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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Fertility Status of Agricultural Soils in İstanbul Province

İstanbul İli Tarım Topraklarının Temel Verimlilik Durumu

Emel KAYALI[1*], Orhan YÜKSEL[2]

Abstract

As a region of geopolitical significance and industrialization, İstanbul province has a traditional production system in which intensive agricultural production is carried out, especially in Silivri and Çatalca districts, where sunflower and wheat agriculture is carried out in alternation under irrigated conditions due to sufficient rainfall. These agricultural areas, which are also under intense urbanization pressure, need to be protected in order to be used sustainably. For this purpose, it is a priority to determine the current productivity status of agricultural areas. There is no study in the literature that reveals the current agricultural productivity status of İstanbul province. In this study, some physical and chemical soil properties of the agricultural areas where the same agricultural production system has been practiced for many years were determined in terms of sustainable agriculture. In order to determine these soil properties, surface soil sampling (0-20 cm) was carried out according to the grid system at 2.5 × 2.5 km intervals covering all agricultural areas and a total of 196 soil samples were taken and the field study was completed. All soil samples were analyzed for texture, pH, EC, organic matter, available phosphorus, available potassium and the current fertility status of the agricultural areas in the province of İstanbul was determined. According to the results of the research, the agricultural soils of İstanbul province are generally medium-heavy and heavy textured, medium alkaline and neutral pH, without salinity problems, 50% of them have very low CaCO3 content and the rest are calcareous soils with varying levels of $CaCO_3$. It was determined that the high CaCO3 content in 11% of the soils was due to the rendzina great soil group formed on marl parent material. In terms of organic matter, 59% were classified as low, 26% as moderate, 50% as high and very high in terms of available phosphorus, and 79% as high and very high in terms of extractable potassium. After the classification of all analyzed parameters, the distribution maps of a parameter were created by using Geographical Information Systems (GIS). IDW, which is an inverse distance weighting method widely used in soil science, was used to create the distribution maps.

Keywords: Istanbul province, Soil fertility, Geographic information systems, Soil quality, Geostatistical analysis

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Öz

İstanbul ili, jeopolitik önemi ve sanayileşmenin yanı sıra, özellikle Silivri ve Çatalca ilçelerinde yoğun tarımsal üretimin gerçekleştirildiği, yağışların yeterli olması sayesinde ayçiçeği ve buğday tarımının susuz koşullarda münavebe şeklinde sürdürüldüğü gelenekselleşmiş bir üretim sistemine sahiptir. Aynı zamanda yoğun şehirleşme baskısı altında da olan bu tarım alanlarının, sürdürülebilir bir şekilde kullanılabilmesi için korunması gerekmektedir. Bunun içinde tarım alanlarının mevcut verimlilik durumlarının belirlenmesi önceliklidir. Literatürde İstanbul ilinin mevcut tarımsal durumunu ortaya koyan herhangi bir çalışmaya rastlanmamıştır. Bu çalışma ile uzun yıllar boyunca aynı tarımsal üretim şeklinin uygulandığı bu tarım alanlarının sürdürülebilirliği açısından bazı fiziksel ve kimyasal toprak özelliklerini mevcut durumlarının belirlemek amaçlanmıştır. Bu toprak özelliklerini belirlemek için tüm tarım alanlarını kapsayacak şekilde 2,5 × 2,5 km aralıklarla grid sistemine göre yüzey toprak örneklemesi (0-20 cm) gerçekleştirilmiş ve toplam 196 adet toprak örneği alınarak arazi çalışması tamamlanmıştır. Alınan tüm toprak örneklerinde bünye, pH, EC, organik madde, alınabilir fosfor ve alınabilir potasyum analizleri yapılarak İstanbul ili tarım alanlarının mevcut verimlilik durumu ortaya konmuştur. Araştırma sonuçlarına göre, İstanbul ili tarım toprakları genellikle orta-ağır ve ağır bünyeli, orta alkali ve nötr pH'a sahip, tuzluluk sorunu olmayan, %50'si kireçsiz iken kalanı değişen oranlarda kireçli topraklardır. Toprakların özellikle %11'inde yüksek kireç içeriğinin, marn ana materyal üzerinde oluşmuş rendzina büyük toprak grubundan kaynaklı olduğu belirlenmiştir. Organik madde bakımından %59'u az, %26'sı orta; alınabilir fosfor bakımından %55'i yüksek ve çok yüksek; ekstrakte edilebilir potasyum bakımından ise %79'u zengin ve çok zengin sınıfa girmektedir. Tüm analiz parametrelerinin sınıflandırılmasının ardından bir parametreye ait dağılım haritaları Coğrafi Bilgi Sistemleri (CBS) kullanılarak oluşturulmuştur. Dağılım haritalarının oluşturulmasından toprak biliminde yaygın olarak kullanılan ters mesafe ağırlık yöntemi olan IDW kullanılmıştır.

Anahtar Kelimeler: İstanbul ili, Toprak verimliliği, Coğrafi bilgi sistemleri, Toprak kalitesi, Jeoistatistiksel modelleme

1. Introduction

Improper tillage practices (Abdollahi et al., 2015), over-fertilization (Aytop, 2023), uncontrolled use of pesticides (Akbay et al., 2023) and yield-oriented agricultural practices (Atmaca and Boyraz Erdem, 2016; Wang et al., 2019), are causing rapid deterioration in soil quality. Sustainable use and management of soils requires the development of new approaches to minimize or eliminate the negative impacts of modern agricultural practices.

A key factor in sustainable agriculture is soil quality. Like air and water quality, soil quality affects the quality of the ecosystem in which it is located. However, compared to water and air quality, soil quality is difficult to define and quantify (Doran and Parkin, 1994). Soil quality is a combination of physical, chemical and biological properties of soils. Therefore, improving and maintaining soil quality is possible by improving these properties. These properties of soils are important not only as a growing medium but also because of their buffering effect on harmful compounds (Larson and Pierce, 1994; Gürbüz et al., 2023; Atav et al., 2024).

Soil quality assessment is one of the key elements of sustainable soil management. The fact that soil fulfills many functions simultaneously makes it difficult to determine indicator properties related to specific functions and processes. However, it is possible to assess soil quality with indicators of physical, chemical and biological properties (Andrews and Carroll, 2001). For example, soil indicators such as water holding capacity, aeration, pH and electrical conductivity are used. In addition, approaches such as integrated soil quality index and productivity index model can be used to assess soil quality (De Lima, 2007). To maintain the productivity of our agricultural areas, the characteristics of these areas should be defined in the best way. For this purpose, establishing a database by determining and updating the physical and chemical properties of agricultural areas will provide preliminary information for new research projects for the proper use of soil resources. As a result of the analyzes to be carried out on soil samples with specific geographical coordinates, the changes of the determined properties over time can be monitored and negative changes in agricultural areas can be taken under control (Özden et al., 2018). For this purpose, studies have been carried out in many regions. Taşova and Akın (2013), in their study covering the province of İstanbul in the Marmara Region, took soil samples to identify all agricultural soils and revealed the nutrient and fertility status of the soils. By evaluating the obtained results with Geographical Information Systems (GIS), they created current soil databases and mapped them. As a result of the research, they determined that the agricultural lands of the Marmara region are generally; clay loamy, slightly alkaline, low organic matter content, non-saline and very low content of $CaCO_3$ soils. They determined that 47% of the soils in the region had very low content of available phosphorus, while 53% of the soils had high content of available phosphorus, iron and copper contents were moderate, while zinc and manganese contents were low. In Başar's study (2001), in which some fertility characteristics of Bursa province soils were determined, a total of 1018 soil samples were taken and analyzed. According to the results of the analyses, it was determined that the soils of the research area were generally medium textured, without salinity problem, with moderately and strongly alkaline reaction and containing varying amounts of $CaCO_3$. The researcher also determined that 56.49 % of the soils were low or very low contents of organic matter, 21.81 % contents of available phosphorus and 21.82 % in contents of available potassium. In the study (Özden et al., 2022) on agricultural soils of Manisa province, it was found that 33.29% of the soils were sandy loam, 62.20% were slightly alkaline, 94.36% were very low in $CaCO_3$, 33.57% were medium calcareous, 64.88% were low in organic matter, 25.39% were very high in available phosphorus and 94.07% were high in available potassium. Lopez Granados et al. (2002) determined the spatial variability parameters of composition, organic matter (OM), phosphorus (P), potassium (K), nitrate (NO_3^-), ammonium (NH_4^+) and pH as soil fertility parameters in Spain by geostatistical modeling and obtained variable rate fertilizer application maps based on these parameters. Alaboz et al. (2020), in their study in Isparta compared different interpolation methods for the creation of the distribution maps.

İstanbul is one of the centers of economy, history, culture and tourism, where two continents meet and has important transit routes. In addition to industrialization, intensive agricultural production activities are carried out, especially in the Silivri and Çatalca districts. Agricultural production in these regions helps to meet the food needs of İstanbul. This study aims to determine the nutrient contents of the agricultural soils of İstanbul province and to create a database and distribution maps of these properties. Studies on determining the fertility status of soils within the borders of the study area are limited. Therefore, the present study will make an important contribution to the literature by evaluating the fertility status of agricultural soils of İstanbul Province.

2. Materials and Methods

2.1. Study area

The province of İstanbul is located in northwestern Türkiye, on both sides of the Bosphorus, on the Çatalca peninsula to the west and the Kocaeli peninsula to the east. It is neighboring Tekirdağ in the west and Kocaeli in the east. It has a total land area of 546.078 hectares and the cultivated agricultural area is 14% of its total surface area (*Table 1*).

Table 1. Crop production cultivation areas (TÜİK, 2024)

Land Use	Land (da)
Field crops area	707.243
Fallow land	7.469
Vegetable area	26.252
Fruit area	28.303
Ornamental plants	484
Total	**769.751**

The districts in agricultural production are Çatalca, Silivri and Şile, and the main crops are wheat, sunflower, barley, canola and corn. The production amounts of some agricultural products are given in *Table 2*.

Table 2. Crop production (TÜİK, 2024)

Land Use	Land (da)
Field crops production	290.464
Vegetable production	61.970
Fruit production	6.620
Total	**359.054**

The great soil groups commonly found in the province are vertisol, non-calcareous brown and brown forest soils. The land use types map prepared according to CORINE classification system showing the land cover and land use types of İstanbul area is given in *Figure 1*.

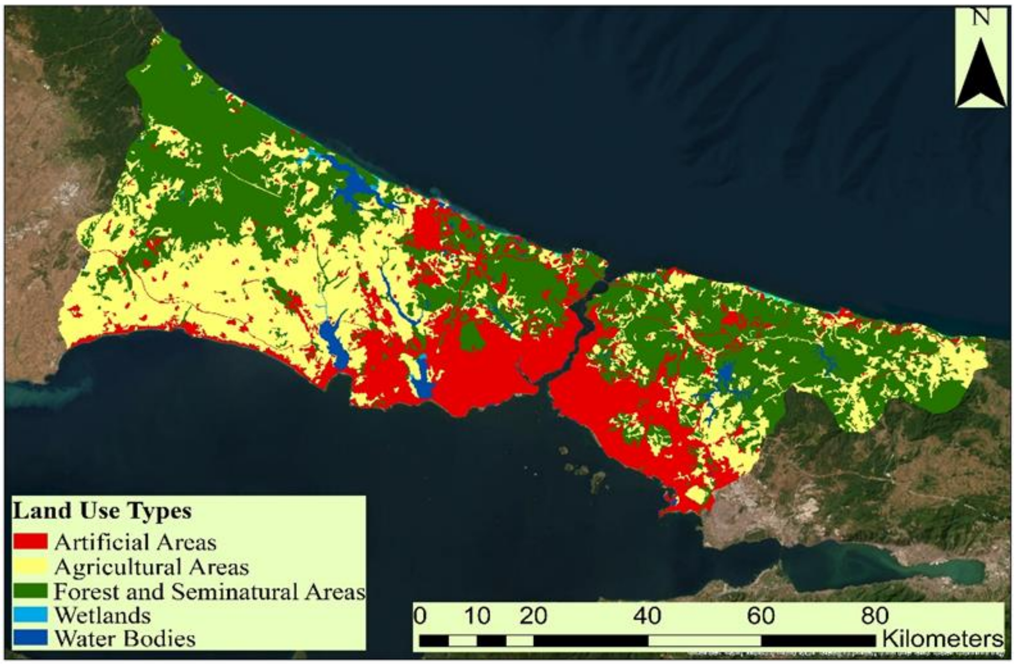

Figure 1. Land use groups of İstanbul province area (CORINE, 2018)

İstanbul has a temperate climate with transitional characteristics between the Black Sea and Mediterranean climates. Summers are hot and humid and winters are cold and rainy. The average temperature is 2°C in winter and 18-28°C in summer, with an annual average temperature of 14.4°C (MGM, 2022).

The provincial area of İstanbul is located in the Marmara region, which covers a wide variety of rock units formed in the Early Palaeozoic-Present interval and where there are current tectonic movements. There are two major rock stratigraphy unit assemblages within the provincial borders: metamorphic and non-metamorphic. The metamorphites forming most of the Istranca Mountains are the Istranca Union, while the non-metamorphosed stack is the İstanbul Union, these two communities are separated from each other by a large tectonic line (Anonim, 2011).

2.2. Soil sampling

In this study, 1/25000 scale soil maps digitized by abolished Directorate of Rural Services were used to determine the soil sampling points. On the map, 2.5 × 2.5 km grids were created and the points coming to the agricultural areas were determined (*Figure 2*). The coordinates of all sampling points were uploaded to a handheld GPS with ±3 m deviation and surface soil sampling (0-20 cm) was carried out. A total of 196 soil samples were taken.

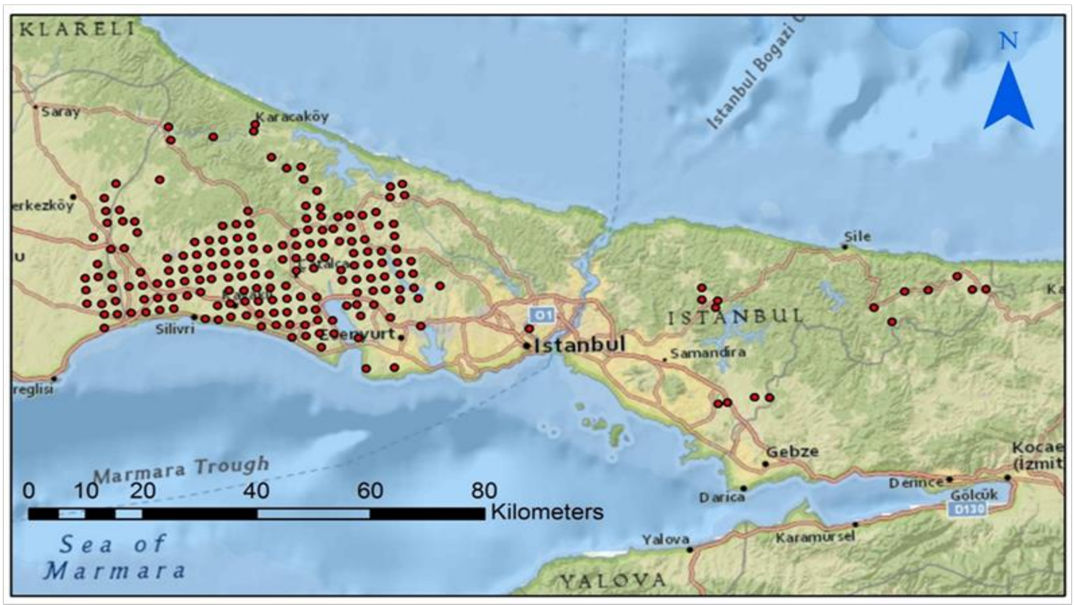

Figure 2. Soil sampling points in agricultural areas of Istanbul province

2.3. Methods of Soil Analysis

Soil samples taken from the study area were dried, grounded and sieved through a 2 mm sieve and prepared for analysis. Organic matter contents of the soil samples were determined by modified Walkley-Black method (Nelson and Sommers, 1996), pH was determined in saturation paste with a pH-meter, EC was determined in saturation paste with an EC-meter (Soil Survey Staff, 1993), CaCO3 contents were determined volumetrically by Scheibler calcimeter (Loeppert and Suarez, 1996), Available Phosphorus contents were determined according to Olsen method (Olsen and Sommers, 1982), Extractable Potassium contents were extracted with Ammonium Acetate and determined by ICP-OES. Soil texture was determined according to the Bouyoucos hydrometer method (Gee and Bauder, 1986).

2.4. Database creation and mapping

Basic descriptive statistical analysis was applied to all analyzed parameters. The data obtained from soil samples were classified according to the limit values used in Kayali and Yüksel (2020) and their distributions were calculated. All data were evaluated and transformed into distribution maps using Geographic Information Systems (GIS) with the "ArcGIS Geostatistical Analyst" module. Distribution maps were created with the inverse distance weighting (IDW) method, which is one of the interpolation methods frequently used in soil quality studies.

The inverse weighting by distance (IDW) method calculated the value of each sample point by weighting it inversely to its distance to the point to be estimated. The formula of the IDW method is given below:

$$Z_{IDW}^{*}(x_0) = \frac{\sum_{i=1}^{n} \frac{1}{d_i^p} \cdot Z(x_i)}{\sum_{i=1}^{n} \frac{1}{d_i^p}} \quad \text{(Eq. 1)}$$

$Z^*\ (x_0)$: x_0 its estimated value at the point,
$Z_{(x_i)}$: x_i the sample point value at the point,
d : the distance between the sample point and the point to be estimated,
p : exponential value,
n : refers to the number of sample points

In the inverse distance weighting method, the influence distance, which significantly affects the prediction values, determines that observation values at a certain distance can be used in the calculation. Points farther away than the influence distance are not included in the calculations (Uyguçgil, 2007).

3. Results and Discussion

In 196 soil samples taken from the agricultural areas of İstanbul province and analyzed, saturation was between 38-86%; sand content between 9.5-76.5%, clay content between 7.5-69.7%, silt content between 0.3-50.9%, soil texture clay, clay loam, loam, loamy sand, sandy clay, silty clay loam, silty loam, sandy loam; pH 4.80-7.91 between strongly acid - moderately alkaline; EC 0,09-2.61 dS m^{-1} between non-saline and very slightly saline, CaCO3 0,01-54,00% between very low-very high calcerous soil, organic matter 0.46-5.23% between very low-very high. Available phosphorus content was found between 0.71-603.20 mg kg^{-1} available potassium content was found between 33.29-3449.38 mg kg^{-1}**.**

3.1. Texture

Soil texture is an important parameter that determines the physical and chemical properties of soils. It has a direct effect on many properties of soils such as water permeability and retention capacity, aeration, nutrient retention capacity and microorganism activities (Gupta, 2007). According to the results of the analysis, 70% of the soils were classified as clay, silty clay and 16% as sandy loam, sandy clay loam (*Table 3*).

Table 3. Distribution of texture classes of soils

Symbol	Number of soils	Distribution (%)
S, LS	1	1
SL, SCL	32	16
SiL, SiCL	2	1
CL, L	20	10
Si, SC	5	2
SiC, C	136	70

Most of the agricultural soils in İstanbul are composed of clay soils. Clay soils have high water holding capacity and low water permeability. These properties are advantageous in terms of meeting the water needs of plants, especially during dry periods (Brady and Weil, 2002). However, clay soils also have the potential to experience compaction and aeration problems, which can negatively affect plant root development. Taşova and Akın (2013), carried out a study in the Marmara region, including the province of İstanbul and found that clay loam (43.7%) and clay soils (34.5%) cover the most area proportionally, while the proportion of sandy soils is only 0.5%. These results are similar to the results of this study. Regarding soil texture, Özden et al. (2018) reported that 33.29% of the agricultural soils in Manisa province were sandy loam and 62.20% were moderately alkaline. This indicates that the soils of İstanbul province have a higher clay content.

3.2. pH

Soil reaction (pH) determines whether soils are acidic or basic and affects the availability of plant nutrients (Neina, 2019). In the study area, 62% of the soil samples were classified as alkaline and 20% as neutral pH (*Table 4*). The map showing the pH distribution of the study area is given in *Figure 3*.

Table 4. Distribution of soils in İstanbul according to pH classes

Value	Classes	Number of soils	Distribution (%)
<5.1	Strongly acid	5	3
5.2-6.0	Moderately acid	18	9
6.1-6.5	Slightly acid	12	6
6.6-7.3	Neutral	39	20
7.4-8.4	Moderately alkaline	122	62
>8.4	Strongly alkaline	-	-

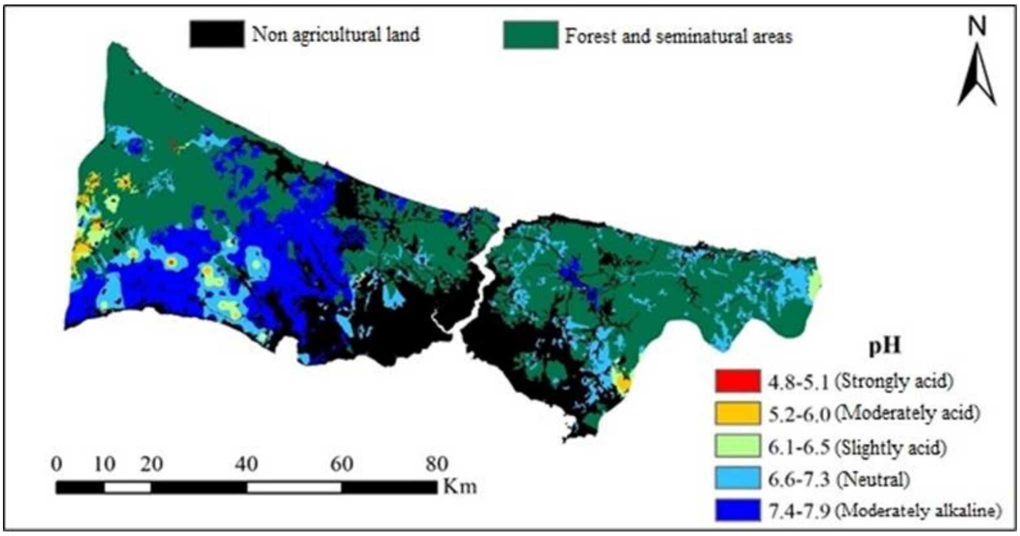

Figure 3. Soil reaction distribution map of the research area

Soil pH is a critical factor for plant growth and development (Oshunsanya, 2018). Soils in the moderately alkaline to neutral pH range are generally the soils with the best uptake of plant nutrients (Zhao et al., 2011). Most of the agricultural soils of İstanbul province have a moderately alkaline pH value. Low soil pH is considered as one of the factors affecting yield (Aktaş and Yüksel, 2020). Moderately alkaline soils are the soils where plant nutrients can be taken up in the best way (Thomas, 1996). However, the 3% with a strongly acid pH value may require regulatory measures such as CaCO3 application (Nkana et al., 2001). The 20% with a neutral pH value is quite suitable for agricultural production (Caritat et al., 2011). Taşova and Akın (2013) determined in their study that moderately alkaline soils had the highest rate with 50,6% in Marmara region, followed by neutral pH soils (30,0%) and slightly acid soils (13,8%). These results are in parallel with our study. These data reveal the pH distribution of the agricultural soils of İstanbul and the effect of this distribution on agricultural production.

3.3. EC (dS/m)

Table 5. Distribution of soils in İstanbul according to salinity classes

EC(dS/m)	Salinity Class	Number of soils	Distribution (%)
<0.75	Non-saline	68	35
0.75-2	Very low saline	125	64
2-4	Very slightly saline	3	1
4-8	Slightly saline	-	-
8-16	Moderately saline	-	-
> 16	Strongly saline	-	-

The salinity class and distribution of the results of electrical conductivity (EC) analyses of the soil samples taken from the research area are given in *Table 5*. Accordingly, 64% of the soils of İstanbul province are classified very low saline and 35% as non-saline (*Figure 4*). Approximately 98% of the soils of Edirne, Kırklareli and Tekirdağ provinces are non-saline, while 2% slightly saline areas were determined (Gürbüz et al., 2018). This result shows that there is no similar salinity problem in the study soils.

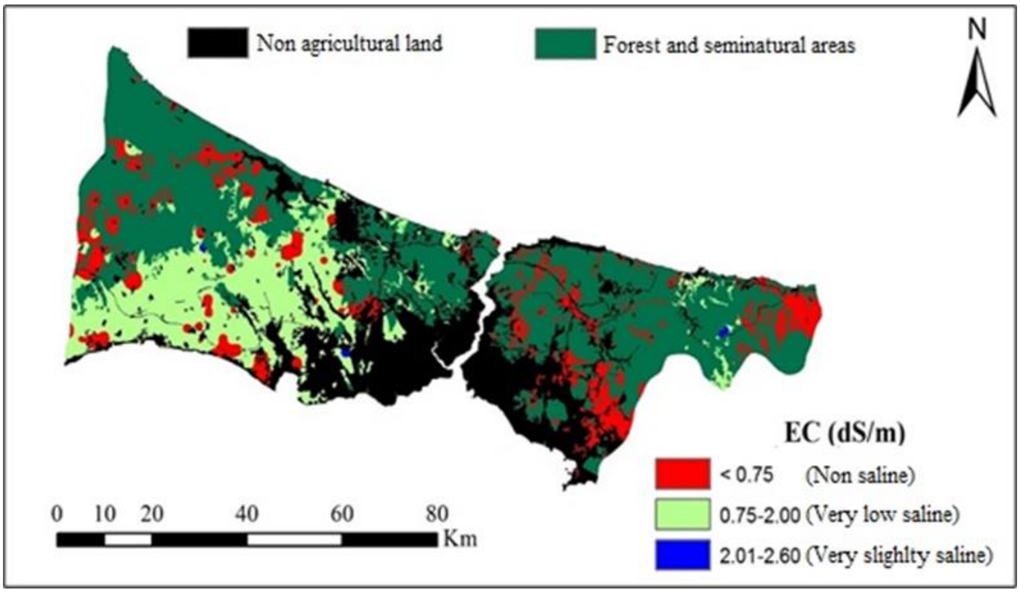

Figure 4. Soil salinity distribution map of the research area

Most of the agricultural soils in İstanbul (64%) are classified as very low saline. This is generally considered a positive characteristic for agricultural production, as low salinity allows plant roots to better absorb water and nutrients (Machado and Serralheiro, 2017). However, the 1% that is very slightly saline may require salinity management in certain areas (Alharbi, 2015). The 35% that is non-saline represents ideal agricultural conditions (Shrivastava and Kumar, 2014).

3.4. CaCO3 (%)

The CaCO3 content of soils is an important parameter for the productivity of agricultural activities (Ameyu, 2019). In İstanbul, 50% of the soils are classified as very low, 10% as medium and 11% as very high (*Table 6*; *Figure 5*).

Table 6. Distribution of soils in İstanbul according to $CaCO_3$ content classes

$CaCO_3$ (%)	Class	Number of soils	Distribution (%)
0-2	Very low	98	50
2-4	Low	18	9
4-8	Medium	20	10
8-15	Calcareous	16	8
15-30	High	23	12
> 30	Very high-marl	21	11

Half of the agricultural soils in İstanbul province have very low content of $CaCO_3$, indicating that acidic soil characteristics are dominant. In acidic soils, $CaCO_3$ applications can increase the uptake of plant nutrients by increasing the pH value (Barman et al., 2014). Medium $CaCO_3$ soils (10%) are generally more nutrient balanced and offer ideal conditions for agricultural production (Haynes and Naidu, 1998). Soils with high $CaCO_3$ content are observed in Çatalca district. Very high $CaCO_3$ containing soils (11%), on the other hand, may not be suitable for certain plant species due to their high $CaCO_3$ content and may require specialized production strategies (Corbett et al., 2021). Taşova and Akın (2013), found that 65.8 % of the soils in the Marmara region are in the very low and low class in terms of $CaCO_3$. They stated that especially high calcareous areas are located around İstanbul. These results coincide with our study

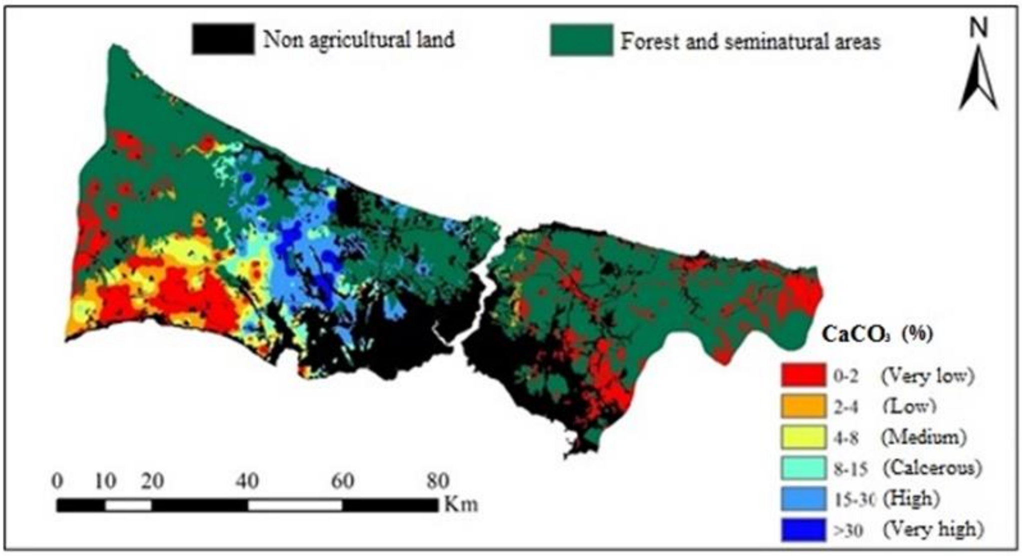

Figure 5. $CaCO_3$ distribution map of the research area

3.5. Organic matter (%)

In terms of organic matter content, 12% of the soils in İstanbul are classified as very low, 59% as low and 3% as high (*Table 7*). The map showing the distribution of organic matter is given in *Figure 6*.

Table 7. Distribution of soils in İstanbul according to organic matter content

Organic Matter (%)	Class	Number of soils	Distribution (%)
<1	Very low	23	12
1-2	Low	116	59
2-3	Moderate	150	26
3-5	High	6	3
>5	Very high	1	-

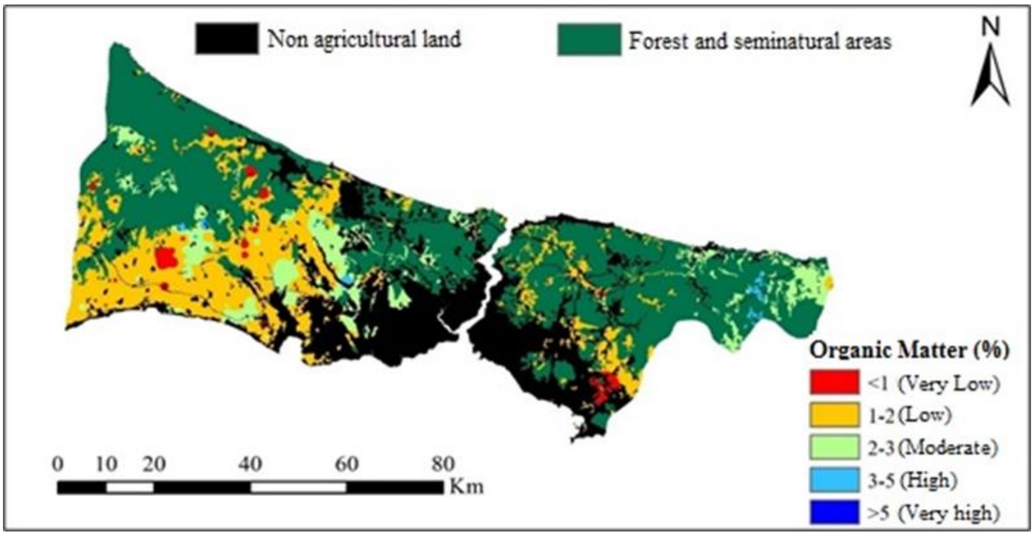

Figure 6. Organic matter distribution map of the research area

It is known that the organic matter content of soils in Türkiye is generally low and very low. However, in this study, the organic matter content of about 30% of the soils of İstanbul province was found to be at moderate and high levels. In a similar study conducted in the Marmara region, organic matter contents were found to be close to 32%. These soils show balanced characteristics in terms of retention of plant nutrients and water holding capacity (Fageria, 2012; Oldfield et al., 2018). Soils with moderate to high organic matter content (29%) have high fertility potential and provide advantages in terms of microorganism activities and soil structure improvement (Zhao et al., 2016). However, the 12% with very low organic matter content may require organic matter additions to improve soil fertility (Syers, 1997).

3.6. Available phosphorus (mg kg^{-1})

Soil samples taken from the research area were classified in terms of phosphorus and their distribution is given in *Table 8*. Accordingly, 4% of the soils in İstanbul are classified as very low, 19% as low and 28% as high (*Figure 7*). It has been reported that the amount of phosphorus in approximately 70% of the soils in Türkiye is below 12 mg $^{-1}$ (Sönmez et al., 2018). This result reveals that the amount of phosphorus in the agricultural soils of the study area is higher than Türkiye in general. Excessive fertilization applied as a result of intensive agricultural activities may have caused this result.

Table 7. Distribution of available phosphorus content of soils of İstanbul province

eP (mg kg^{-1})	Class	Number of soils	Distribution (%)
<0-5	Very low	8	4
6-12	Low	38	19
13-25	Moderate	53	27
26-50	High	55	28
> 51	Very high	42	22

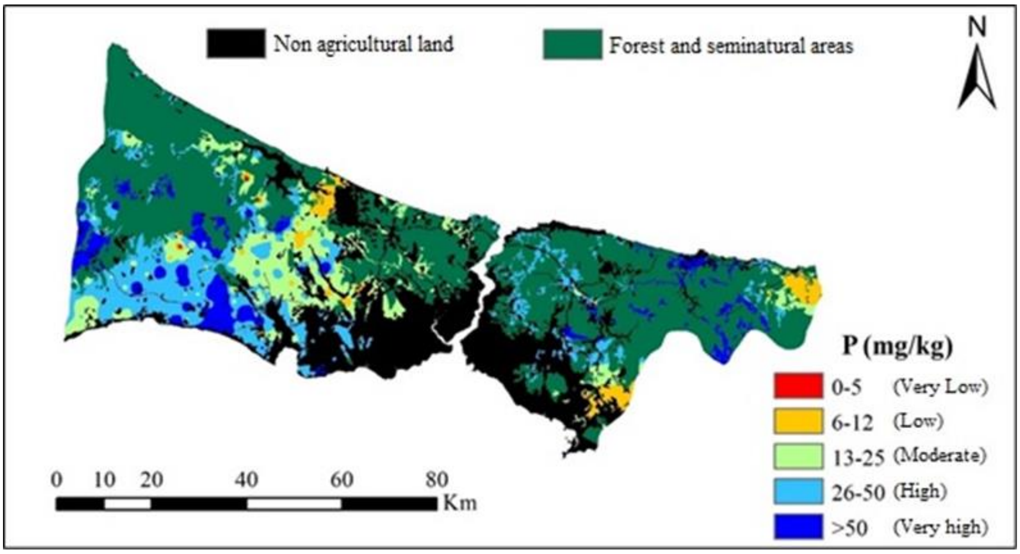

Figure 7. Available phosphorus distribution map of the research

In İstanbul, 50% of the agricultural soils have high and very high phosphorus content, mainly in Silivri district, which is a positive indicator for plant growth and development (Sharpley and Menzel, 1987). However, it should be considered that such high phosphorus levels may be due to factors such as over-fertilization (Vadas and Sims, 2013). An excess of phosphorus can prevent plant roots from taking up other nutrients and can lead to environmental problems (Sarkar, 2005). Soils with very low (4%) and (19%) phosphorus content may require phosphorus fertilization (Sharma et al., 2013). Moderate phosphorus content (27%) promotes a balanced uptake of plant nutrients (Richardson et al., 2009). In case of phosphorus deficiency, plant growth slows down and yields decrease (Bingham and Martin, 1956). Therefore, it is necessary to fertilize soils with low phosphorus content (Miranda et al., 1989).

Available phosphorus is a critical nutrient for plants and its sufficient amount in the soil directly affects plant root development and overall plant health (Chan et al., 2021). An excess of phosphorus can cause environmental pollution and contamination of water resources (Sharpley, 1995). Therefore, phosphorus management is of great importance for sustainable agricultural practices (Etesami, 2019).

3.7. Available potassium (mg kg^{-1})

In terms of potassium content, 7% of the soils of İstanbul province are classified as very low, 7% as moderate and 38% as high (*Table 9*). Due to hot and arid climatic conditions, Turkish soils have high clay content and are rich in this plant nutrient (Sönmez et al., 2018). The available potassium distribution map of the soils of the research area is given in Figure 8.

Table 9. Distribution of available potassiums content of soils of İstanbul province

eK (mg kg^{-1})	Class	Number of soils	Distribution (%)
< 80	Very low	13	7
80-120	Low	13	7
120-160	Moderate	13	7
160-320	High	76	38
>320	Very high	81	41

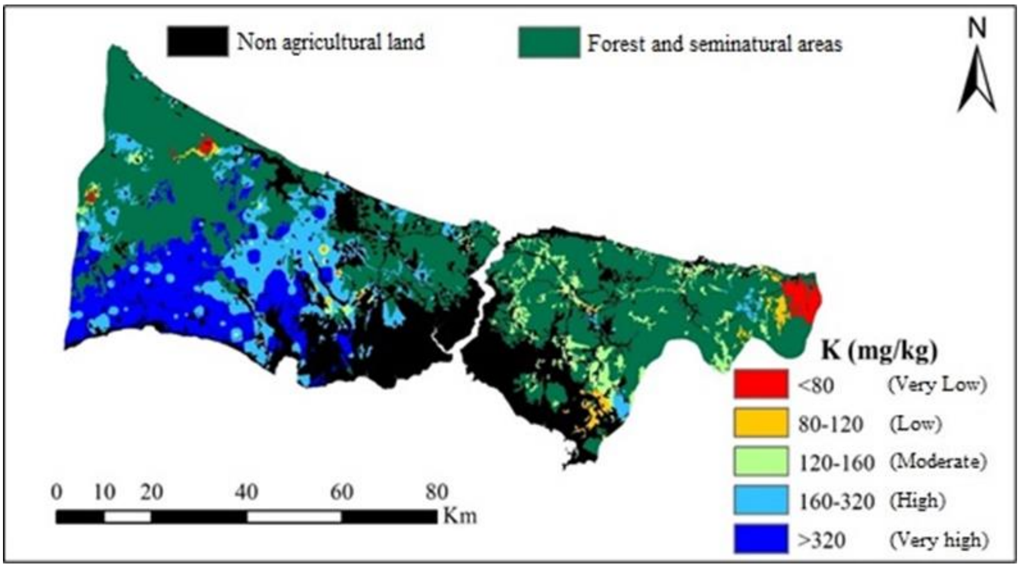

Figure 8. Available potassium distribution map of the research area

Most of the agricultural soils of İstanbul province (79%) are high and very high in potassium. The high levels of available potassium are mostly widespread in Silivri district. Potassium plays a critical role for plants to regulate water balance and develop resistance to diseases (Pettigrew, 2008). Soils with very low potassium content (7%) can lead to slow plant growth and reduced yields (Dotaniya et al., 2016). Moderate potassium content (7%) promotes a balanced uptake of plant nutrients (Ali et al., 2021). Potassium deficiency can lead to problems such as water imbalance in plant cells, wilting and susceptibility to diseases (Wakeel, 2013). Therefore, it is important to fertilize soils with low potassium content (He et al., 2022). Soils with rich potassium content positively affect plant growth and provide high yields (Nanu and Radulov, 2013).

4. Conclusion

The research area generally has a flat, almost flat and slightly sloping land structure. No stony, rocky or any other problem preventing production was detected. Most of the agricultural soils of İstanbul province (82%) are medium-heavy and heavy textured and have high clay content. Improper agricultural practices may increase soil compaction and plough layer. For this reason, tillage should be carried out at appropriate moisture levels in high clay content areas. The pH of the soils is generally in the moderately alkaline (62%) and neutral (20%) classes. Soil pH is thought to be relatively high due to the CaCO3 content of the parent material. The content of 50% of the soils are very low and the remaining soils contain varying amounts of CaCO3. Very high CaCO3 content is especially common in the Rendzina soil group and covers 11% of the area. The EC values of the soils are less than 0.75 dS m-^{1} and there is no salinity problem in the region. Due to climatic conditions, excessive tillage, erosion and insufficient organic fertilization practices, 59% of the soils are low in organic matter and 26% are at moderate level. In soils with low organic matter content, remedial measures need to be taken to increase soil fertility and ensure sustainability. 27% of the soils have moderate, 28% high and 22% very high levels of available phosphorus. In terms of extractable potassium content, 79% of the soils are classified as high and very high, 7% as moderate, and 14% as very low and low. One of the reasons for the high phosphorus and potassium content is the excessive fertilization practices applied in the region. In terms of sustainable agricultural practices, the negative effects of over-fertilization on plant growth and uptake of other nutrients should be evaluated.

Rapid population growth and increasing industrialization cause an increase in the misuse of agricultural lands and İstanbul has its share in this regard. Although approximately 14 % of the total surface area is agricultural land, intensive agricultural activities continue in Silivri and Çatalca regions. Considering the high nutrient needs of the increasing population, the importance of the region draws more attention. The high cost of transport necessitates the continuation of production in the region. Protection of these agricultural areas and sustainable agriculture are important for this region. This study is important in terms of revealing the soil characteristics of İstanbul province and will contribute to the agriculture of the region.

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Ethical Statement

There is no need to obtain permission from the ethics committee for this study

Conflicts of Interest

We declare that there is no conflict of interest between us as the article authors.

Author Contribution

Concept: Kayalı, E., Yüksel, O.; Design: Kayalı, E., Yüksel, O.; Data Collection or Processing: Kayalı, E., Statistical Analyses: Kayalı, E.; Literature Search: Kayalı, E., Yüksel, O.; Writing, Review and Editing: Kayalı, E., Yüksel, O.

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