KASTAMONU UNIVERSITY JOURNAL OF ENGINEERING AND SCIENCES

e-ISSN 2667-8209

CİLT : 06 SAYI 01
VOL : 06 ISSUE 01

KASTAMONU UNIVERSITY JOURNAL OF ENGINEERING AND SCIENCES

e-ISSN 2667-8209

Kastamonu Üniversitesi Mühendislik ve Fen Bilimleri Dergisi

Kastamonu University Journal of Engineeering and Science

Kastamonu Üniversitesi Mühendislik ve Fen Bilimleri Dergisi Hakemli bir dergidir ve yılda 2 defa yayınlanır

Kastamonu Üniversitesi Mühendislik ve Fen Bilimleri Dergisi

Kastamonu University Journal of Engineeering and Science

Cilt: 6	No:1	Haziran 2020	Vol: 6	Issue: 1	June 2020	E-ISSN:2667-8209

Kastamonu Üniversitesi Mühendislik ve Fen Bilimleri Dergisi

Kastamonu University Journal of Engineeering and Science

Cilt: 6	No:1	Haziran 2020	Vol: 6	Issue: 1	June 2020	E-ISSN:2667-8209

Kastamonu Üniversitesi Mühendislik ve Mimarlık Fakültesi 37100- Kastamonu / TÜRKİYE

Tel: +(90)366 2802901 Fax: +(90)366 2802900

Web: http://dergipark.ulakbim.gov.tr/kastamonujes

e-mail: kujes@kastamonu.edu.tr

Bu dergi yılda iki defa yayınlanır. **This journal is published two times in a year.**

(Haziran-Aralık) **(June-December)**

Kastamonu University Journal of Engineeering and Science
Indexed and Abstracted in: Dergipark

Kastamonu Üniversitesi Mühendislik ve Fen Bilimleri Dergisi

Kastamonu University Journal of Engineeering and Science

Cilt: 6	No:1	Haziran 2020	Vol: 6	Issue: 1	June 2020	E-ISSN:2667-8209

İÇİNDEKİLER/ CONTENTS

Kastamonu University
Journal of Engineering and Sciences
e-ISSN 2667-8209
http://dergipark.gov.tr/kastamonujes

Change of Cu Concentration in Some Edible Landscape Plants Grown in Ankara City Center

Hakan Şevik*, [a]

[a] *Department of Environmental Engineering, Faculty of Engineering and Architecture, Kastamonu University, Kastamonu, Turkey*
ORCID ID: 0000-0003-1662-4830

ARTICLE INFO

RESEARCH ARTICLE
Received: April:13.2020
Reviewed: April:13.2020
Accepted: April:17.2020

Keywords:
Edible Landscape,
Heavy Metal,
Cu,
Copper,
Ankara.

Corresponding Author:
E-mail: hsevik@kastamonu.edu.tr

ABSTRACT

New solutions are constantly developed to meet the need for food that is increasing due to the increase in the world population. A new proposal has been made recently: Some plants that are consumed as food should be used in landscaping works, thus both carrying out landscaping works and using plants grown in such areas as food at the same time. Plants used for this purpose have started to be called "edible landscape". However, there is a great risk in this application. The areas where these plants are grown can be areas with high levels of heavy metal pollution and heavy metals do not decompose in nature or disappear easily and most of them are very harmful to human health.

In addition to the high level of heavy metal accumulation in plants growing in areas where heavy metal pollution is high, consumption of these plants as food poses a great risk to human health. However, the extent of the danger has not been determined yet due to the insufficient number of studies on this subject.

This study aims to determine the variation of copper (Cu) concentration by plant species and organs in some plants grown in traffic-intensive areas and used as edible landscape plants.

Anahtar Kelimeler:
Yenilebilir Peyzaj,
Ağır Metal,
Cu,
Bakır,
Ankara.

ÖZ

Artan dünya nüfusuna bağlı olarak artan gıda ihtiyacının karşılanabilmesi amacıyla sürekli yeni çözüm önerileri geliştirilmeye çalışılmaktadır. Son dönemde bu önerilere bir yenisi eklenmiş, gıda olarak tüketilen bazı bitkilerin peyzaj çalışmalarında kullanılması ve böylece hem peyzaj çalışmalarının yapılması hem de bu alanlarda yetişen bitkilerin gıda amaçlı olarak kullanılması gündeme gelmiştir. Bu amaçla kullanılan bitkiler "yenilebilir peyzaj" adı ile anılmaya başlamıştır. Ancak, bu uygulamada büyük bir risk bulunmaktadır. Bu bitkilerin yetiştirildiği alanlar ağır metal kirliliğinin yüksek düzeyde olduğu alanlar olabilir ve ağır metaller doğada bozulmaz, kolay kolay yok olmazlar ve bir çoğu insan sağlığı açısından son derece zararlıdırlar.

Ağır metal kirliliğinin yüksek düzeyde olduğu alanlarda yetişen bitkilerde ağır metal birikiminin yüksek düzeyde olabilmesinin yanı sıra, bu bitkilerin gıda olarak tüketilmesi, insan sağlığı açısından büyük bir risk oluşturmaktadır. Ancak, bu konuda yapılmış çalışma sayısı yeterli düzeyde olmadığından tehlikenin boyutu belirlenebilmiş değildir.

Bu çalışmada trafiğin yoğun olduğu alanlarda yetiştirilen ve yenilebilir peyzaj bitkisi olarak kullanılan bazı bitkilerde, bakır (Cu) konsantrasyonunun bitki türü ve organı bazında değişiminin belirlenmesi amaçlanmaktadır.

1. Introduction

Today, the most important problems in the world are population growth and problems related to population growth in general. While the world population was only 717 million in 1750, it is estimated that it will exceed 8 billion in 2025 [1]. Population growth and concentration of population in city centers bring along many problems, especially environmental pollution [2-6]. One of the problems associated with population growth is lack of food. It is estimated that approximately 830 million people in the world suffer from chronic hunger and this problem will grow even more [7].

Solutions are sought to the food problem such as increasing production per unit area, determining new areas to produce food products, and using resources that have not been used for food so far as sources of food. In this context, one of the solutions proposed recently is producing food in urban areas. It is recommended to grow plants that can be consumed as food in parks, road refuges, rooftops, i.e. all areas where plants can be grown in cities. This is called "edible landscape" [8].

However, this practice has the potential to reflect the effects of environmental pollution caused by the rapid growth of the world's population and its concentration in city centers. Usually, city centers are areas where there is a high probability of presence of pollution factors due to the high population and human activities. A lot of pollutants caused by exhaust gases, car wheels, vehicles and vehicle wear appear in these areas. Among these, especially heavy metals are of great importance. That is because heavy metals neither decompose in nature nor disappear. They also tend to bioaccumulate [9-12].

Therefore, plants grown and consumed as food in areas where heavy metal pollution is high can lead to significant health problems. However, the number of studies on this subject is not sufficient. This study aims to determine the variation of Cu concentration by plant species and organs in some plants that are grown in city centers and consumed as food.

2. Material and Method

The study was conducted on samples collected from plants grown in Ankara city center. Samples taken from apple, cherry, almond and mulberry trees consumed as food in almost all parts of Turkey were used in this study. Following the maturation of the fruits, branch samples including fruits and leaves were taken from the said samples, the samples were brought to the laboratory and separated as leaf, fruit, branch, wood and bark.

The collected samples were first kept in the laboratory for two months to become dry and then dried for 48 hours at 40 °C in an oven. 2 gr dried samples were soaked in 50 ml NO_3 concentration and kept at room temperature for 1 day. Then 50 ml ultra pure water was added to the samples which were kept in the heater for 1 hour at 80 °C. The samples were prepared by filtering them with a 0.45-micron porous filter paper. The samples were sent to Kastamonu University Central Research Laboratory Application and Research Center after the preliminary preparations and copper (Cu) concentrations were determined with ICP analysis. The results were evaluated and interpreted through variance analysis and Duncan test by means of the SPSS 17.0 package program.

3. Findings

Table 1 shows the results of the variance analysis performed to determine the variation of Cu concentration by species and organs.

Table 1. Mean Values by Species and Organs and Duncan Test Results

	Apple	**Cherry**	**Almond**	**Berry**
Leaf	15015 ^{d}	12707 ^{d}	14594 ^{d}	14093 ^{e}
Branch	17927 ^{e}	4577 ^{a}	29594 ^{e}	6683 ^{b}
Bark	13338 ^{c}	9470 ^{b}	7422 ^{a}	8129 ^{c}
Wood	4317 ^{a}	25035 ^{e}	8067 ^{b}	5177 ^{a}
Fruit	7126 ^{b}	10390 ^{c}	8380 ^{c}	9248 ^{d}
F Value	26940***	27663***	28756***	14766***

The results in the table reveal that the Cu concentration variation by organs in all fruits included in the study was statistically significant ($p<0.001$). The mean values indicate that the highest Cu concentration was in the branches and leaves of the apples while the lowest Cu concentration was observed in the wood and fruit parts.

The lowest concentrations were obtained in the branches and barks of the cherries while the highest concentrations were obtained in the wood and leaf parts. There is a difference of more than five times between the Cu concentration in the branches (4577 ppb) and the woods (25035 ppb) of the cherries. The lowest concentrations were observed in the barks, woods and fruits of the almonds while it stands out that the values are very close. The Cu concentration in the branches where the highest value was obtained is more than 3 times these values.

The results observed in the mulberries are quite remarkable. The highest value in the mulberries was obtained in the leaves and the second highest value was obtained in the fruits. The lowest value in the mulberries was obtained in the woods. Graphic 1 shows the variations in the Cu concentration by species and organs.

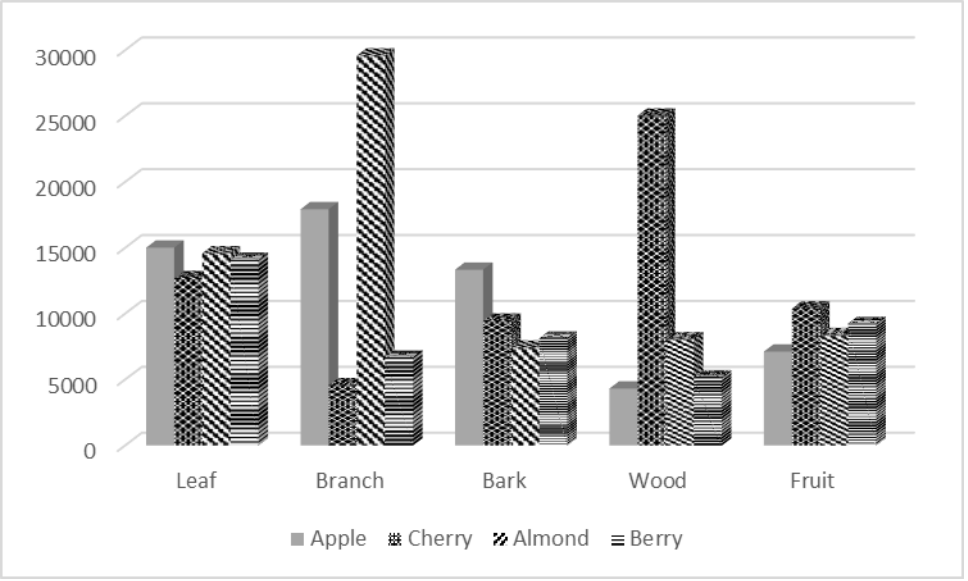

Figure 1. Variations in the Cu concentration by species and organs

4. Result and Discussion

The data obtained from the study revealed highly dreadful results. Heavy metal concentrations determined especially in leaves have been examined and it has been stated that these values are quite high in areas where traffic is intense in studies conducted so far. The results of this study show that the concentrations determined in many species of fruit are quite high.

Cu is a trace element that is essential for human and animal metabolism. Cu is an indispensable part of red blood cells and many oxidation and reduction processes in animals and humans. However, Cu is quite harmful when taken too much. The main symptoms of acute Cu poisoning are abdominal pain, nausea, vomiting, and diarrhea [13]. Low-level copper ions can cause hepatic cirrhosis, Wilson's disease, systematic rheumatism diseases, and kidney diseases while high-level copper ions can cause leukemia [14]. Therefore, it is very dangerous to consume plants grown in regions with Cu pollution as food.

Cu is an element that has been the subject of many studies so far. Mossi [15] found the lowest values in areas without traffic in unwashed Bo leaves (371.3 ppb) while the highest values were in washed leaves (19482 ppb) of Mh. In traffic-intensive areas, the lowest values were obtained in washed Ej leaves (357.4 ppb) while the highest values were obtained in washed Bt branches (11917.2 ppb). Türkyılmaz et al. [16] state that Cu concentration varies depending

on traffic density, and the Cu concentration that is 69,615 ppb in non-traffic areas increases to 71,096 ppb in less traffic-intensive areas and 110,441 ppb in traffic-intensive areas.

Suzuki et al. [17], Demirayak et al. [18], Li et al. [19], and Sawidis et al. [20], determined the variations of Cu concentration in *Rhododendron pulchrum*, *M. grandiflora*, *Sophora japonica*, and *Platanus orientalis* respectively. When the values obtained within the scope of the study were examined, it was determined that there were significant differences in the same organs on the basis of species. It has been determined in studies conducted so far that the most significant differences in the variation of heavy metal concentrations usually occur on the basis of species. It has been determined in a lot of studies that different heavy metals are held more densely by different plants [21-24].

Another result obtained in the study was that Cu concentration in organs varied significantly. There are also numerous studies on how it is kept more densely in different organs of same plants [15,25]. Studies have even shown that there are differences among same plants' organs with varying ages [26-28].

Heavy metal accumulation potentials of plants are closely related to anatomical structures and therefore species of plants. Studies conducted so far have shown that diffusion of heavy metals in the atmosphere and their entry into plant structures are a very complex mechanism [29-31]. The heavy metal accumulation potential of plants growing in the same environment varies depending on factors such as organelle structure, physical and chemical properties of metals, organelle morphology, plant habitus, time of exposure to heavy metal and amount of particulate matter in addition to plant species and plant organ [30-32].

Besides these factors, it is also stated that heavy metal concentrations may be at different levels in subspecies, forms, varieties and origins of the plant [33-36]. Studies show that many phenological, morphological and anatomical structures change depending on these characteristics. It is inevitable that plant metabolism will also change, and this will affect heavy metal absorption [15]. It is stated that many factors affecting the plant metabolism such as the stress level of the plant [37-39], environmental conditions such as climate [40-42], soil [43-44] and genetic structure [45-46] can affect heavy metal absorption and therefore heavy metal concentration in plants.

Besides the toxic effects of metals on plants, food safety has attracted a lot of attention worldwide in recent years. Many studies have been conducted recently on the health risks associated with ingestion of contaminated vegetables. It is reported that metal content in edible parts of plants can cause serious public health conditions by exceeding the maximum permitted limits (MPL). This is because some heavy metals can be quite harmful to humans even at low exposure levels. This is caused by the fact that heavy metals do not have an effective tolerance or excretion mechanism. Consumption of plants contaminated with heavy metals is specified to be highly or slightly harmful to human health [8,47]

5. Suggestion

The variations of the Cu element, which is a heavy metal highly important for human health, in five organs of four plant species were examined in this study. Heavy metals are extremely hazardous to human health. Some of them are particularly toxic, even at low concentrations. Therefore, it is very important to determine the concentrations of these elements in organelles which are consumed as food and thus can be taken directly into the human body.

As a result of the study, Cu concentrations determined in the fruits of some species, especially Mulberry, were found to be quite high. Consumption of food contaminated with heavy metals is extremely dangerous for human health. Therefore, consumption of plants grown in city centers with high levels of traffic and pollution is extremely risky for health and authorities and citizens should be informed about the risks of consuming these plants as food.

Four plant species were evaluated within the scope of this study. However, a large number of vegetables and fruits are grown in city centers and areas where industrial pollution is high, and they can be consumed as food. This situation can lead to very serious health problems. On the other hand, the number of studies on this subject is not sufficient. Therefore, it is recommended that studies related to this subject be continued by increasing and diversifying them.

Competing Interest / Conflict of Interest

"The authors declare that they have no conflict of interests"

Funding

This study is funded by the Scientific Research Projects Committee of Kastamonu University with the project number KUBAP-01/2017-18.

Acknowledgements

We thanks to Scientific Research Projects Committee of Kastamonu University.

6. References

[1] Demir, O. (2018). Some Mistakes About Population. Research Journal of Politics, Economics and Management. 6(1): 143-149

[2] Bayraktar, O.Y., Citoglu G.S., Belgin C.M., Cetin M. (2019). Investigation of the mechanical properties of marble dust and silica fume substituted portland cement samples under high temperature effect, Fresenius Environmental Bulletin, 28(5): 3865-3875

[3] Bayraktar, O.Y., Citoglu G.S., Belgin C.M., Cetin, S., Cetin M. (2019) Investigation of effect of brick dust and silica fume on the properties of portland cement mortar, Fresenius Environmental Bulletin 28(11): 7823-7832.

[4] Bayraktar, O.Y. (2019). The possibility of fly ash and blast furnace slag disposal by using these environmental wastes as substitutes in portland cement. Environmental monitoring and assessment, 191(9), 560. https://doi.org/10.1007/s10661-019-7741-4

[5] Alaqouri, H. A. A., Genc, C. O., Aricak, B., Kuzmina, N., Menshikov, S., & Cetin, M. (2020). The possibility of using Scots pine needles as biomonitor in determination of heavy metal accumulation. Environmental Science and Pollution Research International.

[6] Ozel, H. U., Ozel, H. B., Cetin, M., Sevik, H., Gemici, B. T., & Varol, T. (2019). Base alteration of some heavy metal concentrations on local and seasonal in Bartin River. Environmental monitoring and assessment, 191(9), 594.

[7] Gültekin, Y. (2020). Ordu Kent Merkezinde Yetiştirilen Bazı Kültür Bitkilerinde Ağır Metal Konsantrasyonlarının Yetişme Ortamına Bağlı Değişimi. Kastamonu University Graduate School of Natural and Applied Sciences Department of Sustainable Agriculture and Natural Plant Resources. MSc Thesis

[8] Sevik, H., Cetin, M., Ozel, H. B., Ozel, S., & Cetin, I. Z. (2020). Changes in heavy metal accumulation in some edible landscape plants depending on traffic density. Environmental Monitoring and Assessment, 192(2), 78.

[9] Ozel H. B., Ozel H. U., Varol T. (2015) Using Leaves of Oriental Plane (Platanus orientalis L.) to Determine the Effects of Heavy Metal Pollution Caused by Vehicles. Pol. J. Environ. Stud. 24 (6), 2569-2575

[10] Turkyilmaz, A., Cetin, M., Sevik, H., Isinkaralar, K., Saleh, E.A.A. (2018). Variation of heavy metal accumulation in certain landscaping plants due to traffic density. Environment, Development and Sustainability, 1-14.

[11] Sevik, H., Cetin, M., Ozel, H. B., Akarsu, H., & Cetin, I. Z. (2020). Analyzing of usability of tree-rings as biomonitors for monitoring heavy metal accumulation in the atmosphere in urban area: a case study of cedar tree (Cedrus sp.). Environmental Monitoring and Assessment, 192(1), 23.

[12] Aricak B., Cetin, M., Erdem, R., Sevik, H., Cometen, H. (2019) The change of some heavy metal concentrations in Scotch pine (Pinus sylvestris) depending on traffic density, organelle and washing, Applied Ecology And Environmental Research 17(3): 6723-6734.

[13] Asri, F.Ö. ve Sönmez, S. (2006). Ağır metal toksisitesinin bitki metabolizması üzerine etkileri. Derim, Batı Akdeniz Tarımsal Enstitüsü, Dergisi, 23(2): 36- 45.

[14] Hayta, A. B. (2006). Çevre kirliliğinin önlenmesinde ailenin yeri ve önemi. Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi, 7(2), 359-376.

[15] Mossi, M.M.M (2018). Determination of Heavy Metal Accumulation in The Some of Landscape Plants For Shrub Forms Kastamonu University Institute of Science Department of Forest Engineering. PhD. Thesis

[16] Turkyilmaz A, Sevik H, Cetin M, Ahmaida Saleh EA (2018) Changes in heavy metal accumulation depending on traffic density in some landscape plants. Pol J Environ Stud 27(5):2277–2284. http://www.pjoes.com/Changes-in-Heavy-Metal-Accumulation-Depending-non-Traffic-Density-in-Some-Landscape,78620,0,2.html

[17] Suzuki, K., Yabuki, T. & Ono, Y. (2009). Roadside Rhododendron pulchrum leaves as bioindicators of heavy metal pollution in traffic areas of Okayama. Japan, Environ Monit Assess,149,133–141

[18] Demirayak, A., Kutbay, H.G., Kilic, D., Bilgin, A. & Huseyinova, R. (2011). Heavy Metal Accumulation in Some Natural and Exotic Plants in Samsun City. Ekoloji, 20(79): 1-11.

[19] Li, F. R., Kang, L. F., Gao, X. Q., Hua, W., Yang, F. W., & Hei, W. L. (2007). Traffic-related heavy metal accumulation in soils and plants in Northwest China. Soil & Sediment Contamination, 165), 473-484.

[20] Sawidis, T., Breuste, J., Mitrovic, M., Pavlovic, P. &Tsigaridas, K. (2011). Trees as bioindicator of heavy metal pollution in three European cities. Environmental Pollution, 159, 3560-3570.

[21] Alaqouri, H. A. A., Ozer Genc, C., Aricak, B., Kuzmina, N., Menshikov, S., Cetin, M. (2020) The Possibility of Using Scots Pine (Pinus sylvestris L.) Needles as Biomonitor in the Determination of Heavy Metal Accumulation Applied Ecology and Environmental Research 18(2):3713-3727.

[22] Bozdogan Sert, E., Turkmen, M., Cetin, M. (2019) Heavy metal accumulation in rosemary leaves and stems exposed to traffic-related pollution near Adana-İskenderun Highway (Hatay, Turkey), Environmental Monitoring and Assessment, 191:553, https://doi.org/10.1007/s10661-019-7714-7, https://rd.springer.com/article/10.1007/s10661-019-7714-7

[23] Turkyilmaz A., Sevik H., Isinkaralar K, Cetin M (2019) Use of tree rings as a bioindicator to observe atmospheric heavy metal deposition, Environmental Science and Pollution Research, 26(5): 5122-5130. DOI: 10.1007/s11356-018-3962-2

[24] Cetin, M., Sevik, H., Aricak, B., Ozturk, A., Ozer Genc, C. Aisha, A.E.S.A, Jawed, A.A., Aljama, A.M.O., & Alrabiti, O.B.M., (2019b). The Investigation of the Change in Concentrations of Some Heavy Metals in Seeds, Leaves, and Branches because of Traffic Density: a Case Study of Acer platanoides L., Kastamonu Üniversitesi Mühendislik ve Fen Bilimleri Dergisi, 5(2): 83-92

[25] Sevik, H., Cetin, M., Ozel, H. B., & Pinar, B. (2019). Determining toxic metal concentration changes in landscaping plants based on some factors. Air Quality, Atmosphere & Health, 12(8), 983-991.

[26] Cetin, M., Sevik, H., & Cobanoglu, O. (2020). Ca, Cu, and Li in washed and unwashed specimens of needles, bark, and branches of the blue spruce (Picea pungens) in the city of Ankara. Environmental Science and Pollution Research, 1-10.

[27] Turkyilmaz A, Sevik H, Cetin M (2018) The use of perennial needles as bio-monitors for recently accumulated heavy metals. Landsc Ecol Eng 14(1):115–120. https://doi.org/10.1007/s11355-017-0335-9

[28] Turkyilmaz A, Sevik H, Isinkaralar K, Cetin M (2018) Using Acer platanoides annual rings to monitor the amount of heavy metals accumulated in air. Environ Monit Assess 190:578. https://rd.springer.com/article/10.1007%2Fs10661-018-6956-0.

[29] Aricak B., Cetin, M., Erdem, R., Sevik, H., Cometen, H. (2019) The usability of Scotch pine (Pinus sylvestris) as a biomonitor for traffic originated heavy metal concentrations in Turkey, Polish Journal of Environmental Studies 29(2):1-13. (2020). DOI: 10.15244/pjoes/109244.

[30] Sevik, H., Ozel, H. B., Cetin, M., Özel, H. U., & Erdem, T. (2019). Determination of changes in heavy metal accumulation depending on plant species, plant organism, and traffic density in some landscape plants. Air Quality, Atmosphere & Health, 12(2): 189-195.

[31] Sevik, H., Cetin, M., Ozel, H. U., Ozel, H. B., Mossi, M. M. M., & Cetin, I. Z. (2020). Determination of Pb and Mg accumulation in some of the landscape plants in shrub forms. Environmental Science and Pollution Research, 27(2), 2423-2431.

[32] Elfantazi, M.F.M., Aricak, B., Ozer Genc, C. (2018). Concentrations In Morus Alba L. Leaves and Branches Due To Traffic Density. International Journal of Current Research. 10(05): 68904-68907.

[33] Yigit, N., Cetin, M., Ozturk, A., Sevik, H., & Cetin, S. (2019). Varitation of Stomatal Characteristics in Broad Leaved Species Based on Habitat. Applied ecology and Environmental Research, 17(6), 12859-12868.

[34] Yigit, N., Sevik, H., Cetin, M., & Gul, L. (2016b). Clonal variation in chemical wood characteristics in Hanönü (Kastamonu) Günlüburun black pine (Pinus nigra Arnold. subsp. Pallasiana (Lamb.) Holmboe) seed orchard. Journal of Sustainable Forestry, 35(7), 515-526.

[35] Yucedag, C., Ozel, H.B., Cetin, M., Sevik, H., (2019). Variability in morphological traits of seedlings from five Euonymus japonicus cultivars. Environmental Monitoring and Assessment. 191:285.

[36] Sevik, H., Topacoglu, O., (2015), Variation and Inheritance Pattern in Cone and Seed Characteristics of Scots pine (Pinus sylvestris L.) for Evaluation of Genetic Diversity, Journal of Environmental Biology, 36(5), 1125-1130

[37] Sevik, H., Karaca, U. (2016). Determining the Resistances of Some Plant Species to Frost Stress Through Ion Leakage Method. Feb-fresenius environmental bulletin, 25(8), 2745-2750

[38] Sevik, H., Cetin, M., (2015), Effects of Water Stress on Seed Germination for Select Landscape Plants, Pol.J.Environ.Stud., 24(2), 689-69

[39] Yigit, N., Sevik, H., Cetin, M., & Kaya, N. (2016a). Determination of the effect of drought stress on the seed germination in some plant species. Water stress in plants, 43-62.

[40] Yiğit, N., Çetin, M., & Şevik, H. (2018). The Change in Some Leaf Micromorphological Characters of Prunus laurocerasus L. Species by Their Habitat. Turkish Journal of Agriculture-Food Science and Technology, 6(11), 1517-1521.

[41] Cetin, M., Sevik, H., Yigit, N., Ozel H.B., Aricak, B., & Varol, T. (2018) The variable of leaf micromorphogical characters on grown in distinct climate conditions in some landscape plants. Fresenius Environmental Bulletin, 27(5): 3206-3211.

[42] Ertugrul, M., Ozel, H. B., Varol, T., Cetin, M., & Sevik, H. (2019). Investigation of the relationship between burned areas and climate factors in large forest fires in the Çanakkale region. Environmental monitoring and assessment, 191(12), 737.

[43] Kuscu, I. S. K., Cetin, M., Yigit, N., Savaci, G., & Sevik, H. (2018). Relationship between enzyme activity (urease-catalase) and nutrient element in soil use. Pol J Environ Stud, 27(5), 2107-2112.

[44] Kuscu, I. S.K, Sariyildiz, T., Cetin, M., Yigit, N., Sevik, H., & Savaci, G. (2018). Evaluation of the soil properties and primary forest tree species in Taskopru (Kastamonu) district. Fresenius Environmental Bulletin, 27(3), 1613-1617.

[45] Sevik, H., Yahyaoglu, Z., & Turna, I. (2012). Determination of genetic variation between populations of Abies nordmanniana subsp. bornmulleriana Mattf According to some seed characteristics. Chapter, 12, 231-248.

[46] Hrivnák M, Paule L, Krajmerová D, Kulac S, Sevik H, Turna I, Tvauri I, Gömöry D (2017) Genetic variation in tertiary relics: the case of eastern-Mediterranean Abies (Pinaceae). Ecol Evol 7(23):10018–10030

[47] Batır, D. (2019). Heavy metal accumulation in some edible landscape plants breeding in Eskişehir. Kastamonu University Institute of Science, Msc. Thesis. Kastamonu

Kastamonu University
Journal of Engineering and Sciences
e-ISSN 2667-8209
http://dergipark.gov.tr/kastamonujes

Changes in Land Use Between the Years of 1990-2018 in Mersin Province Based on CORINE (Coordination of Information on The Environment) System

Ersin Kaya Sandal[a], Fatih Adıgüzel*[, b], Nadire Karademir [c]

[a] *Department of Geography, Faculty of Science and Letters, Kahramanmaras Sütcü Imam University, Kahramanmaras, Turkey,*
e-mail: esandal@ksu.edu.tr
ORCID ID: 0000-0002-6969-1570
[b,*] *Department of Geography, Faculty of Science and Letters, Nevsehir Haci Bektas Veli University, Nevsehir, Turkey,*
e-mail: fadiguzel@nevsehir.edu.tr
ORCID ID: 0000-0002-5978-2495
[c] *Department of Geography, Faculty of Science and Letters, Kahramanmaras Sütcü Imam University, Kahramanmaras, Turkey,*
e-mail: n.karademir45@gmail.com
ORCID ID: 0000-0002-5850-0580

ARTICLE INFO

RESEARCH ARTICLE
Received: April:13.2020
Reviewed: April:24.2020
Accepted: June:1.2020

Keywords:
Corine System,
Land use,
Mersin.

Corresponding Author:
E-mail:fadiguzel@nevsehir.edu.tr

ABSTRACT

By determining the change of land use characteristics over the years, changes in urban growth and land use can be revealed. Monitoring of the change in the land cover allows for better protection of forest areas as well as efficient agricultural areas and regular urbanization. Corine System is one of the commonly used methods for the determination of land use. This system established by the European Union countries, is used by Turkey. In this study, changes in urban growth and land use in Mersin province between 1990-2018 were determined using the Corine System Based on the Corine System, simplification was made in the classification. Thus, the change in the land was tried to be revealed more clearly. The changes in land cover in Mersin province have been tried to be presented based on 15 classes considering 1990, 2000 and 2018. Within the scope of the study, the reasons and consequences of the changes occurring in these periods are emphasized. As a result, the changes occurring in the 28 years in the land cover examined in 3 periods are presented within the frame of visual and measurement values. It has been observed that residential areas in Mersin are getting bigger and bigger. Planning for the future in Mersin should be made by considering these changes in land cover.

Anahtar Kelimeler:
Corine Sistemi
Arazi kullanımı,
Mersin.

ÖZ

Arazi kullanım özelliklerinin yıllar içerindeki değişiminin tespiti ile kentsel büyüme ve arazi kullanımında meydana gelen değişimler ortaya konulabilir. Arazi örtüsünde meydana gelen değişimin izlenebilmesi verimli tarım alanlarının yanında orman alanlarının daha iyi korunabilmesi ve düzenli bir kentleşmenin sağlanmasına olanak sağlar. Arazi kullanımının tespiti konusunda yaygın olarak kullanılan yöntemlerden birisi de Corine Sistemidir. Avrupa Birliği ülkeleri tarafından kurulan bu sistem, Türkiye tarafından da kullanılmaktadır. Bu çalışmada Corine Sistemi kullanılarak 1990-2018 yılları arasında Mersin ilindeki kentsel büyüme ve arazi kullanımında gerçekleşen değişiklikler tespit edilmiştir. Corine Sistemi baz alınmış ancak sınıflamada sadeleştirmeye gidilmiştir. Böylece arazideki değişim daha net ortaya konulmaya çalışılmıştır. Mersin ilinde arazi örtüsünde meydana gelen değişimler 1990, 2000 ve 2018 yılları dikkate alınarak 15 sınıf temelinde ortaya konulmaya çalışılmıştır. Çalışma kapsamında, bu dönemlerde meydana gelen değişimlerin

nedenleri ve sonuçları üzerinde durulmuştur. Sonuç olarak, 3 dönemde incelen arazi örtüsünde 28 yıllık süreç içerisinde meydana gelen değişiklikler görsel ve ölçüm değerleri çerçevesinde ortaya konmuştur. Mersin'de özellikle yerleşim alanlarının gittikçe büyüdüğü gözlemlenmiştir. Mersin'de geleceğe yönelik olarak yapılan planlamalar, arazi örtüsündeki bu değişimler göz önünde bulundurularak yapılmalıdır.

1. Introduction

Areas that survive on the earth without being affected by human activity are called natural environments. The general feature of these environments is that they are free from human influences in terms of climate, vegetation, and morphology. While these areas continue their existence with these features, on the other hand, they met the needs of people such as water, air, and food without any problems until a certain period. However, natural environments have been exposed to human influences in the last two hundred years, with an increasing population and especially industrialization and urbanization movements also increasing need for raw materials, food, and residential areas cause great changes in natural environments. However, in addition to the areas where people change according to their needs, they also need natural areas for a healthy life and sustainable progress. Firstly, he continued his life by making use of the resources and lands offered by his environment [1].

Today, more than half of the world's population lives in cities. This rate is increasing every year. However, urbanization, which we cannot define only with the demographic movement, also covers economic and social changes.

After the industrial revolution, urbanization, which emerged as a byproduct of his, after 1950 in Turkey are redesigned with migration from rural areas to cities continues today [2,3]. As a result of the population accumulation caused by excessive migration in the cities, the existing settlement in the cities cannot meet the need for shelter.

Also, as a result of the unplanned development of large cities, which spread over a large area in many developing countries, on the one hand, there are problems in the proper use of the land, and on the other hand, the opportunities of remote districts to benefit from public services, especially infrastructure, remain limited. Changes in urbanization and land cover/land use, improper land use, natural balance deteriorates with the destruction of natural vegetation, so the ability of the land falls from upper classes to lower classes. Not only affect global climate change, but also damage forests, negatively affect available water resources and cause vegetation to disappear. When urban growth does not occur in a planned way, it also causes a waste of energy resources and landscape degradation [4].

When these developments are not considered, increasing urbanization movements, despite the economic and social development provided, make it inevitable to face environmental and health problems. Also, especially the misuse of the existing land, it has reached the maximum level with urbanization and increasing population [5]. However, the main purpose of people is to live healthily and happily in the world. For all these reasons, it is important for people to be aware of the changes occurring in their environment, to monitor the changes and to direct the change for a healthy development when necessary. In this way, while maintaining healthy modern settlements, on the other hand, the protection of agricultural areas, forests, and water resources necessary for life will be ensured. Thus, land use and urban development plans will be more accurate and predictable. In this context, the area of this study covers the Mersin province (Figure 1). When Mersin province is examined, it is observed that there have been significant changes in land use in the last 30 years as a result of population growth, industrialization and urbanization activities. On the one hand, the population of the city increases with the intense migration movements from rural and other cities to Mersin, the existing housing stock and urban area are not sufficient for the incoming population, and there is a slum and an unplanned development.

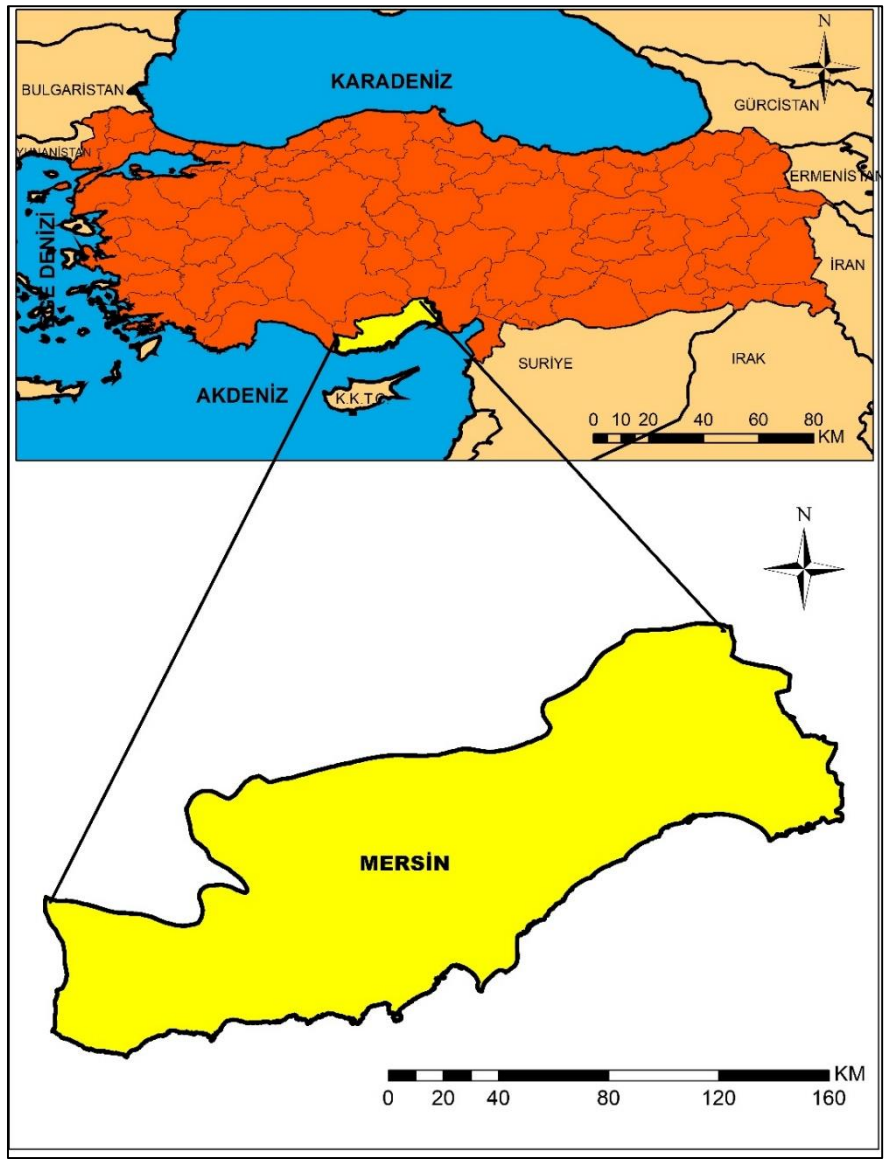

Figure 1: Working Area Location Map

Especially in the Black Sea and the Mediterranean region, the altitude level that starts from the coast, which affects cities negatively, causes the cities to get stuck in the coastline [6]. Urban development and industrial areas create pressure on fertile agricultural lands and cause these areas to be lost in time. Besides, the opening of natural areas that are not suitable for agriculture due to economic reasons also leads to deterioration in land use. In recent years, the expansion of the spring grassland in the area between 700-1250 meters also contributes to the changes on the land. In this study, the change in the land cover of Mersin province since 1990 is examined based on the Corine System.

2. Materials and Methods

In this study, CORINE (Coordination of Information on the Environment) land use data were used (Table 1). CORINE project is one of the important land management projects carried out within the scope of the European Union GMES (Global Monitoring for the Environment and Security) program. This project was started by the European Commission in 1985. An environmental information system was created until 1990, and the terminology and

methodology of the CORINE system were developed and the system was accepted at the European Union level. The main idea in this project is to create a standard database of the entire European land piece with common evaluation criteria. The purpose of the Corine project is to create land cover/use maps containing satellite images and geographic information systems, as well as location-related land information. The data obtained with this project is computer-aided land use data of satellite images according to the determined land use classification. The project also includes Turkey, where 39 countries (an area of 5.8 million square kilometers) covers [7,8].

CORINE system in our country in 1998 Turkey Statistical Institute, optimal use of land resources has been launched to be created using satellite images of the required land cover inventory for the work to be done on a geographic basis, such as the creation of a framework that will allow the field sampling in various studies [2]. There are essentially 3 levels in the CORINE system. There are 5 basic land cover classes at level 1, 15 classes with land cover/use at level 2, and 44 land use classes at level 3 [9].

In this study, to perceive the changes better between 1990 and 2018, it was decided that the merging of some classes in the Corine Land Use classification would be more accurate in terms of reality and interpretation as a result of the observations in the field. The level used in the study is usually the second level. However, a total of 15 classes were created by combining them with some classes at the third level (Table 2). To combine classes, ArcGIS 10.5 program and merge tool for polygon classes.

The changes occurring in the land cover in Mersin province were explained by taking into consideration the years 1990, 2000 and 2018. The amount of areal changes in this process has been revealed.

Table 1: CORINE Land Cover Classes

Level 1	Level 2	Level 3
1. Artificial Regions	1.1. **City Structure**	1.1.1. Continuous City Structure
		1.1.2. **Discrete City Structure**
	1.2. Industrial, Commercial and Transport Units	1.2.1. Industrial or Commercial Areas
		1.2.2. Road and Railway Related Areas
		1.2.3. Ports
		1.2.4. Airports
	1.3. Mining, Discharge and Construction Sites	1.3.1. Mine Extraction Areas
		1.3.2. Discharge Fields
		1.3.3. Construction Sites
	1.4. Artificial Non-Agricultural Green Areas	1.4.1. Green City Areas
		1.4.2. Sports and Entertainment Areas
2. Agricultural Areas	2.1. Arable Areas	2.1.1. Irrigable Arable Lands
		2.1.2. Continuously Irrigated Lands
		2.1.3. Rice Fields
	2.2. Continuous Products	2.2.1. Vineyards
		2.2.2. Fruit Gardens
		2.2.3. Olive Gardens
	2.3. Grasslands	2.3.1. Grasslands
	2.4. Heterogeneous Agricultural Areas	2.4.1. Annual Products with Continuous Products
		2.4.2. Mixed Agricultural Areas
		2.4.3. Agricultural Lands with Natural Vegetation
		2.4.4. Forest Agriculture Lands
3. Forest and Semi Natural Areas	3.1. Forests	3.1.1. Broad Leaved Forests
		3.1.2. Coniferous Forests
		3.1.3. Mixed Forests
	3.2. Maki or Herbaceous Plants	3.2.1. Natural Meadows
		3.2.2. Shrubberies
		3.2.3. Sclerophyll Vegetation
		3.2.4. Plant Change Areas
	3.3. Little or No Vegetation/ Flora Areas	3.3.1. Coast, Beach and Sandbox
		3.3.2. uncovered Cliffs
		3.3.3. Sparse Vegetable Areas
		3.3.4. Burnt Out Areas
		3.3.5. Glaciers and Permanent Snow
4. Wet Areas	4.1. Internal Wet Areas	4.1.1. Swamps
		4.1.2. Turfs
	4.2. Near Coastal Areas	4.2.1. Salt Marsh
		4.2.2. Salts
		4.2.3. Flats formed by the tide event
5. Water Communities	5.1. Inner Waters	5.1.1. Water Trails
		5.1.2. Water Bodies
	5.2. Sea Waters	5.2. 1. Coastal Lagoons
		5.2. 2. Golden Horn (River Mouths)
		5.2. 3. Seas and Oceans

Table 2. Land Use Classification Based on Corine System in Mersin

Ranking	**Land Usage**
1	Residential area
2	Transportation Area
3	Industrial and Commercial Area
4	Dry Field
5	Watery Field
6	Vineyards
7	Fruit Gardens
8	Olive Gardens
9	Grassland and Meadows
10	Other Agricultural Areas
11	Sand Dunes
12	Uncovered Cliffs
13	Forest Area
14	Swamps
15	Streams and Lakes

3. Results and Discussion

The changes occurring in the land cover in Mersin province were explained by taking into consideration the years 1990, 2000 and 2018. The amount of areal changes in this process has been revealed. Based on the results, forward-looking predictions were made.

When the land use status of the study area with a surface area of 15908 km^2 in 1990 is examined, it is seen that most of this area consists of forests, grasslands, and meadows, followed by agricultural fields. While the forest area is 6566 km^2, grasslands and meadows are 4776 km^2 and agricultural areas are 3987 km^2 (Table 3-4). While dry field cultivation is 339 km^2 in agricultural areas, the irrigated field is 727 km^2, fruit gardens are 138 km^2, olive gardens are 4 km^2 and other agricultural areas are 2758 km^2. Other agricultural areas consist of forest areas, mixed agriculture areas, and areas where continuous crops and annual crops are planted and planted together. These agricultural areas mostly correspond to the belt with high slopes and natural forest cover (Figure 2). Settlement, industry, and transportation areas constitute a very low rate. While the area of the residential areas reaches 135 km^2, the areas where the industrial facilities spread are 21 km^2 and the transportation areas outside the residential areas are about 2 km^2.

Table 3. Land Use Status of Mersin Province Over the Years According to Corine System

		Years	
Agricultural Area Usage	**1990 Km²**	**2000 Km²**	**2018 Km²**
Dry Agriculture	339,7	338,4	316,6
Irrigated agriculture	727,0	726,4	643,3
Vineyards	20,0	19,9	40,7
Fruit Gardens	138,0	127,1	747,4
Olive Gardens	4,1	4,1	27,7
Grassland and Meadows	2758,7	6557,2	3215,0
Total	**3987,5**	**7773,1**	**4990,6**

Table 4. Agricultural Area Usage Status in Mersin Province by Year Based on Corine System

	Years		
Land Usage	**1990 Km²**	**2000 Km²**	**2018 Km²**
Residential	135,8	162,8	217,9
Transportation	1,9	38,1	66,1
Industrial	21,1	15,7	36,6
Dry Agriculture	339,7	338,4	316,7
Irrigated agriculture	727,0	726,4	643,3
Vineyards	20,0	19,9	40,7
Fruit Gardens	138,0	127,1	747,4
Olive Gardens	4,1	4,1	27,7
Grassland and Meadows	4776,0	2729,1	2327,8
Other Agricultural Areas	2758,7	6557,2	3215,0
Sand Dunes	25,7	25,4	30,4
Uncovered Cliffs	314,7	314,7	678,5
Forest Area	6566,0	4768,0	7479,4
swamps	25,2	25,2	20,0
Streams and Lakes	54,1	55,9	61,0
Total Area	**15908,0**	**15908,0**	**15908,0**

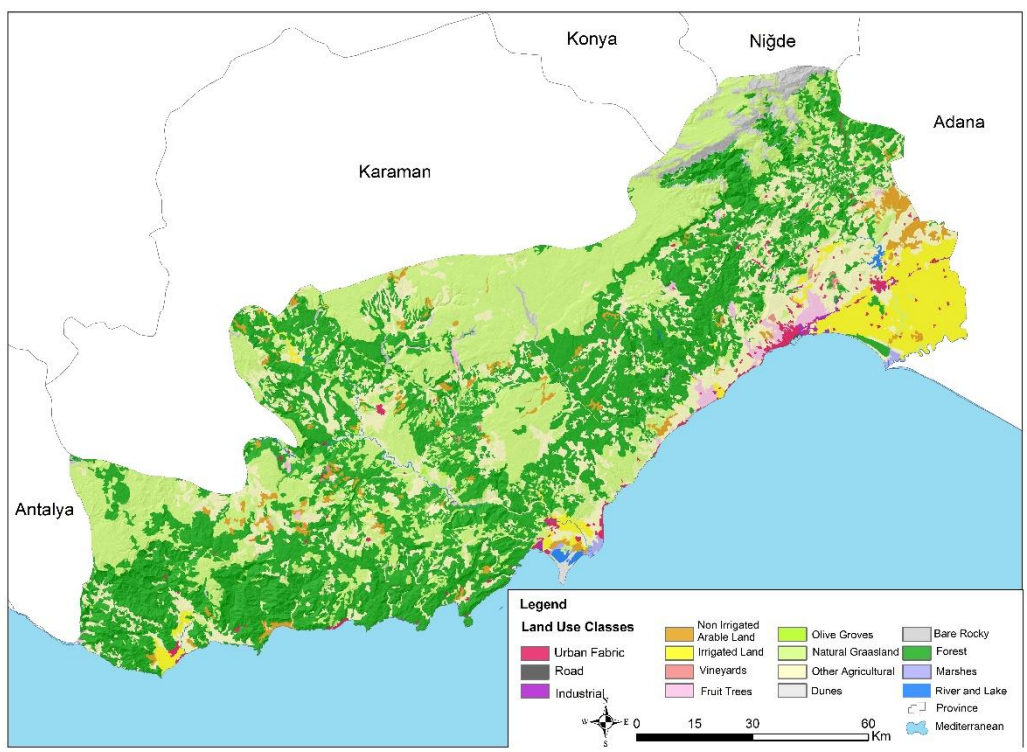

Figure 2. Land Use Status of Mersin Province (1990)

When the land use status in 2000 is analyzed, it is seen that the agricultural lands rose to the first rank, followed by forests, grasslands, and meadows. Compared to 1990, while the forest areas were 4768 km^2 with a decrease of 1798

km^2, grasslands and meadows decreased to 2729 km^2 with a decrease of 2046 km^2. Agricultural fields expanded by 3785 km^2 and reached 7773 km^2. The largest expansion among the agricultural lands took place in the category of other agricultural lands. There was also an expansion of 10 km^2 in the fruit gardens category. There was a large expansion in favor of agricultural areas adjacent to or mixed with forests, grasslands, and meadows in the belt where the slope is high and natural forest cover is located. While there is a significant expansion in settlement and transportation areas, there is a contraction in the industrial area. The area of the residential areas has increased from 135 km^2 to 162 km^2, and the transportation areas outside the residential area have increased from 2 km^2 to 38 km^2. The areas of industrial facilities spread from 21 km^2 to 15 km^2. The decrease in the industrial areas is because many industrial areas remain within the settlements as a result of the expansion of the settlement areas. This situation is mostly seen in the east of Mersin city center (Figure 3). In areas covered by rivers and lakes, there was an expansion of about 2 km^2 and the surface area of these areas exceeded 55 km^2.

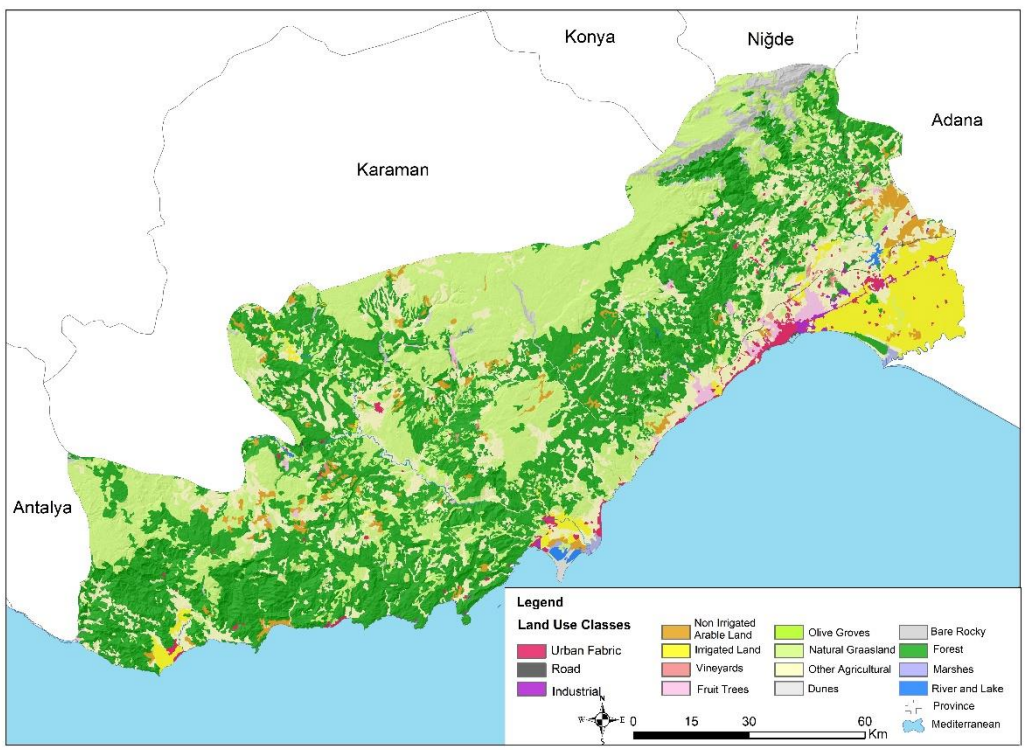

Figure 3. Mersin Province Land Use Status (2000)

When the land use situation in 2018 is analyzed, it is seen that the forest areas rose to the first rank and this was followed by agricultural fields, grasslands, and meadows. Compared to 2000, forest areas increased by 2711 km^2 and reached from 7468 km^2 to 7479 km^2. Agricultural areas decreased by 2782 km^2 from 7773 km^2 to 4990 km^2. A 3342 km^2 contraction has occurred in areas adjacent to forest areas within the agricultural areas and mixed with natural vegetation or where long-term and annual agricultural plants are intertwined. The contraction in agricultural areas in this category has exceeded 50% compared to 2000. Fruit gardens increased by 620 km^2 and reached from 127 km^2 to 747 km^2. Olive gardens increased from 4 km^2 to 27 km^2 and the vineyards increased from 19 km^2 to 40 km^2. On the other hand, there has been a decrease of 83 km^2 in areas where irrigated farming has been done. Grasslands and meadows decreased from 2729 km^2 to 2327 km^2 with a decrease of 401 km^2. On the other hand, there have been significant expansions in the areas of settlement, transportation, and industry. The residential area has increased from 162 km^2 to 217 km^2, transportation area from 38 km^2 to 66 km^2 and industrial areas from 15 km^2 to 32 km^2. Expansions in the field of industry and transportation mostly originated from highways and industrial facilities built in the east of the study area (Figure 4).

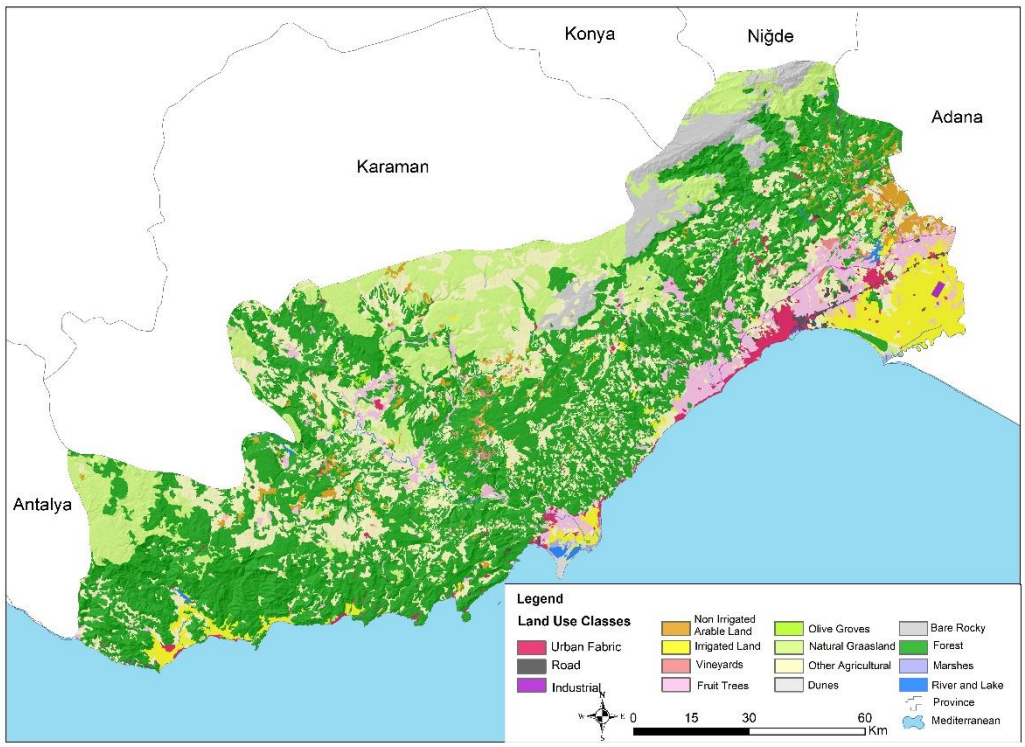

Figure 4. Land Use Status of Mersin Province (2018)

According to the calculations made based on the Corine System in 2018, the total agricultural area in the study area is around 4990 km^2. Its ratio to the total area is 31%. In the study area, irrigated farming mostly takes place in the south of Mersin-Adana highway and the Göksu Delta, whereas dry farming areas are concentrated especially in the northeast of Tarsus district.

The vineyards, on the other hand, are common in a hilly area of 10-15 km in the north of Tarsus and Mersin settlements and in the southeast part of Mut district.

Olive gardens are concentrated in the Göksu basin and especially north of Mut district center. Olive gardens are also common in hilly areas north of Tarsus district.

Fruit gardens, on the other hand, are dense in an area about 10 km wide, starting from the surroundings of the Erdemli district where the irrigation facilities are sufficient and the Mersin-Tarsus highway. It is also spreading increasingly in the Göksu basin, around Silifke and Mut district centers.

Other agricultural areas are concentrated especially in Göksu basin, plateau area in the north of Silifke and Erdemli districts, in hilly areas in the north of Çukurova. The fields included in this classification include areas with annual products mixed with continuous crops and areas where natural vegetation is mixed with agricultural areas, forest agricultural areas, and areas where mixed crops are grown.

While the grasslands are common in the plateau area in the north of the province, the bare areas occupy a large area in the north of Tarsus, Çamlıyayla and Toroslar districts, where the slope and elevation are very high.

The forests extend from east to west of Mersin and reach an average depth of 50 km. The forests go down to the sea in the section from Antalya province border to Erdemli district.

Dunes and swamps are located at the mouth of Göksu, Seyhan and Tarsus Stream.

Industrial areas are mostly concentrated around Mersin-Adana highway in the east of Mersin city. There are also some industrial facilities to the west of Silifke district.

Although the settlement areas are spread throughout the province, it covers a large area between Mersin and Tarsus.

4. Conclusion and Suggestions

In the study area covering Mersin province and 15908 km^2, the changes in the land cover were examined according to the Corine system in 15 categories and based on 3 separate years.

As a result of this review, an increasing trend was observed in settlements, transportation, industrial areas and vineyards between 1990 and 2018, while a decrease was observed in dry and irrigated agricultural areas, grasslands and meadows. In this process, while bare areas doubled, a fluctuating course was observed in forest and fruit areas. Due to the increasing population in the expansion of the settlement areas and the economic development, the expansion of the settlements and the effect of the development plans made are in question. Likewise, as a reflection of the population and economic developments, the construction of new transportation networks, highways, the establishment of new industrial facilities and the expansion in the Organized Industrial Zones have led to the expansion of transportation and industrial areas. These enlargements in residential, transportation and industrial areas have caused some other areas of use to contract. While there is a decrease in dry and irrigated farming fields around the densely populated areas, as well as in fruit gardens and vineyards, fruit gardens, vineyards, and olive gardens have expanded away from the shore and in places where the altitude is increased. The places where this expansion has occurred were mostly realized in areas bordering forests and grasslands. The increase in river and lake areas in this process is due to newly built dams and ponds. Rises and decreases in other agricultural areas are mostly related to the situation in forest areas. Here, the decrease in one was reflected in the other as an increase. While the surface area of other agricultural lands increased by more than two times in 2000 compared to 1990, it can be said that the economic process and population movements were effective in decreasing to 3215 km^2 in 2018. In recent years, especially in places where the altitude is over 1000 meters, despite the increasing agricultural cost, the relative decline in sales prices has made it impossible for people to cultivate in these low-yield areas. For this reason, people who could not make a living generally stopped cultivating in this area and migrated to the city center. In this case, a large part of these areas started to look like a forest again.

When the changes in the land cover over the years taken into consideration, it can be predicted that there will be an expansion in settlement, transportation, industrial areas, fruit gardens, olive gardens and vineyards. However, it should be noted that the areas mentioned above should not be against each other. Because settlement, transportation, industrial areas, and fruit gardens, olive gardens and vineyards are largely adjacent to each other and mostly concentrated in the southeast of the study area. For this reason, especially settlement, transportation, industrial areas; away from fruit gardens and olive gardens; grassland or slope rate is high; low agricultural productivity; It would be more appropriate to direct it to the areas with dry farming areas that are not 1^{st} and 2^{nd} class. In addition, the forest areas around the rural settlements are under the pressure of a large population and settlements due to the developments in the spring land. The forests must lose their quality due to the fires that have been cut or intentionally removed, and consequently, these areas should not be allowed to settle for the sake of rent. In this context, water resources in these areas are also under threat. The awareness that a modern residential fabric that is compatible with nature and a healthy life away from environmental problems is indispensable for our future should be expanded in the society. Planning at different scales (regional, urban, tourism, recreation, etc.) should be done correctly by considering the past process and considering future generations.

Competing Interest / Conflict of Interest

The authors declare that they no conflict of interest. The none of the authors have any competing interests in the manuscript.

Funding

There is no financial support and commercial support.

Acknowledgements

We declare that all Authors equally contribute.

5. References

[1] Garipağaoğlu, N. & Duman, E., (2018). Land Use Changes of Çatalca District (1987-2016). Marmara Geographical Review, 37, 219-232.

[2] Çivi, A., Akgündüz, E., Kalaycı, K., İnan, Ç., Sarıca, E. & Toru, E., (2009). CORINE (Cordination of Information on the Environment) Projesi. in TMMOB Coğrafi Bilgi Sistemleri Kongresi, İzmir.

[3] Çivi, A., Akgündüz, E., Kalaycı, K., İnan, Ç., Sarıca, E., & Serter, G., (2011). CORINE (Cordination of Information on the Environment) Projesi. in TUFUAB 2011 , 6. Teknik Sempozyumu, Antalya.

[4] Türkiye Cumhuriyeti Tarım ve Orman Bakanlığı, corine.tarimorman.gov.tr. Tarım ve Orman Bakanlığı, 28 Haziran 2019. [Online]. Available: https://corine.tarimorman.gov.tr/corineportal/index.html. [Accessed 12 Eylül 2019].

[5] Doğan, M. & Vural, E., (2019). Changes and Developments Occurred in the Land Use of Kırıkkale City (1990-2018). 1st. Istanbul International Geography Congress, Istanbul.

[6] Vural, E., (2019). Görele Şehrinin Alansal Gelişimi. Beşeri ve İktisadi Coğrafya Araştırmaları içinde. Ed. Doç. Dr. Süheyla Üçışık Erbilen, Dr. Güven Şahin, Eski Babil Yayınları, İstanbul.

[7] Çakır, G., Kaya, L. G., Yücedağ C., & Bayram, S., (2019). Determination of the Effects of Alucra Forest Planning Unit's Population Dynamics on Land Use Changes. Kastamonu Univ., Journal of Forestry Faculty, 19(1), 35-46.

[8] Işık, Ş., (2005). Urbanisation and Urbanisation Models in Turkey. Aegean Geographical Journal, 14, 57-17.

[9] Koca, H. & Karadeniz, V., (2014). The Activities of Housing Development Administration (Toki) in Erzincan. Eastern Geographical Review, 19(31), 101-128.

Kastamonu University
Journal of Engineering and Sciences
e-ISSN 2667-8209
http://dergipark.gov.tr/kastamonujes

Determination Structural Properties of In-Doped CdTe/CdS Thin Films Solar Cells

İbrahim Kırbaş*, [a], Duygu Takanoğlu Bulut [b], Rasim Karabacak[c], Koray Yılmaz[d]

[a] *Vocational School of Technical Sciences, Burdur Mehmet Akif Ersoy University, Burdur, Turkey*
e-mail: ikirbas@mehmetakif.edu.tr
ORCID ID: 0000-0002-5560-638X
[b] *Department of Physics, Arts and Science Faculty, Pamukkale University, Denizli, Turkey*
e-mail: dbulut@pau.edu.tr
ORCID ID: 0000-0001-6691-7813
[c] *Mechanical Engineering Department, Engineering Faculty, Pamukkale University, Denizli, Turkey*
e-mail: krasim@pau.edu.tr
ORCID ID: 0000-0002-2226-570X
[d] *Department of Physics, Arts and Science Faculty, Pamukkale University, Denizli, Turkey*
e-mail: kyilmaz@pau.edu.tr
ORCID ID: 0000-0002-7724-4068

ARTICLE INFO

RESEARCH ARTICLE
Received: April:24.2020
Reviewed: May:5.2020
Accepted: May:8.2020

Keywords:
Thermal evaporated,
Thin film solar cells,
In-doped CdTe,
Structural properties.

Corresponding Author:
**E-mail: ikirbas@mehmetakif.edu.tr*

ABSTRACT

Many methods have been used to produce thin film solar cells. Many of these methods are technically complex and expensive. In the present study, a thermal evaporation method with fewer usage parameters was used to produce thin film solar cells. In addition, the impacts of annealing on the structure of solar cells were investigated. The surface morphology of solar cells and the approximate content of each element were carried out with a QUANTA (FEG-250) model scanning electron microscopy and Energy Dispersive X-Ray Spectroscopy (SEM/EDS). The X-ray diffraction (XRD) measurements were performed using a BRUKER XRD system (D8 Advance) X-ray diffractometer. In the SEM analyzes, it was determined that the reduced in the roughness of the film surfaces was and clumping occurred as a result of annealing. But if the crystallite size is at submicron level, this negative situation can be overlooked. An increase in Cd was observed with EDS analysis. XRD diffraction has shown that the peaks in the (111), (200) and (211) planes increase the intensity of these peaks in the annealing result. As a result, it was determined that annealing affects positively the structural characteristics of In-doped CdTe/CdS solar cells.

Anahtar Kelimeler:
Isısal buharlaştırma,
İnce film güneş pili,
In katkılı CdTe,
Yapısal özellikler.

ÖZ

İnce film güneş pilleri üretiminde birçok yöntem kullanılmıştır. Bu yöntemlerin çoğu teknik olarak karmaşık ve pahalıdır. Bu çalışmada ince film güneş pillerini üretmek için daha az kullanım parametresi içeren ısısal buharlaştırma yöntemi kullanılmıştır. Ayrıca tavlamanın güneş pillerinin yapısı üzerindeki etkileri araştırılmıştır. Güneş pillerinin yüzey morfolojisi ve her bir elementin yaklaşık içeriği bir QUANTA (FEG-250) model tarama elektron mikroskobu ve enerji dağılımlı X-ışını spektroskobu (SEM/EDS) ile gerçekleştirilmiştir. X-ışını kırınımı (XRD) ölçümleri bir BRUKER XRD sistemi (D8 Advance) X-ışını difraktometresi kullanılarak gerçekleştirildi. SEM analizlerinde tavlama sonucunda film yüzeylerindeki pürüzlüğün azaldığı topaklanmaların oluştuğu tespit edilmiştir. Fakat tanecik boyutunun micron altı seviyesinde olması bu olumsuz durumun göz ardı edilebileceğini göstermektedir. EDS analizleri ile Cd oranında bir artış gözlemlenmiştir. XRD saçılmaları ile (111), (200), (211) düzlemlerinde pikler gözlemlenirken tavlama sonucunda bu piklerin şiddetlerini arttığını göstermiştir. Sonuç olarak tavlama işleminin In-katkılı CdTe/CdS güneş pillerinin yapısal özellikleri üzerinde olumlu yönde etki ettiği belirlenmiştir.

1. Introduction

In recent years, compounds II-VI have been intensively studied for practices in the semiconductor devices, electronic, optoelectronic, and photovoltaic industries [1-4]. Consist of II-VI compounds; CdTe has a solar energy ideal band gap of 1.45 eV. This range is very suitable for solar cells production [5-9]. CdTe crystal structure is usually cubic or hexagonal [10-12].

Yılmaz et al. (2017) in studies, as-grown CdTe films have high Cd spaces and due to which limits its use in solar cell applications result p-type conduction. They reported that it would be possible to fill Cd spaces by adding indium atoms to the structure, thus resulting in n-type conduction [13].

CdS films are n-type semiconducting materials with a band gap of 2.42-2.5 eV [14-17]. Along with semiconductors such as CdTe (1.5 eV), which has a narrower bandwidth than itself, in the heterojunction thin film solar cells is preferred as window material that collects and transmits the incoming rays [18-20].

There are many studies on CdTe and In-doped CdTe structures. The structural and electrical properties of these structures are available in the literature [21-25]. A study of In-doped CdTe/CdS solar cell produced by thermal evaporation has not yet been reported in the literature. For this reason, the primary goal of this work is to determine the structural properties of the In-doped CdTe/CdS solar cell produced by thermal evaporation and the effect of annealing to the structural characteristic of this solar cell.

2. Material and Method

2.1. Sintered of Polycrystalline Materials

For CdTe prepared by weighing at stoichiometric ratios, 8 grams of Cd corresponding to 9.08 grams Te was added. For doping 1% In, 0.17 grams of In added material reached 17.25 grams weight. The materials were placed in chemically cleaned quartz tubes. The mouths of the tubes were closed. The sintering process was started by placing the tubes in a horizontal tube furnace. The oven was heated gradually. When the oven temperature reached 1150 ^{o}C after 48 hours, it was left for 24 hours [13]. The tube in the oven was shaken at regular intervals to form a homogenous mixture. After the crystal formation was achieved, the cooling was also carried out gradually (10-15 $^{\circ}$C/h). The obtained polycrystalline material was pulverized again.

2.2. Deposition of In-doped CdTe Thin Films

The powdered polycrystals were bound to the holder of the thermal evaporation system in tungsten crucibles. The chemically and ultrasonically cleaned Indium Tin Oxide (ITO) coated substrate was placed in a circle. Once the compression of the vacuum chamber arrives $5x10^{-5}$ Torr, the flow was gradually started to flow through the pot. When the current passing through the cruiser reached 50 Ampere, the material started to flush. The current was initiated by opening the cutter at the value of 71 Ampere. The evaporation rate of the material was about 9-13 Å/s. When the thickness of 0.7 μm (7 kÅ) was reached after about 10 minutes, the cutter was closed and storage was terminated.

2.3. Annealing of In-doped CdTe Thin Films

In-doped CdTe substrate produced by thermal evaporation was located in a Protherm trademark annealing-furnace warmed to 400 $^{\circ}$C [26]. Along the annealing, nitrogen gas was continuously injected through the furnace to prevent oxidation on the film. The oven temperature was kept at 400 ^{o}C and annealing was performed for 1 hour. Then the oven was turned off. The oven was cooled to room temperature naturally in nitrogen gas, and then the samples were removed.

2.4. Deposition of CdS Thin Films

After the generation of the glass/ITO/In-doped CdTe structure, the annealed and non-annealed specimens were positioned in the holder in the system to deposition the CdS polycrystalline at window layer. Afterwards the chamber was shut down by placing 99.999% pure CdS powder in the tungsten crucible. Vacuum chamber internal pressure was brought to $5x10^{-5}$ Torr. Then 30 ampere current was started to flow on the pot. As the current value was gradually increased, the potential of the pot was observed when the amperage reached 70 A passing through the pot. When the current value reached 100 A, the cutter was opened and the storage process started. Substrate temperature 0 $^{\circ}$C and evaporation rate of material was kept at 10-11 Å/s during the process. When the coating thickness from the thickness monitor was read as 0.7 μm (7 kÅ), the cutter was closed and the storage process was terminated.

2.5. Deposition of Top Contact

After the solar cell structure has been formed, the annealed and non-annealed samples are placed in the holder of the thermal evaporation system to receive contact. The upper contacts were removed from indium by thermal evaporation in the Van der Pauw geometry.

2.6. Characterization

The surface morphology of solar cells and the approximate content of each element were carried out with a QUANTA (FEG-250) model scanning electron microscopy and Energy Dispersive X-Ray Spectroscopy (SEM/EDS). The X-ray diffraction (XRD) measurements were carried out using a BRUKER XRD system (D8 Advance) X-ray diffractometer.

3. Results and Discussion

The samples were prepared by thermal evaporation at a thickness of about 1.4 µm. ITO coated glass is used as the substrate. For the In-doped CdTe/CdS thin film solar cells, the non-annealed was named S1and the 400 ºC annealed at 1 hour was named S1_400.

3.1. Structural Analysis

XRD scattering results of thin film solar cells are shown in Figure 1. In the S1 and S1_400 samples, peaks were observed at approximately 2θ=23.9º, 26.6º and 33.0º. The positions of the designated peaks are the same and it is observed that the severity is increased due to the annealing. Due to annealing, the peak positions have not changed. But their density has increased. This situation can be interpreted as the reduction of structural defects and the structure of thin films are polycrystalline rather than amorphous. The diffraction lines produced by the 2θ=23,9º, 2θ=26,6º and 2θ=33,0º peaks correspond to the (111), (200) and (211) [1], [27].

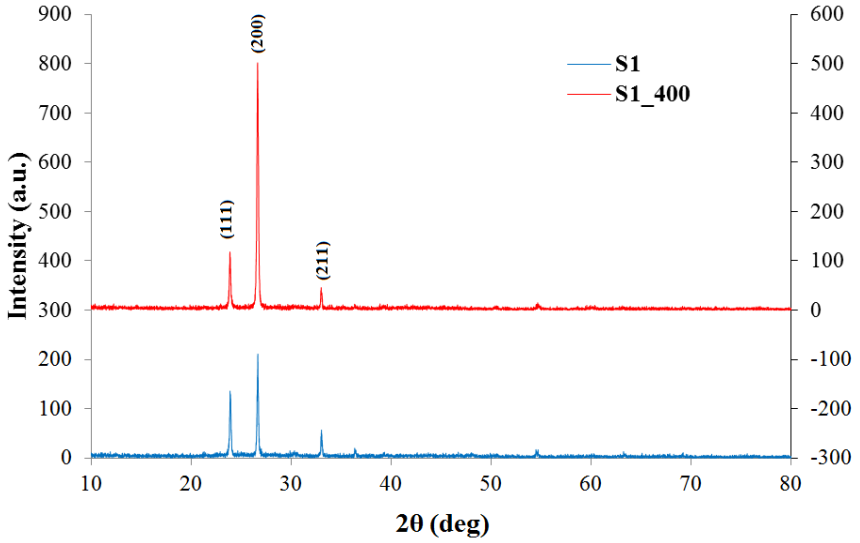

Figure 1. The X-ray diffraction patterns of S1 and S1_400

The Inter-planar distance (d) and the lattice constant (a) with the help of the XRD profile can be calculated according to the following equation known as Bragg law.

$$d = \frac{\lambda}{2sin\theta} \quad (1)$$

Here, X-ray wavelength used λ, lattice spacing d, Bragg's angle θ. The plane-spacing equation can be calculated with the following equation.

$$\frac{1}{d^2} = \frac{(h^2+k^2+l^2)}{a^2} \quad (2)$$

Miller indices of the planes are expressed as (h k l).

Scherrer formula is used to calculate the crystallite sizes of thin films with XRD data.

$$D = \frac{k\lambda}{\beta Cos\,\theta} \quad (3)$$

Here; expressed in terms of crystal size *D*, wavelength of the X-ray source used λ, the half-maximum width of the diffraction peak in radians β, Bragg diffraction angle of the XRD peak θ and a constant related to the film whose crystallite size is calculated *k* [28].

Using equations (1) and (2), the distance between planes (d) and lattice constant (a) in thin film solar cells were calculated. The crystallite size was calculated using equation (3). These values calculated for S1 and S1_400 samples are delivered in Table 1. With the effect of annealing, it was determined that the crystallite size increased, that is, the films passed from the amorphous structure to the polycrystalline structure. The crystallite size comparisons given in Table 1 and obtained from the SEM images in Figure 2 together with the XRD scattering crystallite size calculations show compatibility. Calculations of inter-planar distance (d), lattice constant (a) [29] are similar to the ones they have done.

Table 1. Calculations for S1 and S1_400 samples

	S1				**S1_400**			
hkl	2θ (deg)	*d* (Å)	*a* (Å)	*D* (nm)	2θ (deg)	*d* (Å)	*a* (Å)	*D* (nm)
(111)	23,95	3,711	6,427	31,41	23,93	3,715	6,435	49,89
(200)	26,68	3,337	6,674	34,11	26,65	3,340	6,681	42,63
(211)	33,05	2,707	6,631	29,84	33,09	2,703	6,623	36,06

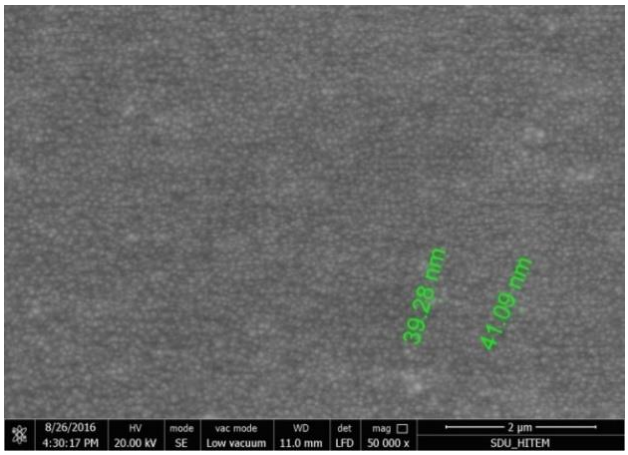

Figure 2. The crystallite size obtained in SEM images

3.2. Compositional and surface topographical analysis

Thin film solar cells are produced using ITO coated glass as substrate, In-doped CdTe as the lower film material and CdS (powder) materials as the upper film material. These solar cells were production by thermal evaporation. In Figure 3, energy dispersive X-ray spectroscopy (EDS) plots are given in Figure 4 and Figure 5 for SEM images of annealed and non-annealed solar cells with the aim of determining the surface morphology of the materials. When Figure 3 is examined, it is seen that the surface roughness of the annealed film decreases and clumping occurs. The crystallite size of films is generally known to depend on film thickness, surface temperature and annealing temperature. The resulting crystallite

size is lower microns in size. Chander and Dhaka (2016) have achieved similar results in their work [18]. In Figure 4 and Figure 5, while the increase in the annealing result Cd was observed in the lower films deposited by the thermal evaporation method, a decrease in the ratio of in and Te was detected.

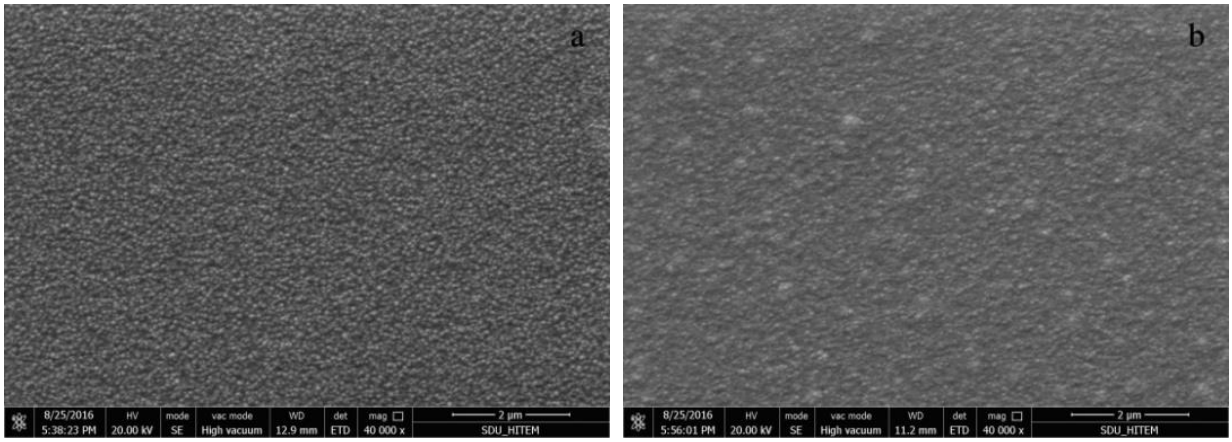

Figure 3. The SEM images of (a) S1 and (b) S1_400

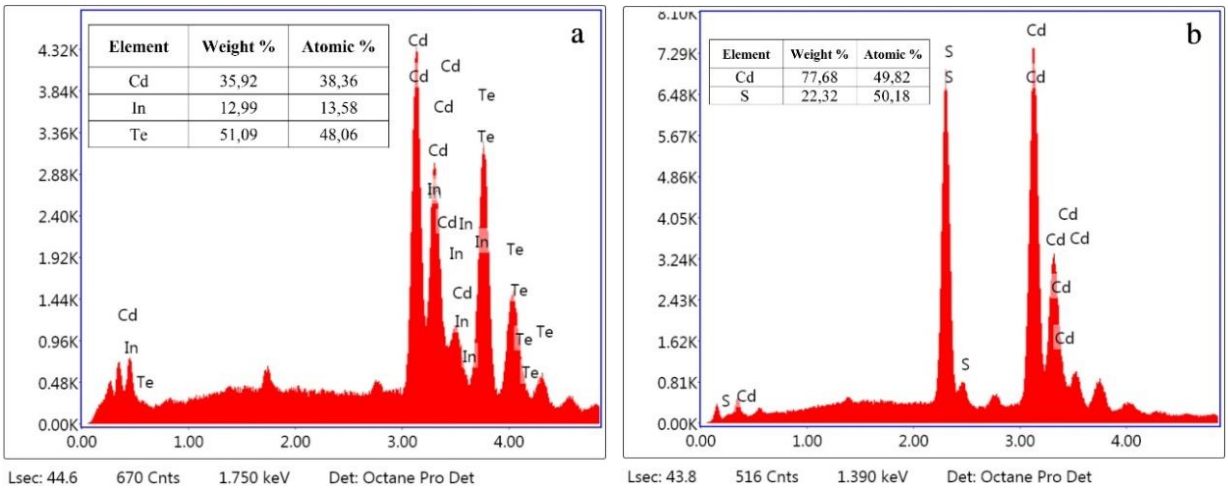

Figure 4. The typical energy dispersive spectrum (EDS) of S1 (a) In-Doped CdTe layer (b) CdS layer

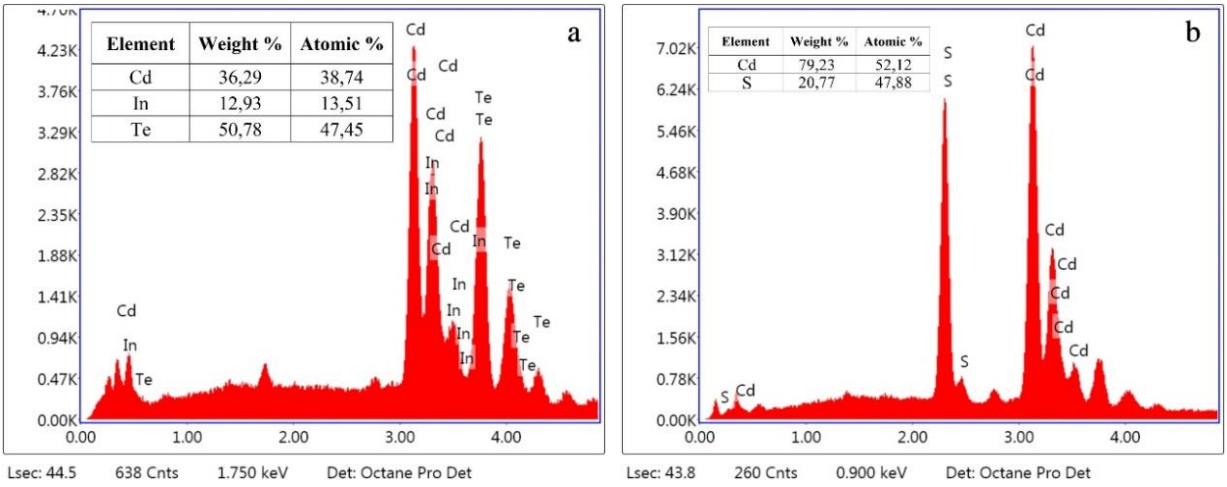

Figure 5. The typical energy dispersive spectrum (EDS) of S1_400 (a) In-Doped CdTe layer (b) CdS layer

4. Conclusion

The effect of annealing on the structural properties of In-doped CdTe/CdS thin film solar cells produced using the thermal evaporation method is investigated. $2\theta=23.9^{o}$, $2\theta=26.6^{o}$ and $2\theta=33.0^{o}$ peaks were observed after XRD scattering and the diffraction lines produced by these peaks corresponded to the (111), (200) and (211) structures respectively. As a result of annealing, these peak positions have not changed but their intensity has increased. This situation is interpreted as a decrease in structural defects. The crystallite size (D), the Inter-planar distance (d) and the lattice constant (a) calculations are similar to those in the literature. As a result of SEM analysis, annealing resulted in lumps in the film structure. From the calculated calculations and SEM images, it is seen that the crystallite size is below micron level. EDS analysis showed an increase in annealing result Cd, a decrease in In and Te ratio. As a result, it has been determined that annealing to the structural properties of In-doped CdTe/CdS solar cells produced by thermal evaporation effects positively.

Competing Interest / Conflict of Interest

"The authors declare that they have no conflict of interests"

Funding

This work was financially supported by the Scientific Research Projects Center (BAP) of Pamukkale University (project number: 2014FBE007).

Acknowledgment

SEM and EDS analysis were performed in the HITEM laboratory of Süleyman Demirel University. We declare that all Authors equally contribute.

5. References

[1] Tariq, G.H. and Anis-ur-Rehman, M., (2015). Annealing effects on physical properties of doped CdTe thin films for photovoltaic applications. Mater. Sci. Semicond. Process, 30: 665-671.

[2] Singh S., Kumar R. and Sood K.N., (2010). Structural and electrical studies of thermally evaporated nanostructured CdTe thin films. Thin Solid Films, 519: 1078-1081.

[3] Garadkar, K.M., Pawar, S.J., Hankare, P.P. and Patil, A.A., (2010). Effect of annealing on chemically deposited polycrystalline CdTe thin films. J. Alloys Compd., 491: 77-80.

[4] Lalitha, S., Karazhanov, S.Z., Ravindran, P., Senthilarasu, S., Sathyamoorthy, R. and Janabergenov, J., (2007). Electronic structure, structural and optical properties of thermally evaporated CdTe thin films. Phys. B Condens. Matter, 387: 227-238.

[5] Echendu, O.K., Dejene, B.F. and Dharmadasa, I.M., (2018). The effects of anode material type on the optoelectronic properties of electroplated CdTe thin films and the implications for photovoltaic application. J. Phys. Chem. Solids, 114: 100-108.

[6] Zia, R., Saleemi, F. and Nassem, S., (2016). Optical properties of thermally evaporated CdTe thin films by varyingsubstrate temperature. Opt. - Int. J. Light Electron Opt., 127: 1972-1974.

[7] Chander, S. and Dhaka, M.S., (2015). Physical properties of vacuum evaporated CdTe thin films with post-deposition thermal annealing. Phys. E Low-dimensional Syst. Nanostructures, 73: 35-39.

[8] Shenouda, A.Y., Rashad, M.M. and Chow, L., (2013). Synthesis, characterization and performance of $Cd_{1-x}In_xTe$ compound for solar cell applications. J. Alloys Compd., 563: 39-43.

[9] Kırbaş, İ. and Karabacak, R., (2016). Effect of annealing on the structural properties of thermal evaporated $CdIn_2Te_4$/CdS thin film solar cells. Optik - International Journal for Light and Electron Optics, 127: 7986-7992.

[10] Pandey, S.K., Tiwari, U., Raman, R., Prakash, C., Krishna, V., Dutta, V. and Zimik, K., (2005). Growth of cubic and hexagonal CdTe thin films by pulsed laser deposition. Thin Solid Films, 473: 54-57.

[11] Khairnar, U.P., Bhavsar, D.S., Vaidya, R.U. and Bhavsar G.P., (2003). Optical properties of thermally evaporated cadmium telluride thin films. Mater. Chem. Phys., 80: 421-427.

[12] Patil, V.B., More, P.D., Sutrave, D.S., Shahane, G.S., Mulik, R.N. and Deshmukh, L.P., (2000). A new process for deposition of the CdTe thin films. Mater. Chem. Phys., 65: 282-287.

[13] Yilmaz, K., Golcur, D., Ozcan, Y., Takanoglu, D. and Karabulut, O., (2017). Effect of Substrate Temperature on the Transport Mechanisms of Polycrystalline CdIn2Te4 Thin Films Grown by Thermal Evaporation. J. Ovonic Res., 13(2): 71-76.

[14] Li, H. and Liu, X., (2015). Improved performance of CdTe solar cells with CdS treatment. Sol. Energy, 115: 603-612.

[15] Han, J., Fu, G., Krishnakumar, V., Liao, C., Jaegermann, W. and Besland, M.P., (2013). Preparation and characterization of ZnS/CdS bi-layer for CdTe solar cell application. J. Phys. Chem. Solid, 74: 1879-1883.

[16] Rmili, A., Ouachtari, F., Bouaoud, A., Louardi, A., Chtouki, T., Elidrissi, B. and Erguig, H., (2013). Structural, optical and electrical properties of Ni-doped CdS thin films prepared by spray pyrolysis. J. Alloys Compd., 557: 53-59.

[17] Chavez, H., Jordan, M., McClure, J.C, Cush, G. and Singh, V.P., (1997). Physical and electrical characterization of CdS films deposited by vacuum evaporation solution growth and spray pyrolysis. J. Mater. Sci. Electron, 8: 151-154.

[18] Chander, S. and Dhaka, M.S., (2016). Impact of thermal annealing on physical properties of vacuum evaporated polycrystalline CdTe thin films for solar cell applications. Phys. E Low-dimensional Syst. Nanostructures, 80: 62-68.

[19] Shaaban, E.R., Afify, N. and El-Taher, A., (2009). Effect of film thickness on microstructure parameters and optical constants of CdTe thin films. J. Alloys Compd., 482: 400-404.

[20] Galloway, S.A., Edwards, P.R. and Durose, K., (1999). Characterization of thin film CdS/CdTe solar cells using electron and optical beam induced current. Sol. Energy Mater. Sol. Cells., 57: 61-74.

[21] Ganetsos T., Belas E. and Kotsos B., (2011). Electrical properties and Raman study of In-doped effects in CdTe. Procedia Eng., 25: 354-357.

[22] Belas, E., Grill, R., Franc, J., Hlidek, P., Linhart, V., Slavicek, T. and Höschl, P., (2008). Correlation of electrical and optical properties with charge collection efficiency of In-doped and In+Si co-doped CdTe. Nucl. Instruments Methods Phys. Res. Sect. A, 591: 200-202.

[23] Mohammed, W.F. and Yousif, M.A.S., (2002). The electrical properties of post-deposition annealed and as-deposited In-doped CdTe thin films. Renew. Energy, 26: 285-294.

[24] Seto, S., Suzuki, K., Abastillas, Jr V.N. and Inabe, K., (2000). Compensating related defects in In-doped bulk CdTe. J. Cryst. Growth, 214/215: 974-978.

[25] Kumar, S., Sharma, S.K., Sharma, T.P. and Husain, M., (2000). CdTe photovaltic sintered films. J. Phys. Chem. Solids, 61: 1809-1813.

[26] Rajendra, B.V. and Kekuda, D., (2012). Flexible cadmium telluride/cadmium sulphide thin film solar cells on mica substrate. J. Mater. Sci. Electron, 23: 1805-1808.

[27] Chander, S. and Dhaka, M.S., (2015). Optimization of physical properties of vacuum evaporated CdTe thin films with the application of thermal treatment for solar cells. Mater. Sci. Semicond. Process, 40: 708-712.
[28] El-Nahass, M.M., Youssef, G.M. and Noby, S.Z., (2014). Structural and optical characterization of CdTe quantum dots thin films. J. Alloys Compd., 604: 253-259.
[29] Freik, D., Parashchuk, T. and Volochanska, B., (2014). Thermodynamic parameters of CdTe crystals in the cubic phase. J. Cryst. Growth, 402: 90-93.

Kastamonu University
Journal of Engineering and Sciences
e-ISSN 2667-8209
http://dergipark.gov.tr/kastamonujes

Mapping with Unmanned Aerial Vehicles Systems: A Case Study of Nevsehir Haci Bektas Veli University Campus

Aslı Deniz *, [a], Şenay Güngör[b]

*, [a] *Department of Geography, Institute of Social Sciences, Hacı Bektaş Veli University, Nevsehir, Turkey*
e-mail: adeniz4250@gmail.com
ORCID ID: 0000-0002-4785-3014
[b] *Department of Geography, Faculty of Arts and Sciences, Hacı Bektaş Veli University, Nevsehir, Turkey*
e-mail: senaygungor@nevsehir.edu.tr
ORCID ID: 0000-0001-5453-5930

ARTICLE INFO

RESEARCH ARTICLE
Received: April:29.2020
Reviewed: May:5.2020
Accepted: May:23.2020

Keywords:
Nevsehir,
Campus,
UAV,
GIS.

Corresponding Author:
*E-mail: adeniz4250@gmail.com

ABSTRACT

Today, remote sensing techniques are one of the most frequently used working methods in planning and design studies. Especially thanks to the data produced by photogrammetry with the help of UAV, it is frequently used in commercial and academic periods. Especially thanks to the advantages such as speed, cost, and accuracy provided by UAV, high-resolution data of smaller areas can be obtained. Thanks to these data, orthophoto images and Digital Elevation Model (DEM) data of the land can be produced. The Orthophoto and Digital Elevation Model (DEM) contributes to the creation of many digital bases as it transfers the land to the spatial environment. In this study, aerial photographs of Nevsehir Haci Bektas Veli University Damat İbrahim Pasha Campus were taken with UAV. These photographs produced orthophoto and Digital Elevation Model (DEM) images with a spatial resolution of 2.31 cm using 3D Survey software. The mesh model created after processing the products obtained from the UAV of the campus area was published on the internet address (https://cbs-uzam.nevsehir.edu.tr/tr/projeler).

Anahtar Kelimeler:
Nevşehir,
Kampüs,
İHA,
CBS

ÖZ

Günümüzde planlama ve tasarım çalışmalarında uzaktan algılama teknikleri sıklıkla başvurulan çalışma yöntemlerinin başında gelmektedir. Özellikle İHA yardımıyla fotogrametri ile üretilen veriler sayesinde ticari ve akademik son dönemlerde sık sık kullanılmaktadır. Özellikle İHA'nın sağladığı hız, maliyet ve doğruluk gibi avantajları sayesinde daha küçük alanlara ait yüksek çözünürlüklü veri elde edilebilmektedir. Bu veriler sayesinde araziye ait Ortofoto görüntüleri ve Sayısal Yükseklik Modeli (DEM) verileri üretilebilmektedir. Ortofoto ve Sayısal Yükseklik modeli (DEM) araziyi uzamsal ortama aktardığı için birçok sayısal altlıkların oluşturulmasına katkı sağlamaktadır. Bu çalışmada, Nevşehir Hacı Bektaş Veli Üniversitesi Damat İbrahim Paşa Yerleşkesi hava fotoğrafları İHA ile çekilmiştir. Bu fotoğraflar 3DSurvey yazılımı kullanılarak 2,31 cm mekânsal çözünürlükte Ortofoto ve Sayısal Yükseklik Modeli (DEM) görüntüleri üretilmiştir. Kampüs alanına ait İHA'dan elde edilen ürünler işlendikten sonra oluşturulan mesh model model https://cbs-uzam.nevsehir.edu.tr/tr/projeler internet adresinde yayınlanmıştır.

1. Introduction

Nowadays, the use of different data produced from images obtained by unmanned aerial vehicles in which the cameras are integrated into the map, planning, and design studies has increased a lot. UAVs have been widely used in different working groups due to the many advantages they provide such as speed, cost, and accuracy. The studies

carried out with the help of UAV approach the sensitivity in terrestrial photogrammetry and have the opportunity to be applied in many different areas to complete the studies in a short time [1]. It is used extensively for mapping and 3D land modeling for commercial purposes and scientific studies after military applications [2]. The use of such tools is geography, landscape, cartography, etc. brings many advantages in its fields.

In this study, an Orthophoto and Digital Elevation Model (DEM) application for Nevsehir Haci Bektas Veli University Damat İbrahim Pasha Campus was discussed in detail. The data obtained from the land in this way will constitute a basis for the projects to be used later. The purpose of this modeling is the project work to be carried out for the Damat İbrahim Pasha Campus Information System to collect, transfer, store, analyze and present the information of the university in the desired manner.

Today, one of the main problems of public institutions is that information cannot be easily accessed at any time. Since the existing information does not have a regular structure, it cannot be archived systematically. Besides, generating new information from the information available in the archive and having healthy information is the most demanded by today's institutions. Such requests are important for university institutions as well as many public institutions [3].

Nevsehir Haci Bektas Veli University Damat İbrahim Pasha Campus is one of the most important reasons for the establishment of the Campus Information System is the absence of digital map bases showing the physical condition of the campus. Digital maps of the campus are provided with the created orthophoto and 3D modeling. Also, landscape arrangements and designs can be made quickly and easily thanks to these bases.

1.1. Unmanned Aerial Vehicles

Unmanned Aerial Vehicles are defined as a motor aircraft that does not have many vehicles and pilots on it [2]. The control mechanism of UAVs consists of remote, semi-automatic, automatic, or a combination of several of them. When the UAVs are compared with other aircraft, the most important difference is the absence of a pilot physically in UAVs. [4]. UAVs are one of the most important technologies in many aviation applications, especially civilian and military purposes and applications, due to their low performance. UAVs have a short wingspan (fixed or rotary wing) and a light structure, as well as a sensitive structure during flight [5]. It is very easy to operate and produce. Many of them are a vehicle that can be used by one or two people and can be transported by hand and can be launched from the land by hand. UAVs are designed to fly from a low height to observe objects in the field. However, flying from a very low height increases the probability of a UAV crash. Therefore, strong and accurate autopilot systems are needed to increase the performance at low heights. [6].

UAVs can be integrated with various imaging devices with sensors such as thermal, infra-red, hyperspectral, radar, chemical, and biological and provide day and night images. Along with the real-time data transfer feature, UAVs can transfer important information such as fire, flood, and weather conditions to the ground station. [7]. With the real-time GPS integrated on UAVs, it can work with the ground control station to observe and be guided by the images it collects, so systems that operate in this way are also called fully automatic navigation systems. The image obtained can be processed in the laboratory or at the ground control station immediately. UAVs can record all their actions and forward them to ground control points for image processing. [8]. UAVs for photogrammetric purposes can take photographs in three-dimensional spatial positions planned previously independently, but experienced pilots are needed for takeoff and landing by the flight plan [9]. A multi-rotary UAV, which is frequently used in photogrammetry studies, can be seen in Figure 1.

Figure 1: AtmacaX8 UAV with rotary-wing sold by Geomatics Group (URL-1)

Although UAVs have many advantages, they also have disadvantages. These; Since they can carry limited loads, it is possible to list them as being insufficient in applications involving large areas, having low airtime, limited opportunities to apply in windy weather, and problems in landing, take-off, and flight stages.

2. Material and Method

The material and methodology used during the study are described below.

2.1. Data Production with UAV

Commercial software developed today has its algorithms to perform internal and external orientation processes, which are the main stages of photogrammetric map production. UAV images are directed by geometrically corrected with a high success rate [10]. The workflow for evaluating images using computer vision-based software is shown in Figure 2.

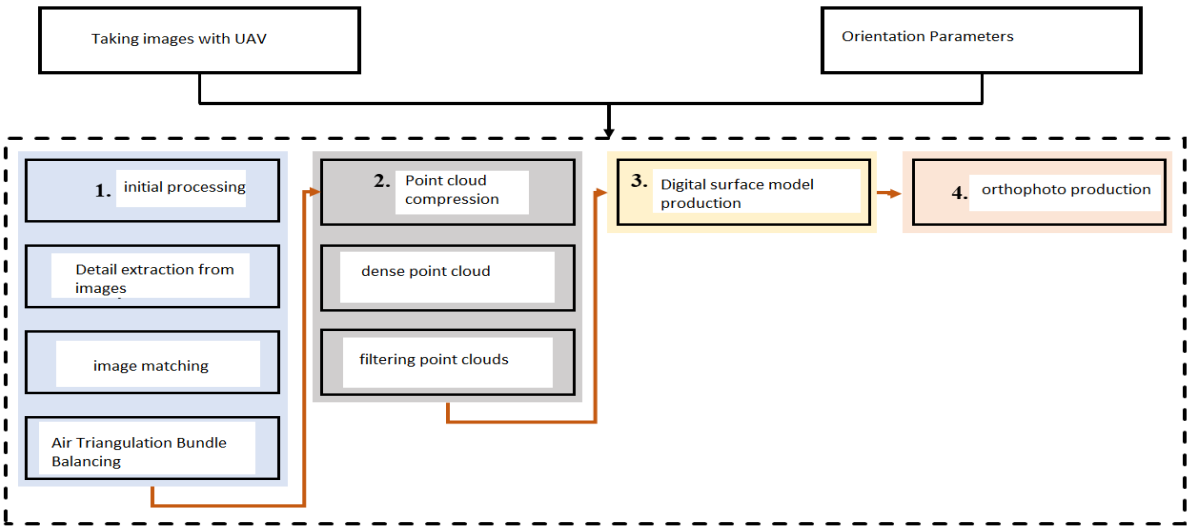

Figure 2: Evaluation of Computer Vision-Based Images [10].

Nevsehir Haci Bektas Veli University Damat İbrahim Pasha Campus has been flying with a DJI Phantom brand unmanned aerial vehicle. After the flight process, 474 aerial photographs were transferred into the 3D Survey 2.10 software and processing started. (Figure 3).

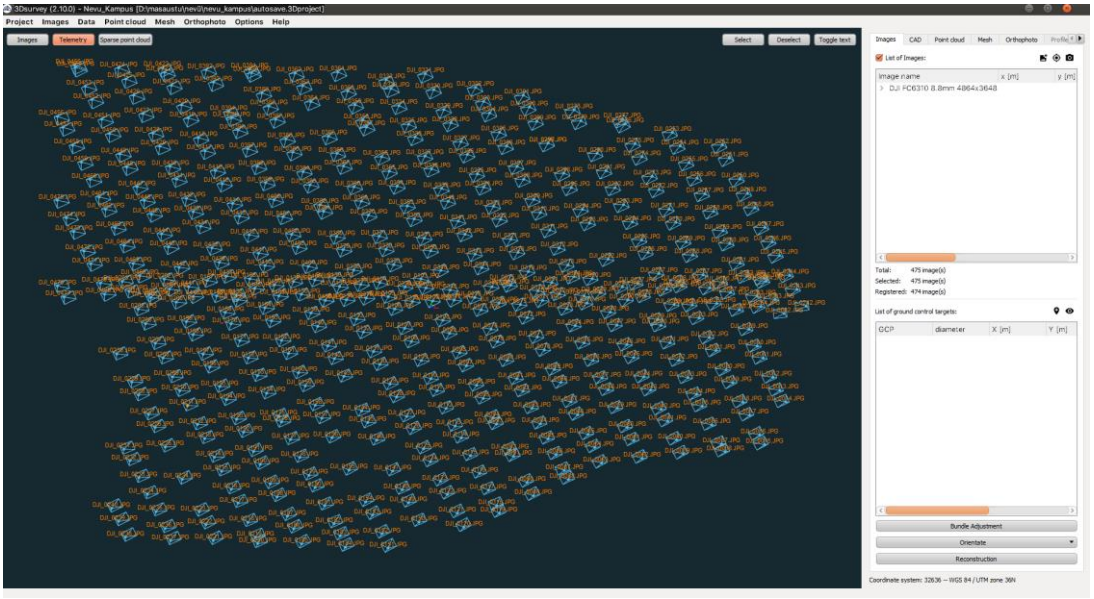

Figure 3: Uploading images to 3D Survey 2.10 software

After the pictures are loaded, the coordinate correction is completed by matching the photographs. After this process, point cloud and digital surface model (DSM) and the mesh model were created with the tools in the program, respectively. Point cloud data consists of 27635264 points in total. With the 3D Survey software, the orthophoto of the work area was produced at 2.31 cm spatial resolution. (Figure 4).

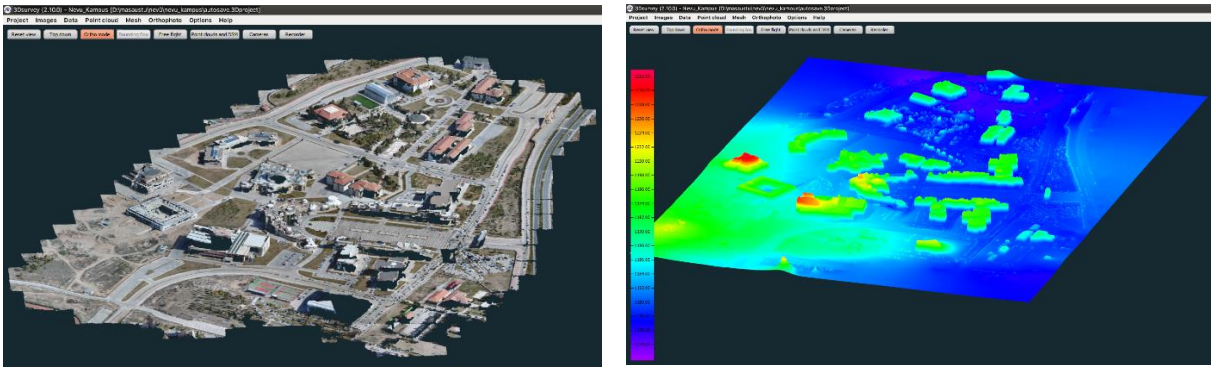

Figure 4: Point cloud and surface model

With the 3D Survey software, the orthophoto of the work area was produced at 2.31 cm spatial resolution. (Figure 5).

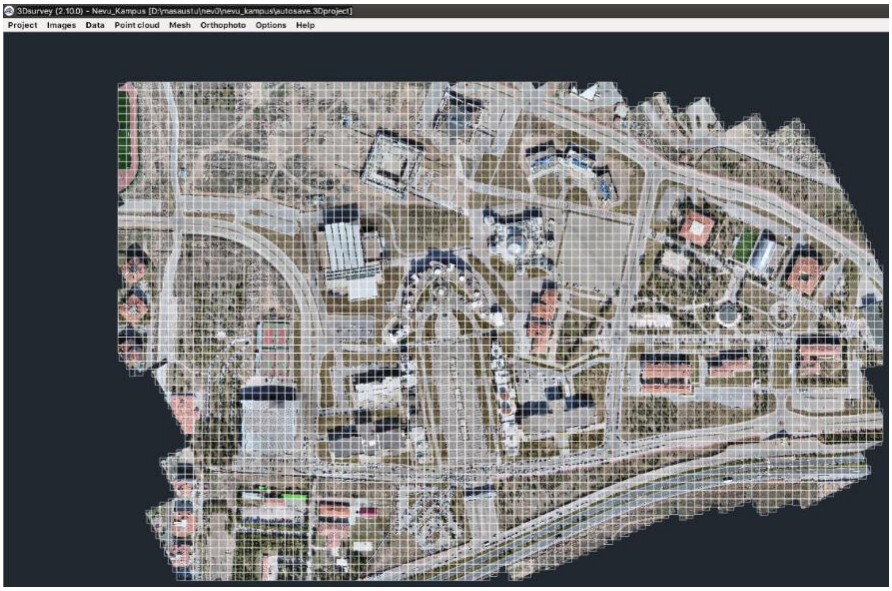

Figure 5. Orthophoto produced

3. Results

The study area is Nevsehir Haci Bektasi Veli University Campus is shown in Figure 6.

Figure 6. Study Area

After the products obtained from the UAV of the campus area were processed, the mesh model created was recorded to be published on the internet. The created model has been published on the website https://cbs-uzam.nevsehir.edu.tr/tr/projeler.

3. Conclusions and Suggestions

Today, there are still lands that are difficult to navigate. UAV systems can be used easily in making maps of these areas. In addition to this advantage, UAVs can be used by geologists in studies for three-dimensional data production due to the rapid data production technique. UAV systems can be easily used in works to gain profit from components such as fast data production and time cost.

Competing Interest / Conflict of Interest

The authors declare that they no conflict of interest. The none of the authors have any competing interests in the manuscript.

Funding

There is no financial support and commercial support.

Acknowledgements

We declare that all Authors equally contribute.

4. References

[1] Eisenbeiss, H., (2009). UAV photogrammetry, Zurıch: Eth Zurıch.
[2] Yılmaz, H. M., Mutluoğlu, Ö., Ulvi, A., Yaman, A., & Bilgilioğlu, S. S., (2018). Orthophoto Production with Unmanned Aerial Vehicle and Aksaray University Campus Example, Geomatik Journal, 130.
[3] Tıryakıoğlu, I. & Erdoğan, S. (2004). Afyon Kocatepe University Campus Information System, Istanbul: 3rd Geographic Information Systems Information Days.
[4] Eisenbeiss, H. (2004). A Mını Unmanned Aerıal Vehıcle (Uav): System Overvıew And Image Acquısıtıon, Processıng And Vısualızatıon Usıng Hıgh-Resolutıon Imagery.
[5] Jung, S. (2004). Design and Development of A Micro Air Vehicle (MAV): Test-Bed For Vision-Based Control, Abstract of Thesis Presented to the Graduate School of theUniversity of Florida in Partial Fulfillment of the Requirements for the Degree of Master of Science.
[6] Chao, H., Cao, Y., & Chen, Y. (2010). Autopilots for Small Unmanned Aerial Vehicles: A Survey, International Journal of Control, Automation, and Systems, 36-44.
[7] Rawat K. S. & Lawrence, E. E. (2014). A mini-UAV VTOL Platform for Surveying Applications, International Journal of Robotics and Automation, 259-267.
[8] Samad, A. M., Kamarulzaman, N., Hamdani, M. A., Mastor T. A. &. Hashim, A. K. (2013). The Potential of Unmanned Aerial Vehicle (UAV), içinde 2013 IEEE 3rd International Conference on System Engineering and Technology, Malaysia.
[9] Graça N., Mitishita, E. & Gonçalves, J. (2014). Photogrammetrıc Mappıng Usıng Unmanned Aerıal Vehıcle, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences.
[10] Bhandari, B., Oli, U., Panta N. & Pudasaini, U. (2015). Generation of High-Resolution DSM Using UAV Images, içinde FIG Working Week 2015, Sofia.
[11] URL 1: 03 04 2020. [Online]. Available: http://www.geomaticsgroup.com/urunler/atmaca-x8 Access Date: 03.04.2020.

Kastamonu University
Journal of Engineering and Sciences
e-ISSN 2667-8209
http://dergipark.gov.tr/kastamonujes

Per Capita Solid Waste Generation and Characterization in Makurdi Metropolis, Nigeria

Oloche robert Ekwule *, [a], Okechukwu emmanuel Nwafor [b], Martins isaac Ufedo [c]

[a] *Department of Civil Engineering, College of Engineering, Federal University of Agriculture, Makurdi, Nigeria*
e-mail: ekwule.robert.uam@gmail.com
ORCID ID: 0000-0002-4835-3951
[b] *Department of Civil Engineering, College of Engineering, Federal University of Agriculture, Makurdi, Nigeria*
e-mail: engineerokeb@gmail.com
ORCID ID: 0000-0002-5177-4941
[c] *Department of Civil Engineering, College of Engineering, Federal University of Agriculture, Makurdi, Nigeria*
e-mail: ufedomartins111@gmail.com
ORCID ID: 0000-0001-9181-6432

ARTICLE INFO

RESEARCH ARTICLE
Received: May: 11.2020
Reviewed: May: 18.2020
Accepted: June: 9. 2020

Keywords:
Solid waste,
Per capita waste generation,
Characterization,
Makurdi.

Corresponding Author:
E-mail: ekwule.robert.uam@gmail.com

ABSTRACT

This study is aimed at ascertaining the per capita generation and characterization of waste in Makurdi metropolis. The study population consists of all the residents in the households of the selected study areas. Sample sizes of 60 households were selected purposively from three (3) residential areas in Makurdi metropolis which includes Wadata (low income areas), High Level (medium income areas), and Judges Quarters (high income areas). Field observations, secondary data and key informant interviews were also used. Simple random sampling and analysis of solid waste from specific sources (Households) was used for waste characterization whereas house-to-house weight analysis method was used to quantify the waste. The solid waste generation rate in the areas which the survey was conducted revealed that a total sample waste load of 1185.95 Kg was weighed for the three areas. From the analysis of the primary data gathered on the samples of solid waste generated, the order of waste generated is as follows; organic waste (81.30 %) > ash/sand (5.86 %) > Paper (2.78 %) > Metal/Tin (2.03 %) > Bag/Shoes (1.84 %) > Leather (1.74 %) > textiles (1.47 %) > Plastic (1.24 %) > glass/ceramics (0.41 %). The average per capita generation rate was also estimated to be 0.45 kg/ capita/ day with an average household size of 6 persons.

Anahtar Kelimeler:
Katı atık,
Kişi başı atık üretimi,
Karakterizasyon,
Makurdi.

ÖZ

Bu çalışmada Makurdi metropolünde kişi başına atık üretimi ve karakterizasyonu amaçlanmıştır. Çalışma popülasyonu, seçilen çalışma alanlarındaki hanelerde yaşayan tüm sakinlerden oluşmaktadır. Makurdi metropolündeki Wadata (düşük gelirli alanlar), High Level (orta gelirli alanlar) ve Judges Quarters 'ı (yüksek gelirli alanlar) içeren üç (3) yerleşim alanından 60 hane örneklem büyüklüğü seçilmiştir. Saha gözlemleri, ikincil veriler ve kilit bilgi verici görüşmeler de kullanılmıştır. Atıkların karakterizasyonu için basit rastgele örnekleme ve belirli kaynaklardan (hane halkı) gelen katı atık analizi kullanılırken, atıkları ölçmek için evden eve ağırlık analizi yöntemi kullanılmıştır. Anketin gerçekleştirildiği alanlardaki katı atık üretim oranı, üç alan için toplam 1185,95 Kg örnek atık yükünün tartıldığını ortaya koymuştur. Üretilen katı atık örnekleri üzerinde toplanan birincil verilerin analizine göre, üretilen atıkların sırası şu şekildedir; organik atık (% 81.30) > kül / kum (% 5.86) > Kağıt (% 2.78) > Metal / Kalay (% 2.03) > Çanta / Ayakkabı (% 1.84) > Deri (% 1.74) > tekstil (% 1.47) > Plastik (% 1.24) > cam / seramik (% 0.41). Kişi

başına ortalama üretim oranının da, ortalama 6 kişi hanehalkı büyüklüğü ile 0.45 kg / kişi / gün olduğu tahmin edilmektedir.

1. Introduction

It is obvious that many cities in Nigeria have developed over time without proper planning, thus, resulting to the presence of open/indiscriminate dumping of solid waste especially on undeveloped areas [1]. The problem of solid waste generation and management is a global phenomenon that is not just peculiar to Nigeria alone but cuts across the entire universe [2]. This problem is such that it has forced the adoption of frameworks that can effectively handle waste especially in developed countries of the world. According to Giusti [3] the practices of solid waste management may not be uniform across countries (i.e. both developed and developing). However, some very advanced frameworks that enhance solid waste management practices include the waste hierarchy, which is the 3Rs of waste management; Reduce, Reuse and Recycle have been adopted. In this practice, waste characterization is dependent on their desirability in terms of waste minimization.

Municipal solid waste management is considered a complex concept because it often affects the lifestyle of the people together with factors such as rapid development and under-estimated contributors and stakeholders [4]. According to Kum et al. [5], most urban settlements are not without waste generation and they are generated from residential, commercial, industrial, and institutional areas. A high proportion of these wastes are solid in nature. Municipal solid waste (MSW) consists of degradable items such as paper, textiles, food waste, straw and yard waste, partially degradable items such as wood, disposable napkins and sludge, sanitary residues and non-degradable items such as leather, plastics, rubbers, metals, glass, ash from fuel burning like coal, briquettes or woods, dust and electronic waste [6]. These wastes are produced from the economic activities and consumption patterns in a particular locality. The amount and characterization of these wastes vary from place to place and mostly influenced by the population density and level of income. For instance, industrialized countries are expected to generate higher amount of waste, while low-income countries with lesser commercial activities are expected to produce lower waste [5].

UNU-WIDER in 2010 [7], opinionated that organic fractions of municipal solid waste (OFMSW) generated in developing countries is about three times what is generated in developed countries. For us in this part of the world (i.e. Nigeria), OFMSW constitute up to 50 percent of solid waste generated. On a general note, the component of municipal solid waste is considered to be dependent on factors such as source and age of the waste characterized. In Nigeria today, the most seen solid waste sample can be obtained directly from source namely: households, offices, market stores and stalls. This study is aimed at obtaining the quantity of waste generation per head in Makurdi metropolis.

2. Material and Method

2.1. Area of Study

Makurdi is the capital of Benue State which is located along River Benue with coordinates 70.43’50”N and 80.32’10”E having an estimated population of over 600,000 as at 2006 [8] and still growing. It has an Average annual temperature of about 31°C and relative humidity of 66% annually. The town is divided by River Benue into North and South banks, which are connected by two bridges (Old and New brigde). The southern part of the town is made up of several wards which includes the Old GRA, Ankpa Ward, Wadata Ward, High Level, Wurukum (Low Level), New GRA, etc.

2.2. Population of the study

The study population consisted of all the residents in the households of the selected study areas. Sample sizes of 60 households were selected purposively from the three (3) residential areas of Makurdi metropolis which includes Wadata (low income areas), High Level (medium income areas), and Judges Quarters (high income areas).

2.3. Data collection technique

Data collection was initiated by informing selected households of the aim of carrying out such a study and to receive feedback on their willingness to participate in the study. Copies of the prepared questionnaires were administered to them in order to meet the objectives of the study. It was explained to the various residents in the selected households in the three (3) study areas selected for the research that on a daily basis, their garbage would be collected for a period of 7 days. On that basis, trash bags were provided for each household in the study areas in order t allow for collection of all

their solid waste products generated within the period of the study. And the samples were collected at the end of the week and given a label according to the perception of the income levels of the households, i.e. High, Middle and Low.

2.4. Data Analysis

The weekly waste collected from the various households across the study areas were moved to the laboratory, after which analysis was carried on the weights of each trash bags as well as the characterization of the wastes. In other words, the wastes were sorted into specified categories, which were then bagged, weighed, and recorded. The data gathered for each household was analyzed, using the weighted average technique. And a composition table was drawn, showing the percentage generation rate, as well as the rate in Kilogram generated per household. Charts were also presented to show the analysis on the composition of solid waste generated within the study period as well as the population of the generators. The data was analyzed by Microsoft excel software. The raw data was inputted into the software and related charts were generated.

3. Result and Discussion

3.1. Combined Composition of Waste Generated for the selected Zones

It is usual for municipal solid waste to be characterized by materials such as, paper and paperboard, yard trimmings, food scraps, plastics, furniture, and clothing [9]. Thus, the municipal solid waste (MSW) collected in the study was analyzed. The municipal solid waste generated was because of items used and thrown away by the generators. A total sample waste load by weight of 1185.95 Kg was weighed. The details regarding the overall composition of household solid waste sampled over the study period for the three selected communities is presented in Table 1.

Table 1. Overall composition of waste generated

WASTE COMPOSITION	WASTE GENERATED (KG)	WASTE GENERATED (%)
Paper	32.96	2.78
Plastic	14.71	1.24
Leather	20.59	1.74
Ashes/Sand	69.48	5.86
Textile	17.4	1.47
Glass	4.82	0.41
Bag/Shoes	21.76	1.84
Food/Kitchen Waste	964.16	81.30
Poultry Waste	16	1.35
Metal/Tin	24.04	2.03
TOTAL	**1185.9 kg**	**100%**

From the analysis of the primary data gathered on the samples of solid waste generated, the order of waste generated is as follows; organic waste (81.30 %) > ash/sand (5.86 %) > Paper (2.78 %) > Metal/Tin (2.03 %) > Bag/Shoes (1.84 %) > Leather (1.74 %) > textiles (1.47 %) > Plastic (1.24 %) > glass/ceramics (0.41 %). The chart showing the percentage composition generated for the three communities is presented in Figure 1.

3.2. Composition of Waste Generated for the selected Zones

Raw data was collected from different socioeconomic class which includes low, middle and high income earners

within the selected residential areas in the municipality. The composition of waste generated at the different zones is presented in Table 2.

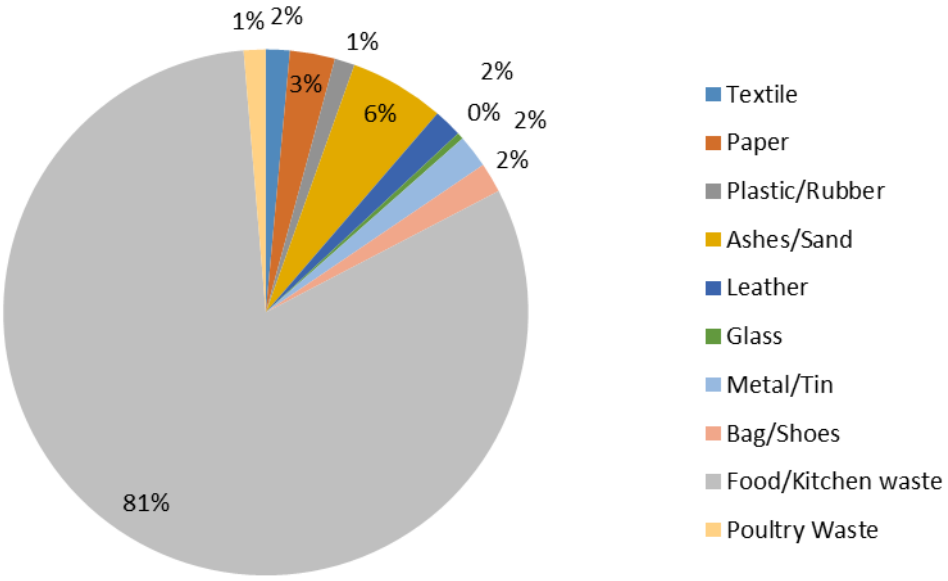

Figure 1. Composition of Municipal Solid Waste

Table 2. Composition of waste generated by the different zones

Waste Composition	Low Income Earners	Middle Income Earners	High Income Earners
Paper	5.96	18	9
Plastic	2.1	6.41	6.2
Leather	5.99	6.1	8.5
Ashes/Sand	24.68	22.2	22.6
Textile	3.6	2.4	11.4
Glass	0	4.82	0
Bag/Shoes	0	6.4	15.36
Food/Kitchen Waste	402.55	260.6	301
Poultry Waste	0	0	16

Metal/Tin	1.6	10.2	12.24
TOTAL	446.48 Kg	337.13 Kg	402.3 Kg

Wadata Community (low income): Wadata was classified under low income residential area in the municipality with sampled total household size of 112 and total waste generation of 446.48 Kg from a sample size of 20 households. The per capita waste generation rate for the low income earning residential area was 0.569 Kg / person / day and an average household size of 5 persons.

High Level (middle-income): High level was classified under middle income earners residential area. It had sampled total household size of 102 and total waste generation of 337.13 Kg from sampled size of 20 households. The per capita waste generation rate was 0.430 Kg / person / day and an average household size of 5 persons.

Judges Quarters (high income): Judges Quarter was classified as a high-income earners residential area. It had a total household size of 115 and total waste generation of 402.3 Kg from a sample size of 20 households. The waste generation rate of this residential area was 0.5178 Kg / person / day with an average household size of 6 persons. The average per capita waste being generated in the study area is estimated to be 0.45 kg/capita/ day. Authors such as Samuel et al. [10] hinted that the per capita waste generation for different cities in Nigeria such as Lagos (0.63 kg/ capita/ day), Kano (0.56 kg/ capita/ day), Ibadan (0.51 kg/ capita/ day), Kaduna (0.58 kg/ capita/ day), Port Harcourt (0.60 kg/capita/day), Onisha (0.53 kg/capita/day), Nsukka (0.44 kg/capita/day) and Abuja (0.66 kg/capita/day) have been obtained. Solomon [11] quoted 0.49 kg/capita/day for average Nigerian communities with household and commercial centers. Therefore, the per capita generation rate as revealed in the study is 0.45kg/capita/ day and is in line with previous studies. Figure 2 shows the population densities of the selected zones as well as their generation rates.

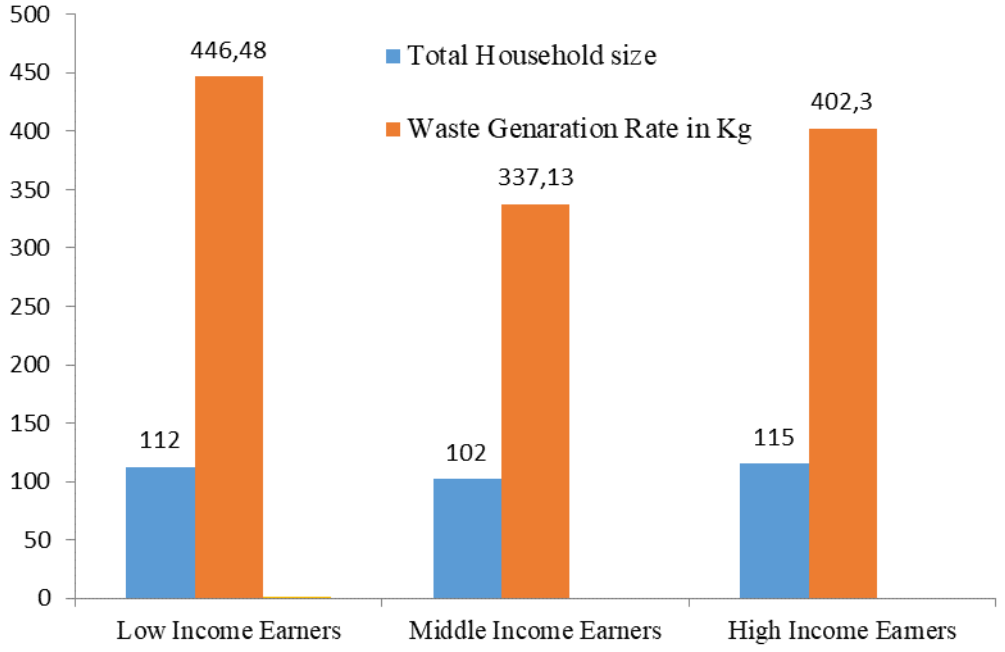

Figure 2. Population Density for selected Zones and their waste generated

The population densities for the three zones and their solid wastes generated is present in Figure 2. This study reveals that population density of a particular municipal area can greatly influence waste generation rate as this is seen by the estimated fractions of household waste generated from the three different locations. The middle income earners

residential area (High Level) and the High income Earners residential area (Judges Quarter) was estimated to have generated the lowest amount of solid waste, while the low income earners residential area (Wadata), generated the highest amount of solid waste. This trend is undoubtedly influenced by income and the socio economic activity and population density.

3.3. Percentage composition of waste collected from the selected zones

The Table below (i.e. Table 4.3) shows the percentage of solid waste generation rates for each of the selected zones. The constituents of these solid wastes are mostly organic solid waste and hazardous waste in different quantities. And the highest percentage of solid waste constituents is Food/Kitchen waste. High Income Earners consumes more of packed products of which give rise to a higher percentage of non-Biodegradables (inorganic materials) like metals, glass/ceramics, and plastics as higher percentage of inorganic materials were influenced by their income rate.

Table 3. Composition of waste generation of the zones in percentage

WASTE COMPOSITION	LOW INCOME EARNERS	MIDDLE INCOME EARNERS	HIGH INCOME EARNERS
Paper	1.34	5.34	2.24
Plastic	0.47	1.90	1.54
Leather	1.34	1.81	2.11
Ashes/Sand	5.53	6.59	5.62
Textile	0.81	0.71	2.83
Glass	0	1.43	0
Bag/Shoes	0	1.9	3.82
Food/Kitchen Waste	90.16	77.29	74.82
Poultry Waste	0	0	3.97
Metal/Tin	0.36	3.03	3.04
TOTAL	100%	100%	100%

3.5. Storage of Solid Waste in the Home

The study also revealed from the questionnaire distributed to the various households that there were variations in the temporary storage of solid waste at home, based on their socioeconomic status. Out of the 20 sampled households of the low-income earners 8 used polythene bags, 9 used broken buckets, and 3 used 120 liters plastic bin. Their solid wastes generated are usually dumped at a nearby heap of indiscriminate dumps. Most of the residents lived in rented apartments.

Ten (10) members of the middle-income class used small bins for waste storage as Ten (7) of them used rubber bucket without cover and three (3) members used polythene bags for waste storage. The wastes generated, are sometimes collected by mechanized trucks, and are dumped at designated points.

15 households of the high-income earners sampled used purposely manufactured large volume plastic bins of 240 liters in storing their solid waste and 5 households, 120 liters plastic bins. The compactor truck usually collects the

waste directly and empties them into their own trucks. Although the wastes generated are sometimes dumped at the refuse heap/dumps nearby. Most of the residents in this zone live in apartments owned by them.

4. Conclusion

This study has been able to evaluate the per capita waste generated in some selected zones within Makurdi metropolis. The findings from the study states thus: A total sample waste load of 1185.95 Kg was weighed for the three communities. From the computation of the primary data gathered on the sample solid waste, the ratio of the broad composition/characteristics of solid wastes generated shows that the dominant solid waste of the selected zones which the study was carried out is organic waste which accounts for 81.30%, followed by ash/sand with 5.86%, Paper with 2.78%, Metal/Tin with 2.03%, Bag/Shoes with 1.84%, Leather with 1.74%, textiles with 1.47%, Plastic with 1.24%, glass/ceramics with 0.41%. The average per capita generation rate was also estimated to be 0.45kg/capita/day for an average household size of 6 persons. Also, it was discovered that income generation level of households influences the quantum and type of waste generated.

Competing Interest / Conflict of Interest

"The authors declare that they have no conflict of interests"

Funding

There is no financial support and commercial support.

Acknowledgements

We declare that all Authors equally contribute.

5. References

[1] Amadi, A. N. Effects of urbanization on groundwater quality: A case study of Port-Harcourt, Southern Nigeria. Natur. Appl. Sci. J., 11(2), 143-152, 2010.

[2] Nnaji, C. C."Status of municipal solid waste generation and disposal in Nigeria", Management of Environmental Quality: An International Journal, 26(1): 53 – 71, 2015.

[3] Giusti, L. Review of Waste Management Practices and Their Impact on Human Health, Waste Management, 29(8); 2227-2239. doi:10.1016/j.wasman.2009.

[4] Arvind, K. JHA., Singh, S. K., Singh, G. P., and Prabhat, K. G. Sustainable Municipal Solid Waste Management in Low Income Group of Cities: A Review. Tropical Ecology, 52(1): 123 – 131, 2011.

[5] Kum V, Sharp A, Harnpornchai N. Improving the solid waste management in Phnom Penh city: a strategic approach. Waste Management 25(1): 101-109, 2005.

[6] Herat, S. Electronic waste: an emerging issue in MOEF. Hazardous Waste: Special Reference to Municipal Solid Waste Management. Electronic publication URL: http://envfor.nic.in/soer/2001/ind_ waste.pdf, 2009.

[7] Unu-Wider. “Solid wastes, poverty and the environment in developing country cities: challenges and opportunities”, Working Paper No. 2010/23, United Nations University World Institute for Development Economics Research, Helsinki, 2010.

[8] Nigeria National Population Commission. Population and housing Census Enumerator’s Manual. Federal Republic of Nigeria, Abuja, 2006.

[9] United Nations Environment Programme (UNEP). Converting Waste Plastics into Fuel: Report on Situation Analysis of Existing Solid Waste Management System for Bangkok Metropolitan Administration; International Environmental Technology Centre: Bangkok, Thailand, p. 40, 2009.

[10] Samuel, M. M., Davou, D. D., Juliet, D. D and Ruth, A. N. Environmental Hazards of Continued Solid Waste Generation and Poor Disposal in Municipal Areas of Nigeria. Journal of Geography, Environment and Earth Science International. 6 (3): 1 – 10, 2016.

[11] Solomon, U. U. The state of solid waste management in Nigeria. Wuhan, Hubei, Department of Environmental Engineering, China University of Geosciences, Wuhan, Hubei, 2009.

Kastamonu University
Journal of Engineering and Sciences
e-ISSN 2667-8209
http://dergipark.gov.tr/kastamonujes

Investigation of Experienced Air Pollution on Selected Pollutants Scale in Kırıkkale City (2018-2019)

Ercan Vural*, [a]

[a] *Department of Geography, Faculty of Science and Letters, Harran University, Şanlıurfa, Turkey*
e-mail: ercanvural@harran.edu.tr
ORCID ID: 0000-0002-7310-413X

ARTICLE INFO

RESEARCH ARTICLE
Received: May.17.2020
Reviewed: May.23.2020
Accepted: May.31.2020

Keywords:
Kırıkkale City,
Air Quality,
Sulfur Dioxide,
Particulate Matter,
Carbon Monoxide.

Corresponding Author:
E-mail: ercanvural@harran.edu.tr

ABSTRACT

The city of Kırıkkale, which gained importance with the industrial facilities established in the Republican period, began to receive immigration from the surrounding regions and beyond in the 1920s and 1930s. The everexpanding industrial facilities that were on the outskirts of the city at the time became part of the urban area as the city grew bigger. The city, trapped in a valley topographically, was developed in the east-west direction as it has a defective structure in the north and south. The density and severity of air pollution occurring in the low-lying city is high compared to its surroundings. The change in air pollution in the city of Kırıkkale between 2018 and 2019 was investigated based on the number of dwellings, population size and density, fuel type, industrial facility presence and traffic. This study is important because it is the most up to date of its kind. While the amount of SO_2 and PM10 was high in 2018, CO values increased in 2019 as well. The number of lost data is high in 2018 and 2019. The reasons for this include failure of the measuring devices due to the lack regular maintenance; power cuts…etc. In order to fully measure the air pollution and air quality of the city, measurement stations should be installed at different points, supported by mobile measurement tools, fossil fuel consumption without standard features should be reduced and people should be kept informed about air pollution values in certain parts of the city.

Anahtar Kelimeler:
Kırıkkale Şehri,
Hava Kalitesi,
Kükürt dioksit,
Partikül Madde,
Karbon monoksit.

ÖZ

Cumhuriyet döneminde kurulan sanayi tesisleri ile önemi artan Kırıkkale şehri 1920 ve 1930'lu yıllarda yakın ve uzak çevreden göç almaya başlamıştır. Artan göç ile nüfus miktarında da artış meydana gelmiş ve şehir plansız gelişme ile karşı karşıya kalmıştır. Kurulduğu dönemde şehir dışında kalan sanayi tesisleri zamanla şehir içinde kalmış ve ayrıca bu tesislere de yenileri eklenmiştir. Topografik olarak vadi içinde sıkışıp kalan şehir kuzeyi ve güneyi sorunlu bir yapıda olduğu için doğu-batı yönünde gelişme göstermiştir. Çevresine göre alçakta kalan şehirde oluşan hava kirliliğinin yoğunluğu ve şiddeti fazladır. Ayrıca şehrin gelişme yönünü etkileyen önemli meteorolojik faktörlerden olan rüzgârın doğu-batı yönünde esmesi ve çevrede bulunan yüksek alanları aşamaması kirli havanın şehir üzerinde kalmasında etkili olmaktadır. Bu çalışmada, 2018-2019 yılları arasında Kırıkkale şehrinde hava kirliliği açısından oluşan değişimler incelenmiştir. Güncel olması nedeniyle bu çalışma önem arz etmektedir. 2018'de SO_2 ve PM10 miktarı fazla iken 2019'de da CO değerleri artış göstermiştir. 2018 ve 2019'da kayıp veri sayısı fazladır. Bunun nedenleri arasında ölçüm cihazlarının arıza vermesi, bakımlarının zamanında yapılmaması, enerji kesintisi vb. durumların yer aldığı görülmektedir. Şehrin hava kirliliğinin ve hava kalitesinin tam anlamıyla ölçülebilmesi için farklı noktalara da ölçüm istasyonları kurulmalı, mobil

ölçüm araçları ile desteklenmeli, standart özelliği olmayan fosil yakıt tüketimi azaltılmalı ve anlık olarak insanlar şehrin belirli alanlarında hava kirliliği değerleri konusunda bilgilendirilmelidir.

1. Introduction

With the industrial revolution, the replacement of the people forces with the machines ensured the formation of industrial societies. People who migrated to cities had to make continuous production in order to raise the standards of development and living, thereby causing the environmental and human health problems, which are among the biggest problems of our age [1]. The most important of the environmental problems are those related to water, soil, and air. Air, which is the subject of our study, is an important factor that directly affects human health. In the best climatic conditions, people feel more dynamic and healthier in parameters such as humidity, temperature, wind, and precipitation [2]. Because a healthy person breathes approximately 16 kg of air per day [3], air pollution becomes critical for the human's wellbeing and can cause serious problems. Not only do these problems affect human, plant, and animal health, they can also cause deformation of soil and human structures. Air pollution is estimated to cause the death of 1 in 8 people globally for reasons ranging from heart disease, stroke, respiratory disease, and cancer. The World Health Organization (WHO) reported that in 2016, 91% of the world's population lived in areas where satisfactory air quality levels were not achieved [4]. According to a report released by the Chamber of Environmental Engineers Chamber of Turkey in 2018, 60 million people are exposed to polluted air.

There are two important reasons for air pollution in Turkey: urbanization and industrialization. Significant concentrations of air pollution grew during the breakthrough in urbanization and industrialization [5]. In cities with rapid urbanization, industrialization and high number of vehicles, air pollution levels are important. In Kocaeli, Zonguldak, Karabük, Kırıkkale, Gaziantep, Kayseri and Tekirdağ; and especially in Istanbul, Izmir and Ankara, the level of air pollution is above or very close to the limit values. The intensity of air pollution varies according to topographic and meteorological characteristics. The air pollution intensity and severity differ in areas topographically in the pit or high, and in areas with meteorologically stable or unstable weather conditions.

Kırıkkale is situated in the Central Anatolia Region; it is surrounded by high areas where the valley floor of the Central Kızılırmak section expands. In 1989, the winner of Kirikkale province status, are known for their industry during the Republican period established in the context of industrial facilities in Turkey. Air pollution conditions were examined in Kırıkkale, which is a dense field in terms of industry, where factories affiliated with MKEK in 1920s and TÜPRAŞ refinery were established in 1960s. The aim of our study is to evaluate and compare the amount of air pollution experienced in Kırıkkale in 2018-2019, the amount of pollutants originating from point (residential), areal (factory) and linear (traffic or vehicle) and to propose solutions to the problems that arise as a result of these comparisons.

2. Materials and Methods

Some selected air pollutants data of 2018-2019 of Kırıkkale city were used. Sulfur dioxide (SO_2), particulate matter 10 (PM10) and carbon monoxide (CO) values, which are major air pollution contributors in the area, were examined and explained in tables and graphics. It has also been compared with the limit values under Turkey Air Quality Assessment and Management Regulations. These limit values are 125 µg / m³ for 24 hours in SO_2, 50 µg / m³ for 24 hours in PM10, and 10,000 µg / m³ for 8 hours in maximum. The data of the study were obtained from the reports of the Ministry of Environment and Urbanization Air Quality Monitoring stations. The data provided were calculated as monthly, yearly, and seasonal averages, a 24-hour average for SO_2 and PM10 values, and a maximum of 8 hours for CO.

3. Results

Kırıkkale city is located in the Central Kızılırmak section of the Central Anatolia Region that is home to Turkey's longest river, especially in the north and south of the Red River tributary of the creek valley Çoraköz Kırıkkale. It's located in the area where the expansion is converted with high space (Figure 1). The fact that the valley is in the pit area where it expands and its north and south are surrounded by high areas causes the intensity and severity of air pollution and adds complications towards dissipating the existing pollution.

In terms of climate characteristics, Kırıkkale city is in the temperate climate zone. The terrestrial climate characteristics seen in the Central Anatolia Region are also observed in the city. For this reason, winters are cold and

rainy, and summers are hot and dry [6]. Winters are very cold in the city, as the average height of the city of Kırıkkale is approximately 700 m and the continental climate prevails. Therefore, the need to warm up in winters is high. The average annual temperature in Kırıkkale was 12.6 ° C, the highest temperature was measured at 31 ° C in July and the lowest at 2.9 ° C in January [7]. Temperature values fall below 0 ° C in the city in December, January, and February.

Another meteorological factor that plays a role in the severity of air pollution is the frequency of wind blow and the dominant wind direction. The direction depending on the maximum number of winds blows throughout the year in the city of Kırıkkale is NW-E-SW and W, respectively [8]. Since the city is located at the base of the valley in the east-west direction morphologically, the wind is channeled in the east-west direction.

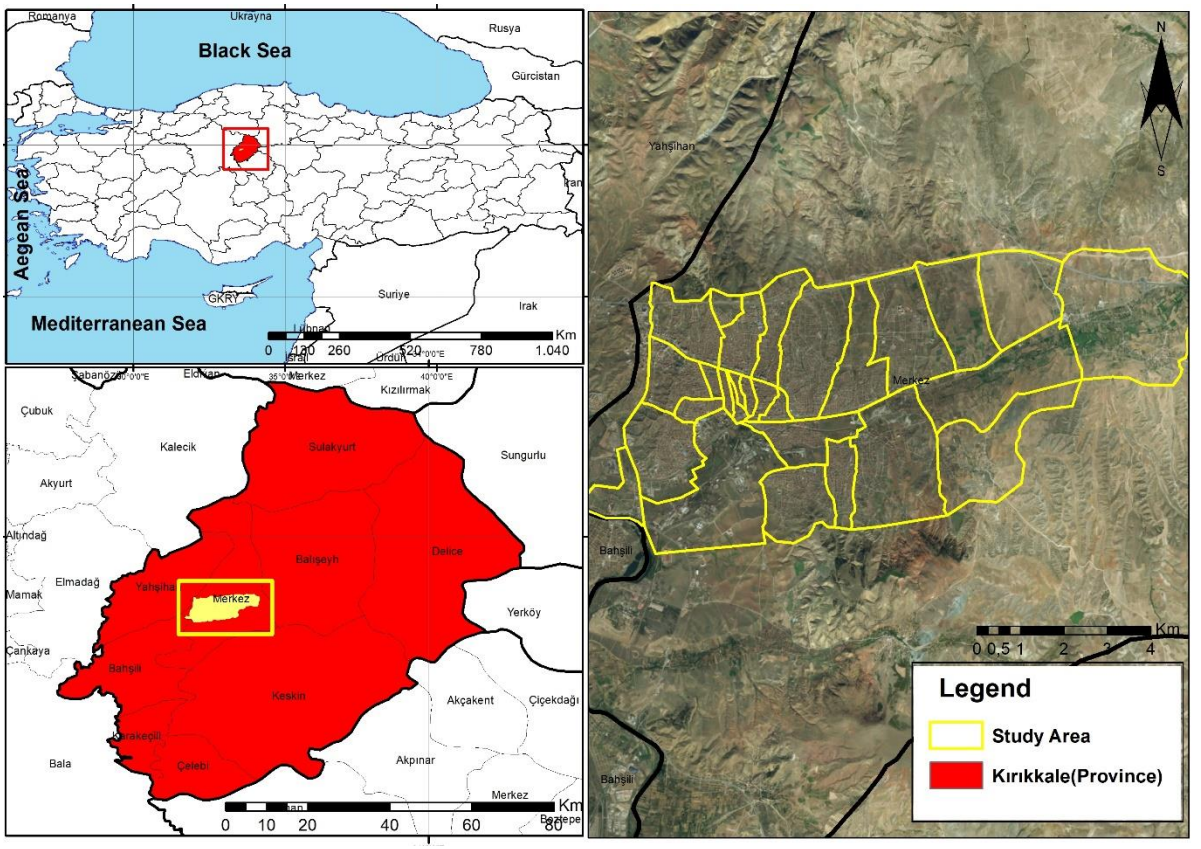

Figure 1. Study Area Location

The existence of TÜPRAŞ and iron and steel factories affiliated to MKEK, which was established in the first years of the Republic, which are actively producing in the city of Kırıkkale, constitutes an important source of air pollution in the city of Kırıkkale. MKEK facilities, which remained outside the city during the first years but became part of the city as the city developed and expanded, and TÜPRAŞ which is located near the city cause significant air pollution. Gas complaints originating from TÜPRAŞ have been the subject at local, regional, and national levels in some periods [9].

Transportation is also a very important factor. In addition to the increase in the number of vehicles, the transportation networks developed and became more complex [10]. Complex transportation networks and vehicle equipment have become more environmentally harmful. Carbon monoxide gas, especially from exhausts of motor vehicles, is a very toxic pollutant. The number of motor vehicles, which has an important effect on the increase of carbon monoxide level in Kırıkkale city, was 69,696 in 2018 and 68,142 in 2019. The number of cars within the number of motor vehicles was 42,634 in 2018 and 40,906 in 2019. The number of cars per thousand was 149 in 2018 and 145 in 2019 [11].

The high amount and density of the population is also a major factor in the formation of air pollution. The large population increases the amount of housing available and the domestic warming increases with the increasing amount of housing. The population density in Kırıkkale was 63.21 in 2018 and 62.42 in 2019. The total population was 286,602 in 2018 and 283,017 in 2019.

With all these factors taken into consideration, it is observed that the limit value of the Pm10 in particular, exceeded the amount almost every month. Especially in 2019, PM10 limit value had exceeded or reached the limit level every month. Particulate substances that settle in the lungs and bronchi cause harmful consequences such as COPD, asthma, and lung cancer. In the amount of SO_2, it is seen that the limit value has been exceeded in some months (Figure 2). It is seen that SO_2 amount exceeded the limit value in May, June, and July in 2018. In 2019, it is seen that limit values are not exceeded in SO_2. When 2018 and 2019 are compared, it is seen that there are missing measurements in both Pm10 and SO_2 values in 2018 and even no measurements were made in some months. Pm10 and SO_2 averages in 2018 were considerably lower than those in 2019 (Figure 2).

When analyzed seasonally, it is observed that both pollutants increased in winter in 2018. In addition to the summer and spring seasons, there was an increase in the two pollutants in the winter and autumn seasons in 2019. This increase was more than what was recorded in 2018.

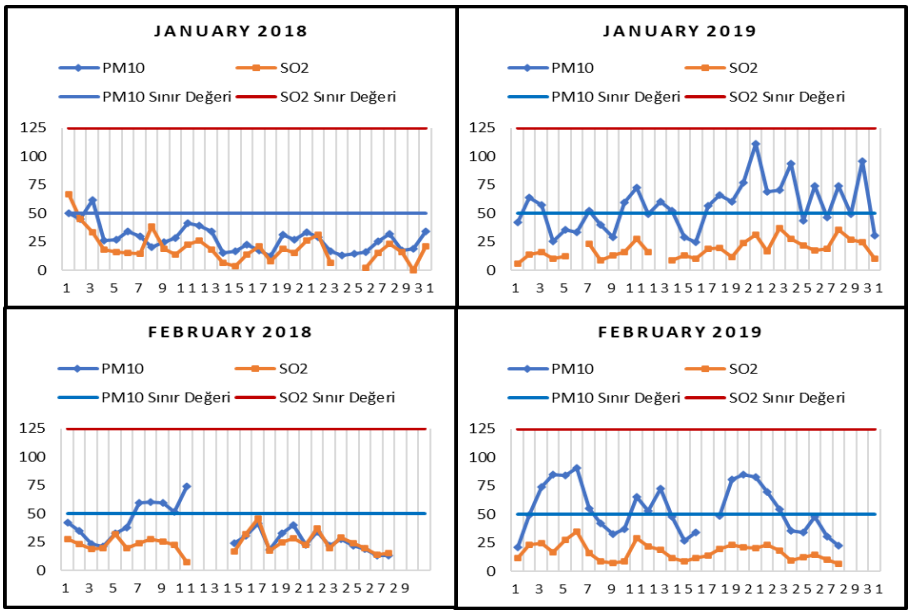

Figure 2. Monthly PM10 and SO_2 Amounts and Limit Values of Kırıkkale City (2018-2019)

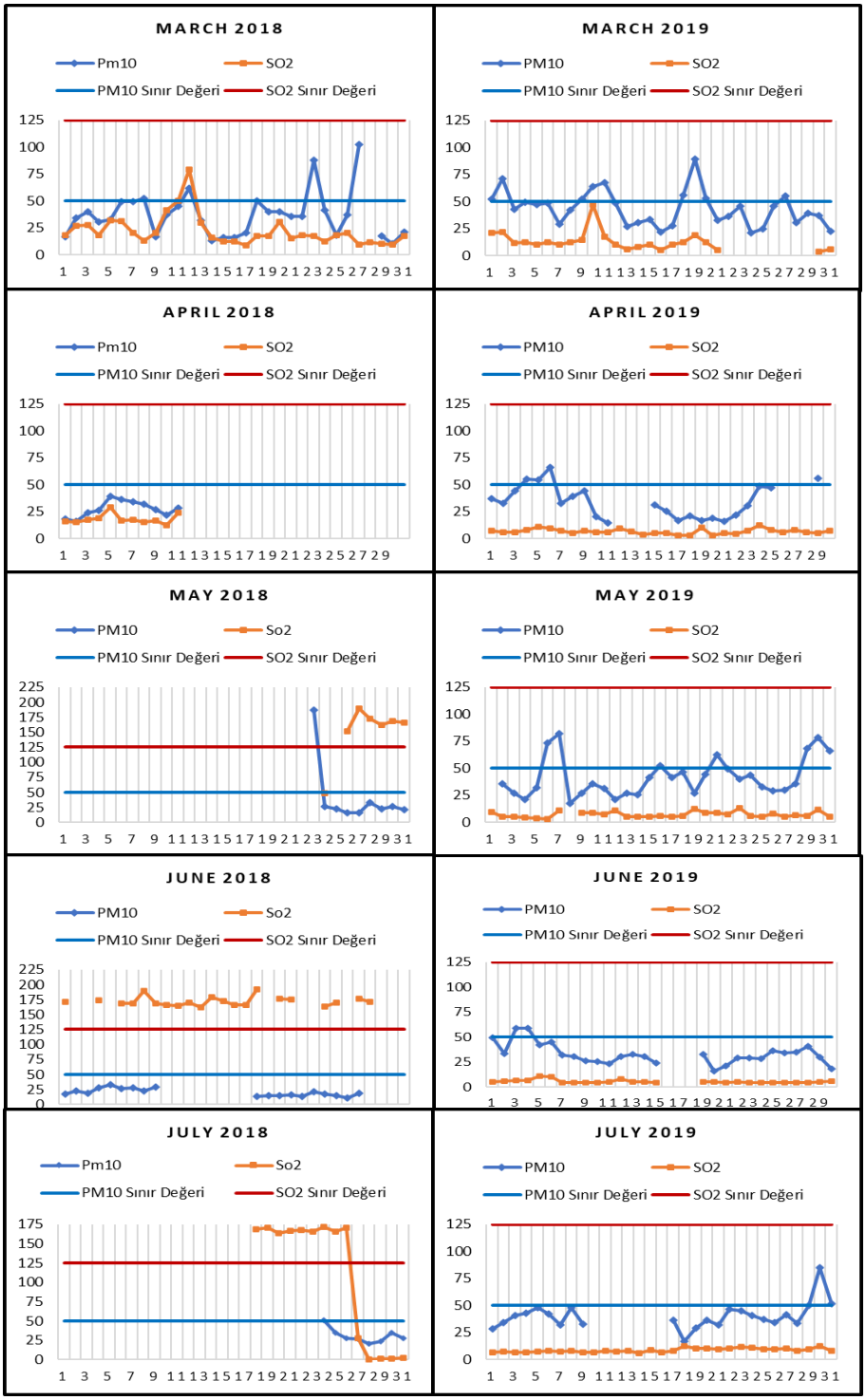

Figure 3. Monthly PM10 and SO_2 Amounts and Limit Values of Kırıkkale City (2018-2019)

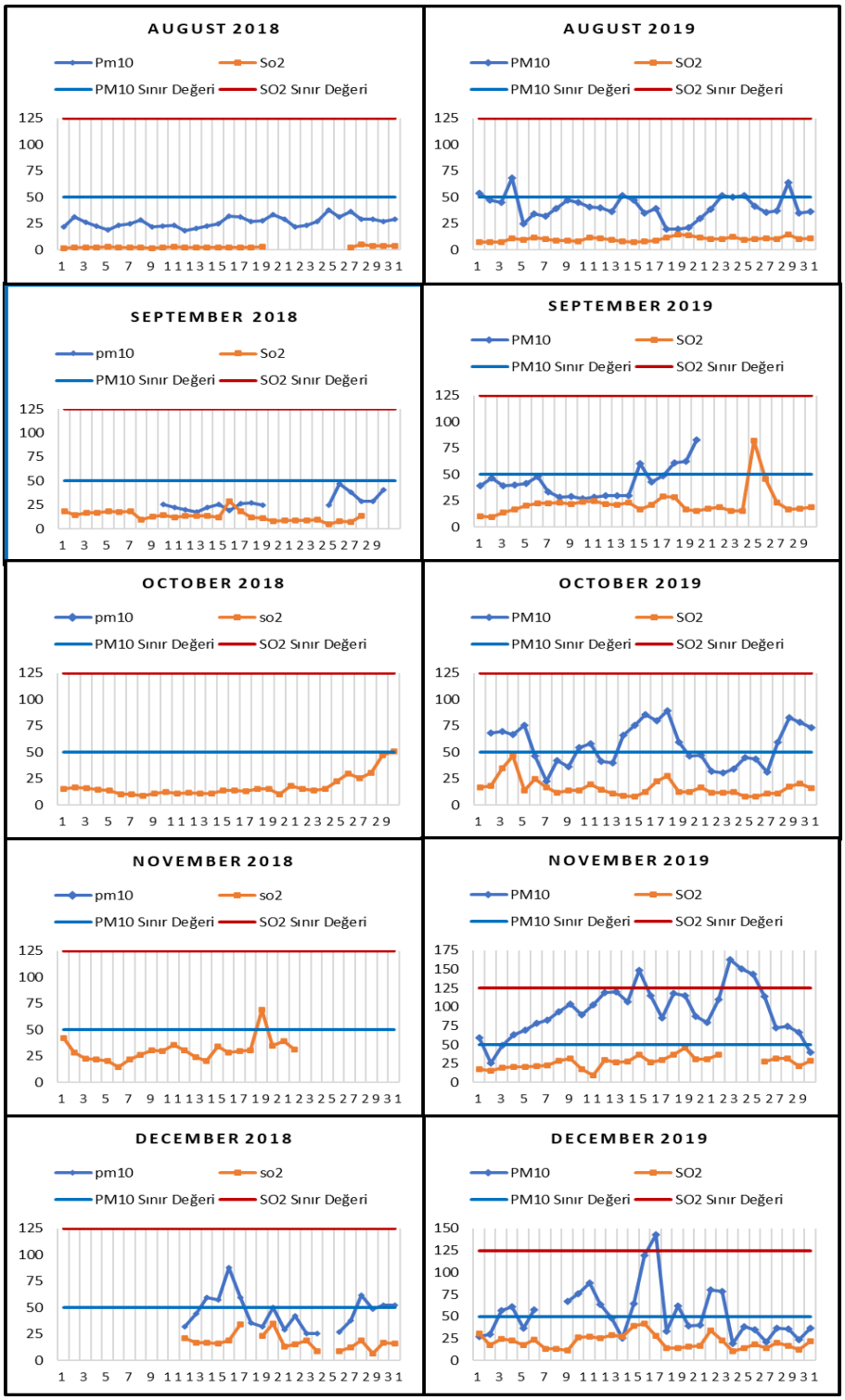

Figure 4. Monthly PM10 and SO_2 Amounts and Limit Values of Kırıkkale City (2018-2019)
Source: Environment and Urban Ministry, 2018-2019

The amount of CO has also exceeded the limit value in some periods in the city of Kırıkkale. CO gas, which is generally sourced from traffic, arises as a result of incomplete fuel burning in vehicles, as well as not burning fuels used for heating purposes in houses (Figure 3).

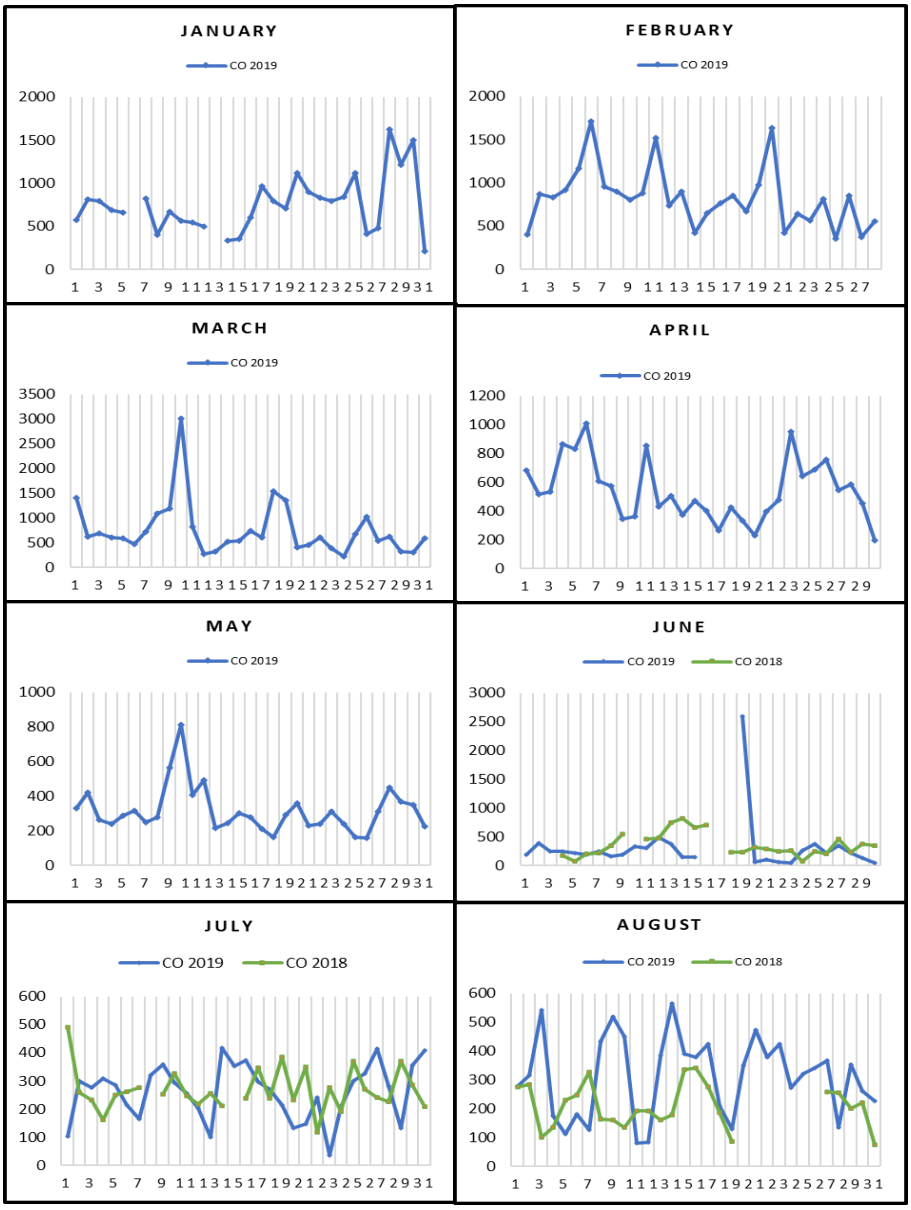

Figure 5. Monthly CO Amount of Kırıkkale City (2018-2019)

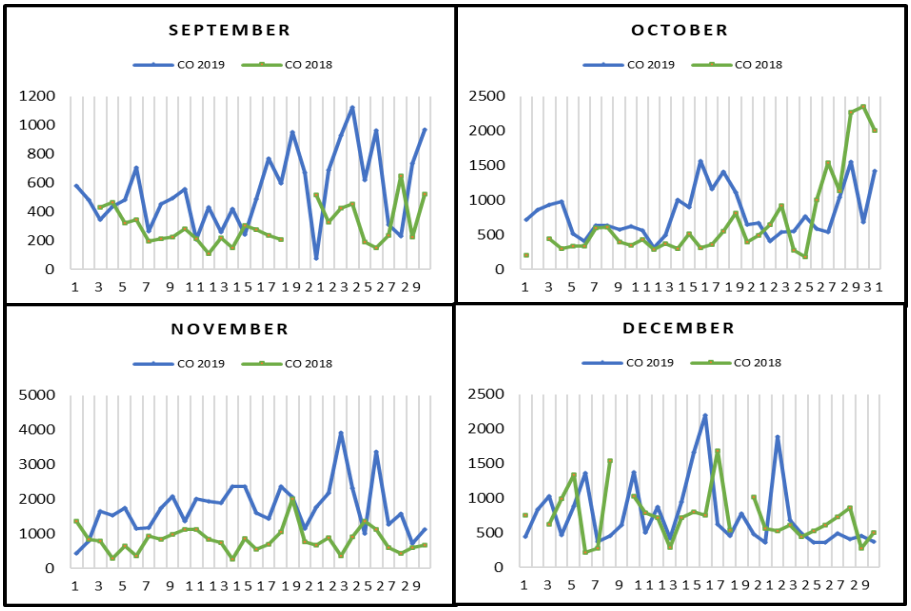

Figure 6. Monthly CO Amount of Kırıkkale City (2018-2019)
Source: Environment and Urban Ministry, 2018-2019

In Kırıkkale city, CO measurements were not performed until June 2018. After June, measurements were made with the deficiencies until December. However, measurements were made every day in 2019. The limit value in CO pollutants was calculated based on a maximum of 8 hours average. In this sense, the limit value is based on 10,000 µg / m^3.

According to the random 8-hour measurement results from the Kırıkkale city measurement station, the limit value was not exceeded. However, even if the limit value has not been exceeded, CO pollutant values are still high. In the months of January, February, March, April, October, November and December, the amount of CO was particularly high (Figure 3). The main reason for this is that the measuring station is on the roadside. In addition, the air quality measurement station is between the buildings. This reduces the reliability of the measurements (Figure 7).

Figure 7. Kırıkkale Air Quality Measurement Station
Source: https://www.haber71.net/hava-kalitesi-anlik-olarak-olculebilecek/

4.Conclusions and Suggestions

The air pollution is close to or above the desired levels in the city of Kırıkkale. Only few studies in this regards were conducted in Turkey, and our study of Kırıkkale is not sufficient. Moreover, there was only one measuring station in Kırıkkale city, some measurements could not be made at some hours of the day, some days or even some months. This is a critical situation that prevents the determination of the air quality of Kırıkkale city. The need to increase the measurements in the cities where the industrial facilities are dense, and in this context, the need to increase the number of stations, especially in the city of Kırıkkale, cannot be stressed enough. Because air pollution data that occurs due to production in industrial cities may show sudden changes in hour and day scale.

Kırıkkale has a natural gas infrastructure. Natural gas is used in the context of heating and production in residences and industrial facilities, but the use of poor-quality coal in residences is also an important condition that increases air pollution. The use of coal that does not comply with the standard ingredients should be prevented.

It is of great importance to place illuminated screens that show the current air quality value is in the areas where the crowd of population is dense. As a matter of fact, provincial-based air quality data are shared by the relevant ministry online and can be accessed from phones and computers, but these channels suffer from lack of following. The local administrations and the Ministry of Environment and Urbanization have a great responsibility to raise awareness and take measures to tackle these problems until the pollution levels are at low levels again.

Competing Interest / Conflict of Interest

The authors declare that they no conflict of interest. The none of the authors have any competing interests in the manuscript.

Funding

There is no financial support and commercial support.

Acknowledgements

We declare that all Authors equally contribute.

5. References

[1] İbret B. Ü., Aydınözü, D. (2009). A Sample For The Effect Of The Wrong Settlement Choice In Urbanizatipn On Air Pollution: The Center Of Kastamonu, Istanbul University Faculty Of Letters, Department Of Geography, Journal Geography,18, 71-88.

[2] Cetin, M., Adiguzel, F., Gungor, S., Kaya, E., & Sancar, M. C. (2019). Evaluation of thermal climatic region areas in terms of building density in urban management and planning for Burdur, Turkey. Air Quality, Atmosphere & Health, 12(9), 1103–1112.

[3] Şengün T. M., Kıranşan, K. (2013). Effects of Desert Dust on Air Quality in the Region of Southeastern Anatolia, Turkish Geography Journal, 59, 59-68.

[4] Yılmaz, M. (2018). Evulation of Particulate Matter and Sulfurdioxide Measurements Between 2011 and 2015 Years in Southeastern Anatolia Region", Konuralp Medical Journal, 10(3), 305-310.

[5] Sümer Çakır, G. (2014). Air Pollution Control: Analyse Of Legal Arrangements and Organizations Devoted to Preventipn of Air Pollution, International journal of Economic and administrative studies, 13, 37-56.

[6] Vural, E. (2018). Spatial Development of Kırıkkale City From Rebuplic to Today, Istanbul Universty Social Sciencesi Institute, Unpublished Master Thesis.

[7] Kırıkkale Meteorology Station Directorate, 2019.

[8] Kırıkkale Meteorology Station Directorate, 2019.

[9] https://www.hurriyet.com.tr/kirikkale-de-pis-koku-panige-neden-oldu-37208166

[10] Vural, E. (2019). Geographical Analysis of The Traffic Accidents In Viransehir (Sanlıurfa) City Center (2013-2017), Journal of Urban Culturel and Management, 12 (38), 340-363.
[11] https://biruni.tuik.gov.tr/ilgosterge/?locale=tr
[12] Environment and Urban Ministry, 2018-2019
[13] https://www.haber71.net/hava-kalitesi-anlik-olarak-olculebilecek/