JJBS

Volume 9, Number 1, March .2016
ISSN 1995-6673
Pages 53 - 61

Jordan Journal of Biological Sciences

Spatial-Temporal Variation in Algal Community in Freshwater Springs Inhabited by Aquatic Salamander *Neurergus crocatus*

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Received: September 16, 2015 Revised: December 26, 2015 Accepted: January 20, 2016

Abstract

The basic idea of the present study was to assess the population of algal flora in two different aquatic ecosystems inhabited by a salamander *Neurergus crocatus.* According to the results of physico-chemical parameters, there were significant differences between the two ecosystems in all the measured parameters, and the two locations characterized by low nutrient contents. At site one, the variation in all physico-chemical parameters was significant and there was no stability of the water quality parameters during the period of study, while site two was characterized by a sort of stability in all physico-chemical parameters of water quality. Regarding the algal flora at two sites, there was a clear variation in this aspect. At site one, three species of macrobenthic and seven species of microbenthic algae were identified during the period of study. Whereas in site two, only one species of red algae and one species of cyanobacteria was noticed in March. Low number of algal species in this site can be attributed to the lytic activity of *Pseudomonas fluorescens*.

Keywords: : macrobenthic, microbenthic, salamander, *Pseudomonas fluorescens*.

1. Introduction

Over two thirds of the Earth's surface are covered by water and less than a third is taken up by land. As Kurdistan population continues to grow, people are putting pressure on the Kurdistan's water resources. Rivers, springs, lakes and other inland waters are being affected by the human activities. Water resources in Kurdistan are productive water, and they provide drinking water to many villages; but all these resources are being threatened by human activity. During the last ten years, people widely went out for pleasure and recreation leaving huge quantities of their litter and residue at the watershed of water recourses, which led to the environmental disturbance changes in the structure and function of biological systems. Ecological assessment of the water body includes both chemical and biological indicators of water quality (Zhang, 2006). Algae are one of the biological indicators used for the measurement of water quality (Allison *et al*., 2014) and constitute an important component of wetland and springs (Robinson *et al.*, 2000). Springs usually lack true phytoplankton, but may have benthic algae because spring waters are shallow and have abundant submersed substrata utilized for colonization (Sanley *et al*., 2003). The algal distribution pattern in waters usually indicates the type of environment they inhabited; therefore algae have been widely used as an ecological indicator. Algae are naturally found in all types of ecosystems and can indicate the conditions of an ecosystem, so the presence of a certain species can indicate the amount and type of the available nutrients (Whitton, 1979; Symoens *et al*., 1981; Hosmani and Bharati, 1982; Austin and Deniseger, 1985). *Neurergus crocatus*an aquatic salamander but it is not commonly found in aquatic habitats in Kurdistan region. It is well known that in an ecosystem when chemical, physical and nutritional requirements of a specific organism are not provided it cannot survive (Thomas and Smith, 2012). The problem of pollution is widely spread in Kurdistan Region. Therefore, studying the algal flora of aquatic ecosystem inhabited by the salamander *Neurergus crocatus* will indicate its physical, chemical and biological requirements. In the present study, we reviewed the recent publications in combination with classical freshwater approaches to highlight the importance of freshwater benthic algal ecology. So, the aims of this study are:

1. To study the spatial and temporal variation in algal community in two aquatic ecosystems inhabited by the salamander *Neurergus crocatus*.
2. To describe spatial and temporal differences patterns in the physical and chemical conditions of the two studied aquatic ecosystem environments.
3. To diagnose which alga is a bio indicator for such aquatic habitat.

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2. Materials and Methods

2.1. Field Sampling

Two aquatic habitats inhabited by *Neurergus crocatus* were selected at Duhok province. The first site is located 40 km north east of Duhok city near Swaratoka resort in a deep canyon surrounded by a rugged mountain, and its freshwater creek emanates from a spring at the foot of the Gare Mountain (Plate 1) located at 37º 1′ 29″ N and 43º 15′ 31″ E. The second site is a freshwater pool, located 70 km far away from the first site near Sheladezi village at 39º 17′ 25″ N and 45º 37′ 8″ E, its water originates from a spring at the foot of Gare Mountain. The bottom of the pool is covered with calcareous stones (Plate 2). The first site is located at a region with a low human disturbance at the watershed, while the second site is commonly used as a public place for local picnics.

Plate 1: View of site one

Plate 2: View of site two.

2.2. Sample Collection and Analysis

The present study was conducted for five months, from January to May 2014.Water and algal samples were collected monthly. Water samples were taken randomly from the aquatic habitat by plastic bucket, while epipelic, epilithic, and epiphytic algae were collected from different places of each location and preserved in a glass container for identification. The parameters of water quality, which were measured in the field, included: air and water temperatures using mercury thermometer, dissolve Oxygen using portable DO-meter (Model 407510, EXTECH Instruments), pH using portable pH-meter (Model 430, JENWAY), and electric conductivity using portable conductivity-meter (Model inoLab Cond level 1 E 163694).

Total hardness, total alkalinity, calcium hardness, magnesium hardness, nitrate and phosphate were measured according to A.P.H.A. (1998).Three replicates of water sample from each parameter were analyzed at the Department of Biology, Faculty of Science, University of Duhok. Soft algae were identified under magnification (40 X) of light microscope. Cleaning of diatoms was carried out according to Patric and Riemer, (1966) and fixed on slides for identification. Identification and classification of macrobenthose and microbenthose were done to species level according to the methods described by Desikachary (1959), Patrick and Riemer (1966), Weber (1971), Prescott (1975), Edward and David (2010). Yellow-greenish stones, collected from site two, grossly expected to be algae but when examined microscopically no algae were found and only bacterial species were dominated. For bacterial identification, samples were cultured on blood agar (Oxoid, UK), McConkey agar (Oxoid, UK) and Nutrient agar (Oxoid, UK). All inoculated culture media were incubated at 37 ºC under aerobic conditions for 24 hours. Preliminary tests such as Gram stain, oxidase test, triple sugar iron agar and motility tests were used.

2.3. Statistical Analysis

Data were analyzed statistically using excel and GraphPad Prism 5 using XY analysis (nonlinear regression) by plotting concentration of parameters on Y axis and periods of parameters on X axis followed by Tukey's test for comparing each parameter's concentration in different periods. *P*-values < 0.05 were considered statistically significant. Common letters between any two mean values express no significant difference.

3. Results and Discussion

Abiotic factors

The average values of the selected parameters in each location were measured during the study period as shown in Table 1 and Figure 1. The results of the air temperature at site one ranged from 6 to 23ºC, while at site two it ranged from 7.5 to 25ºC. Based on the results, there was a significant temporal variation in the air temperature in each site during the period of study, while a significant spatial variation in air temperature was found in March and May. The temporal variation in the air temperature depends on the climate of the region which is close to the Irano-turanian type (Guest, 1966). A significant spatial variation in the air temperature is due to the time of sampling and the weather conditions.

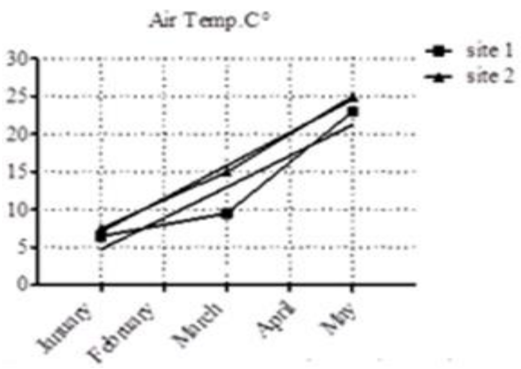

Figure 1. Air temperature at the two sites during the period of study

Table 1. Values of physico-chemical parameters of the water at the two sites during the period of study. Note: Small letters express statistical differences between different months in the same location while capital letters express statistical differences between the same months in different locations at p=0.05.

Months / variables	Site 1			Site 2		
	January,2014	March	May	January	March	May
Air tem. Cº	6.5±0.115aA	9.5±0.057bA	23±0.057cA	7.5±0.057aA	15±0.577bB	25±0.577cB
Water Tem. Cº	4.9±0.057aA	7.7±0.057bA	16±0.577cA	12.7±0.0577aB	12.6±0.1000aB	13±0.5774aB
Ecμs/cm^2	1516±3.055aA	1272±2.082bA	1084±3.512cA	690±2.517aB	690±2.082aB	672±1.528bB
TDS mg/l	1364±4.163aA	1145±1.528bA	975±3.0cA	621±1.732aB	621±1.528aB	605±1.155bB
pH	8.08±0.0116aA	8.3±0.0577bA	8.33±0.0116bA	7.5±0.0577aB	7.21±0.0116bB	7.29±0.0116bB
DO(mg/l)	7±0.1528aA	6.7±0.100aA	6.5±0.1528aA	4.5±0.0577aB	4.1±0.0577bB	3.8±0.0577cB
NO_3^- μg/l	191.3±0.173aA	104.2±0.152bA	114.7±0.173cA	335.4±0.288aB	212.8±0.321bB	239.3±0.153cB
PO_4^- μg/l	97.8±0.208aA	30±1.0bA	44.2±0.145cA	84.43±0.0929aB	28±1.0bB	42.1±0.115cB
TH mg $CaCo_3$/l	552±3.055aA	490±3.055bA	460±2.082cA	289±2.309aB	291.5±0.252aB	271±1.528bB
Ca H(mg/l)	260±1.732aA	238±1.528bA	195±2.082cA	203±2.517aB	212.5±0.3055cB	175±1.0bB
Mg H(mg/l)	292±1.528aA	252±2.646bA	265±1.000cA	86±1.0aB	79±0.2333aB	96±2.517bB
Ca^{++}mg/l	104.2±0.7229aA	95.4±0.611bA	78.16±0.829cA	81.36±1.01aB	85.17±0.122bB	70.14±0.4000cB
Mg $^{++}$mg/l	70.96±0.3688aA	61.24±0.6413bA	64.4±0.2433cA	20.9±0.2433aB	19.2±0.05859aB	23.33±0.6106bB
Alkalinity mg $CaCo_3$/l	260±1.732aA	255±1.528aA	226±1.528bA	197±1.155aB	190±1.528aB	156±2.082bB

Water temperature in site one varied from 4.9 to 16 ºC, while in site two it varied from 12.6 to 13 ºC. The temporal variation in water temperature at site one was 11.1ºC. Water temperature at site one showed a significant variation in the different months of the study (Table 1).This wide range of water temperature can be attributed to the shallow depth of water in this site which can be easily affected by seasonal changes (Hassan *et al.*, 2008). In site two, a very narrow variation in the water temperature (0.4ºC) was noticed (Figure 2) which was not significant at the different times of sampling.

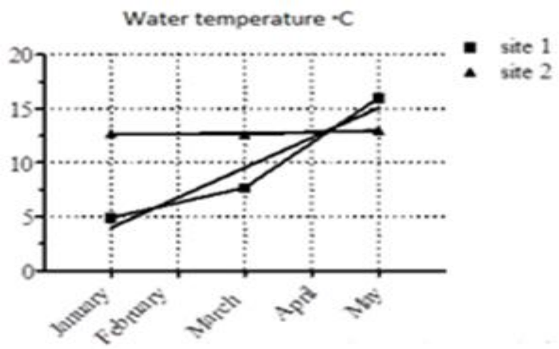

Figure 2. Water samples temperatures at the two sites during the period of the study

This result shows the steady state environmental condition of the aquatic ecosystem of freshwater spring which, within temperature, aeration, and nutrient supply, remains relatively constant throughout the year (Allan and Castillo, 2007; Aloisie *et al.*, 2008). There was a significant spatial variation in the water temperature between the two sites during the period of the study.

At site one, the EC ranged from 1084 to 1516 µs/cm, while at site two it ranged from 672 to 690 µs/cm. At both sites, the lowest value was measured in May, whereas the highest value was measured in January. It is clear from the results of EC (Figure 3) that the temporal variation at site one was 432 µs/cm, and there was a significant variation in the results of EC between the periods of the sampling. This wide range of variation in EC is related to the climate and the season of the sampling. The highest value of EC in January was due tothe rainy and snowy conditions which cause the dissolution of Ca and Mg salts from the rocks (Onyema and Emmsnuel, 2009; Barinova and Tavassi, 2009).The temporal variation in EC in site two was 18 µs/cm and this narrow variation can be attributed to the underground water which is not affected by the climate (Aloisie *et al.*, 2008). Statistically, there was no significant variation in EC between January and March, but it differed significantly with the result of May. So the spatio-temporal variation of EC depends on the Ca and Mg salts concentration. These results were similar to those reported by Adil (2010) and Bhrdwaj *et al.* (2010). There was a significant spatial variation in EC between the two locations during the period of the study.

The results of TDS at both sites were followed consistently with the results of EC (Figures4 and 3). At site one, the value of TDS was 975 mg/l in May and 1364 mg/l in January. Whereas at site two, the minimum value was 605 mg/l in May and the maximum value was 621 mg/l in January and March (Table 1).

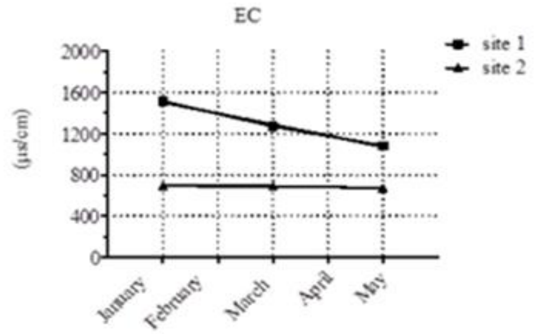

Figure 3. Electrical conductivity of water samples at the two sites during the period of the study

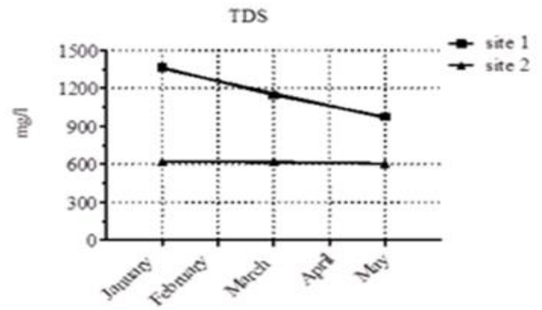

Figure 4. Total dissolved salts of water samples at the two sites during the period of the study

The temporal variation in site one was 389 mg/l and 16 mg/L in site two. In site one there was a significant temporal variation in the TDS during the periods of study, while in site two no significant variation in the results of TDS was found between January and March but it differed significantly from that of May. There was a significant spatial variation in TDS between the two sites during the period of the study. The spatio-temporal variation of TDS was due to the climate, geological formation and the time of sampling (Allan and Castillo, 2007; Aloisie *et al*., 2008).

The pH values of water at both sites were alkaline, and this is a characteristic of the freshwater in Kurdistan Region because calcium carbonate is the main component of the geology formation of the area, which is mainly composed of calcium carbonate (Ezat, 2002; Toma, 2006; Adil, 2010). At site one, the values of pH ranged from 8.08 to 8.33,in which the minimum value was recorded in January, whereas the maximum value was recorded in May (Table 1 and Figure 5). The temporal variation in this site was 0.25.ThepH value in January varied significantly with the pH in March and May. While in site two the minimum value was 7.21 in March and the maximum value was 7.50 in January. So the temporal variation at this site was 0.259. Statistically, the results in site two were similar to those of site one. There was a significant spatial variation in pH value between the two sites throughout the period of the study. These results are in agreement with the results of many researchers at Kurdistan region (Toma, 2006; Hamasalh, 2008), who found that the pH of water ecosystem in the region was alkaline and this is due to geological formation of the area. According to the water criteria and standards for pH, the pH of the two sites are coincident with the Environmental Protection Agency (EPA) in which the pH of most unpolluted surface water is generally between 6.5-8.5, and the pH of natural unpolluted ground water is generally between 6.0-8.5. For aquatic life the pH should be 6.5-9 and should not vary more than 0.5 units beyond the normal seasonal maximum and minimum (Eugene, 2008).

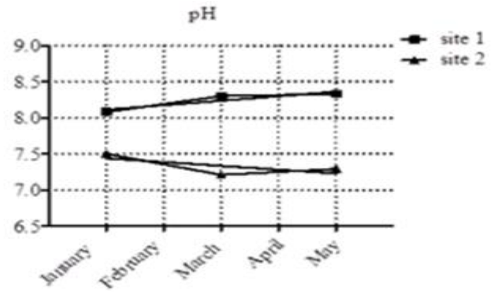

Figure 5. pH of water samples at the two sites during the period of the study

The results of DO at site one were 6.5 mg/l in May and 7.0 mg/l in January (Table 1 and Figure 6). The maximum value was in January because the water temperature was low and the water was turbulent in winter with a high flow, whereas the minimum value was in May because the water temperature was high with a low flow water and high salts content (Oprean *et al*., 2008; Barbaro, 2008). No significant temporal variation was found in the DO in site one during the study period. As forsite two,there was a very low temporal variation in the value of DO which was 3.8 mg/l in May and the maximum value was 4.5 mg/l in January. In site two, a very low temporal variation was noticed in the value of DO (0.7 mg/L),which was due to the fact that the underground water lacks DO (Allan and Castillo, 2007).There was a significant temporal variation in the values of DO during the times of sampling at site two. The spatial variation showed a significant difference during the period of the study, and this was due to the water temperature, partial pressure of Oxygen in the water and the salts content of water (Oprean *et al*., 2008; Barbaro, 2008).

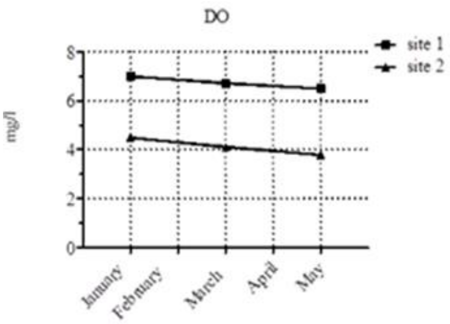

Figure 6. Dissolved oxygen water samples at the two sites during the period of the study

Water alkalinity in site one was 226mg$CaCO_3l^{-1}$ in May and 260 mg $CaCO_3l^{-1}$ in January, whereas at site two it was 156mg$CaCO_3l^{-1}$ in May and 197mg$CaCO_3l^{-1}$ in January (Table 1 and Figure 7). A significant temporal variation was found between May and that of January and March in both sites, while a significant spatial variation was noticed throughout the period of the study, which can be attributed to the surface water and groundwater draining from carbonate mineral formation, becoming more alkaline in January because of the increase in the carbonate minerals dissolution (Eugene, 2008;Hasan *et al*.,2009).According to the quality and standards for alkalinity, naturally occurring levels of alkalinity reaching at least 400mg$CaCO_3l^{-1}$ are not considered a health hazard (Eugene, 2008). Also, according to the results, it is clear that there was a small temporal variation in the values of alkalinity and this reflects the values of pH and the total hardness at both sites.

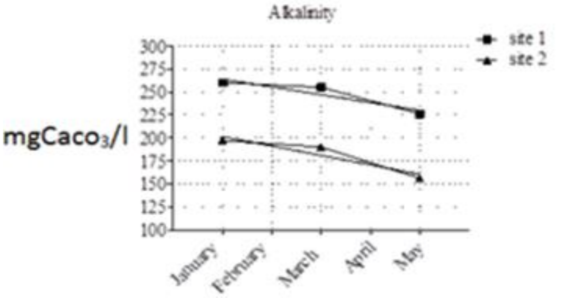

Figure 7. Alkalinity of water samples at the two sites during the period of the study

Measuring hardness is useful as an indicator for the Total Dissolved Solids (TDS). Ca, Mg, CO_3^{-2} and HCO_3^- form the largest part of the total hardness. The values of total hardness at site one varied from 460 to 552 mg $CaCO_3l^{-1}$ (Figure 8) and at site two from 271 to 291mg $CaCO_3l^{-1}$. At site one; the highest value was in January, whereas the lowest value was in May. The temporal variation at site one was 92mg $CaCO_3l^{-1}$, whereas at site two it was 20 mg $CaCO_3l^{-1}$. This temporal variation is due to the discharge and the speed of water flow which cause more dissolution of Ca and Mg salts (Allan and Castillo, 2007). The highest and the lowest values of hardness at site two were recorded in March and May, respectively.

It is obvious from the results of the total hardness at site two that temporal variation was very narrow (Figure 8), because the underground water was characterized by a limited variation in its physical and chemical characteristics (Aloisie *et al*., 2008).

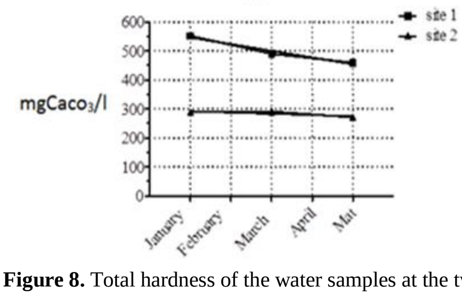

Figure 8. Total hardness of the water samples at the two sites during the period of the study

The result of the total hardness at both sites was coincident with the results of EC and TDS (Figures 3 and 4). According to the classification of Spellman (2008), the water at site one was very hard and at site two it was hard. There was a significant temporal variation in the values of the total hardness in site one during the period of the study, whereas in the site two no significant difference was found in the values of the total hardness between January and March but they differed significantly from those of May. Also, statistical analysis showed that there was a significant spatial variation between the two sites during the period of the study.

Mg hardness was slightly more than the Ca hardness at site one. The values of Ca hardness varied from 195 in May to 260 mg $CaCO_3l^{-1}$in January and the values of Mg hardness varied from 252 in March to 292mg $CaCO_3l^{-1}$ in January (Table 1, Figures 9 and 10). At site two, Ca hardness was more than the Mg hardness, and this hardness was due to the dominance of Ca ions, and its value varied from 175mg $CaCO_3l^{-1}$ in May to 212 $CaCO_3l^{-1}$ in March, whereas the Mg hardness varied from 79mg $CaCO_3l^{-1}$ in March to 96mg $CaCO_3l^{-1}$ in May.

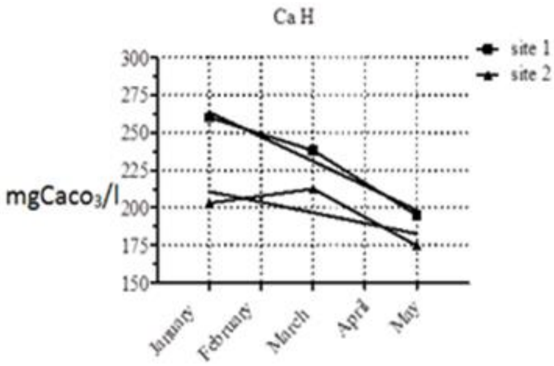

Figure 9. Calcium hardness of the water samples at the two sites during the period of the study

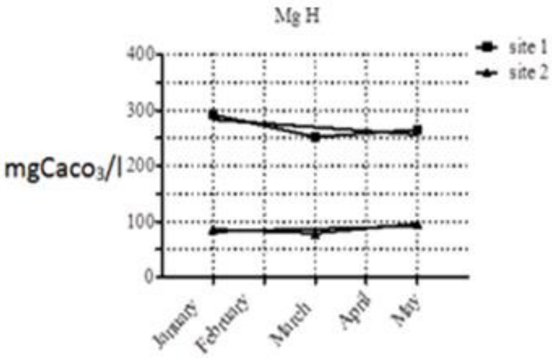

Figure 10. Magnesium hardness of the water samples at the two sites during the period of the study

The results of Ca ions and Mg ions reflect the results of Ca and Mg hardness. The Ca ions values at site one varied from 78 mg/l in May to 104.2 mg/l in January. While in site two, it varied from 70 in May to 85 mg/l in March (Figure 11). Mg ions at site one varied from 61 mg/l in March to 70.9 mg/lin January, while at site two they varied from 19 mg/l in March to 23 mg/l in May (Figure 12).A significant spatio-temporal variation was found in the values of Ca hardness at both sites throughout the period of the study. In site one; there was a significant temporal variation in the values of Mg ions during the period of the study, while Mg ion values in May were significantly differed from those in January and March at site two.

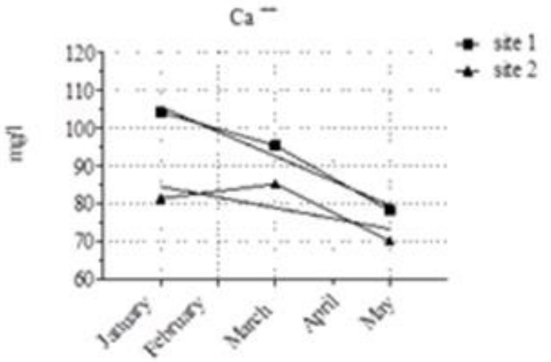

Figure 11. Calcium ions of the water samples at the two sites during the period of the study

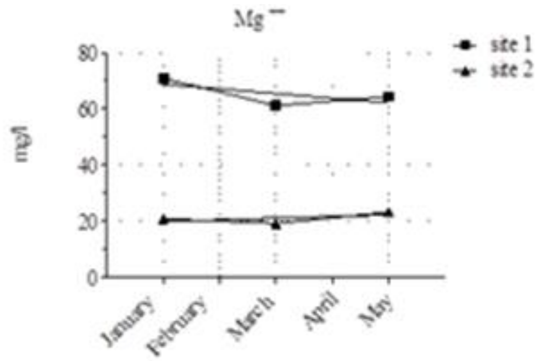

Figure 12. Magnesium ions of the water samples at the two sites during the period of the study

Nitrate values varied from 104 µg /l in March to 191 µg/l in January at site one, whereas at site two they were212 µg/l in March and 335 µg/l in January. A high temporal variation was found at site two (123 µg/l), while less temporal variation was found at site one which was 87 µg/l. So the fluctuation of nitrate concentration during the period of the study was very clear at both sites in which the low concentration was found in March and the high concentration was found in January. A high concentration of nitrate in springs is very common and it was found in many parts of the world (Odum, 1971). In Kurdistan Region, Eza t(2002) found that the nitrate concentrations in some springs at Duhok region ranged from 10 µg/l to 80 ugl^{-1}. The high concentration of nitrate in January is expected because of the high deranging of water through the different parts of its catchments area, and the lower value of nitrate was recorded in March because of the low deranging of water from the aquifer; this is explained by David (1996).Statistically, there was a significant spatio-temporal variation in nitrate concentrations during the period of the study (Table 1 and Figure 13).

Concerning the results of phosphate(Table 1andFigure14), the values of phosphate at site one were 30 µg/l in March and 97.8 µg/l in January, while at site two they were 28µg/l in March and 84.4 µg/l in January. So the results at both sites are coincident and the low values at both sites were recorded in March and the high values in January. The concentration of both nitrate and phosphate increased in January which is due to the high deranging of water at both sites (Veenie, 1999; Ezat, 2002). Also, the results showed that the low spatial variation was in March and in May, and it was quite high in January; generally there was a marginal variation in the values of phosphate between the two regions. A significant spatio-temporal variation in soluble reactive phosphate was found in both sites.

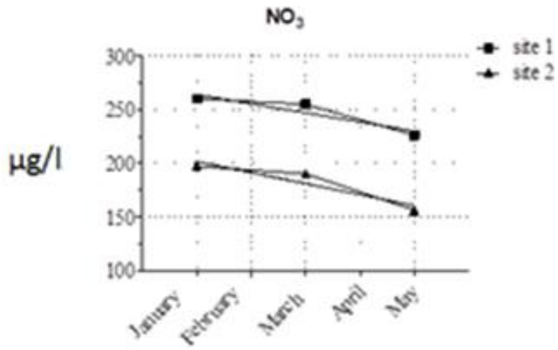

Figure 13. Nitrate ions of the water samples at the two sites during the period of the study

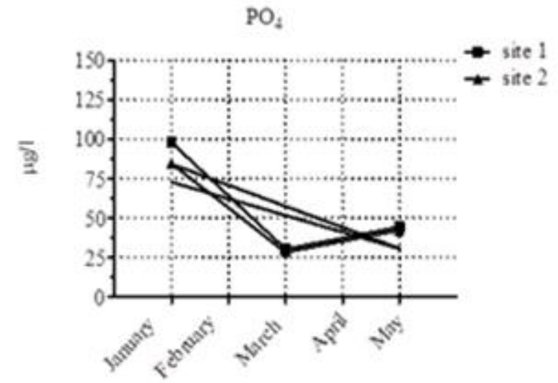

Figure 14. Orthphosphate ion concentrations of the water samples at the two sites during the period of the study

Algal Communities

A total of twenty species belonging to ten genera of four algal divisions (Chlorophyta, Cyanophyta, Baccllariophyta and Rhodophyta) were recorded (Table 2).Identified algal flora in the present study included epipelic, epilithic and epiphytic algae. Although Aloisie (2008) found that the Benthos algae in freshwater habitats were mainly dominated by cyanobacteria, green algae, diatoms and red algae, but the present study did not show this fact. In site one, the algal composition was dominated by diatoms and at site two only one species of red algae and one species of blue green algae were found during the period of the study. From the results of algal flora (Table 2), there was no temporal variation at both sites, whereas a spatial variation was very conspicuous between the two sites. At site one the algal flora included *Cladophora glomearat* and *Zygogonnium ericetarum* belonging to Chlorophyta, *Oscillatoria simplicissima*, *Oscillatoria formosa*, *Oscillatoria limnetica* and *Oscillatoria srubescens* belonging to Cyanophyta, *Cymbellacy biformis var. nonpuctata* (Plate 3-C), *Cymbella turgid* (Plate 3-B), *Cymbella ventricosa* (Plate 3-A), *Cymbella affinis*,*Diatoma hiemale*, *Diatoma anceps var. linearis*

(Plate 3-E), *Diatoma vulgare*,- *Rhopalodia gibba*, *Rhopalodia gibberula* and *Navicula sp.* belonging to the Bacillariophyta.

At site two, during the period of sampling only one taxon was identified which was *Batrachospermum gelatinosia* (Plate 3- F) belonging to the Rhodophyta, and in March one taxon was identified which was *Sticosiphon sansibaricus* belonging to the Cyanophyta (Plate 3-D). Mature carposporphyte of *Batrachospermum gelatinosa* was noticed in March (Plate 3 G and H ;Plate 4).

A surprising result was noticed at site two in which yellowish green color covered the stones at the bed of the spring's pool. This yellow green color was due to the dense growth of bacteria which were Gram negative bacilli, motile, oxidase positive and non-sugar fermentative. The primary diagnosis was *Pseudomonas* species. All isolates were tested against 45 different biochemical tests using Phaenix ID system (BD Diagnostic Systems, Sparks, MD), and the diagnosis was *Pseudomonas fluorescens* with a confidence value 96.Fluorescent *Pseudomonas* strains constitute a diverse group of bacteria that can be distinguished from other Pseudomonads by their ability to produce water-soluble yellow-green pigment (Dabboussi *et al.*; 1999).Dense growth of *Pseudomonas fluorescens* as a biofilm covering the stones prevented the growth of other types of algae because of the lytic- activity of this bacteria (Jeong *et al.*,2007)(Table 2).

Table 2. Showing the identified microbentheic and macrobenthic algae at two sites during the period of study.

Locations	Time of sampling		
	January,2014	March	May
Site 1	1-*Cladophora glomearat:* 2-*Cymbella cybiformis var. nonpuctata* 3-*Cymbella turgida* 4-*Cymbella ventricosa* 5-*Cymbella affinis* 6-*Diatoma hiemalis* 7-*Diatoma anceps var. linearis* *8-Diatoma vulgare.* Note :*Diatoma vulgare* densely epiphytic on *Cladophora glomearat* Note: epilithic sample of diatoms was dominantly *Diatoma vulgaris* and *Cymbella* spp. and *Synedra ulna*were rarely found.	1-*Cymbella cymbiformis* 2-*Cymbella affinis* 3-*Cymbella microcephala* 4- *Synder ulna* 5-*Diatoma anceps* Note: the following algae were found far from the source of water: 1-*Oscillatoria simplicissima* 2-*Oscillatoria formosa* 3-*Oscillatoria limnetica* 4-*Oscillatoria rubescens*	1-*Zygogonnium ericetarum* 2- *Cymbella affinis* 3-*Cymbella cymbiformis* 4-*Cymbella minuta* 5- *Synedra ulna* 6- *Rhopalodia gibba* 7-*Rhopalodia gibberula* 8-*Naviculaspp.*
Site 2	1-*Batrachospermum gelatinosia*	1-*Batrachospermum gelatinosia:* mature cystocarpus observed in March. Also in this month the alga present in dense form on the stones at the bed of springs pool. 2-*Sticosiphon sansibaricus*	1-*Batrachospermum gelatinosia*

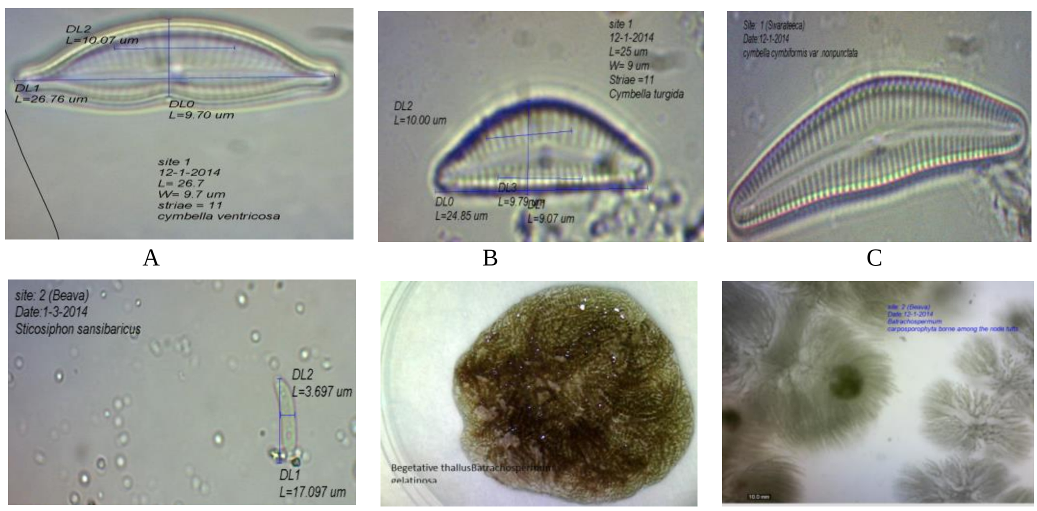

Plate 3. Cymbella ventricosa (A), *Cymbella turgida* (B), *Cymbella cymbiliformis* var. *nonpunctata* (C), *Sticosiphon sansibaricus* (D),Vegetative thallus of *Batracospermum gelatinosa* (E), F mature carposporophyte of *Batracospermum gelatinosa*.

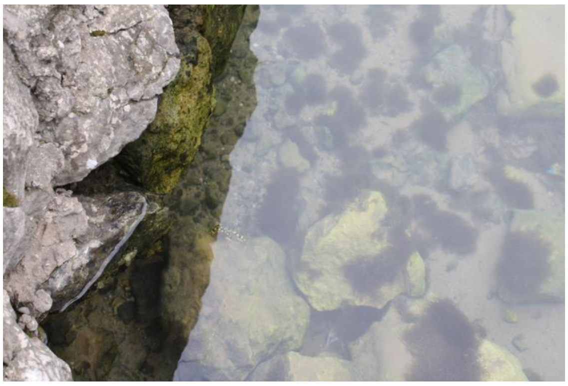

Plate 4. View of Site two showing *Batrachosperum gelatinosia* covered the stones in the bottom of the pool.

4. Conclusion

In site one, there were significant differences between all physico-chemical parameters except for DO and alkalinity, while a less significant difference was observed at site two. Presence of *Neurergus crocatus* salamander in the aquatic ecosystem indicates low algal species richness and low nitrate and phosphate concentrations in the water. The algae, listed in Table 2,can grow in oligotrophic aquatic ecosystem. Only *Batrachospermum gelatinosa* can resist the lytic activity of *Pseudomonas fluorescens.* The spatial variation in the structure of algal community between both sites was clearly evident. No temporal variation was noticed in algal community at each site during the period of the study.

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