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Short Communication

Soil pollution under intensively cropped chili growing areas of Guntur division of Andhra Pradesh, India

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ABSTRACT

With the goal of monitoring pollution caused by agriculture in the Guntur division, a study titled "Monitoring Soil and Water Pollution in intensively farmed areas of Guntur division" was undertaken. Soil samples from the farmers' fields of the study area in different *mandals* of Guntur division of Guntur district were collected at three stages of the crop season, and concentrations of heavy metals and different pollutants were analyzed. The overall nickel level in soils from chili-growing locations ranged from 2.8 to 14.8 ppm, well within the Indian Standards' permitted limits of 75 ppm. It is, nevertheless, undetectable in many places. The overall chromium level in soils of chili-growing areas ranged from 0.1 to 16.3 ppm, well within the European Union's allowed threshold of 150 ppm. At Prathipadu, TRPalem, Koyavaripalem, and Pedaparimi, however, it is not detectable. The findings show that the amount of chromium accumulated in the soil as a result of fertilizer application is not significant and well below the permissible limits. The amount of lead in the soils of chili-growing areas ranged from 0.7 to 12.8 parts per million. The lead concentration in these soils, however, is within the acceptable range of 250-500 ppm according to Indian regulations and 300 ppm according to European Union standards. The presence of cadmium in the soils of chili-growing areas was not discovered. The findings revealed that the amount of heavy metals accumulated in soils of chili-growing areas as a result of fertilizer application is not significant and far below the safe limits. In terms of various pollutants such as nitrates, fluorides, and chlorides, the findings revealed that the nitrate content of the soils of chili-growing areas ranged from 9.59 to 38.51 ppm and increased in the middle of the season before declining towards the end of the season. The mean available fluoride content in the soils of chili growing areas ranged from 0.70 to 0.99 ppm, which was well within the safe levels in all soil samples of chili growing areas. The mean chloride content in the soils ranged from 46.19 to 140.58 and increased significantly with an increase in the middle of the season followed by a decline by the end of the season in all soil samples of chili growing areas.

Keywords: Guntur, Soil Pollution, Chilli

INTRODUCTION

Guntur is one of Andhra Pradesh's most important coastal districts, with over a hundred distinct crop varieties grown throughout the year. From broomsticks to curry leaves, the district grows every type of crop imaginable. Hence, the district is recognized as a museum of crops by agronomists. Paddy, cotton, chilies, turmeric, and pulses are the most common crops planted in the Kharif season, whereas maize, groundnut, and pulses are grown in the rabi season. Intensive agriculture has been conducted in most regions in the Guntur district for a long time, however, there is little information on soil and groundwater pollution caused by

agriculture. The main crops farmed in this region are cotton, chili, paddy, and maize. Excessive use of fertilizers, insecticides, and other agricultural chemicals is frequent in this area. As a result of these practices, the land and water in this area are polluted. Pollution levels in soil, water, and other food products such as vegetables, fruits, and oils will also be investigated. Due to their entry into the food chain, heavy metals in soil caused by excessive fertilizer use may induce malignant diseases in people.

MATERIAL AND METHODS

The research area, Guntur revenue division of Guntur district, is located on Andhra Pradesh's east coast. It is located between 160 30' North latitude and 800 45' East longitudes, with an average elevation of 33 meters above mean sea level and 64 kilometers west of the Bay of Bengal. Tenali, Guntur, Gurajala, and Narsaraopet are the headquarters of the Guntur district, which is divided into fifty-seven mandals and four revenue divisions. Guntur, Mangalgiri, Pedakakani, Prathipadu, Vatticherukuru, Pedanandipadu, Tadepalli, Tulluru, Tadikonda, Amaravathi, Sattenapalli, Pedakurapadu, Medikonduru, Phirangipuram, Muppalla, Krosuru, Atchempet, Rajupalem, and Bellamkonda are among the nineteen mandals. The district's overall geographical area is 1.15 million hectares, with the Guntur revenue division covering 0.31 million hectares. Twenty locations with a chili planting method were chosen for the current study. Where 15 locations indicate high input usage areas and five locations represent low resource areas, with the latter being used as a control for comparing pollution levels. Representative surface soil samples (0-15 cm depth) were collected from 20 locations in the Guntur division of the Guntur district at three stages of the crop season, namely, i) before sowing of crops during May and June, ii) during the middle of the crop season in December and January, and iii) at the end of the crop season in April in Guntur division of Guntur district, covering intensively cropped areas. The samples were taken according to Jackson's instructions (1973). In the farmers' field, a 'V-shaped pit was dug to a depth of 15 cm, and 6-8 subsamples were gathered at random in a zigzag movement. By using the quartering procedure, all sub-samples representing the farmer's field area were pooled, combined, and reduced to one kilogram. At each step of the crop season, a total of 60 soil samples were collected at a rate of 20 samples, which were then processed for analysis.

RESULTS AND DISCUSSION

Heavy metals

The heavy metal content of soil samples from chili-growing locations is given in table 1.

Nickel

At the start of the crop season, the nickel concentration of soils in high-input chili-growing areas ranged from 4.4 to 14.8 ppm, with a mean of 9.5 ppm. It ranged from 4.3 to 14.8 ppm in the middle of the crop season, with a mean of 9.8 ppm. It ranged from 3.5 to 13.9 ppm towards the end of the crop season, with an average of 8.6 ppm. At the start of the crop season, the nickel concentration of soils in low-input chili-growing areas ranged from 3.7 to 7.2 ppm, with a mean of 4.9 ppm. It ranged from 3.3 to 8.6 ppm in the middle of the crop season, with a mean of 5.2 ppm. At the end of the crop season, it ranged from 2.8 to 6.3 ppm with a mean of 4 ppm.

The overall nickel level in soils of chili-growing areas ranged from 2.8 to 14.8 ppm and was within the Indian Standards (Awashthi, 2000) permitted limits of 75 ppm in both high and low input areas. It is, nevertheless, undetectable in many places. The findings show that the amount of nickel accumulated in the soil as a result of fertilizer application is small and well within safe limits. This was in line with previous workers' reports. Nickel concentrations in soil samples from Tanda Dam Koh ranged from 0.150 to 1.031 mg kg^{-1} (Ruqia Nazir *et al.*, 2015). The average content of Ni in soil samples from the Islamabad highway was 32 mg kg^{-1} (Faiz *et al.*, 2009). Nickel concentrations in soils in the southeastern section of Andhra Pradesh's Ranga Reddy district ranged from 7 to 57 parts per million, with an average of 27.3 parts per million (Sujatha., 2009).

Chromium

At the start of the crop season, the chromium content of soils in high-input chili-growing areas ranged from 0.4 to 13.0 ppm, with a mean of 5.8 ppm. It ranged from 0.1 to 14.6 ppm in the middle of the agricultural season, with a mean of 6.1 ppm. It ranged from 0.7 to 16.3 ppm at the end of the crop season, with a mean of 6.9 ppm. At the start of the

Table 1. Heavy metal content in soils of chili growing areas at three stages of crop growth

S. No.	Name of the village	Ni (ppm)			Pb (ppm)			Cr (ppm)		
		Stage of sampling			Stage of sampling			Stage of sampling		
		Initial	Middle	Harvest	Initial	Middle	Harvest	Initial	Middle	Harvest
1	Ananthavarapadu	4.4	4.3	3.5	10.2	10.9	10.5	0.8	0.7	0.7
2	Vatti Cherukuru	ND	ND	ND	ND	ND	ND	0.7	0.9	0.9
3	Prathipadu	14.8	14.8	13.9	ND	ND	ND	ND	ND	ND
4	Abbinenigunta palem	5.2	7.4	4.3	8.2	8.7	8.3	1.8	1.7	1.7
5	Pedanandipadu	ND	ND	ND	10.7	12.8	12.4	9.1	9.5	10.0
6	Tikkareddy palem	11.9	12.6	11.0	ND	ND	ND	ND	ND	ND
7	Yanamadala	8.1	8.0	7.2	3.9	3.2	2.8	2.0	2.8	2.3
8	Gundlapalem	13.5	13.8	12.6	11.5	11.0	10.6	0.4	0.1	0.7
9	Medikonduru	ND	ND	ND	ND	ND	ND	1.9	2.1	2.9
10	Tadikonda	8.8	9.9	7.9	0.7	0.5	0.1	12.9	12.6	12.8
11	Koyavaripalem	ND	ND	ND	10.6	11.5	11.1	ND	ND	ND
12	Tulluru	8.6	7.3	7.7	ND	ND	ND	12.0	14.6	16.0
13	Pedakurapadu	9.5	9.1	8.6	7.9	9.0	8.6	9.0	10.1	11.5
14	Amaravathi	ND	ND	ND	11.9	10.7	10.3	13.0	12.3	16.3
15	Pedaparimi	10.5	10.4	9.6	7.9	9.7	9.3	ND	ND	ND
	Mean	9.5	9.8	8.6	8.3	8.8	8.4	5.8	6.1	6.9
	Min	4.4	4.3	3.5	0.7	0.5	0.1	0.4	0.1	0.7
	Max	14.8	14.8	13.9	11.9	12.8	12.4	13.0	14.6	16.3
16	Krosuru	3.7	3.8	2.8	4.1	4.9	4.5	0.9	1.0	1.0
17	Bellamkonda	ND	ND	ND	ND	ND	ND	1.3	2.0	1.8
18	Avulapallem	7.2	8.6	6.3	ND	ND	ND	3.0	2.2	2.5
19	Malladi	ND	ND	ND	2.2	2.8	2.4	4.9	4.2	4.0
20	Didugu	3.9	3.3	3.0	1.8	1.3	0.9	2.5	2.8	2.9
	Mean	4.9	5.2	4.0	2.7	3.0	2.6	2.5	2.4	2.4
	Min	3.7	3.3	2.8	1.8	1.3	0.9	0.9	1.0	1.0
	Max	7.2	8.6	6.3	4.1	4.9	4.5	4.9	4.2	4.0

crop season, the chromium level of soils in low-input chili-growing areas ranged from 0.9 to 4.9 ppm, with a mean of 2.5 ppm. It varied from 1.0 to 4.2 ppm in the middle of the crop season, with a mean of 2.4 ppm. At the end of the crop season, it ranged from 1.0 to 4.0 ppm with a mean of 2.4 ppm.

The overall chromium level in soils of chili-growing areas ranged from 0.1 to 16.3 ppm, falling within the allowed limits of 150 ppm set by European Union guidelines in both high and low input locations. At Prathipadu, TRPalem, Koyavaripalem, and Pedaparimi, however, it is not detectable. The findings show that the amount of chromium accumulated in the soil as a result of fertilizer application is not significant and well below the permissible limits. This was in line with previous workers' reports. According to a multivariate study, Cr and Ni contents in soils of intensively cultivated areas, Sin Yucheng City, Shandong Province, China, were predominantly from indigenous clay minerals, as reported by Lin *et al.* (2010). Agricultural fertilizer use was shown to have no impact on soil heavy metal levels. The chromium concentration in surface and subsurface soil samples from waste dumpsites in Guntur, Andhra Pradesh, was found to be 1.8 mg kg^{-1}, 1.9 mg kg^{-1} maximum, 0.5 mg kg^{-1} minimum, and the mean value was 1.06 mg kg^{-1} and 1.1 mg kg^{-1}, according to Jyothi *et al.* (2017).

Lead

At the start of the crop season, the lead level of soils in high-input chili-growing areas ranged from 0.7 to 11.9 ppm, with an average of 8.3 ppm. It ranged from 0.5 to 12.8 ppm in the middle of the crop season, with an average of 8.8 ppm. It ranged from 0.1 to 12.4 ppm towards the end of the crop season, with an average of 8.4 ppm. At the start of the crop season, the lead level of soils in low-input chili-growing areas ranged from 1.8 to 4.1 ppm, with a mean of 2.7 ppm. It ranged from 1.3 to 4.9 ppm in the middle of the crop season, with a mean of 3.0 ppm. It varied from 0.9 to 4.5 ppm towards the end of the crop season, with a mean of 2.6 ppm.

The lead level of soils in chili-growing areas ranged from 0.7 to 12.8 ppm in high-input areas,

which is slightly higher than the values found in low-input areas (0.9 to 4.9 ppm). The lead concentration in these soils, however, is below the acceptable range of 250-500 ppm according to Indian Standards (Awashthi, 2000) and 300 ppm according to European Union standards (EU 2002). Because of its CEC, organic matter has been discovered to influence heavy metal absorption in soils (Kabata-Pendias, 2001).

Cadmium

The presence of cadmium in the soils of chili-growing areas was not discovered in either high- or low-input areas. Even though increased use of chemical fertilisers and livestock and poultry manure can lead to a rise in heavy metals such as Cd, Pb, Cu, and Zn in soils and plants (He *et al.*, 2005), this was not proven to be true in all cases. According to Lin *et al.* (2010), agricultural fertilizer use has little impact on soil heavy metal content, and local anomalies of As, Cd, Hg, and Pb in wheat and corn grain are attributed to the interactive effects of irrigation and fertilizer use in soils of Yucheng City, Shandong Province, China. In our study also, the cadmium levels in the soil were not detected.

Pollutants

Table 2 shows the chlorides, fluorides, and nitrate concentration of soil samples collected in the chili growing region.

Chlorides

At the start of the crop season, the chlorides in the soils of high input chili growing locations ranged from 46.90 to 75.30 mg l^{-1}, with a mean of 55.42 mg l^{-1}. It ranged from 68.20 to 245.70 mg l^{-1} in the middle of the crop season, with a mean of 140 mg l^{-1}. It ranged from 46 to 139.20 mg l^{-1} at the end of the crop season, with a mean of 79.80 mg l^{-1}. At the start of the crop season, the chlorides in the soils of low input chili growing locations ranged from 40.60 to 54.80 mg l^{-1}, with a mean of 46.19 mg l^{-1}. It ranged from 47.70 to 119.70 mg l^{-1} in the middle of the crop season, with an average of 81.35 mg l^{-1}. It ranged from 40.60 to 65.11 mg l^{-1} at the end of the crop season, with a mean of 49.58 mg l^{-1}.

This pattern can be seen at both the input and output levels. Using fertilizers and manures during the crop season may result in an increase in soil chloride concentration in the middle of the season, followed by a decrease by harvest. Rainwater depositions of Cl, fertilizer applications (KC1), irrigation fluids, sea spray, dust, and air pollution are the principal sources of chlorine inputs to soils. Rainwater's Cl content changes dramatically depending on its closeness to saline water. In the soil, chlorine is mostly found in the form of Cl. Cl^- is rejected from mineral surfaces in many soil particles because it does not form complexes easily and because exchange sites on layer silicates in soil clays are primarily negatively charged (Bohn *et al.*, 1979). Studies in a Swedish spruce forest ecosystem have found evidence of net organic Cl buildup, suggesting that it could be a substantial sink for Cl in places with minimal Cl inputs (Hjelm *et al.*, 1995).

Fluorides

At the start of the crop season, the accessible fluoride concentration of soils in high input chili growing locations ranged from 0.41 to 1.96 ppm, with a mean of 0.92 ppm. It ranged from 0.51 to 1.66 ppm in the middle of the crop season, with a mean of 0.99 ppm. It ranged from 0.31 to 1.09 ppm at the end of the crop season, with a mean of 0.71 ppm. At the start of the crop season, the accessible fluoride concentration of soils in low-input chili-growing areas ranged from 0.28 to 1.35 ppm, with a mean of 0.70 ppm. It ranged from 0.47 to 1.32 ppm in the middle of the crop season, with a mean of 0.76 ppm. It varied from 0.37 to 0.75 ppm towards the end of the crop season, with a mean of 0.55 ppm. The mean accessible fluoride content in the soils of chili-growing areas ranged from 0.55 to 0.99 ppm, well within safe levels and indicating that fertilizer and pesticide use had no discernible effect on soil fluoride (F) content.

During kharif and rabi, the accessible F in soils in different villages in Narkatpally mandal of Nalgonda district ranged from 0.26 to 2.64 ppm and 0.53 to 2.64 ppm, respectively, with an average of 1.18 and 1.66 ppm. The total F concentration of soil during kharif and rabi ranged from 195 to 481 ppm and 246 to 485 ppm, respectively, with average values of 310 and 338 ppm. The greatest total F value (481 ppm) was discovered in Brahmanavellemla village, while the lowest (195 ppm) was discovered in Indiranagar village. Nearly 7.7 % of soil samples were found to be over the normal range, while the remaining samples were found to be within the normal range, indicating geochemical origin without any artificial contamination. As a result, a threat

Table 2. Chloride, Fluoride, and Nitrate content in soils of chili growing areas at three stages of crop growth

S. No.	Name of the village	Chloride (mg l^{-1})			Fluoride (mg l^{-1})			Nitrate (mg l^{-1})		
		Stage of sampling			Stage of sampling			Stage of sampling		
		Initial	Middle	Harvest	Initial	Middle	Harvest	Initial	Middle	Harvest
1	Ananthavarapadu	46.90	174.70	78.85	1.21	1.06	0.91	26.74	28.97	25.66
2	Vatti Cherukuru	61.10	188.90	85.95	0.61	0.61	0.31	18.43	18.56	18.25
3	Prathipadu	46.90	167.60	125.00	0.51	0.51	0.36	28.89	32.04	31.52
4	Abbinenigunta palem	61.10	89.50	68.20	1.01	1.01	0.86	25.53	33.67	29.56
5	Pedanandipadu	46.90	88.90	89.50	0.67	0.67	0.67	21.68	28.78	27.58
6	Tikkareddy palem	46.90	245.70	78.85	0.74	1.04	0.44	24.65	34.45	30.35
7	Yanamadala	61.10	167.60	139.20	1.96	1.66	1.06	21.51	29.31	29.31
8	Gundlapalem	75.30	132.10	89.50	0.71	1.01	0.71	14.70	17.80	12.90
9	Medikonduru	46.90	245.70	85.95	1.11	0.81	0.96	35.26	35.36	35.76
10	Tadikonda	61.10	117.90	54.00	0.62	0.92	0.92	26.27	26.47	26.17
11	Koyavaripalem	46.90	89.50	50.45	1.69	1.09	1.09	26.10	28.40	24.90
12	Tulluru	75.30	117.90	61.10	1.06	1.66	0.76	10.59	10.89	10.79
13	Pedakurapadu	46.90	89.50	89.50	0.77	1.07	0.47	36.81	38.31	36.51
14	Amaravathi	61.10	68.20	46.90	0.41	0.71	0.71	19.47	19.77	19.67
15	Pedaparimi	46.90	125.00	54.00	0.76	1.06	0.46	31.68	34.08	30.78
	Mean	55.42	140.58	79.80	0.92	0.99	0.71	24.55	27.79	25.98
	Min	46.90	68.20	46.90	0.41	0.51	0.31	10.59	10.89	10.79
	Max	75.30	245.70	139.20	1.96	1.66	1.09	36.81	38.31	36.51
16	Krosuru	54.8	58.35	47.7	0.37	0.67	0.37	24.10	26.40	22.90
17	Bellamkonda	40.6	62.9	45.8	0.77	0.47	0.62	9.59	9.89	9.79
18	Avulapallem	41.60	119.70	48.70	0.28	0.58	0.58	35.81	37.31	35.51
19	Malladi	53.36	118.09	65.11	1.35	0.75	0.75	17.47	17.77	17.67
20	Didugu	40.6	47.7	40.6	0.72	1.32	0.42	29.68	32.08	28.78
	Mean	46.19	81.34	49.58	0.70	0.76	0.55	23.33	24.69	22.93
	Min	40.6	47.7	40.6	0.28	0.47	0.37	9.59	9.89	9.79
	Max	54.8	119.7	65.1069	1.35	1.32	0.75	35.81	37.31	35.51

from F accumulation in plants and its toxicity to humans and animals is unlikely. The available F percentage as a proportion of total fluoride content ranges from 0.10 to 0.82. The accessible F content was extremely low (3 mg kg^{-1}), accounting for less than 2% of the overall amount. Because of its conversion to an inaccessible form, 95-98 percent of the F deposited on the soil surface is not available for plant absorption (Vijaya Lakshmi *et al.*, 2016).

Nitrates

At the start of the crop season, nitrate levels in the soils of high-input chili-growing areas ranged from 10.59 to 36.81 ppm, with a mean of 24.55 ppm. It ranged from 10.89 to 38.31 ppm in the middle of the crop season, with a mean of 27.79 ppm. It ranged from 10.79 ppm to 36.51 ppm with a mean of 25.98 pm at the end of the crop season. At the start of the crop season, nitrate levels in low-input chili growing areas ranged from 9.59 to 35.81 ppm, with a mean of 23.33 ppm. It ranged from 9.89 to 37.31 ppm in the middle of the crop season, with a mean of 24.69 ppm. At the end of the crop season, it ranged from 9.79 to 35.51 ppm with a mean of 22.93 ppm.

Overall, the nitrate concentration of the soils in chili-growing areas ranged from 9.59 to 38.31 ppm, with an increase in the middle of the season followed by a reduction at the end. Certain low nitrate levels could be due to poor organic matter and accessible nitrogen levels in these soils. Nitrates are highly soluble, and unless they are intercepted and absorbed by plant roots, they either seep into the soil with irrigation or rainwater, or are transported away by runoff. Leaching of NO_3^--N can be significant when high fertilizer N rates are paired with heavy irrigation regimes on coarse-textured soils (Singh and Sekhon, 1976). High NO_3^- concentrations are not toxic to plants but may cause health problems to animals and humans consuming such plants (NRC, 1978).

CONCLUSIONS

The findings of this investigation revealed that the levels of heavy metals, chlorine, fluoride, and nitrate in the soils of the Guntur division's chili

growing area were all well within safe limits. Heavy doses of fertilizers and pesticides did not result in heavy metals or other contaminants accumulating in these soils. The fertilizers being used by the farmers do not seem to have any impact on the heavy metal concentrations of the soils.

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