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ORIGINAL ARTICLE

Effects of Different Enrichment Treatments on Chemical Properties of Vermicompost during Maturation

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ABSTRACT
One of the main limitations of application of vermicompost (VC) in field is the need for application of relatively high amounts of VC to sensible yield increase. Therefore one alternative to increment VC efficiency is the enrichment with plant nutrients. In the present study we evaluated changes in chemical properties of VC in response to different enrichment treatments including chemical fertilizers. Results showed that during enrichment all of added elements greatly decreased except S. Addition of N as urea by increasing pH had unfavorable effects on VC quality e.g. reducing available P. Concomitant addition of urea and S and P has beneficial effects on VC quality like increasing available P. Humic acid in all enriched treatments significantly increased while fulvic acid decreased. Analyzing the extracted humic acid showed that enriching increased functional groups and O/C ratio and decreased C/N and H/C ratios. Overall, results showed that enriching VC by chemical fertilizer could be appropriate alternative to increment VC efficiency.
***Keywords**: Carbon biomass, incubation, functional groups, humic matter, vermicompost.*

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INTRODUCTION

Nowadays sustainability of agricultural systems considered as an important matter worldwide. Increasing the cost of chemical, lack of sustainability of soil nutrition, environmental health disorder, negative effects on soil physical and chemical characteristics as well as disorder in soil biological properties including reduction in N_2-fixation as a result of frequent and excessive use of chemical fertilizers, forced us to decrease utilizing these fertilizers and replaced by organic and biologic fertilizers [1, 2].
Vermicompost is a plant growth promoting, redundant, biased and ecologically friendly bio-fertilizer [3, 4]. One of the main limitations of application of vermicompost in field is the need for application of relatively high amounts of VC to sensible increasing of yield. One alternative to increment VC efficiency is the enrichment with plant nutrients. Numerous studies showed that in order to development of sustainable agriculture, enriching of organic wastes could be useful. Enriching of compost with ammonium sulfate and urea as nitrogen was added to bed at the composting initiation in the solid or solution forms, was conducted and increased total nitrogen and compost efficiency [5,6].
Present study attempted to evaluate the possibility of VC enriching with nutrients and also effect of nutrients on VC quality such as humification. The main hypothesis is that chemical enrichment of VC with nutrients could improve VC quality and its efficiency to use in field applications. By measuring the some chemical parameters and also assessing some of the main and important properties of humic acid (as a most important component of humic matter) in enriched VC ability of efficient applying was evaluated.

METHOD AND MATERIALS

Vermicompost production
VC produced from cow manure in the presence of composter worm, *Eisenia fetida*, over a four-month period in Mazrae Nemuneh, of Etka organization, Humand Absard, Iran. For this purpose, initially cow manure were placed in plastic bins (0.2 m W, 0.15 cm H, and 30 cm L) under laboratory conditions for four months. After excessive irrigation and leachate removal, fifty adult E. *fetida* were introduced into

each plastic bin. Bins moisture over the vermicomposting period was about 50-60% and to maintain the moisture content daily irrigation was carried out. At the end of process, earthworms were separated from final product (VC) and VC so obtained was analyzed for its characteristics as reported earlier [7]. The characteristics of the vermicompost are given in Table 1.

Experimental design

In order to evaluation the effect of enrichment on VC quality, an experiment was conducted as completely randomized design with three replications for 60 days. In the present study we attempted to use most important essential nutrients which have highest application in agriculture. For this purpose five treatments as following were selected:

VA: VC without enriching (control)

VN: VC + 1% nitrogen (as urea)

VS: VC + 1% elemental sulfur (elemental sulfur)

VP: VC + 1% phosphorous (as super phosphate triple)

VE: VC + 1% nitrogen + 1% elemental sulfur + 1% phosphorous

All treatments were moistened to 60% holding capacity by distilled water. Samples were incubated in 28 ºC for 60 days and enriched VC treatments were analyzed for chemical characteristics at 0, 20, 40 and 60 days.

Chemical analyses

Chemical properties of treatments were measured by following methods in three replications: soluble sulfate according to Bardsley and Lancaster [81960), total-N by Kjeldahl, available P by Olsen, organic carbon by Walkley-Black, pH by pH-meter in saturated extract (EYELA PHM-2000) [9].

The HA were extracted with 0.5 M NaOH as described in Qi et al. (2004); briefly, 20g of air dried samples of vermicompost were mixed with 200 ml of 0.5 M NaOH under N_2 at a ratio (vermicompost/solution) of 1/10 (w/v). Before centrifuging, samples were shaked for 18 hour at 150 rpm. The treated slurry was left to stand by 1, 7 and 9 days in dark at room temperature, then, the supernatant was separated by centrifugation at 10,000 rpm. The supernatant was acidified at pH of 1.17–1.50 with HCl 6 M in order to separate the humic acids from alkaline suspension containing humic acid and fulvic acid. Then the precipitated humic acids was purified with HCl/HF 0.1/0.3 M, and washed with distilled water until the pH of the H^+ -exchanged soil was in the range 4–5, and finally, dried at temperatures below 50 C°. Fulvic acid was determined by alkali method according to Carter and Gregorich, (2006). The humification ratio (HR) and humification index (HI) were determined as follows (Amir et al., 2008):

HR = [(HA + FA)/TOC] ×100.

HI = (HA/TOC) ×100.

Degree of polymerization = HA/FA.

In the present study, main chemical properties of humic acid, as the most important component of humic matter, in enriched VC was evaluated and results were presented.

The elemental composition was determined by C, H, N, and S in an analyzer instrument (Elementar Analysen System GmbH Vario EL). Oxygen was calculated by difference as following: O%= 100 - (%C+%H+%N+%S) (ash and moisture-free basis).The ash content was determined as the percentage of dry solid weight after combustion in the air at 660 C °for 6 h.

Total acidity and carboxylic groups (COOH) content was determined according to conventional methods described by Page et al. [9] and phenolic-OH group content was calculated by differences of two values. All these determinations were performed in three replicates.

Statistical analysis

Tow way analysis of variance (ANOVA) was used to test the significant difference between treatments followed by Tukey's post-hoc tests. The probability levels used for statistical significance were $P<0.05$.

Results and Discussion

Enriched nutrients during incubation have considerable changes. Considering to VS and VE with elemental sulfur, available sulfur increased by incubation duration (Table 2). In order to make sulfur available by converting it to sulfate, following condition is required; moisture, organic matte and sulfur oxidizing microorganisms [10]. During incubation, these conditions were provided and available S is increased but increase in VE was more than other treatments that could be attributed to increasing in biological activities (Table 2).

Total of organic carbon decreased in all treatments during incubation. VE has the highest and VA has the lowest decrease in organic carbon content (Fig. 1). Decreasing in organic carbon during enriching process resulted from increasing in bacterial activity and respiration indicating humification and stabilization of organic matter as incubation time is increased [11, 12]. As incubation time is increased organic carbon content decreased rapidly which could be due to increasing in microbial population.

VS has the lowest pH which attributed to reduction and oxidation of S during incubation (production of H_2S and SO_4^{2-}) which resulted in production of H^+ and reduced pH in this treatment [13]. Highest pH was observed in VN which possibly during incubation urea converted to ammonium carbonate, then hydrolyzed and transformed to ammonium bicarbonate, ammonium and ammonium hydroxide and caused increasing in pH in this treatment [5]. In VP, also, pH decreased during incubation which could be attributed to increasing in microbial population and organic acid production. VE, enriched by S and urea, has little changes in pH; possibly during incubation urea and elemental S neutralized each other effects. Increasing the temperature decreased pH in all treatments (Fig. 2).

In the present study, by increasing incubation duration, amount of humic acid was increased, while fulvic acid decreased. VE and VA (control) had the greatest and lowest amounts of humic and fulvic acid, respectively. VE had lost greater part of organic matter and according to Veeken et al. [11] possibly converted to more stable matters, therefore this treatment had highest humic acid and lowest amount of fulvic acid (Table 3). More degradability of fulvic acid than humic acid could explain the reduction of fulvic acid at final weeks [14]. The amount of humic acid in treatments little increased by increasing temperature and fulvic acid has little reduction (Table 3).

Polymerization ratio represents the formation of more complex molecules (HA) from more simple ones (FA). This index also known as maturity index [15, 14]. Results showed that this ratio became higher with the vermicomposting process and VE has highest and VA (control) has the lowest values. Other indices (HR and HI) represent VC maturity ratio and as can be seen in Table 3, VE has the highest and VA (control) has the lowest values during vermicomposting.

Elemental analysis of humic acid as representative of humic matter showed that VE has greater changes than other treatments. According Table 4, carbon and hydrogen content in all treatments decreased about 6 and 14 percent, respectively. Nitrogen and sulfur increased by 3 and 13% in all treatments which could be due to increasing of these nutrients during vermicomposting [16, 17]. It is reported that as vermicomposting duration increased some compounds were forms in humic matter which resulted in increase in N content in humic matter structure [17]. C/N of humic matter declined during vermicomposting and decrease was greater for VE. Oxygen increased at the end of vermicomposting and O/C ratio increased by 15%. This could be attributed to active decomposition of aliphatic compounds and peptide structures and formation of oxidized humic structures [14]. H/C ratio decreased during vermicompost indicating the increase in aromatic compounds and reduction of aliphatic compounds [14, 17]. As time increased, humification was intensified; carbon greatly decreased but other parameters were not changed so much.

Analysis of extracted humic acid samples presented in Table 5. Enriched VC significantly increased functional groups of humic acid which could be due to increasing the microorganism's activity and stability and efficiency of resulted humic acid [18]. In the present study, increasing the temperature has not significant effect on functional groups changes.

Table 1- Initial vermicompost (VC) properties

pH	EC (dSm^{-1})	Total N (%)	OC (%)	P (%)	K (%)	Na (%)	Fe (%)	Ca (%)	C/N
7.63	2.14	1.2	24.37	0.82	6.52	1.10	0.57	8.5	20.3

Table 2- Nitrogen and phosphorous and sulfur content (%) of VC across experimental treatments

Treatments [a]	N		S		P	
	Start	End	Start	End	Start	End
VA	1.20^b	1.23^b	1.94^b	1.942^c	0.82^b	0.81^c
VN	2.20^a	2.10^a	1.94^b	1.933^c	0.82^b	0.77^d
VS	1.20^b	1.15^c	2.12^a	2.557^b	0.82^b	0.88^b
VP	1.20^b	1.17^c	1.94^b	1.942^c	1.25^a	1.16^a
VE	2.20^a	2.09^a	2.12^a	2.652^a	1.25^a	1.14^a
C.V.	1.62	1.302	0.76	0.32	1.15	1.71
SEM±	0.015	0.012	0.009	0.004	0.006	0.010

Means differ if they have a different letter at: lower case superscript (a, b, c...) for comparison of treatments (ANOVA; Tukey's test, $P<0.05$)

a for treatment description see text.

Table 3. HA, FA contents and HA/FA, HR and HI values of the VC across treatments through time

Treatments [a]	HA (%)		FA (%)		HA/FA		HR		HI	
	Start	End	Start	End	Start	End	Start	End	Start	End
VA	5.17^{c}	5.53^{e}	3.59^{b}	3.35^{b}	1.44^{c}	1.65^{e}	35.93^{c}	39.38^{e}	21.21^{c}	24.52^{e}
VN	5.78^{a}	7.30^{b}	3.89^{a}	3.51^{a}	1.48^{a}	2.08^{c}	39.68^{a}	48.65^{b}	23.71^{a}	32.84^{b}
VS	5.04^{d}	5.77^{d}	3.52^{b}	2.80^{cd}	1.43^{d}	2.06^{d}	35.13^{d}	38.95^{d}	20.68^{d}	26.21^{d}
VP	5.17^{c}	6.40^{c}	3.59^{b}	2.92^{c}	1.44^{c}	2.20^{b}	35.93^{c}	42.24^{c}	21.21^{c}	29.02^{c}
VE	5.23^{b}	8.41^{a}	3.62^{b}	2.74^{d}	1.45^{b}	3.07^{a}	36.29^{b}	51.23^{a}	21.46^{b}	39.50^{a}
C.V.	0.32	0.87	1.64	2.77	0.09	0.98	0.29	1.30	0.67	1.49
SEM±	0.010	0.034	0.035	0.05	0.001	0.013	0.06	0.34	0.08	0.27

Means differ if they have a different letter at: lower case superscript (a, b, c...) for comparison of treatments (ANOVA; Tukey's test, $P<0.05$)
a for treatment description see text.

Table 4- Elemental analysis of HA across treatments through time

Treatments [a]	C	H	N	S	O	Atomic ratios C/N	H/C	O/C
Initial								
VA	50.6^{a}	6.3^{b}	4.8^{c}	0.3^{b}	37.9^{b}	12.34^{b}	1.50^{a}	0.56^{b}
VN	50.2^{c}	6.4^{a}	6.3^{b}	0.3^{b}	36.8^{d}	9.39^{c}	1.54^{a}	0.55^{c}
VS	50.5^{a}	6.3^{b}	4.8^{c}	0.6^{a}	37.7^{c}	12.37^{ab}	1.51^{a}	0.56^{b}
VP	50.3^{bc}	6.4^{a}	4.8^{c}	0.6^{b}	38.1^{a}	12.40^{a}	1.52^{a}	0.57^{a}
VE	50.4^{b}	6.3^{b}	6.5^{a}	0.3^{a}	36.1^{e}	9.15^{d}	1.51^{a}	0.54^{d}
C.V.	0.16	0.89	0.14	3.47	0.07	0.28	3.22	0.25
SEM±	0.047	0.033	0.004	0.009	0.015	0.018	0.028	0.001
Final								
VA	49.1^{a}	5.7^{a}	4.9^{d}	0.4^{b}	39.9^{d}	11.73^{a}	1.41^{a}	0.61^{c}
VN	48.2^{b}	5.7^{a}	6.4^{b}	0.4^{b}	39.2^{e}	8.85^{c}	1.42^{a}	0.61^{c}
VS	47.2^{d}	5.4^{b}	5.0^{cd}	0.7^{a}	41.7^{a}	11.21^{b}	1.38^{a}	0.66^{b}
VP	47.9^{c}	5.4^{b}	5.1^{c}	0.4^{b}	41.1^{c}	11.10^{b}	1.37^{a}	0.64^{b}
VE	45.9^{e}	5.2^{c}	6.8^{a}	0.7^{a}	41.4^{b}	7.91^{d}	1.36^{a}	0.68^{a}
C.V.	0.21	0.78	1.43	1.90	0.11	0.53	2.50	1.98
SEM±	0.058	0.025	0.046	0.006	0.027	0.031	0.021	0.007

Means differ if they have a different letter at: lower case superscript (a, b, c...) for comparison of treatments (ANOVA; Tukey's test, $P<0.05$)
a for treatment description see text.

Table 5- Acidic functional groups (total acidity, carboxylic and phenolic-OH groups) contents of the studied HA (mmol g−1)

Treatments [a]	Total acidity		carboxylic groups		phenolic-OH group	
	Start	End	Start	End	Start	End
VA	4.53^{c}	5.67^{e}	2.73^{b}	3.41^{c}	1.80^{c}	2.25^{d}
VN	4.86^{a}	6.32^{c}	2.92^{a}	3.22^{d}	1.93^{a}	3.09^{a}
VS	4.65^{b}	6.51^{b}	2.80^{b}	3.92^{b}	1.85^{b}	2.59^{c}
VP	4.56^{c}	6.11^{d}	2.75^{b}	3.94^{b}	1.81^{c}	2.17^{e}
VE	4.54^{c}	6.81^{a}	2.73^{b}	4.10^{a}	1.81^{c}	2.71^{b}
C.V.	0.54	0.93	1.77	1.29	0.82	0.58
SEM±	0.015	0.034	0.028	0.028	0.009	0.009

Means differ if they have a different letter at: lower case superscript (a, b, c...) for comparison of treatments (ANOVA; Tukey's test, $P<0.05$)
a for treatment description see text.

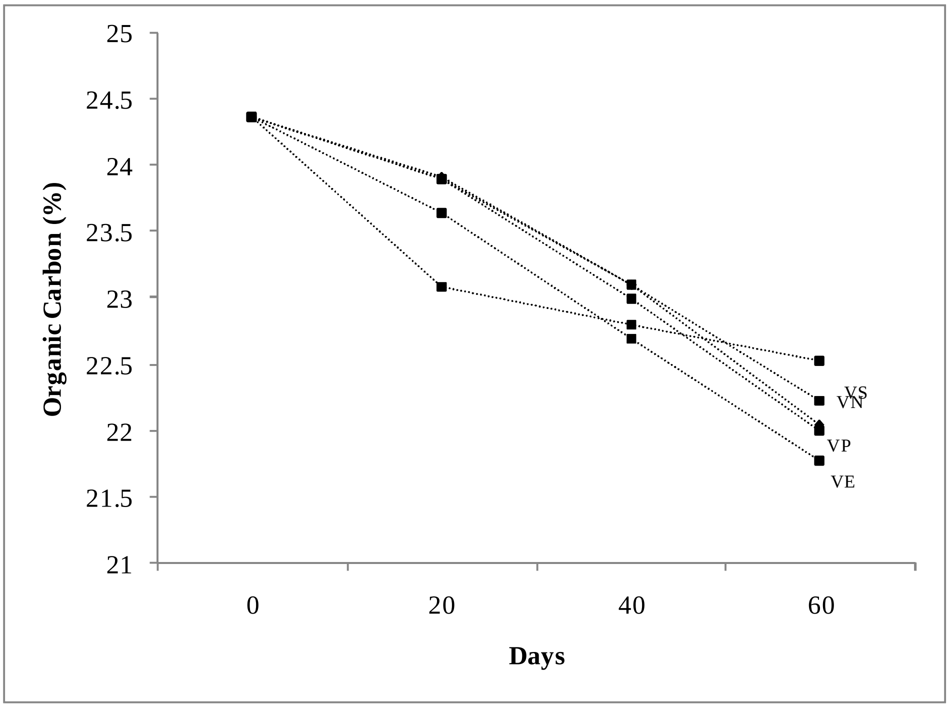

Figure 1- Organic carbon content in VC in different enriching treatments through time

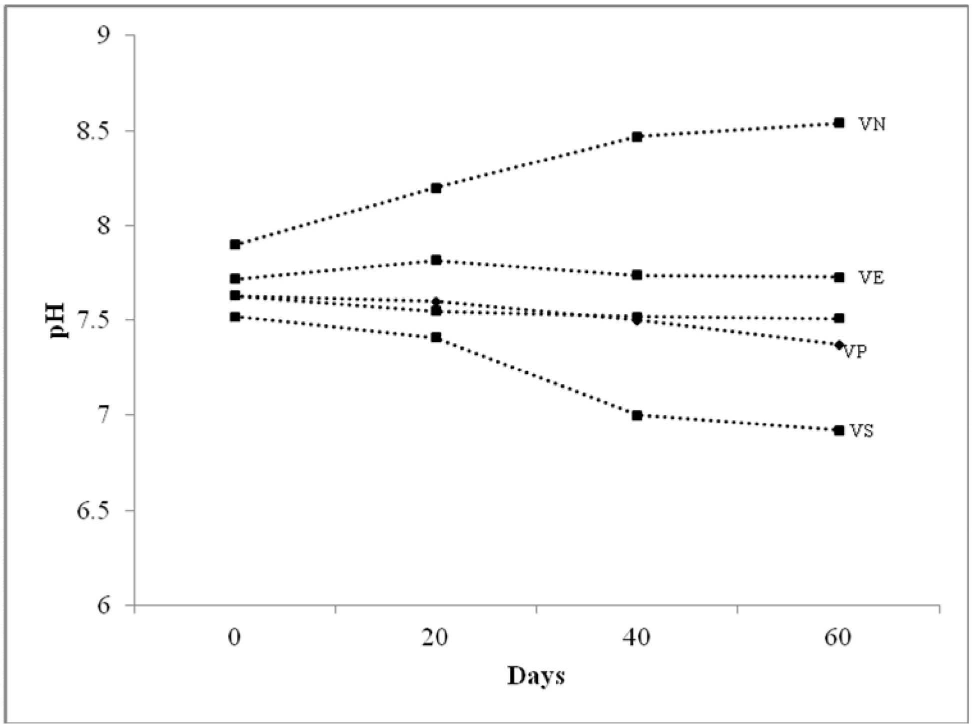

Figure 2- pH of VC in different enriching treatments through time

CONCLUSION

Incubation duration is one of the important criteria in VC enrichment and according to results of our study and those of others, 45 to 60 days at 28 ºC is sufficient to induce biased chemical properties of VC. Enrichment VC with chemical fertilizers improved its quality. Enrichment process showed that VC is the appropriate carrier and bed to increasing bioavailability and uptake ability of added nutrients. It means that enriching VC with chemical fertilizer could be used for increasing VC efficiency and reducing the amount of VC application in soils.

REFERENCES

1. Hojjati, S., Nourbakhsh, F., (2006). Enzyme activities and microbial biomass carbon in a soil amended with organic and inorganic fertilizers. J Agron. 5, 563-579.
2. Canali, S., Trinchera, A., Intrigliolo, F., Pompili, L., Nisini, L., Mocali, S., Torrisi, B., (2004). Effect of long term addition of composts and poultry manure on soil quality of citrus orchards in Southern Italy. Biol and Fertil Soils. 40, 206-210.
3. Rashtbari, M., Alikhani, H.A., Ghorchiani, M., 2012. Effect of vermicompost and municipal solid waste compost on growth and yield of canola under drought stress conditions. Intl J Agric: Res & Rev. 2 (4), 395-402.
4. Lazcano, C., Arnold, J., Tato, A., Zaller, J.G., Domínguez, J., 2009. Compost and vermicompost as nursery pot components: effects on tomato plant growth and morphology. Span J Agric Res. 7(4), 944-951.
5. Adamtey, N., Cofie, O., Ofosu-Budu, G.K., Danso, S.K.A., Forster, D., 2009. Production and storage of N-enriched co-compost. Waste Management. 29, 2429–2436.
6. Ahmad, R., Khalid, A., Arshad, M., Zahir, Z.A., Mahmood, T., (2008). Effect of compost enriched with N and L-tryptophan on soil and maize. Agronomy for Sustainable Development. 28(2), 299–305.
7. Gupta, P.K., (2002). Vermicomposting for sustainable agriculture. Agrobios (India) Publishers: Jodhpur.
8. Bardsley, C.E., Lancaster, J.D., (1960). Determination of Reserve Sulfur and Soluble Sulfates in Soils. 24(4), 265-268.
9. Page, A.L., (1982). Methods of Soil Analysis. Agronomi 9 ASA SSSA Madison Wiscosin USA.
10. Prasad, R., Power, J.F., (1997). Soil Fertility Management for Sustainable Agriculture. Boca Raton, FL: CRC Press LLC.
11. Veeken, A., Nierop, K., Wilde, V.D., Hamelers, B., (2000). Characterisation of NaOH-extracted humic acids during composting of a biowaste. Biores Technol. 72, 33-41.
12. Busato, J.G., Lima, L.S., Aguiar, N.O., Canellas, L.P., Olivares, F.L., 2012. Changes in labile phosphorus forms during maturation of vermicompost enriched with phosphorus-solubilizing and diazotrophic bacteria. Biores Technol. In press.
13. Druschel, G.K., Hamamers, R.J., Banfield, J.F., 2003. Kinetics and mechanism of polythionate oxidation to sulfate at low pH by O_2 and Fe^{3+}. Geochimica et Cosmochimica Acta. 67(23), 4457–4469.
14. Amir, S., Benlboukht, F., Cancian, N., Winterton, P., Hafidi, M., 2008. Physico-chemical analysis of tannery solid waste and structural characterization of its isolated humic acids after composting. J Hazard Mater. 160, 448–455.
15. Sanchez-Monedero, M.A., Roig, A., Cegarra, J., Bernal, M.P., 1999. Relationships between water-soluble carbohydrate and phenol fractions and the humification indices of different organic wastes during composting. Biores Technol. 70, 193–201.
16. Adani, F., Genevini, P., Tambone, F., Montoneri, E., 2006. Compost effect on soil humic acid: a NMR study. Chemosphere. 65, 1414–1418.
17. Amir, S., Jouraiphy, A., Meddich, A., Gharous, M.E., Winterton, P., Hafidi, M., 2010. Structural study of humic acids during composting of activated sludge-green waste: Elemental analysis, FTIR and ^{13}C NMR. J Hazard Mater. 177, 524–529.
18. Tan, K.H., 2003. Humic Matter in Soil and the Environment. Marcel Dekker: New York.

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