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Toxicity study of metals contamination on vegetables grown in the vicinity of cement factory

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Abstract- The aim of this study was to measure the toxicity levels of heavy metals (Fe, Zn, Cu, Pb, Cd, Mn and Cr) found in tested vegetables (Spinach, Cabbage, Cauliflower, Brinjal, Lady's Finger, Tomato and Radish) grown in contaminated Cement Factory area compared with those grown in reference Clean (control) area. When compared with the reference in contaminated area, water, soil and vegetables contents of all analyzed metals was significantly higher, usually over normally content for Fe, Zn, Cu, Pb, Cd, Mn and Cr. Particularly, higher values than safe limits were found for Pb, Cd, Mn and Cr in water and for Cd in soil and Pb, Cd and Cr were observed higher in leafy vegetable especially Spinach, in contaminated (Cement Factory) areas. In an attempt to understand the pattern of metal contamination in the area, useful tools including Enrichment Factor were also employed to indicate the sources of soil contamination were anthropogenic in character.

Index Terms- Industrial Effluent; Industrial Pollution; Toxic Heavy Metals; Quantification; AAS; Water Pollution; cement factory (Industrial Area).

I. Introduction

Although all industries in India function under the strict guidelines of the Central Pollution Control Board (CPCB) but still the environmental situation is far from satisfactory. According to Kumar *et al.*, (2003) Cement industry is one of the 17 most polluting industries listed by the Central Pollution Control Board (CPCB).Different norms and guidelines are given for all the industries depending upon their pollution potentials. Most major industries have treatment facilities for industrial effluents. But this is not the case with small scale industries, which cannot afford enormous investments in pollution control equipment as their profit margin is very slender. As a result in India there are sufficient evidences available related with the mismanagement of industrial wastes. Consequently, at the end of each time period the pollution problem takes menacing concern. During the past few decades Indian industries have registered a quantum jump, which has contributed to high economic growth but simultaneously it has also given rise to severe environmental pollution. Consequently, the water quality is seriously affected which is far above in comparison to the national and international standards. The surface water is the main source of industries for waste disposal. Untreated or allegedly treated effluents have increase the level of surface water pollution up to 20 times the safe level in 22 critically polluted areas of the country. The problem of water pollution has become still worse due to toxic heavy metals. The increasing trend in concentration of heavy metals in the environment has attracted considerable attention amongst ecologists globally during the last decades and has also begun to cause concern in most of the major metropolitan cities. Untreated or allegedly treated industrial effluents and wastewater contains variable amounts of heavy metals such as arsenic, lead, nickel, cadmium, copper, mercury, zinc and chromium, which have the potential to contaminate vegetables growing under such irrigation. These heavy metals have a marked effect on crops and vegetables through which bio-accumulator enter the food chain and ultimately affect the human beings as well. Cement is produced world-wide in large amounts as an important binding agent for the construction industry. Cement factory through the release of waste effluents such as heavy metals (HM), generated in the process of crushing limestone, bagging, and transportation of cement are carried by wind and/or water and deposited on soil, plants and water bodies. Globally, the problem of soil contaminated due to heavy metals has begun to cause concern in most cities since this may lead to geoaccumulation, bioaccumulation and biomagnifications in ecosystem. Several studies have been carried out on effect of cement and stone dust on stomatal clogging of *Iphonia grantioides* Boiss leaves (Abdullah and Igbal, 1991), groundnut (Prasad and Inamdar, 1990), chlorophyll contents of selected plants (Shah *et al.*, 1989), periodical effect on growth of some plant species in Karachi, Pakistan (Iqbal and Shafig, 2001), production externalities and profitability of crop (Tijani *et al*., 2005) and growth of *Phaseolus vulgaris* L. cv. (Ade-Ademilua and Umebese, 2007) in the vicinity of a Cement Factory, Nigeria. However, very limited studies have been carried out on cement site in India. Extensive literature search showed that very few or no apparent toxicity studies were undertaken on heavy metals concentration in soil and vegetables in cement factory locations in India. However wastewater uses for agricultural irrigation can have multiple benefits for almost all countries, but it is particularly beneficial and cost-effective in low-income arid and semi-arid countries. In such areas additional low-cost water resources can have a high payoff in human welfare and health, with increased possibilities for food production and increased employment opportunities for poor population groups living in the peripheries of towns and cities, which are the source of copious wastewater channel. However, in humid areas of low- and middle-income countries, including India, wastewater flows from large industrial areas are untreated and laden with heavy metals in the nearby farmlands, thus presenting a serious health risk when entering water sources used for irrigation. The use of wastewater for irrigating agricultural crops, including high-value crops such as fruits and vegetables is common practised in India because of the scarcity of clean water resources and because wastewater is seen by small-

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scale producers as a cheap means to improve soil fertility and add essential nutrients for their crops. Although wastewater has a high nutrient value, it also has a food-safety risk due to the possibility of the transmission of many diseases through consumption of wastewater irrigated crops and vegetables and posing a potential human health hazard. In addition, farmers and irrigation workers can acquire toxic heavy metals due to direct contact with untreated wastewater and contaminated soils, especially if exposed for a long duration (Ensink, 2006). Despite this knowledge, it is often difficult to get farmers, particularly poor small-scale producers, to alter behaviour by applying risk-reducing practices to wastewater irrigation, because food production using wastewater generates significant livelihood1 opportunities (Buechler and Devi 2002a, 2003b; Hamilton et al., 2005; Toze, 2006). Therefore, effective risk reduction strategies must account for farmers' practices and attitudes towards the adoption of intervention to mitigate these risks.The present day by day increasing tremendous industrial pollution has prompted to carry the toxicity study of heavy metals contamination on vegetables grown in the vicinity of Cement Factory, Rewa, India, which is considered as the India's 3rd largest cement producer Factory in the country. It is estimated that up to 447.8 hectares of agricultural land in Rewa city is being irrigated with cement wastewater (According to J.P. Cement plants, official data). This wastewater had been generally used as irrigating crops and vegetables. Along the industrial agricultural land the water had supplied directly to the fields. No canals, tanks and/or cha nnelled to the fields for irrigation were available. Hence more than 94 per cent of the water supplied to the agricultural land to the industrial sites (Cement plants) of Rewa city returns as waste water. The discharge of untreated waste water into agricultural field had made it highly polluted due to accumulation of heavy metals. Many of peoples in these sub urban area of Rewa city have been depending upon wastewater irrigated vegetables for their food requirement. Agriculture land livestock rearing had amongst the most impo rtant livelihoods of the villages. So the main purpose of the present study was to determine the toxicity level in vegetables due to wastewater from A Cement Factory in North- East Region of Rewa within a rural area with no other industrial source in the area. Specifically, the study focuses on the distribution of heavy metals in soils and vegetation around the Cement Factory. Enrichment Factor was also employed to improve whether the source was anthropogenic or natural in contents?

II. Materials and Methods

EXPERIMENTAL
Study Area

Figure 1. Location site map for experimental sites

The study area is bounded between $24^0$28'24" to $24^0$39'11" north latitude and 81^0 05'46" and $81^0$17'23" east longitude (Approx). The J.P. Cement (Rewa) Limited factory is operating a 2.8 MTPA cement manufacturing plant at Jaypee nagar which is 18 km north of the Rewa Township in the Rewa District . There are no other industrial developments within the area. The cement factory plays a significant role in the local building industry in the economy of Rewa. The annual rainfall of this region is 1139.15 mms and average maximum and minimum temperature are 36.8^{0}C and 12^{0}C respectively. More than 90% annual rainfall occurs during the monsoon months. The factory's surrounding area is essentially rural with minor agricultural activities. Settlements are scattered houses at varying distances with the nearest settlement of about 200m. Three sites following different irrigation sources (Bela, Naubasta and

Bhiti) were selected as the experimental sites. Bela and Naubasta are two large industrial areas in which cements are produced. The bulk of this untreated industrial effluents are mixed with water which is known as wastewater, used to irrigate vegetables and Bhiti site was rural area where irrigation was done by clean (ground) water on agricultural land, was selected as control site, around the Rewa city. **Map of the sampling site is shown in Figure 1.**

Sample Collection

The sampling sites were selected in such a manner to cover the entire vicinity of the Cement Factory. Surface water samples were taken from the route into which waste water from factory is discharged; but also from vegetable fields where wastewater was used for irrigation. As control, surface water was sampled in fields irrigated with clean (deep bore well) water. Wastewater irrigated soil samples were collected from the cultivated fields near the Cement Factories Bela and Naubasta Limited along a distance of 60m from the Factory. Soil Samples were taken from the upper (0-20 cm) of soil because of the surfaces effective upper depth of cultivated soils, within the experimental sites with the help of a 25 mm diameter stainless steel tube auger which was pushed to the required depth when the tube had been removed from the soil, the core was extruded from the corer with the aid of a stainless steel rod and packed into polyethylene bags. Clean water irrigated soils (control soil) was also sampled for comparison.Vegetable samples were taken in the agricultural fields around the commune where they were known to be affected by waste water and where they were not (control). Samples of seven different kinds of vegetables; leafy vegetables included Spinach (*Betavulgaris L. CV.* All green), and Cabbage (*Brassica oleracea L. Var. Capatuta*). Inflorescence vegetable included Cauliflower (*Brassica oleracea L. Var. botrytis*), Fruit vegetables included Lady's Finger (*Abelmoschus esculentus L.*), Brinjal (*Solanum melongena L.*), Tomato (*Lycopersicon esculentum L.*) and Root vegetable included Radish (*Raphanus sativus L.*) were taken from the same experimental sites where waters and soils samples were taken .The detailed of the vegetable samples collected from the experimental sites are given in Table 1.

Table 1: Description of vegetable samples analyzed

Common Name	Designation	Scientific Name	Edible Parts
Spinach	SP	*Betavulgaris L. CV.*	Leaf
Cabbage	CA	*Brassica oleracea L. Var. Capatuta*	Leaf
Cauliflower	CF	*Brassica oleracea L. Var. botrytis*	Inflorescence
Lady's Finger	LF	*Abelmoschus esculentus L.*	Fruit
Brinjal	BR	*Solanum melongena L.*	Fruit
Tomato	TO	*Lycopersicon esculentum L.*	Fruit
Radish	RA	*Raphanus sativus L.*	Root

Sample digestion

Water samples were digested according to APHA, (2005); the irrigation water sample, 50 ml. was transferred into beaker and 10 ml. of concentrated nitric acid (HNO_3) was added. The beaker with the content was placed on a hot plate and evaporated down to about 20 ml at 80^0C .The beaker was cool and another 5 ml. concentrated HNO_3 was also added. The beaker was covered with watch class and returned to the hot plate. The heating was continued, and then small portion of HNO_3 was added until the solution appeared transparent. The beaker wall and watch glass were washed with distilled water and the solution was filtered through whatman NO. 42 filter paper and the total volume were maintained to 50 mL with distilled water. Soil and vegetable samples were digested according to Allen *et al.*, (1986). To 5g of each of the air dried and sieved samples was thoroughly grinded, 1.0g of each of the ground samples were placed in 100 ml beaker. 15 ml of HNO, H_2SO_4 and HCl mixture (5:1:1) of tri-acid were added and the content heated gently at low heat on hot plate for 2 hrs at 80^0C until a transparent solution was obtained. After cooling, the digested sample was filtered using whatman NO. 42 filter paper. It was then transferred to a 50 mL volumetric flask by adding distilled water. Triplicate digestion of each sample was carried out together with blank digest without the sample.

Sample analysis

Concentrations of Fe, Zn, Cu, Pb, Cd, Mn and Cr in the filtrate of digested soil, water and different kind of vegetables samples were estimated by using an Atomic Absorption Spectrophotometer (AAS, Perkin Elmer analyst 400). The instrument was fitted with specific lamp of particular metal. The instrument was calibrated using manually prepared standard solution of respective heavy metals as well as drift blanks. Standard stock solutions of 1000 ppm for all the metals were obtained from Sisco Research Laboratories Pvt. Ltd., India. These solutions were diluted for desired concentrations to calibrate the instrument. Acetylene gas was used as the fuel and air as the support. An oxidising flame was used in all cases. Guideline for maximum limit of heavy metals (Fe, Zn, Cu, Pd, Cd, Mn and Cr) in irrigation water, soil and vegetable was adopted from the reference by Indian Standard, WHO/FAO, European Union Standard and USEPA (see table 2).

Table 2: Guideline for safe limits of heavy metals

Samples	Standards	Fe	Zn	Cu	Pb	Cd	Mn	Cr
Water ($mg\ L^{-1}$)	Indian Standard (Awashthi 2000)	NA	5.0	0.05	0.10	0.01	0.1	0.05
	WHO/FAO (2007)	NA	2.0	0.20	5.0	0.01	0.2	0.10
	European Union Standards (EU2002)	-	-	-	-	-	-	-
	USEPA (2010)	NA	2.00	1.00	.015	.005	.05	0.10
	Kabata-Pendias (2010)	0.80	NA	NA	NA	NA	NA	NA
Soil ($mgkg^{-1}$)	Indian Standard (Awashthi 2000)	NA	300-600	135-270	250-500	3-6	NA	NA
	WHO/FAO (2007)		-	-	-	-	-	-
	European Union Standards (EU2002)	NA	300	140	300	3.0	NA	150
	USEPA (2010)	NL	200	50	300	3.0	80	NA
	Kabata-Pendias (2010)	1000	NA	NA	NA	NA	NA	NA
Plant ($mgkg^{-1}$)	Indian Standard (Awashthi 2000)	NL	50.0	30.0	2.5	1.5	NL	NA
	WHO/FAO (2007)	450	60.0	40.0	5.0	0.2	500	5.0
	European Union Standards (EU2002)	NL	60	40	0.30	0.20	NL	NA
	USEPA (2010)	-	-	-	-	-	-	-

Source: CPCB

Enrichment Factor(EF)

The enrichment factor (EF) has been calculated to derive the degree of soil contamination and heavy metal accumulation in soil and in plants growing on contaminated site with respect to soil and plants growing on uncontaminated soil (Kisku *et al.*, 2000).According to Ergin *et al.*, (1991) and Rubio *et al.*, (2000) the metal enrichment factor (EF) is defined as follows:

$$\text{Enrichment Factor } (EF) = \frac{[M_x /\ \mathrm{M_{ref}}]Sample}{[M_x /\ \mathrm{M_{ref}}]Background}$$

Where M = Metal Concentration in soil sample and EF is the enrichment factor. (M_x/M_{ref})sample is the ratio of metal and (M_x/M_{ref})background is the ratio of metals and heavy metal concentration of a background. The background concentrations of metals were taken from an undisturbed area.

Five contamination categories are recognized on the basis of the enrichment factor as follows:

EF<2 is deficiency to minimal enrichment

EF<2-5 is moderate enrichment

EF<5-20 is significant enrichment

EF20-40 is very high enrichment

EF>40 is extremely high enrichment

(Sutherland 2000)

Despite certain short comings, the enrichment factor, due to its universal formula, is relatively simple and easy tool for assessing enrichment degree and comparing the contamination of different environment.

Quality assurance

Appropriate quality assurance procedures and precautions were taken to ensure the reliability of the results. Samples were carefully handled to avoid contamination. Glasswares were properly cleaned, and reagents were of analytical grades. Deionized water was used throughout the study. Reagent blank determinations were used to correct the instrument readings. For validation of the analytical procedure, repeated analysis of the samples against internationally certified plant standard reference material (SRM-1570) of National Institute of Standard and Technology were used, and the results were found within ±2% of the certified values.

Statistical analysis

The recorded data were subjected to two-way analysis of variance (ANOVA) to assess the influence of different variables on the concentrations of heavy metals in the vegetables tested. All the statistical analyses were computed with SPSS software version 17.

III. RESULTS AND DISCUSSION

Metal concentrations in irrigation water and soil

Tables 3 summarize the concentrations of seven heavy metals, respectively, in water and soil and samples collected in the vicinity of the J.P. Cement factories as well as control site. All the seventh elements display their presence in all the water and soil samples used for the study. It is clear from the results that the concentration of heavy metals in contaminated water (wastewater) samples obtained from the two source sites: Bela and Naubasta Cement Limited were significantly higher than those of the samples of control (clean) water obtained from Bhiti village (Table 3). In Bela and Naubasta Cement Limited sites, the concentration of Zn and Cu were however below the permissible limit set by Indian Standard (Awashthi, 2000), FAO/WHO (2007), EU Standard (EU 2002) And USEPA (2010), but the concentration of Pb by USEPA (2010), Cd by Indian Standard (Awashthi, 2000) and FAO/WHO (2007), Mn by FAO/WHO (2007) and Cr by Indian Standard (Awashthi, 2000) were higher than permissible limits. However, because no permissible limits were available for Fe, level of Fe suggested by Kabata Pendias (2010) was used for Fe and it was found that Fe concentration in all three sites were below the permissible level (see Table 2 Guideline & 3). In comparison of the concentration of heavy metals in contaminated water of J.P. Cement Factory Rewa with Cement Factory of NIGERCEM, Nigeria showed that Cd (0.04 mg L^{-1}) and Cr (0.149 mg L^{-1}) were lower, but for Fe (0.298 mg L^{-1}) and Zn (0.069 mg L^{-1}) were higher during the present study. The data obtained from heavy metals in waste water from the present study varied more or less regularly with the findings of the other authors (Khan *et al.,* 1998; Nakshabandi *et al.,* 1997 and Sridhara *et al.,* 2008).

Soils around cement factories showed high concentrations of metals especially Cd ,which showed exceed the permissible limit set by EU Standard (2002) and USEPA (2010) (Table 2 & 3) on top soils of 0-20 cm deep. Since there were no other sources of contamination in the area, the source of Cd in soil may be attributed to dust particles from cement factory (Bela). The lower concentrations of remains heavy metals (except for Cd) than the safe limits may be due to the continuous removal of heavy metals by the vegetables and cereals grown in this contaminated areas and also due to leaching of heavy metals into the deeper layer of soil (Singh *et al.,* 2010). This highest conc. of Cd in contaminated soil of Bela Cement Factory was significantly higher than 3.02 mg/kg at Nigeria Cement Company (NIGERCEM) site reported by C. Ogbonna *et al*., (2011) but significantly lower than 7.84mg/kg reported by Mandal and Voutchkov (2011) in the vicinity of cement factory. Whereas the lower (within safe limits) concentration of all seven metals at control site, indicating that there were no sources of contamination in the area, hence the site is free of contamination, represented as control site.

Table 3: Mean heavy metals concentration in irrigated water and soil

SAMPLE	SITES	Mean Heavy Metal Concentrations						
		Fe	Zn	Cu	Pb	Cd	Mn	Cr
For contaminated water (mg L^{-1} DW)	WWI-I	0.689±0.445	0.248±0.005	0.041±0.013	0.067±0.013	0.031±0.006	0.375±0.024	0.077±0.010
	WWI-II	0.371±0.093	0.109±0.0513	0.025±0.004	0.105±0.081	0.027±0.006	0.230±0.030	0.036±0.009
	CWI-III	0.005±0.0032	0.003±0.0008	0.002±0.0008	ND	ND	0.001±0.0002	ND
for contaminated soil (mg kg^{-1} dw)	WWI-I	174.38±3.39	163.42±5.77	29.19±3.03	20.08±1.74	4.03±0.053	66.08±2.41	21.05±0.779
	WWI-II	185.22±6.12	156.95±11.06	40.70±4.95	14.47±0.799	3.24±0.353	57.88±3.03	24.84±2.02
	CWI-III	61.01±8.25	43.75±6.71	16.54±2.87	7.4±1.04	0.65±0.023	44.52±9.38	5.76±2.27

Mean±SD Values ; ND= Not Detected; Student t- test was done for mean heavy metal concentrations between WWI and CWI sites ; Level of significance: $p<0.001$

Metal concentration in plants

It is observed from the results Pb (8.9 mg/kg), Cd (2.39 mg/kg) and Cr (5.25 mg/kg) conc. in all vegetables (Highest for Spinach) exceeded the permissible limits for contaminated cement areas. Present study revealed that the conc. of Pb was exceedingly and/or slightly above in all seven vegetables at all sites including control and crossed safe limits. Pb concentration in all vegetables from both contaminated sites were exceedingly high whereas at control site, was slightly high concentration. As there was no industrial unit near the control area, it seems soil of that area naturally have high concentrations of those elements which may be come from atmospheric deposition by air or other anthropogenic sources. Accumulation of Pb mainly due to J.P. Cement plants due to transportation, re-suspended road dust and diesel generator sets. The reason for highest Cd accumulation in contaminated vegetables especially for greens (Spinach) from cement factories was that they were Cd sensitive and relatively high Cd accumulators. Cd was easily taken up by food crops especially leafy vegetables. The concentration of Cd (2.39 mg/kg) was much higher than 0.85-1.186 ppm and 0.92 ± 0.92 µg/g in greens and Piptatherum sp. around cement factories in Konya, Turkey (Onder *et al*., 2007) and Vallcarca, Spain (Schuhmacher *et al*., 20098), respectively. Plants absorb Cd from the soil via the roots (Pip 1991; McLaughlin *et al*., 1999) and can become toxic by displacing Zn (Singh *et al*., 2010).Also, comparable to others studies the highest mean concentration of Cd from cements factories was higher than 0.15-0.60mgkg^{-1} reported by Sardans *et al.*, (2005). This was also similar to Demirezen and Ahmet (2006) that highest Cd accumulation in leafy vegetables from industrial area of Turkey and of Greece, reported by Fytianos *et al.*, (2001). Present results are in conformity with Farooq *et al.*, (2008), Singh *et al*., (2010), Sharma *et al*., (2010) Yogananda *et al*.,

(2012) and Yadav *et al.*, (2013) who reported that this high concentration of Cd in leafy vegetables might be a threat for the consumers. The highest Cr conc. obtained in this study was much higher than world average of Cr (0.06 mg/kg) reported by Forstner and Whittmann(1984). Also comparable to others studies the highest conc. was higher than concentration of Cr (0.217 mg/kg) Industrial site of Faisabad, reported by Farooq *et al.*,(2008) but several fold lower than Cr concentration in Spinach (70.79mg/kg) from Industrial area of Bellandur,Bangalore, reported by Ramesh and Murthy (2012).

Enrichment Factor (EF)

Tables 4 display a summary of the EF values for each heavy metal in terms of Different irrigation sources. According to Zhang and Liu , EF values between 0.5 and 1.5 indicate that a metal is entirely from crusted material or natural processes, whereas EF values greater than 1.5 suggests that the source were more likely to be anthropogenic. The result of the present study showed that, the enrichment factor for Fe and Zn in all studied sites were within 0.5 and 1.5, indicated that factors mostly from natural sources. Enrichment factors (EF) for Cu showed that they were deficiency to minimally enriched (EF <2), since the EF values of the metal (Cu) were less than 2. Enrichment factors for Pb showed that with the exception of samples from **C_B-V C_N-II C_N-V and C_N-VII sites** Pb enrichment for all sites were moderately enriched (EF<2-5) whereas for Cd enrichment for all sites were deficiency to minimal enriched(EF <2) except from **C_B-III C_B-V and C_N-VI which showed** moderately enriched (EF <2-5) while for Mn samples from **C_B-VI C_N-IV and C_N-VII sites indicated that they were** moderately enriched (EF <2-5) while from remaining site it showed minimally enriched (EF <2). Enrichment factors for Cr showed that Chromium is the only metal with significantly enriched (EF>5-20) from **C_B-V and C_B-VII sampling sites while from remaining site it was found to be** moderately enriched (EF <2-5). The result of the present study show that, with the exception of Fe and Zn enrichment, all the metals were over deficiency to minimally enriched to significantly enriched (EF>5-20) in all the studied sites (Table 4). Since the EF values of the metals are greater than 1.5 (except for Fe and Zn) this indicated that the environment under the study is minimally/ moderately enriched to significantly enrich with all the metals. The differences in the EF values may be due to the difference in the magnitude of input for each metal in the soil and/or differences in the removal rate of each metal from the soil. All these prediction were made in accordance with Zhang and Liu (2002).Environment and human health impact of toxic trace metal contamination is a function of mobility and phytoavailalability The movement of heavy metal down the soil profile is often evident in high applications of heavy metals, usually in sewage sludge, in soils with low organic matter and clay contents, acidic conditions and when high rainfall or irrigation water rules have been applied. The movement occurs through soil macropores or cracks which is also referred to as preferential flow (Dowdy and Volk, 1983).

Table 4: Values of the Enrichment Factor (EF) for heavy metals from the cement factories

Sampling areas	Enrichment Factor						
	Fe	Zn	Cu	Pb	Cd	Mn	Cr
C_B-I	0.78	1.06	1.69	3.76	1.90	1.55	2.38
C_B-II	0.22	0.67	1.51	2.99	1.93	1.57	2.32
C_B-III	0.67	0.78	1.65	4.22	2.45	1.55	4.67
C_B-IV	1.29	1.06	1.89	3.90	1.78	1.90	4.90
C_B-V	0.57	1.40	1.50	1.95	2.99	1.89	7.00
C_B-VI	0.47	0.99	1.56	2.67	1.90	2.45	4.33
C_B-VII	1.23	0.98	1.85	2.45	1.60	1.50	10.95
C_N-I	0.65	1.04	1.79	2.55	1.56	1.67	2.99
C_N-II	1.18	0.55	1.56	1.89	1.88	1.59	2.67
C_N-III	1.29	1.00	1.50	2.41	1.52	1.94	3.09
C_N-IV	1.37	0.83	1.63	3.11	1.57	2.04	4.67
C_N-V	0.78	1.00	1.58	1.67	1.90	1.81	3.70
C_N-VI	1.16	0.57	1.77	2.56	2.15	1.55	5.00
C_N-VII	1.20	0.90	1.51	1.53	1.85	2.10	4.23

C_B= Contaminated areas of Bela cement Ltd;
C_N= Contaminated areas of Naubasta cement Ltd.

IV. CONCLUSION

Around the world as countries are struggling to arrive at an effective regulatory regime to control the discharge of industrial effluents into their ecosystems, Indian economy holds a double edged sword of economic growth and ecosystem collapse. Heavy metals accumulation increases with time in the soils when irrigation is carried out using wastewaters. In this scenario the present study gains significance indicating the need for proper disposal of wastewater and further abatement of metal pollution and associated risk due to the consumption of foods grown on wastewaters. The present experimental data indicates high level of pollution along Cement Factories of Rewa, India. The experimental data suggests a need to implement common objectives, compatible policies and programmes for improvement in the industrial waste water treatment methods. It also suggests a need of consistent, internationally recognized data driven strategy to assess the quality of waste water effluent and generation of international standards for evaluation of contamination levels. The existing situation if mishandled can cause irreparable ecological harm in the long-term well masked by short term economic prosperity. The study showed elevated concentrations of metals in all environmental media suggesting a definite adverse impact on the environmental quality of the disposal area. All these studies have clearly indicated the distressing situation and warrant the need for controlling the metal pollution from industrial wastewater .From this study Concentrations of metals were found to be high in vegetables with special reference to Pb, which were found to be very high.

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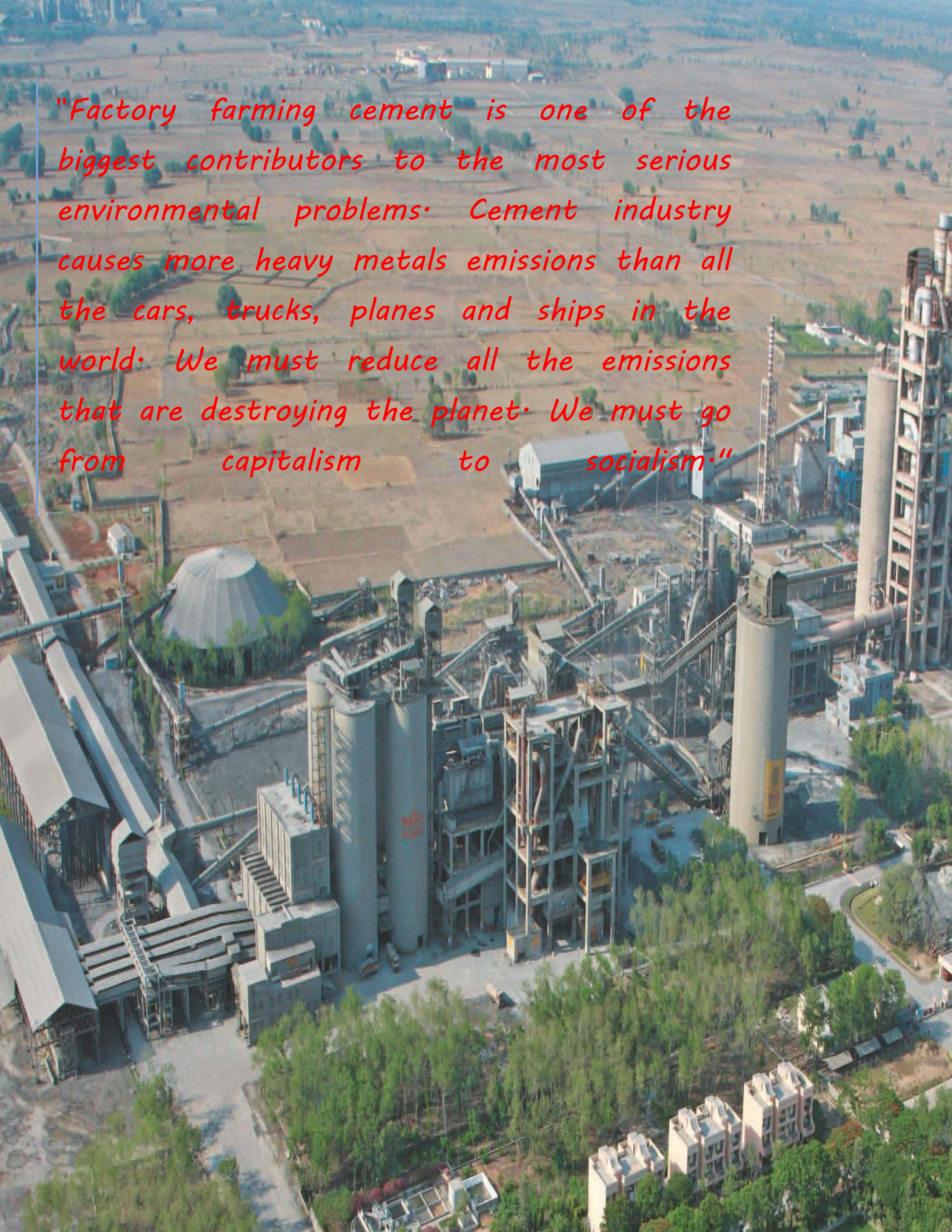

"Factory farming cement is one of the biggest contributors to the most serious environmental problems. Cement industry causes more heavy metals emissions than all the cars, trucks, planes and ships in the world. We must reduce all the emissions that are destroying the planet. We must go from capitalism to socialism."