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Impact of Land Use and Agrochemicals on Quality Potential of Wetland Soils of Odeda Farm Institute, Eweje, Ogun State, Nigeria

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Abstract: A study was conducted to examine the impact of land use and agrochemicals on wetland soil quality of Odeda Farm Institute, Eweje, Ogun State, Nigeria. The land use types studied were maize, plantain, rice, vegetable, and fallow. Five profile pits were dug, four at agrochemicals applied fields and one at fallow field as control. The results showed that soil texture was not influenced by land use and agrochemicals. The particle size distribution data showed that the soils consisted of high sand content (>600 g/kg). Soil pH, organic carbon and total nitrogen were low at agrochemicals applied fields when compared with the fallow field. The reverse is the trend for available P which is low at the fallow field due to non application of phosphate fertilizer. The heavy metals (Cd, Cu, Fe, Mn, Pb and Zn) results differed significantly ($p<0.05$) between the agrochemicals applied fields and the fallow field. Soil nutrients depletion and heavy metal accumulation were very prominent under agrochemicals applied fields. However, the impact of land use and agrochemicals which mostly accounted for major changes in the soil quality indicators can be immediate or long term, and wetland users should take into consideration long effect of current land decisions.

Keywords: Wetlands, Agrochemicals, Land Uses, Soil Quality

1. Introduction

The desire to meet up with the food demands of looming populace in the world, wetlands which occupy 6% of the world's land surface are valuable ecosystems considered to achieve the goal [1]. This is so, since wetlands are crucial to life-support functions, human health and the natural environment [2]. They also provide many important services to human society, but are at the same time ecologically sensitive [3]. In Southwest Nigeria, wetlands stands as relief for food shortage and production since it contributed about 56.3% of the food supply while upland and other domestic production contributed 33.4% and 10.3% respectively [4].

In recent decades, agricultural use of wetlands has increased significantly in many developing countries particularly in Africa [5]. This increase is driven partly by population increase, upland soil deterioration, economic and financial motivation [6], as well as increasing issue of food security in developing countries like Nigeria [7]. Production from the uplands cannot meet the increasing population food demand; thus, wetlands may be the most logical environment in which to close the gap because, physical conditions for cropping within wetland/inland valley are more favourable than uplands since there is more water in this ecosystem [8].

Land use is one of the main drivers of many processes of environmental change, as it influences basic resources within the landscape, including the soil resources. Poor soil use and management can rapidly deteriorate vast amounts of land, which frequently becomes a major threat to rural subsistence in many developing and developed countries [9]. Conversely, impact of land use changes on soil can occur so unnoticed that land managers hardly contemplate initiating ameliorative measures. Knowledge and understanding of soil properties and processes ensures remediation or reclamation of disturbed or damaged soils.

The effects of the agrochemicals can be either direct (immediate or short-term impacts) due to harm to the organisms that come in contact with the chemical, or indirect due to changes caused by the chemical to the environment, or food source of organisms [10]. The direct effects of agrochemicals can be short; obvious in the first season after application of the fertilizer or long term; if repeated additions have taken place. Indirect effects are usually long-term; take more than one season to develop, and are due to changes in pH or changes in productivity, residue inputs and soil organic matter levels [11].

There is knowledge gap on the significance of land use and agrochemicals on soil quality in the study area. However, in order to make sound decisions regarding sustainable land use systems, understanding the impact of land use and agrochemicals on soil morphological, physical and chemical characteristics are very critical. It is therefore, most important to assess the level of influence land use types and agrochemicals on wetland soil quality in the study area. This will guide and help the peasant farmers on effective ways of managing their wetlands for optimal and sustainable crop production.

2.Materials and Methods

2.1. Description of the Study Area

The study was done at the Odeda Farm Institute, Eweje, Ogun State, Nigeria located at Latitude 07°23'N and Longitude 03°51'E. The site elevation is 165m above the sea level. The rainfall pattern is bimodal: the rainy (April – November) and the dry seasons (December – March). The mean temperature of 27℃ and relative humidity is rarely below 70%. Equally, there is a short period of relative coldness and hazy weather from late December to February, known as the Harmattan season [12]. Its clay mineralogy is composed mainly of kaolinite and quartz [13].

2.2. Field Study

Five land use types namely: maize field (land use 1), plantain plantation (land use 2), rice field (land use 3), vegetables field (land use 4) and fallow field (land use 5) were identified and studied. At each of the chosen land use type, an area of one hectare (10,000 m^2) was identified with the aid of tape measurement. Bulk samples consisting of ten core samples from two depths (0 to 15 cm and 15 to 30 cm) were collected randomly for physical, chemical and biological analyses. Profile pits ($2 \times 1 \times 2$ m^3) were dug at the different land types or slopes segment encountered at each of the chosen land use type. The profile pits were also described morphologically after FAO [14], sampled and then followed by placing them in labeled bags and then transported to the laboratory for air-drying.

2.3. Laboratory Analysis

After being air dried for seven days and the samples were crushed to pass through sieved using a 2 mm and 0.5 mm screens. Soil samples were analyzed for the following parameters: Particle size analysis was by hydrometer method as described by Gee and Bauder [15]. Saturated hydraulic conductivity was determined using a constant head method, bulk density by core method [16], while soil porosity was estimated from the bulk density data at an assumed particle density 2.65 g/cm^3. Soil pH was determined electrometrically in 1:2 soil/water suspensions [17]. Total nitrogen was determined by the macro-kjeldahl digestion method [18]. Bray-1 P was determined by molybdenum blue colorimetry [19], exchangeable cations were extracted with 1 M NH_4OAC (pH 7.0), K and Na were determined using flame photometer and exchangeable Mg and Ca by atomic absorption spectrophotometer [20]. Exchangeable acidity was determined by the KCl extraction method [21] and organic carbon was after dichromate wet oxidation method of Walkey and Black as described by Nelson and Sommer [22]. The Effective Cation Exchange Capacity was expressed as the summation of exchangeable cation and exchangeable acidity [23]. Heavy metals were determined by taking subsamples of air dried sediment samples and thereafter sieve with 500 micron sieve. 100 mg of the samples were digested with a mixture of 6 ml HF, 4 ml HNO_3 and 1 ml $HClO_4$ following a method described by Bruce and Whiteside [24]. The metals were read using Atomic Absorption Spectrophotometer.

2.4. Statistical Analysis

The data obtained were subjected to Analysis of Variance (ANOVA) using GenStat 12th edition to assess the spatial variation as affected by land use types and agrochemicals, means were separated using Duncan Multiple Range Test (DMRT)at 5% level of probability and were ranked.

3. Results and Discussion

3.1. Soil Morphological Properties

The described profiles pits were located on a gentle slope that is between 2 to 4%. The properties of the pedons varied from one land use type to another in terms of some morphological properties such as colour, texture, structure, consistency, and horizon boundary (Table 1). The results show that the soils were generally deep, with no surface stones or rock outcrops. All the soils are gleyed and have a hue of 10YR and low chroma which reflects poor drainage (aquic soil moisture) or seasonal mottling. The major morphological features such as grey or low chroma (<3) colours, mottles observed in some pedons is an indication of soil wetness brought about by oxidation-reduction cycles due to ground water fluctuation. The reduced Fe present in these soils impact grayish colour on the soil matrix [25]. The soils have weak to moderate crumb subangular blocky peds, non-sticky friable loose to sticky firm hard consistence, and this is attributed to high clay and low organic matter contents. The general absence of Fe/Mn concretions within the first 50 cm is an advantage for plant roots development [26].

Table 1. *Morphological Properties of Wetland Soils at Eweje.*

Horizon Designation	Depth (cm)	Land Use Types	Slope (%)	Parent Material	Colour Moist	Dry	TC	Structure	Consistency	Boundary	Root conc.	Mottles Concretions
Land Use 1												
Ap	0-34	Maize	3	Basement	10YR2/2	10YR3/2	LS	f, cr	ns, lo, lo	sm, cl	f, fe	n
B_1	34-86			Complex	10YR5/4	10YR5/6	SL	f, sab	ss, fr, so	sm, cl	co, cm	n
B_2	86-141				10YR3/4	10YR4/4	SL	f, sab	ss, f, sh	-	f, vfe	n
Land Use 2												
Ap	0-21	Plantain	3	Basement	10YR2/2	10YR3/2	LS	f, cr	ns, fr, lo	sm, cl	f, cm	n
AB	21-38			Complex	10YR5/3	10YR6/3	SL	f, sab	s, f, h	sm, cl	vf, fe	n
B_1	38-84				10YR4/4	10YR4/4	SL	me, sab	ss, f, sh	wv, ab	-	n
B_2	84-131				10YR5/4	10YR5/6	SCL	f, sab	ss, f, sh	-	-	n
Land Use 3												
Ap	0-31	Rice	4	Basement	10YR3/2	10YR4/3	LS	f, cr	ns, lo, lo	sm, cl	f, fe	n
AB	31-69			Complex	10YR5/2	10YR6/2	SL	me, sab	ns, lo, lo	ir, cl	vf, vfe	n
Bc	69-115				7.5YR5/6	10YR7/2	SCL	me, sab	ss, fr, so	-	-	f, Fe
Land Use 4												
Ap	0-28	Vegetable	3	Basement	10YR3/1	10YR3/3	LS	f, cr	ns, lo, lo	ir, ab	f, fe	n
BA	28-70			Complex	10YR4/3	10YR5/6	SL	me, cr	ns, fr, so	wv, df	-	n
B	70-94				10YR5/1	10YR6/1	SCL	me, sab	ss, f, so	-	-	n
Land Use 5												
A	0-42	Fallow	2	Basement	10YR2/2	10YR3/4	SL	f, cr	ns, fr, lo	sm, cl	me, c	n
B_1	42-89			Complex	10YR5/3	10YR6/3	SL	f, sab	ns, lo, lo	sm, cl	f, vfe	n
B_2	89-128				10YR5/4	10YR5/6	SCL	f, sab	ss, fr, sos	-	-	n

Textural Class (TC): LS = loamy sand, SL = Sandy loam, SCL = Sandy clay loam.Structure: f = fine, me = medium, co = coarse, cr = crumb, gr = granular, sab = subangular blocky, ab = angular blocky, b = blocky. Consistency: ns = non-sticky, ss = slightly sticky, s = sticky, vs = very sticky, lo = loose, f= firm, fr = friable, vf = very firm, so = soft, h = hard, vh = very hard, sh = slightly hard. Boundary: ab = abrupt, cl = clear, di = diffuse, sm = smooth, wv = wavy, ir = irregular. Roots: vf = very fine,f = fine, me = medium, co = coarse (size), vfe = very few, fe = few, c = common, m = many (concentration). Mottle Concretions: n = none, f = few, vm = very many, Fe/Mn = Iron and Manganese.

3.2. Soil Physical Properties

The particle size distribution data showed that sand dominates at all the horizons of the profiles with >70% and this decreased with depth, while the clay contents basically increased with increasing depth across the pedons (Table 2). The increased in clay content with soil depth indicates that some clay content had migrated by lessivage to the subsurface horizon [27]. The clay distribution patterns in soils might also be attributed to eluviation, illuviation and faunal activities. The silt/clay ratios results showed that the soils were made up of young parent materials with low degree of weathering. Akinbola [26] reported that old parent materials usually have silt/clay ratios below 0.15 while silt/clay ratios above 0.15 were indicative of young parent materials. In all the pedons, the bulk density is lower than 1.65 g/cm^{3}critical value which can cause hindrances to root development, root penetration and water movement [28]. This is an indication that the soils are non-compacted. However, the saturated hydraulic conductivity (Ksat) was in conformity with the bulk density of the soils. The porosity values of the study sites were generally low being less than 50% and this could be attributed to the result of bulk density as affirmed by Aminu *et al.* [28].

Table 2. *Physical Properties of Wetland Soils at Eweje.*

Horizon Designation	Depth (cm)	Land Use Types	Slope (%)	Gravel (g/kg)	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Silt/Clay Ratio	Textural class	BD (g/cm^3)	Ksat. (cm/hr)	Porosity (%)
Land Use 1												
Ap	0-34	Maize	3	11c	832a	64a	104c	0.62a	LS	1.50a	0.93b	43.4a
B_1	34-86			41b	792ab	64a	144b	0.44ab	SL	1.54a	1.12a	41.9b
B_2	86-141			51a	772b	54b	174a	0.31b	SL	1.55a	1.09ab	41.5b
Land Use 2												
Ap	0-21	Plantain	2	20b	822a	64b	114d	0.56a	LS	1.51ab	0.83bc	43.0b
AB	21-38			09c	742bc	74ab	184b	0.40ab	SL	1.49b	0.73c	43.8ab
B_1	38-84			11c	762b	84a	154c	0.55a	SL	1.53ab	1.01b	42.3c
B_2	84-131			74a	712c	64b	224a	0.29b	SCL	1.45a	0.52a	45.3a
Land Use 3												
Ap	0-31	Rice	4	15b	822a	74a	104c	0.71a	LS	1.5a	1.71a	41.1c
AB	31-69			43a	782b	64b	154b	0.42b	SL	1.48b	0.94c	44.2b
Bt	69-115			18b	702c	64b	234a	0.37b	SCL	1.43ab	0.45b	46.1a
Land Use 4												

Horizon Designation	Depth (cm)	Land Use Types	Slope (%)	Gravel (g/kg)	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Silt/Clay Ratio	Textural class	BD (g/cm^3)	Ksat. (cm/hr)	Porosity (%)
Ap	0-28	Vegetable	3	23b	812a	84a	104c	0.81a	LS	1.54a	1.06a	41.9b
BA	28-70			31ab	802a	54b	144b	0.48b	SL	1.51ab	1.10a	43.0ab
Bt	70-94			53a	722b	64ab	214a	0.30c	SCL	1.46b	0.59b	44.9a
Land Use 5												
A	0-42	Fallow	2	08b	802a	74a	124c	0.60a	SL	1.55a	1.31b	41.5c
B_1	42-89			12ab	752ab	54ab	194b	0.28b	SL	1.48ab	0.72ab	44.2b
B_2	89-128			18a	732b	44b	224a	0.20b	SCL	1.45b	0.50a	45.3a

BD = Bulk Density; Ksat. = Saturated Hydraulic Conductivity

Means with the same letter are not significantly different from each other $p<0.05$

3.3. Soil Chemical Properties

The chemical properties data of the wetland soils show that the pH increased down the profiles. The steady rise in soil pH with increasing depth recorded is attributed to the acquisition of bases from laterally percolating drainage water (Table 3). Also the lower pH value recorded at the agrochemicals polluted pedons may be an indication of effect of land use and agrochemicals on those soils. Acidification or lowering of soil pH has negative impacts on most crop growth and occurs as a direct result of application of specific types of fertilizers [29]. Electrical conductivity (EC) was generally low and less than the critical value of 4 dSm^{-1} reported by Yoshida [30] as causing salinity. The possibility of salinity problem in the soil is therefore absent.

The organic carbon decreases with depth and this is an indication of continuous deposition of organic material and its higher content at the surface horizons in fallow pedon is an indication of poor natural drainage (aquic soil moisture regime) which may have slowed the rate of decomposition. The impact of agrochemicals is noticed by interfering with the decomposition rate of the organic materials. The organic matter content of the surface horizons in all the land use types is acceptable. The total N is low in agrochemical applied fields compared with the critical value of 0.2% recommended [31]. This compares well with the report of [25] that N is normally deficient in most wet soils for growing crops. The low levels may be associated with leaching coupled with intermittent flooding and drying which is known to favour N loss through nitrification-denitrification process [32]. However, at the surface horizon of fallow field, total N is above the critical value and this value corresponds with organic carbon content. Available P (Bray) which is the second most important nutrient limiting crop yield is generally low. Other pedons tend to have higher value than the fallow pedon. This indicates that the phosphate fertilizers applied to these fields has boost P content as against the fallow field. Phosphate are resistant to leaching and this enhances their continued accumulation in the soil. Thus, they are readily available for absorption by crops and plants grown on soils rich in the anions [33].

The exchangeable bases in all the pedons were generally low and this may be attributed to intense cultivation, leaching of nutrients and weathering consequently leading to the inherent low fertility status of the soil [34]. In ferrolysis, excessive Fe (II) in the soil solution displaces exchangeable cations from the exchange complex into the soil solution and these are eventually replaced mainly by Al from clay lattices after oxidation. This process is dependent on the volume of water passing through the soil which eventually leads to clay mineral and CEC destruction. The sandy nature of the soils coupled with heavy tropical rainfall also promotes leaching. The release of large amount of Fe^{2+} and Mn^{2+} into the soil solution during soil submergence also displaces the exchangeable cations from the soil exchange complex. The effective cation exchange capacity (ECEC) of the soils is also low to moderate, an indication that the soils at their natural pH levels remain low in CEC indicating a low capacity of the soils to retain nutrients [35]. Soils in the derived savanna are prone to frequent bush burning.

Table 3. *Chemical Properties of Wetland Soils at Eweje.*

Horizon	Depth	Land Use	pH	EC	OC	TN	Avail. P	Ex. Bases cmol/kg				Ex.Acid	CEC/Clay	ECEC	BS
Designation	(cm)	Types	(H_2O)	µS/cm	%	%	mg/kg	Na	K	Ca	Mg	cmol/kg	cmol/kg	cmol/kg	%
Land Use 1															
Ap	0-34	Maize	6.7a	10.7b	1.04a	0.10a	12.60a	0.69ab	0.22a	2.52a	1.19a	0.07b	10.10b	4.69a	98.5a
B_1	34-86		6.1b	11.0ab	0.40b	0.04b	4.11b	0.71a	0.19b	2.08b	0.69ab	0.11a	16.46a	3.77b	97.1ab
B_2	86-141		6.4ab	11.7a	0.34c	0.04b	3.89c	0.48b	0.21ab	1.44c	0.60b	0.11a	9.37c	2.82c	96.3b
Land Use 2															
Ap	0-21	Plantain	6.9a	11.3a	1.28a	0.16a	12.77a	0.72a	0.51a	2.33ab	1.97a	0.07b	9.74c	5.59a	98.8a
AB	21-38		6.3c	11.0b	0.39c	0.04b	2.65bc	0.59bc	0.35b	2.26b	1.84ab	0.07b	20.35b	5.11ab	98.6ab
B_1	38-84		6.6b	10.3bc	0.47b	0.05ab	11.09b	0.53c	0.24bc	2.72a	1.39b	0.08ab	21.53a	4.96b	98.4ab
B_2	84-131		6.9a	10.0c	0.44bc	0.04b	2.47c	0.61b	0.19c	1.25c	0.78c	0.10a	6.21d	2.93c	96.7b
Land Use 3															
Ap	0-31	Rice	6.3a	14.3a	1.25a	0.15a	12.97a	0.52ab	0.22ab	2.91a	1.62a	0.09ab	9.38b	5.35a	96.2ab
AB	31-69		5.6b	12.3b	0.93b	0.07ab	8.55b	0.48b	0.18b	2.30b	0.44c	0.13a	1.79c	3.53c	94.9b
B	69-115		6.0ab	11.0c	0.37c	0.04b	5.41c	0.57a	0.28a	1.92c	0.87b	0.08b	10.41a	3.72b	97.8a
Land Use 4															

Horizon Designation	Depth (cm)	Land Use Types	pH (H_2O)	EC µS/cm	OC %	TN %	Avail. P mg/kg	Ex. Bases cmol/kg Na	K	Ca	Mg	Ex.Acid cmol/kg	CEC/Clay cmol/kg	ECEC cmol/kg	BS %
Ap	0-28	Vegetable	6.9a	12.7a	2.48a	0.26a	18.65a	0.52b	0.32a	3.15a	1.64a	0.07b	-28.85c	5.68a	99.0a
BA	28-70		6.5b	11.0b	0.46b	0.05ab	5.80ab	0.64a	0.29ab	2.00b	0.82b	0.08ab	13.13a	3.82b	97.7ab
B	70-94		6.6ab	12.0ab	0.32c	0.04b	5.18b	0.59ab	0.25b	1.89c	0.96ab	0.11a	12.62b	3.80b	97.2b
Land Use 5															
A	0-42	Fallow	7.6a	11.0a	2.52a	0.27a	5.98a	0.62a	0.22a	2.11a	1.63a	0.11b	-33.71c	4.64a	94.6ab
B_1	42-89		7.5ab	10.0b	0.98b	0.11b	4.83ab	0.52ab	0.22a	1.75b	1.49b	0.13a	3.45a	4.10ab	93.8b
B_2	89-128		7.0b	10.3ab	0.52c	0.05c	4.68b	0.48b	0.18b	0.67c	0.58c	0.11b	0.89b	2.02b	96.0a

EC = Electrical Conductivity; OC = Organic Carbon; TN = Total Nitrogen; Avail. P = Available Phosphorus; BS = Base Saturation.
Means with the same letter are not significantly different from each other p<0.05

3.4. Soil Heavy Metals

The heavy metals like Cu, Fe, Mn, Zn, Cd and Pb were found in soil samples (Table 4). These results differed significantly ($p<0.05$) between the agrochemicals applied fields and the fallow field. The soils from the agrochemicals applied fields recorded higher contents of these heavy metals. These conditions may not be unconnected with the usage of chemical fertilizers and herbicides in these fields. The presence of these metals in the soil showed common sources of these metals which could be related to known geochemical association between the metals [36]. The increase in Cd, Pb, Cu, Fe, Zn, and Mn content of the soil can lead to increased plant uptake of metals that may be injurious to human health [37]. Use of copper oxychloride pesticide has been reported to increase Cu concentration in soil and consequently in edible crops [38]. Plants grown on soil containing high levels of Cd show visible symptoms of injury reflected in terms of chlorosis, growth inhibition, browning of root tips and death [39; 40]. Lead was also reported to exert adverse effect on morphology, growth and photosynthetic processes of plants [41].

Table 4. *Heavy Metals Concentration of Wetland Soils at Eweje.*

Horizon Designation	Depth (cm)	Land Use Types	Cd mg/kg	Cu	Fe	Mn	Pb	Zn
Land Use 1								
Ap	0-34	Maize	0.21a	1.41a	21.22a	59.71a	0.32a	17.86a
B_1	34-86		0.18ab	0.96b	20.44ab	53.08b	0.23ab	15.72ab
B_2	86-141		0.07b	0.64c	16.68b	30.37c	0.17b	14.80b
Land Use 2								
Ap	0-21	Plantain	0.21a	1.46a	23.80a	75.89a	0.31a	24.28a
AB	21-38		0.18ab	0.78c	14.13bc	66.67bc	0.21ab	13.61bc
B_1	38-84		0.14b	0.65d	13.53c	66.45c	0.18b	12.51c
B_2	84-131		0.19ab	0.89b	17.29b	69.24b	0.22ab	18.71b
Land Use 3								
Ap	0-31	Rice	0.16a	0.68a	27.06a	36.77a	0.93a	23.95a
AB	31-69		0.07ab	0.59ab	25.13b	31.76b	0.27b	20.07ab
B	69-115		0.06b	0.32b	15.94c	10.97c	0.15c	18.24b
Land Use 4								
Ap	0-28	Vegetable	0.46a	1.29a	23.04a	71.78a	0.31a	35.49a
BA	28-70		0.23ab	1.20b	13.22ab	41.90b	0.26ab	21.59b
B	70-94		0.19b	0.49c	13.07b	38.47c	0.16b	16.14c
Land Use 5								
A	0-42	Fallow	0.07a	0.52a	14.25a	26.82b	0.17a	15.55a
B_1	42-89		0.05b	0.48ab	12.92ab	27.00a	0.15b	15.44ab
B_2	89-128		0.05b	0.38b	11.75b	17.07c	0.16ab	15.00b

Means with the same letter are not significantly different from each other p<0.05.

4. Conclusions and Recommendations

The results of this study revealed that land use and agrochemicals (pesticides and fertilizers) had significant effects on the quality of the wetlands in the study area thereby making soil polluted. It was noticed that land use and agrochemicals had major effect on some chemical properties and heavy metal concentration of the soil. The impact was evident on soil pH, organic carbon, total nitrogen, available P, and ECEC. The varying concentrations of cadmium, copper, iron, manganese, lead and zinc in the soil revealed the level of pollution. Although, the present levels of some heavy metals are still within the regulatory limits; continuous accumulation is a concern to produce safety and quality. However, the study has provided relevant information that can guide decision on the use and management of wetland soils of the Institute on a sustainable basis. Hence, the impact of land use and agrochemicals which mostly accounted for major changes in the soil quality indicators can be immediate or long term, wetland users should take into consideration the potential long effect of current land decisions, and soil quality assessment test on the wetlands is needed in assessing the overall quality of soil.

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