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Research Article

General Trends in Atmospheric Pollen Concentration in the High Populated City of Ankara, Turkey

Ankara İli Atmosferik Polen Konsantrasyonunun Genel Eğilimi

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Abstract

Long term pollen trend studies are important to precisely estimate the pollen season, and determine the meteorological factor which is effect on pollen concentrations. Ankara is the city which is the longest pollen survey has been done by both of gravimetric and volumetric methods in Turkey. Airborne pollen was monitored by continuous sampling with a Hirst volumetric sampler. We examined the long term trends in airborne pollen concentrations in Ankara, Turkey, over the period 1990-2011 by using linear regression and correlation analysis using mean annual and monthly pollen concentrations. We also tested for general monthly pollen concentration trends and effect of meteorological factors towards between the years. There was decreasing trend in total pollen concentration. We observed a significant increase in January, February, October and November and a decrease in from March to September and December by comparing monthly pollen concentrations. Regarding the pollen-season related attributes, there were very few significant trends. Consequently, pollen could seem to display a faster response to climate change than other airborne particles.

Keywords: Ankara, Atmosphere, Long term, Pollen trend

Öz

Uzun dönemde polen eğilimlerini kapsayan çalışmalar, polen sezonunun daha kesin bir şekilde belirlenmesi ve polen konsantrasyonuna etki eden meteorolojik faktörlerin belirlenmesi için önemlidir. Ankara ili, gravimetrik ve volumetrik metotlarla Türkiye'de en uzun süreli çalışılan ildir. Bu çalışmada Burkard volumetrik tuzağı kullanılarak uzun yıllarda atmosferde polen izlenmiştir. Ankara ilinde 1990-2011 yılları arasında, aylık ve yıllık ortalama polen konsantrasyonları baz alınarak linear regresyon ve korelasyon analizleri ile atmosferik polen trendi araştırılmıştır. Ayrıca yıllar içerisinde aylık polen konsantrasyonlarının genel eğilimi ve meteorolojik faktörlerin etkisi de ortaya konmuştur. Total polen konsantrasyonunda yıllar içerisinde genel olarak azalma eğilimi görülmüştür. Aylık polen konsantrasyonları yıllar içerisinde kıyaslandığında, Ocak, Şubat, Ekim ve Kasım aylarında polen konsantrasyonunda anlamlı bir artış olurken, Mart–Eylul ayları arasında ve Aralık ayında ise anlamlı bir azalış söz konusudur. Polen sezonu üzerindeki çevresel etmenlerin etkisi de hesaba katıldığında anlamlı bir trend elde etmek oldukça zordur. Sonuç olarak polenlerin diğer airborne partiküllere nazaran küresel iklim değişikliklerine daha çabuk yanıt verdiği, yada etkilendiği söylenebilir.

Anahtar Kelimeler: Ankara, Atmosfer, Uzun dönemli, Polen trendi

1. Introduction

There are different organisms by using the air for their transportation such as fungi spores, pollen grains, virus, bacteria, cyanobacteria, microalgae and insects. These aerobiological particles, especially pollen, have a great effect on human health, cultural heritage or the dynamics of terrestrial ecosystems among others. Pollen emission patterns reflect the flowering phenology and pollen productivity of the regional flora (Osborne et al. 2000). As flowering phenology is strongly affected by temperature and rainfall, climate change is expected to modify pollen distribution patterns and loads with possible consequences on incidents of respiratory allergy (Defila and Clot, 2001, Petanidou et al. 1995) Knowledge about pollen content in the air offers us a quantitative value on floral phenology,

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importance for systematics, agriculture and forest studies and also especially for protection and treatment of sensitive individuals. According to recent researches, the prevalence of pollen allergy in Europe is estimated to be about 40 % (D'amato et al. 2007). Using score for Allergic Rhinitis (SFAR) questionnaire, the prevalence in Turkey is 30 % and the prevalence of allergic rhinitis in school children is 16 % (Mahboub et al. 2014). Several reports suggest that the simultaneous increase in pollen abundance or pollen season length and in respiratory allergy prevalence are to some extent interdependent, the latter being potentially the result of the first (Ault, 2004, Clot, 2003, Ziska et al. 2003). Many studies have examined the relationship between airborne pollen concentrations and allergy in Turkey (Altıntas et al. 2004, Çelik et al. 2004, Dursun et al. 2008, Can et al. 2010). To describe the seasonal variations in pollen recorded at the locations, pollen calendars have been prepared for many cities in Turkey (Ince 1994, Inceoğlu et al. 1994, Bıçakçı et al. 1996, Pınar et al. 1999, Güvensen and Öztürk 2002, Potoğlu Erkara et al.2007, Çeter et al. 2012, Öztürk et al. 2013, Tosunoğlu et al. 2015, Acar 2016).

There are also some aeropalynological studies in Ankara province by volumetric and gravimetric methods. Preliminary studies on allergenic pollen producing plants in Ankara atmosphere were conducted by Özkaragöz and Karamanoğlu by using Durham samplers. Then, İnceoğlu et al. (1994) carried out an aeropalynological study in Ankara using the Hirst-Burkard trap, for a period of three years, from 1990 to 1993. All these studies show that Pinaceae, Poaceae, Cupressaceae/Taxaceae, *Populus*, are the most dominant taxa over the study periods (Inceoğlu et al.1994, Pınar et al. 1999, Kaplan 2003, Kızılpınar and Doğan 2010, Kızılpınar et al. 2011). The pollen content of atmosphere varies according to local flora, climate changes, meteorological factors and the pollen season period (Emberlin et al.1997, Jato et al.2002, Pınar et al.2004, Jato et al. 2009, Bogawski et al 2014, Çeter et al. 2012). Therefore, detecting pollen types and their concentrations are very important, particularly in the atmosphere of highly populated cities.

In this study, general trends in pollen concentrations in Ankara province were performed using linear regression and correlation analysis. To do so, we investigated a comprehensive spectrum of pollen data collected in Ankara, over the last two decades (1990-2011). There is evidence that respiratory allergy episodes have increased in Ankara (Sin et al. 1997,1998 and 2001, Çelik et al. 2004). Also, a significant increase in air temperature has already been observed for Ankara overall. Our main aim was to see whether there are consistent changes in the pollen load and distribution pattern of atmospheric pollen.

2. Material and Methods

2.1. Study Area and Aeropalynological Survey

Ankara is situated in the Inner Anatolian Region of Turkey at an altitude 1,093 meters, at 39°57' N, 32°53' E. The small part of the North of the province is situated in the Black Sea Region of Turkey. The province is part of the Irano-Turanian, Euro-Siberian and Mediterranean floristic regions. In flora of province, there are forests (*Abies nordmanniana* subsp. *bornmuelleriana* Mattf., *Pinus sylvestris* L., *Pinus nigra* J.F.Arnold., *Quercus pubescens* Willd., *Juniperus oxycedrus* L. etc.) wetlands, steppe areas and halophytic areas. There are many public parks and gardens in the city center and natural or cultivated vegetation areas near the city. The major physiognomy of the landscape in the province is formed by steppe vegetation, which is influenced by arid and semiarid aspects of the Mediterranean climate.

Airborne pollen measurements were carried out in Ankara, during the pollen season from January to December during 1990 to 2011 with a Burkard volumetric 7-day spore trap. The trap was placed on the roof of the building (F block) in Tandoğan campus of Ankara University at a height of 30 m above ground level. All pollen counts were converted into daily average concentrations (grains/m^3) referred in REA (The Spanish Aerobiology Network). The level of allergenicity of pollen grains from these identified taxa was classified according to information found in literature (D'Amato et al 2007; Sin et al 2007).

2.2. Meteorological Data

Daily and monthly mean meteorological data (mean daily temperature, relative humidity, rainfall and wind speed) were obtained from the Turkish State Meteorological Service located at Ankara (1990-2011).

2.3. Statistics Analysis

Pollen trends were investigated by linear regression and Spearmen's correlation analysis using mean annual and monthly pollen concentrations. All calculations were carried out in IBM SPSS Statistics V21. The aerobiological results were compared with meteorological data (temperature, rainfall, relative humidity and wind speed).

3. Results and Discussion

During the study period, in total for eleven years dataset was evaluated. Pollen grains of about 60 different taxa were

identified during 1990-2011 in the atmosphere. Twenty taxa formed about 87.06 % of the total pollen spectrum. These taxa are Pinaceae, Poaceae, *Populus, Platanus*, Cupressaceae, Moraceae, Betulaceae, *Fraxinus*, *Acer, Ailanthus, Quercus, Salix, Juglans,* Rosaceae, *Aesculus, Ulmus,* Chenopodiaceae/ Amaranthaceae, Apiaceae, *Artemisia* and *Ambrosia.* In average, over the twelve-years study period, pollen grains from arboreal taxa were the largest contributors to the airborne catch (86 %), followed by grasses (Poaceae) (8 %) and the non arboreal (6 %) (Figure 1). Four of the twenty most dominant taxa in the atmosphere of Ankara are considered to be highly allergenic (Poaceae, Cupressaceae/ Taxaceae, Betulaceae and Amaranthaceae).

In the region investigated, pollen grains generally were recorded all year round and reached their maximum levels in April and May (Table 1). No temporal trend was found for the total airborne pollen concentration, but differences were observed for monthly data especially in April and in May. We observed a significant trend for monthly pollen count against to the years in April and in May ($p<0,05$) (Table 2). Also, there was an increasing trend in January, February, October and November and a decreasing trend from march to september (Table 1).

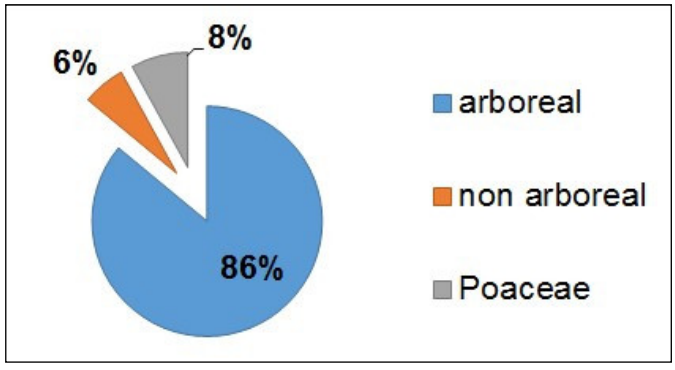

Figure 1. Percentages of arboreal, non arboreal and Poaceae pollen in Ankara for the period 1990-2011.

The negative correlation was found between relative humidity and total pollen counts during 1990-2011 (Table 3). Over the period 1990–2011, mean air temperature significantly increased in Ankara ($R^2=0,1569$), thus making winter and spring warmer. There was a general significant trend toward decreased values in the pollen grains ($R^2=0,572$, $p<0,05$) (Figure 2), and this trend seemed to be related to increasing of daily rainfall over years (except in 1991). The higher numbers of pollen in the air samples collected in 1991 was attributed to greater wind speed in the spring. The mean wind speed in the spring of 1991 was 4.8 m/sec while it was 2 m/sec in the spring of other years. Another reason for the greater amount of pollen in 1991 is higher precipitation during December 1990 (44.2 mm) and January 1991 (25.3 mm) than in the other years. Storage of water in the soil during the winter, caused plant growth and increased flowering intensity in the spring. There are so many reasons about decreasing pollen levels in Ankara in total. Considering the quick building up in rural areas of the city and destroying the natural flora by new constructions, it seems to be normal.

Table 1. Monthly and annual total pollen concentration in Ankara, 1990-2011.

	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
1990	0	33	6175	5533	5404	3626	886	1561	498	22	15	11	**23763**
1991	0	29	4412	10588	15588	7647	2647	1471	59	24	9	5	**42478**
1992	0	0	235	5294	3588	3529	765	1412	412	29	6	1	**15272**
1993	0	0	3529	7941	8824	10588	1765	1471	441	21	3	1	**34583**
1994	1	38	4965	9603	6624	2445	881	882	68	5	1	0	**25512**
1995	0	9	958	6022	3824	2254	1220	2311	244	100	5	0	**16945**
1996	0	276	124	6061	8566	5345	2182	5721	189	54	4	0	**28521**
2004	8	22	1694	1778	1440	509	100	42	6	8	7	1	**5616**
2009	44	213	1694	1908	2619	3302	421	347	105	128	17	0	**10798**
2010	15	1322	1367	1567	1173	384	409	421	95	46	11	0	**6810**
2011	2	8	841	1749	791	1412	149	42	25	28	8	2	**5058**
Total	**70**	**1950**	**25994**	**58044**	**58441**	**41041**	**11424**	**15680**	**2141**	**465**	**86**	**20**	**215357**

Our conclusions that there is a strong downward trends in annual pollen abundance, reflecting increased human impact on environment and hence the levels of pollen production.

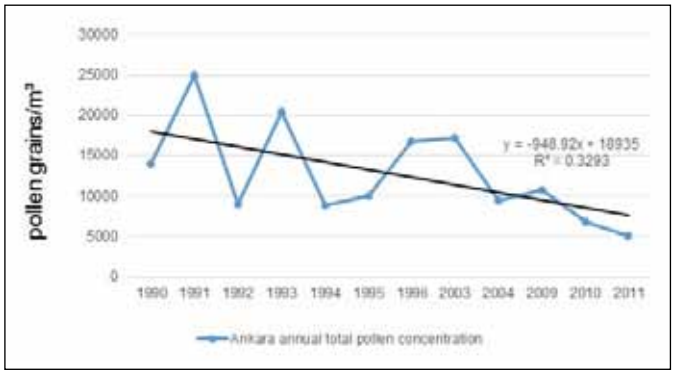

Figure 2. Annual pollen concentration trend in Ankara for the period 1990-2011.

In addition it was found that pollen concentration was getting lower in some taxa which produce very high amount of pollen such as Cupressaceae, Pinaceae, Poaceae, *Populus*, Betulaceae and Amaranthaceae over the study period.

Simple linear regressions of pollen counts against to year were carried out for six pollen taxa. It was found that only Amaranthaceae and *Populus* pollen counts have significant negative trends between the taxa. Others also showed negative trends during the year but this decreasing was not found statistically significant. In addition, we performed correlation analysis between pollen counts and meteorological factors.

Pinaceae, is one of the most abundant pollen type present in Ankara atmosphere, also has showed decreasing trend during the recent years. However the linear regression of

Table 2. Linear regression analysis of pollen concentrations in April and May.

Coefficients[a]						
Model B		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		Std. Error	Beta			
1	(Constant)	669517.571	143953.433		4.651	.001
	Years	-332.347	72.025	-.838	-4.614	.001*
2	(Constant)	748144.316	261369.923		2.862	.019
	Years	-371.669	130.773	-.688	-2.842	.019*

1. *Dependent Variable: April* **Significant values.*
2. *Dependent Variable: May*

Table 3. Spearman's correlation applied to annual pollen concentrations and meteorological parameters during the studied years.

	Years	Annual pollen	Betulaceae	Cup/ Tax	Poaceae	*Populus*	Amaranthaceae	Pinaceae
Years (Pearson)	1,00	-0,784**	-0,47	-0,47	-0,55	-0,619*	-0,688*	-0,52
Years (Spearman)	1,00	-0,727*	-0,681*	-0,49	-0,55	-0,745*	-0,790**	-0,727*
Mean temparature (Pearson)		-0,27	-0,05	-0,22	-0,11	-0,07	-0,21	-0,06
Mean temparature (Spearman)		-0,27	-0,26	-0,10	0,02	-0,19	-0,14	-0,02
Wind speed (Pearson)		-0,238	0,05	-0,05	0,05	0,07	0,00	0,10
Wind speed (Spearman)		-0,155	0,64	0,27	0,41	0,05	0,17	0,14
Relative humidity (Pearson)		-0,728*	-0,57	-0,629*	-0,662*	-0,03	-0,32	-0,53
Relative humidity (Spearman)		-0,39	0,15	-0,07	-0,10	0,51	-0,02	0,04
Total rainfall (Pearson)		-0,59	-0,21	-0,48	-0,40	-0,25	-0,50	-0,35
Total rainfall (Spearman)		-0,51	-0,43	-0,34	-0,04	0,02	-0,57	-0,54

**Correlation is significant at the 0,05 level (2-tailed)*
***Correlation is significant at the 0,01 level (2-tailed).*

pollen data against to time there was no significance. We also observed that Poaceae pollen have decreasing trend in Ankara. Maximum annual Poaceae pollen concentration was detected in 1991 while minimum concentration was found in 1994. Generally, the highest pollen concentrations were observed in May and June, while the lowest concentrations was observed in January and February. Previous investigations have shown Poaceae pollen to be a major cause of seasonal allergic rhinitis in Turkey, affecting 1.3–6.4 % of the population (Çelik et al. 1999, Bostancı et al. 1999). Another pollen type which decreasing trend has been obtained is that of *Populus*. Although there is a misunderstanding about *Populus* pollen and white pappus which bearing seeds *Populus* trees have been cut in recent years due to allergic effects in Ankara. Simple linear regression of *Populus* pollen counts against time (years) gave significant negative trend by using raw data (R^2=0,634 p<0,05). Betulaceae pollen, are one of the most important allergy provokers, have decreasing trend during the years. Although Betulaceae pollen formed only a minor proportion of the pollen load, approximately 18 % of patients were allergic to these pollen (Can et al. 2010). In Amaranthaceae and Cupressaceae, decrease in their annual pollen concentration was accompanied by a similar timing especially since 1994. For Amaranthaceae there was a significant negative trend among the years (R^2=0,700 p<0,05) (Figure 3).

Both in terms of ecological and allergenic effect, *Ambrosia artemisiifolia* become important ever, has also been investigated in this study. There was a statistically significant increasing *Ambrosia* pollen concentration trend among the years (R^2=0,333 p<0,05) (Figure 4). There are some modellings that showing pollen of *Ambrosia* could be enter our country from Crimea region, especially through West Black Sea region.

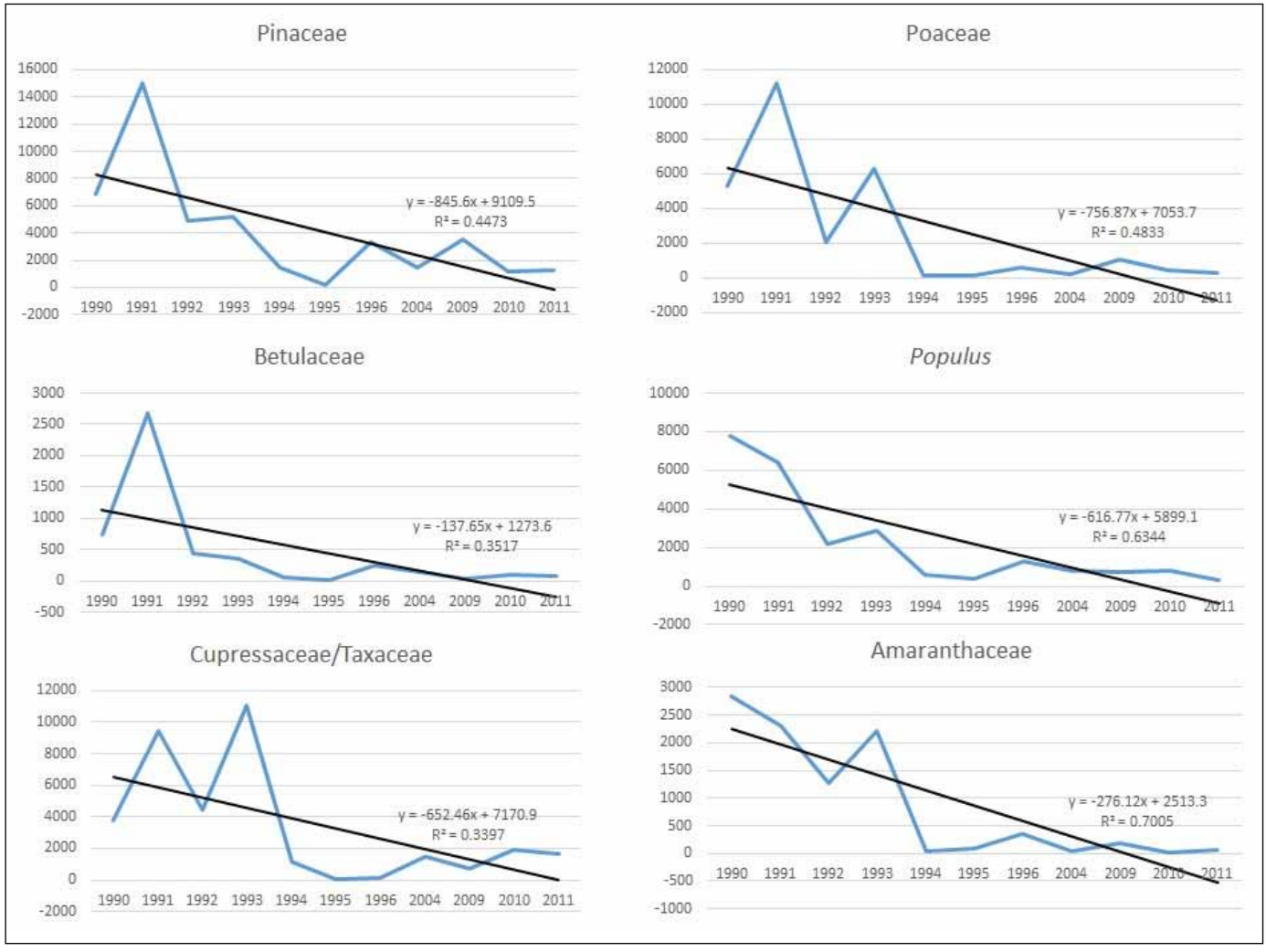

Figure 3. Annual pollen concentration trends for most abundant taxa in Ankara atmosphere.

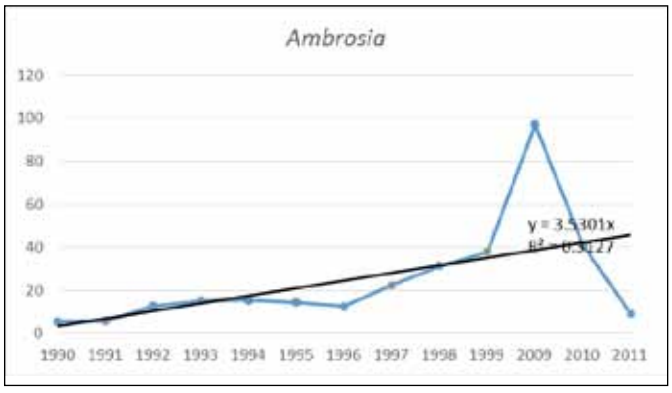

Figure 4. Annual pollen concentration trends for *Ambrosia* in Ankara atmosphere.

In recent years, we observed that the climate in our region seems to be getting warmer and wet. There is probably a general decreasing trend of airborne monthly pollen concentrations, and this increase seems to be related to the increasing temperature, relative humidity and rainfall.

In brief, this is the first report of decreasing patterns of airborne pollen abundance associated with a increase human impact on landscape and vegetation thereby pollen production. This situation may be attributed to the urbanization of the area close to sampler as a consequence of city development.

4. Conclusion

Information obtained from these kinds of studies will help us to determine both the knowledge of the distribution mechanisms of pollen and minimizing the negative effect on the health of pollen sensitive people in densely populated cities as Ankara. The long term pollen calendar presented in this study may be useful for allergologists and visitors in timing their visit to the city and people living in Ankara province. Also it will help understanding the biological-behavior of pollen grains in the atmosphere. We suggest that these long-term studies should be carried out routinely in consideration of climate change impacts as well as urbanization on pollen amount and pollen season.

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