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Available Nutrients and Heavy Metal Status in *Typic Sulfaquents* of Kuttanad Ecosystem of Kerala

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Heavy metal accumulation in six acid sulphate soil series (Ambalapuzha, Kallara, Thakazhi, Purakkad, Thottapally and Thuravur) of Kuttanad ecosystem was studied to estimate toxicity level of heavy metals. In the present study twenty soil samples were collected from each series. Characterizations of macro and micro nutrients as well as heavy metals were done. Soils were extremely acidic with high content of organic carbon. Toxicity of Fe and Al was observed in acid sulphate soil. Available Cu was deficient in all the soil series. Presence of Pb and Cr was noticed in different series. Available Hg and Cd content were below detectable level.

(**Key words:** *Acid sulphate soil, Heavy metals, Kuttanad)*

Soil pollution is contamination of soil with toxic materials that are present at a concentration higher than the normal; it may adversely affect living organisms in the ecosystem. Soil pollution is linked with water and air pollution. Toxic chemicals from soil leach into ground water or run off from contaminated land ultimately reach lakes, streams and oceans cause water pollution. Toxic volatile compounds released from soil into the atmosphere causes air pollution. Rapid urbanization has led to high accumulation of heavy metals in soils.

With the development of urbanization heavy metal accumulation in environment is gradually increasing. Kuttanad is a region lying 0.6-2.2m below mean sea level, covering the districts Alappuzha, Pathanamthitta and Kottayam. The rivers such as Pamba, Meenachil, Achencovil and Manimala are flowing into this region. Kuttanad is popular for its extensive paddy cultivation and is known as "rice bowl" of Kerala. An estimated area of 50,000 ha of land is under rice cultivation. Among this, acid sulphate soils (*Typic Sulfaquents*) cover an area of 14,227 ha. Ambalapuzha, Kallara, Thakazhi, Purakkad, Thottapally and Thuravur were identified as acid sulphate soil series of Kuttanad (Beena, 2005). Stable metals or metalloids whose density is greater than 5 Mg m^{-3} are known as heavy metals. Mainly heavy metals include mercury, cadmium, cobalt, lead, molybdenum, nickel, copper and zinc. Heavy metals can be classified into two categories 1) Essential elements and 2) Non-essential elements. Essential elements include Fe, Zn, Mo and Ni. Trace amount of essential elements are required by living organisms to perform their life cycle. Insufficient quantity of these elements causes many problems and excess amount causes toxicity. As, Ag, Cd, Hg and Pb are known as non-essential elements. Heavy metals can cause harm to plants and animals, when their concentrations are above normal ranges. These are not destroyed or degraded and their toxic effects will be continuing for long term. Heavy metal contamination adversely affects soil ecology, agricultural production and quality of water. The heavy metals in soil can enter into higher trophic levels by biomagnifications and can harm human beings. Therefore, keeping all this in view, the present investigation was carried out to study the available macro and micronutrients as well as heavy metals distribution in soils.

MATERIALS AND METHODS

The present investigation was undertaken in six acid sulphate soil series (Ambalapuzha, Kallara, Thakazhi, Purakkad, Thottapally and Thuravur) of Kuttanad, Kerala. Twenty georeferenced soil samples were collected using GPS (Model No.VX 140, Brand-MAPMYINDIA) from each series at a depth of 20 cm. Samples were packed in air- tight pre- labeled polyethylene bags and kept for analysis. Wet analysis was carried out with proper moisture correction.

The soil samples were analyzed for texture, organic carbon, available nutrients (N, P, K, Ca, Mg, S, Fe, Al, Mn, Zn, Cu) and heavy metals (Pb, Cr, Hg, Cd). International pipette method was employed for the estimation of soil texture (Robinson, 1922). Organic carbon was estimated by Walkely and Black method (Walkely and Black, 1934), available N was estimated

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Table 1. Textural classes of soil samples collected from six acid sulphate soil series of Kuttanad

Soil series	Sand	Silt	Clay	Textural class
	(%)			
Ambalapuzha	14.43	43.88	24.60	Silty loam
Kallara	25.98	33.06	28.88	Clay loam
Thakazhi	46.1	19.1	29.11	Sandy clay loam
Purakkad	49.35	18.83	28.23	Sandy clay loam
Thottapally	54.72	41.81	14.85	Sandy loam
Thuravur	22.08	35.74	50.63	Clayey

using alkaline permanganate method (Subbiah and Asija, 1956). Available P was extracted using Bray No.1 and estimated using spectrophotometer (Bray and Kurtz, 1945). Available K, Ca and Mg were extracted by neutral normal ammonium acetate extract. K was estimated using flame photometer, while Ca and Mg were determined using Atomic Absorption Spectrophotometer (Jackson, 1958). Available S in soil was estimated turbidimetrically by $BaCl_2$ method (Williams and Steinbergs, 1959). Available Fe, Mn, Zn, Cu,Pb, Cd, Cr, Hg and Al were extracted using 0.1 M HCl and estimated using ICP- OES (Sims and Johnson, 1991).

Statistical analysis was done using Statistical Package for the Social Sciences (SPSS). Analysis of Variance (ANOVA) with Duncan's Multiple Range Test (DMRT) was used to compare the significance of different among the six series.

RESULTS AND DISCUSSIONS

Among soil physical properties, textural analysis revealed that sand, silt and clay content showed high variation among the different series (Table 1). Soils collected from Thuravur series had the highest clay content (50.63%). The highest sand content (54.72%) was found in Thottapally series and was followed by Purakkad series (49.35%). Soils from Ambalapuzha series recorded highest silt content (43.88%). The soils of Purakkad and Thakazhi series were sandy clay loam in texture.

The soils were extremely acidic with a pH ranging from 2.88 to 3.89. The extreme acidity of these soils was due to the presence of sulphuric acid. Oxidation of reduced sulphur compounds in pyritic mud releases sulphuric acid which results in a dramatic drop of pH in acid sulphate soils. The data on soil reaction and electrical conductivity of soil are presented in Table (2). In acid sulphate soils, acidity was contributed by presence of pyrite. The Ambalapuzha soil recorded pH of 3.9 and EC 0.42 dS m^{-1}, while in Purakkad soil pH was 2.9 and EC 1.02 dS m^{-1}. From this it is evident that an inverse relationship exists between pH and EC. This may be due to the proximity of Purakkad area to sea when compared to Ambalapuzha series.

Available nutrient composition of acid sulphate soils from six series is presented in Table 3. Organic carbon content in the study area ranged from 1.73 to 6.20%. Among these six soil series, Kallara series recorded the highest value (6.2%). Content of available nitrogen was low to medium range in all series. Kallara series recorded significantly highest value of available nitrogen (310.01 kg ha^{-1}). Soil samples from different series were deficient in available P. This is due to the presence of kaolinite clays along with oxides and hydroxides of Fe and Al which lead to high P fixation. Potassium content of the soil samples from different acid sulphate soil series was in medium to high range and the values ranged from 116.99 to 388.36 kg ha^{-1}. The highest value was reported in Thuravur series where the textural class was clay.

Soil samples from Thuravur series had highest calcium and magnesium contents compared to other soil series. The high calcium content in Thuravur series may be due to intrusion of saline water in this area. In *Typic sulfaquents* of Kuttanad, Ca was the dominant cation in exchange complex (Thampatti, 1997). High amount of sulphur was noticed in acid sulphate soils due to the

Table 2. Electrochemical properties of soil samples collected from six acid sulphate soil series of Kuttanad

Soil series	pH	EC (dS m^{-1})
Ambalapuzha	3.9	0.42
Kallara	3.7	0.66
Thakazhi	3.5	0.87
Purakkad	2.9	1.02
Thottapally	3.9	0.73
Thuravur	2.9	0.96
CD (0.05)	0.44	0.29

Table 3. *Available nutrient status of soil samples collected from six acid sulphate soil series of Kuttanad*

Soil series	OC (%)	N	P	K	Ca	Mg	S
		(kg ha^{-1})					
Ambalapuzha	1.73	61.15	10.12	156.91	206.04	93.60	228.95
Kallara	6.20	310.01	12.41	202.83	367.98	131.62	320.98
Thakazhi	2.95	79.31	9.25	116.99	204.04	92.79	319.55
Purakkad	3.20	299.12	13.67	252.56	287.44	104.39	356.26
Thottapally	3.48	108.08	10.07	313.48	437.45	123.53	502.62
Thuravur	2.47	263.03	11.93	388.36	584.05	141.06	550.48
CD (0.05)	0.53	57.36	3.18	60.34	86.15	2.08	140.54

Table 4. *Available micronutrient and heavy metal status of soil samples collected from six acid sulphate soil series of Kuttanad*

Soil series	Fe	Mn	Zn	Cu	Pb	Cr	Hg	Al	Cd
		(mg kg^{-1})							
Ambalapuzha	1452.82	11.86	11.09	1.33	0.22	0.67	BDL	265.35	BDL
Kallara	2965.04	15.58	8.68	0.29	0.86	1.41	BDL	549.90	BDL
Thakazhi	2036.68	11.68	13.57	2.62	1.03	0.45	BDL	422.03	BDL
Purakkad	1793.56	6.25	3.85	0.27	0.38	0.28	BDL	154.24	BDL
Thottapally	2238.34	10.92	4.24	0.24	0.50	0.62	BDL	147.79	BDL

BDL- Below Detectable Level

presence of sulphur containing minerals. Acid sulphate soils contain iron sulfide minerals (commonly pyrite), if this soils are drained they come into contact with oxygen. The pyrite in the soil reacts with the oxygen and breaks down; this process turns pyrite into sulphuric acid. In the present study, available sulphur content varied from 228.95 to 550.48 mg kg^{-1}.

Available micronutrients and heavy metal composition of acid sulphate soil from six series is presented in Table 4. High organic matter content generally increased the availability of micronutrients in acid soils (Rulkowska *et al.,* 2014). Acid sulphate soils have high content of iron. Available iron content ranged from 1452.82 to 3039.48 mg kg^{-1}. High content of iron in these series may be due to low soil pH and submerged condition. Under submerged condition, free CO_2 in water can dissolve Fe and it gets solubilised and thereby increases its availability. Iron- bearing minerals such as pyrites and jarosites cause increase in iron content. A significant positive correlation was observed between Fe and soil organic carbon. Iron content increased with increase in soil organic carbon. High amount of organic carbon in soil led to production of more amount of complexing agent which enhanced better extractability of Fe (Katyal and Sharma, 1991).

A wide fluctuation in total Fe and Mn contents is mainly due to nature of parent material, climatic condition and anthropogenic activities (Behera and Shukla, 2013). The soils contained available Mn in the range of 6.25 to 15.58 mg kg^{-1}. In case of available Mn in soil, toxicity was not reported. Continuous submergence has maintained Mn in soluble form due to soil reduction. Like Fe, availability of Mn increased during submergence, but content of Mn in soil was less compared to iron. Iron and Mn availability to plant was based on soil properties and plant type (Frageria *et al.,* 2002). In the present study, among the six acid sulphate soil series of Kuttanad, Kallara series showed highest available Mn. This may be due to high organic carbon content in these series (6.20%). Organic matter enhanced Mn availability to crop. In the present study, available Cu content ranged from 0.24 to 2.62 mg kg^{-1}. Toxicity of Fe and Al was observed in soils. In these soils, content of heavy metals were within the safe limit.

Presence of lead and chromium was noticed in these soils. The highest lead availability was reported in Thakazhi series. Available mercury content of soil samples from all the six series were below detectable level. Aluminum content was very high in acid sulphate soil. The soil pH below 4.5 enhanced the extractable and water soluble Al content of these soils (Raju, 1988). High content of aluminum in these soils may be due to hydrolysis of clay minerals under low pH condition which releases soluble Al into the soil solution.

CONCLUSION

The acid sulphate soils series were extremely acidic. Extreme acidity of soil may enhance the availability of some toxic elements including heavy metals. In this study, the metals such as cadmium and mercury were below detectable level and the content of Pb and Cr was observed in soil. The present study, we found that heavy metal accumulation was observed in all acid sulphate soil series of Kuttanad ecosystem. But the available heavy metal content is low except Fe and Al. The toxicity of Fe and Al was observed in soils and this may cause damage to plant. The content of available heavy metals was within the safe limit except Fe and Al.

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