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# Study on chemical compounds of precipitation and determination of nitrogen and sulfur input from precipitation in guilan province, Iran

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**Key words:** Acid Rain, Guilan Province, Nitrogen, Pollution, Precipitation.

**Abstract**

Study on precipitation in order to determinate the compounds in the rain and their effects on quality of surface and ground water and also, soil resource is very important. In this research, sampling of precipitation was performed in Guilan Province in order to study rain composition for a period of 5 months (from March, 2013 up to June 2013). Sampling was performed from four meteorology synoptic stations located at four counties of Guilan Province consisting of Manjil, Lahijan, Rasht and Bandaranzali. In Rasht, two sampling stations have been determined consisting of Rasht Airport and Moallaem Blvd., synoptic stations. In this study, all precipitations in this time limit were sampled with consideration to the amount of precipitation in mentioned time. The samples were obtained at the beginning of precipitation that were 35 samples from all stations. For all samples, pH, EC (Electrical Conductivity), nitrate, nitrite, sulfate, ammonia, calcium, magnesium, sodium and potassium have been measured. Nitrate, nitrite and sulphate were determined through spectroscopic method based on standard methods. The results indicate that maximum amount of pH has been in Moallem Bld., of Rasht 7.92 and minimum amount of pH has jointly been at Rasht Airport and Lahijan stations, 6. Average amount of nitrate and nitrite at all precipitations are 0.14±0.19 and 0.06±0.02 mg $L^{-1}$, respectively and minimum amount of nitrate in 14 samples has been less than detection limit of method. Average of other factors has been consisting of calcium 15.82±7.69, magnesium 7.50±5.06, sodium 2.50±0.50 and potassium 0.24±0.07 mg $L^{-1}$. Amount of nitrogen and sulfur input studied up to March, 2013, has been calculated in the Province, 1.94 kg and 1.06× Kg. $year^{-1}$, respectively. Comparison of the amount of nitrogen and sulfur input in a year and with other regions in the world indicates that the amount of input of these two elements in the studied region is very low. Therefore, Guilan Province does not have acidic precipitation and after precipitation, there is not been noticeable amounts of pollutants in it.

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## Introduction

Does Guilan Province contain impermissible amount of pollutants and destructive acidic precipitation similar to some other metropolises of Iran? Increase of wet deposition in atmosphere is an important omitting procedure for suspended particles in the air and also returning them to the ground surface. Soluble minerals are gained in wet precipitation from different resources such as natural resources (soil, dust, minerals, seal salts, volcanoes, natural forests and fire) and human resources (burning fossil fuels, industrial activities, agricultural activities and burning bio-bulk) (Liu *et al.*, 2013). Nowadays production of effluence of anthropogenic $NO_x$ (NO and $NO_2$) has been increased due to combustion of fossil fuels. Through different chemical reactions, $NO_x$ in the air is converted to some compounds such as nitric acid ($HNO_3$), nitrate and (PANs)[1] that may be entered to the ground and surface water through wet and dry precipitation (Kimberly *et al.*, 2005). Wet or dry acid precipitation have destructive effects on surface waters, ground waters, soil resources, forests and monuments that is one of the major problems during last 30 years. Rain water has pH up to 5.6, naturally and if the amount of pH will be less than 5.6, it will be used as a threshold limitation for identification the acidic precipitation (Gulsoy *et al.*, 1999). Alebic *et al* (1998) performed a research under title of "Chemical Compounds of the Obtained Rain Water" that was on the basis of pH in urban region. Mehdizadeh *et al* (2000) performed a study under title of "the Amount of Minerals and Chemical Compounds of Precipitation in the Region of Shahroud", generally the average amount of EC was high at all stations in Shahroud Region (Kazemi and Mehdizadeh, 1995). Shivashankara *et al* studied on the amount of nitrite in four cities of India. The amount of measured nitrite was 5.57 micro equivalent per Litre in Hebbal, 4.02 in Jayanagar, 1.80 in Ramanagar, 7.29 in Mandya. Production resources of nitrite and its increment in these regions are related to effluence raised from industries and automobiles (Shivashankara and Sharmila, 2012). Mphepya *et al* reported the average nitrate of wet precipitation at Kroger National Park in Southern Africa equal to 8.1 micro equivalent per Lit. High amount of nitrate in this region may be related to industrial region of Hifgveld (Mphepya ey al., 2006). Average amount of sulfate at southwestern of Mexico city was 61.94 mg $L^{-1}$, high amount of sulfate was related to human resources of producers of pollutants (Báez *et al.*, 2007). Okay *et al* (2002) studied on the wet precipitation's compounds at Kayarsa in Turkey and concluded that the average amount of ammonia was 40.69 micro equivalent per Lit. in this region. Amount of ammonia existing at this region is less that amount in Central Europe (Okey at al., 2002). At all performed studies the amount of pollutants was high and these regions had acidic rains. Objective of the present study is determination of rain water compounds, also nitrogen and sulfur input and determining of being acidic or not of precipitation. This study was performed for a period of 5 months from March, 2013 up to July, 2013. Region of case study was four counties at Guilan Province (Rasht, Bandar anzali, Lahijan and Manjil) and obtained samples were analyzed through Standard Method.

## Materials and methods

In this project, studied region was limited to four counties of Guilan Province (Rasht, Bandar Anazali, Manjil and Lahijan). In order to collect the samples in these regions, meteorology synoptic stations were used. Sampling in Rasht city was performed in two meteorology synoptic stations of Airport and Moallem Blvd. (home station).

### *Sample preparation*

Sampling of precipitations was commenced as from March 2013 up to June 2013. The samples were collected from all precipitations with consideration to the amount of precipitations in the mentioned time duration. Of course, it is necessary to mention that amount of precipitations was very low in Manjil due to weather conditions in these seasons and doing the

[1] Proxy acetyl nitrate

tests was impossible there. Samples were collected at the beginning of precipitations. Total amount of collected samples was 35 samples from all stations; of course in the months of May and June, only two samples were collected from Moallem Blvd. Station and in other stations, there were not precipitations. Sampling was performed at synoptic stations using brass containers (Rain Gauge). Table No. 1 indicates sampling times in different days at meteorology synoptic station.Then, samples were transferred to laboratory in order to measure considered elements.

**Table 1.** Sampling Times of Precipitations at Different Stations.

| Moalem Bolvard | Lahijan | Anzali | Rasht Airport |
|---|---|---|---|
| 3.19.2013 | 3.18.2013 | 3.18.2013 | 3.19.2013 |
| 4.15.2013 | 3.30.2013 | 3.30.2013 | 3.24.2013 |
| 4.17.2013 | 4.18.2013 | 3.26.2013 | 4.17.2013 |
| 5.17.2013 | 4.20.2013 | 4.17.2013 | 4.21.2013 |
| 6.17.2013 | 4.23.2013 | 5.11.2013 | 4.24.2013 |
| 4.22.2013 | 4.24.2013 | 5.20.2013 | 5.19.2013 |
| 5.13.2013 | 5.12.2013 | 6.22.2013 | 6.22.2013 |
| 5.19.2013 | 6.22.2013 | | |
| 5.20.2013 | | | |
| 5.22.2013 | | | |
| 5.26.2013 | | | |
| 6.22.2013 | | | |

*Laboratory determinations*

pH, EC, nitrite, nitrate, calcium, magnesium, sodium, potassium, ammonia and sulfate were measured in the laboratory. In order to measure pH and EC, pH Meter and Eutech Electrical Conductivity Meter were used. Measurement of nitrite was performed through absorption reading at 520 nm by Spectronic spectrophotometer after adding nitrite solution to each sample. Measurement of nitrate was performed at 220 and 275 nm after adding nitrate indicator solution to each sample and reading the absorption by spectrophotometer (Unico, Model UV-2100). Also, measurement of total hardness, calcium and magnesium was performed through titration method using EDTA. Ammonia measurement was done by Nesler Method through reading absorption at 410 nm. Measurement of sodium and potassium was performed through flame photometer. Calculation of the obtained results was performed using Excel Software, consequently SPSS Software was used for statistical analysis.

*Calculation Method for the Amount of Nitrogen and Sulfur Input*

In order to determine the amount of sulfur and nitrogen input, annual volume of precipitation was calculated. The precipitation volume was calculated through the following formula:

Precipitation Height * Area = Volume of Precipitation (1)

*Calculation of the Amount of Nitrogen in Precipitation*

With consideration to this matter that volume of precipitation was calculated, based on the following formulas, the amount of nitrogen was calculated in the considered regions. Average amount of nitrate, nitrite and ammonia were separately calculated from all stations and thereafter, were calculated through the following formulas:

$$\text{Amount of nitrogen in precipitation (mg/L)} = \frac{\text{Average amount of nitrate of a city} * 4}{62} \quad (2)$$

$$\text{Amount of nitrite in precipitation (mg/L)} = \frac{\text{Average amount of nitrite of a city} * 14}{46} \quad (3)$$

$$\text{Amount of ammonia in precipitation (mg/L)} = \frac{\text{Average of ammonium of a city} * 14}{18} \quad (4)$$

The numbers obtained from the above three formulas were added up and was multiplied by the volume of annual precipitation of the considered city and consequently the amount of nitrogen input from the precipitation was determined.

*Calculation of sulfur in precipitation*

Based on the following formula, amount of sulfur in the considered regions was calculated. Average amount of sulfate was separately taken from all stations, and then was calculated through the following formulas:

$$\text{Amount of sulfur in precipitation (mg/L)} = \frac{\text{Average of sulfate in a city} * 32}{96} \quad (5)$$

Obtained value from this formula was multiplied by the annual volume of precipitation in the considered city and consequently amount of sulfur input from precipitation was determined.

**Results**

In this study, qualitative analysis and statistical analysis was performed for all 35 collected rain samples from the considered stations and the related results were presented in separate tables. Regarding to the gained results from four studied stations, at all stations, pH less than 6.00 was not observed and other elements in the stations do not show considerable changes against each other. Sampling dates were supposed as sampling repetitions and the test was analysed as unilateral grouping shape or in the frame of complete randomly test design. The groups consist of sampling regions (Rasht, Lahijan, Bandaranzali and Moallem Blvd.). Table 3 indicates Analysis Variance of the measured parameters.

**Table 2.** Average and Limit of measured parameters in Rain Samples.

| Station | Rasht Airport | Anzali | Lahijan | Moalem Boulvard |
|---|---|---|---|---|
| Number of samples | 7 | 7 | 8 | 13 |
| pH | 6.43±0.56<br>6.00-7.25 | 6.85±0.65<br>8.04-6.19 | 6.66 ± 0.71<br>6.00-7.46 | 6.82±0.60<br>6.00-7.92 |
| EC $(\mu s/cm)$ | 56.11±60.40<br>15.25-179.50 | 87.79±62.58<br>32.30-187.00 | 82.74±66.71<br>19.38-152.60 | 88.68±46.06<br>33.40-199.90 |
| $NO_2^-$ (mg/l) | 0.07±0.03<br>0.04-0.13 | 0.04± 0.01<br>0.06-0.03 | 0.05± 0.03<br>0.02-0.08 | 0.06±0.02<br>0.04-0.10 |
| $NO_2^-$ (mg/l) | 0.07 ±0.09<br>ND-0.18 | 0.24±0.29<br>ND-0.77 | 0.10±0.19<br>ND -0.54 | 0.13±0.15<br>ND -0.49 |
| $Ca^{2+}$ (mg/l) | 10.55±7.59<br>4.80-27.25 | 21.69±7.01<br>9.61-32.06 | 18.57±5.94<br>11.60-30.46 | 13.81± 6.91<br>1.60-23.06 |
| $Mg^{2+}$ (mg/l) | 9.15±7.92<br>0.97-19.24 | 8.63±3.79<br>1.66-13.61 | 6.50±3.50<br>0.97-10.69 | 6.61±4.71<br>1.94-18.74 |
| $Na^+$ (mg/l) | 2.59±0.43<br>3.00-2.00 | 2.19±0.30<br>1.90-2.70 | 1.99±0.31<br>1.50-2.35 | 2.95±50.23<br>2.50-3.50 |
| $K^+$ (mg/l) | 0.21±0.07<br>0.10-0.30 | 0.21±0.07<br>0.10-0.30 | 0.21±0.06<br>0.10-0.30 | 0.28±0.07<br>0.20-0.40 |
| $So_4^{2-}$ (mg/l) | 2.24±0.32<br>1.75-2.65 | 2.79±0.45<br>2.46-3.60 | 2.61±0.32<br>2.06-3.10 | 3.07±0.34<br>2.50-3.54 |
| $NH_4^+$ (mg/l) | 0.29±0.02<br>0.27-0.31 | 0.28±0.02<br>0.26-0.31 | 0.39±0.02<br>0.35-0.41 | 0.33±0.03<br>0.25-0.36 |

**Table 3.** Analysis variance for $SO_4$, K, Na, Mg, Ca, $NO_3$, $NO_2$, EC, pH and $NH_3$ at four Stations, Rasht (Airport), Bandaranzali, Lahijan, Moallem Blvd. in Rasht.

| Sources of change | Degrees of freedom | Mean-square | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | pH | EC | $NO_2$ | $NO_3$ | Ca | Mg | Mg | Na | $SO_4$ | $NH_3$ |
| Environment | 3 | 3.088 ns | 1814.923 ns | 0.001* | 0.041 | 182.939* | 15.473 ns | 15.473 ns | 1.804** | 1.217 ** | 0.019** |
| Error | 33 | 1.523 | 3290.359 | 0.000 | 0.035 | 47.125 | 26.540 | 26.540 | 0.097 | 0.126 | 0.001 |

ns: not significant *: Difference at 5% probable level **: Significant differences at 1% probable level

**Table 4.** Comparison of Average with Duncan Multi-amplitude Test for parameters of Mg, Ca, $NO_2$, $NH_3$, $SO_4$, pH, K, EC and Na.

| Environment | pH | EC | $NO_2$ | $NO_3$ | Ca | Mg | Na | K | $SO_4$ | $NH_3$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Rasht Airport | 5.5 A | 56.11 A | 0.0700 A | 0.0657 A | 10.5486 C | 9.1543 A | 2.5857 B | 0.2143 A | 2.2371 C | 0.2929 C |
| Moalem Bolvard | 6.81A | 88.6769 A | 0654 A | 1338 A | 13.8085 BC | 6.6077 A | 2.94 A | 0.2769 A | 3.0715 A | 0.3323 B |
| Lahijan | 6.66 A | 82.73 A | 0.0543 A | 1200 A | 19.3943 AB | 6.6171 A | 1.9386 C | 0.2 A | 2.5914 B | 0.3929 A |
| Anzali | 6.85 A | 87.7857 A | 0.429 B | 0.2429 A | 21.6900 A | 8.6271 A | 2.1857 C | 0.2143 A | 2.9657 A | 0.2829 C |

Table 4 indicates comparison of Average with Duncan Multi-amplitude Test.

Table 4 indicates comparison of Average with Duncan Multi-amplitude Test.

In Table 5, amount of nitrogen and sulfur input from March 2013 up to July 2013, are observed. Maximum amount of nitrogen and sulfur input was at Lahijan station and minimum amount was at Rasht station. Maximum and minimum amount of nitrogen and sulfur input up to July 2013 was at Rasht and at Bandar Anzali stations, respectively.

**Table 5.** Amount of nitrogen and sulfur input of stations (Rasht, Bandaranzali and Lahijan) as from March 2013 up to July 2013 (kg / year).

| Stations | ingredients | Nitrogen and sulfur input '2013 (Kg per year) | Nitrogen and sulfur input '2013 (Kg per year) |
|---|---|---|---|
| Rasht (Airport, moalem Bolvard) | Nitrogen | $3.7*10^{-7}$ | 25.06 |
| Rasht (Airport, moalem Bolvard) | Sulfur | $1.26*10^{-6}$ | 85.39 |
| Anzali | Nitrogen | $1.17*10^{-6}$ | 5.98 |
| Anzali | Sulfur | $4.29*10^{-6}$ | 21.93 |
| Lahijan | Nitrogen | $1.94*10^{-6}$ | 19.38 |
| Lahijan | Sulfur | $5.13*10^{-6}$ | 51.09 |

With consideration to the performed tests and examination of considered parameters, the following results have been obtained that obtained results of each parameter have been mentioned along with comparison with others studies in this section.

*pH and EC*

With consideration to the tests performed on the samples of four studied stations (Rasht Airport, Lahijan, Bandaranzali and Moallem Blvd.), maximum amount of pH was 6.85 at Bandaranzali station and minimum amount of pH was 6.43 at Rasht Airport. Those rains are considered as acid rain that their pH will be less than 5.6 (Erfan Manesh and Afiouni, 2008), consequently, with regarding to the results obtained from all studied stations, pH less than 5.6 was not observed. Therefore, acid rain was not observed in Guilan Province during sampling period. Maximum amount of average of EC was 87.79 µS/cm at Anzali station and minimum amount of the average of EC was 56.11 µS/cm at Rasht Airport station. Average EC of rain water indicates existence of some ions therein. High amount of EC at Anzali station is due to sprayed chloride ions from the sea, whereas the meteorology station has been located near the sea. Alebic *et al* (1998) have accurately analyzed chemical compounds of rain water at two sites of Rika City in Croatia. Because of high vehicles traffic, pH of the site located at City Centre was acidic and pH of the site located at suburb was not acidic (Alebic *et al*., 1998). Kazemi *et al* (2000) performed a study under the title of "amount of minerals and chemicals of precipitations at Shahroud", sampling was performed from two stations located at the center and suburb of Shahroud City and two stations located at 30-km distances from the city. Generally, average amount of EC was calculated 51.8 µS/cm for all considered stations, because high amount of EC was related to the increase of interval between raining, and the decrease was related to increase of the amount of rains (Kazemi and Mehdizadeh, 1995). Amount of average pH in four regions of Guilan Province with other mentioned regions indicate that Guilan Province does not have acid rain in comparison with the other regions, and also comparison of EC of four regions in Guilan Province with two stations in Shahroud City indicates that the amount of EC in Guilan Province is high that it may be related to Anzali Station, due to vicinity to the sea.

*Nitrite, nitrate and sulfate*

Maximum amount of average nitrite was 0.07 mg $L^{-1}$ at Rasht airport station, minimum amount of average nitrite was at Anzali and Lahijan stations, equal to 0.04 mg $L^{-1}$, maximum amount of average nitrate was 0.24 mg $L^{-1}$ at Anzali station, minimum amount of average nitrate was at Lahijan station equal to 0.04 mg $L^{-1}$, maximum amount of average of sulfate was 3.01 mg $L^{-1}$ at Moallem Blvd Station and minimum amount of average of sulfate was 2.24 mg $L^{-1}$ at Rasht airport station. Shivashankara *et al* studied on the amount of nitrite in four cities of India. Amount of

measured nitrite was 5.57 at Hebbal, 4.02 at Jayanagar, 1.80 at Ramanagar, and 7.29 µeq/L at Manday. Sources of nitrite production at these regions have been related to effluence raised from industries and automobiles (Shivashankara and Sharmila, 2012). De-Yin Huang *et al* (2009) performed a study under title of " Chemical Composition and Seasonal Variation of Acid Deposition in Guangzhou, South China: Comparison with Precipitation in other Major Chinese Cities ". Average amount of nitrate in the city of Kwangju City was 51.8 µeq/L. $NO_3^-$ is one of the main elements of acid rain and high amount of its average in this region was related to the combustion of coal and consumption of fertilizer effluence raised from traffic (De-Yin Huang *et al.*, 2009). Mphepya *et al* indicated the average amount of sulfate at Kroger National Park of South Africa. Average amount of sulfate was 14.50 µeq/L. one of the reasons for high amount of sulfate at the region was being adjacent to the industrial region of Highveld (Mphepya *et al.*, 2006). Comparison between average of nitrite, nitrate and sulfate of four stations considered at Guilan Province with other mentioned regions indicates that the amount of average of nitrite, nitrate and sulfate at Guilan Province precipitations is very low.

*Calcium, Magnesium, Sodium, Ammonia and Potassium*

Maximum amount of calcium was 21.69 mg $L^{-1}$ at Anzali station, maximum amount of average magnesium was 8.63 mg $L^{-1}$ at Anzali Station, maximum amount of average sodium was 3.00 mg $L^{-1}$ at Moallem Blvd Station, maximum amount of average potassium was 0.29 mg $L^{-1}$ at Moallem Blvd Station and maximum amount of average of ammonia was 0.39 mg $L^{-1}$ in Lahijan Station. In a study on the chemicals of precipitations in Shahroud Region, Kazemi *et al* (2000) stated the amount of calcium equals to 11.5 mg $L^{-1}$ in Shahroud and high amount of average calcium was related to low precipitation, existence of dry precipitations along with the samples, air pollution of the region, limy particles of the region and hard winds in different seasons of the year (Kazemi and Mehdizadeh, 1995). Báez *et al* studied on the average amount of sodium and magnesium at southwestern of Mexico City and concluded that the amount of magnesium was 2.46 mg $L^{-1}$ and amount of sodium was 7.00 mg $L^{-1}$. Magnesium in this research was the only considerable element with shell resource (Báez *et al.*, 2007). Okay *et al* indicated average amount of potassium equals to 40.69 µeq/L and amount of average ammonia equals to 40.69 µeq/L at Kayarsa in Turkey. Amount of ammonia in this region is less than average amount in central Europe (Okey *et al.*, 2002). Comparison between the amount of average of calcium and magnesium in four regions of Guilan Province with other mentioned regions indicates that amount of average calcium and magnesium in some stations of Guilan Province is more and the average amount of sodium, potassium and ammonium in the province showed that less than the mentioned areas.

*Nitrogen and Sulfur Input from Precipitations*

The results gained from measurement of the amount of nitrogen and sulfur input at the considered stations up to March 2013 indicated that maximum amount of nitrogen and sulfur input was at Lahijan Station and minimum amount was at Rasht (Moallem Blvd. and Rasht Airport) Station. Also study on nitrogen and sulfur input up to July 2013 indicated that maximum amount of nitrogen and sulfur input in this period was related to Rasht station (Moallem Blvd. and Rasht Airport) and minimum amount was related to Anzali station. Precipitations at the first four months in Rasht station was more than two other stations, consequently amount of nitrogen and sulfur input at Rasht station up to July 2013 was high and through this way, more pollutants have been entered to Rasht. Mphepya *et al* (2006) studied on the amount of input nitrogen and sulfur at Kroger National Park at South Africa. Wet precipitations in this region contained 5.9 kg $S.ha^{-1}yr^{-1}$ sulfur and 2.8 $kgS\ ha^{-1}yr^{-1}$ nitrogen (Mphepya *et al.*, 2006). Pan *et al* (2012) performed a research under title of "Dry and Wet Precipitations of Atmospheric nitrogen at ten sites in the north of China". Passive effluence of nitrogen may effect on

surrounding ecosystem through atmospheric precipitations. In this study, dry and wet atmospheric precipitations were selected from types of nitrogen compounds during three years at ten sites of the north part of China and studied. The results indicated that nitrogen precipitation levels in China during three years was high and its average was 60.6 $kgNha^{-1}$ (Pan *et al.*, 2012b). Pan *et al* (2012) performed a study under title of "Spatial Distribution and Seasonal Variations of Atmospheric Sulfur Deposition over Northern China. ". In this study, sulfur precipitations were observed, as quantitative aspect that had been selected in the regional scale through raining, particles and gases during three years in the north side of China. The related results indicated that total sulfur precipitations in the objective region have been as from 35.0 $kgSha^{-1}yr^{-1}$ up to 100.7. Average of total amount of sulfur precipitations in ten sites has been 64.8 $kgSha^{-1}yr^{-1}$ during three years that 0.32 is related to dry precipitations (Pan *et al.*, 2012a). Amount of nitrogen and sulfur input to Guilan Province is very low in comparison with the other mentioned regions and indicates very low amount.

*Comparing measured parameters in different stations*

As sampling dates did not have fix procedure, it was supposed as sampling repetition and the experiment was analyzed in unilateral grouping shape or in the frame of complete random experimental plan. The groups consist of sampled regions (Rasht, Lahijan, Anzali and Moallem Blvd.). Based on the results of variance analysis, a significant difference has been observed between the studied regions in the viewpoint of the amount of sodium, sulfate and ammoniac in the 1% probable level and for calcium and nitrite in the 5% probable level. Comparison of the average with Duncan Multi-amplitude Test indicated that pH and EC of atmospheric precipitation have been equal at all four regions and there was not any significant difference (P>0.05). Amount of nitrite was minimum (0.04 mg/Lit) in Anzali and was maximum (0.07 mg/Lit) in Rasht (Airport and Moallem Blvd.) and there was significant difference with Lahijan and Anzali in the 5% probable level. Significant difference was observed between the amount of calcium in Lahijan and Anzali. Amount of sodium measured in Moallem Blvd., Rasht was more than the other regions. It was not observed any statistical difference in potassium of atmospheric precipitations of different regions. Rasht airport had minimum amount of sulfate (2.23 mg/Lit) but Moallem Blvd had 3.05 mg/Lit and Anzali had 2.9 mg/Lit, maximum amount of Sulfate that it must be probably due to nearness to the sea and spray of sea water containing of high amount of sulfate, and Lahijan had less sulfate in precipitations in comparison with Anzali and Moallem Blvd and it has been classified in the second group. In the statistical viewpoint in 5% probable level, significant difference was observed between three groups.

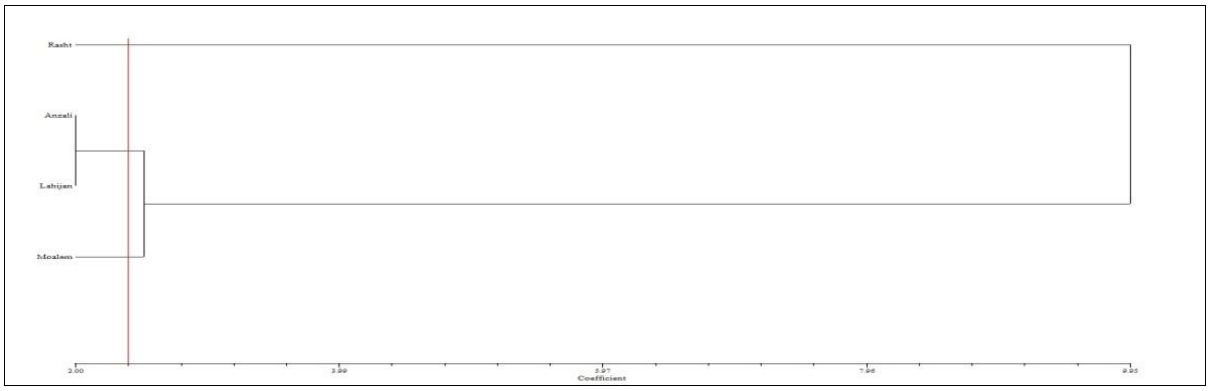


**Fig. 1.** Cluster Analysis of 4 Regions (Rasht Airport, Bandaranzali, Lahijan, Moallem Blvd.).

Rasht Airport and Anzali had less ammoniac in comparison with Lahijan and Moallem Blvd. Ammoniac in Moallem Blvd. was between Rasht, Anzali and Lahijan. Amount of ammoniac in Lahijan

has been registered more than three other regions, and there is significant difference in the level of 5%. Consequently, based on Cluster Analysis, 4 stations are divided into 3 groups that Rasht is related to the first group, Anzali and Lahijan in one group, and the third group is related to Moallem Blvd. Parameters measured in precipitation of Guilan Province indicated that there is many similarities between Anzali and Lahijan counties in the viewpoint of pollution, but two stations of Rasht County (Moallem Blvd. and Rasht Airport) have been located in two groups far from each other that indicates complete separation of these two regions in the viewpoint of pollution in precipitations.

**Discussion**

The results obtained from measured elements in the rain samples of Guilan Province and comparing them with other polluted regions of the world indicate that precipitations of Guilan Province have very low pollution. After measurement the amount of pH in four considered stations (Rasht Airport, Lahijan, Anzali and Moallem Blvd.), it was observed that there is not acid rain at the stations and other measured elements in the rain samples such as nitrite, nitrate, sodium, potassium, calcium, magnesium, sulfate and ammoniac has been less than the other polluted regions of the World. Based on the results from the precipitations in Guilan Province, harmful pollutants have not been transferred to the surface more than permissible limit and do not cause to increase pollution in water and soil resources of Guilan Province. With consideration to this point that acid rain has not been observed in Guilan Province and other measured parameters indicated low amounts in comparison with the other polluted regions, consequently there are not harmful effects for biological variety such as plants in the studied region from the precipitations.

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