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Study of some Chemical Properties of some Algae and Aquatic Plants

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Abstract

The aim of the study was to know the chemical properties of some algae,*Enteromorpha* and *Cladophora*,and some selected aquatic plants,*Typha domingensis*,*Ceratophylum demersum*, *Vallisneria eriaspiralis*, Sodium, potassium and calcium at different times of the seasons.*Cladophora* alga showed the highest percentage in water contentwhich amounted to (89.50%), proteins (41.13%)and calcium (2.06%)while *Enteromorpha* algae showed the highest percentage in dry matter which amounted to
(88.72%), carbohydrates (62.40%)and sodium (7.89%).

As for the plants,clear significant differences appeared in the different seasons, as the results showed that the highest value of water content in the spring season was in each of *Typha*(85.42), *Vallisneria*(95.81) while the rest of the seasons did not show significant differences between them.As for the dry matter, the highest value was in the winter season in *Typha* (25.33)and *Vallisneria* (9.56).The spring season was characterized by having the highest percentage of carbohydrates in each of *Typha*(73.61) and *Ceratophylum*(44.98),And the highest percentage of proteins in the summer season was in each of *Typha* (12.62) and *Ceratophylum* (22.13) .The highest percentage of sodium in the spring was in *Typha*(0.37) and *Ceratophylum*(1.39) .The highest percentage of potassium in the summer was in all of *Ceratophylum*(6.35)and*Vallisneria*(6.08).The summer season was characterized by containing the highest percentage of calcium in all of *Ceratophylum* (0.83) and *Vallisneria* (2.62).

Introduction :

The marshes and swamps of southern Iraq were a distinct environment for many living organisms, and they are characterized by a nature in which only plants and animals capable of adapting and living in such an environment can live (Ministry of Environment, 2007).Algae are a group of single-celled or multicellular organisms, and their sizes range from minute (1) micrometer to large (more than 200) feet (Lee *et al.*, 2008).Algae also have an important role in the industrial ,food ,medical and agricultural fields,as well as the environmental aspect (Athbi, 2014).Algae were also used in the industrial field, including the manufacture of dental molds, paper, rubber, and cosmetics (Fuller *et* *al.*, 1997).In the food field,algae is a source of many elements, vitamins, proteins and amino acids (Gross, 2000 ; Yun ; Park, 2003).In the agricultural field, some algae perform the process of nitrogen fixation, and crops such as rice and corn benefit from this process(Fuller *et al.*, 1997).In the environmental field, algae reduce the intensity of water pollution by absorbing phosphates and nitrates from the water for the purpose of their growth (Hussein, 2013).In the medical field, algae have been used to treat diseases such as cough, asthma, hemorrhoids, abscesses, enlarged thyroid gland, headaches, and ulcers.(Kandale *et al.*,2011).

Aquatic plants are an important ecosystem for many living organisms, as well as a food source for many animals and humans, and they regulate the reproduction and growth of aquatic organisms (Amiard *et al.*, 1998).The aquatic plants provide the water with oxygen and reduce the velocity of the running water and the accumulation of alluvial materials at the bottom (Al-Miyah ; Al – Himeem, 1991).Aquatic plants have a major role in maintaining the aquatic ecosystem from the physical ,chemical and biological aspects in terms of softening the environment, preventing fluctuations in temperature, controlling nutrient enrichment, and creating a suitable place for the growth of bacteria and algae (Njau ; Maly, 2003).

Materials and methods

Algae and plant samples

Algae and plant samples were collected from the marshes, and some of the fresh samples were weighed to be used in laboratory experiments. The rest of the samples were dried in an oven at a temperature of (105 C)then ground by an electric mill in order to be ready for chemical analysis.

1- Determination of water content and dry matter:

The water content and dry matter were estimated using the Oven drying method (5 gm) was dried at a temperature of (75) C for a period of (48) hours, and the sample was weighed after cooling it using a desicator. The percentages of water content and dry matter were calculated on The basis of the following two equations (Dalali ; Al – Hakim, 1987).

$$\text{Percentage of water content} = \frac{\text{Fresh sample weight} - \text{dry sample weight}}{\text{Fresh sample weight}} \times 100$$

$$\text{Dry matter percentage} = \frac{\text{sample dry weight}}{\text{Fresh sample weight}} \times 100$$

2- Estimation of soluble carbohydrates:

For the purpose of estimating soluble carbohydrates,the method of Herbert *et al.* ,(1971), when a certain weight of (200) mg was taken from the samples and crushed with (10) cm3 of distilled water in a ceramic lid,after which a centrifugation process was conducted for(15) minutes, then heating at a temperature of (50) h for a period of (30) minutes, then the centrifugation process was repeated and the filtrate free of solids and chlorophyll was taken,and the absorbance was measured in a spectrophotometer at a wavelength of (490) nm.

3- Estimation of soluble proteins:

Soluble proteins were estimated according to the method of Herbert *et al.* ,(1971),by taking a specific weight of (200) mg of soft samples,then crushing with(10)cm3 of distilled water in aceramic lid,and then centrifuging for(15)minutes,then heating at a temperature of(50°C)for(30) minutes, then the centrifugation process was repeated and the filtrate free of solids and chlorophyll was taken,and the absorbance was measured using a spectrometer at a wavelength of (600) nm.

4- Determination of mineral element concentrations:

The collected samples were taken and air-dried at laboratory temperature, then the dry matter was ground using an electric mill and passed through a sieve with a slot size of (1) millimeter and digested according to the method suggested by (Gresser ; Parsons , 1979) by taking(200) mg of the dry ground sample and placing it in a Caldal flask. A capacity of(100) cm3,which was washed with distilled water and a 6-N solution of hydrochloric acid .An acidic mixture of concentrated sulfuric and pyrochloric acid was used in digestion. After the end of the digestion process, the following ions were estimated:

1- Sodium and potassium ions (K+ Na+ and)

They were estimated by a flame – photometer, each separately, according to the method described by(Jackson , 1958).

2- Calcium ions (Ca++)

They were estimated by leaching with fernsite (Na2 EDTA), as miroxide was used as a calcium indicator (Black, 1965).

Statistical analysis

The data were analyzed statistically according to the randomized complete block design (CRBD)with three replications using Tow-way ANOVA and the Statistical Package for social science program (Spss ver 23) was used to extract the results and the Duncan test was used to calculatethe least significant difference(L.S.D)Least significant differences forcomparison between the means below the probability level$P \leq 0.05$ (Bryman ;Cramer, 2012).

Results and discussion

Table (1) shows the effect of the interaction between seasons and species on the percentage of water content of algae, as the high value of the water content percentage was in *Cladophora*algae, which did not show clear significant differences between them for all seasons, while the low percentage was in the algae *Enteromorpha*, which did not show clear significant differences between them for all seasons.As for the effect of species, the high value of water content percentage was in *Cladophora* algae (89.50%), while the low percentage was in *Enteromorpha* algae (8.24%). As for the average effect of seasons on the percentage of water content of algae, the highest percentage was in the summer, which amounted to (51.62%). While the remaining seasons did not show clear significant differences between them, and these results agree with the findings of(Aguilera *et al*., 2005).

Table (1) the effect of the interaction between seasons and species on the percentage of water content of algae

Species Seasons	*Enteromorопha*	*Cladophora*	Impact rate Seasons
Winter	**11.33**	**87.91**	**49.62**
Spring	**9.51**	**90.34**	**49.92**
Summer	**12.13**	**91.12**	**51.62**
Autumn	**12.14**	**88.65**	**50.39**
Impact rate Species	**8.24**	**89.50**	

R . L . S .D (P ≤ 0.05)

Species = 10. 45Seasons =0.88Overlap (Species * Seasons) = 7. 83

Table (2) also shows the effect of the interaction between seasons and species on the percentage of water content of plants. In the *Typha* plant, there were no significant differences between seasons except for winter, when the water content value was low (74.67%). As for the *Ceratophylum* plant, no significant differences appeared between the seasons except for the spring season, when the value of water content was low (82.17%), and in *Vallisneria*plant, also, no significant differences appeared between the seasons except for the spring season, when the water content value was high (95.81%). The results are consistent with the findings of (Mahmoud ,2008; Katea ,2009).

Table (2) the effect of the interaction between seasons and species on the percentage of water content of plants

Species Seasons	*Typha*	*Ceratophylum*	*Vallisneria*	Impact rate seasons
Winter	74.67	91.65	90.44	85.58
Spring	85.42	82.17	95.81	87.8
Summer	81.81	91.48	90.03	87.77
Autumn	84.89	90.11	91.13	88.95
Impact rate Species	81.69	88.85	91.85	
R.L.S.D	4.28	3.90	2.31	

R . L . S .D (P ≤ 0.05)

Also, the differences that appeared in the percentage of water content between the seasons of the year may be due to the difference between algae and plants in the stages of growth(Dykyjora, 1979), and the water content of any plant is affected by the rapid fluctuations of the water content of the soil and even the relative humidity in the atmosphere surrounding the plant (Al –Wahaibi,1984). and the reason for the difference in water content ratios in algae and plants may be attributed to genetic or environmental factors.

Table (3) shows the effect of the interaction between seasons and species on the percentage of dry matter of algae. As for the effect of species, the high value of the dry matter percentage of the alga *Enteromorpha* was (10.49%) while the low percentage was for the alga *Cladophora* (88.72%). As for the average effect of the seasons on the percentage of dry matter of algae, it was the lowest percentage in the summer, which amounted to (48.60%) while the remaining seasons did not show clear significant differences between them. These results agree with the findings of(Jassim;Ahmed , 2010)

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Table (3) the effect of the interaction between seasons and species on the percentage of dry matter of algae

Species Seasons	*Enteromoropha*	*Cladophora*	Impact rate Seasons
Winter	88.67	12.9	50.38
Spring	90.49	9.66	50.07
Summer	87. 87	8.88	48.37
Autumn	86. 87	11.35	49.60
Impact rate Species	88.72	10.49	

R . L . S .D (P ≤ 0.05)

Species = 9.31 Seasons = 0.88 Overlap (Species * Seasons) = 8.73

Table (4) also shows the effect of the interaction between seasons and species on the percentage of dry matter for plants. In *Typha*plant, there were no significant differences between seasons except for winter, when the percentage of dry matter was high (25.33%). As for *Ceratophylum*plant, there were no significant differences between the seasons, except for the spring season, when the percentage of dry matter was high (17.83%). Also, in *Vallisneria*plant, there were no significant differences between the seasons, except for the spring season, when the percentage of dry matter was low (4.19%). These results are consistent with the findings of (Al-Qaisi ,1994;Abbas ,2005;Katea ,2009).

Table (4) the effect of the interaction between seasons and species on the percentage of dry matter of plants

Species / Seasons	*Typha*	*Ceratophylum*	*Vallisneria*	Impact rate Seasons
Winter	**25.33**	**8.35**	**9.56**	**14.41**
Spring	**14.58**	**17.83**	**4.19**	**12.2**
Summer	**18.19**	**8.52**	**9.97**	**12.22**
Autumn	**15.11**	**9.89**	**8.87**	**11.29**
Impact rate Species	**18.30**	**11.14**	**8.14**	
R.L.S.D	**4.28**	**3.90**	**2.31**	

R . L . S .D ($P \leq 0.05$)

In the dry weight, it is due to the decrease in the percentage of water content on the one hand and the increase in the rate of accumulation of sugars on the other hand (Rygg, 1977 ; Abbas, 1987). Which encourages the absorption of other nutrients, including phosphate, as it works to increase the vegetative system and thus increase the dry weight.(Havlin *et al.*,1999).

Table (5) shows the effect of the interaction between seasons and species on the percentage of carbohydrates in algae, indicating that there are clear significant differences,as the high concentration of carbohydrates in the alga *Enteromorpha* in winter and autumn reached (67.44%) and (68.62%) respectively, and the low percentage was in *Cladophora* algae in winter, spring and summer (33.12%), (41.53%) and (37.8%) respectively.As for the effect of the species, the high value of the percentage of carbohydrates for the algae *Enteromorpha* was (62.40%) while the low percentage was

for the algae *Cladophora* (39.16%). As for the average effect of the seasons on the percentage of carbohydrates for algae, the highest percentage was in the autumn season, which amounted to (56.41%) while the seasons remained No clear significant differences appeared between them.
These results agree with the findings of (Al-Shteiwi *et al.*,2021; Jassim *et al.*, 2021).

Table (5) the effect of interaction between seasons and species on the percentage of carbohydrates in algae

Species / Seasons	*Enteromoropha*	*Cladophora*	Impact rate Seasons
Winter	**67.44**	**33.12**	**50.28**
Spring	**56.53**	**41.53**	**49.03**
Summer	**57.02**	**37.8**	**47.41**
Autumn	**68.62**	**44.21**	**56.41**
Impact rate Species	**62.40**	**39.16**	

R . L . S .D (P ≤ 0.05)

Species = 8. 43 Seasons =3 .93Overlap (Species * Seasons) =9. 5
Table (6) also shows the effect of the interaction between seasons and species on the percentage of carbohydrates in plants. In *Typha*plant, the high value of carbohydrates in the spring season was (37.61%) and the low value in the winter and autumn seasons was(18.11%) and (20.12%). *Ceratophylum*The high value of carbohydrates was in the spring and summer seasons (44.98%) and (40.86%) and the low value in the winter and autumn seasons was (13.39%) and (12.78%). Also, in *Vallisneria*plant, no significant differences appeared between the seasons except for the winter season, where the value of Low carbohydrates (26.23%). These results agree with the findings of (Al-Qaisi ,1994; Freedman ,1998;Abdullah *et al*., 2001;Al-Issa , 2004; Abbas ,2005;Katea ,2009).

Table (6) the effect of the interaction between seasons and species on the percentage of carbohydrates in plants

Species / Seasons	*Typha*	*Ceratophylum*	*Vallisneria*	Impact rate Seasons
Winter	18.11	13.39	26.23	19.24
Spring	37.61	44.98	37.67	40.08
Summer	30.22	40.86	41.23	37.43
Autumn	20.12	12.78	38.91	23.93
Impact rate Species	26.51	28.00	36.01	
R.L.S.D	7.87	10.99	5.78	

R . L . S .D (P ≤ 0.05)

The difference in carbohydrate concentrations may be due to the difference in water quality and the physical and chemical properties of the soil (Al-Naimi ; Jaafar, 1980). Aquatic plants differ in their chemical composition according to the stage and season of growth (Mahmoud, 2008) .
There is no doubt that the influence of environmental factors affects the process of photosynthesis and thus affects its carbohydrate content (Al –Tamimi, 2006). Because lack of light leads to a lack of carbohydrates in plants (Kraemer ; Denis , 2000).
Table (7) shows the effect of the interaction between seasons and species on the percentage of proteins in algae, as the high concentration of proteins in *Cladophora* algae had no significant differences between the seasons of the year, and the low percentage was in the algae *Enteromorpha* in winter and autumn, reaching (6.12%) and (4.56%) respectively .As for the effect of species, the high value of protein percentage was in *Cladophora* (41.13%)while the low percentage was in *Enteromorpha* (9.02%). As for the average effect of seasons on the percentage of proteins for

algae,the highest percentage was in spring and summer (27.61%) and (27.83%), while the lowest percentage was in winter and autumn, reaching (22.33%) and (22.53%), respectively. These results agree with what It was reached by (Aguilera *et al*. ,2005;Zhang *et al*. , 2019) .

Table (7) the effect of the interaction between seasons and species on the percentage of proteins in algae

Species / Seasons	*Enteromorpha*	*Cladophora*	Impact rate Seasons
Winter	**38.55**	**6.12**	**22.33**
Spring	**43.11**	**12.11**	**27.61**
Summer	**42.36**	**13.31**	**27.83**
Autumn	**40.50**	**4.56**	**22.53**
Impact rate Species	**41.13**	**9.02**	

R . L . S .D (P ≤ 0.05)

Species = 10.70Seasons = 3.05Overlap (Species * Seasons) = 7.44

Table (8) also shows the effect of the interaction between seasons and species on the percentage of proteins in plants. In *Typha* plants, the high value of proteins was in summer and autumn (12.62%) and (12.53%) and the low value was in winter (5.88%). In the *Ceratophylum*plant, the high value of proteins was in the summer season (22.13%)and the low value in winter and autumn was (18.31%) and (17.92%). and the low value in the fall season (14.67%).These results are consistent with the findings of (Al-Sayyab *et al*.,2002;Al-Essa ,2004;Abbas ,2005;Anderson , 2006;Mahmoud ,2008).

Table (8) the effect of the interaction between seasons and species on the percentage of proteins in plants

Species / Seasons	*Typha*	*Ceratophylum*	*Vallisneria*	Impact rate Seasons
Winter	**5.88**	**18.31**	**17.53**	**13.90**
Spring	**9.56**	**19.52**	**20.11**	**16.39**
Summer	**12.62**	**22.13**	**19.21**	**17.98**
Autumn	**12.53**	**17.92**	**14.67**	**15.04**
Impact rate Species	**10.14**	**19.47**	**17.86**	
R.L.S.D	**2.75**	**1.64**	**2.07**	

R . L . S .D (P ≤ 0.05)

Table (9) shows the effect of the interaction between seasons and species on the percentage of sodium in algae, as the high concentration of sodium was in the algae *Entromorfa* in the winter, spring and summer, which did not show significant differences between them, and the low percentage was in the algae *Cladophora* during the winter, spring and autumn seasons. As for the effect of species, the high value of sodium percentage in *Enteromorpha* algae was(7.89%) , while the low percentage was in *Cladophora* algae (3.51%). As for the average effect of the seasons on the sodium percentage of algae, the low percentage was in winter (4.54%), while the rest of the seasons did not exist. There are significant differences between them.
These results are consistent with the findings of(Aguilera *et al*. ,2005)

Table (9) the effect of interaction between seasons and species on the percentage of sodium in algae

Species / Seasons	*Enteromoropha*	*Cladophora*	Impact rate Seasons
Winter	**6.56**	**2.52**	**4.54**
Spring	**9.11**	**3.96**	**6.53**
Summer	**7.70**	**4.81**	**6.25**
Autumn	**8.20**	**2.77**	**5.48**
Impact rate Species	**7.89**	**3.51**	

R . L . S .D (P ≤ 0.05)

Species = 3.09Seasons = 0.89 Overlap (Species * Seasons) = 2.53

Table (10) also shows the effect of the interaction between seasons and species on the percentage of sodium in plants. Spring (1.39%), while the rest of the seasons, there were no significant differences between them. In *Vallisneria*plant, the high value of sodium was in summer and autumn (2.32%) and (2.10%), and the low value in winter and spring (1.43%) and(1.70%).These results agree with the findings of (Briggs *et al*., 1985;Abbas ,2005).

Table (10) the effect of interaction between seasons and species on the percentage of sodium in plants

Species / Seasons	*Typha*	*Ceratophylum*	*Vallisneria*	Impact rate Seasons
Winter	**0.22**	**0.55**	**1.43**	**0.73**
Spring	**0.37**	**1.39**	**1.70**	**1.15**
Summer	**0.25**	**0.62**	**2.32**	**1.06**
Autumn	**0.20**	**0.40**	**2.10**	**0.9**
Impact rate Species	**0.26**	**0.74**	**1.88**	
R.L.S.D	**0.06**	**0.28**	**0.34**	

R . L . S .D (P ≤ 0.05)

Sodium concentrations in plants and algae have a direct and indirect effect on some chemical and physical properties of plants and algae due to the predominance of this element in the waters and soils of southern Iraq (Salman, 1987).

Table (11) shows the effect of the interaction between seasons and species on the percentage of potassium in the algae, as the high concentration of potassium was in the *Cladophora* algae in the spring,summer and autumn seasons, which did not show significant differences between them, and the low percentage was in the algae*Enteromorpha* in the winter, spring and autumn seasons, which did not appear between them moral differences. As for the effect of species, there were no significant differences in the element potassium in the algae *Cladophora* and *Enteromorpha*.As for the average effect of the seasons on the percentage of potassium for the algae, the high concentration of potassium was in the season,spring and summer (2.06%) and (2.17%). The lowest percentage was in the winter season (1.7%). These results agree with the findings of (Ebadi ; Hisoriev ,2018).

Table (11) the effect of interaction between seasons and species on the percentage of potassium in algae

Species Seasons	*Enteromorpha*	*Cladophora*	Impact rate Seasons
Winter	**1.50**	**1.90**	**1.7**
Spring	**1.80**	**2.33**	**2.06**
Summer	**1.90**	**2.45**	**2.17**
Autumn	**1.70**	**2.20**	**1.95**
Impact rate Species	**1.72**	**2.22**	

R . L . S .D (P ≤ 0.05)

Species = 0.35 Seasons = 0.20 Overlap (Species * Seasons) = 0.32

Table (12) also shows the effect of the interaction between seasons and species on the percentage of potassium for plants. (2.39%). The high value of potassium was in the spring season (1.39%). In the rest of the seasons there were no significant differences. In *Vallisneria*plant, the high value of potassium was in the spring and summer (5.44%) and (6.08%). Low in winter and autumn (4.21%) and (3.52%). These results agree with what was reached by (Abbas ,2005).

Table (12) The effect of the interaction between seasons and species on the percentage of potassium for plants

Species / Seasons	*Typha*	*Ceratophylum*	*Vallisneria*	Impact rate Seasons
Winter	**4.22**	**2.37**	**4.21**	**3.6**
Spring	**3.41**	**4.42**	**5.44**	**4.42**
Summer	**1.71**	**6.35**	**6.08**	**4.71**
Autumn	**2.39**	**3.33**	**3.52**	**3.08**
Impact rate Species	**2.93**	**4.11**	**4.81**	
R.L.S.D	**0.95**	**1.47**	**1.004**	

R . L . S .D ($P \leq 0.05$)

The difference in potassium concentrations may be attributed to the fact that potassium is an important element in the process of cell division, Hassan *et al*., (1990). It is also known that the element potassium does not participate in any organic compound inside the plant, but rather it has a major role in activating the vital processes (Mengel ; Kirkby, 1982). The content of potassium in algae and plants changes with the change of plant species and the age of the plant tissue.

Table (13) shows the effect of the interaction between seasons and species on the percentage of calcium in the algae, as the high concentration of calcium in the *Cladophora* moss in the spring and summer season was (3.13%) and (2.60%) and the low percentage was in the algae *Cladophora* *enteromorpha* in the rest of the seasons did not appear between them moral differences. As for the effect of the species, as the high concentration of calcium in the algae *Cladophora* was (2.06%)and the low percentage was in the algae *Enteromorpha* (1.92%). As for the average effect of the seasons on the percentage of calcium for algae, the high concentration of calcium was in the spring season (2.75%). The lowest percentage was in winter and autumn (1.6%) and (1.47%). These results are consistent with the findings of (Ebadi ; Hisoriev ,2018).

Table (13) the effect of interaction between seasons and species on the percentage of calcium in algae

Species Seasons	*Enteromorapha*	*Cladophora*	Impact rate Seasons
Winter	**2.10**	**1.10**	**1.6**
Spring	**2.38**	**3.13**	**2.75**
Summer	**1.67**	**2.60**	**2.13**
Autumn	**1.53**	**1.41**	**1.47**
Impact rate Species	**1.92**	**2.06**	

R . L . S .D (P ≤ 0.05)

Species =0.09 Seasons =0.58 Overlap (Species * Seasons) = 0.68

Table (14) also shows the effect of the interaction between seasons and species on the percentage of calcium for plants. In *Typha* plants, the high value of calcium was in spring (0.93%) and the low percentage was in winter and autumn (0.32%) and (0.47%). As for the *Ceratophylum*plant, the high value of calcium in the winter and summer seasons was (0.76%) and (0.83%) and the low percentage was in the autumn season (0.34%). In *Vallisneria*plant, the high value of calcium in the summer was (2.62%) and the low value in the winter and autumn seasons was (0.37%) and (0.83%). These results agree with the findings of (Briggs *et al*., 1985; Abbas ,1995;Abbas ,;2005).

Table (14) the effect of the interaction between seasons and species on the percentage of calcium for plants

Species / Seasons	*Typha*	*Ceratophylum*	*Vallisneria*	Impact rate Seasons
Winter	**0.32**	**0.76**	**0.37**	**0.48**
Spring	**0.93**	**0.62**	**1.53**	**1.02**
Summer	**0.55**	**0.83**	**2.62**	**1.33**
Autumn	**0.47**	**0.34**	**0.83**	**0.54**
Impact rate Species	**0.56**	**0.63**	**1.33**	
R.L.S.D	**0.22**	**0.18**	**0.51**	

R . L . S .D (P ≤ 0.05)

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