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Irrigation water quality status in mulberry cultivated areas of Erode district, Tamil Nadu

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Abstract
A detailed survey work was carried out in the contamination areas of Erode district, Tamil Nadu, India. A number of tanneries and textile industries have been established since the past three decades. It is reported that the effluents from these industries are directly discharged onto the surrounding land, irrigation fields and surface water bodies. As a result, it deteriorates the quality of irrigation water in the study area. Eight parameters of physico-chemical analysis have been monitored using standard procedures. The results indicated that point source pollutants primarily affected the irrigation water quality of this region recorded pH 6.73 to 6.99, EC 0.38 to 1.38 dsm^{-1}, carbonate 0.28 to 4.38 meq L^{-1}, bicarbonate 2.18 to 9.13 meq L^{-1}, chloride 2.43 to 23.78 meq L^{-1}, potassium 0.27 to 1.44 meq L^{-1}, calcium 1.09 to 4.35 meq L^{-1} and magnesium 0.39 to 3.17 meq L^{-1} respectively.

Keywords: Mulberry, Irrigation water-quality, physicochemical, tanneries and textile

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) [2].

Environmental pollution is one of the most important and vital nuisances of the modern world. Among them, industries are the utmost polluters of the native soil. Textile dyeing industry is one of the fast burgeoning production in India (80%), it consumes substantial volume of water and chemicals (Ahluwalia and Goyal 2007). It categorized by their high load of chemical oxygen demand (COD), biological oxygen demand (BOD), total suspended solids, total dissolved solids (TDS), extreme pH values, and color adding to their odor (Kabra *et al.*, 2013) [7]. However, their excess or insufficiency caused severe damage to the soil, ground water, and food chain production; which ultimately leads to be toxic to human health (Cheraghi *et al.*, 2011) [1].

In addition, cluster of dyeing factories do not have sufficient store for treating the effluents, and hence, it is release into the river without proper treatment thus making the river water unusable (Joo *et al.*, 2007) [6]. As far as western Tamil Nadu is troubled the rivers Amaravathi, Noyal, Cauvery, and Bhavani are polluted by the discharge of effluent water from the nearby industries. Many industries, of late have installed reverse osmosis plants to neutralize and recycle the effluents. In addition, characterization of the effluent is important to resolve its reuse as a safe option due to its high water consumption. The present investigation was aimed to know the bioaccumulation of heavy metals in mulberry and its effect on silkworm.

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 irrigation water samples from the polluted and non-polluted areas of Erode district to assess the physico-chemical status. About 70 irrigation water samples were collected, processed and analyzed for Physico chemical properties viz., pH, EC, carbonate, bicarbonate, chloride, potassium, calcium and magnesium content by using standard procedures, outlined by Jackson (1973) [5] respectively.

Results and Discussion

The characterization of physico-chemical parameters like pH, Electrical Conductivity (EC), carbonate, bicarbonate, chloride, potassium, calcium and magnesium were shown in (Table 1).

Table 1: Characterization of irrigation water samples used for mulberry cultivation in sampling sites of Erode district, Tamil Nadu

Sl. No	District	Block	Name of the village	EC (dSm^{-1})	pH	CO_3^- (meq L^{-1})	HCO_3^- (meq L^{-1})	Cl^- (meq L^{-1})	K^+ (meq L^{-1})	Ca^{++} (meq L^{-1})	Mg^{++} (meq L^{-1})
1	Erode	Gobichettipalayam	Bommanaikanapalayam	0.78	6.92	1.67	3.36	5.32	0.53	1.93	2.16
2			Thasampalayam	1.16	6.95	3.17	5.67	15.30	0.38	2.53	2.33
3			Kugalur	0.48	6.85	1.98	2.56	2.89	0.47	2.86	2.45
4			Kullampalayam	1.08	6.97	3.09	4.24	11.81	0.56	3.91	2.97
5			Othakuthirai	0.67	6.85	3.18	5.68	16.28	1.02	1.83	2.75
6			Thaneerpanthalpudhur	0.48	6.94	1.52	5.07	14.29	0.44	1.96	2.44
7			Arakankottai	1.23	6.85	2.63	7.51	19.37	1.32	2.62	1.96
8			Vellankovil	1.19	6.82	2.85	5.32	16.20	1.44	4.07	2.11
9			Pichandipalayam	1.32	6.84	1.73	8.16	18.42	0.40	2.17	1.77
10			Polavakalipalayam	0.82	6.77	3.32	5.67	11.89	0.34	2.77	2.22
11			Gobichettipalayam	0.73	6.96	2.54	7.27	10.69	0.87	1.09	1.99
12		Nambiyur	Varapalayam	0.91	6.92	2.75	5.34	8.55	0.37	4.31	0.96
13			Kuppipalayam	1.11	6.83	1.71	4.98	9.45	0.82	2.44	2.51
14			Malayapalayam	0.69	6.93	0.38	3.69	8.30	0.32	1.91	0.39
15		Bhavani	Appakudal	0.88	6.91	3.12	4.88	10.76	0.97	2.11	0.67
16			Bhavani-1	1.02	6.86	2.76	2.54	3.19	0.28	1.75	2.91
17			Bhavani-2	1.21	6.94	4.16	5.64	14.21	0.74	2.70	0.72
18			Athani	1.25	6.93	4.02	6.67	17.76	0.47	2.97	2.13
19			Dharmapuri-1	1.38	6.78	2.19	4.74	13.98	0.53	3.63	1.99
20			Dharmapuri-2	0.93	6.90	1.93	3.03	6.28	0.95	2.03	2.31
21			Jambai	0.75	6.91	2.08	6.72	17.75	0.39	2.66	1.16
22			Kavundapadi	0.89	6.82	4.23	4.59	21.75	0.29	2.76	2.47
23			Kuttipalayam	0.81	6.89	2.64	4.01	13.68	0.41	2.23	0.47
24			Kuttipalayam-2	0.94	6.91	3.59	5.47	10.25	0.49	2.39	0.71
25			Kuttipalayam-3	1.23	6.92	4.31	8.34	15.32	0.63	4.12	1.88
26			West kuttipalayam	0.80	6.89	1.38	2.75	4.55	0.86	2.96	2.29
27			Odathurai	0.77	6.98	3.36	4.41	8.46	0.50	3.94	2.33
28			Palapalayam	1.18	6.86	2.38	4.76	7.54	0.27	2.40	2.97
29			P.mettupalayam	1.25	6.88	3.05	7.43	12.87	0.43	1.19	0.87
30			J.J Nagar	0.95	6.92	4.08	9.13	23.78	0.62	2.45	0.96
31			Vairamangalam-1	1.03	6.87	1.96	2.56	3.75	0.59	3.12	1.52
32			Vairamangalam-2	1.15	6.79	3.51	7.57	12.65	0.85	2.34	2.05
33			Kalingarayanpalayam	1.05	6.83	0.83	2.67	3.98	0.75	4.35	0.91
34		Antiyur	Vempathy	0.89	6.97	0.28	2.18	2.43	0.82	4.12	0.45
35			Unjapalayam	0.75	6.92	1.18	3.31	2.55	0.64	2.86	1.28
36			Osaipatti	0.92	6.91	2.77	4.55	13.35	0.59	3.93	3.17
37			Komputhotam	0.83	6.90	3.01	9.10	20.14	0.52	1.93	3.01
38		Perundurai	Palakarai	0.88	6.95	1.84	3.87	5.72	0.45	4.24	2.93
39			Pallapalayam	1.21	6.87	1.95	3.76	7.78	0.88	2.51	1.66
40			Veerachipalayam	0.53	6.84	3.46	4.25	10.35	0.72	2.47	1.25
41			Karattupalayam	0.68	6.90	2.53	5.11	7.63	0.85	3.76	2.08
42			Ponmudi-1	0.74	6.93	1.35	2.89	6.54	0.90	2.87	2.18
43			Ponmudi-2	0.82	6.76	2.50	4.98	11.76	0.38	1.97	0.87
44			Savadipalayam	1.38	6.83	4.28	7.67	18.85	0.89	2.17	0.95
45			Ellapalayam	1.24	6.91	3.98	7.02	12.73	1.03	3.38	2.67
46			Nallampatti	1.05	6.87	3.19	6.87	17.86	0.83	1.84	0.85
47			Thingalur	0.48	6.83	3.75	7.04	14.79	0.67	2.34	2.13
48			Singanallur	0.91	6.92	2.98	3.82	5.86	0.59	3.79	2.24
49			Vellode	0.55	6.97	3.52	5.85	10.92	0.74	3.56	2.68
50			Kanjikovil	1.01	6.96	2.08	3.84	5.96	0.80	2.57	1.97
51			Seenapuram	0.73	6.87	3.70	5.47	12.68	0.68	2.88	2.33
52			Pudupalayam	0.85	6.92	2.36	2.76	4.78	0.52	4.10	3.16
53			Vijayamangalam	0.91	6.89	0.45	2.67	3.76	0.61	2.97	0.96
54			Chinnamalampalayam	1.13	6.96	3.56	5.35	13.81	0.78	2.73	2.54
55			Thoranavavi	0.86	6.79	3.87	6.05	16.93	0.89	3.76	2.87
56			Ramanathapuram	0.71	6.91	0.74	2.79	3.88	0.57	1.94	0.78
57		Erode	Chettipalayam	0.95	6.93	2.31	4.62	7.58	0.49	2.42	1.65
58		Sathyamangalam	Modhur-1	0.51	6.87	4.38	7.54	17.12	0.55	4.13	3.05
59			Modhur-2	0.63	6.77	1.55	3.26	6.75	0.81	2.19	1.56
60			Sathyamangalam	0.42	6.92	2.46	3.78	6.98	0.72	2.91	1.87
61		Modakurichi	Karavalasu	1.38	6.94	2.11	3.32	5.89	0.35	3.56	2.59

62			Odakattuvalasu	0.66	6.86	3.62	5.78	9.96	0.40	2.65	2.12
63			Kasipalayam	0.99	6.73	2.89	4.08	10.92	0.54	2.93	2.47
64			Velampalayam	0.72	6.84	2.19	3.98	5.38	0.66	3.36	2.61
65			Kagam	0.38	6.75	0.98	2.85	4.78	0.79	1.78	0.87
66			Minnapalayam	1.19	6.99	1.78	3.21	5.21	1.06	2.67	2.34
67			KG. vasalu	0.87	6.87	2.82	3.58	6.05	0.96	3.15	1.89
68			Vadugapatti	0.68	6.79	1.67	2.72	3.87	0.63	1.98	0.96
69			Palliyuthu	1.02	6.93	3.08	5.29	11.48	0.97	2.87	2.52
70			Koothampatti	0.75	6.81	3.67	5.78	12.04	0.86	2.16	2.27
Average				0.90	6.88	2.61	4.91	10.52	0.66	2.80	10.52
Maximum				1.38	6.99	4.38	9.13	23.78	1.44	4.35	3.17
Minimum				0.38	6.73	0.28	2.18	2.43	0.27	1.09	0.39
SEd				0.25	0.66	1.03	1.77	5.30	0.24	0.80	5.30
CV %				27.66	0.89	39.47	36.01	50.36	36.85	28.52	50.36

Note: pH: <6.5 = Acidic, 6.5 - 8.5 = Neutral, >8.5 =Alkaline; EC (dsm-1): < 1.0 = Normal, 1.0 – 2.0 = Critical, > 2.0 = Injurious; CO3- (meq L-1): 0-1= Low, 1-5 = Moderate, > 5 = Severe; HCO3- (meq L-1): 0-10 = Low, 10-30 = Moderate, > 30 = Severe; Cl- (meq L-1): 0-10 = Low, 10-30 = Moderate, > 30 = Severe; K+ (meq L-1): 0-1 = Low, 1-2 = Moderate, > 2 = Severe; Ca++ (meq L-1): 0-10 = Low, 10-20 = Moderate, > 20 = Severe; Mg++ (meq L-1): 0-1= Low, 1-5 = Moderate, > 5 = Severe.

The physico-chemical properties of 70 irrigation water samples from Erode district were analyzed and presented in Table 1. With respect to electrical conductivity (EC) in seventy irrigation water samples ranged between 1.38 to 0.38 dsm^{-1}. The highest EC was recorded Dharmapuri-1 (1.38 dSm^{-1}), Pichandipalayam (1.32 dSm^{-1}), Athani (1.25 dSm^{-1}) and P.mettupalayam (1.25 dSm^{-1}). Whereas the lowest EC was found with Kagam (0.38 dSm^{-1}). The results are in accordance with literatures (Sathiyaraj *et al.,* 2017) [13] reported that in contaminated water samples of Erode (0.83 dSm^{-1}), Pallapalayam (0.76 dSm^{-1}) and Bhavani (0.73 dSm^{-1}). Mohanakavitha *et al.,* (2019) [11] reported that in Kalingarayan canal was 1.26 dSm^{-1}. The electrical conductivity increased due to increase of ions which is maintained by salinity (Ramesh *et al.,* 2014) [12] and lower due to increased rate of precipitation (Mohanakavitha *et al.,* 2019) [11].

When compared to average pH 6.88, Minnapalayam, Odathurai, Kullampalayam and Vempathy found have high pH with 6.99, 6.98, 6.97 and 6.97 respectively. Whereas the lowest pH was recorded by Kasipalayam (6.73). The similar findings were observed by Sathiyaraj *et al.,* 2017 [13] reported that in contaminated water samples of Erode (8.75), Pallapalayam (7.51) and Bhavani (7.42). Mohanakavitha *et al.,* (2019) [11] reported that in Kalingarayan canal 7.53. The varied level of pH in irrigation water is attributed due to proper leaching of minerals. The pH of irrigation water is the judgmental factor for quality of aquatic life or ecosystem (Lokhande *et al.,* 2011) [8].

The carbonate content in irrigation water samples varied between 4.38 to 0.28 meq L^{-1}. The maximum carbonate was exhibited Modhur-1 (4.38 meq L^{-1}), Kuttipalayam-3 (4.31 meq L^{-1}), Savadipalayam (4.28 meq L^{-1}) and Kavindapadi (4.23 meq L^{-1}). The lowest carbonate was observed Vempathy (0.28 meq L^{-1}). The results are in line with (Hema *et al.,* 2012) [4] reported that in polluted rivers namely Cauvery (0.5 meq L^{-1}), Amaravathi (2.4 meq L^{-1}), Noyal (4.8 meq L^{-1}) and Bhavani (1.90 meq L^{-1}). The irrigation water is suitable for mulberry cultivation and causes no harm to plants and animals (Manoj 2015) [10].

The bicarbonate content in irrigation water samples ranged from 9.13 to 2.18 meq L^{-1}. The highest bicarbonate was recorded J.J Nagar (9.13 meq L^{-1}), komputhotam (9.10 meq L^{-1}), Kuttipalayam-3 (8.34 meq L^{-1}) and Pichandipalayam (8.16 meq L^{-1}). The lowest bicarbonate was exhibited Vempathy (2.18 meq L^{-1}). The results are accordance with (Hema *et al.,* 2012) [4] reported that in polluted rivers namely Cauvery (2.40 meq L-1), Amaravathi (2.4 meq L-1), Noyal (5.85 meq L-1) and Bhavani (1.46 meq L-1). The lower bicarbonate concentration in water on Bidadi industrial area, investigated by (Madhukar and Srikantaswamy 2013) [9].

The chloride content varied between 23.78 to 2.43 meq L^{-1} obtained from seventy locations of Erode district. The average content of chloride was 10.52 meq L^{-1}. The highest chloride was recorded J.J Nagar (23.78 meq L^{-1}), Kavindapadi (21.75 meq L^{-1}), Komputhotam (20.14 meq L^{-1}) and Arakankottai (19.37 meq L^{-1}). The lowest chloride was observed Vempathy (2.43 meq L^{-1}). The results are good agreement with (Hema *et al.,* 2012) [4] reported that in polluted rivers namely Cauvery (17.51 meq L^{-1}), Amaravathi (20.20 meq L^{-1}), Noyal (14.60 meq L^{-1}) and Bhavani (23.20 meq L^{-1}). This was attributed due to chlorides found in irrigation water through natural and anthropogenic sources, such as weathering of rocks and leaching of inorganic fertilizers, dumps or landfills and industrial effluents (Yadav *et al.,* 2014) [14].

The irrigation water samples were collected from seventy locations of Erode district, ranged between 0.27 and 1.44 meq L^{-1}. The average content of potassium was 0.66 meq L^{-1}. The maximum potassium was recorded Vellankovil (1.44 meq L^{-1}), Arakankottai (1.32 meq L^{-1}), Minnapalayam (1.06 meq L^{-1}) and Ellapalayam (1.03 meq L^{-1}). The minimum potassium was observed Palapalayam (0.27 meq L^{-1}). The findings are similar to (Sathiyaraj *et al.,* 2017) [13] reported that in contaminated water samples of Erode (0.95 meq L-1), Pallapalayam (0.80 meq L-1) and Bhavani (0.65 meq L-1). The irrigation water is suitable for cultivation of various agriculture crops and causes no harm in decreasing productivity (Manoj 2015) [10].

The calcium content ranged between 1.09 and 4.35 meq L^{-1} obtained from seventy villages of Erode district. The average content of calcium was 2.80 meq L^{-1}. The highest calcium was recorded Kalingarayanpalayam (4.35 meq L^{-1}), Varapalayam (4.31 meq L^{-1}), Palakarai (4.24 meq L^{-1}) and Modhur-1 (4.13 meq L^{-1}). The lowest calcium was exhibited Gobichettipalayam (1.09 meq L^{-1}). The results are similar with (Sathiyaraj *et al.,* 2017) [13] reported that in contaminated water samples of Erode (1.34 meq L^{-1}), Pallapalayam (1.20 meq L^{-1}) and Bhavani (1.04 meq L^{-1}). The lower calcium concentration in irrigation water might be due to more seepage (Deshmukh 2014) and (Manoj 2015) [3, 10].

The irrigation water samples were collected from seventy sites of Erode district ranged from 0.39 to 3.17 meq L^{-1}. The average content of magnesium was 1.92 meq L^{-1}. The maximum magnesium was exhibited Osaipatti (3.17 meq L^{-1}), Pudupalayam (3.16 meq L^{-1}), Modhur-1 (3.05 meq L^{-1}) and

Komputhotam (3.01 meq L^{-1}). The minimum magnesium was recorded Malayapalayam (0.39 meq L^{-1}). The results are in line with (Sathiyaraj *et al.*, 2017) [13] reported that in contaminated water samples of Erode (0.19 meq L^{-1}), Pallapalayam (0.17 meq L^{-1}) and Bhavani (0.16 meq L^{-1}). The lower magnesium concentration in irrigation water might be due to more seepage (Manoj 2015) [10].

Conclusion

From the result of physicochemical analysis of textile effluents has been concluded that pH, EC, carbonate, bicarbonate, chloride, potassium, calcium, magnesium are neutral to high in concentration compared to the standards prescribed by the (Richards 1969). The results of the study showed that due to unsafe disposal of textile waste water on the bare land, the organic, and inorganic chemical compounds present in the effluent have leached and found their way into the ground water. Hence, the potable water in the industrial area was significantly contaminated with cadmium, chromium, lead, and nickel which were used in the wet finishing process of textile process and released along with the effluent. In the past, several physical and chemical methods have been recommended for the treatment of wastewater but are not widely used because of the high cost and secondary pollution that can be generated by excessive use of chemicals. In further, phytoremediation is novel technology that uses green plants for cleaning up of contaminated sites, as it seems to be a cost-effective, esthetically pleasant and may contribute to restore soil structure.

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