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# ALGAE, SOIL FERTILITY AND PHYSICOCHEMICAL PROPERTIES IN AGRICULTURAL FIELDS OF BALOCHISTAN, PAKISTAN

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**Abstract**

This study was conducted to evaluate the effect of algal growth on soil physicochemical properties in the fruit farms of Balochistan, Pakistan. The diversity of algal flora and its relation to physicochemical characteristics of soil from 10 different fruit crop fields of Balochistan, Pakistan were analyzed. The physicochemical properties of soil such as sand, clay, silt, organic matter, electrical conductivity, and hydrogen ion concentration, and total nitrogen, available phosphorous and available potassium were evaluated. The soils analysis was performed through standard methods and Atomic Absorption spectrophotometer. In this study 109 species of algae belonging to 54 genera were isolated and identified. Maximum number of species belonged to blue green, followed by diatoms and minimum number of green algae were recorded. The largest numbers of algal species were recorded from apple, grape and plum farms of Khanozai, Ziarat and Akhtarabad. The soils examined in the present study had high organic matter. The pH at all sites ranged from 5.87–8.60. Maximum pH was recorded from Panjpai (8.60), followed by Khanozai and more algal growth was recorded from these sites. Maximum Nitrogen (0.87%), Posphorus (260 ppm), Potassium (260 ppm) and organic matter (2%) was recorded from the soil of Khanozai with maximum number of (74) algal species. Organic matter was found to be positively correlated with Nitrogen. High Phosphorus and Potassium concentration in soils of all locations were found. All the soil characteristics were significantly correlated with the algal flora. Available potassium plays significant role in the overall production of algae and higher plants. The soils at all sites were loamy except from Sibi and Noshki where it was sandy loam. The loamy soils proved to be the best for algal growth as it retains organic matter, moisture, nutrients and promote microorganism's growth. This study proved that good soil algal growth was found to be useful as it improves soil fertility by improving its texture, water holding capacity, organic matter and provides minerals after decay.

**Key words:** Balochistan, Algal flora, Soil physicochemical characteristics.

## Introduction

Soil algae are simple photosynthetic microorganism found in the soil, they also survive few inches under the soil surface. Soil is a significant habitat for algal growth (Zenova *et al*., 1995). Algae play an important role as a soil biofertilizer in sustainable organic agriculture. Favorable temperature and moisture boost algal growth this improves soil structure and fertility thus enhances agricultural production. Soil algae and some other organisms improve soil characteristics such as texture, organic matter and airing (Ibraheem, 2007). Algae fix nitrogen, improve soil fertility and play a significant role in plant succession (Hussain *et al*., 1984; Hameed, 2007). It is also found that algae present on soil increase organic matter, nitrogen and stabilizes it, which helps in improving of its fertility. This promotes germination of seeds and growth of other microorganisms. Some species of Cynobacteria fix elemental nitrogen, while other algae increase soil organic matter, nitrogen and mineral contents after their decomposition. Algae is a good source of fertilizer, resulting in less mineral runoff as compare to the use of other manure or chemical fertilizers (Hameed, 2007).

Soil chemical, and biological characteristics influence soil texture, pH, EC, organic matter and minerals play an important role in algal growth and enhances crop yield. Soil chemical characteristics are important indicators for assessing the soil for sustainable fruit and crop production, nutrient availability, and OM content (Schoenhaltz *et al*., 2000). Soil pH plays an important role in determining the diversity of algal communities. Nitrogen is a limiting nutrient for determining crop growth in farms. Therefore, livestock manure or chemical fertilizers are commonly used on farms for high yield (Malik *et al*., 2001; Vasileva & Athar, 2012; Ilieva & Vasileva, 2013). Soil physical, chemical characteristics, organic matter and microbial communities have a significant correlation with each other (Degens *et al*., 2000). Algal growth is influenced by soil physical and chemical properties. Algae after decay increases organic matter and releases macro and micro nutrients in the soil. The harmful effects of chemical fertilizer are already established. On one hand they are increasing water pollution, supporting land degradation and are hazardous to human health. Therefore, this study was initiated to check the affect of algae as natural fertilizer.

## Materials and Methods

**Study area localities:** Soil and algal samples were collected from10 localities of Balochistan, Pakistan, these locations are given in Map (Fig. 1). Khanozai (1), Akhtar abad (2), Nushki (3), Botanical Garden University of Balochistan, Quetta/ BG, UOB (4), Sibi (5), Mastung (6), Panjpai (7), Hanna Urak (8), Ziarat (9) and Kardgap (10).

**Sample collection:** Algae were collected from the upper wet soil surface by scraping; approximately 100 g of soil was also taken from the same location. Collection was done seasonally from 5 sites of each locality during 2015–2016.

**Algae identification:** The soil and algae from were brought to the laboratory in sterile galss jars. The algal samples were preserved in 4% formaldehyde or 30% methanol. Morphological characteristics were studied through research microscope and identification up to species level was done with the help of literature available (Prescott, 1951; Tiffany & Britton, 1952; Shameel, 2001; John *et al*., 2002: Asrar & Hussain, 2000).

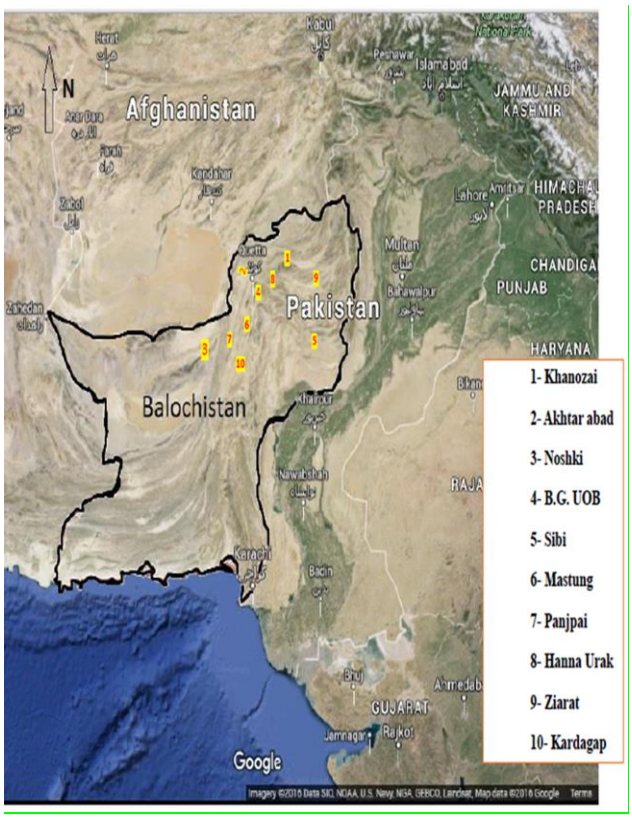


Fig. 1. Map of Balochistan displaying work sites.

**Soil physicochemical properties:** Soil samples were dried in air, ground and sieved through 3-mm mesh screen. The method prescribed by Bouyoucos (1962) was followed to determine particle size through hydrometer. Standard methods described by Jackson (1963) were used to measure soil E.C., pH, O.M. Total nitrogen was checked through Kjeldahl's method while Phosphorus and potassium were measured by the AB-DTPA extraction method.

**Soil nitrogen (N), phosphorus (P), potassium (K) determination:** The samples were analysed by Kjeldahl's method. N was estimated by digesting contents in $H_2SO_4$ followed by distillation and finally titrating the distillate with acid (Jones *et al*., 1982). AB-DTPA was used to extract available Phosphorus (P) and Potassium (K). The blue colour method was used in phosphorous determination. Meanwhile, K was analysed directly by emission spectroscopy coupled with flame photometry (Knudsen *et al*., 1982).

**Statistical analysis**

The Analysis Tool Pak in Microsoft Excel 2013 and Paleontological Statistics Software Package for Education (version 3.1) were used to estimate the values for soil samples. One-way analysis of variance (ANOVA) was constructed for this purpose with a confidence interval of 95% ($p$=0.05). The results were verified through online analysis tools, such as Graph Pad. All results were crosschecked to determine their significance at $p$<0.05 and any values above this level were considered as non-significant.

**Results and Discussion**

This is the first study to analyze and evaluate the role of soil algal flora from the farmlands of Balochistan, Pakistan. Farms were selected with very good cultivation of fruits, vegetables and cereal crops. These places are famous for their fruit production specially apple, cherries, plum, apricot and grapes because of these fruits Balochistan is called as fruit basket of Pakistan. The results of soil physico-chemical analysis from 10 localities during 2016-17 with algal diversity in all seasons are given in Tables (1-4). A total of 51 genera with 109 algal species were recorded belonging to classes Cynophyceae, Chlorophyceae and Bacillariophyceae. Results of soil samples analyzed for their texture and physicochemical properties showed that soils from 8 localities were loamy while at Sibi and Noshki it was sandy. Silty loamy soil was recorded from Khanozai, Hana-Urak and Ziarat (silt 37-25%) maximum number of algae was recorded from these sites, these soils proved to be best as maximum number of algae were recorded from these sites. The most common algal species recorded from these sites belonged to Cyanophyceae, followed by Bacillariophyceae and least species were from Chlorophyceae. Common Cynobacteria identified from almost every site were the species of *Anabaena*, *Chroococcus*, *Lyngbya*, *Oscilliatoria*, and *Phormidium.* The common diatoms included species of *Hantzschia*, *Navicula*, and Nitzschia. The green algae included species of *Chlorococcum*, *Chlorella*, *Cladophora*. However, less number of algal species was recorded from Kardgap, Noshki, Sibi, and Punjpai due to sandy loamy soil (sand 55-72%) and low water availability. These are desert areas with high temperature and low rainfall however; more blue green algae and diatoms were found from the soils of vegetable and cereal crops farms.

**Table 1. Number of genera and species distributed among different algal divisions.**

| S. No | Division | Genera | Species |
|---|---|---|---|
| 1. | Cyanophyta | 21 | 52 |
| 2. | Chlorophyta | 13 | 26 |
| 3. | Bacillariophyta | 17 | 31 |
| | **Total** | **51** | **109** |

Soil electrical conductivity (EC) is an indicator for the amount of salts in soil. High EC promotes algal diversity. Maximum EC (4 $dsm^{-1}$) was recorded from Akhtarabad and minimum was found at Kardgap (1.19 $dsm^{-1}$). Maximum number of algae was recorded from Khanozai (74) and from Akhtarabad (69) during spring season and and minimum number was found (33) from Kardgap during autumn season. High soil pH was found at all sites and overall mean pH value ranged between7.5 - 8.3. High pH was recorded from Khanozai (8.1), followed by Akhtarabad and Ziarat more algal growth was recorded from these areas because alkaline pH supports algal growth. Maximum amount of organic matter (2%), nitrogen (0.87%), phosphorus (242 ppm) and potassium (186 ppm) was also recorded from the soil of Khanozai, highest number of algal species were recorded from this site. Medium concentration of Phosphorus and Potassium was recorded from soil of all sites. Maximum N was found at Akhtarabad and minimum was found at Noshki (0.12 %). Statistical analysis (Tables 2-5) indicated that soil physicochemical characteristics were significantly correlated with the distribution of algal flora.

**Table 2. Physicochemical properties of soil samples with algal density collected from 10 localities during spring season.**

| Soil properties | Localities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Khanozai (1) | Akhtarabad (2) | Nushki (3) | BG, UOB (4) | Sibi (5) | Mastung (6) | Panjpai (7) | Hanna Urak (8) | Ziarat (9) | Kardgap10 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **Physical properties** | | | | | | | | | | |
| Sand | 29.2±2.0$^{b}$ | 28.1±1.0$^{b}$ | 42.3±2.1$^{a}$ | 30.2±1.2$^{b}$ | 45.6±1.4$^{a}$ | 37.1±2.3$^{ab}$ | 41.5±3.0$^{a}$ | 31.5±2$^{b}$ | 30.5±1$^{b}$ | 36.4±1.0$^{ab}$ |
| Clay | 32.8±1.0$^{ab}$ | 34.8±3.1$^{a}$ | 30.2±2.2$^{ab}$ | 32.4±1.7$^{ab}$ | 27.3±1.5$^{b}$ | 34.8±3.2$^{a}$ | 30.3±1.5$^{ab}$ | 33.4±1.6$^{a}$ | 34.4±2.0$^{a}$ | 33.5±2.0$^{a}$ |
| Silt | 38.0±2$^{a}$ | 37.1±2.0$^{a}$ | 28.5±1.0$^{b}$ | 37.4±1.2$^{a}$ | 28.1±2.0$^{b}$ | 28.1±3.1$^{b}$ | 28.2±1.0$^{b}$ | 35.1±2.1$^{ab}$ | 35.1±2.1$^{ab}$ | 30.1±1.0$^{b}$ |
| O.M. | 1.47±0.1$^{a}$ | 1.13±0.1$^{a}$ | 1.20±0.3$^{a}$ | 1.09±0.2$^{a}$ | 0.50±0.2$^{ab}$ | 0.27±0.3$^{b}$ | 0.17±0.1$^{b}$ | 0.63±0.3$^{ab}$ | 1.15±0.1$^{a}$ | 0.37±0.3$^{b}$ |
| **Chemical properties** | | | | | | | | | | |
| EC (dsm$^{-1}$) | 2.34±0.1$^{a}$ | 1.45±0.2$^{b}$ | 2.30±0.1$^{a}$ | 1.45±0.1$^{b}$ | 1.95±0.1$^{ab}$ | 1.93±0.2$^{ab}$ | 2.10±0.1$^{a}$ | 2.99±0.1$^{ab}$ | 1.99±0.1$^{ab}$ | 1.42±0.2$^{b}$ |
| pH | 7.52±2.0$^{a}$ | 7.76±2.0$^{a}$ | 6.1±2.1$^{b}$ | 6.41±2.1$^{b}$ | 6.67±2.0$^{ab}$ | 7.57±2.1$^{a}$ | 7.07±1.2$^{ab}$ | 6.67±2.0$^{ab}$ | 7.37±1.0$^{a}$ | 7.09±2.0$^{ab}$ |
| Total N% | 0.58±0.01$^{ab}$ | 0.92±0.02$^{a}$ | 0.65±0.01$^{ab}$ | 0.12±0.01$^{b}$ | 0.19±0.01$^{b}$ | 0.20±0.01$^{b}$ | 0.29±0.02$^{b}$ | 0.61±0.01$^{ab}$ | 0.48±0.01$^{ab}$ | 0.31±0.01$^{b}$ |
| Available P (ppm) | 242±1$^{a}$ | 232±1$^{a}$ | 139±1$^{b}$ | 142±1$^{b}$ | 141±1$^{b}$ | 222±1$^{ab}$ | 113±1$^{b}$ | 240±1$^{a}$ | 215±1$^{ab}$ | 140±1$^{b}$ |
| Available K (ppm) | 186.4±1$^{a}$ | 148.6±2$^{ab}$ | 166.9±2$^{ab}$ | 165.4±1$^{ab}$ | 107.9±2$^{b}$ | 107.6±2$^{b}$ | 112.8±3$^{b}$ | 157.9±1$^{ab}$ | 112.8±2$^{b}$ | 167.9±3$^{ab}$ |
| Algae sps | 72$^{a}$ | 69$^{a}$ | 43$^{b}$ | 34$^{b}$ | 46$^{b}$ | 57$^{ab}$ | 37$^{b}$ | 53$^{ab}$ | 70$^{a}$ | 35$^{b}$ |

Different letters in the same coloumn shows statistically significant differences; significance level $p$=0.05

**Table 3. Physicochemical properties of soil samples with algal density collected from 10 localities during summer season.**

| Soil properties | Localities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Khanozai (1) | Akhtarabad (2) | Nushki (3) | BG, UOB (4) | Sibi (5) | Mastung (6) | Panjpai (7) | Hanna Urak (8) | Ziarat (9) | Kardgap10 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **Physical properties** | | | | | | | | | | |
| Sand | 29.1±1.0$^{b}$ | 29.8±2.2$^{b}$ | 41.4±1.0$^{a}$ | 38.4±2.0$^{a}$ | 44.8±2.0$^{a}$ | 38.5±1.1$^{a}$ | 41.7±2.0$^{a}$ | 27.3±3.0$^{b}$ | 29.5±1.0$^{b}$ | 36.5±2.1$^{ab}$ |
| Clay | 32.8±2.0$^{a}$ | 33.1±1.0$^{a}$ | 31.5±2.0$^{a}$ | 33.5±1$^{a}$ | 28.1±1$^{b}$ | 33.4±2$^{a}$ | 31.2±1$^{a}$ | 33.5±1$^{a}$ | 34.2±2$^{a}$ | 34.2±1$^{a}$ |
| Silt | 38.1±1.0$^{a}$ | 37.1±2.0$^{a}$ | 28.1±1.1$^{b}$ | 28.1±2$^{b}$ | 28.1±2$^{b}$ | 28.1±3$^{b}$ | 28.1±1$^{b}$ | 39.3±2$^{a}$ | 36.3±3$^{ab}$ | 29.3±2$^{b}$ |
| O.M. | 2.1 ±0.1$^{a}$ | 1.2±0.2.0$^{ab}$ | 1.3±0.1$^{ab}$ | 1.5 ±0.1$^{ab}$ | 0.6±0.2$^{b}$ | 0.3±0.1$^{b}$ | 0.3±0.2$^{b}$ | 0.8±0.2$^{b}$ | 1.2±0.1$^{ab}$ | 0.5±0.3$^{b}$ |
| **Chemical properties** | | | | | | | | | | |
| EC (dsm$^{-1}$) | 2.95±1.0$^{a}$ | 1.99±1.0$^{b}$ | 2.99±1.0$^{a}$ | 1.99±1$^{b}$ | 2.11±1$^{b}$ | 2.08±1$^{b}$ | 2.79±1$^{ab}$ | 3.08±1$^{a}$ | 2.75±1$^{ab}$ | 1.95±1$^{b}$ |
| pH | 8.1±2.0$^{a}$ | 7.76±2.0$^{a}$ | 6.1±2.0$^{b}$ | 6.41±2$^{b}$ | 6.67±2$^{ab}$ | 7.57±2$^{a}$ | 7.20±1$^{a}$ | 6.67±2$^{ab}$ | 7.37±1$^{a}$ | 7.09±2$^{ab}$ |
| Total N% | 0.67±0.1$^{a}$ | 0.87±0.2$^{a}$ | 0.21±0.03$^{b}$ | 0.19±0.1$^{b}$ | 0.22±0.2$^{b}$ | 0.47±0.1$^{ab}$ | 0.37±0.1$^{b}$ | 0.29±0.2$^{b}$ | 0.35±0.1$^{b}$ | 0.38±0.1$^{b}$ |
| Available P (ppm) | 256±4$^{a}$ | 241±2.0$^{a}$ | 155±1.0$^{b}$ | 160±1.0$^{b}$ | 159±1$^{b}$ | 250±2$^{a}$ | 121±1$^{b}$ | 231±3$^{ab}$ | 224±1$^{ab}$ | 156±3$^{b}$ |
| Available K (ppm) | 170±3.0$^{a}$ | 153±2.2$^{a}$ | 109±2.0$^{b}$ | 166±3.0$^{a}$ | 109±3$^{b}$ | 167±3$^{a}$ | 113±2$^{ab}$ | 159±1$^{a}$ | 162 ±2$^{a}$ | 113±1$^{ab}$ |
| Algae sps | 74$^{a}$ | 68$^{a}$ | 42$^{b}$ | 33$^{b}$ | 45$^{b}$ | 54$^{ab}$ | 37$^{b}$ | 52$^{ab}$ | 68$^{a}$ | 34$^{b}$ |

Different letters in the same coloumn shows statistically significant differences; significance level $p$=0.05

**Table 4. Physicochemical properties of soil samples with algal density collected from 10 localities during autumn season.**

| Soil properties | Localities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Khanozai (1) | Akhtarabad (2) | Nushki (3) | BG, UOB (4) | Sibi (5) | Mastung (6) | Panjpai (7) | Hanna Urak (8) | Ziarat (9) | Kardgap10 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **Physical properties** | | | | | | | | | | |
| Sand | 29.3±2$^{b}$ | 37.5±1$^{a}$ | 42.2±1$^{a}$ | 38.1±1$^{a}$ | 44.5±2$^{a}$ | 38.2±2$^{a}$ | 40.4±2$^{a}$ | 31.4±3$^{ab}$ | 27.4±3$^{b}$ | 37.2±1$^{a}$ |
| Clay | 32.5±1$^{a}$ | 33.2±2$^{a}$ | 32.1±1$^{a}$ | 32.4±1$^{a}$ | 30.1±2$^{a}$ | 34.4±1$^{a}$ | 30.5±2$^{a}$ | 32.2±3$^{a}$ | 33.3±2$^{a}$ | 32.4±2a |
| Silt | 38.2±1$^{a}$ | 29.3±2$^{b}$ | 26.7±2$^{b}$ | 29.5±3$^{b}$ | 26.4±3$^{b}$ | 27.4±3$^{b}$ | 30.1±3$^{b}$ | 36.4±2$^{a}$ | 39.5±3$^{a}$ | 30.4±3$^{b}$ |
| O.M. | 2.0±0.3$^{a}$ | 1.2±0.2$^{b}$ | 0.6±0.1$^{b}$ | 1.5±0.3$^{ab}$ | 0.7±0.2$^{b}$ | 0.5±0.3$^{b}$ | 0.4±0.2$^{b}$ | 2.2±0.3$^{a}$ | 1.5±0.1$^{ab}$ | 0.7±0.2$^{b}$ |
| **Chemical properties** | | | | | | | | | | |
| EC (dsm$^{-1}$) | 3.65±1$^{a}$ | 2.70±2$^{b}$ | 3.60±2$^{a}$ | 2.69±1$^{b}$ | 2.30±2$^{b}$ | 3.50±1$^{a}$ | 3.49±3$^{a}$ | 4.50±1$^{a}$ | 3.45±2$^{a}$ | 2.65±1$^{b}$ |
| pH | 8.0±2$^{a}$ | 7.59±3$^{a}$ | 6.93±1$^{ab}$ | 7.24±2$^{ab}$ | 7.50±1.0$^{a}$ | 8.40±3$^{a}$ | 7.60±1$^{a}$ | 7.50±2$^{a}$ | 7.20±1$^{ab}$ | 7.92±2$^{a}$ |
| Total N% | 0.59±0.1$^{a}$ | 0.92±0.3$^{a}$ | 0.18±0.3$^{b}$ | 0.21±0.1$^{b}$ | 0.30±0.2$^{b}$ | 0.62±0.1$^{a}$ | 0.46±0.2$^{ab}$ | 0.56±0.2$^{a}$ | 0.55±0.3$^{a}$ | 0.43±0.2$^{ab}$ |
| Available P (ppm) | 260±2$^{a}$ | 250±1$^{a}$ | 164±3$^{b}$ | 169±1$^{b}$ | 168±2$^{b}$ | 235±1$^{a}$ | 130±2$^{b}$ | 240±2$^{a}$ | 265±1$^{a}$ | 165±1$^{b}$ |
| Available K (ppm) | 160.±2$^{a}$ | 160±1$^{a}$ | 128±2$^{b}$ | 167±1$^{a}$ | 112±2$^{b}$ | 110±3$^{b}$ | 110±2$^{b}$ | 119±1$^{b}$ | 170±2$^{a}$ | 190±3$^{a}$ |
| Algae sps | 70$^{a}$ | 66$^{a}$ | 41$^{ab}$ | 33$^{b}$ | 44$^{ab}$ | 54$^{ab}$ | 36$^{b}$ | 51$^{ab}$ | 65$^{a}$ | 33$^{b}$ |

Different letters in the same coloumn shows statistically significant differences; significance level $p$=0.05

**Table 5. Physicochemical properties of soil samples with algal density collected from 10 localities during winter season.**

| Soil properties | Localities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Khanozai (1) | Akhtarabad (2) | Nushki (3) | BG, UOB (4) | Sibi (5) | Mastung (6) | Panjpai (7) | Hanna Urak (8) | Ziarat (9) | Kardgap10 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **Physical properties** | | | | | | | | | | |
| Sand | 30.1±1$^{b}$ | 29.3±2$^{b}$ | 42.3±1$^{a}$ | 30.5±2$^{b}$ | 45.4±3$^{a}$ | 36.2±1$^{ab}$ | 40.2±1$^{a}$ | 28.1±2$^{b}$ | 30.4±3$^{b}$ | 36.1±1$^{ab}$ |
| Clay | 32.7±2$^{a}$ | 33.5±1$^{a}$ | 31.2±2$^{a}$ | 33.3±2$^{a}$ | 26.3±1$^{b}$ | 34.4±3$^{a}$ | 30.7±3$^{a}$ | 33.1±1$^{a}$ | 34.4 ±2$^{a}$ | 33.6±1$^{a}$ |
| Silt | 37.2±1$^{a}$ | 37.2±2$^{a}$ | 27.5±1$^{b}$ | 36.2±1$^{a}$ | 28.3±1$^{b}$ | 29.4±2$^{b}$ | 30.1±2$^{b}$ | 38.8±1$^{a}$ | 35.2±2$^{a}$ | 30.3±2$^{b}$ |
| O.M. | 1.9±0.2$^{a}$ | 1.09±0.1$^{ab}$ | 1.14±0.3$^{ab}$ | 1.01±0.1$^{ab}$ | 0.32±0.3$^{b}$ | 0.16±0.2$^{b}$ | 0.10±0.1$^{b}$ | 0.49±0.3$^{b}$ | 1.08±0.1$^{ab}$ | 0.29±0.1$^{b}$ |
| **Chemical properties** | | | | | | | | | | |
| EC (dsm$^{-1}$) | 3.24±1$^{a}$ | 4.0±2$^{a}$ | 2.99±1$^{ab}$ | 3.21±1$^{a}$ | 2.42±1$^{b}$ | 2.67±1$^{b}$ | 2.0±1$^{b}$ | 2.57±1$^{b}$ | 3.45±1$^{a}$ | 1.19±1$^{b}$ |
| pH | 7.12±1$^{a}$ | 7.01±2$^{a}$ | 5.87±1$^{b}$ | 6.01±1$^{ab}$ | 6.50±1$^{ab}$ | 6.99±2$^{a}$ | 7.49±2$^{a}$ | 6.50±1$^{ab}$ | 7.90±2$^{a}$ | 6.87±1$^{a}$ |
| Total N% | 0.87±0.2$^{a}$ | 0.85±0.1$^{a}$ | 0.12±0.4$^{b}$ | 0.59±0.1$^{ab}$ | 0.08±0.2$^{b}$ | 0.63±0.4$^{ab}$ | 0.28±0.5$^{b}$ | 0.65±0.1$^{ab}$ | 0.58±0.2$^{ab}$ | 0.22±0.2$^{b}$ |
| Available P (ppm) | 226±1$^{a}$ | 216±3$^{a}$ | 125±1$^{b}$ | 130±2$^{b}$ | 129±1$^{b}$ | 225±1$^{a}$ | 109±1$^{b}$ | 206±1$^{ab}$ | 213±1$^{a}$ | 126±1$^{b}$ |
| Available K (ppm) | 150 ±2$^{a}$ | 156±2$^{a}$ | 165±1$^{a}$ | 163±2$^{a}$ | 109±1$^{b}$ | 110.±1$^{b}$ | 106±2$^{b}$ | 106±3$^{b}$ | 165±2$^{a}$ | 110±2$^{b}$ |
| Algae sps | 70$^{a}$ | 64$^{a}$ | 40$^{b}$ | 32$^{b}$ | 43$^{ab}$ | 53$^{ab}$ | 33$^{b}$ | 50$^{ab}$ | 69$^{a}$ | 33$^{b}$ |

Different letters in the same coloumn shows statistically significant differences; significance level $p$=0.05

The soil of Khanozai, Hana-Urak and Ziarat was loamy which proved to be the best for algal growth as it retained organic matter, moisture, nutrients and promoted microorganism's growth. At these farms where most of the apple orchards of Balochistan were growing, rich algal flora was found most probably due to loamy soils and favourable conditions. Originally the soil of these localities had more pebbles and stones. However, the farmers bring soil from dams to cover the land with thick layer of soil which is most suitable for plant and algal growth. Soil chemical properties influence algal growth as well as the growth of orchards such as apple, plum, grape and crop production. The most common algal species recorded from these sites belonged to Cyanophyceae, followed by Bacillariophyceae and minimum number of species from Chlorophyceae. The literature supports the widespread occurrence of Cynophyceae and Bacillariophyceae from agricultural soil (Song *et al*., 2005; Begum *et al*., 2008; Khaybullina *et al*., 2010). The soil algal flora is affected by substrate physicochemical nature, available moisture, sun light, optimum temperature, pH and minerals. These factors directly affect algal growth and distribution in soil (Zenova *et al*., 1995). Soil physical and chemical properties determine soil quality (Papendick & Par, 1992 Cyanobacteria acts) as best bio-fertilizers these are eco-friendly and cost effective for farmland's agriculture production. Algae present in agricultural fields help and improve soil characteristics such as organic matter, texture, and airing (Ibraheem, 2007). Soil physicochemical properties effect soil fertility directly or indirectly affects it's productively that result in improvement or deterioration of crop production (Chaudhary *et al*., 2012). Varying levels of organic matter were found at all sites this was also influenced by the seasons. However good algal diversity at Khanozai was found with maximum organic matter. Organic matter plays significant role in the overall production of algae and vegetation. High organic matter increased the algal growth and crop yield. Soil algae also produce organic matter after its death and increases soil fertility. Similar was observed by many scientists. Algae is a source of organic matter in soil (Ibraheem, 2007). The death and decay of algae produces organic matter it gets mixed with the soil particles. The algal mucilage acts as binding agent this also improves soil texture, thus increasing the humus content and makes it more habitable for other plants (Marathe & Chandhari, 1975). Humus accumulation also helps in retaining moisture. Algal crusts modify soil increases its nutrient content, availability of water, stops soil erosion and promote other plants growth (Stal, 2007). Organic matter upgrades soil fertility by the growth of microorganisms (Mishra & Pabbi, 2004). Further soil algae produce polysaccharides which enhance soil aggregation, porosity and water retention capacity (Roger & Reynaud, 1982; Chaudhary *et al*., 2007).

However, algal flora abundance and diversity is influenced by soil nutrient. Nitrogen is a limiting factor for algal and crop growth in many farms. Therefore, fertilizers are used to supplement the N-deficient farms (Malik *et al*., 2001). Nitrogenous compounds are constantly supplied to soil by the growth of algae either during their life time or after the decomposition of dead parts (Fogg, 1947; Shield, 1957). Algal inoculation, or algal growth was applied to check its role as an alternative to fertilizer this exerted a positive role on soil properties (Aiyer *et al*., 1972). The use of cyanobacteria results in better yields, aggregate the soil particles, and improves its water holding capacity, availability of phosphorus, as well as the amount of micro flora (Watanabe & Roger, 1984). Bio-fertilizers made by Cyanobacteria are cost effective and eco-friendly for farmlands production. The phosphorus concentration in soils of all ten locations showed significantly positive correlation with soil O.M. same findings were also observed by Das *et al*., (2013) that total amount of N and P in soil was influenced by O.M. content. The amount of phosphorus was found to be directly influenced by the algal growth as maximum species were recorded from the sites where high P was recorded. Phosphorus and Potassium are essential elements as there plays an important role in photosynthesis. Ahmed *et al*., (2011) reported high N and P concentrations produced greater vegetative cover. Soil conditions help in improving plant and animal communities, soil microorganisms are necessary for maintaining the stability and fertility of soils (Metting, 1981). The results showed that good algal growth was observed at the sites where sufficient water, N, P and K was found. Bio fertilizers are better eco-friendly and free of cost as compare to chemical fertilizers. Similar observations were made by Ahmed (2011). Bio fertilizers play a significant role in the nutrient supplies to fruits farms and cereal crops because of high nutrient turn-over in production system; it also reduces exorbitant cost of fertilizers and support environmental protection. The farms in Khanozai, Akhtarabad, Hanna-Urak and Ziarat produce best and largest quantities of apple, cherries, plum, and grapes. Therefore, it is proved that the soil with good algal growth supports good fruit, crop and vegetable production.

## Conclusion

Algal growth was found to be related with EC, pH and soil texture, mineral composition. Khanozai, Ziarat and Akhtar Abad were the best sites as favourable physicochemical conditions, texture, pH, high OM and nutrients were available. Largest number of algal species was recorded and tons of apples, cherries, plums, grapes and vegetables are produced. This shows that high algal growth significantly improves farms soil fertility and thus supports fruit or crop production as bio fertilizer.

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