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IMPACT OF THANNEERMUKKOM REGULATOR ON ACCUMULATION OF HEAVY METALS IN THE WETLANDS OF KUTTANAD

K. C. Manorama Thampatti and A. I. Jose
College of Horticulture, Vellanikkara 680654, Trichur, India

Abstract: Accumulation of heavy metals in the wetland ecosystem of Kuttanad and their variation in accordance with the opening and closure of Thanneermukkom Regulator constructed for the prevention of saline water entry into Kuttanad were evaluated. Fe and Al arc present in toxic quantities and their concentration increased during summer season which coincides with the closure of the regulator, to a level sufficient to create severe crop damage. The area has excess quantity of Mn and there is no deficiency of Cu and Zn. The water of the area is highly contaminated with heavy metals like Fe. Mn and Al. Toxic heavy metals like Cd and Pb were not detected in water.

Key words : Heavy metals, Kuttanad ecosystem, pollution, nutrient deficiency, toxicity, wetland.

INTRODUCTION

Kuttanad is facing severe ecological degradation due to the pollution of soil and water. The major reasons for the pollution are indiscriminate use of fertilisers and pesticides, water stagnation due to the prevention of water flow towards sea, continuous monocropping etc. Most of these factors are the result of the closure of Thanneermukkom Regulator which prevents saline water intrusion and results in water stagnation in Kuttanad. The drainage water from the punja rice fields and organic and inorganic residues due to human activities arc released into the water bodies of Kuttanad. The present paper attempts an evaluation of the accumulation of heavy metals in the wetland ecosystem of North Kuttanad which was the most benefitted area due to the construction of Thanneermukkom Regulator.

MATERIALS AND METHODS

Bulk soil samples to a depth of 0-25 cm were collected from 27 padasekharams representing the study area, during rainy and summer seasons of the years 1993 and 1994 (before and after the closure of Thanneermukkom Regulator). Along with soil samples, surface water samples from field and ground water samples from nearby wells were collected during the above two seasons.

The available Fe, Mn, Cd and Pb were estimated from the DTPA extract (Lindsay and Norvell, 1978) by atomic absorption spectrophotometer. The extractable Al was determined colorimetrically by aluminon method from 1 *M* KG extract (Hsu, 1963; Jayman and Sivasubramaniam, 1974). Water soluble Fe, Mn and Al were estimated from 1:5 soil water extracts (Hesse, 1971). For the analyses of water, the same detection methods as above were used.

RESULTS AND DISCUSSION

Soil : The soils of Kuttanad are highly acidic, mildly saline, high in organic carbon content and CEC with low base saturation. They are highly deficient in available P, medium in K and high in N. The heavy metals that are present in excess quantities in Kuttanad soils are Fe, Al and Mn. The closure of the regulator has considerably altered the concentration of the above elements in soil and water. Fe toxicity is often encountered in Kuttanad soils. The increase in acidity after the closure of the regulator due to lowering of water table results in an increase in concentration of available Fe. The available Fe content was 373 ppm during rainy season (before the closure of regulator) which significantly increased to 429 ppm during summer (after the closure of regulator). The increase in acidity has released more Fe from its exchange complex. The quantity of available Fe present is sufficient to cause Fe toxicity in the area and will be more severe during the summer season due to the greater quantity of Fe and reduction in concentration of exchangeable bases during that period. Fe

Table 1. Accumulation of different forms of Fe, Al and Mn in soil during rainy and summer seasons (before and after the closure of Thanneermukkom Regulator)

Particulars	pH		EC dS m⁻¹		Av. Fe ppm		Water sola Fe ppm		Av. Mn ppm		Water solu. Mn ppm		Extractable Al cmol(+) kg⁻¹		Water soluble Al, ppm	
	SI	SII	SI	SII	SI	SII	SI	SII	SI	SII	SI	SII	SI	SII	SI	SII
Mean	4.3	3.9	1.3	0.62	373	429	16	20	12	11	4	3.5	2.9	3.2	3.11	3.37
Range	3.2 to 5.8	3.2 to 5.0	0.3 to 2.9	0.20 to 1.72	182 to 556	103 to 798	3.1 to 42.0	12.7 to 43.0	3.1 to 25.2	2.3 to 28.5	0.4 to 13	0.2 to 26	0.2 to 9.0	0.8 to 8.4	0.10 to 7.82	1.79 to 9.88
CD (0.05)	0.291		0.027		55.2		NS		NS		NS		NS		NS	
SEm ±	0.101		0.094		18.9		1.57		1.25		0.670		0.347		0.341	

SI = Rainy season (before the closure of Thanneermukkom Regulator)
SII - Summer season (after the closure of Thanneermukkom Regulator)

Table 2. Accumulation of heavy metals in surface water during rainy and summer seasons

Particulars	pH		EC dS m⁻¹		Fe ppm		Mn ppm		Al ppm	
	SI	SII	SI	SII	SI	SII	SI	SII	SI	SII
Mean	6.7	5.9	0.28	0.51	0.79	0.87	0.20	0.19	0.10	0.09
Range	4.8-7.9	3.7-7.0	0.10-0.84	0.31-1.42	0 17-1.84	0.17-3.0	0.01-0.70	0.02-0.86	0.06-0.16	0.01-0.70
CD (0.05)	0.436		0.108		NS		NS		NS	
SEm ±	0.150		0.037		0.516		0.029		0.019	

SI - Rainy season (before the closure of Thanneermukkom Regulator)
SII - Summer season (after the closure of Thanneermukkom Regulator)

Table 3. Accumulation of heavy metals in ground water during rainy and summer seasons

Particulars	pH		EC dS m⁻¹		Fe ppm		Al ppm	
	SI	SII	SI	SII	SI	SII	SI	SII
Mean	6.7	6.3	0.37	0.42	0.85	1.31	0.08	0.03
Range	4.0-7.2	5.4-7.0	0.18-0.52	0.18-1.2	0.34-2.05	0.60-5.46	0.06-0.16	0.01-0.06
CD (0.05)	0.263		NS		0.329		0.(XS	
SEm ±	0.090		0.034		0.113		0.003	

SI - Rainy season (before the closure of Thanneermukkom Regulator)
SII = Summer season (after the closure of Thanneermukkom Regulator)

toxicity has been reported for Fe levels varying from 20 ppm (Van Breeman and Moorman, 1978) to 400 ppm (1RRI, 1964). The water soluble Fe content was 15.9 ppm during rainy season and increased to 19.6 ppm during summer. The Fe status of the area was very high.

The extractable Al content also increased after the closure of the regulator, but was not significant. The mean value was 2.96 cmol (+) kg^{-1} during rainy season which increased to 3.24 cmol (+) kg^{-1} during summer season. The water soluble Al contents were 3.11 and 3.37 ppm, respectively during the above seasons. Compared to Fe, this was very low apparantely due to the submerged condition and the consequent rise in soil pH above 4.0. Compared to the pre-barrage values reported by Kabeerathumma (1975) and Kabeerathumma and Patnaik (1978) only a marginal increase was observed in Fe and Al contents of the tract. .

There was no significant difference in Mn content between two sampling periods. The mean values for available Mn were 12.0 and 10.6 ppm, during rainy and summer seasons, respectively. The water soluble Mn contents during the above two seasons were 3.97 and 3.49 ppm, respectively. The comparison with pre-barrage period was not possible due to want of data for the particular area. The study area did not show any toxic accumulation of Cu and Zn in soil and they were not deficient also.

The toxic heavy metals like Cd and Pb were not detected in the DTPA extract for most of the soil samples collected. In a few cases, concentration between 0.10 to 0.15 ppm for the above elements were recorded irrespective of the closure / opening of the regulator.

Water : Compared to soil, the impact of pollution is more severe on water due to its dynamic nature. The comparison of accumulation *of* heavy metals in water with that of pre-barrage period was not possible due to want of similar studies taken up during the pre-barrage period. Hence the seasonal comparison alone was attempted.

Among the heavy metals present, Fe predominated. The mean value of Fe in surface water was 0.79 ppm during rainy season (before the closure of regulator) and 0.87 ppm during summer (after the closure of regulator). For ground water, the corresponding values were 0.85 and 1.31 ppm, respectively. The ground water registered a higher content which might be due to the accumulation of leachates. The permissible maximum concentration for Fe in irrigation water is 5.0 ppm and for drinking water it is 0.3 ppm as per the standards derived by the National Academy of Sciences and National Academy of Engineering (1972) and ISI (1991). The Fe content of the area did not exceed the permissible limit for irrigation water. The quality of drinking water was very poor as per ISI (1991) standards and it has to be purified before use. The increase in soil acidity and submerged condition maintained more Fe in soluble form which is also released along with the run-off from punja rice fields into the water bodies of Kuttanad.

In the study area, Al was present only in minute quantities both in surface as well as in ground water. However, even this concentration in ground water was above the maximum level prescribed by ISI (1991) for drinking water and hence is sufficient to cause health hazards.

The Mn content of the surface water was 0.20 ppm during rainy season and 0.19 ppm during summer. As per the above standards, the concentration of Mn allowed is 0.20 ppm and 0.05 ppm for irrigation and drinking water, respectively. The Mn content of the irrigation water is approaching the maximum tolerable limit and in future there is every chance for its increase, unless suitable management measures are adapted. In ground water, Mn was detected only in traces. Heavy metals like Cu and Zn were detected in traces only in both surface and ground water. Toxic heavy metals like Cd and Pb were not detected in water.

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