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Assessing Soil quality in Pineapple (*Ananas comosus*) cultivated areas of Ernakulam district

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Abstract: **Pineapple (*Ananas comosus*) is the most economically important plant and its cultivation is a very popular agricultural practice in central Kerala, especially in Ernakulum, Kottayam, Idukki and Pathanamthitta districts. During pineapple cultivation, various agrochemicals are used in the different stages of growth for the better development. These agrochemicals, even at low concentration, will change the soil chemistry thereby affect the soil biota. The sustainable agriculture involves both optimizing agricultural resources and maintaining the soil quality. Modern agricultural practices and changes in land use practices directly or indirectly affect the soil health. Soil quality can be measured by assessing the physical, chemical and biological indicators. So far no serious studies have been undertaken to investigate the impact of pineapple cultivation on soil quality in this part of Kerala. Soil analyses were performed with samples collected from different taluks (Aluva, Kunnathunad, Kothamangalam and Muvattupuzha) of Ernakulam district. To assess the impact of pineapple cultivation on soil quality, chemical indicators such as pH, EC, organic carbon, available nitrogen, phosphorous, potassium, calcium, iron, manganese, zinc, copper, boron, lead, nickel and cadmium were analysed. Among the heavy metals, concentration of available cadmium was found to be significantly high in all cultivated areas with reference to control. Concentration of cadmium was found to be in the range of 0.17±0.11 and 0.21±0.36 mg/kg. Available manganese and nitrogen were found to be marginally significant. The presence of significant amount of heavy metal indicates pollution due to agrochemicals. The results point towards an immediate urge for the detailed study of the possible threats of ongoing pineapple cultivation practices in Kerala**

Keywords: **Pineapple mono-cropping, agrochemicals, soil quality, heavy metals.**

I. INTRODUCTION

India is the second largest producer of fruits and vegetables in the world [5]. Modern agricultural practices and changes in land use directly or indirectly affect the soil health. Excessive usage of chemical fertilisers will pollute the soil and water. Chemical fertilisers used in India is about 121.4 Kg/ha [17].Kerala is the land with highly diversified physical and agro ecological features. Kerala is having a clear environment than any other states of India. About 83 % of the total area of Ernakulam district is under cultivable land [2] and about 54 % of the area is under pineapple cultivation. Pineapple is the most economically important plant coming under Bromeliaceae family. It is an herbaceous perennial [16]. Pineapple cultivation is a very popular agricultural practice in central Kerala especially in Ernakulum, Kottayam, Idukki and Pathanamthitta districts. During pineapple cultivation various agrochemicals are used in the different stages of growth for the better development. These agrochemicals even at low concentration will change the soil chemistry and also affect the soil biota. Soil quality can be measured by assessing the physical, chemical and biological indicators. Important physical indicators include porosity, density, soil strength, structure, water holding capacity, colour etc. Chemical indicators include pH, plant nutrient availability, electrical conductivity, cation exchange capacity, presence of contaminants etc. Biological indicators such as organic carbon, microbial biomass carbon, microbial community, soil respiration, soil enzymes etc [9].

It is difficult to supply adequate amount of all nutrients, so better to avoid negative interaction between nutrients in order to maintain a balanced nutrient supply [15]. Reducing the use of excess agrochemicals such as synthetic fertilisers, pesticides, herbicides and fungicides will directly or indirectly affect the nutrient availability to crops [1].Agrochemicals used in the agricultural fields will runoff to the nearby water sources thereby pollute them [13]. Long term application of lime, fertiliser and manure will influence the soil physical condition also. Addition of N, P, K fertilisers showed an increase in organic matter input to the soil there by stimulate soil biological activity. Continuous application of N, P can decrease bulk density but increases porosity, water stable aggregation, infiltration capacity and hydraulic conductivity [4]. Soil properties like texture, moisture, pH, salinity and also manipulation of soil environmental conditions such as tillage, irrigation, fertilizer and manure application have an effect on CO_2 production and emission[14].Some fertilisers contains heavy metals cadmium and chromium and nitrogen fertiliser contains carcinogenic substances such as nitrosamines. Ammonia is emitted from the agricultural lands which are applied with high amount of ammonium fertilisers [17]. Heavy metals and trace elements due to their non-biodegradable nature and long biological half-lives will accumulate in the plants, human beings and other animals,[3],[13]. Micronutrients interact with each other and with other elements in the soil. Zinc positively interacts with nitrogen and potassium. But negatively interact with phosphorous, calcium, iron and copper. Zinc decreases boron toxicity in crops and also increase absorption of Cu and Mn by plants [10].

Modern agricultural practices for pineapple cultivation include high density planting; foliar application of fertilisers, hormonal applications and excessive use of other biocides such as pesticides, herbicides and fungicides. It is a big challenge for the farmers to get maximum production from a unit area of land with a sound eco-friendly agronomic practice. Here is the need of research to fit modern agricultural farming systems.

II. MATERIALS AND METHODS

Total area of Ernakulam district is 3068 Sq. Km. It lies between North latitudes 09^0 47' 13" and 10^0 10' 44" and East longitudes 76^0 10' 05" and 77^0 05' 24". Pineapple cultivated areas in four different taluks - Aluva, Kunnathunad, Kothamangalam and Muvattupuzha - in Ernakulam district were selected for the study. These taluks were denoted as T1, T2, T3 and T4 respectively. Three forest areas were used as control denoted as "C". A detailed questionnaire survey was conducted among farmers to get the farming practice and usage of agrochemicals.

Map showing study area

Composite Soil samples of 0-20 cm were collected. The soil samples were air dried, sieved through 2 mm sieve (0.2 mm sieve for organic carbon). Soil texture was assessed by international pipette method. Soil pH and Electrical conductivity (EC) were measured at a soil to water ratio of 1:2.5. Soil pH was measured using Systronics Digital pH meter MK VI and Electrical conductivity by Deluxe Conductivity meter-601 (EI). Organic carbon was estimated by Walkey – Black titration method. Available nitrogen was measured by alkaline permaganometry, (PELICAN, Kelplus-Classic DX VATS (E). Available phosphorous was extracted by Bray's No.1 method and measured by Spectrophotometer (Xplorer, Xp 2001). Available potassium was extracted by Neutral 1 N Ammonium acetate solution and was measured by Flame photometer (Elico-CL 378). Available Calcium and Magnesium was extracted by Neutral 1 N Ammonium acetate and

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measured by Atomic Absorption Spectrophotometer (AAS) (Varian-240). Available iron, manganese, zinc and copper were extracted by 1 M HCl and were measured by AAS. Available boron was extracted by hot water and estimated by Azomethine –H method in a Spectrophotometer. Available heavy metals were extracted by DTPA method and were measured by AAS.

Statistical analysis was performed using R software[12].

III. RESULTS AND DISCUSSIONS

Table 1: Soil texture of selected pineapple cultivated areas

Locations	Particle size (USDA) distribution % of(< 2 mm)			Textural class
	Sand %	Silt %	Clay %	
Aluva	61.5	4.5	34	Sandy clay loam
Kunnathunad	69.5	8.5	22	Sandy clay loam
Kothamangalam	68	15	17	Sandy loam
Muvattupuzha	63.55	3.4	33.05	Sandy clay loam

Most of the pineapple cultivated areas were found coming under the texture class of Sandy clay loam. It supports the statement that Sandy and loamy soils were suitable for pineapple cultivation [8].

Table 2: General chemical parameters of pineapple cultivated areas

Variables	Control (C)	T1	T2	T3	T4
pH	5.6 ± 0.29	5.3 ± 0.33	5.5 ± 0.1	5.5 ± 0.22	5.5 ± 0.25
EC (dS/m)	0.052 ± 0.01	0.071 ± 0.04	0.079 ± 0.02	0.081 ± 0.02	0.099 ± 0.04
OC%	1.13 ± 0.03	1.5 ± 0.6	1.03 ± 0.66	0.88 ± 0.75	0.67 ± 0.22

pH for the control location was found to have a mean value of 5.6 ± 0.29 whereas pineapple cultivated areas in the Aluva taluk (T1) was found to be 5.3 ± 0.33, Kunnathunad taluk (T2) was 5.5 ± 0.1, Kothamangalam taluk (T3) was 5.5 ± 0.22 and Muvattupuzha taluk (T4) was 5.5 ± 0.25. All the cultivated areas and control areas showed electrical conductivity less than one (<1) which indicate low EC level. Pineapple cultivated areas of Muvattupuzha taluk shows a low percentage of organic carbon but other cultivated areas and control showed medium organic carbon.

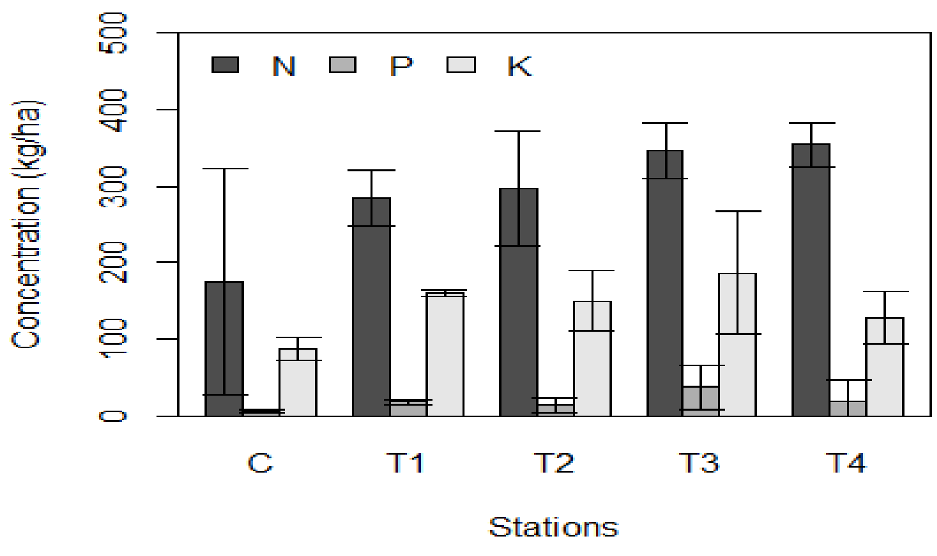

Figure 1: Primary nutrient contents at different sampling stations

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Available nitrogen content was found to be increasing in all the cultivated areas than control and it showed marginally significant result. Available nitrogen in the pineapple cultivated fields of Muvattupuzha taluk was found to be very high (353.74 ± 28.6 kg/ha). Values of available nitrogen for other taluks were 284.3 ± 36.2 kg/ha, 296.87 ± 75.6 kg/ha and 347± 36.2 kg/ha respectively for T1, T2 and T3. Available nitrogen in the control area was 175 ± 147 kg/ha. There was no noticeable change in the available phosphorous content among the cultivated areas but shows small increase than control. Amount of available phosphorous was 5.9 ± 2.4 kg/ha in control. Available phosphorous in all the cultivated areas of T1, T2, T3 and T4 taluks were 17.8 ± 3.6, 13.18 ± 9.2, 36.7 ± 28.9 and 18.9 ± 26.5 kg/ha respectively. Available potassium showed some increase in cultivated areas than control (86.6 ± 14.9 kg/ha). Available potassium in cultivated areas of T1, T2, T3 and T4 taluks were 159.4 ±3.9, 150.08 ± 39.9, 186.2 ± 8 and127.9 ± 34 kg/ha. Generally, pineapple plant needs less phosphorous than N and K. Excessive phosphorous can cause toxicity to plants. Potassium is the second most abundant mineral nutrient in plants after N. The combined effect of N and K will increase 46% of total response [15]. Phosphorous and potassium directly influence the nitrogen uptake by plants and their interaction helps to increase the crop yield and quality [18].

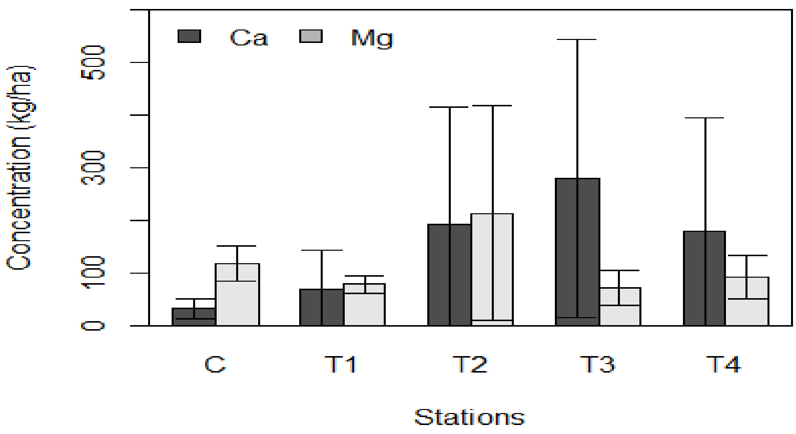

Figure 2 : Secondary nutrient content at different sampling stations

Available calcium was found to be high in all the cultivated areas other than control (31.55 ± 19.9 kg/ha). Cultivated areas in Kothamangalam taluk showed high amount of available calcium (279.44 ± 265 kg/ha). Available Ca in T1, T2 and T4 were 67.95 ± 74.6, 190.58 ± 226 and 179.76 ± 215.6 kg/ha respectively. No significant result was observed in the amount of available magnesium in the cultivated areas with reference to control. Available magnesium of control area was 117.15 ± 32.7 kg/ha. Cultivated areas in the taluk T1, T2, T3 and T4 showed available Mg by the values of 77.87 ± 16.5, 213 ± 204, 69.85 ± 33.5 and 92.09 ± 40.8 Kg/ha.

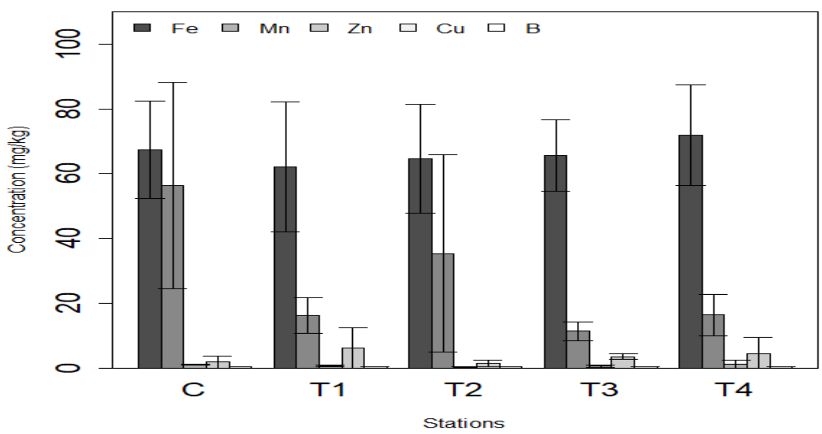

Figure 3: Micronutrient contents at different sampling stations

Among the available micro nutrients studied, only manganese showed marginally significant result. High amount of Mn was reported in control (56.33 ± 31.94 mg/kg of soil) and low Mn content was observed in the cultivated regions of Kothamangalam taluk (11.33 ± 2.92 mg/kg of soil). Available Mn in T1, T2 and T4 were 16.16 ± 5.5, 35.3 ± 30.4 and 16.4 ± 6.38 mg/kg. Available Zn, Cu and B does not show any significant change in the cultivated areas with reference to control. They showed negligible values as compared to other nutrients. Available Zn in the control was 0.98 ± 0.14 mg/kg and in the cultivated areas of T1,T2,T3 and T4 taluks were 0.63 ± 0.16, 0.15 ± 0.13, 0.58 ± 0.36 and 1.1 ± 1.27 mg/kg. Zinc is absorbed on the hydroxides (especially those of iron) and carbonate surface, which decreases its availability to plants [11]. Available Copper in the control was 1.83 ± 1.8 mg/kg. Pineapple cultivated areas of T1,T2,T3 and T4 taluks of Ernakulam district showed available Cu in the values of 6.16 ± 6.3, 1.33 ± 1.03, 3.5 ± 0.86 and 4.4 ± 5.1 mg/kg. Available boron in the control area was 0.41 ± 0.009 mg/kg. Available boron in the pineapple cultivated fields of T1,T2,T3 and T4 taluks were 0.4 ± 0.02, 0.38 ± 0.007, 0.39 ± 0.02 and 0.41 ± 0.06 mg/kg. Available iron also showed no significant result when compared with that of control. Available Iron in the control was 67.43 ± 14.96 mg/kg. Available Iron in the pineapple cultivated areas of T1, T2, T3 and T4 taluks were 62.13 ± 19.9, 64.61 ± 16.8, 65.63 ± 10.9 and 71.92 ± 15.5 mg/kg respectively.

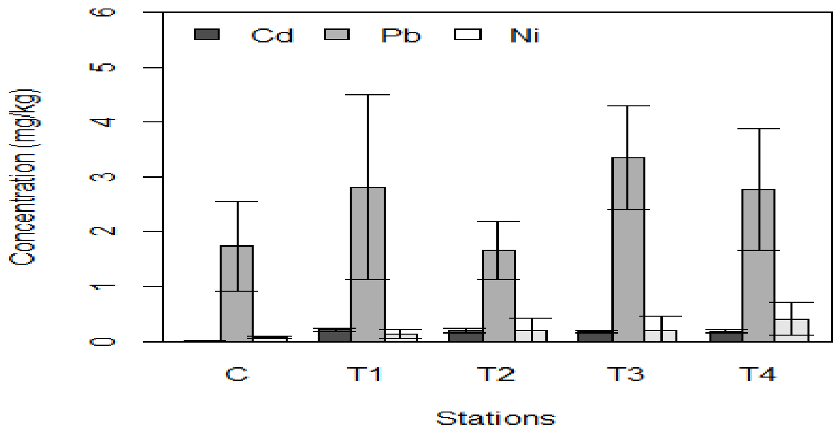

Figure 4: Heavy metal content in different sampling stations

Among the heavy metals studied, cadmium showed significant increase in all the pineapple cultivated areas than control. Control area showed Cd value 0.003 ± 0.005 mg/kg. Pineapple cultivated fields in T1, T2, T3 and T4 taluks of Ernakulam district showed Cd values as 0.21 ±0.03 , 0.19 ± 0.04, 0.17 ± 0.01 and 0.18 ± 0.02 mg/kg. Presence of Cd in the soils of Pala municipality of Kottayam, where rubber was the most cultivated crop, was reported by Jacob and Joseph [7]. Pineapple was planted as an intercrop in most of the rubber plantations for the first three years. So presence of Cd in the soil support these findings. Concentration factor for Cd content was higher in agricultural soils of Koratty [11]. Amount of lead and nickel found to be low in control than other cultivated areas. Available lead concentration in the control station was 1.73 ± 0.8 mg/kg. Lead concentration in the T1, T2, T3 and T4 taluks were 2.81 ± 1.6, 1.66 ± 0.53, 3.35 ± 0.95 and 2.77 ± 1.1 mg/kg. Available nickel content in the control site was 0.07 ± 0.01 mg/kg. Available Nickel concentration in the T1, T2, T3 and T4 taluks were 0.138 ± 0.08, 0.19 ± 0.23, 0.19 ± 0.27 and 0.4 ± 0.3mg/kg.

IV. CONCLUSION

The primary nutrients (N, P and K), and secondary nutrients (Ca and Mg) studied showed an increase in concentration in all the pineapple cultivated areas with respect to control site. No significant change was observed among the micronutrient (Fe, Mn, Zn, Cu and B) contents. An increase in heavy metal content was observed in all the pineapple cultivated areas other than control. Cadmium content was found to be significantly high in all the pineapple cultivated areas of Ernakulam district. The results obtained in the present study suggest the possibility of heavy metal contamination due to excessive use of agrochemicals in pineapple cultivation. Normally, a leasing practice is prevalent in the pineapple cultivated areas and since the pineapple cultivation is carried out by contract farmers, financial benefits are often given a priority over soil quality. Indiscriminate use of agrochemicals will cause an undesirable effect. Further studies was recommended to assess the effect of biocides (pesticides, herbicides and fungicides) applied in the pineapple fields on soil quality.

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