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Environmental Hydro chemistry and genesis of fluoride in drinking water of Govt kallar Hr. Sec Schools, in Dindigul District in Tamilnadu India.

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Abstract: *Our life is governed by the seasons' rhythms. Mainlyhydrology and rainfall depend on the monsoons and make a reasonable impact in the day-to-day life.In thepresent study an attempt has been made to identify the drinking water quality of Govt kallar Hr. Sec Schoolsin Dindigul district during Premonsoon and Post monsoon phases in the year of 2010-2012. The physico-chemical parameters like pH,Electrical conductivity, Total hardness, Total alkalinity, Chloride, Sulphate, Sodium, Fluoride,Potassium, Calcium Magnesium , Nitrate and Heavymetals were studied to analyze the potable ground water quality of the four schools. Meaningful conclusion has been drawn by applying Multistatistical approach such as Box and Whiskers plot, cluster analysis and principal component analysis [1-5]. Chemical relationships in the water quality parameters are explained by cluster analysis. Better water quality was found in Pre-monsoon season than Post-monsoon season. Multivariate statistical analysis explained thatfour Govt. Kallar. Hr. Sec. Schools in Dindigul district are not having potable water. Extent of pollutionoccurred due to dissolution of minerals into rain water with raise in water tableof the drinking water sources. Water sources are affected on account of overexploitation of ground water, urbanization and anthropogenic activities.*

Key words:*Ground Water, Water Quality, Box and Whiskers plot, Cluster analysis, principal component analysis over exploitation, Anthropogenic activities.*

I. Introduction

Ground Water is a renewable natural resource, which is replenished annually by the precipitation. Ground Water quality plays an important role in groundwater protection and quality conservation. Hence, it is very important to assess the groundwater quality not only for its present use but also from the viewpoint of a potential source of water for future consumption. It is well known that occurrence of ground water and its availability for various uses is controlled by the nature of rock formation in which it occurs as well as geological structures, geomorphologic and hydrological setting and hydro metrological conditions [6-8].

Previous research on groundwater quality and drinking water supply between 1990 and 2012 has been carried out in Dindigul district and found the fluoro genesis area and the innovative techniques were implemented to reduce the contamination].However ground water as an essential resource in Dindigul district shall regularly be monitored to ensure its protection from contamination.

The present study focused on assessment of hydro chemical quality of ground water samples collected from Bore wells located in four Govt. Kallar. Hr.Sec. Schools in Dindigul district to compare the results with the different standards and to illustrate ground water suitability for utilizations in drinking, through the calculation of cluster, principal component analysis and Box and whiskers plot. During the sampling periods, severe drinking water shortage and weak drinking water storage practices have also been observed. In some areas, very old cement over tankers which may stay for over six months without cleaning were used to store drinking water and in other areas mainly in tankers made from plastic and clay without covers and necessary cleanups were used to store drinking water. All this together enhance the risk on human health.

Fluoride contaminated schools and the other major ions related with fluoride to degrade the quality of water during post and premonsoon seasons have been identified and the innovative defluoridation techniques will be implemented to provide the pure drinking water to the poor school children. Name of theanalyzed schools are given in the table-1

Table-1Name of the schools located in Dindigul **District and their codes**

School Code	
S1	Government Kallar Hr.Sec School at Kondamanaickenpatti
S2	Government Kallar Hr.Sec School at Vilampattti
S3	Government Kallar Hr.Sec School at AnaiPatti
S4	Government Kallar Hr.Sec School at KamupillaiChattram

II. Results And Discussion

The mean values of various parameters determined in the drinking water samples are summarized in the table 1 and subjected to statistical approach to draw meaningful conclusions. EC, TDS, TA, TH, F^-, HCO_3, SO_4, Chloride, Ca, Mg and Na were higher than the permissible limit.So the water is not for potable and hence further treatment is needed before usage. The pH mean value shows the alkaline nature of water during pre and post monsoon seasons with slight seasonal variations. It infers the alkaline nature of water and the favourable chance for fluoro genesis. High concentration of major ions infers the hardness and the salinity of drinking water. Heavy metals are toxic because they may have cumulative deleterious effects that can cause chronic degenerative changes, especially to the nervous system, liver, and kidneys, and, in some cases, they also have teratogenic and carcinogenic effects. The mechanism of toxicity of some heavy metals still remains unknown, although enzymatic inhibition, impaired antioxidants metabolism, and oxidative stress may play a role. Heavy metals generate many of their adverse health effects through the formation of free radicals, resulting in DNA damage, lipid peroxidation, and depletion of protein sulfhydryl[9-14].

Table-2-Analysed parameters for samples in Dindigul district

	Post-Monsoon 2010-11			**Pre-Monsoon 2010-11**		
WQPs	Min.	Max.	Avg.	Min.	Max.	Avg.
pH	7.70	8.10	7.90	7.40	7.70	7.60
EC	790	6320	2817.5	320	4090	1752.5
TDS	431	3502	1532.25	170	2285	960.25
TA	310	550	431.25	115	575	362.5
TH	350	2220	850	140	1120	538.75
Cl^-	32	1489	437	28	830	292.5
SO_4^{2-}	17	576	162.25	17	288	91.5
F^-	0.4	1.9	1.115	0.5	1.9	0.9375
HCO_3^{2-}	378	671	526	240	702	483
NO_3	2	45	17.75	8	74	29.5
Ca^{2+}	40	344	132	32	200	92.5
Mg^{2+}	51	331	126.5	15	151	75
Na^+	20	442	152.5	11	442	162
K^+	3	11	7.75	2	5	3.25
DO	6.8	7.4	7.05	5.6	7	6.25
COD	3	5	3.75	2.0	4.0	3.0
BOD	0.6	1.6	1.0	0.8	1.4	1.125

*All the values are mg L^- except pH and EC

Table 3.Distribution of Heavy Metals during 2010-2011 Post Monsoon

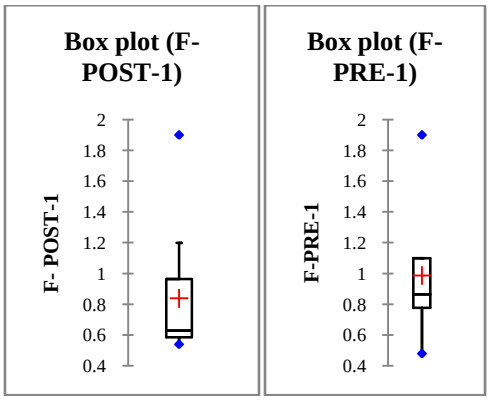
Seasons	**Copper**	**Zinc**	**Iron**	**Nickel**	**Chromium**
2010/11 POST	1.416	0	10.21	0.321	0.222
2010/11 POST	1.430	0	10.45	0.312	0.267
2010/11 POST	1.261	0	8.532	0.297	0.211
2010/11 POST	1.259	0	10.851	0.367	0.231

Table 4Distribution of Heavy Metals during 2010-2011 pre Monsoon

Seasons	**Copper**	**Zinc**	**Iron**	**Nickel**	**Chromium**
2010/11 PRE	1.321	0	10.11	0.471	0.338
2010/11 PRE	1.31	0	10.52	0.411	0.341
2010/11 PRE	1.212	0	8.435	0.478	0.362
2010/11 PRE	1.21	0	10.251	0.432	0.335

1. **Box and whisker plots**

Box and whisker plots show the spatial and seasonal variations in the concentrations of fluoride. As shown in fig-1, the five statistical summaries such as the size and position of the box, upper and lower whiskers, mean and outliers of the Box plots are different for both the seasons. Thus it understood that the seasonal and spatial variations have been observed in the content of fluoride [15-20].



Figs-1 and2 Box and whisker plots for Total alkalinity of 8 schools in Dindigul District during post and premonsoon seasons of year 2010-2011.

2.Cluster analysis:

During post monsoon season the dendrogram for water quality parameters show four clusters. As shown in table-2 Cluster -1 comprises TH,TA, HCO_3^-, and hardness, cluster -2 compriseslarge number of parameters and play a key role to determine the character of water.Cluster-3 comprisesEC,and cluster-4 comprises TDS.The pollution of water quality is in the decreasing order as clusters1 > 2> 3>4.

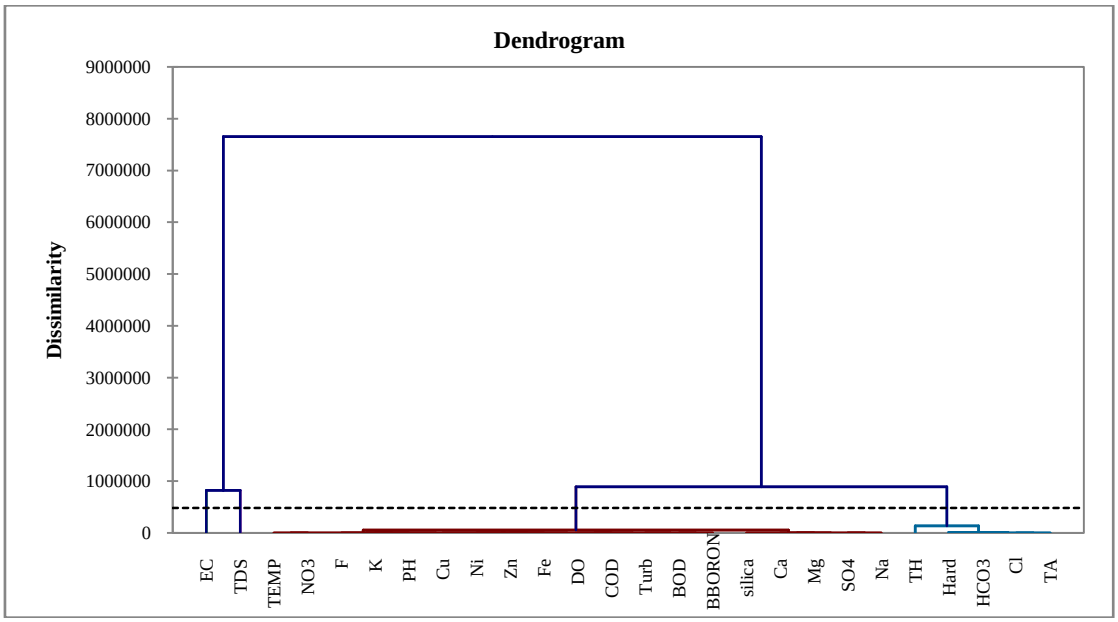


Fig-3Dendrogram of water quality parameters of Dindigul**district during post monsoon season of year 2010-2011**

Table-4total clusters with water quality parameters during post monsoon season of year 2010-2011

cluster-1	cluster-2	cluster-3	cluster-4
TH	Ca	EC	TDS
Cl	Mg2+		
TA	SO4 2-		
HCO3	Na+		
Hard	K+		
	F-		
	PH		
Temperature			
	NO3		
	Turbidity		
	DO		
	COD		
	BOD		
	Borane		
	Silicate		
	COPPER		
	CHROMIUM		
	IRON		
	NIKEL		

It was found that Mg,$^{2+}$,Ca^{2+} Na^{+} K^{+} and F^{-}, Cl^{-},HCO_3^{-} are the dominant cations and anions and heavy metals are also affected drinking water sources in the area. The clusters defined by Q-mode analysis reflect the spatial distribution of samples and the R-mode cluster conveys that salinity, heavy metals and major ions form one group. The same trend has been observed in pre- monsoon season with slight variation of the concentrations of the parameters. It proves the geogenic nature of fluoride on account of the minerals such as CaF_2, KF in the rock types and other anthropogenic factors[21-28].

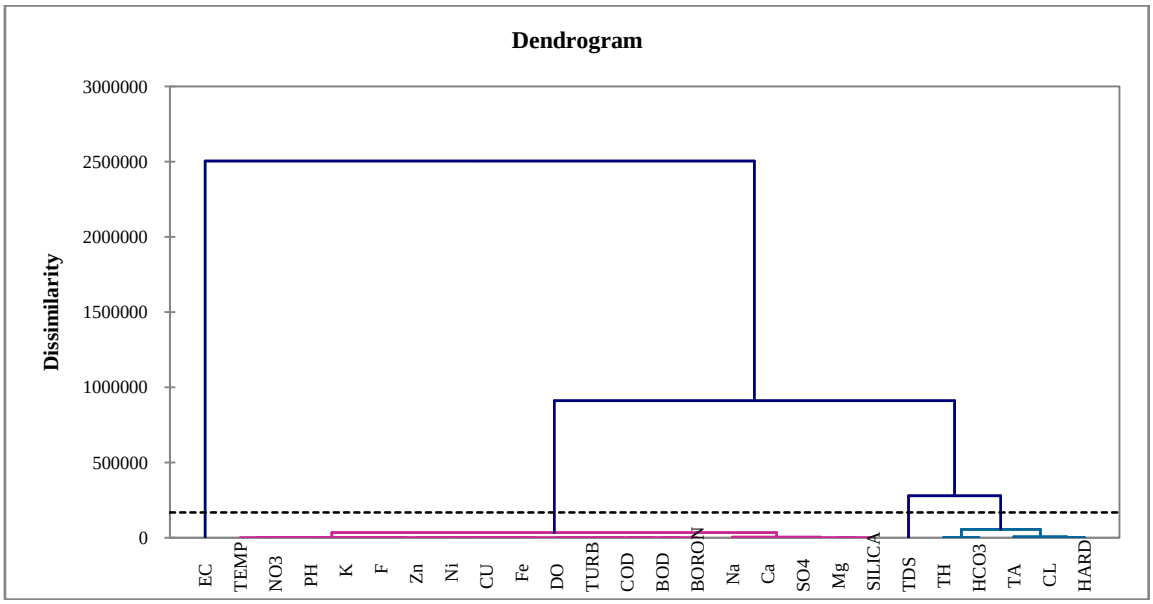


Fig-4Dendrogram of water quality parameters for Dindigul **District during pre monsoon season of year 2010-2011**

Table-5 total clusters with water quality parameters during pre monsoon season of year 2010-2011

cluster-1	cluster-2	cluster-3	cluster-4
TH	Ca2+	EC	TDS
Cl-	Mg2+		
TA	SO4 2-		
HCO32-	Na+		
Hardness(	K+		
	F-		
	PH		
	Temperature		
	NO3		
	Turbidity		
	DO		
	COD		
	BOD		
	Borane		
	Silicate		
	COPPER		
	CHROMIUM		
	IRON		
	NIKEL		

3.Principal componant analysis

As shown in table 6 to 9 the principal component/ Factor analysis explained the dominant parameters comprised in factor-1 and moderately loaded parameters are in factor- 2. For the post monsoon season , factor–1 explains 60.1% of total variance of the following water quality parameters in descending order as DO > COD > BOD > Tub > boron > TA HCO_3^{-} > TH > NO_3^{-}> Cu > Zn > Fe > TA > Cl > EC . Factor -2 explains 39.5% of the total variance of the following the water quality parameters in descending order as F^{-}> pH> K^{+}>Temp > Mg^{2+}> Ca^{2+}> Na^{+}> SO_4^{2-} > Hard >TDS.

For the pre monsoon season factor –1explains 59.4% of total variance of the following the water quality parameters in descending order as DO> COD> BOD>NO3> HCO3> TH >Turb> boron > TA >Cu > Zn > Fe >>Cl > EC > .Factor -2 explains40.1% of the total variance of the following the water quality parameters in descending order as F > PH > K> Temp > SO4 > Ca > Mg >Na> TDS . Total hardness, alkalinity,

heavy metals and biological properties highly affect the water quality in post monsoon on account of dissolution of minerals, and other impurities dissolved in rain water with raise in water table[29-33].

4.Rotated factor analysis

Scattered plot (Fig 5) shows the clusters of parameters in 4 coordinates. It infers that the EC, and TDS are highly affected the water quality. Biological properties and major ions affect the water quality at the same rate. The impact of heavy metals are high in Dindigul confirms the impact of industrial pollutions.

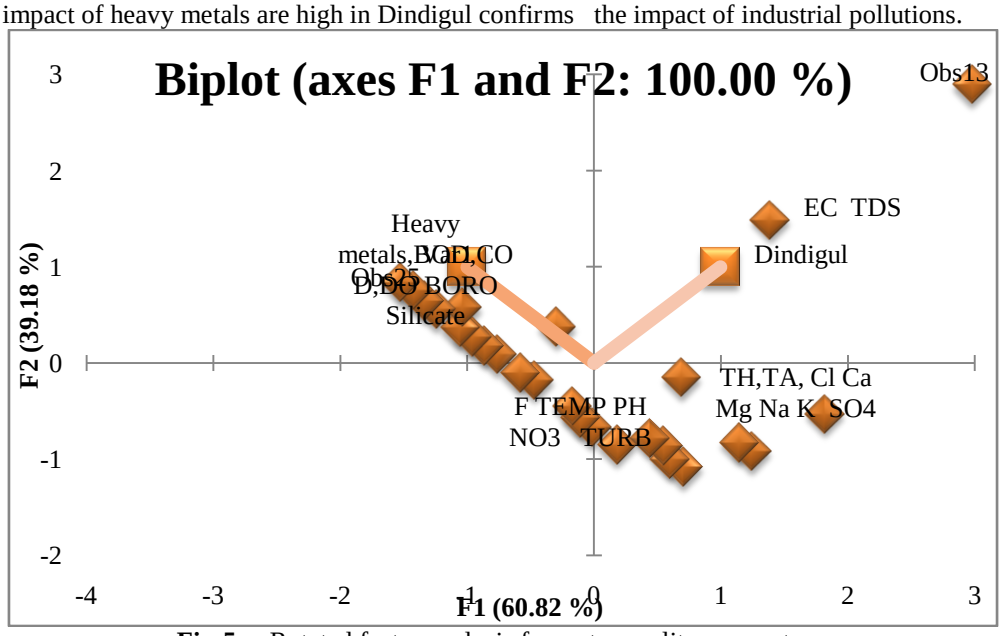


Fig-5 Rotated factor analysis for water quality parameters.

5.Box and whisker plots for evaluate the spatial and seasonal variations (figures not shown)

It explains the different statistical summary for the 4 schools of all the parameters for all the season during analyzed period. This difference infers the seasonal and spatial variations in water quality.

6.Cluster analysis

Cluster analysis explains that all the 4 schools are present in different geographical locations, which infers that 4 clusters for 4 schools.

Post monsoon shows strong impact than pre monsoon on account of mineral dissolution into rainwater, Coir industries; leather industries are nearer to the school locations [34].

Table-6and7 factor scores and % of contribution of water quality

Squared cosines of the observations:

	F1	F2
TH	**0.921**	0.079
Cl-	**0.649**	0.351
TA	**0.656**	0.344
Ca2+	0.297	**0.703**
Mg2+	0.269	**0.731**
SO4 2-	0.291	**0.709**
Na+	0.247	**0.753**
K+	0.044	**0.956**
HCO32-	**0.952**	0.048
F-	0.000	**1.000**
PH	0.029	**0.971**
Temperat	0.123	**0.877**
EC	**0.516**	0.484
TDS	0.467	**0.533**
NO3	**0.867**	0.133
Turbidity	**0.966**	0.034
Hardness(	0.380	**0.620**
DO	**0.987**	0.013
COD	**0.958**	0.042
BOD	**0.926**	0.074
Borane	**0.893**	0.107
Silicate	**0.766**	0.234
COPPER	**0.833**	0.167
CHROMIU	**0.810**	0.190
IRON	**0.780**	0.220
NIKEL	**0.769**	0.231
	F1	F2
Eigenvalu	1.216	0.784
Variability	60.818	39.182
Cumulativ	60.818	100.000

Contribution of the observations (%):

	F1	F2
TH	10.520	1.394
Cl-	4.933	4.149
TA	4.168	3.396
Ca2+	1.574	5.787
Mg2+	1.156	4.889
SO4 2-	0.964	3.648
Na+	0.630	2.980
K+	0.107	3.574
HCO32-	1.517	0.119
F-	0.001	2.220
PH	0.031	1.597
Temperat	0.091	1.006
EC	28.131	40.947
TDS	6.131	10.849
NO3	0.683	0.162
Turbidity	1.061	0.057
Hardness(	0.265	0.673
DO	1.826	0.039
COD	2.328	0.157
BOD	2.887	0.358
Borane	3.492	0.648
Silicate	3.368	1.599
COPPER	4.846	1.503
CHROMIU	5.623	2.051
IRON	6.344	2.776
NIKEL	7.325	3.422

Table-8and 9 factor scores and % of contribution of water quality parameters for pre monsoon

Squared cosines of the observations:

	F1	F2
TH	**0.914**	0.086
Cl-	**0.653**	0.347
TA	**0.777**	0.223
Ca2+	0.287	**0.713**
Mg2+	0.232	**0.768**
SO4 2-	0.236	**0.764**
Na+	0.385	**0.615**
K+	0.029	**0.971**
HCO32-	**0.989**	0.011
F-	0.003	**0.997**
PH	0.040	**0.960**
Temperat	0.130	**0.870**
EC	**0.516**	0.484
TDS	0.466	**0.534**
NO3	**0.872**	0.128
Turbidity	**0.953**	0.047
Hardness(	0.333	**0.667**
DO	**0.993**	0.007
COD	**0.971**	0.029
BOD	**0.942**	0.058
Borane	**0.911**	0.089
Silicate	**0.753**	0.247
COPPER	**0.852**	0.148
CHROMIU	**0.828**	0.172
IRON	**0.794**	0.206
NIKEL	**0.786**	0.214
	F1	F2
Eigenvalu	1.242	0.758
Variability	62.118	37.882
Cumulativ	62.118	100.000

Contribution of the observations (%):

	F1	F2
TH	10.075	1.552
Cl-	4.870	4.244
TA	5.147	2.420
Ca2+	1.498	6.095
Mg2+	1.002	5.426
SO4 2-	0.790	4.195
Na+	0.907	2.377
K+	0.073	3.965
HCO32-	2.774	0.049
F-	0.005	2.484
PH	0.046	1.785
Temperat	0.098	1.078
EC	26.363	40.481
TDS	5.711	10.709
NO3	0.650	0.156
Turbidity	1.139	0.093
Hardness(	0.231	0.759
DO	1.902	0.021
COD	2.420	0.119
BOD	2.985	0.302
Borane	3.596	0.575
Silicate	3.215	1.730
COPPER	4.950	1.409
CHROMIU	5.730	1.948
IRON	6.395	2.714
NIKEL	7.427	3.315

7. Concentration of heavy metals

Concentrations of heavy metals during post monsoon are higher than the pre monsoon season.As shown in fig-6 Iron is higher than the other metals on account of improper plumbing work of water supplying systems. But all the other metal concentrations are within the permissible limit.

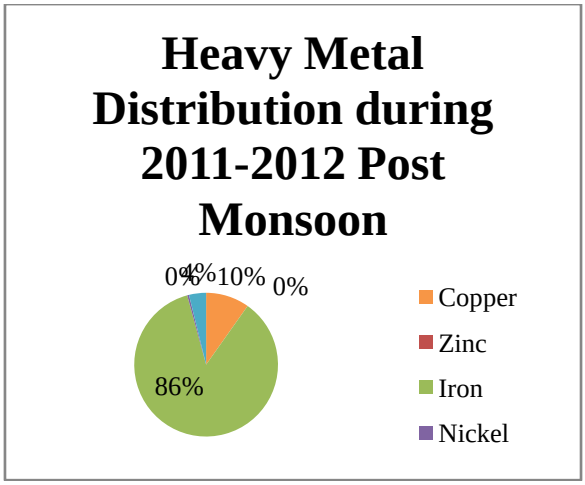


Fig-6 Distribution of Heavy Metals of Theni District schools during 2010-2011 Post Monsoon

III. Conclusion

For the last two consecutive years Tamilnadu is facing a worst ever water crisis that has implications not only for high population density but for the seasonal variations. In Dindigul district four Govt. KallarHr Sec Schools are facing poor water quality problems. During Post monsoon season students and the public are suffering from water related diseases onaccount of the high dissolution of minerals like Fluoride, Calcium, Magnesium, and heavymetals. Dental and skeletal l fluorosis affects the people by taking the contaminated water.The hydro geo chemical relationship of the samples was obtained from Multivariate statistical analysis.

There is a strong positive interrelation among TA,TH,TDS, EC and Major ions.Majority of the water samples are under medium –high salinity hazard.

Scientists have the power to avoid this bleak future of the school children and the people who are taking water. We have planned to takemeasures immediately to implement the novel defluoridation technique in safe manner. This study, therefore, recommends the government and other authorities concerned tosupport further study to be conducted on other physical, chemical and biological parameters of significant health concern and on identification of potential sources of the contaminants including heavy metal contaminants.

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