

# SPATIAL ANALYSIS WITH GIS MAPPING OF FUNGICIDE CONSUMPTION IN AGRICULTURAL AREAS

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## ABSTRACT

The development in agriculture has gradually increased the use of fungicides in Turkey. Fungicides negatively affect the life conditions of living organisms in water, air and soil environments. It's important to be aware of the right amounts of chemicals to be used in certain periods. The aim of this study is to spatially determine the amounts of fungicide consumption using Geographical Information System (GIS) mapping, and also to determine the level of distribution in Nevşehir province and districts during the 2010-2014 period. The data obtained from the Turkish Statistical Institute and Nevşehir Directorate of Provincial Food Agriculture and Livestock has been evaluated by the help of Inverse Distance Weighting (IDW) method in the GIS. While the highest amount of fungicide consumption was observed to be 250.0 tons in 2010, the lowest amount of fungicide consumption was determined to be 179.78 tons in 2013. When examining the spatial distribution of fungicide consumption, the highest consumption intensity was observed in the North (Kozaklı district) and Northwest (Hacıbektaş district) of Nevşehir province, and the lowest consumption intensity is determined to be in the Southern (Central district) and South-western (Acıgöl district) agricultural areas through the whole period. According to the spatial distribution, the highest concentration intensity has been observed in Kozaklı and Hacıbektaş agricultural areas in all years.

## KEYWORDS:

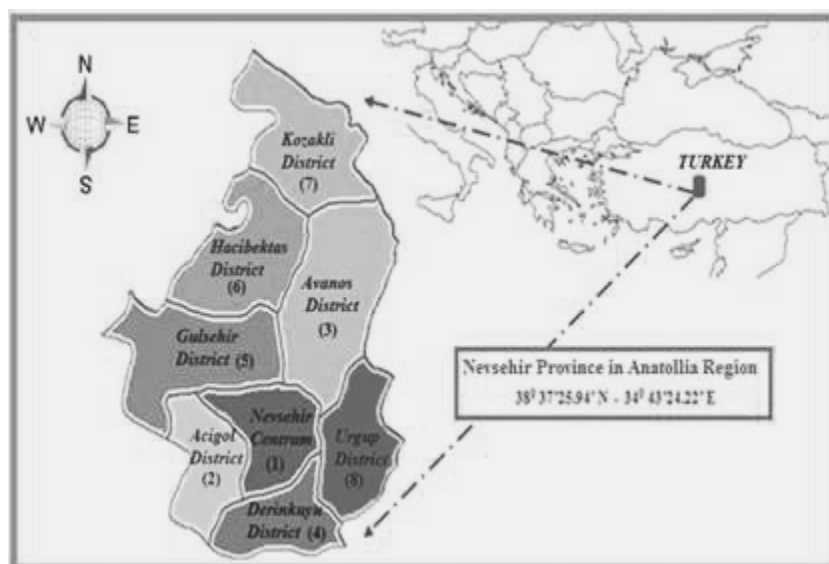
Fungicide consumptions, spatial analysis, GIS mapping, environment, agriculture

## INTRODUCTION

The world's land area is limited and it is not possible to meet this need by opening up new areas for agricultural production. As well as the cultural methods, controlling against disease, pest and weeds should also be performed to ensure high

yield efficiency in agricultural production. Loss of product due to plant diseases, pests and weeds is about 35 % in the world [1]. Lack of control can make this loss double folded [2]. Nowadays, pesticides are considered to be indispensable for more production from existing fields in all over the world [3]. The size of the pesticide market in the world is approximately \$ 45 billion, while the market in Turkey is estimated to be approximately \$ 600 million [4]. The pesticide market is composed of 41.5 % herbicides, plant growth regulators and growth inhibitors, 27.1 % insecticides, 21.5 % fungicides and 9.9 % other chemicals [5]. While 80 % share of the world pesticide market is in developed countries, the share of Turkey is 0.6 % [6]. Latin American countries are ranked top in terms of pesticides consumption, and these countries are followed by Japan, China, Malaysia and New Zealand [7]. The highest number of pesticide consumption in the EU is in the Netherlands and France, the countries with the least amount of consumption are Belgium and Finland. Examining the distribution of the chemicals used on products; we see that 24 % of the total chemicals have been used on fruit and vegetables, 15 % on cereals, 12 % on rice, 11 % on corn, 10 % on cotton, 8 % on soybean, 4 % on sugar beet, 2 % on rapeseed and 14 % on other products [8].

Pesticide consumption is estimated to be 1.3 kg/ha in Turkey [9]. Compared to above mentioned countries, pesticide use per unit area in Turkey is 7 to 28 times lower. However, unlike many developed countries between regions and provinces in Turkey of pesticide use shows a heterogeneous structure [10]. According to data from 2013 year, pesticide consumption is 39.439 tons in Turkey [11]. In the Aegean and Mediterranean Regions the total pesticide consumption accounts for about 50 % of Turkey's whole consumption, while the use of pesticide in the East and Southeast Anatolia Regions of Turkey is only about 10 % [6, 12, 13]. According to the data of 2013, the world consumption of fungicides is estimated to be 645.000 tons [5]. Also in Turkey, fungicide consumption is 16.248 tons, and 206 tons have been consumed in the province of Nevşehir [11, 14]. Considering the studies performed on pesticide and fungicide consumption in Turkey; a study has



**FIGURE 1**  
Study area, Nevşehir.

annually compared the average annual amount of pesticides consumed in Şanlıurfa province during the 2001-2006 period. The study has concluded a substantially increasing average annual consumption of pesticides [15]. Consumption of pesticides was reported to be 12.199 tons in 2002 in Turkey, with an approximate 50 % growth in 2006, amounting to 18.258 tons, and an increase of 24.22 % in 2007, amounting to 22.681 tons [16]. While many studies have been performed on the spatial mapping of the agricultural areas and products with GIS, there has been no study of the pesticides and particularly fungicide consumption in the spatial mapping and GIS in Turkey. In this study, the distribution of fungicide consumption amounts in the province of Nevşehir and her districts for agricultural purposes during the 2010-2014 period has been aimed to be mapped spatially by GIS. The study is the first of its kind in Turkey in this respect.

## MATERIALS AND METHODS

**Study area.** The Province of Nevşehir has been chosen as our study area. It is located in Turkey's Central Anatolian Region with a 5.392 km<sup>2</sup> land area and geographic coordinates of 38°37'N and 25°94'N latitude and 34°43'E and 24°22'E longitude. The study area consists of Avanos, Gölşehir, Kozaklı, Ürgüp, Hacibektaş, Acıgöl, Derinkuyu and Central districts of Nevşehir (Fig. 1). Total agricultural area of Nevşehir province (333.160 ha) is about 8.9 % of the total agricultural area in Central Anatolian Region (2.965.124 ha). 68.4 % of these agricultural areas in Nevşehir are used for production of cereals and other crops, 5.4 % for vegetables, 6.6 % for fruit

and spicy crops and 19.6 % for fallow production. In the province of Nevşehir potato production accounts to 52 % of Turkey's whole potato production, pumpkin accounts to 32.3% bean production accounts to 10 % of whole production in Turkey [11].

**Data use.** In this study, data for total consumption of fungicides for the 2010-2014 period have been acquired from the records of the Turkish Statistical Institute [11] and Nevşehir Directorate of Provincial Food Agriculture and Livestock [14].

**Method.** For Nevşehir's fungicide consumption, Arc GIS 10.3 (Arc Map) software has been used to make spatial evaluations. Inverse GIS, for mapping the spatial environment of fungicide consumption, and Inverse Distance Weighting (IDW) interpolation analysis techniques have been employed. This is the distance across the nearby data points that are based on the technical basis to have more weight. The land area has been established by considering the weighted average of sample points. IDW technique was used in the evaluation of the spatial total fungicide consumption. For determining the total fungicide consumption spatially in the province of Nevşehir, Arc GIS 10.3 software has been used. IDW Interpolation analysis technique is used to spatially map the fungicide consumption in GIS. Equation 1 is used for determining the surface distribution [17].

$$P_i = \frac{\sum_{j=1}^G P_j / D_{ij}^n}{\sum_{j=1}^G 1 / D_{ij}^n} \quad (1)$$

Where;  $P_i$  is the property of location;  $i$ ;  $P_j$  is the property at sampled location;  $j$ ;  $D_{ij}$  is the distance from  $i$  to  $j$ ;  $G$ : number of sampled locations;  $n$ : inverse distance weighting power.

## RESULTS AND DISCUSSION

The total amount of fungicide consumption for the years 2010 to 2014 in Nevşehir province and districts [14] has been provided (Table 1). According to distribution of total fungicide consumption per districts, the highest amount of consumption was observed in Kozaklı (41.40 tons; 35.90 tons; 32.0 tons; 31.20 tons; 34.30 tons respectively), while the lowest consumption level was in the Centrum of Nevşehir (18.50 tons; 15.50 tons; 12.09 tons; 11.38 tons; 13.0 tons respectively) between 2010 and 2014. While fungicide consumption has reached its highest level in 2010,

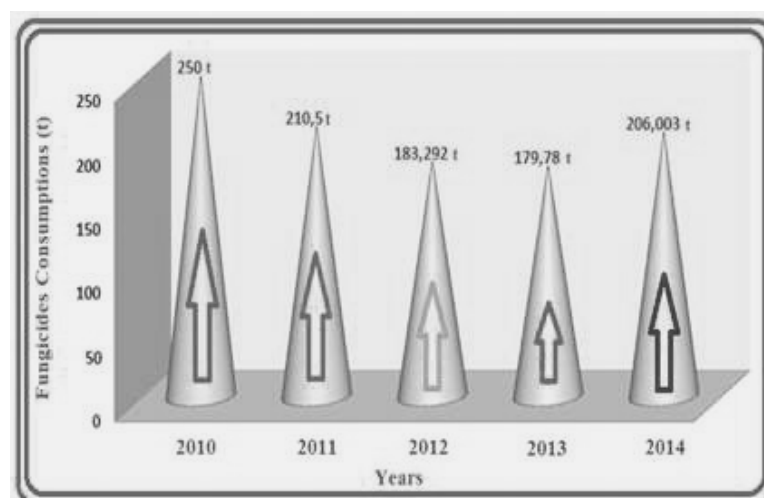
this rate has dropped to its lowest levels during 2012 and 2013, but this amount has increased in 2014 back to the level of 2011 (Table 1).

Changes in fungicide consumption per year are shown in Fig. 2. Examining the distribution of fungicide consumption per year, the highest amount of fungicide consumption was in 2010 by 250 tons, and this amount was decreased by up to 179.78 tons, indicating a downward trend until 2013. However, the amount of fungicide consumption in 2014 was 206.003 tons, and the amount of fungicide consumption in 2011 (210.50 tons) indicated similar levels (Fig. 2).

Accounting for all of the districts, the spatial maps of the total amount of the fungicide consumption in GIS between 2010 and 2014 have been given in Fig. 3. According to the results of all spatial maps, the total amount of the fungicide consumption, particularly in the northern and north-

**TABLE 1**  
Total consumption of fungicides from 2010 to 2014.

| Rank | Districts        | Total consumptions of fungicides (tons) |       |       |       |       |
|------|------------------|---|-------|-------|-------|-------|
|      |                  | 2010                                    | 2011  | 2012  | 2013  | 2014  |
| 1    | Nevşehir Centrum | 18.50                                   | 15.50 | 12.09 | 11.38 | 13.00 |
| 2    | Acıgöl           | 20.50                                   | 16.50 | 13.00 | 12.10 | 14.60 |
| 3    | Avanos           | 36.00                                   | 31.70 | 27.10 | 26.90 | 31.30 |
| 4    | Derinkuyu        | 31.00                                   | 22.10 | 21.00 | 20.20 | 23.40 |
| 5    | Gülşehir         | 34.00                                   | 30.50 | 27.00 | 27.40 | 31.50 |
| 6    | Hacıbektaş       | 39.00                                   | 33.00 | 30.00 | 29.90 | 31.20 |
| 7    | Kozaklı          | 41.40                                   | 35.90 | 32.00 | 31.20 | 34.30 |
| 8    | Ürgüp            | 29.60                                   | 25.30 | 21.10 | 20.70 | 26.70 |



**FIGURE 2**  
Total consumption of fungicide per year in Nevşehir.

western parts of Nevşehir in 2010, Hacıbektas and Kozaklı districts indicate more intensity when compared to other agricultural areas. These consumption levels have been shown to decrease towards the agricultural areas in the districts located in the southern and south-western parts of Nevşehir. While the amount of total fungicide consumption varies between 37.96 tons - 41.40 tons, in south-western farmlands this amount varies between 18.50 tons - 27.26 tons. In agricultural areas of the Central district of Nevşehir this amount has ranged between 30.92 tons to 31.81 tons. When compared to the other areas in the northern parts of Nevşehir, the total amount of fungicide consumption was higher in Kozaklı district in 2011. The level of use in the northwest district of Hacıbektas and northwards showed an upward trend when compared to 2010 consumption rates. Again compared to 2010 figures, the consumption rates in the southern and south-western agricultural lands displayed lower rates than those lands in the north, and this reduction intensified towards the district centrums, where the lowest figures have been observed in the Central and Acıgöl districts. The highest amount of consumption has been observed in Kozaklı, by 33.34 tons - 35.87 tons. The least amount of consumption varies between 15.61 tons-18.13 tons and has been observed at Acıgöl and Central districts. Surpassing the other agricultural areas, the 2012 consumption amounts was at the highest levels by 29.50 tons - 32.00 tons in Hacıbektas and Kozaklı, located north and northwest. The lowest level of consumption, on the other hand, was observed in Acıgöl and Central located in southern and south-western parts of the province, and the figures ranged between 12.09 tons - 14.66 tons. 2013 consumption levels displayed similarities with those of 2010, where the highest consumption was observed in Kozaklı district, located in the north, surpassing the other agricultural areas, and an increase has been observed in the intensity levels of consumption in Hacıbektas district, particularly surpassing the figures of 2010 and 2012. The maximum amount of consumption was in Kozaklı and Hacıbektas districts, ranging between 28.50 tons -31.70 tons, while the lowest amount of consumption was in Central Nevşehir and Acıgöl, found to be between 11.38 tons - 13.94 tons, the highest consumption intensity in 2014 year was seen similar to the northern area figures of 2011. Contrary to this, the highest density of consumption in 2010, 2012 and 2013 years were seen in northern and north-western areas. It was determined that the intensity of the lowest consumption significantly in the southwest and in agricultural areas located in the Centrum and Acıgöl. The highest consumption intensity in agricultural areas in the northern district located in

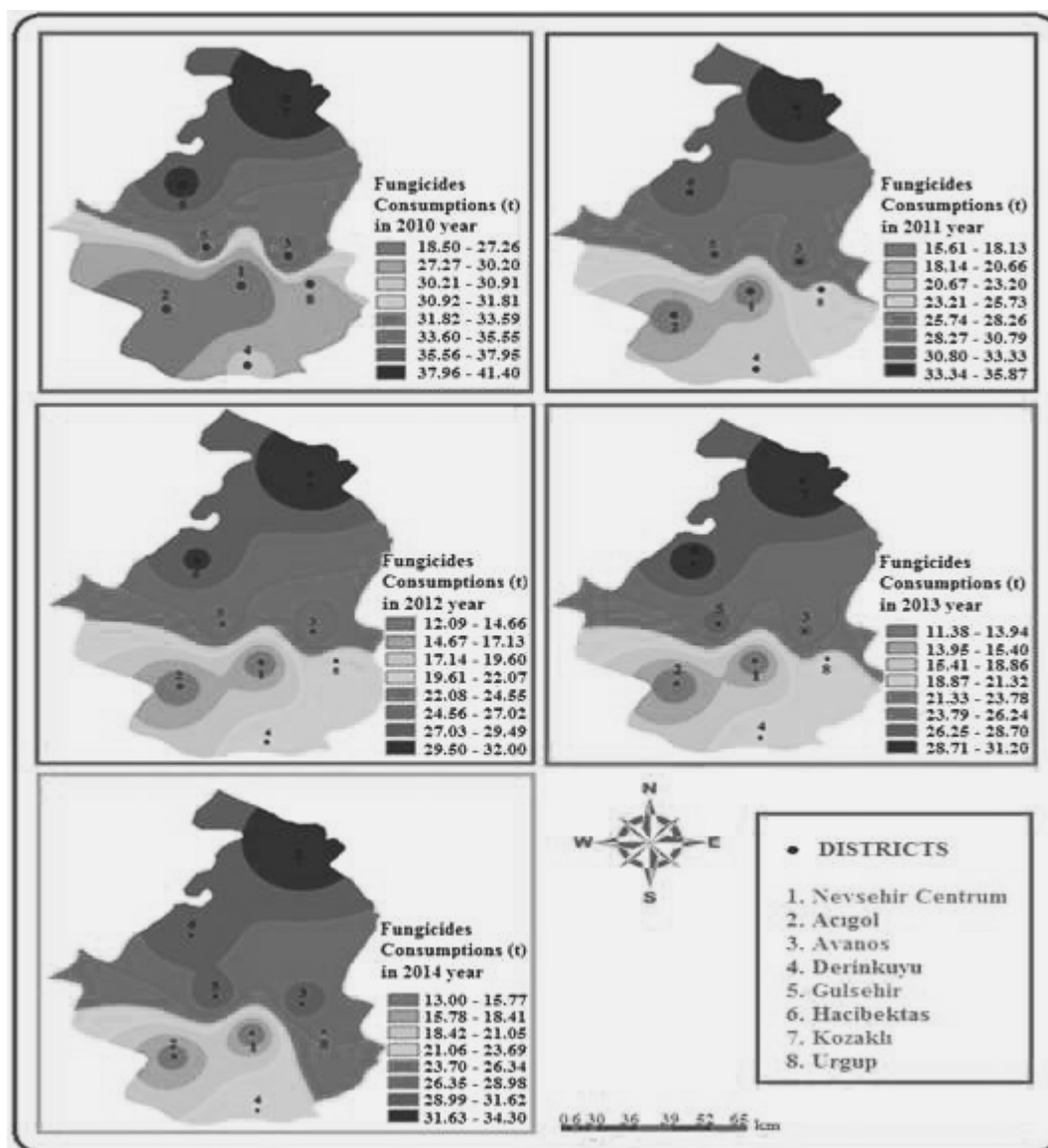
Kozaklı 31.61 - 34.30 tons realized that the lowest intensity between 13.00 tons - 15.77 tons been seen in agricultural areas in the Centrum and Acıgöl (Fig. 3).

Fungicide consumption in Central Nevşehir and districts was at the highest level (250.0 tons) in 2010. This amount decreased by 2013, and after 2011, the level dropped to 179.8 tons. In 2014, it has been determined that it reached 206.003 tons, again showing an upward trend in consumption.

Looking at the studies conducted on the use of pesticides in Turkey, a study on determining the pesticides widely used for agricultural production in the province of Isparta and districts, has reported excess use of insecticides and also that, despite in lower amounts compared to insecticides, fungicides and acaricides are also among the preferred groups in the region [18]. It has also been reported that use of pesticides is on the increase, and particularly in the Mediterranean and Aegean Regions, pesticide use is far above the average figures of Turkey, pesticide consumption would increase even further due to developments in crop production and new areas transforming to irrigated farming, and the study concluded that despite the fact that pesticide consumption is generally low in Turkey, the widely consumed pesticides do pose significant risks in terms of environmental and human health [19]. Regarding the use of chemicals in apple production in the province of Antalya, Kızılay and Akçaöz [20] have reported 77.5 % consisted of insecticides, 20.9 % fungicides and 1.6 % acaricides. The amount of pesticides (1.28 kg/ha) used in Konya in 2010 was determined to be similar to the average in Turkey [21].

## CONCLUSIONS

Polyculture farming is the preferred method in the province of Nevşehir and their districts, where fungicides are being used against the factors of disease in plants throughout agricultural activities. Fungicide consumption has been observed to be higher in Kozaklı district, located in the north of Nevşehir, when compared to the southern parts of the province. Among the reasons for fungicide consumption to be higher in Kozaklı district compared to other areas, we can point to the intensive existence of greenhouse farming activities. It is a known fact that air-borne diseases are observed in higher levels under greenhouse conditions than field conditions. In this sense, more fungicides are being used in greenhouse farming than field farming. Senseless as well as maximum dosage of fungicide application cause increased amounts of consumption in greenhouse farming.



**FIGURE 3**  
**Spatial GIS mapping of total consumptions of fungicides between 2010 and 2014 years.**

In conclusion, the study on spatially evaluating the total fungicide consumption amounts per year in the province and districts of Nevşehir in GIS environment, recommends more effective training for producers in order to reduce the effective use and consumption of fungicides in agricultural production. The Integrated Pest Management (IPM), encompassing biological, cultural, physical, mechanical and chemical control methods against disease factors should be taken into account and activities related to its implementation in this regard should be increased.

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