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CONTENTS

Status and distribution of soil available micronutrients along a hill slope in Ekpoma, Edo State, Nigeria

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ABSTRACT: This study was carried out to assess the status and distribution of soil available micronutrients along a hill slope in Ekpoma and to determine the physical and chemical properties of the soils. Soil samples were obtained from upper, middle and lower slope in the land scape within Ambrose Alli University main campus environment at depth intervals of 0-15cm and 15-30cm. Soil samples were collected and analysed for some micronutrients using standard laboratory methods. The results showed that chlorine increased in depths for all the locations in the landscape. Iron increased with increase in depth in all the locations. In the case of Zinc, the content in the soils in all three locations decreased with increase in depths. Copper was irregular in the three locations in the landscape. The result also shows that Nickel is irregular in the research area. Manganese was irregular in the three locations. Cadmium was same for both depths at the upper slope but absent at the middle and bottom of the landscape. Boron and Chromium were irregular in the three locations of the landscape. Micronutrients were available and well distributed in the landscape except for cadmium which was completely absent in the middle and lower slopes.

Key words: Cadmium, chlorine, landscape, micronutrients distribution

The task of feeding the global human population estimated at 9.6 billion by 2050 (United Nations 2013), combined with dietary transitions accompanying the change in human socioeconomic status, calls for the intensification of farming systems. Achieving this goal entails increasing the quantity and quality of crop production inputs such as water, seed, pesticide, and fertilizer (Tilman *et al*., 2011). As a crucial input in modern agriculture, fertilizers make an important contribution to the attainment of high crop yields (Erisman *et al*., 2008). Along this line, a reflection on the need for innovative fertilizers was recently presented by Bindraban *et al.* (2015). Together with NPK, calcium (Ca), magnesium (Mg), and sulfur (S) are classified as essential macronutrients. The eight other essential nutrients constitute a distinct group of elements required by plants in very small amounts, described conventionally as micronutrients: namely (copper [Cu], iron [Fe], manganese [Mn], molybdenum [Mo], nickel [Ni], zinc [Zn]), boron [B], and chlorine [Cl]). Still, other elements like selenium (Se), silicon (Si), and sodium (Na) are regarded as nonessential, although they have been found to enhance growth and confer other benefits to plants (Datnoff *et al.,* 2007; Marschner, 2012). Collectively, these nutrients also play crucial roles in humans and, in many cases, dictate our physical and mental development and how we respond to diseases, especially the micronutrients. In fact, many of the enzymes, proteins and other biological compounds that perform important metabolic functions in humans cannot accomplish such functions without micronutrients. Hidden hunger is a phenomenon borne out of the deficiency of micronutrients in human diets. In countries or regions where staple foods consist mainly of cereals, roots, and tubers grown in nutrient-poor soils, human micronutrient deficiency is widespread. Composite studies (dietary intake, blood sampling, and self-administered questionnaires) from Nigeria, for example, indicate that 20, 21, and 32 % of school children in Lagos were malnourished for Fe, Zn, and Cu, respectively (Akeredolu *et al*., 2011). Indeed, Zn deficiency, with up to 50% prevalence in Sub-Saharan Africa, represents a major cause of loss in child cognitive skills, stunting, and even death, amounting to 450,000 globally per annum (McClafferty and Zuckermann, 2015). It is estimated that by 2030, a mere 9 years from now, the decline in global productivity arising from stunting, loss of cognitive skills, and other chronic illnesses will cost about $35 trillion (Bereuter and Glickman, 2015). However, micronutrient amendments into soil for crop uptake could contribute in lowering the impact of their deficiency in humans (Cakmak, 2008), much like the case of Se in Finland, where fertilization of soils with Se-fortified NPK not only improved food crop yields but also improved daily Se intake and serum Se concentrations in the Finnish population (Ekholm *et al.,* 2005). To permit a concise discussion of this subject, this review will focus on Cu, Fe, Mn, Mo, Ni, Zn, B, and Cl, all of which share in common a low concentration requirement by both crops and humans. Thus, by no means is this review de-emphasizing the importance of macronutrients in crops and humans, since a balanced nutrition requires the presence of all mineral nutrients, as well as vitamins. A comprehensive examination of the crop literature related to micronutrients hints to their multi-functionality in crop production. Such functions, including crop growth and yield enhancement, conferment of resistance/tolerance to diseases and abiotic stressors, and improvement of crop and seed nutritional quality, could have direct consequences for human and environmental health. Major research and investment efforts are warranted in order to increase our understanding of the agro ecological complexities associated with the sustainable use of micronutrients and, thus, harness the full benefits of micronutrients to crops. Most of the inhabitants of Ekpoma are peasant farmers, the need to assess the soils for some micronutrients status is important. This study was therefore to assess the status and distribution of soil available micronutrients along a hill slope in Ekpoma.

MATERIALS AND METHODS

Study Area

This study was carried out in three locations in Ambrose Alli University (AAU), Ekpoma. The various sites were located in different coordinates. Figure 1 below shows the location map of Esan West Local Government Area where the site is located.
The site location is characterized by a tropical average rain fall amount of 1200-1500mm and rainy days of 250. The mean annual humidity range from 30.5% to 94.0% (Weppa, 2013). It has two distinct climatic seasons which are the rainy and dry season. The rainy season lasts between April and October with its climax at July and August, with a short break in mid-August. The average temperature ranges between 25^{0}C in the rainy season and 28^{0}C in the dry season. The samples were collected from 3 different locations, the upper crust of the slope. Middle slope, and lower slope. A gradual sloppy topography was observed in the study area.

The soils of the study area were underlain by sedimentary rock, with about 90% of sand stone and slate intercalation (Cakmak, 2008). The sedimentary rocks constitute Benin formation and geologically in the South Western extension of the Niger Delta Basin. The area was mostly of secondary forest but largely occupied with built up. Land utilization type in the study area includes arable farming, livestock farming, motor pack area, open field and fire wood exploitation. The main crops common in the area were plantain, mango, pear, cassava, maize, yam, pineapple, pawpaw bamboo and a groundnut. Construction site is also going on.
These are some of the economic importance like pineapple, mango oil palm and cassava etc.

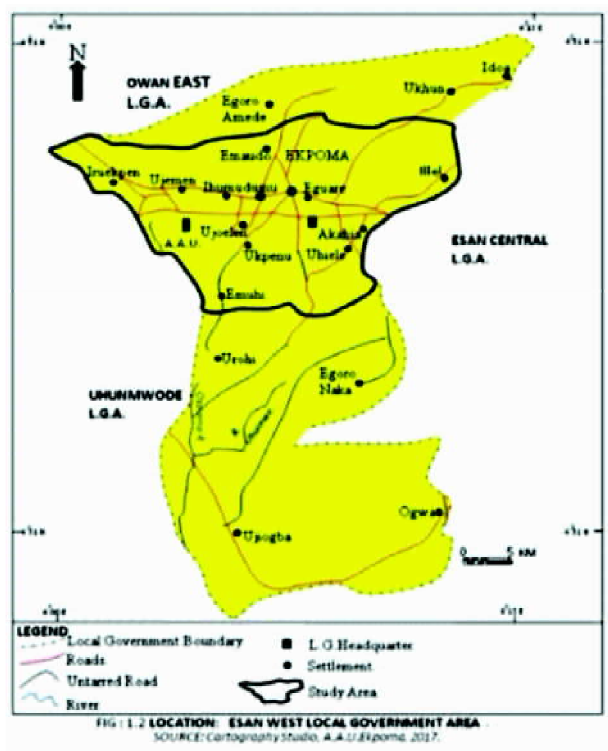

Fig. 1: Map of Study Area

Field Work

Samples were collected along a hill slope in Ambrose Alli University, Ekpoma starting from the school gate.

Sample 1: Obtained from Ambrose Alli University main gate, Benin/Auchi express road, Edo State, Nigeria at latitude $6^0$44'41''N and longitude 6^o54'E. The soil samples were collected with the aid of a soil auger at depths of 0 -15cm and 15-30cm in location 1.

Sample 2: Obtained from the middle slope by faculty of Agricultural Science, Ambrose Alli University, Ekpoma at latitude $6^0$44'23''N and longitude 6^o5'75'' E. The soil samples were collected with the aid of a soil auger at depths of 0 -15cm and 15-30cm in location 2.

Sample 3: Obtained from bottom slope at entrepreneurship office (ENT) in Ambrose Alli University, Ekpoma, Edo State at latitude $6^0$43'53''N and longitude $6^0$4'52''E. The soil samples were collected with the aid of a soil auger at depths of 0-15cm and 15-30cm in location 3. Soil samples from the three locations were air-dried and passed through a 2mm sieve. The sieved samples were bagged and labeled properly for laboratory analysis.

Laboratory Analysis

Soil samples were analysed for some micronutrients eg. Pb, Cu Zn N, Cd Fe and Mn using standard methods. Some other physical and chemical properties were also analysed using standard methods.

Extraction Procedure

10g of the dried soil sample was transfer into an acid-washed 250ml extraction bottle, 100ml of extraction reagent was added. The mixture was shaked for 30-45 minutes on the mechanical shaker. The suspension was filtered through a whatman no. 42 filter paper, a blank sample was prepared using the same procedure without any soil sample. The titrates were further analyzed for Pb, N, Cd, U, Zn, Fe and Mn by using flame Atomic absorption (AA) Spectroscopy. Determination of trace metals in soil and sediment using double extraction method.

RESULTS AND DISCUSSION

Physical and chemical properties of studied area

The particles size distribution of the soils of Ekpoma hill slope showed that sand content ranged from 89-90.0% silt from 3.88-5.88% and clay from 5.22-14.22%, respectively from upper slope. For middle slope the mean value for sand silt and clay mean were 81.90%, 4.38%, and 13.72%, respectively. The lower slope had mean values for sand, silt and clay as 85.90%, 5.38% and 8.72%, respectively.

This showed that the soils from upper slope were loamy sand in texture, soils from middle slope were loamy sand in texture and the soils from the lower slope were also loamy sand in texture. The soil PH ranged from 5.4-6.9 with a mean value of 5.45 for upper slope, 5.95 for middle slope and 6.75 for lower slope, and rated as moderately acidic, moderately acidic and neutral respectively. This pH value can be favourable for plant growth as favourable pH value for plant growth ranges from 5.5-70. Accordingly, organic matter ranged from 0.55-1.94% with mean value of 0.94 for upper slope, 1.42% for middle slope and 0.80% for lower slope. The available phosphorus (P) ranged from 3.31-6.45mg/kg with a mean value of 5.13mg/kg for upper slope, 4.60mg/kg for middle slope and 3.62mg/kg for lower slope. Lead (Pb) was not detected in any of the locations in the slope.

The Table 1 shows the result of physical and chemical properties as well as the heavy metal content of the soils along a hill slope in Ambrose Alli University, Ekpoma.

Physical and chemical properties of soils

The particles distribution of the soil of Ekpoma hill slope showed that sand content range from 14.1 – 909mg/kg, silt range from 7.1 – 53.8 mg/kg and clay range from 7.1 – 132.2mg/kg respectively, with a mean value of 889mg/kg for sand, 43.8mg/kg for silt and 67.2mg/kg for clay respectively. For the middle slope, the mean value for sand, silt and clay was 819mg/kg, 43.8mg/kg and 137.2mg/kg, respectively.

The lower slope had mean values for sand, silt and clay: 8.49mg/kg, 53.8mg/kg and 87.2mg/kg, respectively. This showed that the soil from the upper slope was sandy in texture, and the soil from the middle slope was loamy in texture, and the soil from the lower slope was also sandy in texture. The soil pH ranged from 5.4 to 6.9 with a mean value of 5.45 for the upper slope, 5.95 for the middle slope and 6.75 for the lower slope and for the upper slope at 0 – 15cm and 15 – 30cm the pH level rate strongly acidic, for the middle slope at 0 – 15cm and 15 – 30cm the pH level rate moderately acidic while for the lower slope at 0 - 15cm and 15 – 30cm the pH level rate near neutral. The pH value can be favorable for plant growth as favorable pH value for plant growth ranges from 5.5 – 7.0 accordingly.

Organic matter ranged from 1.6 – 524.7mg/kg with mean value of 9.4mg/kg for the upper slope, 14.2mg/kg for the middle slope and 8mg/kg for the lower slope, respectively.

The available phosphorus (P) ranged from 0.44 – 121.2mg/kg with mean value of 5.13mg/kg for upper slope, 4.60mg/kg for middle slope. Lead (pb) was not detected in any of the location in the various slope. The Conference Variance (CV) ranged from 11.9 – 3mg/kg at the upper slope, the cv was 13mg/kg that's low, for the middle slope the cv was 31.4 which is moderate.

Available Chlorine (Cl)

As Table 2 show that Cl in the soil at a depth of 0-15cm was 11.8Mg/kg, 15-30cm 15.27Mg/kg with a mean of 13.54mg/kg for upper slope. At a depth of 0-15cm for the middle slope Cl was 15.00mg/kg, at 15-30cm 16.10mg/kg with a mean of 16.55mg/kg. For the lower slope at a depth of 0-15cm Cl was 17.35mg/kg 15-30cm 19.2mg/kg with a mean of 18.28mg/kg. From the above results, chlorine increased in depth for all the locations in the landscape. It occurs predominantly as Cl^- in soil and plants. It is an essential micronutrient of higher plants and participates in several physiological metabolism processes. (FAO, 1990)

Available Iron (Fe)

Iron (Fe) content in the soils of Ekpoma hill slope,

Table 1: Physical, chemical and heavy metals analysis

S/N	PARAMETERS	UNITS	Sample 1	Sample 1	Sample 2	Sample 2	Sample 3	Sample 3
			Location1	Location1	Location2	Location2	Location3	Location3
			0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
1	Ph		5.5	5.4	5.9	6.0	6.6	6.9
2	Av. P	mg/kg	6.45	3.80	5.24	3.96	3.31	3.93
3	Cl	mg/kg	11.80	15.27	15.00	16.10	17.35	19.20
4	Fe	mg/kg	69.70	95.90	75.50	46.40	690.70	84.30
5	Cu	mg/kg	0.30	0.40	1.04	0.70	0.70	0.40
6	Zn	mg/kg	3.24	2.73	13.64	6.90	3.41	2.56
7	Ni	mg/kg	0.34	0.34	0.68	0.34	0.34	0.68
8	Mn	mg/kg	11.34	28.00	39.58	23.55	19.51	9.43
9	Cd	mg/kg	0.12	0.12	ND	ND	ND	ND
10	B	mg/kg	0.11	0.19	0.32	0.22	0.25	0.23
11	Cr	mg/kg	0.15	0.14	0.48	0.17	0.23	0.19
12	Pb	mg/kg	ND	ND	ND	ND	ND	ND
13	Organic Matter	%	1.05	0.83	1.94	0.89	0.55	1.05
14	Clay	%	5.22	8.22	13.22	14.22	8.22	9.22
15	Silt	%	3.88	4.88	3.88	4.88	4.88	5.88
16	Sand	%	90.9	86.9	82.9	80.9	86.9	84.9
17	Particle size	%	LS	LS	LS	SL	LS	LS

Table 2: Critical Levels

Organic Matter	20g/kg
Organic Carbon	10g/kg
Available P	15mg/kg
Iron (Fe)	4.5mg/kg
Copper (Cu)	0.2g/kg
Chlorine (Cl)	22g/kg
Zinc (Zn)	0.8g/kg
Nickel (Ni)	2.4g/kg
Manganese (Mn)	5g/kg
Cd	5.33mg/kg
Boron (B)	0.48mg/kg
Chromium (Cr)	1.5g/kg

at the upper slope 0-15cm was 16.70mg/kg, 15-30cm was 95.90mg/kg with a mean of 82.80mg/kg. At the middle slope at a depth of 0-15cm it was 75.5mg/kg, 15-30cm, 46.40mg/kg with a mean of 60.95mg/kg at the lower slope at a depth of 0 - 15cm, Fe was 69.70mg/kg, 15-30cm, 84.30mg/kg with a mean of 77.0mg/kg. Available iron increased with increase in depth in all the locations. Following the guideline for classification of macronutrient and micronutrient (FAO, 1990), Iron content in same soil of the hill slope was within the median range.

Available Zinc (Zn)

Zinc (Zn) content in the soil of Ekpoma hill slope, at the upper slope 0 - 15cm Zn was 3.24mg/kg, 15-30cm 2.73mg/kg with a mean of 2.99mg/kg. At the middle slope at a depth of 0-15cm it was 13.64mg/kg, 15-30cm, 6.90mg/kg with a mean of 10.27mg/kg. At lower slope at the depth of 0-15cm, 2.41mglkg, 15-30cm, 2.56mg/kg with a mean of 2.99mg/kg. In the case of Zinc, the content in the soils in the three locations decreased with increase in depths. Zinc deficiency was first identified in Nebraska, since that time, much research has been down with zinc. The zinc (Zn) content of soils, according to rather extensive surveys, is generally in the range of 10-300 ppm. Certainly Zn, because of its concentration, can be considered as a trace element in soil. It occurs most frequently in the lithosphere as the mineral ZnS (Saidur *et al.,* 2017).

Available for Copper (Cu)

As shown in Table 3, Cu in the soil at a depth of 0-15cm was 0.30mg/kg, 15-30cm, 0.40mg/kg with a mean of 0.35mg/kg for upperslope. At a depth of 0-15cm 1.04mg/kg, 15-30cm 0.70mg/kg with a mean of 0.87mg/kg. At the lower slopedepth of 0-15cm, Cu was 0.70mg/kg, at 15-39cm, 0.40mg/kg with a mean of 0.55mg/kg. Copper was irregular in the three locations in the landscape. Heavy metals (HM). Like cupper, represent a large group of elements with atomic density >5 g cm^{3} or atomic number >20 (Saidur *et al.,* 2017), among which some are essential to plants.

Available Nickel (Ni)

Nickel (Ni) as shown in the content of the soils of

Table 3: Location distribution of extractable micronutrient

	pH	Av.P	Cl	Fe	Cu	Zn Mg/kg	Ni	Mn	Cd	B	Cr	Organic Matter	Clay g/kg	Silt	Sand	Texture
(UPPER)	5.5	6.45	11.8	69.7	0.3	3.24	0.34	11.34	0.12	0.11	0.15	10.5	52.2	38.8	909	
	5.4	3.8	15.27	95.9	0.4	2.73	0.34	28	0.12	0.19	0.14	8.3	82.2	48.8	869	
MEAN	5.45	5.13	13.54	82.80	0.35	2.99	0.34	19.67	0.12	0.15	0.15	9.4	67.2	43.8	889	LS
SD	0.07	1.87	2.45	18.53	0.07	0.36	0.00	11.78	0.00	0.06	0.01	1.6	21.2	7.1	28.3	
CV	13	365.6	181.3	223.7	202.0	120.8	0.00	598.9	0.00	377.1	48.8	165.5	315.7	161.4	31.8	
(MIDDLE)	5.9	5.24	15	75.5	1.04	13.64	0.68	39.58		0.32	0.48	19.4	132.2	38.8	829	LS
	6	3.96	16.1	46.4	0.7	6.9	0.34	23.55		0.22	0.17	8.9	142.2	48.8	809	
MEAN	5.95	4.60	15.55	60.95	0.87	10.27	0.51	31.57		0.27	0.33	14.2	137.2	43.8	819	
SD	0.07	0.91	0.78	20.58	0.24	4.77	0.24	11.33		0.07	0.22	7.2	7.1	7.1	14.1	SL
CV	11.9	196.8	50	337.6	276.3	464.1	471.4	359.1		261.9	674.5	524.7	51.5	161.4	17.3	
(LOWER)	6.6	3.31	17.35	690.7	0.7	3.41	0.34	19.51		0.25	0.23	5.5	82.2	48.8	869	
	6.9	3.93	19.2	84.3	0.4	2.56	0.68	9.43		0.23	0.19	10.5	92.2	58.8	849	
MEAN	6.75	3.62	18.28	387.50	0.55	2.99	0.51	14.47		0.24	0.21	8	87.2	53.8	859	LS
SD	0.21	0.44	1.31	428.79	0.21	0.60	0.24	7.13		0.01	0.03	3.5	7.1	7.1	14.1	
CV	31.4	121.1	71.6	1106.6	385.7	211.4	471.4	492.6		58.9	134.7	441.9	81.1	131.4	16.5	

the project area, the upper slope 0-15cm Ni was 0.34mg/kg, 15-30cm, 0.34mg/kg with a mean of 0.34mg/kg. At the middle slope at a depth of 0-15cm it was 0.68mg/kg 15-30cm, 0.34mg/kg with a mean of 0.51mg/kg. A the lower slope at the depth of 0 - 15cm, 0.34mg/kg 15-30cm, 0.68mg/kg with a mean of 0.51mg/kg. Nickel was same for both depths at the upper slope, it decreased with increase in depth for middle slope and increased with increase in depth for bottom. The result shows that nickel was irregular in the research area. Nickel (Ni), is the 22nd most abundant element in the earth's crust and is found in natural soils in trace concentrations (Hussain *et al.*, 2013). It is an essential element for plants and for many bacteria.

Available Manganese (Mn)

Manganese (Mn) content in the soils of Ekpoma hill slope, at the upper slope 0-15cm Mn was 11.34mg/kg, at 15-30cm 28.00mg/kg with a mean of 19.67mg/kg. At the middle slope depth of 0 -15cm it was 39.58mg/kg, 15-30cm was 23.55mg/kg with a mean of 31.57mg/kg. At the lower slope at a depth of 0 - 15cm 19.51mg/kg, 15-30cm 9.43mg/kg with a mean of 14.47mg/kg. Recent work on the solubility of manganese compounds in the soil, leading to a general consensus of opinion that the solubility of this element is intimately controlled by the soil reaction and by the oxidation-reduction equilibrium, is shown to have an important bearing on the availability of this element to plants (Hussain *et al.*, 2013).

Available Cadmium (Cd)

As shown in Table 3 the cadmium (Cd) in the soil at a depth of 0-15cm was 0.12mg/kg, at 15-30cm was 0.12mg/kg with a mean of 0.12mg/kg. For upper slope, Cd was not detected at middle and lower slope. Due to potential problems associated with their toxicities, concentration of heavy metals in soils is of great environmental concern. To evaluate Cd content, its spatial patternand availability in the surface soils is of great importance in the agricultural sector. (Karimi *et al.,* 2018).

Available Boron (B)

As shown in Table 3 that Boron (B) in the soil at a depth of 0-15cm was 0.11mg/kg, 15-30cm 0.19mg/kg with a mean of 0.15mg/kg. At the middle slope with a depth of 0-15cm 0.32mg/kg, at 15-30cm was 0.22mg/kg with a mean of 0.27mg/kg. At the lower slope depth of 0-15cm 0.25mg/kg, 15-30cm 0.23mg/kg with the mean of 0.24mg/kg. Boron is an essential micronutrient element required for the normal growth of plants. The range between boron deficiency and toxicity symptoms in plants for tolerant crops is seen from the critical levels above. (Hussain *et al.*, 2013)

Available Chromium (Cr)

Table 3 shows that Chromium (Cr) content in the soil at a depth of 0 - 15cm was0.15mglkg, 15-30cm was 0.14mg/kg with a mean of 0.15mg/kg. At the middle slope with a depth of 0 - 15cm was 0.48mg/kg. At 15-30cm it was 0.17mg/kg with a mean of 0.33mg/kg. At the lower slope depth of 0-15cm it was 0.23mg/kg, at 15-30cm 0.19mg/kg with a mean of 0.21mglkg. The mobility and distribution of metals in the environment is related not only to their concentration but also to their availability in the environment. Most chromium (Cr) exists in oxidation states ranging from 0 to VI in soils but the most stable and common forms are Cr(0), Cr(III), and Cr(VI) species. Chromium can have positive and negative effects on health, according to the dose, exposure time and its oxidation state (Ertani *et al.,* 2017)

CONCLUSION

The status and distribution of soil available micronutrients along a hill slope in Ekpoma was conducted in Ambrose Alli University campus environment. Soil samples were taken from three different locations along the slope graduating from the school gate to faculty of Agriculture and to the base at Entrepreneurship department. The results from the laboratory analysis showed that chlorine increased in depths for all the locations in the landscape. Iron increased with increase in depth in all the locations. In the case of Zinc, the content in the soils in the three locations decreased with increase in depths. Copper was irregular in the three locations in the landscape. The result shows that Nickel is irregular in the research area. Manganese was irregular in the three locations. Cadmium was same for both depths at the upper slope but absent at the middle and bottom of the landscape. Boron and Chromium were irregular in the three locations of the landscape.

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