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Monitoring Heavy Metal Contamination in the Pineapple (*Ananas comosus*) Cultivated tracts of Kerala, India

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ABSTRACT: Agriculture plays an important role in the sustainable development of the country. Use of chemical fertilizers escalate certain components in excess quantity thereby deteriorate the productivity and leads to unpredicted outcome. This study makes an effort to reckon the accumulation of some selected heavy metals [Lead (Pb), Nickel (Ni) and Cadmium(Cd)] and related indices [bio concentration factor(BCF) and translocation factor (TF)] from roots, leaves and fruits of pineapple plantations in Ernakulam district. Contamination factor(CF), enrichment factor(EF) and geo accumulation index (Igeo) disclose the extent of soil contamination in the pineapple cultivated regions of Ernakulam district. Root to shoot TF derived for Pb, Ni, and Cd were 0.25, 0.733 and 0.6731. TF of Pb, Ni and Cd from root to fruit was 0, 0.5 and 0.195 respectively. Values obtained for BCF of Pb, Ni and Cd in root of the pineapple plant were 0.2013,0.5758 and 0.3288. In pineapple leaves BCF showed the values 0.0503, 0.4222 and 0.2214 by Pb, Ni and Cd. Pineapple fruit showed BCF values Zero, 0.2879 and 0.0641 for Pb, Ni and Cd. Enrichment factor for Pb, Ni and Cd in pineapple cultivated areas comes under the value 4.2, 3.7 and 2.8 respectively. Furthermore, the contamination factor of Pb, Ni and Cd was 9.93, 8.26 and 6.23, respectively. The values of geo accumulation index obtained for different heavy metals pass on that the degree of pollution with respect to Pb (6.621) was very strong and extremely contaminated, heavily to extremely contaminated for Ni (5.513) and Cd (4.15).

KEYWORDS: Translocation factor, Bio concentration factor, Contamination factor, Enrichment factor and Geo accumulation index.

INTRODUCTION

Geochemical monitoring is required to find out credible enrichment due to anthropogenic activities. Farmers use a lot of fertilizers knowingly or unknowingly to get more yields. These chemicals stay in the soil for a long time in quantities greater than the required amount by plants. Heavy metals that accumulate in storage tissues of plants, is passed on to the food chain expedite inauspicious health effect to human beings, further reduce the production and quality of crops [1]. Lead can be found in petrol additives, batteries, mineral industries, paper and wood products, animal and vegetable products, lead based paints, lead solder in plumbing or lead pipes. Cd is a byproduct of smelting of Zinc, lead and copper moreover Cd is present in fertilizer and also used as additives in processing PVC resins, color pigments [2]. Cd is toxic to living organism and leads to kidney damage, skeletal damage and cardiovascular diseases. Chief source of heavy metal pollution in agricultural areas are phosphatic fertilizers which have been applied for more than 50 years and keep accumulating in plant tissues [3]. Lead poisoning resulted in headache, abdominal pain, and irritability. It can lead to learning disturbances and diminished intellectual capacity in children due to the mutagenic, teratogenic and carcinogenic properties [4]. Soil contamination of Cd in agriculture is of global importance because it is accumulated in the edible parts of the plant and often exceed food safety standards [5]. Translocation of heavy metals from roots to aerial parts of the plant revealed phytoextraction which is a mechanism of phytoremediation [6]. Numerous plants eg: *Jatropha curcas* [7] have the ability for phytoremediation. Bio concentration factor depicts the ability of the plant to accumulate elements from the substrate and translocation factor give out a clear understanding represents for the phytoremediation purpose. Potency of anthropogenic pollutants such as heavy metals on the surface of the soil were estimated by the indexes such as Enrichment Factor (EF) and Geo accumulation index (Igeo). Elements lacking degradation and vertical mobility were chosen as reference element (Al, Fe, Mn and Rb) [8-10] to normalize the metal concentration by examined environment to that of reference element. Pineapple is a fruit of ever growing demand from domestic together with tourism point of view. Large fertilizer input is indispensible for a large scale pineapple production. Nutrient status do provide an useful insight into the impact of agricultural management practices in pineapple

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cultivation. Haphazed use of chemical fertilizers will increase soil acidity as well as changes in chemical properties consequently affect the soil health. Soil management do need careful consideration to heavy metal for the optimum pineapple growth and for future soil productivity. The study aimed to assess the degree of heavy metal contamination by different indices such as Contamination factor, Enrichment factor and Geo accumulation index.

METHODOLOGY

Pineapple cultivated areas from different agro ecological regions of Ernakulam district (09° 47'13' and 10° 10 '44' North latitudes and 76° 10' 05' and 77° 05' 24' East) were selected for the study. Being plantation area, all sites were exposed to different types of chemical fertilizers and biocides. Soil samples were collected from pineapple cultivated fields of Ernakulam district and the samples were air dried, sieved(2mm) and digested with aqua regia (3:1 concentration of hydrochloric acid : nitric acid) for analysis heavy metals (Pb, Ni and Cd) and also for Iron (Fe). After extraction metals were estimated by Atomic Absorption Spectrophotometer (AAS). Plant parts such as roots, leaves and fruits were also collected from the same field. Roots, leaves and fruits of the Pineapple plants were separated, washed, dried at 60°C in an oven, ground into fine powder and the samples were digested with aqua regia. Heavy metals such as Pb, Ni and Cd were analyzed using AAS.

Translocation factor specify the capacity of the plant to transfer the metals from its roots to shoots and other aerial parts. Translocation factor was calculated by the formula

$$TF = C_{aerial\ parts} / C_{root} \quad (1)$$

Where $C_{aerial\ parts}$ is the concentration of metal in leaves /fruits and C_{root} is the concentration of metal in the root. Here estimated TF from Pineapple roots to pineapple leaves and also from Pineapple root to Pineapple fruit. Bio concentration factor can be measured from each plant parts such as root, leaf, fruit etc and was calculated by the formula

$$BCF = C_{harvested\ tissue} / C_{soil}. \quad (2)$$

Where $C_{harvested\ tissue}$ is the metal concentration in the plant parts (root//leaf and fruit), C_{soil} is the concentration of same metal in the soil [11].

Contamination factor was measured accordingly

$$C_f^i = C^i_{0-1} / C^i_n \quad (3)$$

where C^i_{0-1} is the mean concentration of metals from examined sites, and $C^i_n$is the concentration of metals from background or baseline area. Contamination was assessed by contamination factor (table 1).

Enrichment factor was determined by the following formula,

$$EF_X = [X_s/E_{s(ref)}]/[X_c/E_{c(ref)}] \quad (4)$$

where Xs is the amount of examined metal in the examined environment, $Es_{(ref)}$ is the amount of examined element in the reference environment, Xc is the reference element in the examined environment, $Ec_{(ref)}$ is the content of reference element in the reference environment[12].To study Enrichment Factor, Iron (Fe) is used as the reference element. Five contamination categories are conceded on the basis of enrichment factor (table 2).

Degree of contamination was calculated by geo accumulation index (Igeo).

$$Igeo = ln(Cn/1.5*Bn) \quad (5)$$

where Cn is the measured concentration of metal in the cultivated soil, 1.5 is the ground matrix correction factor, Bn is the back ground value of heavy metal [13]. The geoaccumulation index and the degree of pollution were shown in the table (table 2).

Table 1: Contamination index of heavy metals

	Value	Contamination
Contamination	$C_f^i<1$	low contamination
	$1 \le C_f^i<3$	Moderate contamination
	$3 \le C_f^i<6$	Considerable contamination
	$6 \le C_f^i$	Very high contamination*

Ref: [14]

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Table 2: Indices of Enrichment factor and of Geo accumulation

	Value	soil quality
Enrichment Factor	EF<2	minimal enrichment
	2<EF<5	moderate enrichment *
	5<EF<20	significant enrichment
	20<EF<40	very high enrichment
	EF>40	Extremely enrichment
Geo accumulation Index	Igeo ≤ 0	Uncontaminated
	0<Igeo< 2	moderately contaminated
	2 <Igeo<4	Heavily contaminated
	4 <Igeo< 5	Heavily to extremely contaminated *
	Igeo ≥ 5	Extremely contaminated*

Ref: [15]

RESULTS AND DISCUSSION

Average concentration of heavy metals (Pb , Ni and Cd) in the pineapple cultivated fields are summarized in the (table 3) . Mean concentration of Pb in the pineapple cultivated soil and reference soil ,was found to be 39.73 $mgkg^{-1}$ and 4 $mgkg^{-1}$. Average Pb content in pineapple cultivated soil is lower than the mean concentration of Pb (49.71 $mgkg^{-1}$) in soil reported by earlier studies[16].Pineapple root and leaves showed 8 $mgkg^{-1}$and 2 $mgkg^{-1}$ of Pb. Lead concentration in fruit was found to be below detectable limit (BDL). Nickel showed 10.42 $mgkg^{-1}$ in cultivated soil and 1.26 $mgkg^{-1}$in reference soil. 6 $mgkg^{-1}$,4.4 $mgkg^{-1}$ and 3 $mgkg^{-1}$ were the mean concentration of Ni in roots , leaves and fruits, respectively. Pineapple cultivated soils showed Cd at a mean concentration of 62.33 $mgkg^{-1}$and 10 $mgkg^{-1}$ for reference soil. Mean concentration of20.5 $mgkg^{-1}$,13.8 $mgkg^{-1}$, 4 $mgkg^{-1}$ of Cd was present in roots, leaves,fruits respectively. Mean concentration of 25168 $mgkg^{-1}$of Fe was found in the cultivated soil and mean concetration of 11356 $mgkg^{-1}$ in reference soil. Average concentration of Fe in pineapple root , leaf and fruit was found to be 204 $mgkg^{-1}$,184.97 $mgkg^{-1}$, 145.6 $mgkg^{1}$respectively.

Table 3: Average concentration Pb, Ni, Cd and Fe in studied samples

Element	Average concentration cultivatedsoil ($mgkg^{-1}$)	Average concentration referencesoil ($mgkg^{-1}$)	Average concentration roots ($mgkg^{-1}$)	Average concentration leaves ($mgkg^{-1}$)	Average concentration fruits ($mgkg^{-1}$)
Pb	39.73	4	8	2	BDL
Ni	10.42	1.26	6	4.4	3
Cd	62.33	10	20.5	13.8	4
Fe	25168	11356	204	184.97	145.6

Inorganic chemical fertilisers are the sources of toxic heavy metals such as Cd, Pb and Ni in the agricultural fields[17].Coherence of phytoextraction was quantified by estimating Translocation factor and Bio concentration factor.

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Translocation factor of heavy metals

Value of TF of Pb, Ni and Cd from root to leaf was 0.25,0.733 and 0.6731, among metals TF was higher in Ni and metals in decreasing order of Ni>Cd>Pb (fig 1). Nevertheless, TF of Pb, Ni and Cd from root to fruit was 0, 0.5 and 0.1951, respectively. A TF value (>1) stipulate higher absorption of metal from soil and better suitable for phytoremediation, whereas TF value <1 indicate poor absorption and higher edibility. The TF for Pb in leaf was 0.25, while it was not traceable in fruits at detectable limit. TF for Ni in leaf and fruit was 0.733 and 0.5. Whereas Cd having the TF value 0.673 in leaf and 0.195 in pineapple fruit. From the studied heavy metals TF was found to be high for Ni and metals in decreasing order of TF was Ni>Cd>Pb in both leaf and fruit. Mean concentration of Ni in soil (49.59 $mgkg^{-1}$) in comparison with background concentration of(16.67 $mgkg^{-1}$) was found in artificially contaminated soils of Mumbai, in which vegetables such as Spinach , Fenugreek and Red Amaranth showed higher affinity towards Ni and were readily absorbed by the vegetables[18]. Similar results were spot by [19] by considering on Ni contaminated soil.

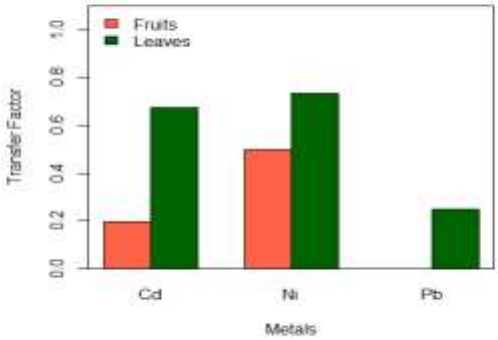

Figure 1: Transfer Factor of heavy metals in leaves and fruits of Pineapple

Bio concentration factor of heavy metals

Bio concentration of heavy metals in roots, leaves and fruits of the pineapple plant were summarized in the (table 4).BCF of Pb in root, leaf and fruit was found to be 0.2013, 0.0503 and 0, respectively. Root, leaf and fruit of pineapple plant showed BCF of 0.5758, 0.4222 and 0.2879 for Nickel. For Cd BCF was 0.3288, 0.2214 and 0.0641 in root, leaf and fruit. Order of decreasing value of BCF in root and leaf were Ni>Cd>Pb. Nickel showed high BCF in fruit than Cd. Zero value for Pb in fruit indicate that Pb is not translocate to pineapple fruit but other studies reported high amount of Pb accumulated in various plants [20]. Value of BCF>1 denotes the plant has the capacity to accumulate metal where as BCF≤ 1 indicates that the plants does not have the capacity to accumulate metals.

Table 4: Bio concentration factor of heavy metals in root, leaf and fruit

Metal	BOC in root	BOC in leaf	BOC in fruit
Pb	0.201	0.05	0
Ni	0.575	0.422	0.287
Cd	0.328	0.221	0.064

Contamination factor, Enrichment factor and Geo accumulation Index of heavy metals

The contamination factor of Pb, Ni and Cd is 9.93, 8.26 and 6.23 respectively (Fig 2).The order of contamination of heavy metals in the increasing order in pineapple cultivated soils in Ernakulam district was Cd<Ni<Pb. Contamination factor for studied heavy metals were high in the pineapple fields and was found to be >6 which suggests very high contamination (table 3). Overall toxicity status of heavy metals (Pb, Ni and Cd) contamination were higher in the coastal areas of Cochin[21]. Similar results were observed in the agricultural soils of Zhejiang Province, China with a contamination factor for Pb (9.87). Seasonal variation also occurs for heavy metal concentration and it was higher in winter as compared to summer [22]. Banana field soils of Southern India especially Kerala, Karnataka and Tamil Nadu were accommodating boatload of heavy metals by the manifold use of chemical fertilizers [23].

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Enrichment factor of heavy metals were measured by using Fe as reference element because it has no synergism or antagonism towards an examined environment. Values of EF <1.5 indicates that the heavy metals arise from natural weathering process and EF>1.5 denotes pollution or contamination of that area (Table 2). Enrichment factor for Pb, Ni and Cd in pineapple cultivated areas was 4.2, 3.7 and 2.8 respectively (fig 2). All of the value comes under moderately enrichment category. Enrichment factor was high for Pb followed by Ni and then by Cd. Pb was the most hazardous contaminant present in the pineapple cultivated area.

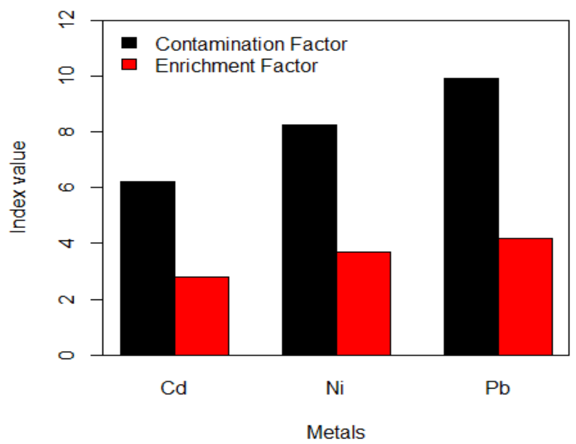

Figure 2: Contamination factor and Enrichment factor of heavy metals

Geo accumulation index (Table 2) varying from Igeo≤ 0, unpolluted or uncontaminated and Igeo>5 represents extremely contaminated area and this suggests at least a 100-fold enrichment factor above background values [15].The values of geo accumulation index obtained for different heavy metals categorizes the degree of pollution with respect to Pb (6.621) as 'extremely contaminated', Ni(5.513)and Cd (4.15)as 'heavily to extremely contaminated'. Depending on the values of geo accumulation index, it is inferred that the extent of pollution was high for Pb followed by Ni and Cd in pineapple cultivated fields of Ernakulam district. Igeo values of Cd ranges from 0.29 to 7.4 in estuarine sediments from the east coast of India including Cochin [24]. Igeo values of surface soil near Nansi Lake in China showed higher ecological risk due to Cd than other heavy metals [25].

CONCLUSION

Although farming is a gift, there is no doubt that indiscriminate farming practices can ruin the fertility and health of the soil. Among the heavy metals studied TF was higher in Ni and metals are in the decreasing order of Ni>Cd>Pb. Bio concentration factor in root and leaf was in the decreasing order of Ni>Cd>Pb. Contamination factor of heavy metals are in the increasing order Cd<Ni<Pb in pineapple cultivated soils in Ernakulam district. Enrichment factor for Pb, Ni and Cd was in the increasing order of Cd<Ni<Pb. Geo accumulation index rely upon that the extent of heavy metal pollution and was high for Pb and followed by Ni and Cd in the pineapple cultivated areas. The present study reveals substantial evidence to show that the pineapple cultivated areas in Ernakulam district is contaminated by toxic heavy metals, which can result in toxicity to humans and other animals through food chain magnification. The study also stresses the importance of scientific management of cultivation practices in this area by the authorities. The present study represents a preliminary assessment and further studies are warranted to elucidate the underlying causes regarding heavy metal contamination in pineapple cultivated area in and around Ernakulam district.

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