Comparative Studies of the Clarification Potentials of Ferric Chloride and *Moringa Oleifera* Coagulants

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Abstract. The significant treatment costs of drinking water make treated water costly, raising the price of clean and helping make clean water inaccessible to the poor people in rural communities. This compels them to turn to readily available sources which are mainly contaminated. This subjects them to waterborne diseases.

In this context, this study was carried out to validate the efficiency and, if feasible, the substitution of Ferric Chloride utilised in the treatment of water using *Moringa Oleifera* seeds, a cheap and widely accessible indigenous coagulant. The quality of water was tested on collection compared to those treated with Ferric Chloride and Moringa Seeds. Doses of 5 g, 10 g, 15 g, 20 g, 25 g and 30 g of both coagulants were used to treat 500 ml of water. Control water without Ferric Chloride and Moringa treatments was included. The pH, turbidity, conductivity and COD were measured. From the ANOVA statistical analysis, several factors such as pH were analysed, and there was a wide variation between the two treatments of Moringa and Ferric Chloride.

Keywords: *Moringa Oleifera*, Ferric Chloride, water treatment, Coagulants, Turbidity.

INTRODUCTION

Potable water supply is a significant endeavour, particularly in underdeveloped nations. This is so because the chemicals necessary for treatment: alum for coagulation, polyelectrolytes as coagulant aids, lime for softening and pH correction, and chlorine for disinfection; have to be imported using limited foreign currency. In reply to this, local resources are being investigated as an alternative.

Various academics have investigated *Moringa Oleifera* seeds in this respect. Among all the plant materials which have been evaluated throughout the years. The sources from *Moringa Oleifera* have indeed been found to be one of the most efficient as the main coagulant for water treatment.

In this Minor field Observation, we will examine the possibility of using Moringa as an alternative water clarification agent for water treatment in Umudike and establish a protocol for the preparation, use and dosage of Moringa to use it for water treatment.

Water is a crucial natural resource needed for maintaining life. It is in a continuous circulation movement (i.e., hydrological cycle) and is not equally distributed in time and location. Due to its various advantages and the challenges generated by its surpluses, shortages and quality degradation, water as a limited resource demands particular care.

Water treatment generally incorporates water clarity and disinfection techniques [11]. In traditional water treatment, several procedures comprising coagulation, flocculation, sedimentation, filtration and disinfection are typically utilised [6]. A combination of numerous methods is frequently required to enhance raw water quality depending on the water quality issues present, the desired quality of the treated water, the costs of different treatments and the scale of the water system [4].

Methods of water treatment from biological materials will undoubtedly be successful in delivering water at a low and reasonable price and at all times in every home. One strategy that has been performed by people in some areas of the developing world is using locally available natural coagulants to lower turbidity and decrease bacteria in surface water [1].

Lack of safe drinking water is the world's most significant health issue. About 4 billion instances of diarrhoea are recorded yearly, of which two million result in death. Every day roughly 6 thousand children die from lack of safe drinking water. Today, more than one billion people in developing nations use polluted water for drinking and other domestic purposes. Moringa is recognised as the solution to lower the prevalence of water-related infections, which is one of the leading causes of fatalities in developing countries. United Nations has set Millennium Development Goals (MDG's), aiming to eliminate half the number of people without access to clean water by 2020. The aim can be accomplished only through the utilisation of locally available resources and by the adoption of low-cost treatment options.

The study aims to carry out comparative studies of the clarification potentials of Ferric Chloride and *Moringa Oleifera* coagulants. In this research, we seek to compare the water clarification potentials of these two coagulants to identify which is more effective for water clarification. These objectives can be achieved through the completion of the following steps. They are mixing different dosages of the coagulants with the effluent to determine their different rates of clarification.

There are various kinds of Natural Coagulants, but this research is restricted solely to studying *Moringa Oleifera* and comparing its Clarification capability to that of Ferric Chloride.

Although water treatment chemicals are efficient and utilised globally, research data reveals that exposure to chemicals during coagulation with metal salts might be connected with detrimental health consequences [6]. Aluminium, which is the primary component of Aluminium Sulphate (alum), Polyaluminium chloride (PAC) and Polyaluminium Silica Sulphate (PASS), might cause Alzheimer's disease and other similar connected disorders that are associated with residual Aluminium in treated water [4]. The use of natural materials to purify drinking water in various places around the globe has been documented throughout human history. However, these natural materials have not been accepted or appropriately supported owing to a lack of understanding of their specific nature and the mechanism by which they work. As a result, the natural materials cannot compete successfully with the regularly utilised water chemicals [9, 10].

There has been a renewed interest in using naturally occurring alternatives to currently used coagulants for water treatment in developing countries [3], mainly due to cost implications linked with inorganic chemicals, synthetic organic polymers and disinfectants [9, 10]. There is also an interest in utilising some of the by-products from natural coagulants in other industries [5].

The conclusions of this research will be valuable to stakeholders in the academic and environmental sectors. These stakeholders comprise healthcare personnel, government health authorities, teachers and students if *Moringa Oleifera* is proven more efficient than ferric chloride as a clarifying agent. Findings from this study might give information which could enlighten the government on the necessity for workshops, seminars and conferences to extend the knowledge on the usage of Moringa and the search for Natural alternative sources of Coagulants to be integrated into the water treatment process in the Country.

METHODS

Preparation of Coagulants. *Moringa Oleifera*: The seeds of Moringa will be collected/sourced from a National Root Crops Research Institute. They would be air-dried at 45 °C for 48 hours. The chaff around the seed kernel will be separated, and the grains will be crushed fine using a blender into powder. This was how the *Moringa Oleifera* coagulants would be made.

Ferric Chloride: Ferric Chloride would be obtained from a science laboratory in Umuahia Township. It will also be packaged and sealed on purchase.

Preparation of Effluent. To carry out the preliminary studies to determine the efficiency of these coagulants, we sourced water from a local stream from stream located along Goodluck Ebele Jonathan Hostel in Michael Okpara University of Agriculture, Umudike.

Apparatus: pH Meter – for measuring pH Level; spectrophotometer – for determination of COD; conductivity Meter – measuring conductivity; turbidimeter– for turbidity measurements; jars and beakers; pipettes; measuring cylinders; weighing balance; stopwatch; oven.

Analysis. The jar test is the most often used technique for analysing and optimising the coagulation-flocculation processes. This research consists of a series of simultaneous batch tests, including three steps: quick mixing, gradual mixing, and sedimentation.

Turbidity measurements were made using a turbidimeter. Turbidimeter will be measured using distilled water, and 40 NTU standard solution will be made using 1 g hydrazine and 10 gm hexamethylenetetramine solution. The pH will be adjusted using concentrated Sulphuric acid 0.1 M and sodium hydroxide 0.1 M solution. The pH will be tested using a pH meter.

Conductivity will be determined using a conductivity meter. For estimation of COD, the effluents will be digested in the spectrophotometer, and the titration will be carried out using the standard reagents and technique.

RESULTS AND DISCUSSION

The volume of water at the beginning of the test was 6.5 litres, divided into 12 jars of 500 ml for treatment and an additional pot for control.

The values of the different test parameters for the water at the point of collection (serving as our control) are as follows (Table 1).

Table 1 – The values of the different test parameters for the water

Parameters	Initial values of stream water sample (control)	WHO standard
pH	5.7	7.6
Conductivity (μs/cm)	107	1400
Turbidity (NTU)	7.9	5
COD (mg/L)	6.9	100

Value of POC against WHO standard. The results obtained from the following treatments for these parameters would be tested against the WHO standard for drinking water, and the better coagulant would be selected.

Physicochemical Measurements. The mean values of physicochemical parameters for raw water samples such as pH, Conductivity, Turbidity and Chemical Oxygen Demand before and after treatment with different dosages of the coagulants.

The World Health Organization considers normal drinking water any water with a pH between 6.5 and 8.5 [13]. Although pH typically has little direct influence on water users, it is one of the essential water-quality criteria.

Moringa Oleifera's coagulant efficiency resides in the presence of water-soluble cationic proteins in the seeds. This means that in water, the essential amino acids contained in the protein of Moringa would absorb a proton from water triggering the release of a hydroxyl group [9, 10]. In similar research, [8] discovered that pH did not significantly influence the quality of treated water in a randomised factorial experiment with varying quantities of *Moringa Oleifera*.

The pH of water during treatment is critical for removing organic compounds and heavy metals. Alkaline pH encourages the precipitation of most metals as insoluble solids. The pH of the residential sewage at the time of collection was 5.7. After treatment, the pH value declined and ranged from 3.6 to 4.2 for Ferric Chloride and *Moringa Oleifera*. The matter went from 4.5 to 4.7. The reported pH levels were not within the WHO suggested limit of pH of 8.5 to 6.5 for chemically treated water [13], rendering them unsafe for drinking. The differences were significant ($p<0.05$) between all the treatments at the varied coagulant concentrations on pH. These pH readings do not fall inside the WHO criteria for drinking water. Both Coagulants, however, lowered the pH of the water to acidic levels (Table 2).

Table 2 – Values of laboratory tests conducted on water samples

Ferric chloride					Moringa				
Dosages, g	pH	Turb (NTU)	Cond (μs/cm)	COD (mg/l)	Dosages, g	pH	Turb (NTU)	Cond (μs/cm)	COD (mg/l)
5	3.6	8.5	534	8.11	5	4.5	11.7	250	7.82
10	3.8	8.6	538	8.32	10	4.3	12.0	258	8.10
15	3.9	8.9	542	9.55	15	4.4	12.8	260	8.22
20	4.0	9.2	553	10.25	20	4.3	13.0	264	8.35
25	4.1	9.7	558	11.03	25	4.6	13.4	269	8.51
30	4.2	10.5	565	12.26	30	4.7	13.7	273	8.70

The figure 1 suggests a steady rise in the pH of the water sample with a matching increase in the doses of both *Moringa Oleifera* and Ferric Chloride. From the ANOVA statistical analysis, there was an evident significant difference between the two treatments of Moringa and Ferric Chloride ($P=6.98 \times 10^{-4}$) (Figure 2).

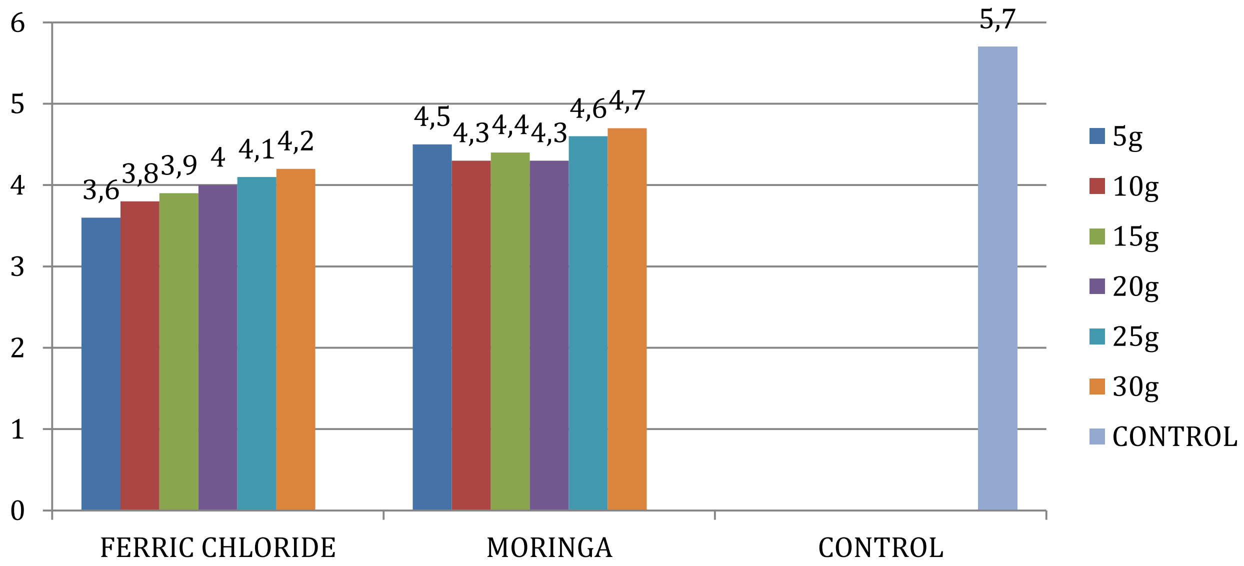

Figure 1 –Effect of different doses of coagulants on water sample wrt ph

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Column 1	6	23.6	3.933333	0.046667		
Column 2	6	26.8	4.466667	0.026667		
ANOVA						
rce of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between G	0.853333	1	0.853333	23.27273	0.000698	4.964603
Within Gro	0.366667	10	0.036667			
Total	1.22	11				

Figure 2 – Anova analysis for Ph of both Moringa and Ferric Chloride

Chemical Oxygen Demand. Chemical oxygen Demand is the measure of oxygen equivalent to the sample's organic content that is subject to oxidation by a strong chemical oxidant. It is an evaluation used to measure the level of water contamination by organic matter. The COD values for the Stream Water were 6.9 on the collection and moved from 8.11 to 13.26 on treatment with different doses of *Moringa Oleifera* coagulant and also moved from 7.82 to 8.70 on treatment with varying amounts of Ferric Chloride coagulant.

Figure 3 indicates a gradual increase in the pH of the water sample with a corresponding increase in the dosages of both *Moringa Oleifera* and Ferric Chloride. The ANOVA statistical analysis showed a significant difference between the two treatments of Moringa and Ferric Chloride. ($P=3.36 \times 10^{-2}$) (Figure 4).

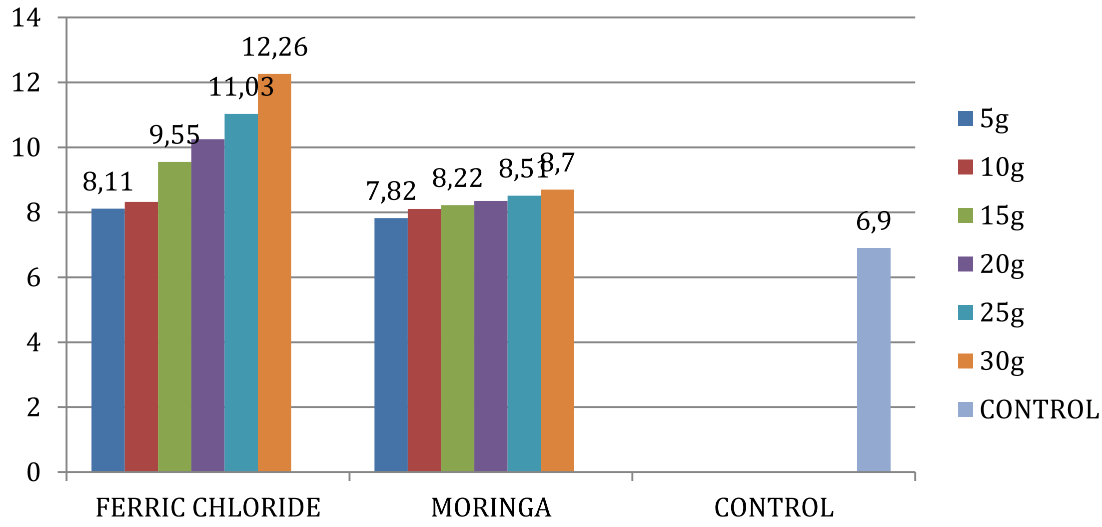

Figure 3 – Effect of different doses of coagulants on water sample wrt COD

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Column 1	6	59.52	9.92	2.55792		
Column 2	6	49.7	8.283333	0.096347		
ANOVA						
rce of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between G	8.036033	1	8.036033	6.055182	0.033635	4.964603
Within Gro	13.27133	10	1.327133			
Total	21.30737	11				

Figure 4 – Anova analysis for COD of both Moringa and Ferric Chloride

Electrical Conductivity. Electrical Conductivity (EC) measures a solution's capacity to conduct electric current, which is significantly reliant on the availability of ionic species. Inorganic ions have a substantial impact on the conductivity of water. High values of EC suggest that inorganic ions are in plenty in the wastewater. EC is directly proportional to the total dissolved solids (TDS) concentration. High EC in wastewater is a sign of high total dissolved solids concentration. This also means that the capacity of an electric current to travel through the wastewater is proportional to the number of ionic solutes dissolved in the water.

Figure 5 suggests a steady rise in the pH of the water sample with a matching increase in the doses of both *Moringa Oleifera* and Ferric Chloride. From the ANOVA statistical analysis, there was an evident significant difference between the two treatments of Moringa and Ferric Chloride. ($P = 2.63 \times 10^{-13}$) (Figure 6).

Turbidity. These turbidity readings obtained following seed coagulation were under the WHO-recommended turbidity threshold of 5 NTU for safe drinking water [13]. Before the water treatment from the Moringa and Ferric Chloride villages, turbidity levels were found to be over the required criteria for drinking water.

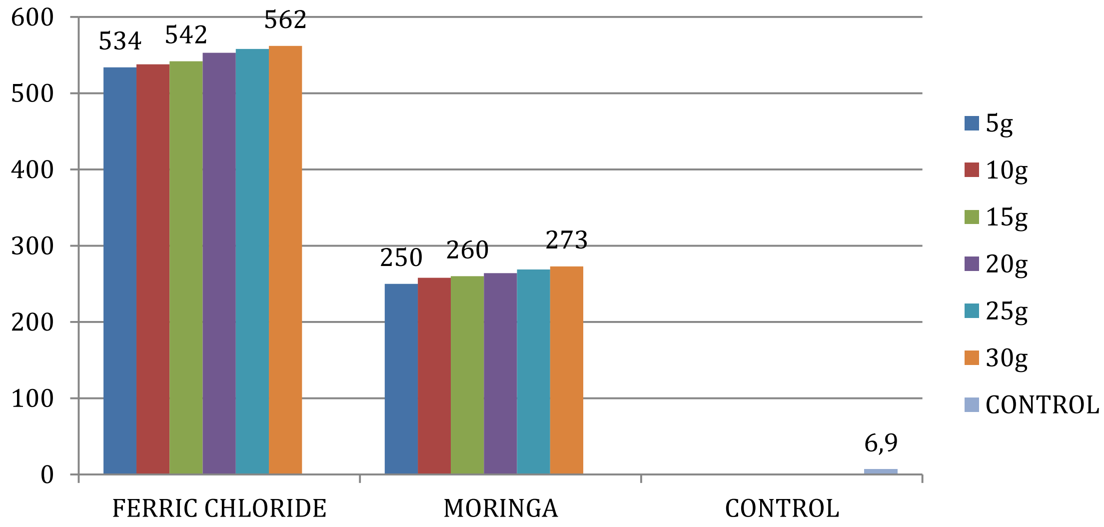

Figure 5 – Effect of different doses of coagulants on water sample wrt conductivity

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Column 1	6	55.4	9.233333	0.574667		
Column 2	6	76.6	12.76667	0.610667		
ANOVA						
rce of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between G	37.45333	1	37.45333	63.1946	1.24E-05	4.964603
Within Gro	5.926667	10	0.592667			
Total	43.38	11				

Figure 6 – Anova analysis for turbidity of both Moringa and Ferric chloride

The turbidity measured might be ascribed to phytoplankton, re-suspended bottom sediments and organic debris. Surface runoffs, features of parent rock and human activities such as farming in the immediate surrounding of water sources also add to the rise of turbidity [13]. Excessive turbidity in water creates issues with the water purification process, such as flocculation and filtration and is usually connected with the likelihood of microbiological contamination [7].

The turbidity at the point of the collection was 7.9 NTU. Figure 7 shows that the turbidity level fell fast for the control culture for both Ferric Chloride and Moringa treatments throughout the experiment.

From the ANOVA statistical analysis, there was an evident significant difference between the two treatments of Moringa and Ferric Chloride ($P=1.24\times10^{-5}$) (Figure 8).

CONCLUSIONS

This study focuses on the introduction and adoption of Natural coagulants in water treatment facilities. Artificial coagulant such as Ferric Chloride, tested for clarity against *Moringa Oleifera*, has indicated that Moringa is a good alternative for Artificial Coagulants in treatment plants.

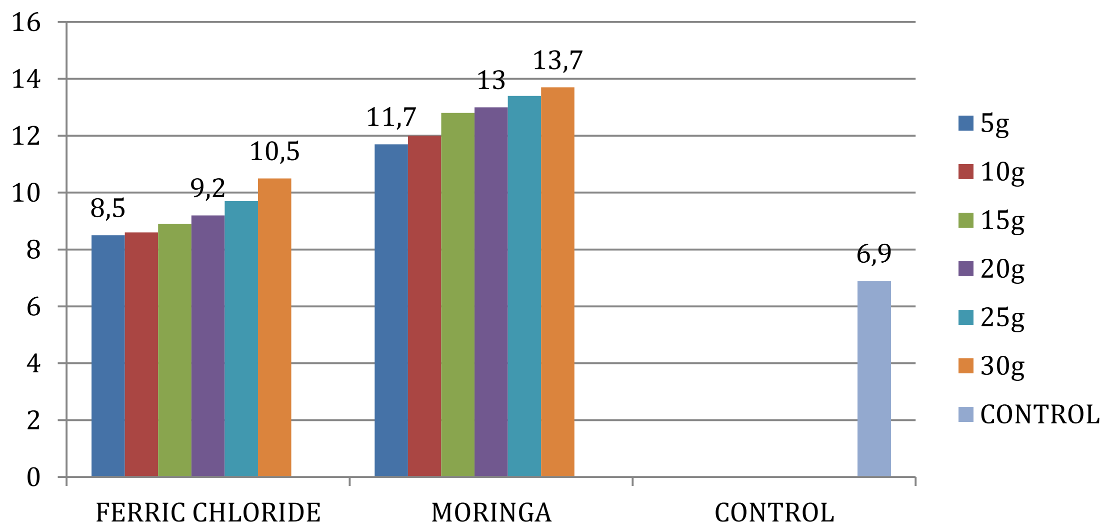

Figure 7 – Effect of different doses of coagulants on water sample wrt turbidity

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Column 1	6	3287	547.8333	130.5667		
Column 2	6	1574	262.3333	67.46667		
ANOVA						
rce of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between G	244530.8	1	244530.8	2469.592	2.63E-13	4.964603
Within Gro	990.1667	10	99.01667			
Total	245520.9	11				

Figure 8 – Anova analysis for the conductivity of both Moringa and Ferric chloride

Moringa Oleifera is an efficient natural coagulant which may be employed in enhancing the physicochemical parameters of water in terms of pH, turbidity, COD and conductivity.

Moringa Oleifera is an ecologically safe natural coagulant best appropriate for treating water with undesired heavy metal concentrations. Based on the experimental test findings, the following conclusions may be drawn:

1. *Moringa Oleifera* is an eco-friendly technology and commercially favourable.

2. *Moringa Oleifera* is an efficient natural coagulant which may be employed in enhancing the physicochemical features of water in terms of pH, turbidity, total dissolved solids, suspended particles, alkalinity and conductivity.

3. *Moringa Oleifera* seeds provide a feasible alternative coagulant to alum purifying water for rural communities because they are ecologically benign and inexpensive.

4. The data obtained demonstrate that powder from the seed of M. Oleifera includes specific coagulating capabilities. These concentrations have the same impact as the traditional coagulum, alum, or Ferric Chloride.

5. *Moringa Oleifera* seeds provide a feasible alternative coagulant to alum purifying water for rural residents because it is ecologically benign and inexpensive.

Based on our results, we may offer the following suggestions. There is a need for public education on the usage of Moringa in water clarity via seminars and the media. Also, there is a need for water treatment facilities to integrate organic coagulants into the treatment plants since they are conveniently obtained and medically suitable. Government and commercial groups should engage more in Moringa farming as it has the potential to lower the cost of water treatment and may help improve the water quality for rural populations.

A future study is proposed on the following:

- the combination of both Natural and Artificial coagulants in various dosages and a study of their combined efficiency on the wastewater sample.

- timed examination of the long-term state of water treated with *Moringa Oleifera* Coagulant.

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