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Characterization of heavy metal contamination in mulberry cultivated soils of Erode district in Tamil Nadu

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Abstract
A detailed survey work was carried out in the contamination areas of Erode district, Tamil Nadu, India. The aim of the present study is to assess the level of heavy metal contamination in soils irrigated with sewage water and industrial effluents. The study showed that the soil irrigated with the sewage water and industrial effluents contained almost the heavy metals like Cr, Cd, Ni, and Pb which exceeded the critical limit. The concentrations of heavy metals namely Chromium, Cadmium, Nickel, and Lead were determined by Atomic Absorption Spectroscopy. The results obtained from the physico chemical analysis indicated that industrial effluents contaminated soils recorded pH 6.71 to 7.10, EC 0.62 to 2.12 dsm^{-1} and exchangeable sodium 144 to 220 ppm. The concentration of heavy metals in soil from the study sites were ranged from 1.20 to 117.4 ppm of Cr, 6.60 to 120.6 ppm of Cd, 6.40 to 73.60 ppm of Ni, and 4.60 to 119.8 ppm of Pb respectively.

Keywords: Mulberry, heavy metals, industrial effluents

Introduction
Mulberry (*Morus indica* L.) belongs to the family moraceae a fast growing, deciduous and perennial plant. It is the sole food plant of the silkworm (*Bombyx mori* .L) for silk production. Mulberry cultivation and silk production together comprises sericulture due to an ecofriendly, agro-based, labour intensive, rural cottage industry providing subsidiary employment and supplementing the income of rural farmers especially the economically weaker section of the society Dandin *et al.* (2000) [4].

Enormous amount of organic and inorganic wastes generated from various industries has been randomly disposed before the passing of severe regulations in India. Compared to organic and inorganic wastes containing heavy metal cause great threat, as they cannot be completely degraded from the ecosystem like organic wastes. Hence, heavy metal contamination of soil, aqueous waste and ground water causes major environmental and human health problems, which is still in need of an effective and affordable technological solution.

In Tamil Nadu there are so many metal based industries located in various districts like Erode, Vellore, Dindugal, and Coimbatore in an unorganized manner. Among them, Erode district is one among the industrially developed districts in Tamil Nadu (Somasundaram 2001) [14]. The agricultural and industrial activities are well supported by the rivers Cauvery, Bhavani and Amaravathi, Noyal and Uppar and Parambikulam Aliyar projects. The major industries include textile, dyeing, electroplating and foundry and metal casting industries. According to present situation, Textiles play a vital role in the industrial manufacture of Erode district. Out of 64 large scale industries in Erode district, 31 are textile industries. It had 3467 units dealing in cotton textiles (41.9 per cent), 61 units in wool, silk and synthetic fiber, 21 units in jute, hemp and Mesta and 1814 units in hosiery and garments. To adopt any type of remedial measures, it is necessary to determine the heavy metal in the contaminated soil. Hence this study was taken up to assess the metal contamination of soils in the Erode district of Tamil Nadu.

Materials and Methods
The study was conducted in Department of Sericulture, Forest College and Research Institute, Mettupalayam Tamil Nadu. A detailed survey work has been carried by collecting the soil samples from the polluted and non-polluted areas of Erode district to assess the heavy metal status. About 40 soil samples were collected, processed and analyzed for Physico chemical properties viz., pH, EC, Na content by using standard procedures, outlined by Jackson (1973) [6] respectively.

The samples were digested with diacid mixture (HNO_3: $HClO_4$ in 2:1 ratio; Hesse (1994) [5] and the extract was used for analyzing total metal status using Atomic Absorption Spectrophotometer. Heavy metal concentration was estimated using the DTPA extractable by adopting the procedure given by Lindsay and Norvell (1978) [9]. The heavy metal in soil was calculated by:

$$\text{Heavy metal concentration (ppm)} = \frac{\text{AAS reading}}{\text{Weight of sample taken}} \text{ x Volume makeup}$$

Results and Discussion

The characterization of heavy metals in the soil such as Chromium (Cr), Cadmium (Cd), Nickel (Ni) and Lead (Pb) and physico-chemical parameters like pH, Electrical Conductivity (EC), and Exchangeable Sodium (Na) were shown in (Table 1.).

Table 1: Variation in amount of heavy metals content in soil samples of Erode district

Sl. No	District	Block	Name of the village	pH	EC (dsm^{-1})	Ex. Na (ppm)	Cr (ppm)	Cd (ppm)	Ni (ppm)	Pb (ppm)
1	**Erode**	**Gobichettipalayam**	Bommanaikanapalayam	6.88	0.88	168	11.8	17.4	-	32.8
2			Thasampalayam	6.87	1.03	196	92.4	-	-	65.8
3			Othakuthirai	6.94	0.72	171	101.3	-	38.4	-
4			Arakankottai	6.95	0.82	186	-	57.8	-	26.6
5			Pichandipalayam	6.97	1.43	192	5.8	36.8	-	14.2
6			Gobichettipalayam	6.85	0.85	200	-	-	-	59
7		**Nambiyur**	Varapalayam	6.93	1.21	210	82.6	52.8	-	39.4
8			Kuppipalayam	6.91	0.89	184	75.7	53.2	12.2	-
9		**Bhavani**	Appakudal	7.01	2.12	172	103.2	-	-	24.6
10			Bhavani	6.91	0.78	176	13	-	27.8	23.6
11			Dharmapuri	6.82	0.82	167	49.3	32.6	19.3	38.1
12			Kuttipalayam	6.99	1.02	220	110.6	117.4	-	107.4
13			Odathurai	6.89	0.75	173	102.2	-	-	86.4
14			P.mettupalayam	7.10	1.62	196	-	-	-	28
15			J.J Nagar	6.95	0.92	160	26.8	19.4	22.4	5.8
16			Vairamangalam	6.87	0.71	162	19.6	18.2	-	32.4
17		**Antiyur**	Vempathy	6.90	0.76	144	8.8	6.6	-	22.6
18			Unjapalayam	6.96	0.85	164	37.4	41.8	-	-
19			Osaipatti	6.92	0.83	194	-	8.6	6.4	-
20			Komputhotam	6.99	1.17	172	115.7	17.4	9.9	88.3
21		**Perundurai**	Palakarai	6.93	0.95	166	-	22.6	6.6	-
22			Karattupalayam	6.90	0.86	201	1.2	33.4	-	4.6
23			Ponmudi	6.85	0.74	172	-	35.8	15	9.4
24			Ellapalayam	6.86	0.62	207	95.8	18.4	24.4	8.8
25			Nallampatti	7.06	1.73	183	106.7	34.7	73.6	-
26			Thingalur	6.99	0.97	169	117.4	120.6	-	119.8
27			Vellode	6.92	0.86	176	6.8	46.8	-	19.2
28			Kanjikovil	6.78	0.68	151	85.4	8.6	-	12.6
29			Thoranavavi	6.82	0.78	191	62.7	31.8	36.9	17.4
30		**Erode**	Chettipalayam	6.71	0.65	178	112.8	107.2	-	66.4
31		**Sathyamangalam**	Modhur	6.95	1.15	167	-	-	30.8	26.8
32			Sathyamangalam	6.92	1.08	152	36.8	31.4	24.6	13.4
33		**Modakurichi**	Karavalasu	6.89	0.93	197	23.4	39.2	16.2	-
34			Kasipalayam	6.78	0.69	211	87.2	47.9	32.4	-
35			Kagam	6.95	1.34	179	78.5	49.4	29.6	-
36			Minnapalayam	6.79	0.70	186	55.7	42.5	-	-
37			KG. vasalu	6.85	0.89	213	-	28.9	34.8	-
38			Vadugapatti	6.91	1.12	156	76.6	-	-	28.9
39			Palliyuthu	6.81	0.77	181	-	-	-	-
40			Koothampatti	6.87	0.85	189	47.9	26.8	-	-
Average				6.90	0.96	180.8	62.94	40.2	25.63	37.86
Highest				7.10	2.12	220	117.4	120.6	73.6	119.8
Lowest				6.71	0.62	144	1.2	6.6	6.4	4.6

Note: pH: <6.5 = Acidic, 6.5 - 7.5 = Neutral, >7.5 =Alkaline; EC (dsm^{-1}): 0.0 -1.0 = Harmless, 1.1 - 3.0 = Critical, >3.1=Injurious; Heavy metals (ppm): Cr= 0.05, Cd= 0.1 – 0.5, Ni= 4.0, Pb= 1.0.

The physico-chemical properties of 40 soil samples from Erode district were analyzed and presented in Table 1. When compared to average pH 6.90, P.mettupalayam, Nallampatti, Appakudal, and Kuttipalayam found have high pH with 7.10, 7.06, 7.01, and 6.99 respectively. Whereas the lowest pH was recorded by Chettipalayam (6.71). Overall the pH content in soils are neutral. The similar findings were observed by Shakila and Keshav mohan (2014) in heavy metal contaminated sites of Pathanamthitta (Kerala) with pH range of 6.24 (acidic) to 6.90 (neutral). Arpna and Shikha (2018) [1] reported pH ranged from 6.76 (neutral) to 9.03 (alkaline) among the 14 different contaminated sites. Higher the pH in soil leads to decrease in the productive potential of crop.

With respect to electrical conductivity (EC) in fourty soil samples ranged between 0.62 to 2.12 dsm^{-1}. The highest EC was recorded Appakudal (2.12 dsm^{-1}), Nallampatti (1.73 dsm^{-1}), P.mettupalayam (1.62 dsm^{-1}) and Pichandipalayam (1.43 dsm^{-1}). Whereas the minimum EC was found with Ellapalayam (0.62 dsm^{-1}). The result denotes that all sampled sites were less harmful except Appakudal (2.12 dsm^{-1}) is critical. The results are in accordance with literatures; Shakila and Keshav mohan (2014) found EC (0.14 to 0.29 dsm^{-1}) in three sites. Kumar Sharma *et al.*, (2007) [8] reported EC varied from 0.30 to 0.37 dsm^{-1}among three sites. The low EC is attributed to proper management of soil and by the leaching of salts from surface to subsurface and also due to the application of acidulating fertilizers in salt affected areas Vijaya kumar *et al.*, (2011). The sources of these enhanced levels were traced in agronomic activities such as use of natural and synthetic fertilizers, herbicides, pesticides used to improve the crop yields. Parental soil quality is another factor that may contribute to the enhanced levels Tariq and Rashid (2013) [15].

The exchangeable sodium content in samples varied between 144 and 220 ppm. The maximum exchangeable Na was exhibited Kuttipalayam (220 ppm), KG.vasalu (213 ppm), Dharmapuri (212 ppm) and Kasipalayam (211 ppm) respectively. However the lowest Na was recorded Vempathy (144 ppm).

With respect to Chromium (Cr), it is ranged from 1.20 to 117.4 ppm. The highest Cr was recorded in Thingalur (117.4 ppm), followed by Komputhotam (115.7 ppm), Chettipalayam (112.8 ppm) and Kuttipalayam (110.6 ppm). However the lowest Cr was observed in Karattupalayam (1.20 ppm).

Whereas, Cadmium (Cd) content was ranged between 6.6 and 120.6 ppm. The maximum Cd was exhibited Thingalur (120.6 ppm), Kuttipalayam (117.4 ppm), Chettipalayam (107.2 ppm) and Arakankottai (57.8 ppm). The minimum Cd was recorded Vempathy (6.6 ppm). High Cd level in soil might be due to application of high doses of phosphate fertilizers and metal-based pesticides in agricultural crops.

In terms of Nickel (Ni) the highest was observed in Nallampatti (73.6 ppm), followed by Othakuthirai (38.4 ppm), Thoranavavi (36.9 ppm) and KG.vasalu (34.8 ppm). Whereas, the least Ni was found in Osaipatti with the value 6.4 ppm. Overall the average content ranged from 6.4 to 73.6 ppm.

The Pb content was ranged from 4.6 to 119.8 ppm. The maximum Pb was exhibited by Thingalur (119.8 ppm), Kuttipalayam (107.4 ppm), Komputhotam (88.3 ppm) and Odathurai (86.4 ppm). The minimum Pb was recorded in Karattupalayam (4.6 ppm).

The results are similar to those in the earlier report of Buzuayehu (2017) in Meki irrigation farms Cr (0.079 ppm), Cd (0.231 ppm) and Pb (202.5 ppm); Pinto *et al*., (2011) found Cd (0.93 to 1.93 ppm), and Pb (18.85 to 43.35 ppm) in industrial polluted sites. Rashid *et al.*, (2016) found Cd (0.22 ppm) Cr (BDL) and Pb (19.43 ppm) in heavy metal contaminated sites of tea plantations. Increased heavy metal concentration in above ground and below ground biomass Kacholi and Sahu (2018) is attributed to change in land use practices viz., industrialization, electroplating, urbanization, shifting of organic to inorganic farming, waste incineration, gasoline disposal, improper disposal of old paints in terrestrial ecosystems, effluent discharge from pulp and paper, textile dyeing, chemical (pesticide) manufacturing industries causes huge soil pollution Mamtani *et al.*, (2011). Generally the polluted soils follows the heavy metal contamination follows the order Cr < Cd < Pb < Ni. This will cause severe health hazards in human beings, animals and ultimately faster rate of environmental degradation in all the tropic levels of ecosystem. Due to heavy metal contamination in soil ecosystem leads to severe damage of micro-flora, micro-fauna and other soil dwelling beneficial organisms. Several reports suggest those heavy metals are highly carcinogenic in nature and leads to vanishing of several indicative microorganisms in soil Chibuike and Obiora (2014) [3].

Conclusion

In this study, a detailed analysis was carried out to study the contamination level of soil, and with heavy metals at Erode district. The level of co-contamination of agricultural areas with effluents based industries, among the heavy metals were detected, content of Cr, Cd, Ni, and Pb was higher than the maximum permissible limits. However, the presence of metal based industries like casting; textile and dyeing industries apart from huge amount of sewage waste water production are the main sources of heavy metal contamination in soil, indicated potential risk to the crop ecosystem and could harm the flora and fauna of the area. The highest concentration of heavy metals in these industrially polluted areas are not only problem with respect to plant nutrition and food chain contamination but also causes a direct health hazards to human and animals, which is still in need of an effective and affordable technological solution.

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