Heavy metals concentration in soil due to cement dust deposition around Birla cement plant, Satna M.P.

Alka Khare [1], Dr. Rajesh Kumar Garg[2]

[1] Research scholar A.P.S university Rewa(M.P.)

[2] Department of Botany Govt. Autonomous college Satna (M.P.)

Abstract

This study is aimed to determine the heavy metals (Pb, Cd, Cr, Co, and Ni) concentration in soil due to cement dust deposition around Birla cement plant, Satna M.P. The soil samples were collected at different distance from Cement factory and also from a control site, an area of 10 km away from cement factory and were analyzed by using Atomic Absorption Spectroscopy Technique. The result shows that the highest concentration of Lead (Pb) (42.76 mg/kg), cadmium (Cd) (2.74 mg/kg), chromium (Cr) (43.78 mg/kg), cobalt (Co) (1.683 mg/kg) and nickel (Ni) (3.56 mg/kg) were obtain near the vicinity of cement plant while the concentration of these heavy metals decrease with the increase of distance from cement plant and not detected or obtained in very trace amount at control site.

Keywords: cement dust **,** heavy metals, soil pollution.

Introduction

The rapid growth in industrialization has led to the soil pollution through the emancipation of effluents by the industrial units. Each type of soil has its own structure and texture. The distinctive feature of this individuality is the soil profile, which consists of sequence of layers different from other. The effluents discharged by the industrial units into the soil contain many toxic substances, mineral acids, bases, heavy metals etc. Over a period of time get deposited in the soil due to their retention and adsorption on the soil particles. During cement manufacturing activities two types of particles are to be recognized: the primary particles that are reached directly in the atmosphere and another type of particles are formed in the atmosphere following chemical transformations. These particles can come into the soil as dry, humid or occult deposits and can emaciate its physico-chemical properties. The deposit of these particles is complex and it is controlled by the atmospheric stability, the roughness of the surfaces and also the diameter of the particles[1]. Soil pollution by heavy metals has serious health implication especially with regards to crops/vegetables grown on such soils[*2, 3*]. Most of these heavy metals are necessary for the growth and normal functions of both plants and animals at trace amount such as Fe, Zn, Mn, Cu, Co and Ni but large amount of any of them may cause acute or chronic toxicity. Long-term effect of heavy metal exposure to human and higher animals includes mental lapse, kidney failure, and central nervous system disorder[*3*].

Mandal and Voutchkov (2011) [26] studied the heavy metals in soils around the cement factory in Rockfort, Kingston, Jamaica in close vicinity of the Rockfort and the Harbour view area and analysed by INAA, AAS, XRF for major, minor and trace elements and observed that the top soils of the study area are enriched in Pb, Zn, Cr, Cd, V, Pb, and Hg which are released into the air from the cement kilns. Results show that the soils are enriched in Ca with a maximum value of 18% followed by Al, Fe and Na. Heavy metals in the soils of the study area shows relatively high concentrations of zinc with a maximum of 132 ppm followed by Cr (57) ppm and Pb (32) ppm.[4]Concentration of Cd, Cr and Zn metals were higher in soil surface than sub surface soil samples while, Cu, Pb and Fe concentrations in subsurface soil were higher around the cement factory (Al-Oud *et al*. 2011) [1]. Al-Omran *et al.* (2011) collected soil samples at two depths (0-5 and 20-30 cm) in the vicinity of cement factory and analyzed chemical properties as well as their heavy metal content and indicated that the soil samples were calcareous in nature with 22.1 to 35.5% CaCO3 with higher percentages in the surface soil samples taken near the cement factory, sandy loam to loamy sand in texture and moderately to slightly alkaline. Exchangeable calcium contents ranged from 1.4 to 5.44 c.mol.kgG1 while the mean values of exchangeable potassium reached 0.32 cmol.kgG1.The cation exchange capacity (CEC) was low to medium (1.94 to 8.14 cmol.kgG1) and the soils of the study area were moderately to heavily contaminated with (As, Cd, Pb and Ni) and heavily contaminated with Cr, the most contaminated sites area was found within the 0 to 2 km of the cement factory.

Material and Methods

Study area

Study area for this research work was Birla cement plant Satna Counted amongst the larger plants of the Cement at Satna district. Birla Corporation Limited has two cement plants at Satna (M.P.) - Satna Cement Works & Birla Vikas Cement. Both plants are adjacent to each other and lies about 5 km towards North of satna city and it was surveyed during 2016-17.

Soil sampling

In the period of June 2017, the total number of 10 soil samples were collected from different distance from Birla Cement Plant Satna and also one soil sample were collected from an area of 10 km away from cement plant which is serve as control site or reference site. During sample collection firstly all the area around Birla cement plant was surveyed and 10 different spots were marked to collect the soil sample. The surface litter was removed at the sampling spot before soil collection. Land was ploughed by driving auger to depth of 15 cm and the soil sample was drawn. 'V' shaped cut to a depth of 15 cm in the sampling spot was made by using spade. Soil sample were collected from each sampling spot and placed in a bucket or tray. The soil was thoroughly mixed and foreign materials like roots, stones, pebbles and gravels were removed. The sample was collected in polythene bag and bag was labeled with information like, distance of the site from cement plant, survey number, date of collection, name of the sampler etc. The Soil samples were air-dried and gently crushed and sieved and stored for chemical analysis.

TABLE: 1- List of different soil sample collected at various distance from Birla cement plant Satna

S. No.	Soil sample	Distance from Birla cement plant(in Meter)
1.	S-1	100
2.	S-2	200
3.	S-3	400
4.	S-4	600
5.	S-5	800
6.	S-6	1000
7.	S-7	1500
8.	S-8	2000
9.	S-9	2500
10.	S-10	3000
11.	S-Control	10000

Heavy Metals Determination

An atomic absorption spectrophotometer method was used to determination of heavy metals (Pb, Cd, Cr, Co, and Ni. The absorption wavelength for the determination of each heavy metal type, temperature and other operating parameters of GF-AAS for the working elements are given in table below and each analysis was performed in triplicate.

For digestion of the soil samples wet digestion method was used. 0.5 g of air-dried, ground, and sieved soil samples was taken into a digestion tube. 6 ml aqua regia and 1.5 ml H_2O_2 were measured and added into the digestive tube and the solution was mixed properly. The digestion tube were then placed on digestive furnace and heated at the temperature of 180°C for 3 hours. All the digests were cooled and filtered through Whatman No.42 filter paper and diluted with 50 ml of distilled water. And then sample was kept for heavy metal analysis by atomic absorption spectrophotometer method. The spectrophotometer was calibrated using calibration blank and series of working standard solutions of each metal to be determined. The digested samples were determined for the concentration of heavy metals (Pb, Cd, Cr, Co, and Ni) by flame atomic absorption spectrophotometer. Final concentration of the metals in the soil samples were calculated using the following formula(Uwah et.all.2012)

Final concentration of heavy metals (mg/kg) = concentration (mg/ L) × V/ W

Where,

W= weight of sample (0.5g)

V= volume of solution (50ml)

TABLE: 2- Standard operating condition for FAAS analysis of heavy metals

Heavy metals	Wavelength(nm)	Slit width(nm)	Flame type	Lamp current (mA)
Lead(Pb)	283.3	0.7	Air-Acetylene	6
Cadmium(Cd)	228.8	0.7	Air-Acetylene	4
Chromium(Cr)	357.9	0.7	Air-Acetylene	10
Cobalt(Co)	240.7	0.2	Air-Acetylene	7
Nickel(Ni)	232.0	0.7	Air-Acetylene	7

Results and Discussion

TABLE: 3- Heavy metal contents in different soil samples collected from various distance of Birla

Soil sample from various distance (Meter)	Lead (mg/Kg)	Cadmium (mg/Kg)	Chromium (mg/Kg)	Cobalt (mg/Kg)	Nickel (mg/Kg)
S-1	71.03	2.74	43.78	0.967	3.56
S-2	72.76	1.09	41.64	1.132	3.27
S-3	38.00	1.12	35.07	1.458	3.07
S-4	21.40	0.77	19.80	1.631	1.56
S-5	21.56	1.06	21.96	1.683	1.98
S-6	14.80	0.73	21.53	1.211	1.97
S-7	4.98	0.54	14.87	0.867	0.87
S-8	1.98	0.03	8.6	0.531	0.98
S-9	ND	trace	6.08	0.234	Trace
S-10	ND	ND	Trace	0.232	Trace

S-CONTROL	0.35	Trace	ND	0.211	Trace
Maximum	72.76	2.74	43.78	1.683	3.56
Minimum	0.35	0.03	6.08	0.211	0.87

cement plant Satna:

ND= No data (Heavy metal not detected)

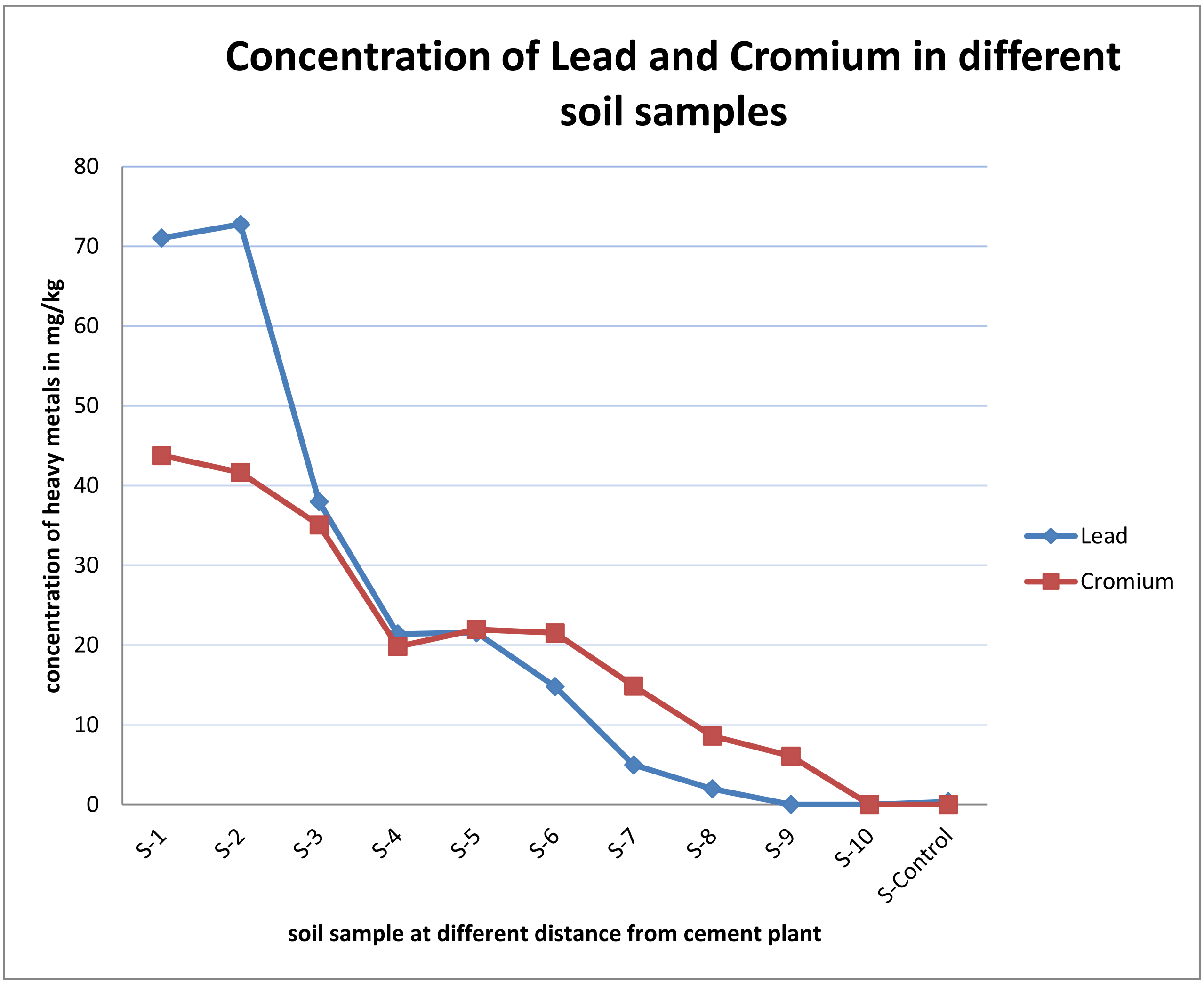

Figure – 1 concentration of Pb and Cr in soil sample collected at various distance from cement plant

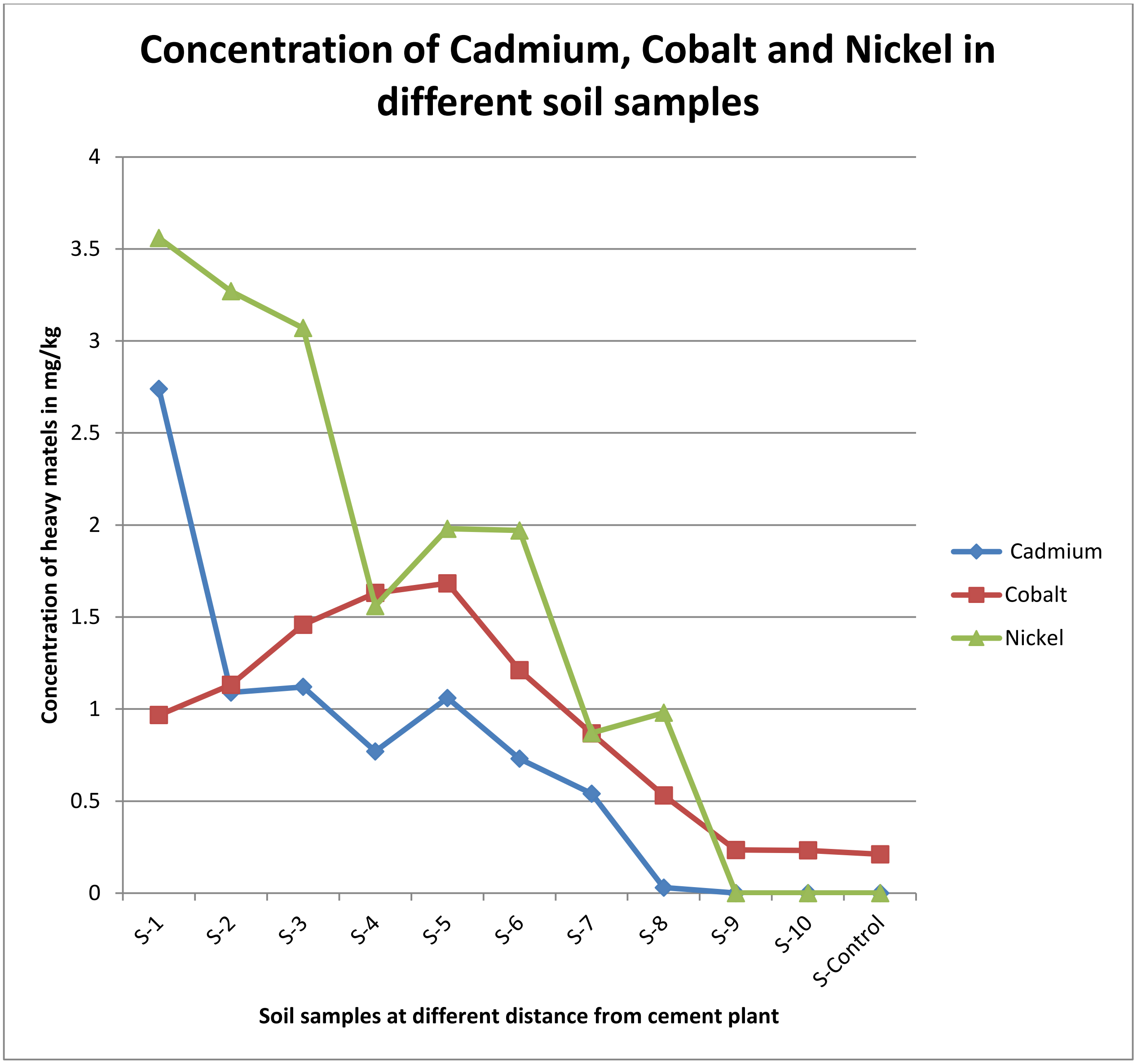

Figure – 2 concentration of Cd, Co and Ni in soil sample collected at various distance from cement plant

This study discriminate the heavy metals (Pb, Cd, Cr, Co, and Ni) concentration in soil due to cement dust deposition around Birla cements plant, Satna M.P. Soil surface at all selected sites except control site show a thick and hard deposition of cement dust. The thickness of cement dust deposition is progressively decrease with the increasing distance from cement plant. Such a crust was formed due to hydration of cement dust in present of moisture, followed by its subsequent crystallization and solidification and affect the chemical properties of soil (Przemeck 1970). The concentration of heavy metals were analyzed in the soil samples at the various sampling sites listed in Table 3 The result shows that the concentration of Lead(Pb) is ranged from 72.76- 0.35mg/kg. The highest concentration of Lead (Pb) (72.76 mg/kg) was observed at 200m distance away from cement plant while the lower Pb content obtained at control site and it is not detected at distance of 2500m and 3000m away from cement plant. Cadmium (Cd) concentration is ranged from 2.74-0.03 mg/kg with highest concentration (2.74 mg/kg) determined nearest at 100m distance and it is gradually decrease with increase in distance from cement plant. The chromium (Cr) concentration is ranged from 43.78- 6.08 mg/kg with highest concentration (43.78 mg/kg) at 100m distance while it is not detected at control site. The content of cobalt (Co) in soil sample is ranged from 1.683-0.211 mg/kg the maximum content of cobalt is found at 800m distance from factory. The levels of Co obtained in this study in all the sampling sites were lower than recommended limit which is 50 mg/kg by Ewers,1991[ ] and the total contents of nickel (Ni) were obtain to decrease with increase in distance from the cement industry. The highest concentration of nickel is 3.56 mg/kg determined at closest distance (100m). Concentration of these heavy metals decrease with the increase in distance from cement plant and not detected or obtained in very trace amount at control site. The highest concentration of Lead and Cadmium at 200m and 100m respectively is higher than permissible limits suggested by WHO (2008) and United Kingdom standards (70mg/kg) while it is lower than Indian standards (Awasthi,1998). The higher concentration of Lead and Cadmium in soil near the cement factory may be related to the burning of leaded fuel by machinery used in different activities around the factory united with cement production process that releasing dust containing Cd, Pd etc. Banat *et al.* (2005). The concentration of Cr and Ni in all soil samples collected at around cement plant and control area is below than permissible limits given in TABLE: 4.

TABLE: 4 –The maximum permissible limit (MPL) values of the trace heavy metals in agricultural soil by different standards

Heavy metal	*Target value of soil (mg/kg)	Indian standards (Awasthi,1998)	United Kingdom Standard Mg/Kg)	WHO (2008)
Pb	85	250-500	70	70
Cd	0.8	3-6	1.4	
Cr	100	-	-	NA
Ni	35	75-150	35	35
Co		-		-

Source: Denneman and Robberse 1990; Ministry of Housing, Netherlands 1994, WHO (1996) *Target values are specified to indicate desirable maximum levels of elements in unpolluted soils.

Conclusion

The concentration of heavy metals analyzed in the soil samples at the various sampling areas near the cement plant and also at control area is resulted that the highest concentration of Lead (Pb) (72.76 mg/kg), cadmium (Cd) (2.74 mg/kg), were determined at distance of 200m and 100m respectively from cement plant which are higher than the maximum permissible limit (MPL) values of the heavy metals in agricultural soil suggested by different standards. The highest concentration of chromium (Cr) (43.78 mg/kg), cobalt (Co) (1.683 mg/kg) and nickel (Ni) (3.56 mg/kg) were obtain in all soil sample collected at around cement plant are below than permissible limits given by different standards. This study also resulted that the concentration of these heavy metals decrease with the increase of distance from cement plant and not detected or obtained in very trace amount at control site .

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