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IMPACT OF CONTINUOUS CULTIVATION ON SOIL PROPERTIES OF IMO STATE SOUTHEASTERN NIGERIA

C.I. Ernest[1] and C.N. Mbah[2]

[1]**Department of Soil Science and Technology, Federal University of Technology,** *PMB 1526 Owerri, Nigeria*
[2]**Department of Soil Science and Land Resource Management, Ebonyi State University,** *Ebonyi State, Nigeria*
For correspondence: ernest.dozie@yahoo.com

The study was centred on the impact of continuous cultivation on soil properties of Imo state Southeastern Nigeria. Field study was carried out in six Local Government Areas of Imo State which include Owerri West, Ideato North, Ikeduru, Ngor Okpala, Mbaitoli, Owerri Municipal. 0-15 cm and 15-30 cm soil samples were collected from a seven year continuous cultivated plots. Soil samples were also collected in fallow plots as a tool for comparison. Soil samples were air dried and sieved for standard laboratory analysis. Data obtained were subjected to statistical analysis. Results show nutrient depletion in the continuous cultivated plots compared to the fallow plot. Mean pH values recorded in the continuous cultivated plots was 5.27 compared to 6.22 recorded in the fallow plots. High total exchangeable acidity was recorded in the continuous plots (2.06 cmol/kg) compared to fallow plots (0.80 cmolkg). The fallow plots recorded higher mean organic matter content (3.66 %), total nitrogen (0.14 %) total exchangeable bases (3.43 com/kg), effective cation exchange capacity (4.23), percentage base saturation (81.1 %) and available phosphorus (19.69 ppm) compared to the continuous cultivated plots having mean organic matter content (0.72 %), total nitrogen (0.07 %) total exchangeable bases (0.84 com/kg), effective cation exchange capacity (2.90 cmol/kg), percentage base saturation (28.7 %) and available phosphorus (4.58 ppm). Deforestation, intensive cultivation and erosion were observed to have aided the decline of nutrient levels in the continuous cultivated plots. Application of organic manure, crop rotation and incorporation of crop residue would boost the fertility status of these soils.

Keywords: *Continuous cultivated plots, fallow plots, soil properties, Southeastern Nigeria.*

1. Introduction

Nigeria, with an area of 923,769 square kilometres is made up of 909,890 square kilometres of land area and 13,879 square kilometres of water area, having about 790,000 square kilometres of arable land, of which 320,000 square kilometres are cultivated. Over 90 % of agricultural production is rain-fed having Smallholders, mostly subsistence producers accounting for 80 % of all farm holdings. Although the aggregate production from these lands has sustained the population and the economy in the time past, the country now faces a looming food security crisis with increase in population, industrialization and land degradation which has made continuous cultivation a common practice.

Continuous cultivation and subsistence level of Agriculture are mostly practiced in Southeastern Nigeria as the region suffers from population hike and land degradation caused by erosion and oil exploration, thereby compelling farmers to engage in same plot exploitation to increase food production and achieve food security. Continuous cultivation could be in form of intercropping or monocropping, whichever is the form; crops are grown year in year out on the same plot [1].

Over exploitation of natural resources results in total loss of soil health [2], it has been reported that Man-made agricultural practices such as the continuous cultivation of crops on the same soil have depleted the soil of essential soil nutrients that help in the sustenance of the crop. Although inorganic fertilizers are now being used on a very large scale to enhance soil fertility, the natural qualities of the native soil are no longer evident.

Land use changes, especially cultivation of natural lands in tropical areas have led to negative effects on soil organic matter components [3] and can rapidly diminish soil quality and lead to severe land degradation because the soil is exposed for long and unprotected from harsh climatic conditions.

With continuous cultivation, physical properties and productivity of soils commonly decline due to decrease in organic matter content [4] and soil pH. Intensive cropping has also been recorded to lead to disaggregation in surface soil due to decrease in organic matter [5].

Finck [6] noted that the reduced yields in variable lands in the tropics, which become apparent, even after a year or two of cultivation is caused by a lowering of soil fertility and thus poses many constraints on intensive food crop production in tropical Africa. Lal [7] added that if adequate care is not taken, tropical soil will be subjected to degradation and the natural purpose the fertile lands suppose to supply will be defeated. The study aims at determining the impact of continuous cultivation on soils properties of Imo State, Southeastern Nigeria.

2. Materials and Methods

Imo state lies between latitude 5°10′N and 5°57′N and longitude 6 °35′E and 7°28′E with an altitude of 91 m above sea level. The annual mean temperature and rainfall ranges from 27-28 °C and 2000-3000 mm respectively. The humidity is high throughout the year averaging 85 % [8] while Obihara [9] classified the soils of the zone as acid sands. Soil samples were collected from a seven year continuous cultivated plots at six Local Government Areas of Imo state viz: Ngor Okpala, Ideato North, Owerri West, Mbaitoli, Owerri Municipal and Ikeduru. Soil samples were also collected at a seven year fallow plot in the study areas to serve as an index for comparison. Crops found in the continuous cultivated plots include cassava and fluted pumpkin, few weeds and grasses were also observed, while the fallow plots comprised of thick vegetation made up of trees and shrubs. Top soil samples were collected at 0-15 cm and 15-30 cm depth respectively using a soil auger. The soil samples were air-dried for four days sieved with 2 mm sieve and were analysed for pH (1: 2.5 soil water and 1:2.5 soil 0.1N KCl) using pH meter [10]. Particle size distribution was determined by hydrometer method [11]. Bulk Density was measured using core method [12]. Organic carbon was determined using wet oxidation method [13, 14]. Available phosphorus was determined using Bray II solution method [15]. Exchangeable bases (magnesium, calcium, sodium and potassium). Exchangeable Na and K were extracted using 1*N* NH_4OAc using flame photometer [16], while Ca and Mg were determined using ethelene diamine tetracetic acid (EDTA) [17]. Total nitrogen was determined by Kjehdahl digestion method [16, 18]. Exchangeable acidity was determined titrimetrically [19]. Effective cation exchange capacity (ECEC) was calculated from the summation of all exchangeable bases and exchangeable acidity [20]. Percentage base saturation (% BS) was determined by computation. Data collected from the study site were subjected to summary statistics such as Mean. Also, Coefficient of variation (CV) was used to estimate the degree of variability existing among soil properties in the study site. Coefficient of variation is ranked as follows; low variation ≤ 15 %, moderate variation 15 %≤ 35 % and high variability 35 % [21].

Table 1

Coordinates of study areas

Location	Co-ordinates		Elevation above sea level, m
	Latitude	Longitude	
Owerri West	5°25′N	6°58′E	61
Ideato North	5°50′N	7°4′E	152
Ikeduru	5°34′N	7°11′E	144
Ngor Okpala	5°02′N	7°10′E	71
Mbaitoli	5°35′N	7°02′E	143
Owerri Municipal	5°25′N	7°02′E	159

3. Results and Discussion

The results of the particle size distribution (tables 2 and 3) of the soils studied showed similarity in their parent materials as the soils were predominantly sandy. The continuous cultivated plots (table 2) recorded mean sand content of 846.3 g/kg, clay content of 105.3 g/kg and silt content of 48.5 g/kg while the fallow plot (table 3) recorded mean sand content of 813.2 g/kg, clay content of 138.5 g/kg and silt content of 48.5 g/kg. The lower clay content recorded in the continuous cultivated plots indicates the removal of clay by erosion and its susceptibility to land degradation as a result of land exposure to harsh climatic conditions. The mean bulk density value recorded in the continuous cultivated plots is 1.34 g/cm^3 compared to the fallow plot recording 0.49 g/cm^3.

Table 2

Selected physical properties of continuous cultivated soils

Location	Depth, cm	Particle Contents, g/kg			Textural class	B.D, g/cm^3	Porosity, %
		sand	*silt*	*clay*			
Owerri West	0-15 15-30	885 804	47.3 48.4	67.7 147.6	SL SL	1.34 1.35	49.5 49.1
Ideato North	0-15 15-30	863 882	38.9 28.5	98.1 89.5	SL SL	1.34 1.33	49.5 50.0
Ikeduru	0-15 15-30	874 823	58.4 48.9	67.6 128.1	SL SL	1.35 1.36	49.1 48.7
Ngor Okpala	0-15 15-30	861 872	52.4 54.4	86.6 73.6	SL SL	1.33 1.34	50.0 49.5
Mbaitoli	0-15 15-30	763 818	80.4 54.4	156.6 127.6	SL SL	1.33 1.34	50.0 49.5
Owerri Municipal	0-15 15-30	870 840	30.0 40.0	100.0 120.0	SL SL	1.30 1.37	51.0 50.6
Mean	-	846.3	48.5	105.3	SL	1.34	49.7
CV, %	-	6.21	26.43	19.72	-	3.68	1.98

B.D = Bulk density; Textural class: SL=Sandy loam

Table 3

Selected physical properties of forest soils

Location	Depth, cm	Particle Contents, g/kg			Textural class	B.D., g/cm^3	Porosity, %
		sand	*silt*	*clay*			
Owerri West	0-15 15-30	805.5 843.1	59.2 41.4	135.3 115.5	LS LS	0.34 0.55	87.2 79.3
Ideato North	0-15 15-30	805.0 804.4	60.1 40.8	134.9 154.8	LS SL	0.31 0.61	88.4 77.0
Ikeduru	0-15 15-30	823.7 784.5	40.3 50.0	136.0 165.5	LS SL	0.39 0.77	85.3 71.0
Ngor Okpala	0-15 15-30	831.5 794.6	46.4 51.2	122.1 154.2	LS SL	0.36 0.49	88.5 81.6
Mbaitoli	0-15 15-30	804.2 803.7	40.0 44.3	157.8 152.0	SL SL	0.49 0.61	81.6 77.0
Owerri Municipal	0-15 15-30	825.2 833.0	48.3 59.4	126.5 107.6	LS LS	0.36 0.57	86.5 78.5
Mean	-	813.2	48.5	138.5	LS	0.49	81.8
CV, %	-	4.54	7.71	5.53	-	11.20	6.28

B.D = Bulk density; Textural class: SL=Sandy loam, LS= Loamy Sand

The high bulk density recorded in the continuous cultivated plots is as a result of lower organic matter in the soils and constant rearrangement of the soil structure due to continuous tillage while in the fallow plot, the vegetative cover alongside litter fall led to the increase in organic matter, increase in the soil's specific surface area and decrease in bulk density. Mbagwu [22] noted that the implication of higher bulk density in cultivated landuse is the reduction in total porosity causing poor aeration which physical restricts root growth. This however corresponds to the results of the soils studied as continuous cultivated plot recorded mean porosity of 49.7 % while the fallow plots recorded mean porosity of 81.8 %. The results showed decline in soil pH values in the continuous cultivated plots (table 4) (5.27) compared to high pH recorded in the forest plot (table 5) (6.22), although having medium coefficient of variation (table 6). This pH levels relates to the total acidity levels observed in the study areas as continuous cultivated soils recorded mean values of 2.06cmol/kg above the critical value of 2.0cmol/kg, while the forest recorded 0.8cmol/kg. This decline of soil pH in the cultivated plots is as a result of the inherent acidic parent material of the soils, rapid oxidation of organic matter through conventional tillage employed by farmers, leaching of basic cations, and the removal of these bases through crop harvests. Application of inorganic fertilizers in the cultivated plot may also aid in raising the acidity level of the soils.

Table 4

Selected chemical properties of continuous cultivated soils

Depth cm	pH H_2O	pH KCl	O.M. %	Al^{3+}	H^+	TEA	Ca^{++}	Mg^{++}	K^+	Na^+	TEB	ECEC	BS	T.N.	Av.P ppm
				cmol/kg									%		
Owerri West															
0-15	5.44	4.68	0.90	1.55	0.50	2.05	0.20	0.08	0.03	0.39	0.70	2.75	25.5	0.08	5.60
15-30	5.88	4.25	0.90	1.57	0.45	2.02	0.40	0.06	0.02	0.33	0.81	2.83	28.6	0.06	5.98
Ideato North															
0-15	5.05	4.03	0.57	1.59	0.47	2.06	0.49	0.09	0.04	0.47	1.09	3.15	34.6	0.07	5.98
15-30	4.89	4.23	0.59	1.56	0.46	2.02	0.40	0.07	0.05	0.50	1.02	3.04	33.5	0.05	6.21
Ikeduru															
0-15	5.04	4.26	0.67	1.53	0.49	2.02	0.23	0.08	0.05	0.35	0.71	2.73	26.0	0.04	5.59
15-30	5.40	3.98	0.53	1.58	0.45	2.03	0.20	0.09	0.08	0.20	0.57	2.60	21.9	0.06	5.75
Ngor Okpala															
0-15	5.23	4.11	0.69	1.52	0.47	2.04	0.38	0.06	0.08	0.22	0.74	2.78	26.6	0.06	5.03
15-30	5.18	4.28	0.52	1.55	0.49	2.04	0.33	0.04	0.07	0.28	0.72	2.76	26.1	0.07	5.18
Mbaitoli															
0-15	4.82	4.20	0.78	1.60	0.53	2.13	0.45	0.05	0.02	0.40	0.92	3.05	30.2	0.08	4.75
15-30	4.90	3.71	0.71	1.58	0.49	2.07	0.41	0.07	0.04	0.36	0.88	2.95	29.8	0.06	5.21
Owerri Municipal															
0-15	5.83	4.08	0.88	1.63	0.54	2.17	0.48	0.09	0.08	0.37	1.02	3.19	32.0	0.09	5.33
15-30	5.60	4.04	0.86	1.60	0.51	2.11	0.43	0.06	0.07	0.34	0.90	3.01	30.0	0.07	5.54
Mean	5.27	4.15	0.72	1.57	0.49	2.06	0.37	0.07	0.05	0.35	0.84	2.90	28.7	0.07	5.51
CV %	4.30	3.10	2.45	2.21	1.76	1.50	4.69	1.64	9.70	13.56	19.23	11.09	15.54	3.12	4.58

OM = Organic matter, Al = Aluminum, Ca = Calcium, Mg = Magnesium, K = Potassium, Na = Sodium, TEA = Total exchangeable acidity, T.N = Total nitrogen, TEB = Total exchangeable bases, ECEC = Effective cation exchange capacity, BS = Base saturation, Av. P = Available phosphorus

Table 5

Selected chemical properties of forest soils

Depth cm	*pH H_2O*	*pH KCl*	*O.M. %*	*Al^{3+}*	*H^+*	*TEA*	*Ca^{++}*	*Mg^{++}*	*K^+*	*Na^+*	*TEB*	*ECEC*	*BS*	*T.N.*	*Av.P ppm*
				cmol/kg									*%*		
Owerri West															
0-15	*6.12*	*5.98*	*3.90*	*0.4*	*0.3*	*0.7*	*2.8*	*1.2*	*0.22*	*0.11*	*4.33*	*4.93*	*87.8*	*0.14*	*19.43*
15-30	*6.03*	*5.04*	*3.77*	*0.7*	*0.4*	*1.1*	*2.4*	*1.2*	*0.22*	*0.07*	*3.89*	*4.99*	*77.9*	*0.13*	*17.25*
Ideato North															
0-15	*6.24*	*6.00*	*3.55*	*0.7*	*0.3*	*1.0*	*1.6*	*0.8*	*0.17*	*0.07*	*2.64*	*3.64*	*72.5*	*0.16*	*21.50*
15-30	*6.31*	*6.08*	*3.49*	*0.2*	*0.1*	*0.3*	*1.2*	*0.8*	*0.27*	*0.06*	*2.33*	*2.63*	*88.5*	*0.12*	*18.7*
Ikeduru															
0-15	*6.18*	*5.75*	*3.78*	*0.3*	*0.2*	*0.5*	*2.0*	*1.2*	*0.12*	*0.31*	*3.63*	*4.13*	*87.8*	*0.13*	*22.11*
15-30	*6.11*	*5.50*	*3.72*	*0.8*	*0.4*	*1.2*	*1.6*	*0.8*	*0.27*	*0.13*	*2.80*	*4.00*	*70.0*	*0.11*	*19.63*
Ngor Okpala															
0-15	*6.35*	*6.17*	*3.61*	*0.7*	*0.2*	*0.9*	*2.4*	*1.2*	*0.11*	*0.15*	*3.86*	*4.76*	*81.0*	*0.14*	*18.50*
15-30	*6.41*	*5.76*	*3.45*	*0.5*	*0.2*	*0.7*	*2.8*	*2.0*	*0.12*	*0.11*	*5.03*	*5.73*	*87.0*	*0.10*	*17.98*
Mbaitoli															
0-15	*6.15*	*5.81*	*3.81*	*0.5*	*0.3*	*0.8*	*1.6*	*0.8*	*0.23*	*0.08*	*2.71*	*3.51*	*77.2*	*0.17*	*20.44*
15-30	*6.21*	*5.96*	*3.73*	*0.5*	*0.2*	*0.7*	*1.6*	*1.2*	*0.26*	*0.13*	*3.19*	*3.89*	*82.0*	*0.16*	*19.16*
Owerri Municipal															
0-15	*6.22*	*5.89*	*3.65*	*0.7*	*0.1*	*0.8*	*1.6*	*0.8*	*0.21*	*0.06*	*2.67*	*3.47*	*76.9*	*0.15*	*22.00*
15-30	*6.31*	*6.04*	*3.40*	*0.6*	*0.2*	*0.8*	*2.8*	*1.6*	*0.34*	*0.11*	*4.85*	*5.65*	*85.8*	*0.12*	*19.47*
Mean	*6.22*	*5.83*	*3.66*	*0.6*	*0.2*	*0.8*	*2.0*	*1.1*	*0.21*	*0.12*	*3.43*	*4.23*	*81.1*	*0.14*	*19.69*
CV %	*1.03*	*4.67*	*5.55*	*12.43*	*7.46*	*3.21*	*16.67*	*34.23*	*49.63*	*78.05*	*27.40*	*56.76*	*37.07*	*13.43*	*39.75*

OM = Organic matter, Al = Aluminum, Ca = Calcium, Mg = Magnesium, K = Potassium, Na = Sodium, TEA = Total exchangeable acidity, T.N = Total nitrogen, TEB = Total exchangeable bases, ECEC = Effective cation exchange capacity, BS = Base saturation, Av. P = Available phosphorus

High coefficient of variation was observed in the organic matter, total nitrogen and available phosphorus content between the fallow and continuous cultivated plots. High values recorded in the fallow plot are due to dense vegetative cover, restricted leaching, high litter fall and its decomposition. The continuous cultivated plots recorded depletion in organic matter, total nitrogen and available phosphorus which are attributed to land exposure, leaching, intensive cultivation and quick oxidation of organic matter. Failure to incorporate crop residues in cultivated lands also led to the depletion of these properties. High total exchangeable bases were observed in the forest plots (0.84 cmol/kg) compared to the continuous cultivated plots (3.43cmol/kg). The low contents of basic cations observed in the continuous cultivated plots may be due to intense leaching and weathering, hence low inherent fertility status with regards to major nutrients.

The Effective cation exchange capacity of all soils studied were low, though the forest plots recorded higher mean ECEC of 4.43cmolkg compared to the continuous cultivated plots of 2.90cmol/kg, in line with values reported for Nigerian soils. High precipitation, nature of the parent material, low buffering capacity and removal by erosion explains the low ECEC. The presence of low activity clays could also be attributed to the low ECEC recorded. Forest-plots studied recorded mean percentage base saturation of 81.1 % while the continuous cultivated plots recorded a mean percentage base saturation of 28.7 %. Landon [23] noted that percentage base saturation of 50 % is the separating index between fertile and less fertile soils. Studies have shown that percentage base saturation is 100 % at pH 7.0-7.2. However, Astera [24] noted that the strongest, healthiest and nutritious crops are grown in soils where percentage base saturation is above 90 % which are strongly affected by soil pH and texture.

Table 6
Variability between mean properties of forest and cultivated soils

Soil property	Parameters of soil properties		CV Ranking
	continuous cultivated soils	forest soils	
Sand (%)	846.3	813.2	14.61
Silt (%)	48.5	48.5	0
Clay (%)	105.3	138.5	15.43
Bulk Density (g/cm^3)	1.34	0.49	39.85
Porosity (%)	49.7	81.8	43.68
pH (H_2O)	5.27	6.22	19.21
O.M. (%)	0.72	3.66	79.54
TEA (*cmol/kg)*	2.06	0.8	64.35
TEB (*cmol/kg)*	0.84	3.43	87.24
ECCE (*cmol/kg)*	2.90	4.23	56.89
BS (%)	28.7	81.1	125.0

4. Conclusion

The study highlighted the damages caused by the continuous cultivation of the same plot over time on soil properties as nutrients are lost due to its susceptibility to erosion and leaching. Soils kept under fallow are more fertile because of the high accumulation of litter fall and decomposition to form organic manure. High population density in Southeastern Nigeria may not give room for bush fallowing and shifting cultivation practices. Therefore, the use of organic manure and practices such as crop rotation should be adopted. Crop debris after harvest should be incorporated into the soil which acts as mulch materials and reduces the rate of nutrient loss.

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ВЛИЯНИЕ ПРОДОЛЖИТЕЛЬНОГО ВОЗДЕЛЫВАНИЯ НА СВОЙСТВА ПОЧВ В ШТАТЕ ИМО ЮГО-ВОСТОЧНОЙ НИГЕРИИ

C.I. Ernest[1], C.N. Mbah[2]

[1]**Department of Soil Science and Technology, Federal University of Technology,** *PMB 1526 Owerri, Nigeria*
[2]**Department of Soil Science and Land Resource Management, Ebonyi State University,** *Ebonyi State, Nigeria*
Для контакта: ernest.dozie@yahoo.com

Исследования были направлены на изучение воздействия постоянного возделывания на свойства почв в штате Имо в Юговосточной Нигерии. Полевые исследования были проведены на шести участках местного самоуправления в штате ИМО: Owerri West, Ideato North, Ikeduru, Ngor Okpala, Mbaitoli, Owerri Municipal. Пробы почвы отбирали в слоях 0-15 и 15-30 см на участках семилетней пашни. В то же время, для сравнения, пробы отбирали на целинных участках. Пробы почвы довели до воздушно-сухого состояния и просеяли для стандартных анализов. Результаты показали уменьшение содержания питательных веществ на постоянно обрабатываемых почвах по

сравнению с целинными участками. Среднее значение pH, определенное на постоянно обрабатываемых почвах равнялось 5,27, по сравнению с 6,22 на целинных участках. На обрабатываемых участках была определена высокая обменная кислотность (2.06 cmol/kg) по сравнению с целиной (0.80 cmolkg).
На целинных участках определили более высокое содержание органических веществ (3.66 %), общего азота (0.14 %), сумму обменных оснований (3.43 com/kg), емкость обмена катионов (4.23), насыщенность основаниями (81.1 %) и содержание доступного фосфора (19.69 ppm) по сравнению с обрабатываемыми почвами, имеющими такие средние значения: содержание органических веществ (0.72 %), общий азот (0.07 %) сумма обменных оснований (0.84 com/kg), емкость обмена катионов (2.90 cmol/kg), насыщенность основаниями (28.7 %) и доступный фосфор (4.58 ppm).
Снижению уровня питательного режима обрабатываемых почв способствуют уничтожение лесов, интенсивная распашка и эрозия. Применение органических удобрений, севообороты и запахивание растительных остатков будут повышать состояние плодородия этих почв.

***Ключевые слова**: постоянно обрабатываемые участки, целинные участки, свойства почвы, Юго-Восточная Нигерия.*

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СЕЗОННАЯ ДИНАМИКА ЭКОМОРФИЧЕСКОГО СТРОЕНИЯ ЧЕРНОЗЕМА

Г.А. Задорожная

Днепропетровский национальный университет имени Олеся Гончара,
Днепропетровск, Украина,
E-mail: zadorojhnayagalina@gmail.com)

Исследована вариабельность твердости чернозема обыкновенного трижды в течение одного года. С помощью инструментов описательной статистики изучены изменения средних значений твердости почвы и коэффициента вариации данных послойно каждые 5 см на глубину 50 см. Путем геостатистического анализа произведено двухмерное картографирование строения почвы и установлена степень пространственной зависимости данных. Описаны изменения строения почвенных экоморф в течение вегетационного сезона.

***Ключевые слова**: твердость почвы, чернозем, экоморфы*, пространственная вариабельность.

1. Введение

Концепция почвенных экоморф базируется на идеях русского генетического почвоведения В.В. Докучаева. Они выражаются в том, что почвы должны диагностироваться на основании тех признаков и свойств, которые отражают их генезис. Почвенные экоморфы обнаружены путем изучения неоднородности почв по признаку твердости. Это элементы неоднородности, которые представляет собой связанные области внутри почвенного пространства, ограниченные со всех сторон субстантивной границей. В трехмерном изображении они представляют собой внегоризонтные морфологические элементы строения почвы, не описанные ни в одной из классификаций морфологических элементов почвы [1, 2]. На основе обнаруженной связи между строением почв и особенностями организации растительного покрова установлено, что генератором этих взаимодействий является растительный покров, который оказывает упорядочивающее воздействие на почвенное тело. Почва, как биокосная система, приспосабливается к условиям своего существования в системе почвообразовательных факторов путем развития временной и пространственной гетерогенизации, формированием анизотропного строения со специфическим горизонтальным и вертикальным профилями [3, 4]. Структурированность почвенного тела создает разнообразие экологической ниши растительного сообщества, в рамках которой протекают динамические перестройки.

Установлено, что устойчивыми являются мера вариации свойства – твердость и общие закономерности ее пространственного поведения, но не топография размещения элементов неоднородности. В разные годы исследования конфигурация элементов неоднородности в большей или меньшей степени меняется [1, 2]. Характер изменений