The present study was undertaken with a view to follow the movement of essential (Fe, Zn, Ca, Cu, Co) and contaminating (Pb, Cd, and Cr) minerals in the food chain from soil and water through various food crops into the blood of residents from selected areas. Since the Census Industry Code has listed coal mining as the highest risk job, the study was undertaken in the geographical belt of the coal mining areas of Singrauli and data was compared with selected agricultural and industrial areas around Allahabad district.

From this study, insight was gained regarding accumulation and potential effects on health of toxic and essential heavy metals through the food chain from soil, water, vegetables, and cereals in various areas such as an agricultural area (AA), industrial area (IA), and coal mining area (CMA). In soil, all metals except Cu were highest in CMA, but levels in IA and AA were similar, except in the case of Pb, which was higher in IA than in AA. In all samples of water, all heavy metals were higher in IA than AA, and highest in CMA. In all food crops in all locations, Pb significantly exceeded both WHO and Indian norms, even though it did not exceed safe limits in soil and water. Spinach and potato showed excessive Cd and Cr also, which was more prominent in CMA. Lead and Cd exceeded the permissible limits given by WHO in all vegetables and cereals studied, except maize, at all the three locations. The overall pattern, with minor exceptions, for both toxic metals Pb and Cd and for essential metals Cr, Zn, Fe, and Co, in all parameters studied including soil adhering to spinach, potato, and cereals, irrigation, ground and tap water, foods crops spinach, potato, rice, wheat, and maize, transfer factors for soil to plant, daily intake of metal from each food and from total diet, and health risk indices for each food item and total from the diet were found to be highest in the coal mining area, followed by industrial area and least in the agricultural area. Copper seemed to be the sole exception, the
levels of which did not seem to depend on location. Spinach had the highest transfer factors, so if it is grown on soils contaminated with toxic elements such as Pb and Cd, it accumulates these, and if grown in soils rich in essential minerals, especially Fe and Zn, it becomes rich in these. This was followed by potato and cereals had the lowest transfer factors, which depended on location, being highest for CMA, followed by IA and AA.

However, cereals form the quantitatively largest staple food item in the Indian diet; hence these contribute more to the daily intake of all metals than spinach and potato, which form a smaller proportion of the diet. Thus, even though transfer of toxic metals Pb and Cd was higher in vegetables, the HRI was higher due to cereals. Therefore, Pb and Cd posed significant health risks for CMA residents, followed by IA and AA in that order, mainly attributable to cereals, while drinking water did not contribute significantly to intake of any metal studied, except Co. It is noteworthy that dietary intake of essential metal Fe was also more in the polluted areas of coal mines.

Iron deficiency is one of the most widespread nutrition problems worldwide, so this observation needs to be evaluated in terms of Fe status indicators of residents in these areas which were done by collecting blood samples of respondents of coal mining area as coal mining exposed respondents and also from non-mining area of Allahabad as Control respondents. The study indicated that some of the essential metals like Fe at every level of food chain and finally in blood of respondents was high and it had the positive impact of increased hemoglobin in respondents working in coal mining areas as compared to controls who were residing far away from mining areas.

Interactions between micronutrients and toxic metals, where the high concentration of one may have a beneficial or harmful effect on another were also studied. This could take place when high doses of a single nutrient is given or when the supply of an individual micronutrient is inadequate. High levels of Pb and Cd entering in coal mining exposed respondents via food consumption or air pollution had effect on levels of essential metals in blood. Lead correlated negatively with Fe, Ca, Cu and Co.
while Cd correlated negatively with Ca and Fe and this initiated the formation of free radicals and induced oxidative stress in blood of miner’s respondents.

Therefore, further studies were undertaken to compare the impact of metals in blood on nutritional status as indexed by hemoglobin, hematocrit and selected markers of oxidative stress in CME respondents and compared with controls (C) not exposed to the same toxic and essential metals. This study determined that coal dust exposure caused imbalance in biochemical parameters in blood of coal workers. Measurements of these parameters make an attractive approach for monitoring dust induced biological phenomena in coal workers. The activities of erythrocytic superoxide dismutase and plasma glutathione peroxidase were inhibited in coal-mining exposed as compared to controls who had not been similarly exposed. Moreover, it indicated that people living in the vicinity of the mining area have higher blood levels of toxic metals Pb and Cd, which correlated with some oxidative stress indices, but not with overall total antioxidant activity, and these effects increased as exposure duration increased. This in-vivo study was corroborated by an in-vitro designed to compare the impact of low to very high concentrations of Pb and Cd on RBCs of coal mining exposed respondents with controls who had not been similarly exposed. Results indicated that as the dose of Pb and Cd increased the activity of superoxide dismutase decreased and levels of MDA increased in both groups with a significant difference. One interesting observation was that at the highest concentration (2µM) of both Pb and Cd, the difference in SOD and MDA between control and coal mining exposed respondents did not remain significant. Similar responses were also found in studies related to coal miners, revealing that adequate protection and therapeutic strategies against such occupational contamination are urgently needed.

This study contributes to present knowledge regarding effects of essential and contaminating metals at each step of food chain. Limited data is currently available which traces the movement of both toxic and essential metals through the food chain from soil and water to food crops and finally into the blood of residents of coal mining areas with industrial and agricultural areas. This is the first study undertaken
in this geographical area to compare coal mining areas of Singrauli to non mining area of Allahabad at various steps of food chain. This study highlights that certain edibles that accumulate more of metals in mining location should not be grown in polluted areas. This study can be extended further to determine the mechanism that enables Fe in coal to become bioavailable and how they contribute to the observation that coal mining exposed respondents have higher Hb levels. Having determined the impact of toxic metals such as Pb and Cd on OS markers, further studies are required to explain redox changes at the molecular level especially with regard to enzymatic modulations.

On another note, the study can be extended to identify plants that can remove polluting metals from the soil of highly polluted mining areas by phytoextraction. The high uptake of metals by leafy vegetable spinach points to the possibilities that these may be weeds that selectively take up toxic metals, thus removing them from the food chain ab initio and thereby contributing to bioremediation.