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Assessment of the relationship between some physico-chemical properties of soil and soil algae in micro basin scale in Kocaeli

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Abstract: In this study, it was aimed to determine the relationship between soil algae and physico-chemical structure of soil. Algae composition and some soil quality parameters from 12 sampling stations were investigated between March 2019 and May 2019 in Kocaeli. Physico-chemical properties that reflect soil nutrient content and fertility status (pH, conductivity, salinity, CaCO₃, organic matter, saturation, P_2O_5 and K_2O) were determined using standard physicochemical techniques. Average in soil parameters were determined as pH: 8.06, conductivity: 5.79 µmhos / cm, salinity: 0.22 ‰, CaCO₃: 9.98%, organic matter: 1.70%, saturation: 59.55%, P_2O_5 : 3.16 kg / da, K_2O : 93.92 kg / da. Algal flora of Kocaeli province was a total of 30 taxa, 14 taxa of Bacillariophyta, 3 taxa of Chlorophyta, 1 taxa of Charophyta and 12 taxa of Cyanobacteria were identified. The determined as the *Chroococcus cohaerens, Limnococcus limneticus, Phormidium nigroviride, Oscillatoria limosa, Gomphonema olivaceum, Hantzschia amphioxys* and *Nitzschia brevissima* most dominant taxa. These taxa have been identified in stations with high industrial activity. Bacillariophyta taxa were found in all months due to their ecological tolerance, while other species belong to spring. In this study, the species diversity were found similar in research stations.

Keywords: Soil, epipelic algae, ecology, micro basin, physico-chemical parameters © 2020 ACG Publications. All rights reserved.

1. Introduction

Soil resources are very important for the sustainability of terrestrial ecosystem and food safety. The quality of soil is highly influential on the structure of food and soil biodiversity. Soil micro algae have an important role in organic matter cycle [1 - 3]. As photoautotrophs, microalgae constitute the basis of soil food nets and play a key role in soil development. Terrestrial algae are very important for increasing soil fertility, preventing wind-borne erosion and sustainable management of soil by identifying biodiversity. Changes in algal biodiversity enable biological monitoring of soil recovery during soil development. In the research was determined the importance of algal diversity in quality assessment of agricultural ecosystems and of land usage [4]. Algae have been utilized as biological assay organisms for anticipating crop reaction to both fertilizers and pesticides because of their biochemical similarity to higher plants and their fast generation time [5]. In the formation of soil structure, flow of matter in the ecosystem and nitrogen fixation,

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algae spreading in the soil are very important. In particular, Cyanobacteria members reduce water erosion from the wind by providing soil water balance. However, algae are used as indicator organisms in the determination of anthropogenic pollution [3,5-8]. Soil algae are affected by pesticides, industrial and domestic wastes. In general, most herbicides, fungicides, and soil fumigants are detrimental to soil algae while most insecticides are not. However, the physico-chemical properties of the soil are also very important for life. The climate, geological structure and population of the region are important factors affecting soil properties [9]. Physical properties of soil (soil color, soil texture, soil structure) and chemical properties of soil are very necessary for ecological cycle. However, increasing industrialization and population growth in recent years has caused adverse effects on the fertile land. In particular, the Kocaeli region is under the influence of industrial pollutants. Kocaeli region and in Turkey, soil physico-chemical structure, heavy metal ratios, determination of pollutants, although the development work carried out in the area of agricultural land, there is less research on soil algae [2, 10-18].

In this study we aimed to determine the algae taxa on soil physical and chemical properties in Kocaeli region. The study will be helpful for detecting changes in soil use, biodiversity conservation and in planning for the land utilization.

2. Experimental

2.1. Materials and Methods

Kocaeli is located between 40 ° 51′ 11 " North latitude and 29 ° 52′ 53" East longitude of Marmara Region. The surface area of Kocaeli province is 3,418 km². It is an important region of industry in Turkey [10].

2.2. Research Stations

The research was conducted between March 2019 and May 2019 at 12 stations in Kocaeli region. The coordinates of the sampling stations were given in Figure 1 and Table 1.



Figure 1. Research area and sampling stations (Turkey)

Stations	Regions	Coordinates
1	Darıca	40°46.55"N - 29°22.12"E
2	Çayırova	40°50.10"N - 29°22.59"E
3	Gebze	40°48.90"N - 29°26.23"E
4	Dilovası	40°46.47"N - 29°32.06"E
5	Körfez	40°42.46"N - 29°44.30"E
6	Derince	40°54.80"N - 29°54.17"E
7	Kandıra	41°04.12"N - 30°09.01"E
8	Izmit	40°45.55"N - 29°56.26"E
9	Kartepe	40°45.12"N - 30°1.23" E
10	Basiskele	40°37.47"N - 29°57.03"E
11	Gölcük	40°42.43"N - 29°50.28"E
12	Karamürsel	40°41.21"N - 29°36.54"E

Table 1. Coordinates of the sampling stations

2.3. Collection and Examination of Samples

Kocaeli region is determined epipelic terrestrial algae and soil structure. Soil samples were taken between March 2019 and May 2019. Soil samples were taken vertically from the surface and just below the surface (1 - 2 cm.) using special perforated metal material. Physico chemical analysis of soils, pH (TS8332 ISO 10390), electrical conductivity (TS 8334), salinity (TS 8334), CaCO₃ (TS EN ISO 10693), organic matter (TS 8336), saturation (TS 8333), P2O5 (TS 8340), K2O (TS 8341), according to standard techniques and methods were determined in the laboratory of Kocaeli Metropolitan Municipality. Soils for algae samples were placed in sterile petri dishes and moistened with sterile water. Lamels were placed on moist soil (22x22mm.). These samples were placed in a natural light area in the laboratory and left to stand for 24 hours. Algae adhering to the lamels by phototaxis were examined in transient preparations in 10% glycerin. Other soil suspension was boiled in 10% H₂O₂ solution to remove any organic material and was repeatedly rinsed with distilled water to obtain cleaned diatom frustules [19,16]. The slides were examined using an Motic type 102M research microscope under 1600 X magnification. Algae taxa were identified by using relevant books and literatures [20 - 29]. Current systematics of taxa were checked from databases [30,31]. However, correlation analysis was performed to determine the relationship of algae species with physico-chemical parameters. Statistical analyzes were performed in SPSS v.11.5 package program [32]. Redundancy analysis (RDA) was carried out using CANOCO software [33].

3. Results and Discussion

Soil algae species distributed in Kocaeli micro basin were investigated qualitatively and quantitatively. Algal flora of Kocaeli province, a total of 30 taxa, 14 taxa of Bacillariophyta, 3 taxa of Chlorophyta, 1 taxa of Charophyta and 12 taxa of Cyanobacteria were identified. *Chroococcus cohaerens*



Figure 2. Taxa identified in the research (%)

(Bréb.) Nägeli, *Limnococcus limneticus* (Lemmerm.) Komárk. et al., *Phormidium nigroviride* (Thwaites ex Gomont) Anagn. & Komárek, *Oscillatoria limosa* C.Agardh ex Gomont, *Gomphonema olivaceum* (Horn.) Brébisson, *Hantzschia amphioxys* (Ehrenb.) Grunow and *Nitzschia brevissima* Grunow were most dominant taxa in the study. Identified taxa and % abundance rates were given in Table 2 and Figure 2 and, general soil characteristics of Kocaeli region were given in Table 3.

Table 2. The list	of abundance of	f soil algae in	Kocaeli regior	in stations 1-12
	, or abundance o	i son aigue in	Rocuen region	

Algae	1	2	3	4	5	6	7	8	9	10	11	12
Cyanobacteria												
Chroococcus cohaerens (Bréb.) Nägeli	R	R	С	D	С	R	R	R	R	R	R	-
Chroococcus sp.	R	R	R	С	R	R	R	R	R	R	-	-
Kamptonema formosum (Broy ex Strunecký, Komárek	С	R	R	С	R	R	R	R	-	R	-	-
& J.Smarda												
Limnococcus limneticus (Lemmermann) Komárková,	С	R	R	D	С	R	R	R	R	-	R	-
Jezberová, O. Komárek & Zapomelová												
Microcystis sp.	-	-	R	R	R	R	-	-	-	-	-	-
<i>Lynbya</i> sp.	R	R	R	R	R	R	R	R	-	-	-	-
Nodularia sp.	R	R	R	R	R	R	R	R	R	R	-	-
Oscillatoria limosa C.Agardh ex Gomont	R	R	R	D	С	R	R	R	R	R	-	-
Planktothrix prolifica (Gomont) Anagnostidis &	R	R	R	R	R	R	R	R	-	R	-	-
Komárek												
Phormidium articulatum (N.L.Gardner) Anagn. &	R	R	R	R	R	R	R	-	-	-	-	-
Komárek												
<i>Phormidium nigroviride</i> (Thwaites ex Gomont)	R	R	R	D	R	R	R	-	-	-	-	-
Anagn. & Komárek												
Trichodesmium lacustre Kleb.	-	R	R	R	R	R	R	-	R	-	-	-
Chlorophyta												
Acutodesmus sp.	-	R	R	R	R	R	R	-	R	-	-	-
Chlamydomonas akinetos Deason & Bold	R	R	R	R	R	R	R	-	R	-	-	-
Oocystis sp.	R	R	R	R	R	R	R	-	R	-	R	-
Charophyta												
Closterium navicula (Bréb.) Lütkem.	R	R	R	R	R	R	R	-	R	-	R	-
Bacillariophyta												
Amphora ovalis (Kütz.) Kütz.	R	R	R	С	R	R	R	R	R	R	R	R
Brebissonia lanceolata (C.Agardh) R.K.Mahoney &	-	-	R	R	R	R	R	R	R	R	R	R
Reimer												
Caloneis silicula (Ehrb.) Cleve	-	R	R	R	R	R	R	R	R	R	R	R
Cymbella affinis Kütz.	R	-	R	R	R	R	-	R	-	-	R	R
Diatoma elongatum C.A Agardh	R	R	R	С	R	-	R	R	R	R	R	R
Gomphonema olivaceum (Horn.) Brébisson	R	R	R	D	R	С	D	R	R	R	R	R
Hantzschia amphioxys (Ehrenb.) Grunow	R	R	С	D	R	R	D	R	R	-	-	R
Luticola nivalis (Ehrenb.) D.G.Mann	R	R	R	R	R	R	R	D	С	R	С	С
Navicula radiosa Kütz.	R	R	R	R	R	R	R	R	R	R	R	R
Nitzschia brevissima Grunow	R	R	R	D	R	R	D	С	R	С	D	С
Nitzschia fonticola (Grunow) Grunow	R	R	R	R	R	R	R	R	R	R	R	С
Nitzschia sp.	R	R	R	R	R	R	R	-	-	-	R	R
Tryblionella jelineckii (Grunow) D.G. Mann	-	-	R	R	R	R	R	-	-	R	-	-
Ulnaria ulna (Nitzsch) Compère	R	R	R	R	R	R	R	R	-	R	-	R

*Abundance: D: Dominant (>20%); C: Common (10-20%); R: Rare (<10%); -: Not found.

Parameters	Analysis	Units	Determined	Result	Reference
	method		value		value
pН	TS8332	-	8.06	Slightly	7.5-8.5
-	ISO 10390			alkaline	
Electrical conductivity	TS 8334	µmhos/cm	5.79	light salty	4-8
Salinity	TS 8334	%0	0.22	light salty	0.5 -0.35
CaCO ₃	TS EN ISO	%	9.98	Limy	1-5
	10693				
Organic matter	TS 8336	%	1.70	Little	1-2
Saturation	TS 8333	%	59.55	Argillaceous	51-70
P_2O_5	TS 8340	kg/da	3.16	Little	≤ 3
K ₂ O	TS 8341	kg/da	93.92	High	≥ 40

 Table 3. Soil properties of Kocaeli region

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Spearman correlation coefficients of soil quality parameters were given in Table 4. A positive correlation was found between salinity - conductivity, P_2O_5 - salinity, P_2O_5 - organic matter, K_2O - Organic matter and K_2O - P_2O_5 (p<0.05). Negative correlation was determined between saturation - CaCO₃, pH-salinity and pH - P_2O_5 (p<0.05).

Table 4. Spearman correlation coefficients in soil parameters

Soil			•	Organic				
parameters	Conductivity	Salinity	CaCO ₃	matter	Saturation	P2O5	K ₂ O	pН
Conductivity	1.000							
Salinity	0.967*	1.000						
CaCO ₃	0.266	0.138	1.000					
Organic	- 0.223	- 0.207	- 0.202	1.000				
matter								
Saturation	- 0.063	0.159	- 0.451*	0.034	1.000			
P_2O_5	0.358	0.404*	0.262	0.504*	0.198	1.000		
K ₂ O	0.042	0.140	0.091	0.545*	0.047	0.768*	1.000	
pН	- 0.384	- 0.566*	0.344	- 0.196	- 0.630	- 0.426*	0.123	1.000

*Values indicate that there is strong statistical relationship (p<0.05)

To determine the relationship between the biomass of the most abundant algae, sampling period and environmental variables, RDA was carried out on the log-normal transformed abundance data. Statistical significance of the environmental predictor variables was assessed by 999 restricted Monte Carlo permutations. To analyze the relationship between epipelic algae distribution and environmental variables were performed in RDA. If the value of the first axis is less than 3, the taxa data is homogeneous and the RDA ordination method is used. The horizontal axis is the primary RDA axis, and the vertical axis is the second ordination axis. The eigenvalues of RDA axis 1 (0.42) and axis 2 (0.08), account for 51.47% of the cumulative variance in the epipelic algae. The most abundant algae and environmental correlations of RDA axis 1 and 2 are high and two-axis account for 85.97% of the variance in the most abundant algae and environmental relationships. *Nitzschia brevissima, Gomphonema olivaceum, Oscillatoria limosa, Phormidium nigroviride*, and *Hantzschia amphioxys* were positively correlated with conductivity and salinity while *Chroococcus cohaerens and Limnococcus limneticus* were positively correlated with P₂O₅. Phosphorus was determined to be more effective in the development of these species. The results of RDA was given in Figure 3.



Figure 3. Multiplicity analysis for environmental variables and dominant taxa (RDA) in research area

Environmental factors are very important on the diversity of soil algae. Such activities (pesticides, herbicides, air pollution, population, heavy industry, other factors) affect the physico-chemical environment of soils and thus reduce the diversity of soil algae. In studied Kocaeli micro basin, the community structure of soil algae varied significantly from type to type, with Shannon diversity index ranging between 2.79 and 3.22, evenness index between 0.61 and 0.91 and Simpson's index between 0.91 and 0.95 (Table 5). The Simpson diversity index is generally similar to the Shannon-Weaver index. According to the Simpson and Shannon-Weaver index, it was concluded that the dominance was low and the number of species was high. However, it was determined that the soil has medium quality according to index values.

Index	1	2	3	4	5	6	7	8	9	10	11	12
Shannon	2.91	3.10	3.22	3.18	3.23	3.18	2.83	2.80	2.84	2.79	2.58	2.63
diversity index												
Evenness index	0.75	0.85	0.84	0.80	0.84	0.83	0.61	0.82	0.86	0.91	0.83	0.84
Simpson index	0.93	0.95	0.95	0.95	0.95	0.95	0.91	0.93	0.93	0.93	0.91	0.91

 Table 5. Diversity indices of soil algae in stations 1-12

4. Conclusion

This study was conducted in Kocaeli micro basin between March 2019 - May 2019. Average in soil parameters were determined as pH : 8.06, Conductivity: 5.79 μ mhos / cm, salinity: 0.22‰, CaCO₃: 9.98%, organic matter: 1.70%, saturation: 59.55%, P₂O₅: 3.16 kg / da, K₂O: 93.92 kg / da. Soil structure of Kocaeli region is generally determined as slightly alkaline, light salty, limy and argillaceous. Organic matter and P₂O₅ values were determined as very low and K₂O values were high. Spearman correlation coefficients of soil quality parameters were determined as positive correlation between salinity – conductivity, P₂O₅ - organic matter, K₂O - Organic matter and K₂O - P₂O₅ (p<0.05). Negative correlation was determined between saturation – CaCO₃, pH - salinity and pH - P₂O₅ (p<0.05). The soil algal flora at 12 stations chosen on Kocaeli micro basin were investigated between March 2019 and May 2019. The flora consisted of 30 taxa belonging to the Bacillariophyta, Chlorophyta, Cyanobacteria and Charophyta divisions. The species of *Chroococcus cohaerens*, *Limnococcus limneticus*, *Phormidium nigroviride*, *Oscillatoria limosa*, *Gomphonema olivaceum*, *Hantzschia amphioxys* and *Nitzschia brevissima* were observed to be abundant and frequent, in the months when the research was carried out.

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The other members of divisions were determined in various frequencies in the stations. As a result, Bacillariophyta was dominant among the soil algal flora of Kocaeli region. These species were identified especially in Dilovası and surrounding stations where industrial activities were intense. Of these taxa, C. cohaerens, C. akinetos, are a true soil algae species was identified in terrestrial habitats in Asia, the Arctic, Europe, America, Australia and New Zealand [31]. These species are cosmopolitan and widespread in various types of soils in literature [34]. In the study, species other than the real soil algae, Turkey was also determined in aquatic ecosystems [30,35]. In the soil samples around Lake Salty (Turkey) that Chroococcus varius, Phormidium agustissimum, Nitzschia vermicularis, Hantzschia species were determined and similar genera were determined in the soil algae of Kocaeli region [11,15,16]. In the study, the most abundant species and their relationship with environmental factors were detemined such as *Nitzschia brevissima*, Gomphonema olivaceum, Oscillatoria limosa, Phormidium nigroviride, Hantzschia amphioxys were positively correlated with conductivity and salinity. However, Chroococcus cohaerens and Limnococcus limneticus species also showed positive correlation with P2O5. It was determined that conductivity, salinity and phosphorus are highly effective in the development of these species. In the study, it was determined that the species diversity of the stations showed similar values and that the stations were medium species diversity.

In this study, it was determined that soil algae was under the influence of industrial pollutants. It was concluded that domestic and industrial pollutant pressures on soils should be reduced. As future research leads to awareness of soil algae importance, it might be expected that agricultural systems and agricultural practices will become more benefits.

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