"Effect of Algal Bio-Fertilizer on Physico-Chemical and Biological Properties of Different Types of Soil"

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Abstract

Soil is an active system in which the physical, chemical and biological components are in a state of equilibrium. Cyanobacteria play an important role in maintenance and buildup of soil fertility. They play multiple roles in the soil by fixing carbon, nitrogen and synthesizing exo-polysaccharides, which increase soil fertility, water retention and improve soil structure and stability. The agriculture production totally depends on the fertility level of the soil. An experiment was carried out in order to test the effect of algal bio-fertilizer on physical, chemical and biological properties. Different types of soils (on the basis of texture) were collected from different areas of Jabalpur and treated with two different types of BGA algal bio-fertilizers. The soil testing was done at 1st day, 15th day and 30th day. The properties of soil were observed by the following parameters of soil test:-
Physical properties- Aggregate stability and water holding capacity. Chemical properties- Soil pH, electrical conductivity (EC) and total nitrogen content. Biological properties- Percent of organic carbon and organic matter.In this study concluded that, no changes were observed in aggregate stability, water holding capacity and pH level, when applied bio-fertilizers in all types of soil. EC, total nitrogen content, organic carbon percent and organic matter percent were increased, when applied bio-fertilizers. Out of the five types of soil, soil type-7 was showed maximum value of EC, total nitrogen content, organic carbon percent and organic matter percent.Among the two bio-fertilizers tested, EC, total nitrogen content, organic carbon percent and organic matter percent showed higher value, when mixed bio-fertilizer (taken from IARI) in soils.

Key words- Algal Bio-fertilizer, Types of Soil

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INTRODUCTION

Biotechnological techniques based on the use of microorganisms as soil inoculants are regarded as promising potential tools to improve soil quality and counteract soil degradation in disturbed dry land areas (Bowker, 2007; Rossi et al., 2017). Recently, the strong interest in crop production is focused on the use of microorganisms, including cyanobacteria and green algae, as bio-fertilizers, which are eco-friendly, can be an alternative to chemical fertilization, and offer economic and ecological benefits to farmers. Biofertilization allows them to reduce the use of chemical fertilizers and pesticides which are dangerous to environment and increase risk for human health (Sahu*et al.* 2012). They increase soil fertility in dry land regions (Zhao et al., 2010).

Cyanobacteria is used as bio-fertilizer

More than 150 genera and 2000 species of Cyanobacteria are present, which play diverse yet significant roles in aquatic and terrestrial ecosystems. This phylum comprises more than 1000 species, are classified using both botanical and bacteriological taxonomic codes (Castenholz, 2001). Cyanobacteria are a gram-negative eubacteria. They are structurally diverse and widely distributed throughout the world and are also known as blue green algae. Cyanobacteria are characterized by their capacity to perform biological nitrogen fixation and oxygenic photosynthesis. Cyanobacteria play an important role in maintenance and buildup of soil fertility, consequently increasing rice growth and yield as a natural bio-fertilizer (Song *et al*., 2005). Cyanobacteria are also capable of fixing atmospheric nitrogen (Choudhary and Kennedy, 2004). Efficient nitrogen fixing strain like *Nostoclinkia, Anabaena variabilis, Aulosirafertilisima, Calothrix sp., Tolypothrix sp., and Scytonema* sp. were identified from various agro-ecological regions and utilized for rice production (Prasad and Prasad, 2001).

Role of cyanobacteria in improving soil fertility

Cyanobacteria are important components of arid and semi-arid ecosystems. Furthermore, their distribution and condition may indicate the health of the environment. Additionally, the presence of algae leads to reduced erosion by regulating the water flow into soils. Similarly, they play a role in soil fertility; soil reclamation. Human civilization depends on agriculture for its existence. The success of agriculture greatly depends on the fertility level of the soil. Cyanobacteria are particularly adapted to scavenge their environments for resources through structural changes, storage or increased resource utilization efficiency (Singh and Dhar, 2007). Algae play an economic role in soil reclamation increases soil fertility and improve the plant conditions under certain environmental factors (Pandey *et al*., 2005; Nisha*et al*., 2007; Prabu and Udayasoorian, 2007).

Different type of soil properties

A study of the soil profile is important from crop husbandry point of view, in agricultural or plantation soils, where plant production is the primary function, the chemical, physical and biological properties that contribute to a high quality soil can be identified and used to preserve nutrient availability, soil structure and bulk density for optimal root growth and soil utilization. However, management of soils for a specific application should not preclude changes in land use in the future (Eijsackers, 1998).

Taxonomically these soils are classified: The most often reported soil characteristics include texture, organic matter content, pH and nutrient status. The proportions of mineral and organic fractions differ extensively between different soils. Soils with a maximum of 20% organic matter are classified as mineral soils. Soil texture refers to the proportion of the soil “separates” that make up the mineral component of soil. Soil structure often gives clues to its texture, organic matter content, biological activity, past soil evolution, human use, and the chemical and mineralogical conditions under which the soil formed (Cherworth, 2008):

Biological control

Blue green algal bio-fertilizer enhances the growth of rice crops and decreases effect of heavy metals such as Cd, Ni, etc., indicating stress amelioration. Integrated use of BGA improves growth, yield and mineral composition of the rice plants (Tripathi*et al*., 2007). Also on using BGA with other microbial inoculants (BGA, Phosphate Solubilizing Bacteria, Vesicular Arbuscular*Michorizia* and *Azospirillum*) results in significant improvement in the yield and nutritional parameters. Application of bio-fertilizers also substantially improves soil (peat) fertility status by increasing the nitrogen (N), phosphorous (P), organic carbon content and nutritional status of rice (Chinnusamy*et al*., 2007). The agriculture production totally depends on the fertility level of the soil. Like other organisms, algae which are found

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in different soil types, may help the soil to improve its characteristics such as, carbon content, texture, aeration and also nitrogen fixation (Hamed, 2007).

Material and Method

Source of soil sample

The different types of soils on the basis of texture were collected from different region of Jabalpur district of Madhya Pradesh (Map No. 1).

Five different types of soil that were collected from different region of Jabalpur are as follows:

(1) 52-Fine montmorilonitichyperthermic,verticUstochrepts (Area- **Gour**)
(2) 53-Fine montmorilonitic(Cal.) hyperthermic,TypicUstochrepts (Area- **Barela**)
(3) 180-Fine montmorilonitichyperthermic,TypicHaplusterts (Area- **Manjholipatan**)
(4) 7- Loamy mixed hyperthermic,LithicUstorthents (Area- **Bargi**)
(5) 141-Clayey mixed hyperthermic,TypicUstochrepts (Area- **SahajpurShahpura**)

The information of above soil types of different region of Jabalpur were provided by Department of Soil Sciences, Jawaharlal Nehru KrishiVishwavidhyalaya, Jabalpur (Figure 1). Source of Commercial Algal Bio-fertilizer

Two different commercial algal bio-fertilizers were used for the present study. One was procured from JNKVV, Jabalpur and second bio-fertilizer was procured from IARI, New Delhi (Figure 2).

Experimental design

The different types of soils (on the basis of texture) were collected (52, 53, 189, 7, 141) and were treated with two types of BGA algal bio-fertilizers (taken from JNKVV and IARI). The soil testing was done at 1st day, 15th day and 30th day. Physical, chemical and biological properties of soil were observed by the following parameters of soil test: -

Physical properties: - aggregate stability and water holding capacity. Chemical properties: - Soil pH, Electrical conductivity (EC) and Total Nitrogen content. Biological properties: -Percentage of organic carbon and organic matter.

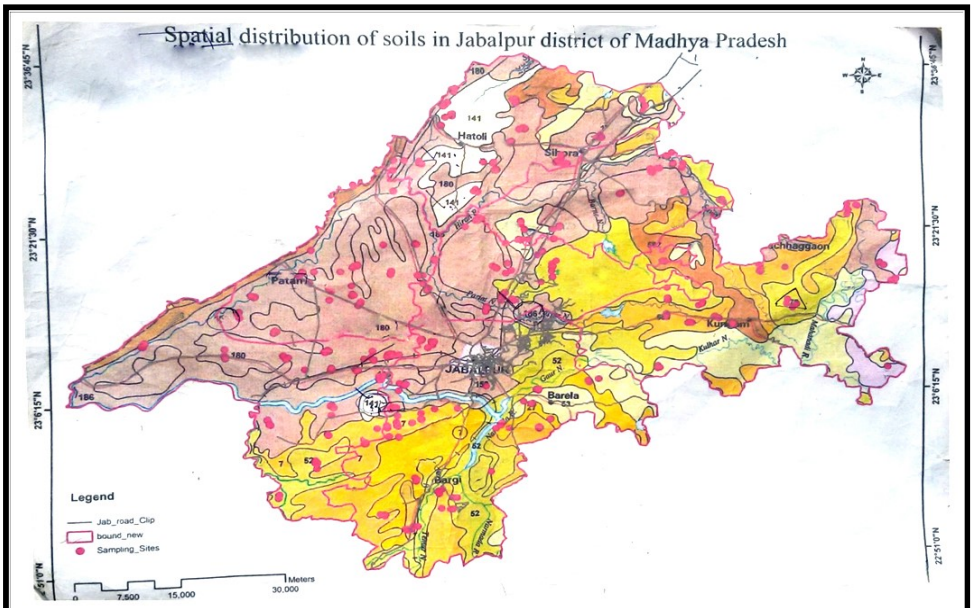

Figure 1- Different region of Jabalpur

Physical Parameters

Aggregate stability

Two pea sized clumps (aggregates) of soil were placed in a shallow dish filled with water and Clumps of soil were observed after 20 min, 1 hour and 24 hours.

Water holding capacity

40 g soil samples were taken to each cup and 50 ml water was added then each of the samples was weighed with water and data was recorded. Samples were set for overnight. Samples were tipped on

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their sides to drain water, which did not allowed soil in cup to drain out with water. Each of the samples was again weighed after the water was drained and then data was recorded. The difference between weight after draining the water and dry weight was calculated.

Chemical Parameters

pH of soil **-**pH of soil was measured by the method of Hanlon,1996

25g soil was taken in 100 ml beakers and 40 ml water (distilled or de-ionized water) was added to each beaker using a pipette and stirred with a glass rod.

The sample was set for 30 min then pH meter was calibrated by two buffer solutions (pH 4.0 and pH 7.0).The sample was stirred immediately before measuring the pH Than pH of the sample was taken.

Electrical conductivity (EC) of soil

Electrical conductivity of soil was measured by the method of Rayment and Higginson, 1992.

1:5 soil: water suspension was prepared by weighing 10 g air-dry soil (<2 mm) into a bottle, 50 ml deionised water was added and was shake at 15 rpm for 1 hour to dissolve soluble salts then Conductivity meter was calibrated by using the KCl reference solution to obtain the cell constant.Conductivity cell was dipped in the soil suspension and was taken out the conductivity cell without disturbing the settled soil and the value indicated on the conductivity meter was recorded.

Total Nitrogen content

Total Nitrogen contain of soil was measured by the method of Kjeldahl, 1883.

1 g sample of soil was weighed, placed in Kjeldahl flask and 0.7 g copper sulphate, 1.5 g K_2SO_4 and 30 ml H_2SO_4 were added.Gently heated until frothing ceases, small amount of glass beads was added to reduce frothing then Boiled briskly until solution was cleared and then digested for 30minutes.Removed the flask from the heater and cool, 50 ml water was added and transferred to distilling flask then 20 ml standard acid (0.1M HCl) was taken in the receiving conical flask then 2-3 drops of methyl red indicator added, enough water was added to cover the end of the condenser outlet tubes.30 ml of 35% NaOH was added in the distilling flask in such a way that the contents did not mixed then The contents were heated to distil the ammonia for about 30-40 minutes.Receiving flask was removed and rinsed outlet tube into receiving flask with a small amount of distilled water then titrated excess acid in the distillate with 0.1M NaOH and Blank was determined by reagents using same quantity of standard acid in a receiving conical flask.

Calculation

$$\text{Percent N} = \frac{1.401\,(V1M1 - V2M2) - (V3M1 - V4M2)}{W} \times df$$

Where,

V1 - ml of standard acid taken in receiving flask for samples

V2 - ml of standard NaOH used in titration

V3 - ml of standard acid taken to receiving flask for blank

V4 - ml of standard NaOH used in titrating blank

M1 - Molarity of standard acid

M2 - Molarity of standard NaOH

W - Weight of sample taken (1 g)

df - Dilution factor of sample (If 1 g was taken for estimation, the dilution factor willbe 100).

Note: 1000 ml of 0.1 M HCl or 0.1 M H_2SO_4 = 1.401 g Nitrogen

Biological Parameters

Organic carbon/Organic matter

Organic carbon/Organic matter was measured by the method of Walkley and Black, 1934.

1.0 g of the prepared soil sample was weighed in 500 ml conical flask and 10 ml of 0.1667M $K_2Cr_2O_7$ solution was added with 20 ml concentratedH_2SO_4containing Ag_2SO_4.Mixed thoroughly and allowed the reaction to complete for 30 minutes then the reaction mixture with 200 ml water and 10 ml H_3PO_4 were diluted.10 ml of NaF solution and 2 ml of diphenylamine indicator were added and the solution was titrated with standard 0.5M $FeSO_4$solution to a brilliant green colour.A blank without sample was run simultaneously.

Calculation

One gram of soil is used; this equation simplifies to:

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3(S − T)/ S
Where,
S = ml $FeSO_4$ solution required for blank
T = ml $FeSO_4$ solution required for soil sample
3 = Eq W of C (weight of C is 12, valency is 4, hence Eq W is 12÷4 = 3.0)
0.003 = weight of C (1000 ml 0.1667M $K_2Cr_2O_7$ = 3 g C. Thus, 1 ml 0.1667M $K_2Cr_2O_7$ = 0.003 g C)
Organic Carbon recovery is estimated to be about 77%. Therefore, actual amount of Organic carbon (Y) will be:
77/100
Percent valueof organic carbon obtained x
Or Percentage value of organic carbon x 1.3
Percent Organic matter =
Y x 1.724 (organic matter contains 58 % organic carbon, hence 100/58 = 1.724.

RESULT

Aggregate Stability

Soil without treatment (control) revealed that soil type- 7 has non-dispersive and non-slaking quality, soil type 141 has dispersive quality, and 52, 53, 180 soil types has slaking quality. Similar results were observed in BGA bio-fertilizer (IARI and JNKVV) treated soil showed in table no.1. Thus the result showed that bio-fertilizers have less effective on aggregate stability of all soil types.

Table No 1: Aggregate stabilityof Soil

S. No	Soil type	Control (Aggregate stability)			JNKVV (Aggregate stability)			IARI (Aggregate stability)		
		1st day	15th day	30th day	1st day	15th day	30th day	1st day	15th day	30th day
1	52	Slaking	Slaking	Slaking	slaking	slaking	slaking	Slaking	slaking	slaking
2	53	Slaking	Slaking	Slaking	slaking	slaking	slaking	Slaking	slaking	slaking
3	180	Slaking	Slaking	Slaking	slaking	slaking	slaking	Slaking	slaking	slaking
4	7	Swollen	Swollen	Swollen	Swollen	Swollen	Swollen	Swollen	Swollen	Swollen
5	141	Slaking	Dispersive	Dispersive	slaking	Dispersive	Dispersive	Dispersive	Dispersive	Dispersive

Water Holding Capacity

The water holding capacity recorded at 30th day ranged between 44.96% - 70.89%, indicating soil type-141 has minimum water holding capacity and soil type-7 has maximum water holding capacity.No changes in water holding capacity was observed in soil treated with BGA bioferilizers and showed in table no. 2.

Table No 2: Water Holding Capacity of Soil

S.No.	Soil type.	Control (WHC) in %			JNKVV (WHC) in %			IARI (WHC) in %		
		1st day	15th day	30th day	1st day	15th day	30th day	1st day	15th day	30th day
1	52	66.06	66.07	66.02	66.08	66.11	66.15	66.07	66.10	67.03
2	53	60.99	60.98	60.82	60.96	61.06	61.08	60.98	61.09	60.12
3	*180*	*68.68*	*68.61*	*68.72*	*68.67*	*68.71*	*68.81*	*68.69*	*68.69*	*69.06*
4	7	71.80	70.79	70.89	71.84	71.86	71.89	71.82	72.04	72.14
5	141	45.39	44.87	44.96	45.37	44.87	43.96	45.38	45.10	44.89

Soil pH

The pH value of soils collected ranged between 6.85-7.95. Table no. 3 showed that no changes in pH values were recorded in soil types treated with bio-fertilizers.

Table No 3: pH Values of Soil

S.No.	Soil type	Control (pH)			JNKVV (pH)			IARI (pH)		
		1st day	15th day	30th day	1st day	15th day	30th day	1st day	15th day	30th day

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1	52	7.91	7.93	7.95	7.92	7.74	7.68	7.91	7.68	7.57
2	53	6.82	6.84	6.85	6.81	6.67	6.61	6.83	6.85	6.69
3	180	7.68	7.71	7.73	7.65	7.41	7.35	7.67	7.34	7.28
4	7	7.58	7.59	7.64	7.59	7.41	7.38	7.58	7.27	7.12
5	141	6.47	6.48	7.53	6.49	6.92	6.96	6.47	6.83	6.86

Electrical Conductivity

The results of EC showed in table no. 4, there was increase in EC of all the soil types applied with bio-fertilizers.

Table No 4: Electrical Conductivity of Soil

S.No.	Soil type.	Control (EC)			JNKVV (EC)			IARI (EC)		
		1st day	15th day	30th day	1st day	15th day	30th day	1st day	15th day	30th day
1	52	0.1	0.1	0.1	0.1	0.2	0.3	0.1	0.3	0.4
2	53	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.2	0.2
3	180	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.3	0.4
4	7	0.2	0.2	0.2	0.2	0.3	0.4	0.2	0.4	0.4
5	141	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2

Total Nitrogen Content

In table no. 5, all the soils type showed increase in total nitrogen content when treated with bio-fertilizers, Maximum increase in total nitrogen contain was observed in soil type-7 treated with bio-fertilizer (IARI).

Table No 5: Total Nitrogen content of Soil

S.No.	Soil type.	Control (N)			JNKVV (N)			IARI (N)		
		1st day	15th day	30th day	1st day	15th day	30th day	1st day	15th day	30th day
1	52	235	228	227	235	258	265	235	271	276
2	53	243	237	221	243	259	264	243	273	279
3	180	241	237	233	241	264	271	241	279	285
4	7	249	248	240	249	259	267	249	282	289
5	141	229	226	221	229	239	247	229	248	266

Percentage of Organic Carbon and Organic Matter

Percentage of organic carbon and organic matter showed increase when treated with bio-fertilizers. Maximum increase was recorded in soil type-7 with organic carbon of 1.08% and organic matter of 1.86% treated with bio-fertilizer of IARI. (Table No. 6 and 7).

Table No 6: Organic Carbon of Soil

S.No.	Soil type.	Control (OC %)			JNKVV (OC %)			IARI (OC %)		
		1st day	15th day	30th day	1st day	15th day	30th day	1st day	15th day	30th day
1	52	0.67	0.65	0.61	0.66	0.71	0.73	0.69	0.74	0.75
2	53	0.84	0.83	0.81	0.83	0.91	0.92	0.84	0.91	0.94
3	180	0.83	0.81	0.75	0.82	0.86	0.88	0.84	0.91	0.94
4	7	0.95	0.93	0.89	0.94	1.01	1.04	0.96	1.05	1.08
5	141	0.54	0.51	0.47	0.53	0.57	0.61	0.55	0.61	0.63

Table No 7: Organic Matter of Soil

S.No.	Soil type.	Control (OM %)			JNKVV (OM %)			IARI (OM %)		
		1st day	15th day	30th day	1st day	15th day	30th day	1st day	15th day	30th day
1	52	1.15	1.12	1.05	1.13	1.22	1.25	1.18	1.27	1.29
2	53	1.44	1.43	1.39	1.43	1.56	1.58	1.44	1.56	1.62
3	180	1.43	1.39	1.29	1.41	1.48	1.51	1.44	1.56	1.62
4	7	1.63	1.6	1.53	1.62	1.74	1.79	1.65	1.81	1.86

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Photo 1: Different Soil Collected.

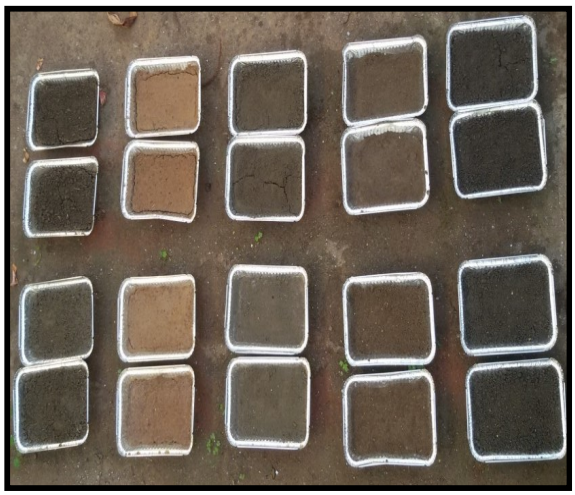

Photo2 : Commercial Algal Bio-fertilizers.



5	**141**	**0.93**	**0.87**	**0.81**	**0.91**	**0.98**	**1.05**	**0.93**	**1.05**	**1.08**

Algalization has been known as an important input in cultivation of rice as it forms a continually renewable source of nutrients and improves the soil health (De, 1993; Venkataraman, 1981; Roger and Kulasooriya, 1980; Goyal, 1993; Roger, 1995; Hedge *et al*., 1999). Result in Table No. 5, showed enhancements in total nitrogen contain in soil. Field experiments conducted at different places also showed that algalization increase the nitrogen content of soil (Aiyer*et al*., 1971; Satapathy, 1999). The organic carbon content was also superior in soil applied with bio-fertilizers. Report are also available that shows increasing trend in organic carbon content in soil in the plots that received the algal inoculation (Aiyer*et al*., 1971; Satapathy, 1999). Result shows enhancement in OC of all soil types in Table No. 6, A buildup of organic matter due to algae has been postulated by De and Sulaiman (1950).Hegde*et al*., (1999) have also reviewed that inoculated BGA on establishment and under good condition of growth contribute sustainable amount of organic matter. The BGA undergoes decomposition and converts 10-15% fixed N into polymers similar to humic acid which is indicative of the residual effect of BGA on the subsequent crop. Thus the status of the present investigation revealed beneficial role of BGA bio-fertilizer improving the status of the soil in terms of chemical and biological properties.

Conclusion and Future Prospects

Based on the above investigation of physical, chemical and biological properties of five types of soils treated with two BGA bio-fertilizers it could be concluded that no changes were observed in aggregate stability, water holding capacity and pH level applied with bio-fertilizers. All the soil types showed increase in EC, total nitrogen content, organic carbon percent and organic matter percent, applied with bio-fertilizers. Out of the five types of soils tested, soil type- 7 has showed maximum increase in EC, total nitrogen content, organic carbon percent and organic matter percent. Among the two bio-fertilizers tested, the bio-fertilizer obtained from IARI showed more increase in EC, total nitrogen content, organic carbon percent and organic matter percent when applied to soils. Bio-fertilizer technology is still not very common to Indian farmers. Use of microbial inoculants for bio-fertilizer in agriculture represents an attractive environment friendly alternative. Attention should be paid to the practice involved in the use of BGA bio-fertilizer to improve soil fertility and productivity of crop yields. This new approach to farming often referred to as sustainable agriculture and can give them an option of producing organic food naturally free from any type of chemical or synthetic fertilizer and pesticides.

Abbreviations

EC-Electrical Conductivity, WHC-Water Holding Capacity, N-Nitrogen, OC-Organic carbon, OM-Organic matter, μgml^{-1}-Micro Gram Per Mililiter, Wt-Weight, NaOH-Sodium Hydroxide, H_2SO_4-Sulphuric acid, Conc.-Concentrated, NaF-Sodium Fluoride.

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