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SOIL CHARACTERIZATION IN RELATION TO AQUACULTURE: A CASE STUDY OF IKWUANO LGA., ABIA STATE, NIGERIA

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ABSTRACT

Soils of Ikwuano Local Government Area (LGA), Abia State, Nigeria, were characterized in relation to aquaculture. The soils are generally acidic with pH ranging from 4.5 – 5.6. Soils of land units I and II have 44 – 56% and 40 – 53% clay respectively, and strongly formed aggregates at 100 – 150 cm depth. Total N and exchangeable K are medium in unit I but low in unit II. Available P is low in Unit I but medium to high in Unit II. Soils of land Units III and IV have 25% and 20 – 28% clay respectively, moderate aggregates, low total N and low exchangeable K but medium to high available P. Essentially, the soils were classified as Alfisols and Ultisols (USDA); Nitisols and Acrisols (FAO-UNESCO).

Non of the land units is highly suitable for aquaculture but units I, II and II are moderately suitable. Land unit IV is marginally suitable because of high sand contents of 70 – 80% at 100 – 150 cm depth. It is concluded that aquaculture could be integrated into the present farming system to boost overall land productivity in Ikwuano Local Government Area.

Key Words:

Soil characterization, aquaculture, Ikwuano.

INTRODUCTION

Soil is a component of land. The most important natural heritage and input available to the African Farmer is land. Soil data are necessary as a first step to land use planning. This will enhance judicious and maximum utilization of any available piece of land without jeopardizing the prospects of future generations. Presently, agricultural land use in Ikwuano Local Government Area (LGA) of Abia State, Nigeria, revolves around arable crops (cassava, and maize) and plantation crops (cocoa, kola, oil palm, raphia palm, banana and plantain). Chude (1995 a & b) reported that fisheries, as an occupation, is non-existent in Ikwuano; and that the river systems in the Local Government Area [illegible] infantile, degenerate and rudimentary. The river system therefore do not favour fish production through fish capture. He suggested fish culture on land (fish pond) as an alternative approach to fish production development in the area.

The major problems militating against agricultural development (fisheries included) in Umuahia zone has, through diagnostic surveys, been identified as poor knowledge of the soil, limited extension services and bad roads (OFAR, 1984 & 1985). An attempt to solve the problem imposed by soil factor was a reconnaissance soil survey of Imo State at a scale of 1:250,000 (FDALR, 1985). The resultant soil mapping units were characterized by Ohiri et al. (1989).

Unfortunately, the results of these studies are not informative enough about the soil resources of Ikwuano Local Government Area as it affects aquacultural development. If fishery is integrated into the farming system, labour will be more efficiently utilized at all seasons, protein requirements of the household can be supplemented from family farm, and bio-conversion of agro wastes from the farm into more useful product (fish) can be achieve.

It was therefore, the objectives of this study to characterize the soils of Ikwuano Local Government Area in relation to their suitability for aquaculture.

MATERIALS AND METHODS

2.1 STUDY AREA

Ikwuano Local Government Area is located in Southeastern Abia State between latitudes $5^0 24^1 - 5^0 30^1$ N and longitudes $7^0 32^1 - 7^0 37^1$ E in the rainforest belt. The area is about 310km^2. It is characterized by heavy precipitation of over 2,000 mm per annum with high temperature and high relative humidity respectively (Table 1). The Local Government Area is made up of four (4) autonomous Communities namely Oboro, Oloko, Ibere and Ariam.

2.2 FIELD WORK, SOIL ANALYSIS AND SOIL CLASSIFICATION

A reconnaissance survey of the area was undertaken to familiarize with the environment and to identify differences in soils, topography, vegetation and drainage. The area was delineated into 4 land units I, II, III, and IV (Figure 1) for detailed soil study.

Two pedons were located on representative sites on each land unit, giving a total of 8 pedons. The pedons were described and sampled as outlined by US Soil Conservation Service (1984) and FAO-UNESCO soil Map of the World Legend (1988). Soil samples were

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TABLE 1: MEAN MONTHLY CLIMATIC DATA FOR A 10 YEAR PERIOD 1984 – 1993.

Month	Rainfall Totals (mm)	Number of days	Temperature (0C) Soil 1500h	Air Max.	Min.	Relative Humidity (%) (0900h	150h	Wind Run (Km/day	Sunshine (hrs)	63 Year Average Rainfall (mm)	Temperature (0C) Max.	Min.	Relative Humidity (%) 0900	1500
Jan.	7.51	1		32	20.9	63	43	97.0	4.59	19.0	31	20	74	54
Feb.	14.3	2		34	22.6	67	42	110.9	5.47	40.9	33	22	75	51
Mar.	148.1	7		33	23.3	77	57	107.5	3.81	123.4	32	23	83	72
April	145.0	10		32.3	23.4	80	66	113.2	3.23	195.9	32	22	81	68
May	244.9	16		31.4	22.9	85	72	100.0	2.79	246.2	32	21	83	72
June	269.4	17		30.1	22.7	85	75	107.6	2.57	268.3	29	22	84	77
July	300.4	22		28.5	22.1	88	80	114.1	1.77	295.9	28	22	87	80
Aug.	352.0	21		28.5	22.3	88	81	121.1	1.54	282.7	29	22	87	77
Sept.	356.7	21		29.2	22.2	86	78	112.6	1.93	333.6	29	22	86	77
Oct.	260.3	16		30.0	22.2	84	74	90.7	2.32	252.9	30	22	84	75
Nov.	42.8	3		31.2	22.7	79	66	77.7	2.93	71.1	31	22	81	67
Dec.	095.6	1		31.5	22.7	68	52	77.3	4.25	14.8	32	22	76	58
Mean Annual	179.2	11		31.0	22.3	79	66.0	102.5	3.1	178.7	30.7	21.8	81.8	69.0

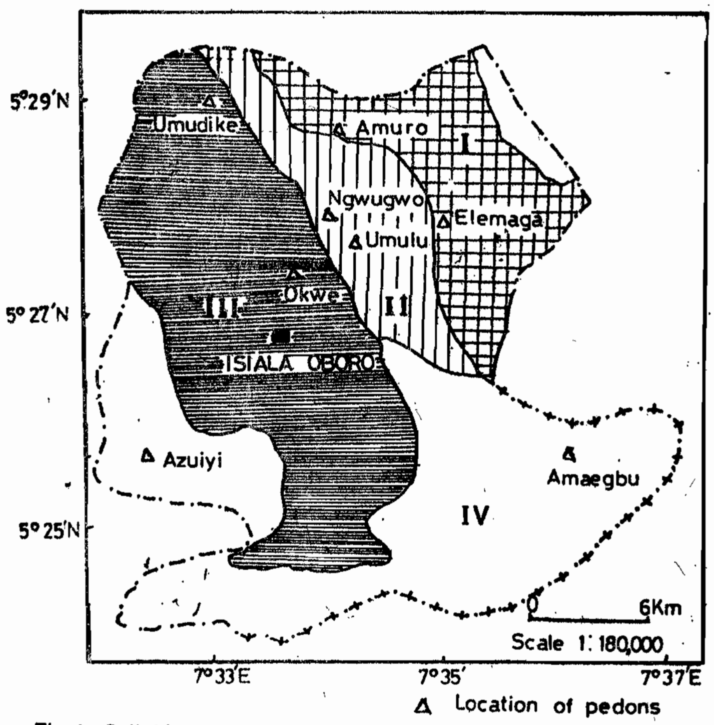

Fig. 1 Soil Map of Ikwuano L. G. A.

SYMBOL	LAND UNIT	SOIL DESCRIPTION
	I	Concave plain with fine loam to clayey soils, low in P but medium to high in K, derived from Alluvium and Shale
	II	Dissected plain with coarse loamy soils, low in N and K but medium to high in P, derived from Coastal Plain Sands.
	III	Gently undulating plain with coarse loamy soils, low in N and K but medium to high P derived from Coastal Plain Sands.
	IV	Nearly level plain with sandy to loamy soils, low in N and K but medium in P, derived from Alluvium and Coastal Plain Sands.

air-dried, crushed and sieved to pass 2mm sieve for the determination of particle size distribution, soil pH, available P, exchangeable bases and exchangeable acidity (EA). Sub-samples of the 2mm –s sieved soils were ground in a mortar and passed through 0.5mm sieve for total N and organic carbon determinations. Effective cation exchange capacity (ECEC) was obtained by summing TEB and EA. Base saturation (BS) was obtained by dividing by TEB by ECEC and multiplying the quotient by 100. All analysis followed the procedures of Soil Survey Laboratory Staff (1992). Soil classification was based on the USDA Soil Taxonomy (Soil Survey Staff, 1990) and the revised legend of the Soil Map of the World (FAO-UNESCO, 1988).

2.3 LAND SUITABILITY FOR AQUACULTURE

The land suitability classification of each land unit for aquaculture was based on the FAO (1976). The following land qualities that are critical for site selection for pond construction (Cole and Rogers, 1985) were assessed. They are topography, soil type, hydrology and soil pH. For each land quality, the least favourable rating determined the suitability class. A combination of 2 or more deficiencies could lower the suitability class of a land unit. Other land qualities like climate which affect the land units equally but not critical in fish pond construction were not assessed.

RESULTS AND DISCUSSION

3.1 SOILS OF LAND UNIT I

These soils occupy a concave surface with 0-2% slope bounded by the Rivers Inyang and Ehie on the north-east. They are shallow to deep with gravel contents ranging from 7% at Nkalunta to 60% at Itunta. The soils are imperfectly to poorly drained as indicated by motles (Pedons 1 and 2, Table 2). The soils have moderate aggregates. The soil colour ranges from light reddish brown (5 YR 4/3) to pale brown (10YR 6/3). Based on soil fertility ratings for soils of southeastern Nigeria (Enwezor et al., 1990), total N is medium (0, 15-0.18%), available P is low (<15mg/kg) and exchangeable K is medium (0.2 – 0.34 me/100g) at the epipedon (pedons 1 and 2, Tables 3). The soil pH ranges from 4.8 – 5.6 within 0.15cm depth. The soils are derived from Shale. Higher base saturation (39.1 – 48%) which is above 35% suggests that pedons 1 and 2 belong to the order Alfisols. They are classified as Typic Paleudalfs (USDA) because of dominant hue of 5 YR and chrome of mottles above 5 in some subhorizons. In the FAO-UNESCO legend they are classified as Haplic Nitisols and Gleyic Acrisols.

3.2 SOIL OF LAND UNIT II

This unit comprises of soils that occur on dissected plains rising from 61-91m above sea level. Soils on the crest and mid-slope have sandy loam top underlain by mottled whitish clay subsoil (10YR 8/2), whereas the valley bottom soils which resemble soils in unit I have clay loam or clay topsoil over clay subsoil (pedons 3 and 4, Table 2). The soils are strongly acidic, deficient in total N and exchangeable K but medium to igh in available P (Table 3). They are derived from Coastal Plain Sands. The low base saturation (<35%) in addition to ochric epipedon, Kandic horizon and an isohyperthermic temperature regime, place the soils in the order Ultisols. They are classified as Typic Kandiudults, Typic Paleudults, and Typic Kandiaquults (USDA); Haplic Acrisols and Gleyic Acrisols (FAO-UNESCO).

3.3 SOILS ON LAND UNIT III

These soils are located on gently undulating plains on a physiographic surface of 91-152m above seal leavel. The soils are deep, well –drained, with dark brown sandy loam texture over yellowish red sandy clay. They have weak to moderate aggregates (Pedons 5 and 6, Table 2). The soils are strongly acidic, and deficient in

TABLE 2: MORPHOLOGY AND PARTICLE SIZE DISTRIBUTION OF THE SOILS

LAND UNIT	HORIZON	DEPTH (cm)	COLOUR (Moist)	BOUNDARY *	STRUCTURE **	PARTICLE SIZE DISTRIBUTION Sand	Silt	Clay (%)	Texture
Element Pedon 1. 61m above sea level (asl) secondarv forest									
	Ap	0-10	5YR 4/3	c,s	2,cr	48	24	28	SCL
	Abg	10-60	5YR 5/8	c,w	2,m,sbk	48	20	32	SCL
I	Btcsg1	60-100	5YR 4/5	g	2,m,sbk	30	15	54	C
	Btcsg2	100-150	5YR 5/3	g	3,m,sbk	32	12	56	C
	BCcsg3	150-180	5YR 7/1	-	3,m,sbk	26	14	60	C
Amuro, Pedon 2, 31m asl, Secondary forest									
	Ap	0-10	10YR 6/3	c,w	2,cr	44	26	30	CL
	AB	10-60	10YR 6/2	c,w	3,c,sbk	40	28	32	CL
	Btg	40-70	5YR 7/6	c	3,c,sbk	33	25	42	C
	BCg	70-120	5YR 7/6	-	3,c,sbk	31	25	44	C
Umulu, Pedon 3, 92m asl, Secondary forest									
	Ap	0-7	7.5YR 4/2	d,s	1,c,cr	78	4	18	SL
	AB	7-20	10YR 7/3	d,s	1,c,cr	70	4	26	SCL
	Bt1	20-85	7.5YR 8/6	g,s	1,c,cr	69	3	28	SCL
II	Bt2	85-100	10YR 8/5	g,s	3,m,sbk	40	12	48	C
	BCg	100-180	5YR 8/1	-	3,m,sbk	35	12	53	C
Ngwugwo, Pedon 4, 92m asl, Secondary forest									
	Ap	0-10	10YR 4/2	d,s	1,f,cr	80	2	18	SL
	AB	10-80	10YR 8/6	g,s	2,m,sbk	69	3	28	SCL
	Bt	80-120	10YR 8/6	g,s	3,m,sbk	50	10	40	SC
	BCg	120-180	10YR 8/2	-	3,m,sbk	35	10	55	C
Okwe, Pedon 5, 92m asl, Secondary forest									
	Ap	0-10	7.5YR 4/2	c	1,c,cr	77	4	19	SL
	AB	10-40	5YR 3/4	c,s	1,c,cr	76	4	20	SL
III	Bt1	40-100	5YR 3/4	d,s	2,sbk	67	3	30	SCL
	Bt2	100-150	5YR 4/6	d,s	2,sbk	73	2	25	SCL
	BC	150-180	2.5YR 4/8	-	2,sbk	64	2	34	SC
Umudike, Pedon 6, 92m asl, Secondary forest									
	Ap	0-15	10YR 3/3	c,s	1,c,cr	75	6	19	SL
	AB	15-40	10YR 4/4	c,s	1,c,cr	70	4	26	SCL
	Bt1	40-70	5YR 3/4	g,s	2,sbk	68	3	29	SCL
	Bt2	70-150	5YR 4/6	g,s	2,sbk	73	2	25	SCL
	BC	150-180	2.5YR 4/8	-	2,sbk	61	3	36	SC
Amegbu, Pedon 7, 92m asl, Secondary forest									
	Ap	0-15	7.5YR 3/2	c,w	1,sg	88	2	10	LS
	AB	15-60	7.5YR 4/4	c,s	1,f,cr	84	2	14	LS
III	Bt1	60-100	7,5YR 5/2	d,s	1,f,cr	82	1	17	SL
	Bt2	100-150	5YR 4/6	d,2	2,m,cr	80	trace	20	SL
	BC	150-180	5YR 4/6	-	2,sbk	76	trace	24	SCL
Umudike, Pedon 6, 92m asl, Secondary forest									
	Ap	0-15	7.5YR 3/2	c,w	1,sg	86	2	12	LS
	AB	15-60	7.5YR 4/4	c,s	1,sg	85	1	14	LS
	Bt1	60-100	5YR 3/3	d,s	2,m,cr	80	2	18	SL
	Bt2	100-150	5YR 5/6	d,2	2.sbk	70	2	28	SCL
	BC	150-180	5YR 5/6	-	2,sbk	67	3	30	SCL

* c = clear, d = diffuse, g = gradual, s = smooth, w = wavy
when a dash (-) is present, the property was not recorded.

** sbk = sub-angular blocky, sg = single-grained, c = coarse, cr = crumb, f = fine, m = medium, 1 = weak, 2 = moderate, 3 = strong

TABLE 3: SOME CHEMICAL PROPERTIES OF THE SOILS

HORIZON	DEPTH (cm)	pH (H_2O)	Total N (%)	ORGANIC Carbon (%)	AVAILABLE (mg P) (mg/kg)	Ca	Mg	K	Na	EA	ECEC	BS (%)
						EXCHANGEABLE CATIONS (me/100g)						
Land Unit I, Pedon 1												
Ap	0-10	5.5	0.10	2.00	10.5	2.37	0.59	0.34	0.13	3.35	7.41	46.3
ABg	10-60	5.4	0.16	1.75	5.0	1.50	0.47	0.30	0.14	3.08	5.47	44.1
Btcsg1	60-100	5.2	0.08	0.96	4.91	1.56	0.58	0.25	0.14	2.39	5.42	46.7
Btcsg2	100-150	5.2	0.06	0.70	2.50	1.22	0.62	0.20	0.14	3.00	5.18	42.1
BCcsg3	150-180	5.2	0.04	0.40	0.50	1.10	0.50	0.26	0.14	2.50	4.48	44.2
Land Unit I, Pedon 2												
Ap	0-10	5.6	0.16	1.80	7.25	2.10	0.67	0.22	0.14	4.50	7.63	41.0
AB	10-40	4.8	0.15	1.60	6.50	1.47	0.51	0.20	0.14	3.20	5.52	42.0
Btg	40-70	4.9	0.08	0.90	2.50	1.18	0.72	0.18	0.10	3.40	5.58	39.1
Bcg	70-120	5.2	0.05	0.50	2.30	1.11	0.37	0.15	0.12	2.70	4.45	39.3
Land Unit II, Pedon 3												
Ap	0-7	4.8	0.16	1.75	28.0	1.15	0.48	0.10	3.50	3.50	5.33	34.3
AB	7-20	4.7	0.09	1.01	23.6	0.84	0.54	0.04	0.10	2.80	4.30	34.9
Bt1	20-85	4.8	0.09	1.00	18.5	0.45	0.32	0.04	0.08	2.10	2.99	29.8
Bt2	85-100	4.9	0.06	0.72	18.0	0.41	0.30	0.02	0.08	2.48	3.27	24.2
Bcg	100-180	4.6	0.04	0.46	12.0	0.32	0.19	0.03	0.06	2.00	2.60	23.1
Land Unit II, Pedon 4												
Ap	0-10	5.0	0.14	1.68	20.0	0.95	0.48	0.08	0.11	4.50	6.12	26.5
AB	10-30	4.8	0.09	0.01	18.6	0.84	0.50	0.05	0.06	2.80	4.25	34.1
Bt	30-80	4 9	0 07	0.75	18.5	0.60	0.39	0.04	0.06	2.10	3.19	34.2
Btg	80-120	4.8	0.05	0.06	13.0	0.40	0.30	0.03	0.06	2.40	3.19	24.8
BCg	120-180	4.6	0.04	0 05	10.0	0.32	0.19	0.03	0.06	2.40	3.00	20.00
Land Unit III, Pedon 5												
Ap	0-10	4 8	0 14	1.69	28.0	1.00	0.54	0.09	0.08	3.85	5.56	30.8
AB	10-40	5 0	0.09	1 05	23.0	1.00	0.42	0.04	0.08	3.70	5.24	29.4
Bt1	40-100	4.8	0.09	0.95	18.5	0.43	0.27	0.06	0.06	2.49	3.31	24.8
Bt2	100-150	4 5	0 08	0.80	18.0	0.40	0.27	0.04	0.04	0.50	3.25	23 1
BC	150-180	4.5	0 06	0 61	15.0	0.33	0.15	0.03	0.04	2.00	2.55	21.6
Land Unit III, Pedon 6												
Ap	0-15	5 1	0 13	1 54	35.0	1.00	0.61	0.13	0.08	3.5	5.32	34 2
AB	15-40	4 9	0 11	1.22	30.0	0.97	0.60	0.10	0.10	3.4	5.17	34.2
Bt1	40-70	4 9	0 09	0 98	20.0	0.70	0.40	0.09	0.05	2.6	3.84	32.3
Bt2	70-150	4 8	0 06	0.70	13 0	0.57	0.50	0.08	0.06	2.2	3.41	33.1
BC	150-180	5 0	0 05	0.56	16.0	0.40	0.35	0.09	0.04	2.2	3.08	28.6
Land Unit IV, Pedon 7												
Ap	0-15	4 7	0 09	0 95	23.0	1.2	0.54	0.06	0.08	4.73	6.61	28 4
AB	15 40	4 8	0 72	0.06	17 0	0.30	0.19	0.06	0.05	4.19	4.79	12 5
Bt1	40 70	4 8	0 49	0.04	15.0	0.21	0.15	0.04	0.05	3.86	4 31	10 4
Bt2	70 150	4 6	0 23	0.02	13.0	0.13	0.18	0.03	0.03	3.28	3 65	10 1
BC	150-180	4 5	0 20	0 02	13.0	0.21	0.18	0.03	0.02	3.00	3.44	12 8
Land Unit IV Pedon 8												
Ap	0-15	4 9	0 08	0.90	15.0	1 16	0.50	0.06	0.08	4.52	6 76	33 1
AB	15-40	4 8	0 70	0.06	14.0	0.28	0.21	0.06	0.08	4 00	4 63	13 6
Bt1	40-70	4.5	0 32	0.03	10.5	0.24	0.12	0.04	0 05	3 56	4 01	11 2
Bt2	70-150	4 6	0 24	0.02	8.5	0.17	0 14	0.02	0.03	3 38	3 74	9.63
BC	150-180	4.6	0.22	0.02	66.0	0.20	0 10	0.02	0 03	3 00	3 35	10 4

EA = Exchangeable acidity

ECEC Effective cation exchange capacity

BS = Base saturation

total N and exchangeable K but medium to high in available P (Pedons 5 and 6, Table 3). The soils are developed from Coastal Plain Sands. They are classified as Typic Kandiudults and Typic Paleudults (USDA); Haplic Acrisols (FAO-UNESCO).

3,4 SOILS ON LAND UNIT IV

Land unit IV occupies nearly level plains with 0-2% slope. This unit is an aggradation zone for sandy depsoits washed from the upper land units by the rivers Anya, Ehie and Qua Iboe. This unit has the highest amount of sand (70-80%) within fish pond depth of 100 – 150cm depth (Pedons 7 and 8, Table 2). Soils of land unit IV suffer multinutrient deficiencies as regards N, P and K status (Pedons 7 and 8, Table 3). They are derived from Coastal Plain Sands and alluvial Sand. The soils have sandy particle size class on top of kandic horizon that is 50-60 below surface, and are classified as Arenic Kandiudults and Arenic Paleudults (USDA); Haplic Acrosle (FAO-UNESCO).

The process of nitidization resulting probably, from pressure faces on soil matrix due to the combination of translocated clay; micro-swelling and shrinkage, gave rise to strong sub-angular blocky structures observed in Pedons 1,2,3 and 4 (Table 2). Homogenization arising from biological pedoturbation by faunal organisms observed by Dijkerman (189) in Nitisiols, could cause the crumby and modrate sub-angular blocky structures as well as diffused soil boundaries observed in Pedons 5, 6, 7 and 8 (Table 2).

3.5 AQUACULTURAL POTENTIALS

Fish culture on land (fish pond) as opposed to fish culture in water (fish pen/fish cage) demands a high degree of soil impermeability. At a Pedon depth of 100 – 150 cm required for fish pond construction, textural classes varied from sandy clay to clay in land units I and II (Pedons 1, 2, 3, and 4), and from sandy clay loam in land Unit III (Pedons 5 and 6) to sandy loam or sandy clay loam in land unit IV (Pedons 7 and 8). At the soil depth under reference, land units I and II have strongly formed aggregates when compared to moderately formed aggregates in land units III and IV. All these suggest the predominance of micro porosity in land units I and II. The implication is that high degree of water

TABLE 4: LAND SUITABILITY CLASSIFICATION FOR AQUACULTURE

LAND UNITS	LAND QUALITIES				
	TOPOGRAPHY	SOIL TYPE	HYDEOLOGY	SOIL pH (H_2O)	OVERALL SUITABILITY
I	SI	SI	SI	S2	S2
II	S2	S2	S2	S2	S2
III	S2	S2	S2	S2	S2
IV	S2	S3	S3	S2	S3

SI = Highly Suitable

S2 = Moderately suitable

S3 = Marginally Suitable.

impermeability is expected within the fish pond depth in units I and II, conversely, with sandy loam to sandy clay loam, the subsoil (land unit IV) will require a clay core to prevent leakage and seepage losses underneath. The construction of a clay core will increase the construction cost of establishing fish ponds in land unit IV.

Apart from the physical considerations, land unit I is naturally the most fertile (Table 3). The fertile top soil removed during pond construction could be used to surface the ponds later as recommended by Cole and Rogers (1985). This will reduce the amount of external inputs in terms of lime and organic materials required to enhance blooming of microbial species/plankton for healthy growth of fish. A rating of the suitability of the land units for aquaculture (Table 4) shows that none of the land units is highly suitable. However, land units I, II, and III are moderately suitable while unit IV is Marginally suitable because of its high sand content and excessive drainage.

All these suggest the need to exploit the fishery potentials of the soils by integrating aquaculture into the agricultural land use of Ikwuano Local Government Area.

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