^{**} \), respectively. The Cd content in soil had a significant positive relationship with the Cd concentration in rice \( r = 0.740^{**} \) and wheat straw \( r = 0.930^{**} \). The Cr content in soil had the ‘r’ value of \( 0.976^{**} \) and \( 0.984^{**} \) in case of rice and wheat straw, respectively. The values of correlation coefficients were more in case of wheat straw than those of rice straw for the Pb, Cd and Cr content.

CONCLUSION - Present study has been done on topic Analytical studies on the effect of cement dust on soil properties and uptake of different metals by crops grown in surrounding area of cement plant in Chhattisgarh and following conclusion were drawn from the investigation.

1. Settle-able cement dust had elevated basic pH, high salinity and was rich in metal oxides of Ca and Si, while, the dust was poorer in the oxides of Al, Fe, K and Mg. The AAS analysis of trace metals showed settle-able dust from cement industry was rich in Pd, Cr, Cd heavy metal content with little amount of Zn, Cu, and K metals.

2. The air quality in the vicinity of the cement plant was found deteriorating due to the factory emissions and the concentration of particulates was higher than the permissible limits; prescribed by Indian air quality standard.

3. (a) An increase in soil pH, soil conductivity, exchangeable Calcium and Magnesium, Calcium carbonate, a decrease in moisture content, organic carbon, organic matter within the vicinity of the cement factory indicated a significant negative effect on the soil.
Available N, P and S content in soil increased significantly, with the increase in distance from the cement industry from 50m to 4500m. On the other hand, the K, Ca and Mg content around the industry, showed decrease with the increase in the distance from the cement industry. The Pb, Cd and Cr contents were significantly higher in the vicinity of industry up to 1000m and decreased significantly, with the increase in the distance from the industry. The Co content in soil after Rice and Wheat harvest followed increasing trend with increasing distance from industry.

4. The concentration of N was increased significantly; there was no significant variation in phosphorus concentration in Wheat as well as in Rice. Concentration of K in Rice as well as Wheat showed relatively higher values at nearer surroundings of the industry than those of distantly located field. The concentration of K was found higher in straw than grain in case of Wheat which showed the little translocation of K to grain in contrast to that of N and P which were found more in Wheat grain than straw. The Zn concentration in rice grain and straw was maximum at 4500 meter which decreased significantly at 50 meter distance. The Cu and Mn concentration in Wheat and Rice both in grain and straw decreased significantly at 4500 meter to 500 meter, similarly, for Fe concentration in Rice grain showed a decreasing trend, while reaching closer to the industry. The Pb, Cd and Cr concentration in Rice and Wheat straw was minimum at 4500 meter which was increased significantly at 500 and 50 meter distance. The Co concentration in Rice grain as well as in straw was increased significantly with the increase in the distance from the cement industry. The concentration of cobalt was higher in Rice straw than grain. In Wheat also the Cobalt concentration was slightly lower in the closely located fields than the distant ones. The
concentration of toxic and heavy metals in grain samples of wheat and rice were below the toxicity limits given by WHO. Concentration of toxic metals in plant parts was found in order soil > straw > grain.

5. Yield of Rice and Wheat crops around the cement industry had exhibited reducing trend up to 2000 meter, as an adverse effect caused due to pollution.

6. N, P, Mn and Fe uptake was increased significantly, with the increase in the distance from the industry, at 500m to 4000m. Toxic metals Pb, Cr, and Cd uptake by crops was increased significantly, from 4500 m to 500 m distance.

7. The photosynthetic pigments including chlorophyll a, chlorophyll b and total chlorophyll content were found to be low in plant species growing closest to the cement factory.

**Suggestions**

Further studies could be done on the influence of chronic toxicity of heavy metals released from cement industry on enzymatic activity of soil, vegetation, soil micro flora, also human subjects from this area, physiological aspects of vegetation and human beings of surroundings of cement industries.

**Recommendations**

Following recommendations could be made on the basis of study for appropriate mitigation in order to control the pollution in the area which includes:-

1. Emission standard as notified under EP Act 1986 and CPCB for control of fugitive emission etc for cement plant to be strictly enforced.

2. Development of a thick green belt around the periphery of each cement factory.

3. Appropriate air pollution control devices to be installed and regularly checked and continuous monitoring of specified pollutants to be initiated in all the locations around the cement and power plant for ambient and stack respectively.
4. Water sprinkling need to be practiced during the transport activity, provision of development of better roads within and around the premises of cement factories are essential.

5. The study recommends minimization of the amount of dust reaching agricultural soils and the use of phosphorus and nitrogen fertilizer supplements as soil management practices to enhance soil fertility status and enhance adequate crop yield in the area.

6. Cement industry emissions are potentially hazardous for the environment therefore, needs to be under periodical control, particularly in the case of very vulnerable soils in the vicinity of cement plants observance of standards of permissible limits for various constituents as prescribed by SPCB (state pollution control board) and CPCB (central pollution control board).

It is believed that this study would be useful to the planners, Regulatory agencies and decision makers (administrators) to take necessary steps to abate the pollution by framing emission schedules and judicious location of new industries in such a manner that the pollutants neither attain threshold levels nor reach the sensitive areas and the human population of the State.