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ÖZEL SAYI/SPECIAL ISSUE 49
MART/MARCH 2023

İÇINDEKILER / TABLE OF CONTENTS

ÖZEL SAYI/SPECIAL ISSUE 49
MART/MARCH 2023

IÇINDEKILER / TABLE OF CONTENTS

Avrupa Bilim ve Teknoloji Dergisi
Özel Sayı 49, S. 1-5, Mart 2023

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Research Article

Assessment of WBCs, CRP, LDH and other Biomarkers of Moderate and Severe COVID-19 Patients in Iraq

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Abstract

Though most Iraqi patients who are infected by COVID-19 only suffering from mild symptoms, but in some cases a patient's condition deteriorates, leading to a negative outcome. This study aims to assess the clinical laboratory features of moderate and severe COVID-19 patients

One hundred diagnosed as moderate and severe COVID-19 patients as well as fifty healthy participants were involved in our current study. Assessment was made for WBCs, Monocytes, Lymphocyte, and Platelets. In addition, serum levels of lactate dehydrogenase (LDH) and C-reactive protein (CRP).

A hundred patients aged 33 to 70 years with COVID-19 had severe and moderate cases. Present in DAR AL-SALAM for COVID-19 isolation in Baghdad, Iraq. COVID-19 patients showed increased serum levels LDH and CRP as well as WBCs count and others when compared to healthy individuals. The severe group showed a statistically significant increase in WBCs account, neutrophil activity and LDH levels, compared with moderate group. While the moderate COVID-19 groups displayed a significant rise in lymphocytes activity, CRP, and Platelet.

The current investigation found that WBC count, lymphocyte count, LDH activity, and CRP level were effective indicators for determining the severity of COVID-19, making them good assessment indicators.

Keywords: COVID-19, biomarkers, moderate, severe

Irak'taki Orta ve Şiddetli COVID-19 Hastalarının WBC'leri, CRP, LDH ve Diğer Biyobelirteçlerinin Değerlendirilmesi

Öz

COVID-19 ile enfekte olan çoğu Iraklı hasta yalnızca hafif semptomlardan muzdarip olsa da, bazı durumlarda hastanın durumu kötüleşerek olumsuz bir sonuca yol açar. Bu çalışma, orta ve şiddetli COVID-19 hastalarının klinik laboratuvar özelliklerini değerlendirmeyi amaçlamaktadır.

Mevcut çalışmamıza yüz orta ve ağır COVID-19 hastası ve elli sağlıklı katılımcı dahil edildi. WBC'ler, Monositler, Lenfosit ve Plateletler için değerlendirme yapıldı. Ek olarak, laktat dehidrojenaz (LDH) ve C-reaktif protein (CRP) serum seviyeleri.

Yaşları 33 ile 70 arasında değişen yüz COVID-19 hastasının ciddi ve orta şiddette vakaları vardı. Irak, Bağdat'ta COVID-19 izolasyonu için DAR AL-SALAM'da mevcut. COVID-19 hastaları, sağlıklı bireylerle karşılaştırıldığında artan serum seviyeleri LDH ve CRP'nin yanı sıra WBC sayısı ve diğerlerini gösterdi. Şiddetli grup, orta grupla karşılaştırıldığında WBC hesabında, nötrofil aktivitesinde ve LDH seviyelerinde istatistiksel olarak anlamlı bir artış gösterdi. Ilımlı COVID-19 grupları lenfosit aktivitesinde, CRP'de ve Trombositte önemli bir artış gösterirken.

Mevcut araştırma, beyaz kan hücresi sayısı, lenfosit sayısı, LDH aktivitesi ve CRP seviyesinin COVID-19'un ciddiyetini belirlemede etkili göstergeler olduğunu ve bu göstergelerin iyi değerlendirme göstergeleri olduğunu ortaya çıkardı.

Anahtar Kelimeler: COVID-19, biyobelirteçler, ılıman, haşin

1. Introduction

Since COVID-19 first appeared in China [1,2], the infections have spread globally led to causing as pandemic [3]. About 2% of COVID-19 patients die from the illness, and 5–10% of them go on to have severe, life-threatening conditions [3]. Multiorgan damage and hyperinflammation are the main features of COVID-19 infection, which results in multiorgan damage.

Acute severe respiratory distress brought on by epithelial infection and activated alveolar macrophages of lungs is the main factor contributing to COVID-19-related death [4]. As a result, immune modulation and suppression medicine may prevent COVID-19 patients' conditions from worsening. [5]. Many COVID-19 patients have mild to moderate illness, while a small number have severe disease or die [6, 7].

A growing body of research revealed that COVID-19 is completely complicated in its pathophysiological modifications, with multiple organs being damaged by the virus infection and the immune system overreacting. Rised cytokines levels and inflammatory reactive proteins have been seen in serum and lung alveoli

A variety of risk factors for severe illness have been found, including age [8, 9], malignant tumors [9], chronic renal disease [10], chronic obstructive pulmonary disease [11], hypertension [12], diabetes mellitus [13], obesity [14], smoking [13], and immunodeficiency following transplantation [15]. There have been reports of particular indicators of severity, such as prothrombin time, lactate dehydrogenase (LDH), lactate dehydrogenase (LDH), D-dimer, ferritin, interleukin-6, white blood cell (WBC) count, lymphocyte count, platelet count, albumin, and levels of these substances (PT) [16].

CRP has been investigated in a variety of diseases and is a universal inflammatory predictor. CRP, which is also involved in COVID-19, has a significant impact on both the disease's prognosis and diagnosis [17].

LDH is an enzyme that is found in almost all the body's cells and helps to produce energy. Measurements from LDH blood tests are frequently used to monitor tissue damage brought on by a variety of illnesses, including interstitial lung disease and liver disease [17,18].

An increase in LDH is a common sign of tissue or cell damage and tissue or cell death, pointing to viral infection or lung damage, such as pneumonia caused by SARS-CoV-2 [18].

A significant biomarker for the activity and severity of idiopathic pulmonary fibrosis has been identified as serum LDH. Results from clinical laboratories are therefore essential for determining the best course of treatment and evaluating a patient's condition [18].

The pathophysiology of COVID-19 is, however, not fully known. Undoubtedly, the development and severity of the illness are significantly influenced by the cytokine storm that causes inflammation and the virus evasion of cellular immune responses [19].

Numerous laboratory anomalies have been linked to worse outcomes in COVID-19 cases [20]. Patients with severe and fatal COVID-19 were shown to have significantly higher levels of inflammatory biomarkers, cardiac and muscle damage, liver and kidney function, and coagulation measurements, according to a meta-analysis by Henry et al. In particular, serum ferritin, interleukin (IL)-6, and IL-10 were strong indicators of severe illness [21].

We examined the clinical laboratory and demographic data of 100 COVID-19 patients who were admitted to the DAR-ALSALAM hospital for COVID-19 isolation as part of the current study with the goal of identifying the predictors of COVID-19 severity.

2. Material and Method

Ethically, Official permissions regarding the ethics of scientific research were obtained prior to the study's launch. The patient's family also gave their consent for the patient to participate in the study and have blood drawn. One hundred COVID-19 patients (their ages 33–70th) were attended to DAR AL-SALAM for COVID-19 isolation in Baghdad/ Iraq from 1 August 2021 to 30 December 2022 and participated in our study. Other fifty healthy subjects were collected from private health centre.

Based on Iraqi and WHO Medical Care Guidelines, the seve rity of COVID-19 was assessed [15]. Some patients had moderate disease (pneumonia treated with oxygen treatment without mechanical ventilation), whereas others had severe disease (pneumonia with mechanical ventilation). Patients suffering from chronic conditions were excluded.

5 ml of blood was drawn from each case. It was separated into two types of gel tubes for separating the serum purpose, and the other part was placed in an EDTA tube for complete blood count purpose.

All analysis were done by Cobas e411 system (Roche Diagnostics K.K., Tokyo, Japan). CBC were tested using a fully automated blood cell counter XN-3000 (Sysmex Co., Kobe, Japan).

The current study's data were analyzed using the Chi-square (X2) test to compare percentages. (Mean SD) was used to describe numerical data. The T test is used to compare two numerical variables, whereas the F test (ANOVA) is used to compare three or more numerical variables. The test was run with a significance level of =0.05. Programs for analyzing current data (SPSS v.22 and Excel 2013).

3. Results and Discussion

3.1. Results

The results showed that all parameters were affected according to age, WBCs levels were significantly higher in the aged between 50-69 years while neutrophil, lymphocytes, and CRP levels were significantly increased in aged ≥ 70. While lymphocytes, Platelets, and LDH showed significantly increasing in the group who their ages between 33-49 years as shown in the table (1).

Table 1. Parameters effects according to age for severe and moderate COVID-19 patients

Age				
Parameters	**N**	**33 – 49 years**	**50 – 69 years**	**≥ 70**
WBCs	**100**	**13.45 ± 5.877 b**	**14.83 ± 12.820 a**	**13.96 ± 5.509 b**
neutrophil	**100**	**4.68 ± 0.555 b**	**4.61 ± 0.570 b**	**5.38 ± 3.193 a**
lymphocyte	**100**	**13.17 ± 1.663 ab**	**13.06 ± 1.826 b**	**15.53 ± 9.375 a**
Platelet	**100**	**282.96 ± 99.957 a**	**265.20 ± 95.261 ab**	**222.96 ± 89.255 b**
CRP	**100**	**33.25 ± 23.936 b**	**36.33 ± 27.110 b**	**53.31 ± 51.843 a**
LDH	**100**	**949.18 ± 503.725 a**	**808.70 ± 298.145 b**	**798.89 ± 353.364 b**
Different litters horizontally mean significant differences at the 0.05 level				

Regarding the laboratory data results, patients in the moderate and severe groups showed significantly higher WBCs count, neutrophils, lymphocytes activities, Platelet, LDH, and CRP level compared with healthy controls. Severe patients showed significantly higher levels of WBCs count, neutrophil, and LDH activity levels compared with the moderate group.

Serum Lymphocyte activity, Platelet, and CRP exhibited a significant increase in moderate COVID-19 patients compared with severe COVID-19 cases with P-value< (0.1, 0.01, and 0.001) as shown in table 2.

Table 2: The levels of WBCs, RBCs, Platelet, CRP, and LDH in sever and moderate patients comparing with healthy control

parameters	**Sever/n=100**	**Moderate/ n=100**	**Healthy/ n=50**
WBCs	**14.27±9.7***	**11.46± 8.54***	**5.92±0.21**
neutrophil	**14.907± 7.024****	**12.74±5.563****	**7.38±1.03**
lymphocyte	**11.507±3.696****	**13.04 ±4.269****	**2.06±0.78**
Platelet	**247.55± 98.469***	**277.59± 93.441***	**175.23±4.68**
CRP	**30.01 ± 38.724*****	**42.15 ± 62.559 *****	**1.97 ±0.19**
LDH	**939.37±381.561 *****	**738.37±329.097 *****	**261.6±3.00**
. mean significant differences at the 0.1 level.** *. mean significant differences at the 0.01 level.** *****. mean significant differences at the 0.001 level.**			

3.2 Discussion

Patients with COVID-19 who had moderate or severe cases had different haematological characteristics. Even though there were differences in platelet counts between moderate and severe cases, WBCs as well as their differential numbers appeared be crucial in determining how severe the condition was. When compared to moderate instances. Therefore, the SARS-CoV-2 infection may cause a variety of clinical manifestations, from mild pneumonia to subclinical illness. Our preliminary results demonstrated that, in addition to age, comorbidity presence, and symptoms at admission, laboratory markers such as WBCs count, lymphocytes count, neutrophil, LDH activities, and CRP levels made the biggest contribution to the prediction of the illness severity.

The patients in the ICU group, according to Wang et al., were older and showed more comorbidities than those in the non-ICU group [22]. Dyspnea and a dry cough were notable admission

symptoms that were significantly more common in the severe group. According to the laboratory analysis, SARS-CoV-2 has an impact on a few common blood indicators. Regarding the admission laboratory results, very ill patients typically have elevated WBCs, neutrophil, lymphocyte activity, LDH, and CRP levels [23].

Higher levels of leukocytes were a distinguishing characteristic of the critically ill patients in the current investigation, which is consistent with the meta-analysis (Zeng et al., 2020) [23], which discovered increased WBC counts in patients with severe COVID-19. Anaemia is a result of SARS-disruption CoV-2's of red blood cells (RBC) and decreased erythrogenesis (Sun et al., 2020) [24]. Lymphopenia was discovered to be a COVID-19 feature that can help differentiate COVID-19 pneumonia from non-COVID-19 pneumonia. According to study, the decrease in lymphocytes is mostly caused by T-lymphocyte subset depletion, specifically T-helper and T-suppressor cells, and the presence of lymphopenia in COVID-19 patients implies significant inflammation and tissue damage [25].

Our data imply that in severe cases, the absolute lymphocyte count is lower, although the difference is not as pronounced as the difference in NLR.

Shi et al., investigated that there is a link between LDH and moderate COVID-19 disease. While Han et al., suggested that the LDH is useful in predicting disease development in severe COVID-19

Henry et al. discovered that an increase in LDH levels is linked with disease severity (OR = 6.53) and death (OR = 16.64) in a meta-analysis comprising nine trials in mild, moderate, and severe COVID-19 patients [26].

Higher WBC, specifically increased neutrophil counts and reduced lymphocyte counts, accurately predicted the severity of COVID-19 disease. An increase in inflammatory cytokines is coupled with a decrease in lymphocytes may due to CD4+ cell death [27]. CRP was also an excellent predictor of the severity of COVID-19 sickness. [28].

In the current study, we discovered that higher WBC counts, CRP levels, and LDH activity were linked to hospital admission in the severe group. Finding a marker that could be used to precisely forecast a severe prognosis was the aim of this study.

We noticed that WBCs, LDH, CRP, and lymphocyte were effective biomarkers for COVID-19 severity diagnosis. As a result, it may be added to the list of severe prognosis predictions that are easy to gather since it is a parameter reported in standard testing. Cellular immunological deficiencies and hypercoagulation may account for all of our study's findings.

4. Conclusions and Recommendations

The coronavirus disease of 2019 exhibits strong haematological symptoms. Common haematological abnormalities have been discovered in COVID-19 individuals with severe and moderate disease. The increases in WBC count, lymphocyte count, and CRP level may be strongly related to other organ injuries, such as liver injury, in COVID-19 patients. WBCs count, LDH activity, CRP level, and lymphocyte count, to a greater extent, were effective predictors for identifying the severity of COVID-19 infection.

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Research Article

Electronic Properties of FLG/InP Schottky Contacts

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Abstract

Graphene (Gr) is of great interest in the development of new electronic, photonic, and composite materials. The physical properties of Gr can vary depending on the number of layers, and this unique property makes it a potential material for different electronic applications. In this study, few-layer graphene (FLG) film was spin-coated onto the InP semiconductor surface and the FLG/n-InP Schottky contact was produced. The properties and quality of the FLG nano-film were determined by using Raman spectroscopy. Parameters such as ideality factor, barrier height, and series resistance of Schottky contacts were calculated using current-voltage (I-V) curves. With the Gaussian distribution, the mean ideality factor of the Gr/InP contacts was found to be <n>=1,47, and the mean barrier height values were found to be <φb>=0.68 eV. The standard deviation values were calculated as σ=0.32 for the ideality factor and σ=0.06 eV for the barrier height. In addition, the series resistance values were calculated from the Cheung functions and were found to be in agreement with the literature. Finally, the current conduction mechanisms of the Gr/n-InP structure were revealed by examining the logarithmic I-V characteristics.

Keywords: Graphene, Gaussian distribution, InP, Raman spectrum.

FLG/InP Schottky Kontaklarının Elektronik Özellikleri

Öz

Grafen (Gr), yeni elektronik, fotonik ve kompozit malzemelerin geliştirilmesinde büyük ilgi görmektedir. Gr'nin fiziksel özellikleri katman sayısına bağlı olarak değişebilmekte ve bu benzersiz özelliği onu farklı elektronik uygulamalar için potansiyel bir malzeme yapmaktadır. Bu çalışmada InP yarı iletken yüzeyi üzerine birkaç katmanlı grafen (FLG) filmi döndürerek kaplandı ve FLG/n-InP Schottky kontakları üretildi. FLG nano filminin özellikleri ve kalitesi Raman spektroskopisi kullanılarak belirlendi. Schottky kontaklarının idealite faktörü, bariyer yüksekliği ve seri direnci gibi parametreler akım-gerilim (I-V) eğrileri kullanılarak hesaplandı. Gauss dağılımı ile Gr/InP kontaklarının ortalama idealite faktörü <n>=1,47, ortalama engel yüksekliği değerleri ise <φb>=0,68 eV olarak bulundu. Standart sapma değerleri idealite faktörü için σ=0,32 ve engel yüksekliği için σ=0,06 eV olarak hesaplanmıştır. Ayrıca Cheung fonksiyonlarından seri direnç değerleri hesaplanmış ve literatür ile uyumlu bulunmuştur. Son olarak logaritmik I-V karakteristikleri incelenerek Gr/n-InP yapısının akım iletim mekanizmaları ortaya konulmuştur.

Anahtar Kelimeler: Grafen, Gauss dağılımı, InP, Raman spektrumu.

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1. Introduction

Schottky-based metal/organic/semiconductor structures have many different usage areas as a result of the developments in semiconductor circuit elements technology and their increasing importance day by day. These devices can generally be used as switching elements, microwave circuit elements, solar cells and detectors. Controlling the barrier height in the formation of a metal/organic/semiconductor is important for designing a high-performance electronic and optoelectronic circuit element. The performance and reliability of the circuit element are closely related to the geometrical and electronic properties of that material at the atomic scale.

Wide-bandgap III-V compound semiconductors for the fabrication of various electronic and optoelectronic devices have had important applications in recent years. The deposition of various organic inorganic films on InP semiconductors is still of interest for the fabrication of modern optoelectronics, microwave devices, and integrated circuits circuits (Cimilli et al, 2009a), (Cimilli Çatır, 2020)

Raman spectroscopy is a very effective method for the characterization of sp2 and sp3 hybrid carbon atoms. The electronic and vibrational properties of monolayer, bilayer and several layers of graphene can be easily investigated by resonance raman scattering (Ferrari et al., 2006).

Graphene is a two-dimensional, hexagonal structure of carbon atoms bonded together by hybridized sp2. These sheets are bonded with π bonded graphite. Graphene has interesting properties such as high electronic conductivity, thermal stability, and mechanical strength that researchers have been working on for a long time. However, the growth of single-layer graphene is critical for production, and it is not easy to control the number of graphene flakes during application. The spherical form of a single graphite layer is called 0D fullerene, and the 1D cylindrical form formed by curling around the edges is called a carbon nanotube. The 2-dimensional structure consisting of one or more graphite layers is called graphene. Few layers of graphene (FLG) in the literature: two to five layers; multilayer graphene, (MLG), two to ten layers; graphene nanoplatelet, (GNP): more than ten layers classified by name (Kauling et al., 2018). The physical properties of graphene material vary depending on the number of layers. For example, single-layer graphene has a sheet resistivity of about 2 KΩ/sq and an optical transmittance of about 97%. However, layer resistance and optical transmittance decrease with increasing layer number (Li et al., 2009).

In one of the first studies on the Gr/n-Si Schottky junction for solar cells, reported by Li et al. (2010), individual layers were mostly composed of single-layer, bi-layer, and several-layer graphene. Consisting of a coherent and continuous graphene sheet film coated on a patterned n-Si/SiO2 substrate with Au contacts, the device's I-V characteristics were highly rectifying (correction ratio 10+4-10+6) and diode ideality factor corresponding to n=1.57. It was almost linear in the 0.1-0.4 V range.

The spin coating method, which is easy to produce, strong, thin, smooth, conductive, and transparent films, is preferred compared to expensive and complex systems such as magnetron scattering, arc plasma, CVD, and spray pyrolysis. Hence, in this study, few-layered graphene (FLG) nano-film was deposited by spin coating onto an n-InP substrate, and then, Ag/FLG/n-InP Schottky diodes were fabricated. By using the forward bias current-voltage (I–V) characteristics, the ideality factor (n) and barrier height (Φb) of Ag/FLG/n-InP diodes were found by I–V and Cheung functions methods. The statistical Gaussian distributions of Ag/FLG/n-InP Schottky diode parameters were evaluated. The electrical and electronic properties of Ag/FLG/n-InP diodes were investigated.

2. Material and Method

First, the InP semiconductor sample was cut with a diameter of 1x1 cm and subjected to various processes in order to be cleaned from some organic and inorganic impurities (Cimilli, Sağlam, & Türüt, 2007). Then it was thoroughly washed with deionized water, dried, and made ready to form a film.

20 mg/ml graphene nano-powder and water dispersion were coated on the InP sample surface by spinning for 10 seconds at 500 rpm, 15 seconds at 1000 rpm, and 30 seconds at 5000 rpm. Next, the graphene films were dried at 100°C under nitrogen gas. The graphene film was subjected to a hydrazine hydrate treatment at 800°C under nitrogen flow and the graphene films were reduced again by a combination of annealing Then, In metal was vaporized on the back side of the sample and ohmic contacts were made (Cimilli et al., 2009b). Schottky contacts were produced by evaporating Ag metal on the graphene film surface with the help of a 0.5 mm diameter mask at about 10−6 mbar. The current–voltage (I-V) measurements for Ag/FLG/n-InP Schottky diodes were measured by using a Keithley 2400 picoammeter/voltage source at room temperature.

3. Results

Raman spectroscopy provides a facile way of structural and quality analysis of graphene materials. Fig. 1 shows Raman spectrum of the FLG film. Raman spectrum exhibited two strong and sharp peaks at 1375 cm−1 (D peak), 1590 cm−1 (G peak), and 2730 cm−1 (2D peak), being in agreement with spectral characteristic of graphene. These peak values show that the graphene-produced film is in the form of graphene, that is, it is not graphene oxide or graphite.

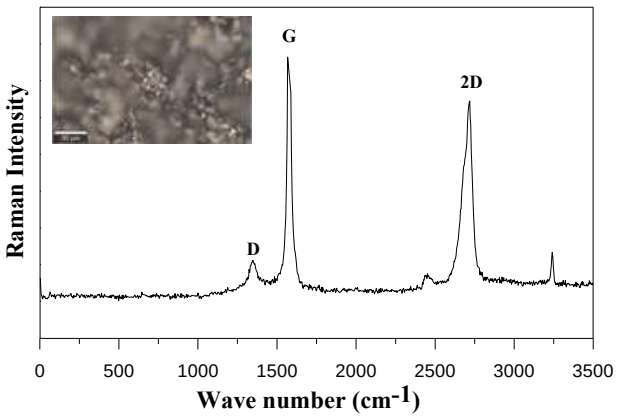

Fig. 1 Raman spectrum of FLG film

Raman spectroscopy is also a technique used to analyze single, double, several, or multilayer graphene films (Wang et al., 2008). The Raman spectrum of graphene is given in the literature as follows: D-peak at 1350 cm-1, G-peak at 1580 cm-1, and 2D-peak at ~2700 cm-1 (Lee et al., 2017). The intensity of these three values is used to separate the number of layers of

the graphene film. The decrease in the intensity of the G peak and a sharper and narrower 2D peak is the most defining features of single-layer graphene. In multilayer graphene, on the other hand, the 2D peak expands and begins to deteriorate.

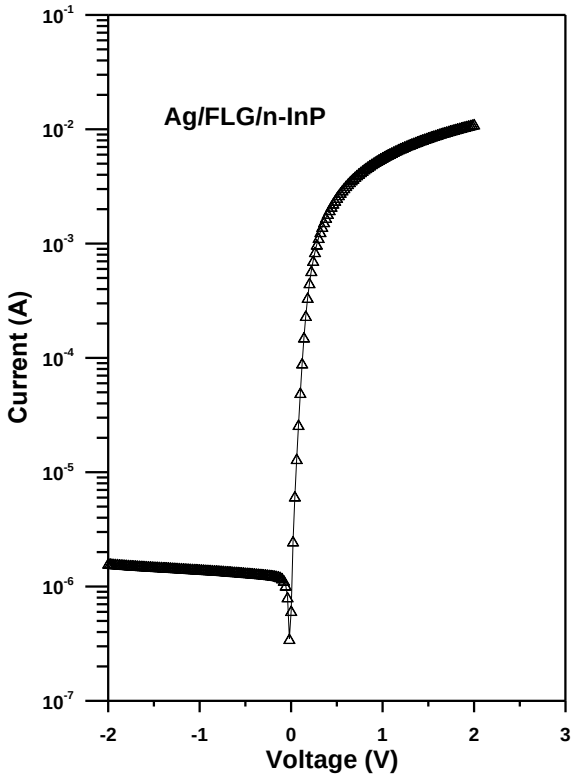

Fig. 2 Current-voltage (I-V) characteristics of Ag/FLG/n-InP Schottky diode

The presence of the D-peak gives a measure of the imperfection of the structure. That is, using the density of the D-peak, the number of microscopic defects in graphene can be explained (Singh et al., 2018). The Raman spectrum of monolayer graphene should not have a D-peak (Li et al., 2011). The presence of D-peak is attributed to the chemical doping of the graphene film and the presence of grain boundaries. The density ratio of D and G-peaks should not exceed 0.1 in a quality-produced graphene film. As shown in Figure 1, the ID/IG = 0.036 value was measured using Raman spectroscopy of manufactured graphene film. This value reveals that the defect density of the produced graphene film is low and relatively high-quality graphene sheets are produced (Li et al., 2011). In addition, the intensity of the 2D peak for monolayer graphene is given twice the intensity of the G peak in the literature. The density ratio of IG/I2D = 1.17 found in Figure 1 shows that the graphene film on the sample has few layers, but not a monolayer. As a result, we concluded that the graphene film we produced is few-layered graphene and our findings are in good agreement with the values reported in previous reports (Ferrari et al., 2006), (Wang et. al., 2008).

When the I-V measurement characteristics were examined, it was seen that all the produced diodes exhibited good rectification behaviour. The linear and semi-log I-V characteristics of a selected Ag/FLG/n-InP Schottky diode are shown in Figure 2. The FLG/n-InP structure showed good rectification properties and the rectifier feature of the diodes is in good agreement with the previously reported results (Baltakesmez et al., 2019), (Çetin & Ayyildiz, 2010), (Devi, Jyothi, & Reddy, 2012), (Bhaskar Reddy et al., 2009), (Cimilli et al., 2009b). The nonlinear I-V characteristic of Schottky diode behavior can be explained by thermionic emission theory (Bhaskar Reddy et al., 2009), (Gülnahar M, 2015). By using thermionic emission (TE) theory and forward I-V graph (Cimilli et al., 2009a), (Gülnahar M, 2015), the ideality factor values (n) of the diodes from the slope of the linear region and the barrier height (φb) values from the current axis intersection point were calculated, respectively.

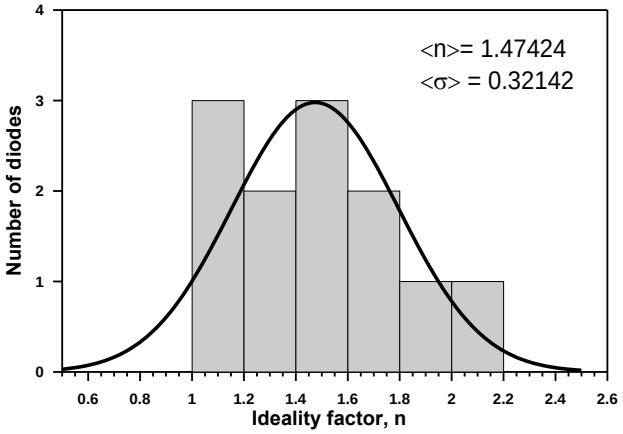

Fig. 3 Statistical Gaussian distributions of ideality factor values Ag/FLG/n-InP Schottky diode.

Statistical Gaussian distributions and Gaussian fits of n and φb are shown in Figures 3-4, respectively. Even if they are prepared identically, n and φb vary from diode to diode. Therefore, it is common practice to average these values (Sağlam, Cimilli, & Türüt, 2004). Ideality factor values were found to be between 1.04 to 2.14, with a mean idealite factor value of <n>=1.47. The standard deviation values were calculated as σ=0.32 for the ideality factor. The small standard deviation values were attributed to Ag/FLG/n-InP Schottky diodes approaching the classical ideal diode behaviour. The ideality factor values were calculated between 1 and 2 values for rectifier metal-semiconductor structures with organic and inorganic interfaces (Türüt, 2020). Balaram et al., (Balaram et al., 2018) studied CuO/n-InP Schottky diodes. The barrier height (φb) and ideality factor (n) were extracted through current voltage (I-V) and capacitance voltage (C-V) methods and the respective values were 0.66 eV (I-V)/0.80 eV (C-V) and 1.24, and 0.78 eV (I-V)/0.94 eV (C-V) and 1.62, respectively. Rajagopal Reddy (Reddy, Reddy, Padmasuvarna, & Narasappa, 2015) has reported that the ideality factor of Ru/Ti Schottky contact is found to be 1.19 for the as-deposited contact. The estimated ideality factor n values are 1.26, 1.59 and 1.64 for the contacts annealed at 200 °C, 300 °C and 400 °C, respectively. Our ideality factor values are in harmony with the classical semiconductor diodes in the literature. This means that the current transports at the Ag/FLG interface are approximately dependent on the thermionic emission theory.

Barrier height values range from 0.57 and 0.78 eV with the mean barrier height value of <φb>=0.68 eV. The standard deviation values were calculated as σ=0.06 eV for the barrier height. Devi et al. (2012) calculated the experimental values of as-deposited Au/Cu/n-InP Schottky contact has a barrier height of 0.64 eV from IV measurements and 0.76 eV from C-V measurements. Rajagopal Reddy et al. (2015) found the Schottky barrier heights of the Au/n-InP and Au/NiPc Schottky contacts as 0.59 eV (I–V)/0.71 eV (C–V) and 0.82 eV (I–V)/1.14 eV (C–V) with ideality factors of 1.22 and 1.83, respectively.

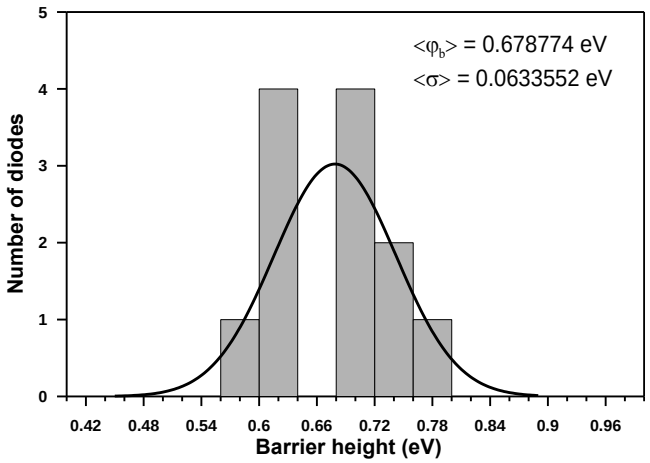

Fig. 4 Statistical Gaussian distributions of ideality factor values Ag/FLG/n-InP Schottky diode.

It is clearly seen that there is a significant change in the barrier height of the diode when compared with the above references due to the presence of the FLG interfacial layer. This can be explained by the chemical bonding of the FLG film to the InP semiconductor. Thus, it is concluded that the FLG interfacial layer causes a significant change in the interface states and the space charge region of the semiconductor, thereby changing the barrier height.

The series resistance (Rs) can be determined from the series resistance region of the I-V characteristics. The n, φb and Rs values were obtained from the equations below using the Cheung functions method again.

$$\frac{dV}{d(\ln I)} = \frac{nkT}{e} + IR_s \quad (1)$$

$$H(I)=n\Phi b + IRs \quad (2)$$

The n and Rs values were obtained from Eq. (1) as 1.20 and 9.37 Ω, respectively. Also, φb and a second Rs values were calculated from Eq. (2) as 0.73 eV and 10.62 Ω, respectively. As a result, it is seen that the barrier height, ideality factor and series resistance values calculated with the help of Cheung functions are in great agreement with the traditional I-V characteristics. This supports the accuracy of the calculations for Ag/FLG/n-InP diodes. In addition, these series resistance values calculated from the dV/d(lnI)-I and H(I)-I functions were found to be close to each other.

As mentioned above, one reason why the ideality factor is greater than 1 is the series resistance (Rs) effect, which causes the DC current voltage curves corresponding to high voltages to deviate from linearity. One of the important factors affecting the current-voltage characteristics of Schottky diodes is the neutral region resistance of the semiconductor body and is called the series resistance. Series resistance is a very important parameter of a metal-semiconductor Schottky diode and it is effective at high voltages. The existence of series resistance has been attributed to inhomogeneities at the metal-interlayer-semiconductor interfaces and/or to differences in surface morphology from region to region.

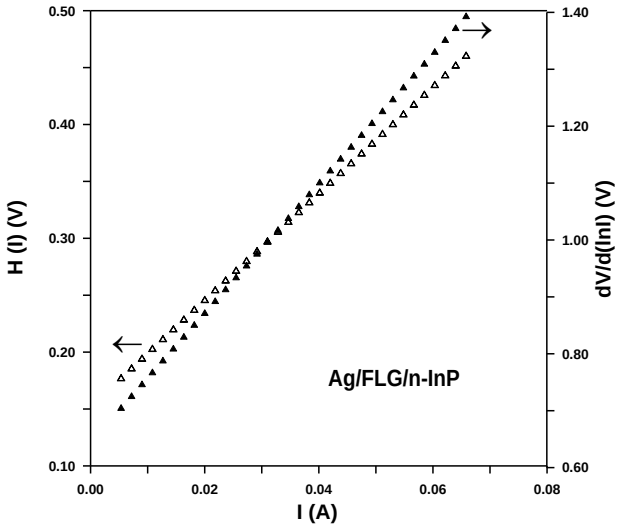

Fig. 5 Plot of dV/d(lnI) and H(I) versus I for Ag/FLG/n-InP Schottky diode calculated from Cheung functions

As can be seen from the above calculations, there are differences between the ideality factors and barrier heights obtained from the I–V and Cheung's methods. These differences are attributed to the fact that both methods calculate from different regions of the lnI-V plot. In the I–V method, the linear region is used for calculation, while the Cheung functions are influenced by the interface layer thickness, interface states, and bulk series resistance between metal and semiconductor.

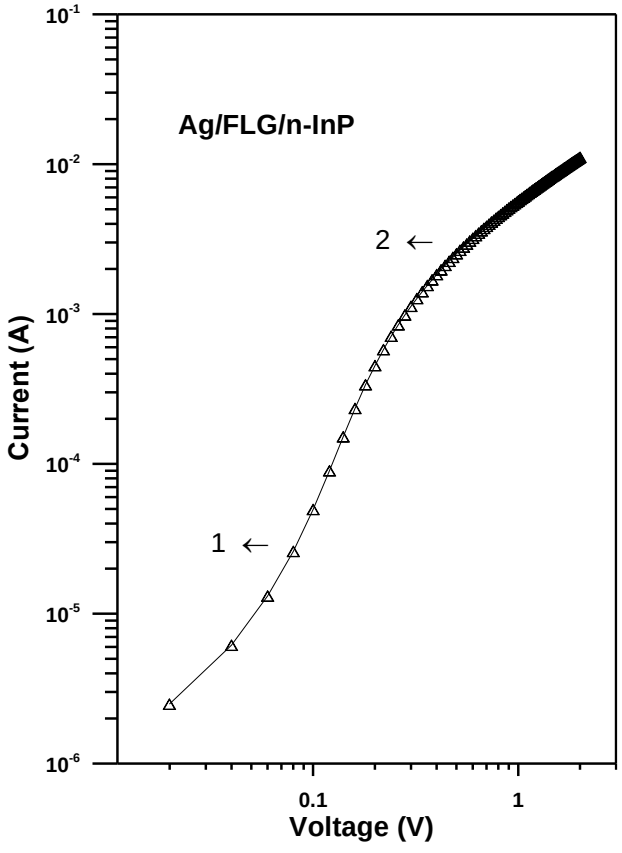

Fig. 6 Current-voltage (I-V) characteristics of Ag/FLG/n-InP Schottky diode in full logarithmic scale

In Figure 6, the current-voltage characteristics of the Ag/FLG/n-InP Schottky diode in the logI-logV scale was given. It is seen that the forward bias I-V plot of the device consists of

two different linear regions. In Figure 6, the device exhibits ohmic behavior in the low voltage region, which is expressed as region 1 in the log-log scale. In this region, the current is proportional to the electric field. Many of the modern organic devices are based space charge limited conductivity (SCLC) interpreted by Mott in 1940 (Mott & Gurney, 1948). In the graph of the Ag/FLG/n-InP device on the logI-logV scale, there is a high voltage region also referred to as region 2. Region 2 is the limited space charge flow (SCLC) region.

4. Discussion

In this research, the electronic properties of Ag/FLG/n-InP device obtained from graphene, an organic material, with an inorganic n-type InP semiconductor were investigated. Basic diode parameters such as ideality factor and barrier height from I-V (current-voltage) measurements made at room temperature and in the dark were calculated by the TE method. From the graph obtained from the I-V measurements, it was observed that almost no current flows from the device in reverse feed, and the current values increase linearly at low voltage values in straight feed. In the calculation made from the linear region under straight feeding, it was observed that the twelve different devices obtained showed similar properties and the barrier height values varied between 0.77 eV and 0.84 eV. From these results, it was seen that Ag/FLG/n-InP device has a Schottky-type rectification feature and the FLG material provides a high barrier between Ag and n-InP. The forward bias logI-logV graph of the Ag/FLG/n-InP device was drawn and this graph exhibited two different regions that have been observed. These regions show ohmic conductivity at low voltages and space charge limited conductivity (SCLC) at high voltages. Ideality factor, barrier height, and series resistance values were calculated with the thermionic emission method of the Ag/FLG/n-InP device as well as the Cheung method. In the calculations made by the Cheung methods, the ideality factor and series resistance values of the Ag/FLG/n-InP device were different from the values obtained from the TE method. This difference is attributed to the calculation made by considering the different regions of the I-V graph, the series resistance effect, and the interface states.

5. Conclusions and Recommendations

Ag/FLG/n-InP Schottky diodes with a few layered graphene nanofilm on the interface were manufactured identically. Schottky barrier diode parameters such as ideality factor, barrier height, and series resistance obtained from the current–voltage (I–V) characteristics of Ag/FLG/n-InP Schottky diodes were studied. Ideality factor values range from 1.04 to 2.14 and barrier height values were found to be between 0.57 and 0.78 eV. The n value was obtained from the dV/d(lnI)-I plot as 1.20 and the φb value was calculated from H(I)-I as 0.73 eV. The series resistance values obtained from Cheung functions graphs were close to each other. The statistical Gaussian distributions of Ag/FLG/n-InP Schottky diode parameters were evaluated. The mean ideality factor of the Ag/FLG/n-InP contacts was found to be $\langle n \rangle = 1.47$, and the mean barrier height values were found to be $\langle \varphi b \rangle = 0.68$ eV. The standard deviation values were calculated as $\sigma = 0.32$ for the ideality factor and $\sigma = 0.06$ eV for the barrier height. The small standard deviation values were attributed to Ag/FLG/n-InP Schottky diodes approaching the classical ideal diode behavior. The forward bias logI-logV graph of the Ag/FLG/n-InP device exhibited that the dominant conduction mechanism is identified as the SCLC process. It is further shown that the traps are distributed uniformly in the forbidden band gap.

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Research Article

Time Series and Data Science Preprocessing Approaches for Earthquake Analysis

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Abstract

Time series are frequently used today to analyze data that changes over time and to predict future trends. Usage areas of time series data include many applications such as financial market forecasts, weather forecasts, sales forecasts, medical diagnostics and stock management. Among the methods, there are techniques such as autoregressive integration, moving average, long-short-term memory neural network, time series condensation, wavelet transform and Frequency Domain. These techniques are chosen depending on the characteristics of the time series data and their intended use. For example, the ARIMA model is used for variable variance and non-stationary time series, while the LSTM model may be more suitable for capturing long-term dependencies. In this article, it has been tried to prove that time series based artificial intelligence systems can be built on fault movements, which are very difficult to predict on earthquake time series data, and it is quite possible to get useful results. In particular, deep learning methods are among the prominent methods in the article. Deep learning methods are used to detect complex structures and analyze large datasets to produce accurate results. These methods include multilayer perceptrons, long-short-term memory neural network, and radial-based function network. It is also emphasized that factors such as the selection of features used in earthquake prediction, data preprocessing, feature engineering and correct model selection are also important. As a result, the use of artificial intelligence techniques on earthquake time series data has great potential in estimating earthquake risk. Deep learning methods perform better, especially for large datasets, and more accurate results can be obtained with the right model selection. However, factors such as data preprocessing and feature selection also need to be considered.

Keywords: API, Data Science, Earthquake.

Deprem Analizi için Zaman Serileri ve Veri Bilimi Ön İşleme Yaklaşımları

Öz

Zaman serileri günümüzde zaman içinde değişen verileri analiz etmek ve gelecekteki eğilimleri tahmin etmek için sık biçimde kullanılır. Zaman serisi verilerinin kullanım alanları arasında finansal piyasa tahminleri, hava durumu tahminleri, satış tahminleri, tıbbi teşhisler ve stok yönetimi gibi birçok uygulama yer almaktadır. Yöntemler arasında ise otoregresif entegrasyon hareketli ortalama, uzun-kısa vadeli bellekli sinir ağı, zaman serisi yoğunlaştırması, dalgacık dönüşümü ve Frekans Domaini gibi teknikler yer almaktadır. Bu teknikler, zaman serisi verilerinin özelliklerine ve kullanım amaçlarına bağlı olarak seçilir. Örneğin, ARIMA modeli, değişken varyanslı ve durağan olmayan zaman serileri için kullanılırken, LSTM modeli, uzun vadeli bağımlılıkları yakalamak için daha uygun olabilir. Bu makale, deprem zaman serisi verileri üzerinde tahmin etmesi oldukça güç olan fay hareketleri üzerine zaman serisi tabanlı yapay zeka sistemleri kurgulanabileceğini ve faydalı sonuçlar almanın oldukça mümkün olduğu kanıtlanmaya çalışılmıştır. Özellikle, makalede öne çıkan yöntemler arasında derin öğrenme yöntemleri yer almaktadır. Derin öğrenme yöntemleri, karmaşık yapıları algılamak ve doğru sonuçlar üretmek için büyük veri kümelerini analiz etmek için kullanılır. Bu yöntemler arasında, çok katmanlı perceptronlar, uzun-kısa vadeli bellekli sinir ağı ve radyal bazlı fonksiyon ağı yer almaktadır. Ayrıca, deprem tahmininde kullanılan özelliklerin seçimi, veri ön işleme, özellik mühendisliği ve doğru model seçimi gibi faktörlerin de önemli olduğu vurgulanmaktadır. Sonuç olarak, deprem zaman serisi verileri üzerinde yapay zeka tekniklerinin kullanımı, deprem riskinin tahmin edilmesinde büyük bir potansiyele sahiptir. Derin öğrenme yöntemleri, özellikle büyük veri kümeleri için daha iyi performans gösterir ve doğru model seçimi ile daha doğru sonuçlar elde edilebilir. Ancak, veri ön işleme ve özellik seçimi gibi faktörlerin de dikkate alınması gerekmektedir.

Anahtar Kelimeler: API, Veri Bilimi, Deprem.

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1. Introduction

X Time series are data sets in which data measured over a period of time is ordered in an orderly fashion. These data are often used in the economic, meteorological and social sciences. Time series analysis is used to predict future values by identifying trends and patterns of historical data.

Time series analysis uses many different mathematical methods and statistical techniques. These techniques are used to characterize time series, identify trends and fluctuations, and predict future trends [1-5].

An earthquake is an event that occurs as a result of sudden breaking of rocks in the earth's crust, releasing great energy [6]. Earthquakes can be divided into 3 classes as foreshocks, main and aftershocks. Major earthquakes are earthquakes with large destructive effects, which can cause a large energy release and subsequent relatively smaller earthquakes. Major earthquakes occur at certain periodic intervals. In this way, it allows to make predictions about when the main earthquakes may occur.

Precursor earthquakes are small earthquakes that occur before a major earthquake will occur. Thanks to the analysis of the forerunners, it can be predicted that the main earthquakes will occur and the opportunity to take early measures can be created. Aftershocks are small earthquakes that occur in nearby areas after the main earthquake.

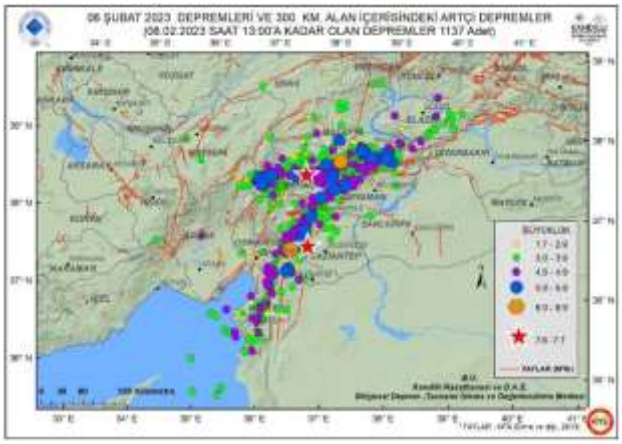

Fig. 1 Main earthquake and its aftershocks [7]

Earthquake data are examples of time series data [8]. The content of these data can be summarized as the earthquake's time, depth, intensity, region name and coordinate information.

In this study, it is aimed to prove that various analyzes of forerunner, aftershock and main earthquakes, which are difficult to obtain effectively by using various pre-processing methods, can be adapted to machine learning models, which are very advanced today, and thus can be beneficial in vital issues such as taking early precautions [9].

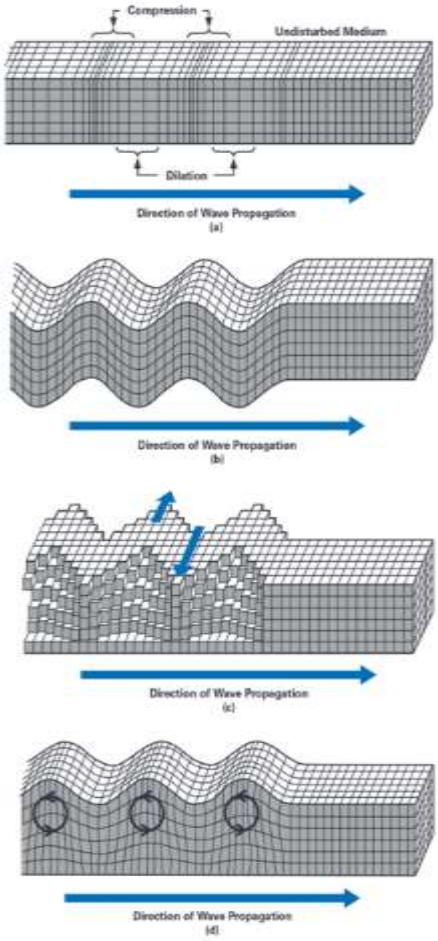

Fig. 2 Earthquake wave types [10]

2. Material and Method

In this section, the acquisition of the data set used in the study and the proposed approach are summarized under sub-titles.

2.1. Dataset

In this study, earthquake data from Kandilli observatory was used as a data source [10]. The data was obtained through the API, transferred to the SQL database and presented as CSV format as a result.

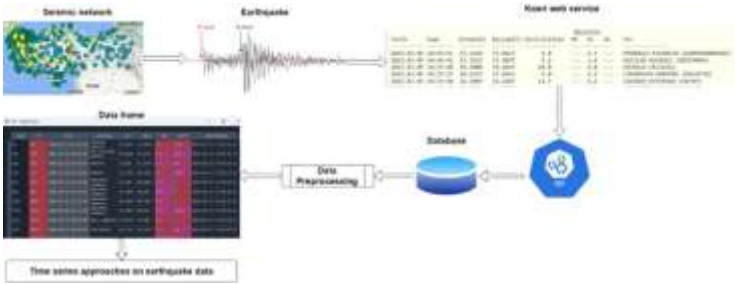

Fig. 3 Material and method pipeline of this study

2.2. Data preprocessing

• The data source is loaded into the Pandas DataFrame.

• The data source was read using the 'pd.read_csv()' function.

```
[1] import pandas as pd

from google.colab import drive
drive.mount('/content/drive')

[3] df = pd.read_csv('/content/drive/MyDrive/datasets/deprem.csv', sep=';')
```

Fig. 4 Loading earthquake dataset

2.3. Data exploration

- After the data set was added to the system as a Pandas Dataframe, it was visualized and analyzed using the 'df.head()' function.
- Requirements have been identified so that the data can be ready for use.
- The amount of data examined, missing data etc. presence of conditions has been checked

Fig. 5 Earthquake dataset as a pandas dataframe

2.4. Data preprocessing

• Earthquake intensity (MAG) data has been converted to float data format with PYTHON programming language.

• Earthquake depth (DEPTH) data has been converted to float data format with PYTHON programming language.

• Earthquake latitude (LAT) and longitude (LNG) coordinate data have been converted to PYTHON float data format.

• Earthquake date (DATE_) and record date (RECORDDATE) data have been converted in accordance with Python date data format.

2.5. Data analysis

• The data are grouped and the number of earthquakes in intensity ranges from 2005 to date has been determined.

• Python Numpy library is used to group the data.

• Python Matplotlib library is used to visualize the data [11].

2.6. Data visualization and analysis

As a result of the analysis of the data, the earthquake numbers were grouped according to their intensity and the opportunity to observe was presented. No missing data was found in the data.

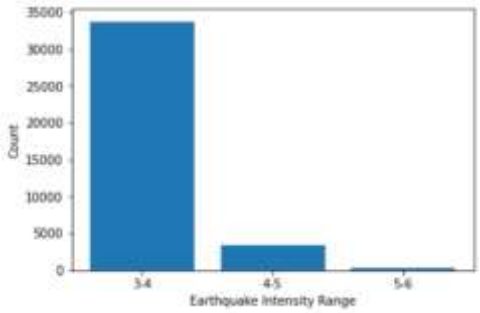

Fig. 7 Earthquakes that between 3 – 6 Mag.

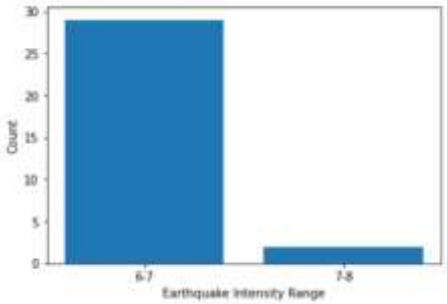

Fig. 8 Earthquakes that between 6-8 Mag.

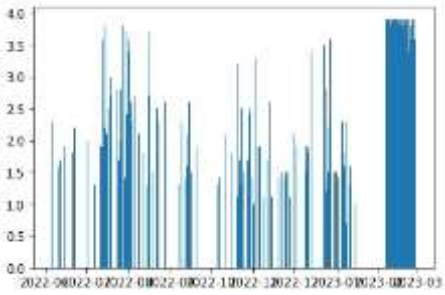

Fig. 9 Earthquake (7.7 Mag) in Kahramanmaraş/Turkey in 2023 and its frequency distributions

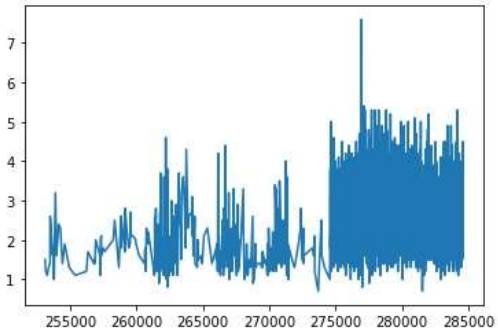

Fig. 10 7 Earthquake (7.7 Mag) in Kahramanmaraş/Turkey in 2023 and its historical line graphics

Python 3.x version was used in this study. Pandas library is used for data preprocessing steps. Matplotlib library is used to visualize data. Numpy library is used to filter data. Google Colab online notebook was used as the development environment [12].

3. Discussion and Conclusion

Earthquakes are unstoppable movements of the earth that have occurred since the formation of the earth. These movements have many parameters such as intensity, depth, location, wave type (p, s, etc.) [13]. By looking at these parameters, predictions can be made about the geological consequences of earthquakes and their effects on future earth movements.

Obtained earthquake data are examples of time series data. Time series data is frequently used in artificial intelligence model training, especially for the prediction of periodic events such as earthquakes [14].

In this study, no estimation or estimation method has been applied, but it is aimed to give information and ideas about the data that will be used or used in artificial intelligence and its sub-branches models that are planned to be developed in the future. For this purpose, the data of earthquakes that occurred in Turkey between the years 2005-2023 were obtained from the Kandilli observatory with APIs, and each data column was converted into a form that can be processed on the Python programming language. As a result, 284.615 processed data obtained were presented to the reader through figures.

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Research Article

Emerging Technologies for Fluorescence-Based Optical Test Strip Readers

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Abstract

Fluorescence-based optical test strip readers are used to detect and quantify fluorescent signals from immunoassay test strips in medicine, especially for point-of-care applications. The design of optical systems including light sources and detection systems in these devices is not only indispensable but also the most critical part for specific detection applications. This study aims to provide detailed information about fluorescence-based optical test strip readers, existing and emerging technologies, and their contributions to the design of the device. The most commonly used technologies of light sources and detection systems have been discussed and compared for the ideal design. Arc and Xenon lamps may not be appropriate for portable and low-cost devices as they are larger and more costly when compared to LEDs and laser diodes. Photodiodes and CMOS detectors can be used for the design of low-cost, portable fluorescence-based optical test strip readers as they are cheaper and smaller in size when compared to CCDs and PMTs. Both light source and detector should be chosen according to the application priorities and spectral characteristics of the fluorescent molecule by integrating them with proper optical elements like filters, mirrors, etc. This study contributes to the people who are interested in the design of fluorescence-based optical test strip readers as it serves as a guideline for the optical test strip reader systems.

Keywords: Fluorescence, test strip, optical reader, light source, light detector.

Floresan Tabanlı Optik Test Şeridi Okuyucuları için Gelişmekte Olan Teknolojiler

Öz

Floresan tabanlı optik test şeridi okuyucuları, özellikle tıpta immünoassay test şeritlerinden floresan sinyallerini algılamak ve ölçmek için kullanılır. Bu cihazlardaki ışık kaynakları ve algılama sistemlerinin tasarımı sadece vazgeçilmez değil, aynı zamanda en kritik noktadır. Bu çalışma, floresan tabanlı optik test şeridi okuyucuları, mevcut ve gelişmekte olan teknolojiler ve bunların cihazın tasarımına katkıları hakkında ayrıntılı bilgi vermeyi amaçlamaktadır. Optik okuyucunun ideal tasarımı için en yaygın kullanılan ışık kaynakları ve algılama sistemleri tartışılmış ve karşılaştırılmıştır. Ark ve Xenon lambalar, LED'ler ve lazer diyotlara kıyasla daha büyük ve daha maliyetli olduklarından dolayı, taşınabilir ve düşük maliyetli cihazlar için uygun olmayabilirler. Fotodiyotlar ve CMOS detektörler, CCD'ler ve PMT'lere kıyasla daha ucuz ve daha küçük oldukları için düşük maliyetli, taşınabilir test şerit okuyucularının tasarımı için kullanılabilirler. Işık kaynağı ve ışık detektörleri uygulama önceliklerine ve kullanılan floresan molekülün spektral özelliklerine göre, gerekli ise filtreler ile bütünleşmiş olacak şekilde seçilmelidir. Bu çalışma, optik test şeridi okuyucu sistemleri için bir rehber niteliğinde olması nedeniyle floresans tabanlı optik test şeridi okuyucularının tasarımı ile ilgilenen kişilere katkı sağlamaktadır.

Anahtar Kelimeler: Floresan, test şeridi, optik okuyucu, ışık kaynağı, ışık detektörü.

1. Introduction

Fluorescence-based optical test strip readers sense and quantify fluorescent signals from immunoassay test strips in rapid and accurate detection of target analytes at the point of care and are used for environmental monitoring, food safety [1,2], and medical diagnosis [3-8]. These devices employ fluorescence technology in detecting specific substances in a biological sample. The biological sample including a fluorescent molecule, a biological marker, or a fluorophore, is exposed to an excitation light with a specific wavelength (excitation wavelength) that causes target molecules in the sample to fluoresce depending on the spectral characteristics [9, 10]. An excited molecule emits fluorescence light with a specific wavelength (emission wavelength). The light emitted is sensed and processed to determine the presence or absence of a specific substance in the sample. A reader device typically consists of a light source, a light detector, and some optical components such as filters, and mirrors [11-13]. In this work, we provide a brief guide for the design of fluorescence-based optical test strip readers focused on the working principle, benefits, and limitations. In addition, we also discuss the details of fluorescent dyes, light sources, detectors, complementary electronic components, and their integration.

1.1. Working Principle

In a fluorescence-based optical test strip reader device, a sample is placed onto the immunoassay test strip where an interaction between the sample and the reagents takes place. This reaction produces a fluorescence signal or light that is detected by the optical system of the device. Specific wavelengths of the generated light are filtered by positioning optical components such as optical filters, mirrors, etc. [14, 15]. The idea behind fluorescent-based OTSRs is that they can detect fluorescent signals from samples that have been dyed fluorescently. These systems make use of lateral flow immunoassay test strips that house fluorescence dyes, antibodies, and reagents to deliver fluorescence emission quantifying a particular antigen or antibody in the sample [16] (Figure 1 shows a typical physical layout of a lateral flow immunoassay test strip).

A light source within the device generates light emission at a certain wavelength that excites the fluorescent dye in the sample. A detector in the device senses the light that the dye or the marker emits. Correct sensing is very important to quantify the target molecule as the amount of the target analyte in the sample immediately correlates with the produced light intensity [17-19]. In some cases, the target analyte concentration in the sample is estimated by comparing the intensity of the fluorescent signal to a reference signal [20]. Additional components such as a microcontroller, a user interface, and software for data analysis and interpretation are included in the design of optical test-strip reader devices [21]. Some devices are capable of performing several tests at once or storing and recalling test results for further analysis. The devices are commonly used for medical monitoring applications for measurements of analytes such as hormones, as well as point-of-care testing of various infections [22-24] and diseases like HIV [25], malaria [26], and diabetes [27].

1.2. Benefits

Fluorescence-based optical test strip reader devices provide several benefits, including rapid response, accuracy, sensitivity, ease of use, adaptability, and portability. Fast results allow medical practitioners to immediately analyze, and evaluate patient conditions and apply appropriate treatments to the patients earlier. Increased accuracy and specificity reduce the possibility of false positive or false negative findings. The devices can be operated by non-technical individuals. They are small in size and lightweight so they can be easily moved to the point of care. Fluorescence detection is a highly sensitive method for detecting low levels of analytes in the sample for a wide range of applications when compared to other detection methods, namely colorimetric or electrochemical. Furthermore, the method is highly selective for the target analyte, so it can identify and distinguish between different analytes even in complex sample matrices, which contributes to its enhanced use in health [28-30].

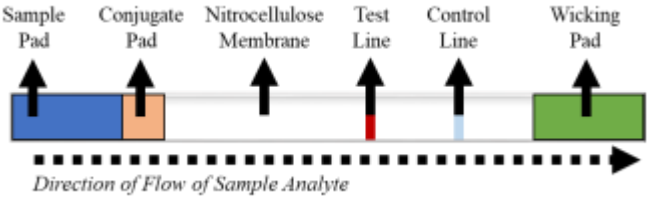

Figure 1. The physical layout of a lateral flow immunoassay test strip

1.3. Limitations

Fluorescence-based optical test strip reader devices suffer from high costs, limited wavelength range, unwanted interference, and the need for maintenance. Depending on the components included in the design, fluorescence-based optical test strip readers can be expensive. The devices may have a limited wavelength range for detection, which may limit the range of fluorescent probes or labels that can be utilized. Detections may be subject to interference from background fluorescence, autofluorescence of the sample components, and other sources of optical noise. This decreases the signal-to-noise ratio and limits the sensitivity and accuracy of the measurements. The maintenance of these optical readers can be challenging as they may require more frequent maintenance than other detection methods, including cleaning, calibration, and replacement of components like optical filters within the device. These limitations can be overcome by using emerging technologies such as optical filters produced using recent technologies [31-33].

2. Material and Method

2.1. Selection of the Fluorescent Dye

Fluorescent dyes, also known as fluorophores, are molecules that absorb light at a specific wavelength and then emit some light at a longer wavelength. There are many different types of fluorescent dyes. Rhodamine dyes (Rhodamine B, excitation/emission wavelength: 554/570 nm) which are known for their excessive illumination [34,35] and photostability [36,37] are preferred for medical imaging including fluorescence microscopy [38], flow cytometry [39] as well as diagnostic tests [40]. Cyanine dyes (Cy5, excitation/emission wavelength: 649/670 nm) are highly sensitive to changes in environmental conditions, such as changes in pH value or the presence of specific molecules, and therefore are often used in biological imaging, including live-cell imaging, and fluorescence resonance energy transfer assays [41-43]. Fluorescein dyes (excitation/emission wavelength: ~495/515 nm) are commonly preferred in optical

readers, to visualize specific biomolecules, such as proteins or nucleic acids, within a biological sample like blood, urine, etc. They are often conjugated to antibodies or other biomolecules to create fluorescent probes that can bind to specific targets in a biological sample to increase the specificity of the diagnosis. The choice of fluorescent dye depends on the application.

2.2. Design of the Optical System

A fluorescence-based optical reader device consists of a light source, some optical filters, a light detector, a sample holder, an electronic control unit, and a power supply unit. These components can be selected and integrated in different ways depending on the spectral characteristics of the fluorescent material considered [44]. Figure 2 shows the block diagram of a typical reader device.

2.2.1. Light Source

The light source plays a critical role in providing the required energy for light emission by the target molecule excited in the sample kept within the lateral flow immunoassay test strip. Common light sources are light-emitting diodes [18, 45-47] and laser diodes [48, 49]. A light-emitting diode (LED) is a solid-state, stable, and compact source producing light when a current is applied. It can be operated with low power while generating a narrow spectral range, so it is very preferable for fluorescence-based OTSRs [46]. They can facilitate the production of specific wavelength ranges to match the excitation and absorption properties of different fluorescent dyes. The possible problem with this type of light source is that commercially available LEDs are produced in narrow wavelength ranges as listed in Table 1. Although a LED can be produced to operate specific wavelengths according to the needs, the cost of production will significantly increase the cost of the reader.

Laser diodes are solid-state semiconductor devices producing highly focused and intense light. Due to their small size, high power efficiency, and ability to produce light with a specific wavelength range from the ultraviolet region (F2 excimer 157 nm) to the mid-infrared region (CO2 10.6 μm) of the spectrum, they are ideal for fluorescence-based optical test strip readers. Three main types of lasers that are gas, liquid (dye), and solid-state-based technologies can be used in specific wavelengths. They can be tuned to various wavelengths by changing the applied current, temperature, or magnetic field, but they are very expensive, which makes optical readers costly. Arc lamps are broad-spectrum light sources generating light by passing an electric current through a gas-filled container. Broad spectrum light generation by these lamps makes optical filters obligatory in optical systems, which causes higher costs for optical readers. Mercury arc lamps providing intense light in the visible range, are used in such reader devices, but additional power consumption, short lifetime, and filter necessity problems are faced. These lamps have illumination lights at different wavelengths based on their broad spectral ranges. 100 Watt mercury arc lamp is one of the types of mercury arc lamps that has unequal light emissions at nine different central wavelengths of 254, 300, 312, 334, 365, 405, 436, 546, and 579 nm. Therefore, it requires an optical filter to emit a specific wavelength of light based on the fluorescent molecule. Xenon lamps are also broad-spectrum light lamps generating light by passing an electric current through a xenon-filled container. Xenon arc lamps of 75 watts have the major light emission at wavelengths in the infrared region of the spectrum (827, 885, 919, 980, 992 nm) while the visible light (475 nm) is provided by only

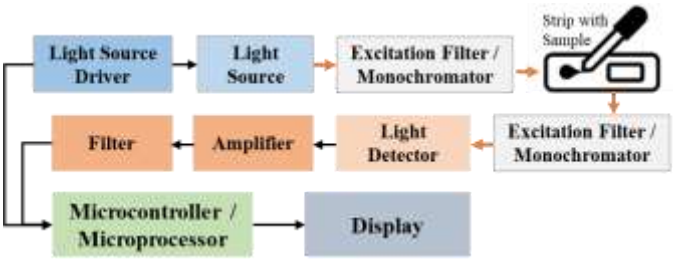

Figure 2. Block diagram of an optical reader device

Table 1. Commercial LEDs

Wavelength (nm)	Spectrum	
410 - 420	Visible (Violet)	Skin therapy
430 - 470	Visible (Blue)	Dental curing
520 - 530	Visible (Green)	Skin rejuvenation
580 - 590	Visible (Amber)	Acne treatment
630 - 640	Visible (Red)	Wound healing
660	Visible (Red)	Blood oximetry
680	Visible (Red)	Blood analysis
800 - 850	Near-Infrared	Pain management
850 - 940	Near-Infrared	Muscle recovery
940	Near-Infrared	Injury recovery

25% with unequal light intensities. Xenon arc lamps are very similar to mercury arc lamps technology, but they provide a more stable and uniform light output even though they are more expensive. These arc lamps are two popular types of lamps used in wide-field fluorescence microscopes.

Table 2 lists the advantages, disadvantages, and application areas of the light sources mentioned above. In some cases, multiple light sources can be positioned in the optical system to detect different fluorescent molecules within the sample. A well-selected light source and a well-defined excitation procedure are needed to increase the accuracy and decrease interference, cost, and size of a reader device. The light source has a significant impact on the quality of the fluorescence signal and should be selected based on the aimed excitation light intensity, and spectral characteristics of the target element.

2.2.2. Optical Filters, Lenses, and Mirrors

The optical filters, lenses, and mirrors, are used to control the light path and direct the excitation light, and produced a fluorescence signal to the detector. These elements are also utilized to decrease the impact of background light and to increase the signal-to-noise ratio. Filtering elements are passive and preferred to improve the reliability level of fluorescence-based optical reader devices. Utilization of filtering elements provides allowing a specific band of light energy to pass through to excite the sample while blocking all other remaining wavelengths. Short-pass, long-pass, and band-pass filters are the three main types of optical filters. Short-pass filters prevent longer wavelengths to be transmitted while enabling wavelengths lower than the cut-off wavelength to pass through. Long-pass filters allow the passing of longer wavelengths and block the shorter wavelengths than the cut-off value. Band-pass filters transmit a

Table 2. Comparison of light sources

Light Source	Advantage	Disadvantage	Place of Use
LED	Cost-effective Compact and stable Low power consumption Broad spectral range Long lifespan	Low light intensity Limited spectral range	General purpose OTSR Portable OTSR
Laser Diode	High light intensity Small size High power efficiency Narrow wavelength range	High Cost Requires cooling Limited spectral range	High sensitivity OTSR Laboratory-based OTSR
Arc Lamp	High light intensity Broad spectral range Wide availability	Large size High power consumption Short lifetime Requires cooling	Laboratory-based OTSR Large-scale OTSR
Xenon Lamp	High light intensity Broad spectral range Stable and uniform light	Large size High power consumption Short lifetime Requires cooling	Laboratory-based OTSR Large-scale OTSR

determined band/range of wavelengths while blocking the others. Also, a monochromator which is a narrow-band example of band-pass filters may be utilized for the filtering aim and its setting should be suitable for the absorption and emission wavelengths of the fluorescent material that is used in the experiment. It is generally used in spectrometers, but may not be affordable for cost-effective optical test strip readers. Also, a dichroic filter/ mirror can be utilized in the design of an optical reader device as it allows the passing of light at specific wavelengths while blocking all the other wavelengths. This mirror reflects specifically defined wavelengths to ensure the light path in optical systems. The filters that can be produced with different properties like wavelength, size, thickness, etc., are used for both excitation and emission light filtering purposes. Therefore, these filters are selected according to the specific wavelength which is planned to be necessary for the spectral characteristics of the target molecule. If the light spectrum of the source and fluorescence is adjusted specifically in the design, filtering elements may be optional in the instrumentation to minimize the cost of the reader device except for broad-range light sources like arc lamps.

2.2.3. Light Detector

The fluorescence light passing through the emission filter is detected by a selected detection system. For a fluorescence-based optical reader design, a detector is crucial as it is used to receive the fluorescence signal which is the main criterion of the analysis to be evaluated. In the detector, the fluorescence light intensity, which is directly proportional to the targeted material concentration, is provided as a digital readout. There are different types of detectors such as photodiodes, photomultiplier tubes, charge-coupled devices, complementary metal-oxide semiconductors, avalanche photodiodes [50], visible light detectors, and spectrometers. However, photodiodes, photomultiplier tubes, charge-coupled devices, and complementary metal-oxide semiconductors are preferred commonly [51, 52].

Photodiodes are simple photodetectors that convert light into electrical signals and are widely used in optical test strip readers due to their low cost and ease of use [53]. Photomultiplier tubes (PMTs) are highly sensitive photodetectors that amplify the fluorescence signal using a cascade of dynodes and are capable of detecting very low-intensity light, making them very applicable for highly sensitive fluorescence light occurrences. [54] They are more expensive than single photodiode detectors. Charge-coupled devices (CDDs) are known as solid-state photodetectors that detect fluorescence signals by converting light into electrical charges and are ideal for imaging applications and are capable of producing fluorescence signals with great resolution and sensitivity in a high dynamic range [55]. They are widely used in the case of image-based analysis in optical systems despite their cost and maintenance problems. Complementary Metal-Oxide Semiconductor (CMOS) sensors are solid-state photodetectors that enable detecting fluorescence signals by converting the light into electrical charges and are well-suited for low-cost, low-power fluorescence measurements and are commonly preferred in consumer-based electronics [45]. Avalanche photodiodes (APDs) are photodetectors that apply an internal gain mechanism to amplify low-intensity fluorescence signals making them ideal for highly sensitive fluorescence measurements. There are also single-photon avalanche diodes that are capable of detecting individual photons in highly sensitive fluorescence signal measurements for optical reader devices.

Table 3 lists the advantages and disadvantages of the light detectors mentioned above. The detection range of the system can be adjusted for the detection of different molecules by the inclusion of optical filters positioned in front of the detector, or detection systems with broader detection ranges are redesigned with these filters to increase the accuracy and reliability of the measurements. The choice of the detection system depends on the specific requirements of the device, including sensitivity, specificity, cost, size, and compatibility with the used fluorescence dyes.

Table 3. Comparison of light detectors

Light Detector	Advantage	Disadvantage	Place of Use
Photodiode	Low cost Simple design Widely available	Low sensitivity Low dynamic range Affected by electronic noise	Portable OTSR Low-cost OTSR
Photomultiplier tube	High sensitivity High dynamic range Capable of detecting very low light levels	Large size High cost Require high power Sensitive to electromagnetic interference	Laboratory-based OTSR Large scale OTSR
Charge-coupled device	High sensitivity High dynamic range Capable of imaging fluorescence signals Solid-state design	Large size, high cost Electronic noise Sensitive to electromagnetic interference	Imaging OTSR High-resolution OTSR
Complementary Metal-Oxide Semiconductor	Low cost Low power consumption Solid-state design Widely available	Low sensitivity Low dynamic range compared to PMTs and CCDs Affected by electronic noise	Portable OTSR Low-cost OTSR Consumer OTSR
Avalanche photodiode	High sensitivity High dynamic range Capable of detecting low light intensity Fast response time	High cost Require high power Sensitive to electromagnetic interference Open to thermal noise	Laboratory-based OTSR Large-scale OTSR

2.2.4. Complementary Electronic Components

Additional electronic components such as buttons and displays can be included in the design of these optical reader devices to improve the simplicity and ease of use for user interface and experience. Their design must be optimized to ensure that the optical test strip reader is accessible and usable for a wide range of users, including patients, healthcare professionals, and laboratory technicians [56]. The algorithm and software must be developed to analyze the obtained fluorescence signal generated by the fluorescent molecules in sample holders like test strips and to process this data to generate appropriate results. The program must be user-friendly with an easy-to-understand interface, and be capable of accurately and rapidly processing massive data.

3. Results and Discussion

In fluorescence-based optical test strip readers design, different existing fluorescence emitting elements like fluorescent dyes, detection antibodies, and other reagents can be used to achieve fluorescence generation. Among them, fluorescent dyes/fluorophores including Rhodamine, Cyanine, and Fluorescein dyes are commonly used as they provide specific detection opportunities by absorbing and emitting light at certain wavelengths. There are recent technologies utilizing these dyes for the production of fluorescent bioprobes for medical and biological imaging in medical diagnostics.

The main component of a reader device is the light source for generating the excitation light and the light detector for sensing the fluorescence light. Different technologies of light sources such as LED, Laser, Arc Lamp, and Xenon lamp, can be utilized. LEDs provide more stable light in a narrow spectral range while consuming low power for the operation that lasts longer. They are cheaper when compared to other light sources, but existing commercially available LEDs have certain bands of wavelengths (410-940 nm). Also, the light intensity of LED sources is lower than that of laser diodes. Laser diodes provide focused, intense light in both visible and infrared ranges with high power efficiency. They can be found in specific wavelengths although they are more expensive and needs additional cooling. Moreover, Arc and Xenon lamps are similar technologies providing high light intensities in a broad spectral range. Both types of lamps require specifically adjusted optical filters, larger spaces to be placed, and need more power for the operation. Xenon lamps differ from arc lamps as they provide more stable and uniform light.

Photodiodes, PMTs, CCDs, and CMOS are the most common detection technologies for use in optical readers. Photodiodes are widely available for use in optical readers since they are affordable prices. However, their response is less sensitive to light intensity and operates at lower dynamic ranges while being affected by electronic noise. The sensitivity property is much more enhanced in PMT technologies in great dynamic ranges, but those require higher costs, increased space, and more power to operate. CCDs offer the same advantages and additional imaging capabilities whereas they can be easily affected by electromagnetic interference. As another option, CMOS devices can be used as a detection system in reader devices with lower costs, but their dynamic range and sensitivity level are less than PMTs and CCDs. These drawbacks can be handled by using APDs while more costs and power consumption problems are likely to

be confronted. In the optical system, some additional elements like optical filters, mirrors, and lenses can be used to direct both excitation and emission light. Optical filters are adjusted based on the spectral characteristics of the fluorescent sample to be detected. Based on their properties, optical filters have three main types: Short-pass filters allowing shorter wavelengths to pass, Long-pass filters allowing longer wavelengths to pass, and Band-pass filters allowing a range of wavelengths to pass through the light path. For different light directions and detection purposes, these filters can be designed and created. A dichroic mirror can also be used to reflect light with specific wavelengths. All of the optical filters can be produced with different properties (like wavelength, size, thickness, etc.) with emerging technologies to increase the specificity and reliability of the optical device. Short-pass, Long-pass, and Band-pass) optical filters and dichroic mirrors can be used in fluorescence-based OTSRs. Monochromator filtering element which is more expensive can also be thought of as an alternative for the same purpose in fluorescence-based optical test strip readers.

Fluorescence-based optical test strip readers provide several benefits, but they also have certain drawbacks that should be taken into account when choosing a detection strategy for a specific application. All of these properties depend on the instrument design by selecting appropriate components to achieve an applicable and more effective diagnostic reader device. In medical applications, fluorescent dyes are often conjugated with antibodies or other biomolecules to create fluorescent probes that can bind to specific targets in a biological sample to increase the specificity of the diagnostic device. The preparation of these materials involves optimizing their stability, specificity, and sensitivity for use in the optical test strip reader. There are different types of fluorescent dyes. Among them, fluorescein dyes are beneficial for medical imaging and diagnosis, as they facilitate the detection and visualization of specific biomolecules within a biological sample. Fluorescent dye selection depends on the application priorities and the features of the optical system.

LEDs, laser diodes, arc lamps, or xenon lamps, are used as light sources in optical test strip readers. LEDs provide more stable light in a narrow spectral range while consuming low power for the operation that lasts longer than laser diodes. They can be placed in the design of cost-effective optical readers. Although they are cheaper when compared to other light sources, commercially available LEDs have certain bands of wavelengths. That means a higher budget is needed to develop LEDs in specific wavelengths. In contrast, a laser diode of a specific wavelength can be obtained easily. They can be used especially for portable fluorescence-based optical readers in which more intense excitation light is needed. Both LEDs and laser diodes are small in size as well as require less power, making them suitable for portable fluorescence-based optical test strip reader devices. Another alternative is using arc or xenon lamps in the optical reader system. They may cause more costly reader device designs with a shorter lifetime when compared to LEDs and laser diodes, so there can be some battery/charge problems for the devices. In addition to this, they are larger, so they may not be the correct choice for the portable design of an optical reader. An important difference between these lamps is that a more stable and uniform light can be achieved by the usage of xenon lamps instead of arc lamps. The selection of a light source is affected by the precise needs of the optical test strip reader, such as the desired sensitivity and specificity, the financial and physical limitations, and the compatibility with the fluorescence dyes utilized. In fluorescence-based optical test strip readers, both LED and laser diodes are frequently used as light sources, so the best option can be chosen based on the device's unique specifications.

Short-pass, long-pass, and band-pass optical filters are constructed based on their filtering principle. The correct optical filter should be selected according to the optical components like the light source, the detector, and the fluorescence-emitting material in the fluorescence-based OTSRs. For specific wavelength adjustments, a monochromator element can be placed in the light detection system, but this element is more expensive than the other filter types. A dichroic mirror can be placed to reflect the light in a wavelength range while eliminating others. These components are to maximize the signal-to-noise ratio, although they all increase the cost of the device.

The light detectors are selected regarding the purpose of use of the reader device under development. For cost-effective readers, Photodiodes or CMOS devices can be utilized, but both of them have sensitivity issues and lower dynamic ranges for a variety of measurements. PMTs, CCDs, and APDs are highly sensitive to greater dynamic ranges compared to other options. Between them, APDs provide rapid responses during analysis while PMTs can detect very low levels of light intensity. Also, CCDs are large, so they may not be suitable for portable diagnostic reader devices in general. As seen from these results, each detection technology can provide separate properties according to their usage aim. Therefore, the choice of the detection system is dependent on the specific requirements of the device, including sensitivity, specificity, cost, size, and compatibility with the fluorescence dyes used.

In this study, fluorescence-based optical test strip readers, emerging and existing technologies, their advantages and disadvantages, and contributions to the device design with their remarkable properties are discussed. This study explains, compares, and discusses different technologies for optical system design in such diagnostic readers. For these reasons, this paper will contribute to people who are interested in the practical design of fluorescence-based optical test strip readers by serving as a guideline for the design of an optical system for fluorescence-based test strip readers with emerging technologies.

4. Conclusions and Recommendations

Diagnostic fluorescence-based optical test strip readers are widely used to detect and quantify fluorescent signals from immunoassay test strips, especially in the medical area for point-of-care applications. It offers many advantages like fast readings, accuracy, portability, ease of use, sensitivity, versatility, and selectivity whereas it can be affected by interference effects in limited wavelength ranges requiring frequent maintenance. Fluorescein dyes are valuable markers for medical imaging and diagnosis, as they facilitate the detection and visualization of specific biomolecules within the test strip inserted into the reader device. Two critical issues for fluorescence-based optical test strip reader design are the light source and the light detector. For light sources, LED, laser Diode, arc lamp, and xenon lamp technologies can be utilized in the optical system. For cost-effective devices, LED light sources are suitable for excitation purpose but their light intensity is lower than the laser diodes which costs higher and needs cooling. Moreover, Arc and Xenon lamps are similar technologies providing high light intensities in broad spectral ranges, but they may not be appropriate for portable and low-cost devices as they are larger and more costly when

compared to LEDs and laser diodes. Short-pass, long-pass, and band-pass filters are the three main types of optical filters that are classified based on their filtering principle. The type of filters and mirrors should be selected according to the spectral properties of the light source, detector, and fluorescent material in the fluorescence-based optical test strip readers. For the design of the detection part, photodiodes, PMTs, CCD and CMOS are the most common detection technologies for use in optical readers. Photodiodes and CMOS devices can be used for the design of low-cost fluorescence-based optical test strip readers. Other mentioned technologies, PMTs, CCDs, and APDs, are highly sensitive to greater dynamic ranges compared to photodiodes and CMOS. Furthermore, CCDs are large, so they may not be suitable for portable readers. In the optical system, some additional components can also be utilized to achieve more reliability and specificity of the device. All of the optical components should be adjusted based on the spectral characteristics of the fluorescent molecule to be detected in the sample. These can be implemented using different methods with emerging technologies. The light sources and detection systems must be selected to maximize the sensitivity and specificity while minimizing the cost and the size of the reader device.

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Research Article

Examination of the Relationship between Existing Playground Designs and Children's Fundamental Movement Skills

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Abstract

A limited number of children receive proper physical education between the ages of 0-6 which is the main period for children to learn fundamental movement skills (FMS). In contrast to physical education opportunities, most of the children have access to neighborhood playgrounds. Proper interventions and improvements to playground designs may be the easiest and most efficient way to provide for many children to develop the FMS they need to acquire in their early years. This study aims to investigate the efficiency of the existing playground equipment and to provide an answer to the question regarding the qualification of existing playgrounds in terms of children's FMS. The method of this study consists of three main steps; the first step is to analyze the commonly used assessment tools for FMS development to generate a list of mostly assessed movement skills. The second step is to inspect the mostly preferred playgrounds in the study area and analyze every piece of equipment they have, and finally to correlate the results from the first two steps. The results reached in the study were evaluated based on the level of competence gained by playground designs in terms of providing opportunities for necessary physical movements and their support rates for basic movements. It is thought that the interpretation of the study results will provide insight and a detailed guide in the early stages of the design process for future playground designs.

Keywords: Child Development, Physical Development, Fundamental Movement Skills, Playground Equipment, Playground Design

Mevcut Oyun Alanı Tasarımları ile Çocukların Temel Hareket Becerileri Arasındaki İlişkinin İncelenmesi

Öz

Çocuklarda Temel Hareket Becerilerinin (FMS) öğrenimi için ana dönem olan 0-6 yaşları arasında ancak sınırlı sayıda çocuk uygun beden eğitimi almaktadır. Beden eğitimi fırsatlarının aksine, çocukların birçoğunun mahalle oyun alanlarına erişim imkânı vardır. Oyun alanı tasarımlarında yapılacak uygun iyileştirmeler ve müdahaleler, birçok çocuğun erken yaşlarda edinmeleri gereken FMS'yi geliştirmelerini sağlamanın en kolay ve en etkili yolu olabilir. Bu çalışma, mevcut oyun alanı ekipmanlarının çocukların FMS üzerindeki etkinliğini araştırmayı amaçlamaktadır. Bu çalışmanın yöntemi şu üç ana adımdan oluşmaktadır: İlk adım, FMS gelişimi için en yaygın olarak kullanılan değerlendirme araçlarını analiz etmektir. İkinci adım, mevcut araştırma bölgesinde en çok tercih edilen oyun alanlarını incelemek ve bu alanlarda bulunan her bir ekipmanı analiz etmektir. Son adım, ilk iki adımdan elde edilecek sonuçları birbiriyle ilişkilendirmektir. Araştırma sonuçlarına göre, mevcut oyun alanlarındaki ekipman tasarımları, temel hareketlerin çoğunu doğrudan desteklenmediği için, gerekli fiziksel hareketler için fırsatlar sağlama açısından ancak sınırlı bir yeterlilik düzeyindedir. Bu çalışma, mevcut oyun alanlarının, çocukların FMS açısından yeterliliği ile ilgili soruyu cevaplamaktadır. Gelecekteki oyun alanı tasarımları için ayrıntılı tasarım yönergeleri geliştirilebilmesi adına daha ileri çalışmaların yapılması gerekmektedir.

Anahtar Kelimeler: Çocuk Gelişimi, Fiziksel Gelişim, Temel Hareket Becerileri, Oyun Alanı Ekiplanları, Oyun Alanı Tasarımı

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1. Introduction

Fundamental Movement Skills (FMS) is an important area of study approached by researchers in a variety of fields. There are several studies in child development literature about the importance of FMS, the ways of improving these skills, and the assessment of these skills. FMS development has many different positive effects on children. Different studies show that physical activity and FMS have many beneficial effects on children's motor development (Duman et al., 2019), social and emotional development (Brown & Cairney, 2020; L. Eddy et al., 2021; Rodriguez et al., 2019), sports-specific skills (Poest et al., 1990), and brain development (Meijer et al., 2020).

Fundamental movement skills are basic movement patterns that begin developing when a child can walk independently and move freely through his or her environment (Goodway et al., 2019). In addition to that, preschool years are where kids' FMS evolve (Toussaint et al., 2020). However, FMS development is mostly applied in school settings. For the mentioned reasons, it seems to be a waste of potential to wait until a child starts school to start actively developing FMS considering that, not all children have access to preschool at an early age and not all preschool curricula involve structured FMS education.

There are also studies focusing on physical development outside of the school setting. Some of these studies point out the importance of playgrounds and the time spent in playgrounds in terms of the physical development of children. However, there is a major misconception about the development of FMS which is the belief that they are only determined by maturation (Goodway et al., 2019) On the contrary, children's performance in these skills will only increase if they engage in structured practices continuously (Seefeldt, 2013). Even if they develop these skills on their own up until some point, providing kids with the right opportunities increases their performance of development (Duman et al., 2019).

The idea of creating neighborhood playgrounds that support FMS in every aspect could be an efficient way to provide children with these skills in natural settings. When successfully applied, this approach can be a long-term, socially inclusive, and feasible solution to children's developmental needs on FMS.

Even though there are plenty of studies on the relationship between playgrounds and children's physical activity, the number of studies that focus on both FMS and playgrounds is very limited. So, this study aims to investigate the relationship between existing neighborhood playground equipment and children's FMS development to explore the usefulness of such kind of approach to FMS development and to create a reference point for future intervention on playgrounds and new playground designs.

2. Material and Method

2.1. Method

This study is conducted in 3 main steps. The first step is to identify what kinds of FMS are expected for a child to master before they reach adolescence and how relevant body parts get involved in the movements associated with these skills. The second step is to determine the types of equipment that are currently being used in the neighborhood playgrounds and analyze their movement values. The last step is to relate the outcomes from the analysis of the first two steps.

2.1.1. Determination of FMS

The focus of the literature search in the study was to determine valid FMS assessment tools and extract data from them to come up with a list of movements that are commonly assessed in children and expected to be mastered in childhood. Eddy et al.'s study (2020) gives us the necessary knowledge about existing observational FMS assessment tools and their psychometric validity. In the study, 24 assessment tools were found to be studied in the literature in terms of their reliability. The authors also identified all the FMS assessed with each tool and conducted a systematic review. In the conclusion section, the writers discuss the validity and reliability of the tools and none of the assessment tools were stated as completely reliable or unreliable. As a result, for this study, all the FSM assessment tools and the movements that were assessed in these tools (n=31) were accepted as FMS that are expected to be acquired by children. This inclusive approach was adopted to include all possible FMS in the study. A detailed list of the tools can be found in the original study (L. H. Eddy et al., 2020).

2.1.2. Analysis of FMS

All the FMS mentioned in one or more of the assessment tools were listed along with the percentage of the assessment tools with which they were assessed, and the active body parts in motion when performing that movement.

2.1.3. Playground Selection

This study was conducted in Dallas-Fort Worth Metropolitan Area and used purposeful sampling as the sampling method. To analyze the neighborhood playgrounds that are preferred and visited the most by the residents of the area, data from Google Reviews was used. 10 playgrounds or parks that have playgrounds with more than 1000 reviews and 4.5 review points were randomly selected and visited. 2 of the visited playgrounds (PG3 and PG10) did not have a separate area for 2-5 years old children, so these playgrounds were not included in the equipment analysis. The playgrounds that are included in the equipment analysis are Hope Park Frisco Playground, Cottonwood Park Playground, Bethany Lakes Park Playground, Haggard Park Playground, Bob Woodruff Park Playground, Reverchon Park Playground, Kids Quest Mesquite and Mary Heads Parker Playground. These 8 playgrounds were located in 7 different cities in Dallas-Fort Worth Metropolitan Area which are: Frisco, Richardson, Allen, Plano, Dallas, Mesquite, and Carrollton. The only city hosting 2 playgrounds was Plano, while all the other cities host only one of the selected playgrounds.

2.1.4. Analysis of the Playgrounds

Selected playgrounds were visited in person and every piece of equipment, including components of play structures, play sets, and individual apparatuses, was recorded. All 8 of the playgrounds had a separate area for kids aged between 2 to 5. Equipment that stood outside of these areas were not included in the analysis except for the ones that were also outside of the 5-12 age area and were not specifically designated for older kids. This equipment category consists of swings, seesaws, and rotation equipment.

2.1.5. Relating the Equipment with FMS

After the analysis of the FMS and the playground equipment, all the movements and types of equipment were associated with certain body parts that are actively involved in

that motion. As the first step in this stage of the study, the equipment that is directly related to a fundamental movement was stated. Then, the section "active body parts involved" were used to correlate these pieces of equipment with the FMS they are affecting indirectly. After the completion of Table 3, correlations between existing playground equipment and FMS were stated in the results section and inferences were discussed in the conclusions section.

Table 1. Summary of FMS assessed by the 24 assessment tools

Name of the FMS	Category	Percentage of tools mentioned in	Body parts in motion
Jumping	Locomotor Movement / Non-locomotor Movement	91.7% (n=22)	Lower Body (Legs)
Hopping	Locomotor Movement	91.7% (n=22)	Lower Body (Legs)
Running	Locomotor Movement	83.3% (n=20)	Lower Body (Legs)
Skipping	Locomotor Movement	41.7% (n=10)	Lower Body (Legs)
Leaping	Locomotor Movement	37.5% (n=9)	Lower Body (Legs)
Sliding	Locomotor Movement	29.2% (n=7)	Lower Body (Legs)
Bouncing	Manipulative Movement	25% (n=6)	Upper Body (Arms)
Walking	Locomotor Movement	20.8% (n=5)	Lower Body (Legs)
Rolling	Locomotor Movement	12.5% (n=3)	Whole Body (In motion)
Crawling	Locomotor Movement	12.5% (n=3)	Whole Body (In motion)
Climbing	Locomotor Movement	4.2% (n=1)	Whole Body (In motion)
Catching	Manipulative Movement	87.5% (n=21)	Upper Body (Arms)
Throwing	Manipulative Movement	79.2% (n=19)	Upper Body (Arms)
Kicking	Manipulative Movement	62.5% (n=15)	Lower Body (Legs)
Galloping	Locomotor Movement	42% (n=10)	Lower Body (Legs)
Striking	Manipulative Movement	33% (n=8)	Upper Body (Arms)
Dribbling	Manipulative Movement	17% (n=4)	Whole Body (In motion)
Hitting	Manipulative Movement	8.3% (n=2)	Upper Body (Arms)
Dodging	Locomotor Movement	8.3% (n=2)	Lower Body (Legs)
Underarm rolling	Manipulative Movement	4.2% (n=1)	Upper Body (Arms)
Dynamic Balance	Balance	29.2% (n=7)	Whole Body (Coordination)
Static Balance	Balance	25% (n=6)	Whole Body (Coordination)
Sitting	Posture	4.2% (n=1)	N/A
Standing	Posture	4.2% (n=1)	N/A
Bending	Non-locomotor Movement	4.2% (n=1)	Whole Body (Coordination)
Stretching	Non-locomotor Movement	4.2% (n=1)	Selected Body Part
Twisting	Non-locomotor Movement	4.2% (n=1)	Selected Body Part
Turning	Non-locomotor Movement	4.2% (n=1)	Whole Body (Coordination)
Swinging	Non-locomotor Movement	4.2% (n=1)	Whole Body (Coordination)
Stopping	Posture	4.2% (n=1)	N/A
Carrying	Manipulative Movement	4.2% (n=1)	Upper Body (Arms)

Table 2: Investigated playgrounds and the types of equipment they have

Name of the Playground	Code	Location	Types of equipment
Hope Park Frisco	PG1	Frisco, TX	Hanging equipment (n=1) Tunnel (n=2) Balance equipment (n=1) Unstable or angled bridge (n=2) Horizontal slide (n=1) Steering wheel (n=6) Crawl circle (n=5) Slide (n=2)

			Stairs (n=5) Ramp/stable bridge (n=6) Swing (n=4)
Cottonwood Park	PG2	Richardson, TX	Balance equipment (n=4) Steering wheel (n=1) Slide (n=4) Stairs (n=3) Ramp/stable bridge (n=4) Swing (n=7) Seesaw (n=1) Rotation equipment (n=2) Tenpin push (n=2) Climber (n=3)
Bethany Lakes Park	PG4	Allen, TX	Tunnel (n=1) Horizontal slide (n=1) Rotation equipment (n=1) Slide (n=2) Stairs (n=2) Swing (n=5) Crawl circle (n=5) Climber (n=3)
Haggard Park	PG5	Plano, TX	Unstable or angled bridge (n=2) Steering wheel (n=2) Crawl circle (n=1) Slide (n=3) Stairs (n=3) Swing (n=4) Climber (n=3)
Bob Woodruff Park	PG6	Plano, TX	Steering wheel (n=1) Slide (n=2) Stairs (n=4) Ramp/stable bridge (n=1) Swing (n=5)
Reverchon Park	PG7	Dallas, TX	Balance equipment (n=2) Steering wheel (n=1) Tunnel (n=1) Slide (n=2) Stairs (n=1) Ramp/stable bridge (n=3) Swing (n=6) Climber (n=1)
KidsQuest - DeBusk	PG8	Mesquite, TX	Crawl circle (n=1) Slide (n=2) Stairs (n=2) Swing (n=7) Climber (n=3)
Mary Heads Carter Park	PG9	Carrollton, TX	Balance equipment (n=2) Free column (n=1) Steering wheel (n=1) Rotation equipment (n=2) Tunnel (n=1) Slide (n=2) Stairs (n=3) Swing (n=5) Climber (n=1)

Table 3: List of equipment and their relationship with FMS mentioned in Table 1.

Type of the Equipment	Used Playgrounds	Percentage of Playgrounds Used	Percentage in All Equipment in All Playgrounds	Type of Movement	FMS Affected Directly	FMS Affected Indirectly
Hanging Equipment	PG1 (n=1)	12.5% (n=1)	0.6% (n=1)	Upper Body (Arms)	N/A	Bouncing Catching Throwing Striking Underarm Rolling Hitting Carrying
Balance Equipment	PG1 (n=1) PG2 (n=4) PG7 (n=2) PG9 (n=2)	50% (n=4)	5.4% (n=9)	Whole Body (Coordination)	Dynamic Balance	Static Balance Bending Turning Swinging
Unstable or Angled Bridge	PG1 (n=2) PG5 (n=2)	25% (n=2)	2.4% (n=4)	Whole Body (Coordination)	Dynamic Balance	Static Balance Bending Turning Swinging
Horizontal Slide	PG1 (n=1) PG4 (n=1)	25% (n=2)	1.2% (n=2)	Upper Body (Arms)	N/A	Bouncing Catching Throwing Striking Hitting Carrying Underarm Rolling
Steering wheel	PG1 (n=6) PG2 (n=1) PG5 (n=2) PG6 (n=1) PG7 (n=1) PG9 (n=1)	75% (n=6)	7.2% (n=12)	Upper Body (Arms)	N/A	Bouncing Catching Throwing Striking Hitting Carrying Underarm Rolling
Crawl circle	PG1 (n=5) PG4 (n=5) PG5 (n=1) PG8 (n=1)	50% (n=4)	7.2% (n=12)	Upper Body (Arms) Lower Body (Legs)	Crawling	Rolling Climbing Dribbling
Slide	PG1 (n=2) PG2 (n=4) PG4 (n=2) PG5 (n=3) PG6 (n=2) PG7 (n=2) PG8 (n=2) PG9 (n=2)	100% (n=8)	11.4% (n=19)	Whole Body (Coordination)	N/A	Dynamic Balance Static Balance Bending Turning Swinging

Stairs	PG1 (n=5) PG2 (n=3) PG4 (n=2) PG5 (n=3) PG6 (n=4) PG7 (n=1) PG8 (n=2) PG9 (n=3)	100% (n=8)	13.8% (23)	Lower Body (Legs)	N/A	Jumping Hopping Running Skipping Leaping Sliding Walking Kicking Galloping Dodging
Swing	PG1 (n=4) PG2 (n=7) PG4 (n=5) PG5 (n=4) PG6 (n=5) PG7 (n=6) PG8 (n=7) PG9 (n=5)	100% (n=8)	25.7% (n=43)	Whole Body (Coordination)	Swinging Bending	Dynamic Balance Static Balance Turning
Ramp/Stable Bridge	PG1 (n=6) PG2 (n=4) PG6 (n=1) PG7 (n=3)	50% (n=4)	8.4% (n=14)	Lower Body (Legs)	Walking Running	Jumping Hopping Skipping Leaping Sliding Kicking Galloping Dodging
Seesaw	PG2 (n=1)	12.5% (n=1)	0.6% (n=1)	Whole Body (Coordination)	N/A	Dynamic Balance Static Balance Bending Turning Swinging
Rotation Equipment	PG2 (n=2) PG4 (n=1) PG9 (n=2)	37.5% (n=3)	3% (n=5)	Whole Body (Coordination)	N/A	Dynamic Balance Static Balance Bending Turning Swinging
Tenpin Push	PG2 (n=2)	12.5% (n=1)	1.2% (n=2)	Upper Body (Arms)	Hitting	Bouncing Catching Throwing Striking Carrying Underarm Rolling
Tunnel	PG1 (n=2) PG4 (n=1) PG7 (n=1) PG9 (n=1)	50% (n=4)	3% (n=5)	Upper Body (Arms) Lower Body (Legs)	Crawling	Rolling Climbing Dribbling
Free Column	PG9 (n=1)	12.5% (n=1)	0.6% (n=1)	Whole Body (Coordination)	Static Balance Jumping	Dynamic Balance Bending Turning Swinging
Climber	PG2 (n=3) PG4 (n=3) PG5 (n=3) PG7 (n=1) PG8 (n=3) PG9 (n=1)	75% (n=6)	8.4% (n=14)	Upper Body (Arms) Lower Body (Legs)	Climbing	Rolling Crawling Dribbling

Table 4: Body parts in motion related to FMS and playground equipment.

Body Parts in Motion	FMS	Percentage of FMS	Equipment Type	Percentage of Equipment Type
Upper Body	Bouncing Catching Throwing Striking Hitting Carrying Underarm Rolling	22.6% (n=7)	Hanging Equipment Horizontal Slide Steering wheel Tenpin Push	25% (n=4)
Lower Body	Jumping Hopping Running Skipping Leaping Sliding Walking Kicking Galloping Dodging	32.25% (n=10)	Stairs Ramp/Stable Bridge	12.5% (n=2)
Whole Body (Coordination)	Dynamic Balance Static Balance Bending Turning Swinging	16.1% (n=5)	Balance Equipment Unstable/Angled Bridge Slide Swing Seesaw Rotation Equipment Free Column	43.75% (n=7)
Whole Body (In Motion)	Rolling Crawling Climbing Dribbling	12.9% (n=4)	Climber Tunnel Crawl circle	18.75% (n=3)
Selected Body Part	Stretching Twisting	6.45% (n=2)	N/A	
None	Sitting Standing Stopping	9.7% (n=3)	N/A	

3. Results and Discussion

3.1. Results

3.1.1. The Analysis of FMS

A total number of 31 fundamental movement skills were assessed by the 24 assessment tools according to Eddy et al.'s study (2020). 29% of them (n=9) were manipulative (object control) skills, 35.5% of them (n=11) were locomotor skills, 16.1% of them (n=5) were non-locomotor skills, 3.2% of them (n=1) were locomotor or non-locomotor depending on the action type, 6.45% of the movements (n=2) were balance skills and 9.7% (n=3) were postures. The 9 manipulative movements mentioned are: bouncing, catching, throwing, kicking, striking, dribbling, hitting, underarm rolling, and carrying. The 11 locomotor skills are: hopping, running, skipping, leaping, sliding, walking, rolling, crawling, climbing, galloping, and dodging. The 5 non-locomotor skills are: bending, stretching, twisting, turning, and swinging. The only movement that can be eighter locomotor or non-locomotor is jumping since it can be jumping at a fixed point or from one point to another. The 2 balance skills are dynamic balance and static balance. Finally, the 3 skills that are categorized as posture are: sitting, standing, and stopping.

Another categorization for FMS was based on the body parts that are actively involved in the action. This section has 4 categories as follows: lower body, upper body, whole body in

motion, and whole body in coordination. “Lower body actions” are mostly associated with legs, while “upper body actions” are mostly associated with arms. “Whole body in motion” actions are the ones where both lower and upper body parts are in use. The “whole body in coordination” skills are the ones where there is no dominantly active body part and all body parts work together to keep the state of the body. The movements that were categorized as “upper body” are: bouncing, catching, throwing, striking, hitting, carrying, and underarm rolling. These skills are also all categorized as manipulative skills. The “lower body” category consists of jumping, hopping, running, skipping, leaping, sliding, walking, kicking, galloping, and dodging. Most of these skills are locomotor, one of them is manipulative, and one of them is eighter locomotor or non-locomotor. The “whole body in motion” skills are rolling, crawling, climbing, and dribbling, 3 of which are locomotor, and one is a manipulative movement. The “whole body in coordination” skills are dynamic balance, static balance, bending, turning, and swinging. The first two are balance skills and the others are non-locomotor skills. Stretching and twisting are the ones that make up the “selected body parts” category, and these movements are both non-locomotor movements. The 3 remaining movement skills are sitting, standing, and stopping for which there is no specific body part in the action. These are also the only ones that are counted as “posture skills”.

3.1.2. Analysis of the Playground Equipment

The 8 playgrounds out of 10 visited playgrounds met the criteria of having a separate play area for children aged between 2-5. All these 8 playgrounds were investigated and a total number of 167 apparatus and play structure components were identified. These apparatus/components consist of 16 types of equipment. These are slide, swing, hanging equipment, balance equipment, unstable or angled bridge, horizontal slide, steering wheel, crawl circle, ramp or stable bridge, seesaw, rotation equipment, tenpin push, tunnel, free column, and climber.

In the first playground (PG1), 11 types and 35 pieces of equipment were identified. In PG2, there were 10 types and 31 pieces of equipment. There were 8 types and 20 pieces of equipment for PG4, 7 types and 18 pieces of equipment for PG5, 5 types and 13 pieces of equipment for PG6, 8 types and 17 pieces of equipment for PG7, 5 types and 15 pieces of equipment for PG8, and 9 types and 18 pieces of equipment for PG9. Types and numbers of the equipment are shown in table 2.

As can be interpreted from table 3, swings, stairs, and slides are the 3 types of equipment that were found in all 8 playgrounds. Steering wheels and climbers were found in 75% of the playgrounds (n=6). Balance equipment, holes for crawling, ramp/stable bridge, and tunnel were found in half of the playgrounds (n=4). Rotation equipment was the only one with a rate of 37.5% (n=3). Unstable/angled brides and horizontal slides were found in 25% of the total playgrounds (n=2). Finally, hanging equipment, seesaw, tenpin push, and the free column was found in only one of the playgrounds which gives them a rate of 12.5% among all playgrounds.

Swings were the mostly encountered equipment with a rate of 25.7% among all pieces of equipment (n=43). Following that, stairs with 13.8% (n=23), slides with 11.4% (n=19), ramp/stable bridges and climbers with 8.4% (n=14), steering wheels and holes for crawling in with 7.2% (n=12), balance equipment with 5.4% (n=9), tunnels and, rotation equipment with 3% (n=5), horizontal slides and tenpin push with 1.2% (n=2), and finally hanging equipment, seesaws, and free columns dominated only 0.6% of all pieces of equipment as there were only one for each.

The “lower body” category for playground equipment consists of stairs and ramps/stable bridges which are the equipment that makes kids use their legs actively, while the “upper body” category is made of hanging equipment, horizontal slide, steering wheel, and tenpin push and these are the ones that require mostly arm movement. Balance equipment, unstable/angled bridge, slide, swing, seesaw, rotation equipment, and free column are under the “whole body coordination” category. Climber, tunnel, and crawl circle are kinds of equipment that require upper and lower body action at the same time. For this reason, they were included in the “whole body in motion” category. In contrast to FMS, there was no playground equipment under the categories of “selected body parts” and “none”. The reason for that is all the equipment required a certain movement to be played.

Most of the equipment was titled “whole body coordination” (43.75%, n=7). While 25% of them (n=4) are upper body equipment, 18.75% of them (n=3) are “whole body in motion”, and only 12.5% of them (n=2) are lower body equipment. This shows us that playground equipment is mostly focused on whole body coordination and features for improving lower body skills are lacking compared to the upper body skills and the skills that require both lower and upper body motion.

4. Conclusions and Recommendations

4.1. Conclusions

The findings show that 56.25% of the equipment types (n=9) are directly related to at least one FMS. 6 of these are related to only one FMS, which are balance equipment, unstable/angled bridge (related to dynamic balance skill), crawl circle and tunnel (related to crawling), tenpin push (related to hitting), and climber (related to climbing). 3 of the equipment types are directly related to 2 different FMS and this is the most FMS a single type of playground equipment is related to. These are swing (related to swinging and bending), ramp/stable bridge (related to walking and running), and free column (related to static balance and jumping).

The remaining 7 types of equipment (43.75% of all types) are not related directly to any FMS. These types of equipment are hanging equipment, horizontal slide, steering wheel, slide, stairs, seesaw, and rotation equipment. Even though these types of equipment are not providing the same movement as any FMS, they do help children improve some of their muscles and bones. Each type of equipment was related to some body parts that are supposed to be used when interacting with that equipment, and those parts of the body get closer to the level where the child can perform some FMS related to the same body parts. The types of equipment and their indirect relation are shown in table 3.

Only 10 of the 31 FMS are directly related to playground equipment usage. These FMS are dynamic balance, static balance, crawling, swinging, bending, walking, running, hitting, jumping, and climbing. 16 of them are related to the equipment indirectly. These are bouncing, catching, throwing, striking, underarm rolling, carrying, turning, hopping, skipping, leaping, sliding, kicking, galloping, rolling, dodging, and dribbling. Stopping, twisting, stretching, standing, and sitting are the movements that do not fall into both categories.

4.2. Limitations

This study only covers the FMS that are included in the assessment tools that are reviewed by Eddy et al. (2020) in their study. There might be more FMS, not listed in any of these tools that also need to be considered in playground settings.

The other limitation of this study is that only primary usage of the playground equipment was related to FMS. Even though these are the most popular uses of the equipment, kids always find creative ways to interact with the object. A type of equipment might be designed for sliding; however, some kids may prefer to use it as a climber and use different parts of their body. The design of the current study did not allow for the assessment of such possible uses of the playground equipment.

Another limitation is that kids tend to play with kinds of equipment that are not designed for their age. A four-year-old child might prefer to play in older kids' areas every time they go to the playground and may not interact with the equipment designed for their age. Even though this was a limitation in some way, it does not contradict the aim of the study, as this study focuses on the improvement of 2–5-year-old kids' playground area itself, and not just in comparison to 5-12 years olds'.

4.3. Implications

This study shows that there is a valid relationship between playground equipment and children's fundamental movement skills. Some of the FMS are already supported by existing equipment and the remaining FMS can be implemented in future or existing playgrounds. Further studies on the relationship between FMS and playground equipment and relevant interventions to the playgrounds may contribute to creating easy and feasible opportunities for most of the children who have access to a neighborhood playground. Findings of this study demonstrating the relationship between given playground equipment and the FMS incorporated by each may serve as a reference point for future playground designs. Moreover, results identifying the FMS that are not supported directly by any of the playground equipment offer a promising area of investigation for future playground design research.

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Research Article

Microstrip Patch Antenna Array Design for RF Energy Harvesting Applications

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Abstract

In recent years, with the rapid developments in the field of technology and the development of wireless communication systems; led to a noticeable increase in the number of portable, rechargeable and low-power devices. These electronic devices have become a necessity even in our simplest works, due to the increase in their number and variety; It is desired that the energy needs can be met continuously and quickly at a low cost. Batteries, which are non-renewable generators, provide the energy required for such low-power devices in the world. The increase in the tendency towards non-renewable energy sources leads to negative environmental and economic consequences. Therefore, it becomes important to turn to renewable energy sources and to work on it. Energy harvesting systems, which are an innovative energy source, are the best potential alternatives to collect the energy needed by the mentioned low-power devices. With the increase of different frequency bands such as GSM 900, GSM 1800, UMTS, 3G, Wi-Fi, Wi-Max and LTE, RF energy harvesting is becoming quite common. In this paper, a printed multiband microstrip patch antenna is presented. Antenna design covers numerically calculated frequencies of 1.6dBi at 2.4GHz, 3.95dBi at 5.2GHz, gain values, and frequencies often used for electronic device communication such as Wi-Fi 2.4GHz and WiMAX. The proposed antenna design has allowable gain values to be used for RF energy harvesting applications.

Keywords: RF Energy Harvesting, Antenna Design, Microstrip Patch Antenna, Array Antenna, Low Power Application

RF Enerji Hasatlama Uygulamaları için Mikroşerit Dizi Anten Tasarımı

Öz

Son yıllarda teknoloji alanındaki hızlı gelişmeler ve kablosuz iletişim sistemlerinin de geliştirilmesiyle; taşınabilir, şarj edilebilir ve düşük güçlü cihazların sayısında gözle görülebilir bir artışa neden olmuştur. Bu elektronik cihazlar en basit işlerimizde dahi ihtiyaç haline gelmiş olup, sayılarının ve çeşitlerinin artması nedeniyle; enerji ihtiyacının düşük maliyetle, sürekli ve hızlı bir şekilde karşılanabilir olması istenmektedir. Dünyada bu tarz düşük güç tüketen cihazlara gereken enerjiyi genellikle yenilenemeyen üreteç olan piller sağlamaktadır. Yenilenebilir enerji kaynaklarına yönelmek ve bunun üzerine çalışmalar yapmak önemli hale gelmektedir. Bahsedilen düşük güçlü cihazların ihtiyacı olan enerjinin toplanabilmesi için yenilikçi bir enerji kaynağı olan enerji hasatlama sistemleri en iyi potansiyel alternatiflerdir. GSM 900, GSM 1800, UMTS, 3G, Wi-Fi, Wi-Max ve LTE gibi farklı frekans bantlarının artmasıyla birlikte RF enerji hasadı oldukça yaygın hale gelmektedir. Bu yazıda, basılı birçok bantlı mikroşerit yama anteni sunulmaktadır. Anten tasarımı, sayısal olarak hesaplanan 2,4 GHz'de 1,6 dBi, 5,2 GHz'de 3,95 dBi frekansları, kazanç değerlerini ve genellikle Wi-Fi 2,4 GHz ve WiMAX gibi elektronik cihaz iletişimi için kullanılan frekansları kapsar. Önerilen anten tasarımı, RF enerji hasatlama uygulamaları için kullanılmasına izin verilen kazanç değerlerine sahiptir.

Anahtar Kelimeler: RF Enerji Hasatlama, Anten Tasarımı, Mikroşerit Yama Anten, Dizi Anten, Düşük Güç Uygulamaları

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1. Introduction

With the development of wireless communication systems and their enrichment in terms of content, these technologies have been widely used and become widespread. Today, with the rapid development of technology, the problem of finding a reliable and sustainable energy source for wireless communication devices has been encountered [1]. In this paper, radio frequency energy harvesting systems have become promising solutions to power next generation wireless networks such as wireless sensors, autonomous internet of things (IoT), wireless communication devices [2]-[3]. In urban areas, there are many radio frequency energy sources such as television broadcasting, mobile phone signals and wireless networks [4]. Thus, there is a huge amount of electromagnetic energy in the environment and if this energy is collected, it can be used in low-power devices [5]. RF wireless power providers are the best potential alternatives for devices that help these devices run smoothly. Under favour of RF energy harvesting systems, some of the energy can be collected and converted into usable DC voltage.

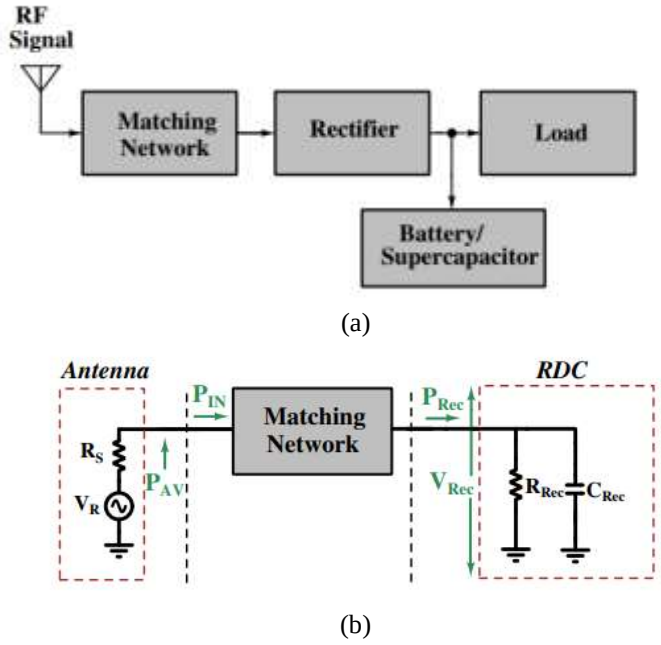


Fig. 1 RF energy harvesting system. (a) Simplified block diagram and (b) its equivalent circuit representation [6].

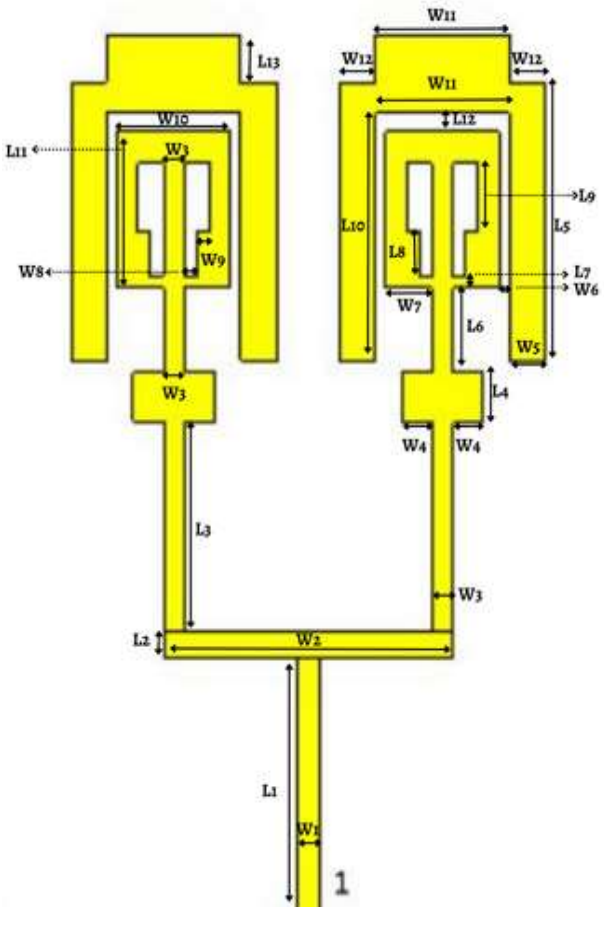
Radio frequency energy harvesting using electromagnetic waves to power such systems is becoming widespread with the increase of different frequency bands such as GSM 900 (925–960), GSM 1800 (1805–1880), UMTS (1920-1980) (2110–2170), LTE (2620–2690), Wi-Max (3400-3800) and Wi-Fi (2400-2495) (5150-5850) which used in communication [3]-[7]. Wireless energy, can be harvested using a suitable rectenna system. Rectennas consists of microstrip antenna, matching circuit, rectifier and low pass filter. The rectifier converts the RF power to a DC voltage. A resistor is usually connected as a load to the output of the rectifier to obtain the DC voltage. Proper matching with the rectifier should be made to increase the conversion efficiency.

Microstrip antenna is the most preferred antenna for energy harvesting due to its advantages such as small size, light weight and ease of manufacture [8]. To improve the demanding power requirements of the RF energy harvesting system, multiband and broadband antennas have been explored for practical options regarding efficiency. A multi-band and broadband receiving antenna is expected to efficiently collect energy from simultaneously available frequency bands in the real environment.

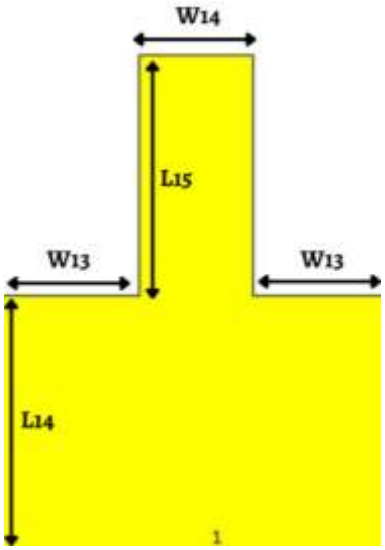
In this study, a microstrip patch antenna was designed for RF energy harvesting systems. In section II, the methods used in antenna design and antenna parameters are explained. The simulation results of the designed antenna are shown and discussed in section III. In section IV, the conclusion of the study is summarized.

2. Material and Method

The most common in wireless transmission technologies, especially in microwave systems, is the microstrip patch antenna because of its characteristics. They provide high performance and low cost in production [9]-[10]. For these reasons, microstrip patch antenna was used in antenna design for RF energy harvesting. In this study, microstrip fed antenna was used as the feeding technique. In this report, a dual-band microstrip patch antenna operating at 2.4GHz and 5.2GHz frequencies was designed and simulated for use in RF energy harvesting systems. The proposed antenna is fabricated on a low cost FR4 substrate with a thickness (h) of 1.6 mm. Annealed copper is used as ground and patch materials with 0.035 mm thickness. The designed antenna has compact dimensions of 28mm x 47mm. Antenna layout is shown in the Fig. 3 and its design was carried out with the numerical calculation program.



(a)



(b)

Fig. 2 (a) Front and (b) Back of the microstrip antenna

A dual-band microstrip antenna for RF energy harvesting is presented in [11]. Based on the proposed microstrip antenna geometry, a two-slot microstrip antenna was designed. The microstrip feed line can be thought of as a patch extension and can be easily matched by adjusting the inset feed position; however, it increases the substrate thickness and limits the bandwidth [11]-[12]. In this study, based on references, inset feeding and stub were tried and improvement was observed in S11 results. Radiated harmonics can be controlled using a stub in the feed line.

In order to improve the gain values of the additionally designed antenna, the antenna is turned into an array antenna.

Table 1. Parameters of the Proposed Antenna.

Par.	Value (mm)	Par.	Value (mm)	Par.	Value (mm)
W1	1	W11	5.9	L7	0.5
W2	12.7	W12	1.6	L8	1.9
W3	0.9	W13	10	L9	2.8
W4	1.4	W14	8	L10	10.3
W5	1.6	L1	10.8	L11	6.5
W6	1	L2	1	L12	1.5
W7	2	L3	8.8	L13	2
W8	0.6	L4	2	L14	18.5
W9	0.5	L5	11.5	L15	17
W10	5	L6	3.5		

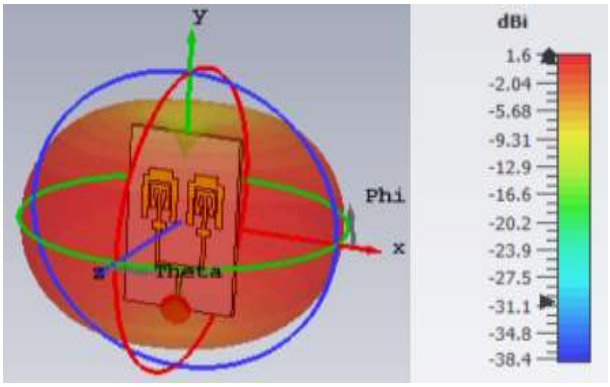
3. Results and Discussion

3.1. Results

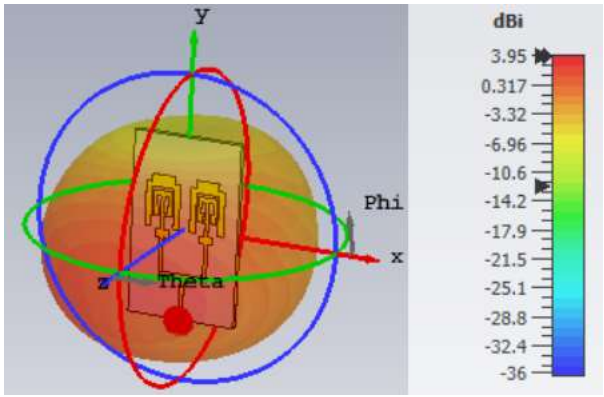
According to the simulation results, when the S1,1 properties of the antenna are examined, it is seen that it resonates at 2.4GHz and 5.2GHz frequencies. The reflection coefficient of proposed antenna are -20.6dB for 2.4GHz, -16dB for 5.2GHz. Bandwidths of the antenna are 340.5MHz (2.2961GHz-2.6366GHz), 293.4MHz (5.0606GHz-5.354GHz) respectively.

In addition, 3D radiation patterns and gains for 2.4GHz and 5.2GHz are given in Figure 4 (a, b).

Fig. 3 S11 graph of proposed antenna



(a)



(b)

Fig. 4 Simulated 3D Radiation Pattern and Gain of the Proposed Antenna (a) 2.4GHz (b) 5.2GHz

Table 2. Gain, S11 and Efficiency values of proposed antenna

Frequency	Gain (dBi)	S11 (dB)	Rad. Effic.	Tot. Effic.
2.4GHz	1.6dBi	-20.6dB	%81	%80
5.2GHz	3.95dBi	-16dB	%69	%67

3.2. Discussion

With the rapid development of technology, many wireless systems emit electromagnetic energy to the environment. A large part of this emitted energy is faded away before it reaches its target, and antenna studies aiming at the recovery of ambient energy ensure that this problem is effectively eliminated. In addition, for the design of the wireless communication network, providing the energy to replace the battery or charge the battery from the environment, that is, to be a renewable energy source, will be the most appropriate solution in terms of both cost and environment.

4. Conclusions and Recommendations

This study presents a step-by-step procedure for the design and optimization of a two-band microstrip patch antenna in Wi-Fi 2.4GHz and WiMAX bands for RF energy harvesting applications. The optimized antenna has two resonant frequencies of 2.4GHz and 5.2GHz, covering various media communication networks and systems. The simulation results show that the antenna gains 1.6dBi and 3.95dBi at the resonant frequencies, respectively. The designed antenna has satisfactory parameter values such as bandwidth, VSWR and reflection coefficient. As a result, it can be used in RF energy harvesting applications with the designed antenna combiner, rectifier and matching circuits. Thus, the antenna can be a source of energy to power low-power electronic devices

5. Acknowledge

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Research Article

Drimaren Orange Boyar Maddesinden Renk Gideriminde Tuz Türü ve Konsantrasyonun etkisi

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Öz

Bu çalışmada son yıllarda endüstrilerde sıklıkla kullanılmakta olan boyar maddelerden renk gideriminin ve sistemin elektrik tüketiminin incelenmesi amaçlanmıştır. Boyar madde olarak Drimaren Orange tercih edilmiştir. Elektrooksidasyon yöntemi kullanılarak yapılan çalışmalarda tuz türü olarak NaCI, KCI, $NaNO_3$ ve Na_2SO_4 kullanılmıştır. 2.5, 5, 7.5 ve 10 mM tuz konsantrasyonlarında 1 saatlik denemelerde çalışmalar gerçekleştirilmiştir. Tuz türünün etkisini incelemek için yapılan çalışmalar 1 amper akımda, 250 mg/L kirletici madde konsantrasyonu, 5 mM NaCI ve 200 rpm karıştırma hızında atıksuyun doğal pH değerinde gerçekleştirilmiştir. İncelenen sonuçlarda en verimli elektrolitin %98.91 verimle KCI olmuştur. Bunu %93.35 verimle NaCI, %84.79 verimle $NaNO_3$ ve %79.12 verimle Na_2SO_4 izlemiştir. Tuz konsantrasyonu etkisi için yapılan çalışmalarda tüm konsantrasyonlar için %99 üzerinde verimler elde edilmiş ve etkili giderim sağlandığı görülmüştür. Elektrik tüketimi etkisini incelemek için yapılan çalışmalarda destek elektrolit konsantrasyonu arttıkça elektrik tüketiminin azaldığı görülmüştür. Farklı elektrolitlerin elektrik tüketiminde ise renk giderim verimleri ile ters orantılı sonuçların olduğu görülmüştür. En yüksek verim elde edilen KCI elektrolitinde en düşük elektrik tüketimi gözlemlenmiştir.

Anahtar Kelimeler: Atıksu Arıtımı, Drimarine Orange, Tuz Türü, Renk Giderimi, Enerji Tüketimi.

Effect of Supporting Electrolyte Type and Concentration on Color Removal from Drimaren Orange Dyestuff

Abstract

In this study, it is aimed to examine the color removal of dyestuffs that have been used frequently in industries in recent years and the electricity consumption of the system. Drimaren Orange was preferred as the dyestuff. In studies using electrooxidation method, NaCl, KCl, $NaNO_3$ and Na_2SO_4 were used as salt types. Studies were carried out in 1-hour trials at 2.5, 5, 7.5 and 10 mM salt concentrations. Studies to examine the effect of salt type were carried out at 1 ampere current, 250 mg/L pollutant concentration, 5 mM NaCl and 200 rpm mixing speed at natural pH value of wastewater. In the results examined, the most efficient electrolyte was KCl with 98.91% efficiency. This was followed by NaCl with 93.35% yield, $NaNO_3$ with 84.79% yield and Na_2SO_4 with 79.12% yield. In the studies carried out for the effect of salt concentration, efficiencies above 99% were obtained for all concentrations and it was observed that effective removal was achieved. In studies conducted to examine the effect of electricity consumption, it has been observed that as the support electrolyte concentration increases, the electricity consumption decreases. In the electricity consumption of different electrolytes, it was observed that the results were inversely proportional to the color removal efficiencies. The lowest electricity consumption was observed in the KCl electrolyte with the highest efficiency.

Keywords: Wastewater Treatment, Drimarine Orange, Type Of Salt, Decolorization, Energy Consumption.

1. Giriş

Dünya çapında artan su kıtlığı bu kaynakların korunması için kısıtlayıcı çevre politikalarının benimsenmesini gerekli kılmıştır. Tatlı su kaynaklarının mevcut durumu azalırken tekstil endüstrisi gibi yoğun su kullanımı olan endüstrilerde kısıtlama oluşturmaktadır. Bunun için endüstrilerin yeni su yönetim stratejileri benimsemesi gerekmektedir (Pinto et al., 2022). Daha etkili bir kaynak yönetimi için arıtılmış atıksuyun yeniden kullanımı AB su politikasında bu konuda etkili bir önlem olarak vurgulanmıştır (Directors, 2016). Endüstriyel üretimde dünya çapında 10 bin farklı boya ve pigment türünün kullanıldığı ve 700 bin ton sentetik boyanın üretildiği tahmin edilmektedir (Chequer et al., 2013; Keyikoğlu, 2018). Diğer kimyasalların yanı sıra güneş ışığı altında yüksek stabilite ve mikrobiyal çoğalmaya ve sıcaklığa karşı direnç sunan sentetik organik boyaların yaygın kullanımı nedeniyle, tekstil endüstrisi tarafından üretilen atık suyun arıtılması çok zordur ve olası yeniden kullanımını engellemektedir (Martínez-Huitle & Brillas, 2009; Yaseen & Scholz, 2019). Bu nedenle, son yıllarda, tekstil endüstrisi atık sularının yeniden kullanım standartlarına uygun şekilde arıtılmasını sağlayan teknolojilerin geliştirilmesine yönelik çeşitli çalışmalar yoğunlaşmıştır (Buscio, López-Grimau, Álvarez, & Gutiérrez-Bouzán, 2019; Ergas, Therriault, & Reckhow, 2006; López‐Grimau, Gutiérrez‐Bouzán, Valldeperas, & Crespi, 2012; Riera-Torres, Gutierrez-Bouzan, Valldeperas Morell, Jose Lis, & Crespi, 2011; Sala, López-Grimau, & Gutiérrez-Bouzán, 2014).

2000'den önce, elektrokimyasal teknolojilerin atık sulardan boyaları giderme konusundaki etkisini gösteren çok az sayıda çalışma yapılmıştır (Gutierrez & Crespi, 1999; Naim & El Abd, 2002; Robinson, McMullan, Marchant, & Nigam, 2001).

Daha sonra, birçok araştırma grubu, sentetik ve endüstriyel atıklardan boyaların giderilmesi için potansiyel alternatifler olarak gelişmiş ileri oksidasyon prosesleri ve diğer elektrokimyasal yaklaşımları önermek için büyük çaba sarf etmiştir (Brillas & Martínez-Huitle, 2015). Sentetik boya çözeltileri veya gerçek tekstil endüstrisi atıkları, organik kirleticilerin güçlü oksidanlar sayesinde dolaylı elektro-oksidasyon yöntemleriyle tamamen dekontamine edilebilirler.

Elektrooksidasyon organik kirleticilerin uzaklaştırılmasında en popüler elektrokimyasal proseslerden biridir. Atıksulardan arıtım sonrası çamur ve konsantre kirletici üretmeyen basit ve temiz bir arıtım sağlamaktadır (Brillas & Martínez-Huitle, 2015). Uygun anot malzemesi seçimi ile organik kirleticilerin mineralizasyonunu sağlayan yüksek oranda hidroksil radikali üretimini teşvik etmektedir (Martínez-Huitle & Brillas, 2009).

Elektrooksidasyon mekanizması direkt ve dolaylı olarak iki farklı şekilde meydana gelmektedir. Kirleticilerin anot yüzeyinde adsorbe edildiği direkt oksidasyon ve elektrokimyasal olarak oluşan klor, hipoklorit, hidroksil radikalleri, ozon ve hidrojen peroksit gibi oksidanların aracılık ettiği dolaylı oksidasyon prosesleri meydana gelmektedir. Hipoklorit organik kirleticileri oksitleyebilen önemli bir oksidandır. Bu oksitleme işlemi sırasında meydana gelen reaksiyonlar aşağıdaki gibidir (Chiang, Chang, & Wen, 1995).

Anodik reaksiyonlar:

$$2Cl^- \rightarrow Cl_2 + 2e^- \quad (1)$$

$$6HOCl + 3H_2O \rightarrow 2ClO_3^- + 4Cl^- + 12H^+ + 1{,}5O_2 + 6e^- \quad (2)$$

$$2H_2O \rightarrow O_2 + 4H^+ + 6e^- \quad (3)$$

Çözelti reaksiyonları:

$$Cl_2 + H_2O \rightarrow HOCl + H^+ + Cl^- \quad (4)$$

$$HOCl \rightarrow H^+ + OCl^- \quad (5)$$

Katodik reaksiyonlar:

$$2H_2O + 2e^- \rightarrow 2OH^- + H_2 \quad (6)$$

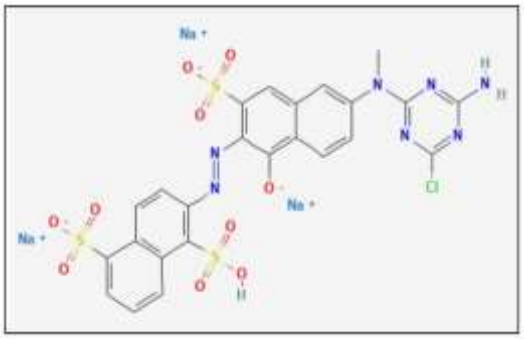
$$OCl^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^- \quad (7)$$

Bu çalışmada Drimaren Orange boyar maddesinden elektrooksidasyon yöntemi ile renk gideriminde, kullanılan destek elektrolit türü ve konsantrasyonun etkisi ve proses boyunca sistemin elektrik tüketiminin etkisi incelenmesi amaçlanmıştır.

2. Materyal ve Metot

2.1. Kullanılan boyar maddenin yapısı

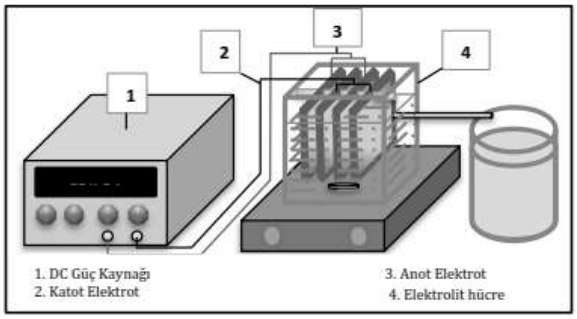
Drimaren Orange'dan 50 mg alınıp 500 mL kullanım suyunda çözdürülmüş ve 1000 mL kullanım suyu ile tamamlanarak stok boyar madde çözeltisi olarak kullanılmıştır. Drimaren Orange kimyasal formülü $C_{24}H_{15}C_lN_7Na_3O_{10}S_3$ ve moleküler ağırlığı 762 g/mol'dür. Kullanılan boyanın kimyasal yapısı aşağıda Şekil 1'de gösterilmiştir.



Şekil 1. Drimaren Orange boyar maddesinin kimyasal yapısı

2.2. Deney düzeneği

Elektrooksidasyon çalışmalarında 2000 mL hacimli ceketli cam reaktör tercih edilmiştir. Elektrot plakaları 70x100 mm boyutlarında ve 3080 cm^2 yüzey alanına sahiptir. Tüm plakaların yaklaşık ıslak yüzey alanı 2464 cm^2 olarak hesaplanmıştır. $Ti/IrO_2/RuO_2$ anot (DSA tipi) ve paslanmaz çelik katot (plaka tipi) elektrotlar tercih edilmiştir. Reaktör kabında beş anot ve beş katot elektrot monopolar düzenek oluşturularak paralel bağlı aralarında 5 mm mesafe olacak şekilde dizilmiştir. Voltaj ve akım ölçümü dijital "Control Unit PE280" marka güç kaynağı ile yapılmıştır. Reaktördeki karıştırma işlemini dijital "Yellowline MST" marka manyetik karıştırıcı tercih edilmiştir. Sistemin çalışması için doğru akım güç kaynağı seçilmiş ve manyetik karıştırıcı ile solüsyon devamlı karıştırılma halindedir. Başlangıç şartlarını belirlemek için numune alınarak pH, sıcaklık, iletkenlik "Thermo Orion" marka cihaz ile ölçülmüştür. Sistemin sıcaklığının sabit tutulması için soğutucu cihaz kullanılmıştır. Renk tayinin yapılması için "Lovibond" marka fotometre tercih edilmiştir. Fotometrenin dalga boyu 490 nanometre olarak belirlenmiştir. Deneysel düzenek Şekil 2'de sunulmuştur.



Şekil 2. Elektrooksidasyon sistemi

2.3. Deneyin yapılışı

Deney 1 Amper (0,325 mA/cm^2), 200 rpm karıştırma hızı 250 mg/L başlangıç konsantrasyonu ve 25°C sıcaklıkta yapışmıştır. 1000 ml stok çözeltiden 5 mL numune otomatik pipet ile çekilerek plastik tüplere aktarılmıştır. Toplam deney süresi 60 dakika olarak tanımlanmıştır. Numuneler başlangıç, 5. dk, 10. dk, 15. dk, 20. dk, 30. dk, 45. dk ve 60. dk olmak üzere 8 adet alınmıştır. Alınan her numunenin sıcaklık, iletkenlik, pH değerlerine bakılıp 10 mL cam numune tüplerine alınarak renk tayini yapılmıştır. Renk verimleri aşağıdaki formülle hesaplanmıştır.

% Renk Giderim Verimi

$$\eta(\%) = \left(\frac{C_0 - C_e}{C_0}\right) x100 \quad (8)$$

Burada;
C_0: Giriş konsantrasyonu, mg/L
C_e: Çıkış konsantrasyonu, mg/L

Enerji Tüketimi hesaplanırken;

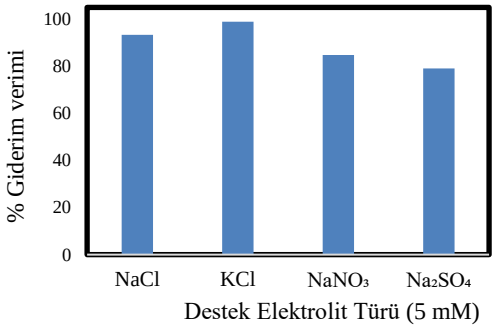
$$W\left(\frac{kWsaat}{m^3}\right) = \frac{VxIxt}{v} \quad (9)$$

Bu denklemde, W ifadesi enerji sarfiyatı (kW-saat/m^3), I akım şiddeti (A), V: Volt, t: zaman (dakika) ve v: toplam çözelti hacmini (m^3) ifade etmektedir.

3. Araştırma Sonuçları ve Tartışma

3.1. Destek elektrolit türünün renk giderimi üzerine etkisi

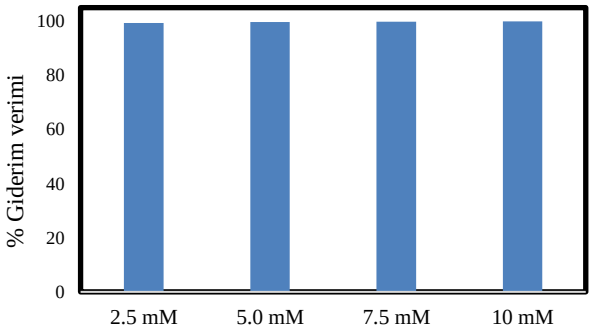
Elektrooksidasyon prosesi için önemli parametrelerden biri kullanılan elektrolit türüdür. Atıksu içerisinde oksitlenme reaksiyonlarını etkileyen ve su ortamına doğrudan etki eden bu elektrolitlerin kullanımı önemlidir. Proses sırasında ortamın iyonlaşmasına katkı sağlayarak prosese pozitif etki etmektedir. Özellikle klor içeren destekleyici elektrolitlerin varlığı verim açısından en yüksek etkinliğe sahip olduğu görülmüştür. Destek elektrolit türünün renk giderimine etkisini araştırmak için yapılan çalışmalar 1A (0.325 ma/cm^2) akım yoğunluğunda, 250 mg/L kirletici konsantrasyonunda, 5 mM NaCI kullanılarak 200 rpm karıştırma hızı ve atıksuyun doğal pH değerinde yapılmıştır. Elde edilen renk giderim verimi sonuçları sırasıyla KCI>NaCI>$NaNO_3$>Na_2SO_4 olarak sırasıyla %99.90, %93.35, %84.79, %79.12 olarak hesaplanmıştır (Şekil 3). KCl ve NaCl'nin diğer elektrolitlere göre daha yüksek giderim sağladığı görülmektedir. Yapılarında klor bulundurmaları yönüyle suda daha iyi iyonlaşma sağlaması sebebiyle daha etkili elektrolitler olarak bulunmuşlardır. Renk giderimi konusunda benzer sonuçlar diğer çalışmalarda da bulunmuştur (Erkmen & AdigÜZel, 2022; Fil & Günaslan, 2022).



Şekil 3. Destek elektrolit türünün renk giderimine etkisi

3.2. Destek elektrolit konsantrasyonunun renk giderimi üzerine etkisi

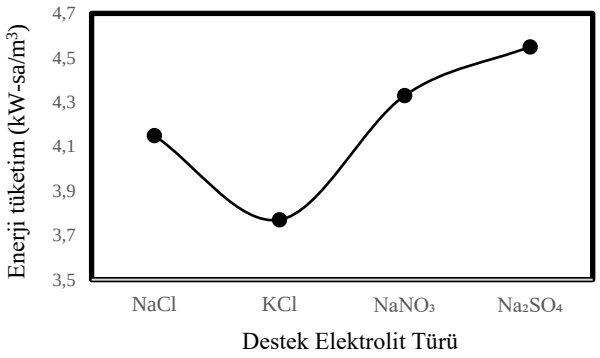
Destek elektrolit konsantrasyonunun etkisini araştırmak için 250 mg/L sentetik atıksu konsantrasyonunda, doğal pH değerinde 2.5, 5, 7.5 ve 10 mM konsantrasyonlarda ve 200 rpm karıştırma hızında çalışmalar yapılmıştır. Elde edilen sonuçlarda tüm konsantrasyonlar için renk gideriminin %99 üzerinde olduğu görülmüştür (Şekil 4). Bu yüzden fazla kimyasal sarfiyatını önlemek amacıyla düşük konsantrasyonlar tercih edilebilir. Elektrooksidasyon prosesinin renk gideriminde oldukça verimli olduğu sonucuna varılmıştır. Benzer sonuçlar literatürde mevcuttur (Chou & Wang, 2011).



Şekil 4. Destek elektrolit konsantrasyonunun renk giderimine etkisi

3.3 Enerji tüketimi üzerine destek elektrolit türünün etkisi

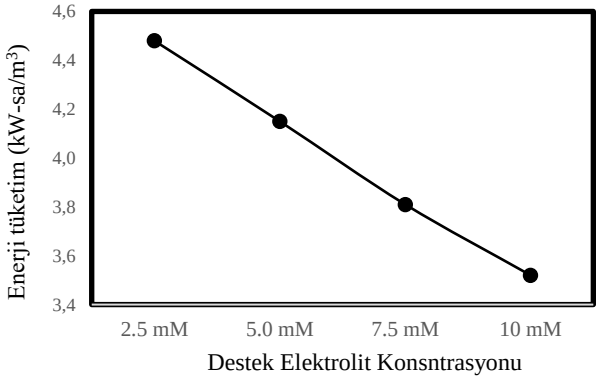
Elektrik tüketimi elektrokimyasal arıtım konusunda prosesin maliyetini doğrudan etkilediğinden önemli bir parametredir. Yapılan çalışmada incelenen NaCI, KCI, Na_2SO_4 ve $NaNO_3$ elektrolitleri için elde edilen sonuçların renk giderim verimleriyle ters orantılı olduğu görülmüştür. En yüksek giderim sağlayan KCI elektrolitinde enerji tüketiminin en düşük olduğu görülmüştür. Çünkü bu elektrolitlerin iyonlaşma kapasitesi ne kadar yüksek olursa ortamın iletkenliğini sağladığından potansiyel farkın düşüşüyle daha düşük enerji tüketimine sebep olmaktadır. Elde edilen sonuçlar aşağıda Şekil 5'te gösterilmiştir (Fil & Günaslan, 2023).



Şekil 5. Enerji tüketimi üzerine destek elektrolit türünün etkisi

3.4 Enerji tüketimi üzerine destek elektrolit konsantrasyonunun etkisi

Destek elektrolit konsantrasyonunun etkisini incelemek için sentetik atıksuyun doğal pH değerinde, 200 rpm karıştırma hızında, 1A (0.325 mA/cm^2) akımda, 250 mg/L başlangıç kirlilik konsantrasyonunda denemeler yapılmıştır. Elde edilen sonuçlar Şekil 6'da grafiksel olarak sunulmuştur. 2.5, 5, 7.5 ve 10 mM konsantrasyonlar için hesaplanan elektrik tüketimleri sırasıyla:4.48 kWh/m^3, 4.15 kWh/m^3, 3.81 kWh/m^3, 3.52 kWh/m^3 olarak bulunmuştur .



Şekil 6. Enerji tüketimi üzerine destek elektrolit konsantrasyonunun etkisi

4. Sonuç

Yapılan çalışmalarda sentetik boyar maddelerden renk gideriminde elektrooksidasyon yönteminin etkinliği kanıtlanmıştır. Prosesin uygulama kolaylığı, kısa sürelerde yüksek verim elde edilmesi, proses sonrası çamur oluşum miktarının diğer proseslere oranla çok düşük olması gibi avantajlarıyla bu tür atıksular ve diğer endüstrilerden kaynaklanan çeşitli atıksular için etkin bir yöntem olması en önemli tercih sebeplerindendir. Ayrıca farklı sentetik boyar maddeler için farklı tip anot malzemeleri kullanılarak verim açısından karşılaştırma yapılabilir.

Arıtımı konusunda çeşitli zorluklar bulunan ve endüstrilerde sıklıkla kullanılan sentetik boyar maddelerin elektrooksidasyon yöntemiyle arıtımında yüksek etkinlik gösterdiği görülmektedir. Farklı destek elektrolitler kullanılarak yapılan çalışmalarda en etkili tuzların NaCI ve KCI olduğu görülmüştür. Elektrik tüketimi atıksu arıtım proseslerindeki maliyetle doğrudan ilişkisi sebebiyle önemlidir. Atıksuların deşarj kriterleri için önemli bir parametre olan renk giderimi için elektrooksidasyon prosesi güvenilir bir yöntem olarak bulunmuştur.

5. Teşekkür

Deneysel çalışmaların gerçekleştirilmesinde katkısı olan Balıkesir Üniversitesi Çevre Mühendisliği Bölümü Atıksu Arıtma Laboratuvarı'na teşekkürler

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Research Article

Harvesting the Wind: A Study on the Feasibility and Advancements of Wind Energy in Turkey

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Abstract

This research delves into the potential of wind energy, drawing on recent studies to explore its advantages and disadvantages. The study will begin by providing a comprehensive explanation of the concept of wind energy, followed by an in-depth analysis of wind turbines, which are key components of wind power plants. This will involve a discussion of the various types of wind turbines and their individual characteristics. The research will also examine Turkey's wind and wind energy potential, providing valuable insights into the country's renewable energy prospects. In conclusion, the findings of this study will be used to propose recommendations for the development of wind energy in Turkey. Overall, the study aims to highlight the significance of wind energy as a clean, abundant, and sustainable source of power, and to explore ways in which it can be harnessed to meet the energy needs of the future.

Keywords: Wind Energy, Wind Turbines, Wind Technologies, Turkey's Wind Potential, Wind Power.

Rüzgarı Hasat Etmek: Türkiye'de Rüzgar Enerjisinin Fizibilitesi ve Gelişmeleri Üzerine Bir Araştırma

Öz

Konvansiyonel yanıcı (fosil) yakıtların (kömür, madeni yağ ve doğal gaz) rezervleri, bugünkü hızla kullanılması halinde 50 ila 200 yıl içinde tükenecektir. Doğal gaz, petrol, kömür veya nükleer gibi konvansiyonel enerji kaynakları sınırlıyken, rüzgar, güneş, biyogaz/biyokütle, jeotermal vb. gibi yenilenebilir enerji kaynakları temizdir ve doğada bol miktarda mevcuttur. Yenilebilir enerji kaynaklarından olan rüzgar enerjisi temiz, emisyonsuz bir enerji üretim teknolojisidir. Rüzgar enerjisi, üstün özellikleri, yenilenebilir enerji, geniş dağıtım ve sıfır kirlilik nedeniyle "yeşil enerji"nin ana destekçilerinden biridir.
Bu çalışma, son yıllarda yapılan araştırmalara dayanarak rüzgar enerjisinin potansiyelini tartışmaktadır. Çalışmada öncelikle rüzgar enerjisi kavramı kapsamlı bir şekilde anlatılacak, rüzgar enerjisi kullanımının avantaj ve dezavantajlarına değinilecektir. Daha sonra rüzgar enerjisi santrali bileşenlerinden rüzgar türbinleri üzerinde durulacaktır. Rüzgar türbinleri türleri ve özellikleri açıklanacaktır. Son olarak Türkiye'nin rüzgar ve rüzgar enerjisi potansiyeli hakkında bilgi verilecektir. Araştırmanın sonuç kısmında ise araştırmada elde edilen bilgilere dayanılarak, Türkiye'nin rüzgar enerjisi gücünün gelişimine yönelik önerilerde bulunulacaktır.

Anahtar Kelimeler: Rüzgar Enerjisi, Rüzgar Türbinleri, Rüzgar Teknolojileri, Türkiye'nin Rüzgar Potansiyeli, Rüzgar Gücü

1. Introduction

As economies continue to industrialize and develop, the demand for energy becomes increasingly vital for progress. The consumption of energy per capita has become a metric for measuring a country's level of economic development on a global scale. The importance of energy as a crucial component for sustained economic and social development is growing. Energy plays a vital role in ensuring continuous growth and economic prosperity (Rogner and Popescu, 2001). The energy sector is a key factor in addressing current global challenges such as sustainable development and climate change. Several studies have highlighted the rising demand for energy, the role of remaining fossil fuels, and the importance of alternative sources. According to the International Energy Agency (IEA), world energy demand is expected to increase by 90% until 2035 if the annual average increase trend persists (Köktürk & Tokuç, 2017). As a result, significant efforts are being made to ensure the sustainability of both exhaustible and renewable energy sources.

In addition to concerns about the sustainability of energy sources, the role of carbon dioxide (CO_2) emissions from fossil fuels in contributing to global warming has been a significant driver for renewable energy. Among the various forms of renewable energy, wind energy has emerged as a widely utilized alternative. The widespread availability of wind resources and the relative convenience of wind energy technology when compared to other renewable energy sources are considered key factors behind this trend (Esteban, Diez, López, & Negro, 2011).

This research focuses on exploring the potential of wind energy based on recent studies. Firstly, the concept of wind energy is comprehensively discussed, highlighting its advantages and disadvantages. Additionally, the role of wind turbines as a crucial component of wind power plants is emphasized, with a detailed analysis of various types of wind turbines and their specific characteristics. The study also provides an overview of Turkey's wind resources and the potential for wind energy development in the country. The research concludes by providing recommendations based on the findings, to promote the sustainable development of wind energy in Turkey.

2. Material and Method

2.1. Wind Energy Concept

Wind is the movement of atmospheric air, and it is formed due to uneven heating caused by the sun's rays hitting the earth's surface, including bodies of water. Wind is a fundamental element of the environment that is present everywhere (Mustafakulov & Arzikulov, 2020). The speed of wind determines its strength, which can range from barely noticeable to powerful and destructive. When wind is strong, it can carry debris and become visible. The power of wind is directly related to its kinetic energy, which increases as the speed of air movement increases. Therefore, the faster the wind is, the more energy it carries, and the more powerful it becomes (Kalmikov, 2017). Wind power as a form of renewable energy that is gaining global attention. It is a clean and widely available source of energy. Wind energy has the potential to generate electricity continuously, making it suitable for systems that require continuous energy supply (Demolli, Dokuz, Ecemis, & Gokcek, 2019). The energy content of wind is referred to as kinetic energy, which is a function of the mass and velocity of the air flow. As the air moves faster, it has more kinetic energy and can generate more power. Therefore, wind energy can be harnessed by wind turbines to produce electricity that can power homes, businesses, and industries (Kalmikov, 2017).

$$KE = \frac{1}{2} \cdot m \cdot U^2$$

The basic equation of wind energy and the difference between power and energy. The basic equation of wind energy determines how much energy is present in the wind. The concepts of power and energy are distinguished, where power is the ratio of energy to time, and it expresses how much energy can be produced per unit time. For instance, in wind energy, power expresses the amount of energy a wind turbine can generate in a given time. The power of the wind is the speed of the energy flow through an open window. This means that the faster the wind, the more energy it carries, and the more power it can generate. Therefore, understanding the basic equation of wind energy is crucial for designing wind turbines and optimizing wind energy production (Kalmikov, 2017). Wind energy is generated based on the movement of air, and it depends on several factors. The amount of air or the volume of considered air is one of the significant factors that influence wind energy production. The velocity of the air, which is the magnitude of its velocity, is also an important factor. The higher the velocity of the air, the more energy can be harnessed from the wind. The air mass, which depends on the volume of air via density, is another factor that affects wind energy (Kalmikov, 2017). The higher the density of the air, the more energy it carries. Wind turbines are used to convert the kinetic energy of wind into electrical energy. The amount of power that can be harnessed from the wind by a wind turbine depends on several factors. These factors include the air density, the swept area of the turbine blades, and the cube of the wind speed along the rotor plane. This means that a wind turbine can generate more power if it has larger blades that capture more wind energy and if the wind speed is high. The air density also affects wind energy production, as it determines how much energy the wind carries (Pryor, Barthelmie, Bukovsky, Leung & Sakaguchi, 2020). Table 1 includes Wind Energy Classes Measured at 50 m Above Ground According to NREL (United States National Renewable Energy Laboratory) Wind Energy Intensity Based Classification (Kalmikov, 2017). Wind energy depends on the amount of air, velocity of the air, and air mass. The power that can be harnessed by a wind turbine is a function of air density, swept area of the blades, and the cube of wind speed along the rotor plane. Table 1 presents typical values of wind power classes with power densities and average wind speeds (Kalmikov, 2017). The average wind power density has advantages over average wind speed for comparing sites with different probability distribution skewness. Wind speed varies with altitude, and wind turbines are typically placed in open plains, hill areas, and coastlines where wind speeds can be high. The power produced by wind turbines is proportional to the cube of the wind speed, meaning that doubling wind speeds results in an eightfold increase in energy production. Wind turbines placed in hilly areas can collect an appropriate amount of wind, and the tunnel effect can increase wind speed by up to 40% (Begeç, 2022). Modern wind turbines are designed to be relatively quiet, and the noise they produce is typically drowned out by the sound of the wind itself on a windy day. In fact, many studies have found that wind turbines do not significantly impact human health or well-being due to noise. Additionally, because wind energy does not rely on the combustion of fossil fuels, it produces no air or water pollution, and it does not generate hazardous waste or contribute to climate

change. Overall, wind energy is a relatively clean and sustainable source of electricity that has many environmental benefits. In addition to these benefits, there are some obstacles to large-scale application of wind energy. The barriers (Archer & Jacobson, 2005), there are several other obstacles to large-scale application of wind energy:

-Grid Integration: One of the major challenges associated with wind energy is the intermittent nature of wind. Wind turbines generate power only when wind is blowing, and the power output fluctuates with changes in wind speed. This poses a challenge for integrating wind energy into the grid, as the grid requires a stable and reliable supply of electricity. Solutions to this challenge include energy storage systems, demand-side management, and advanced grid management systems.

-Infrastructure and Transmission: Wind farms are typically located in remote areas, which can pose challenges for infrastructure and transmission. Building the necessary infrastructure, including access roads, electrical substations, and transmission lines, can be costly and time-consuming. In addition, transmission capacity may be limited, which can limit the amount of wind energy that can be delivered to the grid.

-Environmental Concerns: While wind energy is generally considered to be a clean source of energy, there are some environmental concerns associated with wind farms. These include the impact on bird and bat populations, noise pollution, and visual impacts. Addressing these concerns requires careful site selection, technology improvements, and ongoing monitoring and mitigation measures.

-Public Acceptance: Finally, wind energy projects can face opposition from local communities, which may have concerns about the impact on property values, scenic views, and local wildlife. Effective engagement and communication with local communities can help to address these concerns and build support for wind energy projects. In addition to estimating future wind speed values, there are several other ways to assess wind energy resources and design viable wind energy infrastructures:

-Site Selection: The first step in assessing wind energy resources is to identify potential sites with high wind speeds and low turbulence. This requires a detailed analysis of wind patterns, terrain, and other factors that affect wind energy production. Site selection can be aided by advanced modeling tools, such as computational fluid dynamics (CFD) simulations, which can provide detailed information about wind patterns and turbulence.

-Resource Assessment: Once potential sites have been identified, a detailed resource assessment is needed to determine the expected energy output of a wind energy project. This involves installing wind measurement equipment, such as anemometers and wind vanes, to collect data on wind speed, direction, and other variables. Resource assessment can also be aided by remote sensing technologies, such as lidar and satellite imaging, which can provide detailed information on wind patterns and turbulence.

-Technology Selection: Wind energy projects require careful selection of wind turbines and other equipment to ensure optimal performance and reliability. This involves consideration of factors such as turbine size, rotor diameter, and tower height, as well as maintenance and repair requirements.

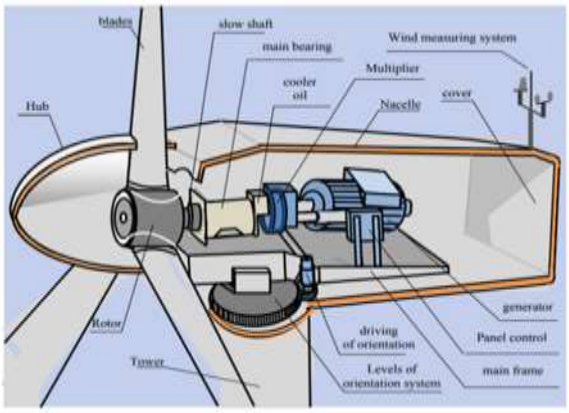
-Grid Integration: Finally, wind energy projects must be integrated into the electricity grid in a way that ensures stable and reliable power supply. This requires careful planning and coordination with grid operators, as well as the installation of advanced grid management systems and energy storage technologies to mitigate the intermittent nature of wind energy production (Sharifian et al., 2018; Ammar et al., 2018). To assess wind energy resources and design wind energy infrastructures, high-quality and comprehensive wind speed data are required. However, such observational datasets are often rare, insufficient or nonexistent in potential areas for wind energy development. Therefore, modeling approaches are used to overcome these barriers and create useful wind resource guidance. Accurate estimation of wind speed is critical to increase the safety, reliability and profitability of wind farms. Modeling can help to estimate future wind speed values, assess wind patterns and turbulence, select appropriate wind turbine technology, and integrate wind energy projects into the electricity grid. Overall, a comprehensive approach that considers a range of factors is necessary to assess wind energy resources and design viable wind energy infrastructures. In addition to the barriers to implementing wind energy, there are also several disadvantages associated with wind turbines (Demolli, Dokuz, Ecemis, & Gokcek, 2019; Atılgan, 2022). These include their potential to affect electromagnetic waves, the requirement for high hilly areas to generate yield, risks to birds, the risk of overturning and burning, dependence on optimal wind conditions, high initial investment costs, environmental noise, and aesthetic pollution. In addition, wind energy potential is often located in remote areas, requiring extensive transmission lines to connect to the national grid. However, these disadvantages can be mitigated through careful site selection, advanced technology, and effective grid integration. Despite these challenges, wind energy remains a promising source of renewable energy with the potential to contribute significantly to global energy needs. Wind power is an intermittent power supply due to the high stochasticity and low predictability of wind. This intermittency greatly affects the safety and stability of large-scale grid-integrated renewable energy systems, and wind power is also affected by transmission and distribution losses. Planning, management and optimization are the main challenges for the high penetration of renewable energy sources, including wind and solar, in grids of different scales. To overcome these challenges, advanced grid management systems and energy storage technologies can be used to mitigate the intermittency of wind power, and effective planning and management strategies can be developed to optimize renewable energy integration into the grid. Overall, careful planning and effective management are necessary to ensure the safe and stable integration of wind power into the electricity grid (Wang, Zou, Liu, Zhang & Liu, 2021). A wind power plant consists of several basic components including a tower, 2 or 3 bladed wind turbine, mechanism to adjust the direction of the blades/turbine based on wind direction, mechanical gear unit, electric generator, speed sensors and speed control unit, power-electronic unit and control, energy storage systems (especially for off-grid operation), transformer, transmission line and breaker for connection to the local power grid. These components work together to convert wind energy into electricity and transmit it to the grid for distribution.

2.2. Wind turbine

The wind turbine is the most important part of a wind energy system, as it converts wind energy into mechanical and electrical energy. The use of wind energy dates back to AD 644 when

windmills were used to lift water. In 1891, Danish inventor Poul La Cour produced electricity in DC form for the first time from a wind turbine, demonstrating the potential of wind energy as a source of electricity. Although wind energy is often considered a new energy source, it has a long history and has been used for centuries to perform various tasks. The development of wind energy technology has significantly advanced over time, and modern wind turbines are highly efficient in converting wind energy into electrical energy (Beig & Muyeen, 2015).

Figure 1. Cross-section view of a horizontal axis wind türbine



There are two main types of wind turbines used to implement wind power systems:

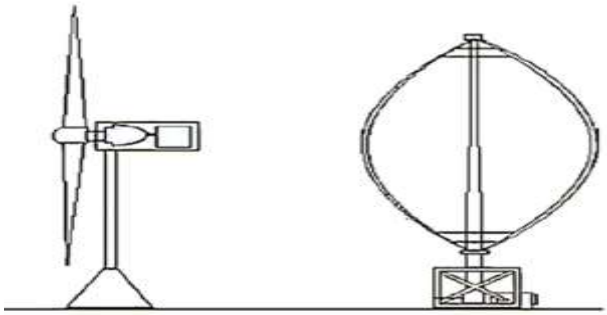
-horizontal axis wind turbines (HAWTs) and

-vertical axis wind turbines (VAWTs).

-HAWTs are the most common.

Horizontal Axis Wind Turbine has horizontal shaft while Vertical Axis Wind Turbine has vertical shaft (Günhan, 2020).

Figure 2. Horizontal and Vertical Axis Wind Turbines



Horizontal Axis Wind Turbine rotation axis is parallel to the ground. These wind turbines are used for large wind farms located both offshore and on land (Günhan, 2020).

Figure 3. Horizontal Axis Wind Turbine

In these wind turbines can be designed with different numbers of blades, with the rotor rotating faster as the number of blades decreases. Fewer blades can theoretically reduce costs, but can also lead to uneven torque. The difference in torque between tri-wing and biplane configurations is approximately 5%. Wind turbines can be manufactured with a single, two, or three blades, with three-bladed turbines being the most commonly used. Three-bladed turbines are preferred due to their ability to generate more uniform torque. In Horizontal Axis wind turbines, the blades of the propeller rotate, the shaft connected to the hub rotates. Opposite the shaft is a gearbox to adjust the speed. The shaft rotating at the specified speed drives the generator. The ratio obtained by dividing the wind speed by the rotor blade tip speed is called the blade tip speed ratio (λ). If; λ= 1–5 multi-bladed rotor, λ=6–8 three-bladed rotor, λ= 9–15 two-bladed rotor, λ>15 single-bladed rotor are used. An important variable of wind turbines is the swept area. In reality wing cost changes with increasing length and power output increases with large swept area. Then it is aimed to maximize the ratio of the swept area according to the wing length.

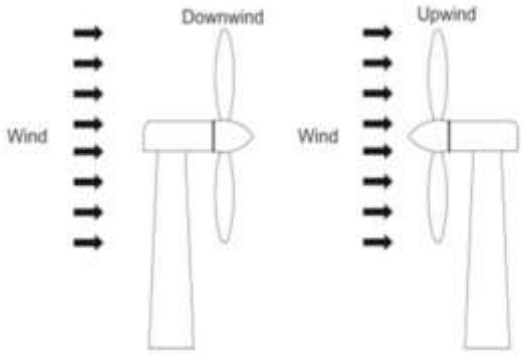
Rotor swept area for horizontal axis turbine;

$$A = \frac{\pi}{4} D^2$$

The wind power generated by a horizontal axis turbine is proportional to the square of the blade diameter, and larger wind turbines are more economical. Turbines with more blades operate at low speeds and have a higher initial power coefficient, but the coefficient decreases rapidly as the speed increases. Turbines with fewer blades operate at high speeds, and the power coefficient takes large values initially, but gradually decreases as the speed increases (Boulouiha, Allali, & Denai, 2017).

The turbine can be in front (downwind) or behind (downwind) the engine compartment.

Figure 4. Turbine wind direction



Horizontal axis wind turbines (HAWTs) can be divided into two categories: lift type and drag type.

Wind wheels driven by drag force

1. Savonius type wind impellers (a.Single blade b.Multi bladed)

2. Lafond type wind impellers

3. Panemone type wind impellers

Wind turbines powered by buoyancy

1. Darrieus type wind impellers

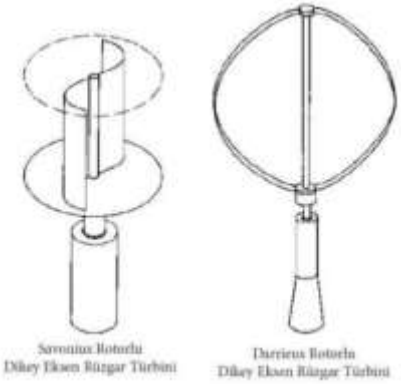
(a. Cylindrical type b. Conical type c. Mixer type)

(c1. Chain Curve (catenary) c2. Parabolic c3. Troposkien c4. Sandia)

2. Cross Flow Wind Wheels

There are different types of wind turbines, including horizontal axis wind turbines with reverse blade designs or swirling features, and vertical axis wind turbines like Darrieus and Savonius. Vertical axis turbines are more complex to manufacture due to their blade structure, but Savonius turbines have lower power efficiency and are suitable for low-power wind energy systems. The main drawback of horizontal axis turbines with swirling features is increased fatigue from wind fluctuations (Yılmaz, 2022).

Figure 5. Vertical axis wind türbine



Some vertical axis wind turbines do not start by themselves and require an external power source. Another type of vertical axis turbine is known as Musgrove blades with H-shaped rotors. For high wind speeds, the rotor blades are rotated around a horizontal point caused by centrifugal force. This eliminates the risk of higher aerodynamic forces on the wings.

Since the area swept by the vertical axis wind turbine (rotor) is not fully circular, it presents a more complex structure. This area is approximately;

$$A = \frac{2}{3} D.H$$

Here;

D: Maximum width of rotor blades

H: Vertical maximum height of rotor blades One of the most important points in wind turbines is the amount of energy to be captured at different wind speeds.

In the design phase of wind power plants, estimates of operating (or outside) conditions are used, including a range of wind parameters (such as wind storm, 50-year rotation period continuous wind speed, and turbulence intensity) to identify fatigue and mechanical overloads. It guides the selection of an appropriate WT class for a particular location (Pryor, Barthelmie, Bukovsky, Leung & Sakaguchi, 2020).

2.3. Wind Energy in Turkey

Turkey's best wind source areas are the Aegean and Marmara coasts, with high wind speeds in the northeast of the Aegean Sea and an area near Antakya. Central Turkey has moderate wind speeds, while the coastal regions of the Central Black Sea and the central part of the Mediterranean Sea also have suitable wind speeds for energy investments (Malkoç, 2008).

According to a report, Turkey has a wind potential of 37.83 MW on land and 10.01 MW at sea, for a total of 47.84 MW at an altitude of 50 m. In the first half of 2020, Turkey produced 11,506,233 kW of electrical energy from wind power, representing 8.5% of the total electricity produced in the country (Özkan, Uslu & Gedikli, 2022).

To evaluate wind energy potential, reliable wind resource data must be obtained through meteorological measurements. In Turkey, wind measurements are made by the General Directorate of Meteorology using Wind Energy Observation Stations at a height of 10-30 m, in one hour and 10-minute intervals, and processed and archived in software programs (Şenel & Koç, 2015).

To effectively invest in wind energy, it is crucial to identify the wind energy potential and prioritize the most suitable wind resource areas. The Wind Energy Potential Atlas (REPA) was developed to provide wind resource information. REPA utilizes medium-scale numerical weather forecast models and micro-scale wind flow models to produce wind resource information. These atlases can be integrated with geographic information systems (GIS), meteorological models, and computer software to provide valuable information about the wind regime on hourly, daily, monthly, seasonal, and annual time scales, helping to determine the most suitable wind resource areas(Malkoç, 2008).

The Wind Energy Potential Atlas (REPA) provides various types of data related to wind resources, which include:

-Annual, seasonal, monthly, and daily wind speed averages at -0, 50, 70, and 100 m altitudes

-Annual, seasonal, and monthly wind power densities at -50 and 100 m altitudes

-Annual capacity factor at 50 m height for a reference wind turbine

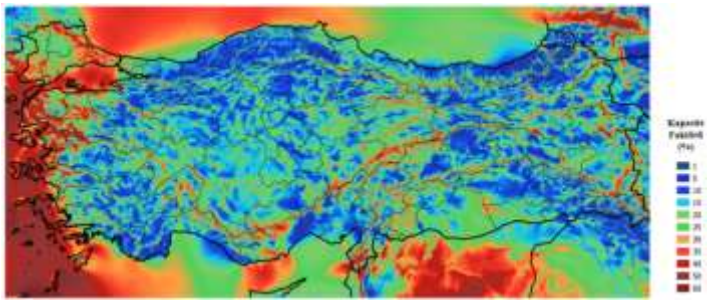
-50 m high annual wind classes

-Monthly temperature values at -2 and 50 m altitudes

-Monthly pressure values at sea level and 50 m altitude

This information is crucial for accurately assessing the wind energy potential of a particular area and determining the feasibility of wind energy investments. With the REPA maps, the areas where wind power plants can be installed have become easily identifiable (Çalışkan, 2019). The Capacity factor distribution map prepared by REPA, taking into account the technical values of a 3 MW wind turbine, is given in Figure 6.

Figure 6. Capacity Factor Distribution (100m) (Source: www.repa.enerji.gov.tr



A capacity factor of 35% or more is required for economic WPP investment. The Distribution of Wind Power Plants in Operation and Under Construction as of 2020 by Regions is given in Table 2.

Table 2. Distribution of Wind Power Plants as of 2020 (Source: Özkan, Uslu & Gedikli, 2022).

Bölgeler	İşletmede Bulunan Santraller		İnşa Halindeki Santraller	
	Kurulu Güç (MW)	Kurulu Güç (%)	Güç (MW)	Güç (%)
Ege	3.511,00	37,73	165,90	8,86
Marmara	3.290,72	35,36	1.487,43	79,45
Akdeniz	1.120,20	12,04	19,20	1,03
İç Anadolu	921,05	9,90	110,40	5,90
Karadeniz	353,80	3,80	7,20	1,92
Güneydoğu Anadolu	93,05	1,00	-	-
Doğu Anadolu	15,20	0,16	53,20	2,84

Table 1. Wind energy classes (Source: Kalmikov, 2017)

Wind power classification			
Wind power class	Source	Wind power Intensity /W.m^{-2}	Wind speed /m.s^{-1}
1	Potential	0-200	0.0-5.9
2	Bad	200-300	5.9-6.7
3	Marginal (borderline)	300-400	6.7-7.4
4	Middle	500-600	7.4-7.9
5	Good	500-600	7.9-8.4
6	Perfect	600-800	8.4-9.3
7	Extraordinary	>800	>9.3

3. Results and Discussion

Wind energy is a clean and renewable source of energy that does not produce any harmful emissions, unlike fossil fuels which are responsible for a significant amount of greenhouse gas emissions. As such, wind energy is seen as a key solution in the global effort to reduce carbon emissions and combat climate change. Many countries have set ambitious targets to increase the share of renewable energy in their energy mix, including wind energy, in order to reach the goal of zero emissions by 2050. Increasing the number of wind measurement stations in Turkey can definitely provide more accurate and reliable data, which will help to better determine the potential of wind energy in the country. The Wind Energy Potential Atlas of Turkey can be updated with this new data and provide a better understanding of the country's wind energy potential. This, in turn, can attract more companies to invest in the sector and promote the use of renewable energy sources, which is a critical step towards achieving zero emissions by 2050. It is important to continue efforts to expand the wind energy infrastructure and encourage the development of more efficient wind turbines to increase the efficiency of wind energy production (Şenel, & Koç, 2015). wind energy has a variable character, meaning that wind speed and direction can fluctuate over time. However, with the help of modern wind turbine technologies and energy storage systems, wind energy can be integrated into the power grid and provide a reliable source of electricity. Additionally, as you mentioned, diversifying energy sources is important to ensure a stable and sustainable energy supply. Wind energy can play an important role in this diversification, along with other renewable energy sources such as solar, hydro, and geothermal (Malkoç, 2008).

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Research Article

In silico Interaction of Rhamnus' Flavonoids With Fat Mass And Obesity Associated Protein

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Abstract

The anti-obesity potential of various plant extracts and their associated bioactive compounds is well known. Molecular docking studies of FTO with flavonoids, using Orlistat (an anti-obesity drug) as a control, were performed to identify the effects of *Rhamnus*' flavonoids with FTO (Obesity and obesity associated protein). Prior to molecular docking simulation, Rhamnus flavanoids were analysed using AutoDockTools (version 1.5.6). Docking simulations of the interaction of Rhamnus flavanoids with FTO were performed using AutoDock Vina version 1.1.2. Their binding affinities were obtained. BIOVIA Discovery Studio software was used to visualise the interaction between receptor and ligand. Our study approved the binding ability to FTO protein, and the affinity was as Aloe Emodin Dimer>Emodin>6-Methoxysorigenin. As a results, Rhamnus flavonoids have the remarkable ability to FTO protein, which means they are potent molecules as a potent FTO-inhibitor. Interestingly, Orlistat has lower affinity than Aloe-emodin dimer (-8.7 vs -10.8), which means aloe-emodin dimer more potent to bound the active site. In contrast, two other Rhamnnus flavonoids were shown lower binding affinity when compared to Orlistat.In conclution, Rhmanus phytomolecules able to bind to the catalytic site of FTO as well as "Orlistat" has been demonstrated by molecular docking. Thus, Rhamnus flavonoids especially "Aloe-emodin dimer" is a potent molecule to develop "anti-obesity drug".

Keywords: Rhamnus, emodin, FTO, fat mass and obesity, molecular docking.

Rhamnus Flavonoidlerinin Yağ Kütlesi Ve Obezite İle İlişkili Protein ile İn Silico Etkileşimi

Öz

Çeşitli bitki özlerinin ve bunların içeriğindeki biyoaktif bileşiklerin obeziteye karşı potansiyeli iyi bilinmektedir. Flavonoidlerin obezite ve obezite ile ilişkili protein (FTO) ile ilişkisinin mekanizmasını keşfetmek için kontrol olarak Orlistat (obezite karşıtı bir ilaç) kullanılarak FTO'nun flavonoidlerle moleküler kenetlenme çalışmaları yapılmıştır. Moleküler kenetlenme simülasyonundan önce, Rhamnus flavanoidleri AutoDockTools (sürüm 1.5.6) kullanılarak analiz edilmiştir. Rhamnus flavanoidlerinin FTO ile etkileşiminin docking simülasyonları AutoDock Vina versiyon 1.1.2 kullanılarak gerçekleştirilmiştir. Bağlanma afiniteleri elde edilmiştir. Reseptör ve ligand arasındaki etkileşimi görselleştirmek için BIOVIA Discovery Studio yazılımı kullanılmıştır. Çalışmamız FTO proteinine bağlanma yeteneğini çalışılan Rhamnus'a özgü flavanoidler için Aloe Emodin Dimer>Emodin>6-Methoxysorigenin olarak bulundu. Sonuç olarak, Rhamnus flavonoidleri FTO proteinine dikkat çekici bir bağlanma affinitesine sahiptir, bu da güçlü bir FTO inhibitörü olarak aday moleküller olabilecekleri anlamına gelir. İlginç bir şekilde, Orlistat, Aloe-emodin dimerinden daha düşük afiniteye sahiptir

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(-8.7 vs -10.8), bu da aloe-emodin dimerinin aktif bölgeye bağlanmak için daha güçlü olduğu anlamına gelir. Buna karşılık, diğer iki Rhamnnus flavonoidi Orlistat ile karşılaştırıldığında daha düşük bağlanma afinitesi göstermiştir. Sonuç olarak, Rhmanus fitomoleküllerinin FTO'nun katalitik bölgesine "Orlistat" kadar bağlanabildiği moleküler yerleştirme ile gösterilmiştir. Bu nedenle, Rhamnus flavonoidleri, özellikle "Aloe-emodin dimer", "obezite karşıtı ilaç" geliştirmek için güçlü bir moleküldür.

Anahtar Kelimeler: Rhamnus, emodin, FTO, fat mass and obesity, molecular kenetleme

1. Introduction

It is currently proven that, without affecting the human genome, the mother's nutrition or the father's eating habits, especially during pregnancy, affect the newborn's health. Many herbs are used for the purpose of slimming among the public (van Dijk et al., 2015) If gene-environment interactions have an effect on gene regulation, can we interfere with the regulatory mechanisms of the gene with a food we consume, or can we trigger or treat obesity by manipulating proteins via food? In Turkey, particularly among the public, many herbs are used for weight loss. Could these extracts with traditional use be effective in the regulation of obesity?

Rhamnus sp. is popularly known as buckthorn or bitter buckthorn and grows naturally in the Mediterranean basin, Europe, southwest and central Asia. Rhamnus sp, leaves and fruit used for years for their diuretic, and depurative action upon the organism (Chen et al., 2018). The antioxidant and antimicrobial activities of the plant, with the cytotoxic action of the plant possibly accounting for the antimicrobial activity (Chen et al., 2018; Khuda et. Al., 2022). Rhamnus species are known to be rich in anthraquinones, flavanol triheterosides, anthracenes, anthrones, naphthalenes (Bouhlel Chatti et. al. 2022).

Despite Rhamnus sp.'s unknown side effects and toxicity, the extract is still used as a laxative by people who want to lose weight without a prescription.

The first obesity susceptibility gene identified by GWAS was FTO (fat mass and obesity associated gene), which consists of 9 exons with a cytogenetic location in the 12.2nd region (16q12.2) on the long (q) arm of chromosome 16 (Scuteri et.al., 2007; Peters el. al. 2013). The FTO gene was given this name because of the fused toes (FT) phenotype characteristic that occurs with the deletion of 1.6 megabases of sequence in the genomic sequence of the mouse by insertional mutation. Fto is a nuclear protein and regulates energy balance by establishing a functional relationship between nutrition and genes encoding peptides as a transcription co-factor.

In that frame, due to its obesity-related popularity, we want to evaluate the molecular affinity of Rhamnus' flavonoids to "FTO" in silico. This is the first report that evaluate the possible action of mechanism of Rhamnus' flavonoids with FTO protein interaction. Rhamnus sp. is a plant that is popularly used for weight loss and has a cathartic effect. Therefore, we compared the plant extract with "orlistat", a commercially available drug for weight control of obese individuals, which also has a cathartic side effect.

2. Material and Method

To obtain detailed binding information, analyses were performed for Rhamnus flavonoids such as Emodin (PubChem CID: 3220), Aloe-emodin dimer (PubChem CID: 437987), and 6-Methoxysorigenin (PuBChem ID: 12442904), using AutoDockTools (version 1.5.6) prior to molecular docking simulation. The anti-obesity drug Orlistat (PubChem CID: 3034010).

Docking simulations of the interaction of Rhamnus flavonoids on the FTO protein (PDB ID: 3LFM) in a box with x × y × z dimensions 40 40 40 were performed.

We removed all water molecules and ions in the protein (receptor) and added polar hydrogen atoms to the receptor molecule. To predict the docking interaction energy, a 3D grid box where the protein molecule was surrounded. The input 'grid parametres' files were set to X = 29.043, Y = -6.644 and Z = -29.329 (Hardinsyah et.al., 2023), the others were set to the default values given by the software.

The docking simulations of Rhamnus flavanoids interaction on FTO protein were done using version 1.1.2 of AutoDock Vina (Trott et. Al., 2010). Their affinity for binding and RMSD values were obtained.

The interaction between receptor with ligand were visualized with the BIOVIA Discovery Studio software (BIOVIA).

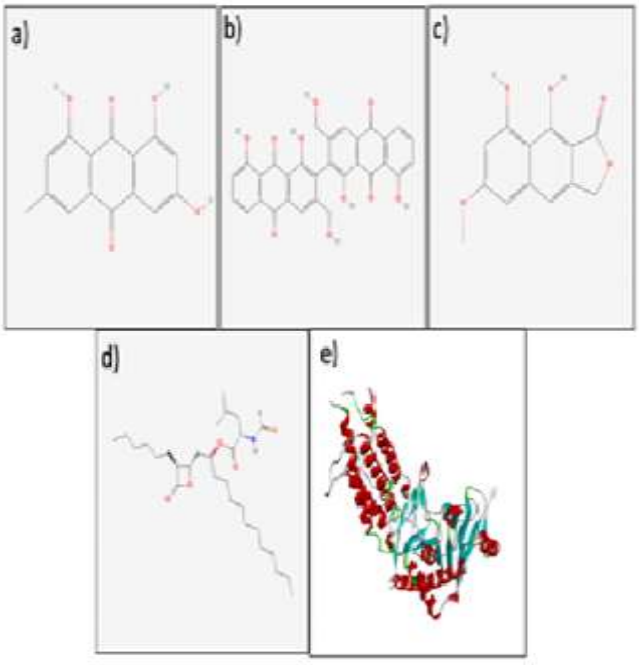

Figure 1. Structure of ligands used for the study. a) Emodin b) Aloe-Emodin Dimer c) 6-Methoxysorigenin, d) Orlistat, e) FTO protein (PDB ID: 3LFM)

3. Results and Discussion

In that study, we evaluated the interaction between FTO protein and Emodin, Aloe-Emodin Dimer, and 6-Methoxysorigenin in silico. The result of our study, we found that binding affinity of flavonoids was in the order of Aloe-emodin Dimer >Emodin> 6-Methoxysorigenin.

In the analysis of the interaction of each ligand with the FTO protein, interactions with different sites on the receptor have been observed. We compared the ligand binding site with anti-obesity

drug "Orlistat" and found x and y has similar binding site. (or none of the ligand has similar binding site as anti-obesity drug "Orlistat").

The minimum bond length was found between the receptor and Orlistat, and flavonoids had relatively long binding distances even though they bind to similar amino acid as Orlistat. (Table 1). Interestingly, both Orlistat, which is used to combat obesity, and the common flavonoids of Rhamnus sp, which is used for weight loss, bind to the FTO protein at ARG 96.All the flavonoids have strong binding capacity to FTO. The molecular interactions were recognized by FTO through hydrogen bonds and all molecules bind FTO (Table 1).

We have found four hydrogen bonds between 3LFM and Emodin with ARG(A:96), TYR(A:106), HIS(A:232) and ARG(A:322) with a distance of 2.80, 2.26, 2.93 and 2.88, respectively (Figure 2).

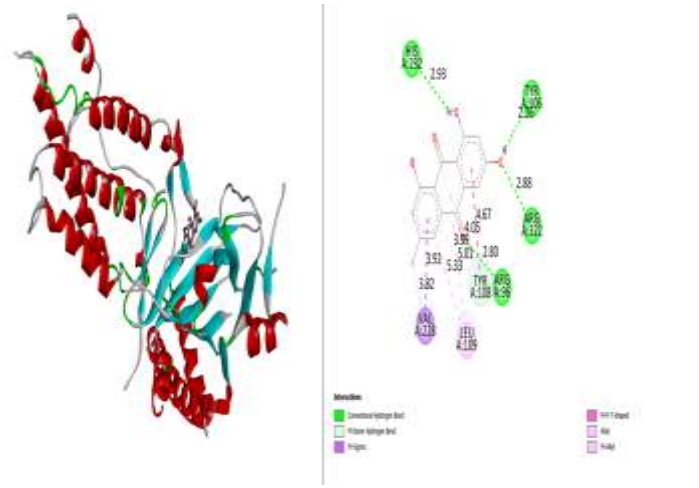

Figure 2. Emodin docked onto FTO receptor (Left) and molecular interactions between Emodin (PubChem CID: 3220) and 3LFM.

The Aloe-emodin dimer shown four different hydrogen binding ability with 3LFM by ARG(A:96), TYR(A:108), SER(A:229) and MET(A:226) with a distance of 2.81, 3.0, 3.36 and 2.47 (Figure 3).

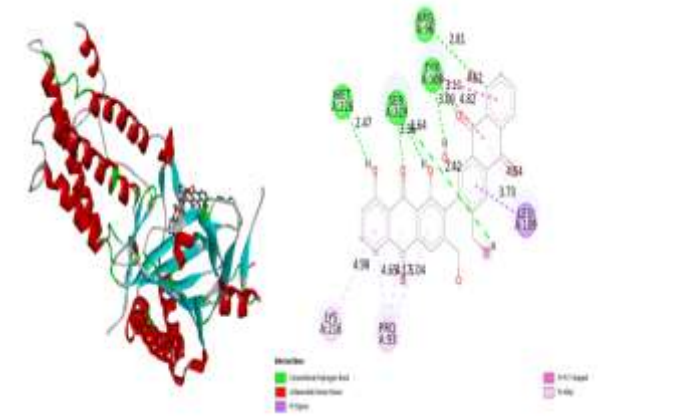

Figure 3. Aloe-emodin dimer docked onto FTO receptor (Left) and molecular interactions between Aloe-emodin dimer (PubChem CID: 437987) and 3LFM.

6-Methoxysorigenin similarly had three hydrogen bonds between 3LFM, two of them TYR(A:106) and ARG(A:322) was the same with Emodin, still one more with GLU (A:234) with 3.01 distance (Figure 4).

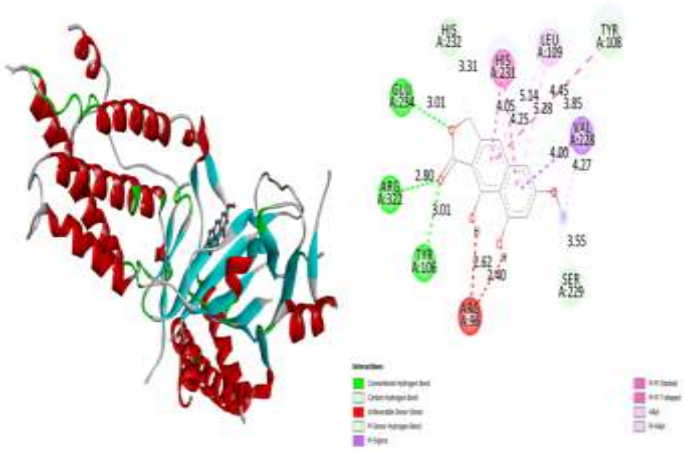

Figure 4. 6-Methoxysorigenin docked onto FTO receptor (Left) and molecular interactions between 6-Methoxysorigenin (PubChem CID: 12442904) and 3LFM.

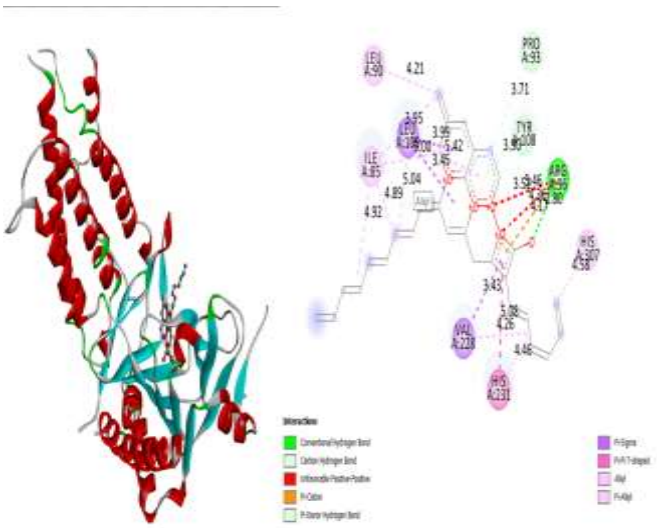

Figure 5. Orlistat docked onto FTO receptor (Left) and molecular interactions between Orlistat (PubChem CID: 3034010) and 3LFM.

Also, all flavonoids shown interaction via Pi-pi bounds and pi-sigma bounds with FTO. All three flavonoids were shown ARG (A:96) bounds; but this interaction was an unfavourable donor-donor bound for 6-Methoxysorigenin.

Table 1. The binding affinities and the molecular interactions between Emodin, Aloe-emodin dimer, 6-Methoxysorigenin and Orlistat target DNA, obtained by molecular docking simulations.

FTO (PDB ID: 3LFM)	**Docking molecules**			
	Emodin	**Aloe-emodindimer**	**6Methoxysorigenin**	**Orlistat**
Binding Affinity (kcal/mol)	-8.6	-10.8	-7.4	-8.7
H.Bonding interaction (Distance; Å)	ARG-A:96 (2.80) ARG- A:322 (2.88) TYR-A:106 (2.26) HIS-A:232 (2.93)	ARG-A:96 (2.81) MET-A:226 (2.47) TYR-A:108 (3.00) SER-A:229 (3.36)	ARG-A:322 (2.80) TYR-A:106 (3.01) GLU-A:234 (3.01)	ARG-A:96 (2.80)
Carbon-Hdrogen bond (Distance; Å)	NA	NA	TYR-A:108 (3.85) SER-A:229 (3.55) HIS-A:232 (3.31)	PRO-A:93 (3.71) TYR-A:108 (3.9)
Pi-Sigma (Distance; Å)	VAL-A:228 (3.92)	LEU-A:109 (3.73)	VAL-A: 228 (4.00)	LEU-A:109 (3.45) VAL-A: 228 (3.43)
Pi-Donor Hydrogen bond (Distance; Å)	TYR-A:108 (4.67)	NA	SER-A:229 (3.55) HIS-A:232(3.31) TYR-A:108 (4.45)	NA
Unfavorable donor-donor (Distance; Å)	NA	NA	ARG-A:96 (2.40)	NA

3.2. Discussion

The European Food Safety Authority (EFSA) has approved the supposedly safe use of plants that contain hydroxyanthracene (rheum, rhamnus, and aloe), even though they are used by the public, especially as laxatives, in 2018. In contrast, its widely used for loose weight; none of the studies was performed to evaluate the molecular interactions of these hydroxyanthracene with FTO.

Previously, Mohammed et al. have been studied molecular docking of flavonoids (Exemestane >Kaempherol >Letrozole >Rutin) and found quercetin has significant binding capacity and establish physical interaction with FTO. Similarly, Hardinsyahd and collauges shown that, the flavonoids of Clitoria ternatea kombucha exhibited better binding affinity to 3LFM compared to orlistat. Their results were as Quercetin (ΔG-7.78), Dibenzylamine> Trifolin(ΔG-7.72)> Quercetin-3β-D-glucoside(ΔG-7.66)> and α-Pyrrolidinopropiophenone (ΔG-5.67), while orlistat was found -3.71 kcal/mol (Hardinsyah et.al., 2023).

Our study approved the binding ability to FTO protein, and the affinity was as Aloe-Emodin Dimer>Emodin>6-Methoxysorigenin.

Similar to the previous research, we have found Rhamnus flavonoids have the remarkable ability to FTO protein, which means they are potent molecules as a potent FTO-inhibitor. Interestingly, Orlistat has lower affinity than Aloe-emodin dimer (-8.7 vs -10.8), which means Aloe-emodin dimer more potent to bound the active site. In contrast, two other Rhamnnus flavonoids were shown lower binding affinity when compared to Orlistat.

4. Conclusions and Recommendations

Flavanoids from Rhamnus sp. have promising potential as FTO inhibitors. However, it does not bind as tightly to the molecule as the commercially available active form 'Orlistat', except that Aloe-emodin dimer binds with higher energy than the commercially available form.

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Research Article

Risk Analysis and Risk Assessment in Laboratory Studies

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Abstract

In this study, risk analysis is investigated by using 5X5 L Type Matrix Method in laboratories determined within the scope of occupational health and safety. In the risk analysis, 50 risks are identified, of which 30 (60 %) have a high risk level, 18 (36 %) have a medium risk level, and 2 (4 %) have a low risk level. Occupational health and safety rules are applied to control these risks in laboratory research and to minimize their effects. In this context, the things to be done in laboratory studies are listed as follows. Students, lecturers, and laboratory staff working in the laboratory should receive occupational health and safety training. Emergency plans, teams, and drills should be made for situations that may occur during laboratory studies. Chemical use, transport, and storage must be recorded in laboratory research. Physical inadequacies such as ventilation in the laboratory and work area should be eliminated. Chemical hygiene and an accident prevention program are recommended. This study, it is aimed to raise awareness about occupational health and safety in laboratory conditions.

Keywords: L type matrix, occupational health, safety rules, risk analysis, risk assessment.

Laboratuvar Çalışmalarında Risk Analizi Ve Risk Değerlendirmesi

Öz

Bu çalışmada iş sağlığı ve güvenliği kapsamında belirlenen laboratuvarlarda 5X5 L Tipi Matris Yöntemi kullanılarak risk analizi araştırılmaktadır. Yapılan risk analizinde 50 risk tespit edilmekte olup bunlardan 30 tanesi (% 60) yüksek risk derecesine sahip, 18 tanesi (% 36) orta risk derecesine sahip, 2 tanesi de (% 4) düşük risk derecesine sahip olduğu tespit edilmektedir. Laboratuvar araştırmalarında oluşan bu riskleri kontrol altına almak ve etkilerini en aza düşürmek amacıyla iş sağlığı ve güvenliği kuralları uygulanmaktadır. Bu kapsamda laboratuvar çalışmalarında yapılması gerekenler aşağıdaki gibi sıralanmaktadır. Laboratuvarda görev yapan öğrenci, öğretim üyesi ve çalışanların iş sağlığı ve güvenliği eğitimlerini alması gerekmektedir. Laboratuvar çalışmaları sırasında oluşabilecek durumlar için acil durum planları, ekipleri ve tatbikatları yapılmalıdır. Laboratuvar araştırmalarında kimyasal kullanılması, taşınması ve depolanması kayıt altına alınması gerekmektedir. Laboratuvarda havalandırma ve çalışma alanı gibi fiziki yetersizlikler ortadan kaldırılmalıdır. Kimyasal hijyen ve kaza önleme programı yapılması önerilmektedir. Bu araştırma, labaratuvar koşullarında görev yapan kişilere iş sağlığı ve güvenliği konusunda bir farkındalık sağlamak için yapılmıştır.

Anahtar Kelimeler: L tipi matris, iş sağlığı, güvenlik kuralları, risk analizi, risk değerlendirmesi.

1. Introduction

Occupational health and safety are branches of science that constantly develop as a result of the importance given to human beings in contemporary societies and undergo technology and innovation over time. The main purpose of occupational health and safety is to protect employees against work accidents and occupational diseases and to enable them to work in healthier environments. Depending on the industrial and technological investments made for high-quality and low-cost production, causes more competition in the sectors. The intense competition in industrial areas causes more mention of work accidents and occupational diseases. Although human power has been replaced by machinery and advanced systems due to the development and spreading of technology, the value of employees is gaining more and more importance.

The basic approach of occupational health and safety is to protect and secure the health of employees. Those working in the laboratory are exposed to various risk factors, including physical, chemical, biological, and psychosocial. For this reason, it is necessary to constantly monitor the health status of the employees and to reduce the risk factors arising from the working environment. Besides, it is necessary to prevent work accidents and occupational diseases by eliminating the sources of danger.

Occupational safety evaluates known, unknown, foreseeable, and unpredictable hazards and risks. The resulting hazards and risks threaten production, workflow, employees, production tools, and the environment. It is necessary to reduce the risks that may arise from the working environment and the production system so that the employees, the production system, and the environment are less affected by occupational accidents and emergencies. Once the danger arises, it can have irreversible consequences. Therefore, it is necessary to foresee, keep under control and eliminate the risks, and dangers that may occur [1].

The purpose of risk management in occupational health and safety is to evaluate the causes of work accidents and occupational diseases and the factors affecting them. It is also to establish an effective safety net to prevent the emergence of unseen threats by collecting information that will provide a valid and correct approach. A good risk analysis with a large team is of great importance in terms of protection from workplace accidents that may occur. Also, it provides the discovery of invisible dangers and the taking of effective security measures [1].

In Turkey, with Occupational Health and Safety Law No. 6331 enacted in 2012, serious responsibilities have been imposed on employees and employers. By law numbered 6331, employers are obliged to make a risk assessment in the workplace. Risk assessment is not an activity independent of management processes and should be fully integrated into all elements. Risk assessment consists of a comprehensive risk recognition process, risk analysis, and detection. The implementation of this process is based not only on the risk management process but also on the methods and techniques used in risk assessment [2].

World Health Organization defines occupational accidents as events that cause unplanned personal injuries, damage to machinery and equipment, and stop production for a certain period. International Labor Organization explains an occupational accident as an unplanned, unknown, and uncontrolled event that can harm the environment. It is very difficult to predict the size, impact, and consequences of occupational accidents that may occur and depend entirely on coincidence [1-4].

88 % of occupational accidents are caused by dangerous movements, 10 % by dangerous situations, and 2 % by unavoidable movements. The causes of dangerous actions are defined as personal faults arising from the employee's own body and structure. Hazardous situations are expressed as unsuitable mechanical conditions and environmental activities in the working environment. Loss of limbs and minor injuries can occur based on every event that results in serious injury or death in occupational accidents. Before occupational accidents occur, it is necessary to identify the hazards, predict the risks, reduce them to an acceptable level, take precautions, and carry out revisions. Risk assessment has provided an important roadmap for preventing occupational accidents.

When occupational accidents are examined, it is understood that they occur as a result of five basic factors coming together. Weakness of human nature against mechanical forces, personal defects, dangerous behavior (condition), accident event, and injury (damage or damage) constitute these five basic factors. These five basic factors make up the chain of accidents. Unless one of these happens, the next one does not occur, and unless the chain is completed, there is no accident or injury [1].

To prevent occupational accidents, and to ensure the health and safety of employees, it is of great importance to identify, rank, and evaluate hazards and risks. For this reason, Occupational Health and Safety Law No. 6311 makes risk assessment mandatory, and workplaces are subject to certain classifications. It makes it mandatory to repeat the risk analysis every 6 years in less dangerous workplaces, 4 years in dangerous workplaces, and every 2 years in very dangerous workplaces [5,6].

It is very important to carry out a risk assessment because it includes laboratory studies and multiple risks that may arise from studies. They are responsible for the work done in the laboratory, for their safety and the safety of other employees, as well as for the safety of the environment. Most of the accidents that occur in the laboratories are caused by the employees, although a small percentage of the accidents are due to technical errors. It is known that the rate of accidents occurring in laboratories is 10-50 times higher than the number of accidents occurring in the chemical industry [7].

Between 2006 and 2016, 120 fatal accidents occurred in university laboratories in United States. When the causes of these accidents are examined, it has been determined that there are events such as chemical burns, not paying attention to the waste rules, not knowing the quantities of the chemicals used, and incorrect applications [7].

There are differences in dangers and risks because they are used in many different areas such as educational institutions, health institutions, research centers, and forensic medicine centers since different scientific and technical research areas are diversified. Even when the researches, experiments, and analyses carried out in the laboratories are the same, there are differences in the methods and tools used. It makes it almost impossible to include the same degree of risks and hazards in laboratories due to features such as the different education levels

of the working personnel and the change in the number of employees [8].

While performing risk analysis and assessment, some basic concepts should be known in full detail. These are concepts such as hazard, risk, risk management, and risk assessment. Sources, situations, and processes that may cause injury to people, deterioration of health, or their occurrence together are defined as hazards. The combination of the probability of occurrence of an event or situation and the severity of the consequences if it occurs is a risk. Risk management is the assessment of risks related to human life and environmental safety and the systematic modification and implementation of policies. Risk assessment is a systematic approach to organizing and analyzing all kinds of materials with potential danger and all kinds of scientific knowledge and experience to be made about the situation [9-19].

Although the general laboratory rules are the same for all laboratories in which there is such a degree of differentiation, it is necessary to carry out special studies on risk analysis and evaluation in terms of occupational health and safety. In the literature research on laboratory activity areas, it is seen that there is no international classification standard according to the types of laboratories. It is striking that there are serious deficiencies in terms of occupational health and safety and that there is not enough work in this field. It is striking that there are serious deficiencies in terms of occupational health and safety and that there is not enough work in this field.

From the design and establishment phase of the laboratories, the infrastructure of occupational health and safety management systems is created with a series of measures. Employees should be informed about the dangers by organizing training. Occupational health and safety need to make risk analysis and assessment by considering the accidents that may occur in the laboratories.

2. Materials and Methods

The method used in risk analysis is listed as taking the necessary precautions according to the order of importance of the risks, finding the focus of the risks, and making the evaluations. In addition to minimizing the losses that may occur in work and equipment, it is to prevent work accidents that may occur and to determine the most economical method for businesses without sacrificing safety.

The workflow chart to be followed during risk analysis and assessment is given in Figure 1.

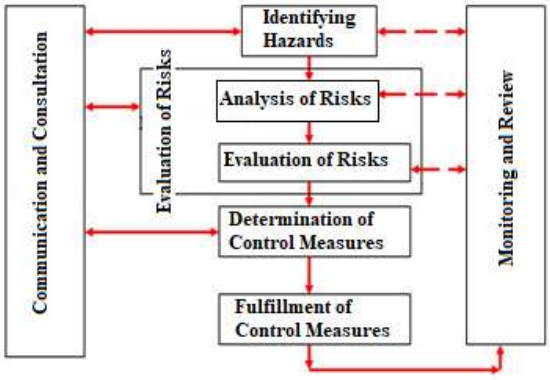

Figure 1. The workflow chart in risk analysis and assessment

It is the probability of not achieving a certain result or the probability of an undesired event occurring (probability) and the effect of the risk in case of occurrence (intensity). As stated, risk has two main components.

Risk = f (probability, intensity)

Risk = (Likelihood of the threat)·(Impact of threat)

In this study, 5x5 L Type Matrix Method has been used while evaluating the risks.

The occurrence (probability) of the event for each identified hazard is found using the probability scale shown in Table 1 and L Type Matrix method. Besides, the severity of the hazard has been determined by considering the severity scale in Table 2, L Type Matrix method.

Table 1. The probability of a risk

Score	Likelihood	Likelihood of occurrence
1	Unlikely	So unlikely
2	Remote	Unlikely, but possible to occur
3	Occasional	Likely to occur sometime in the life of an item
4	Moderate	Will occur several times in the life of an item
5	Frequent	Likely to occur frequently

Table 2. The severity of risk for occupational health.

Score	Likelihood	Potential Consequence
1	Negligible	Injuries and diseases that do not require medical treatment
2	Minor	Minor injuries that require first-aid only
3	Serious	Severe injuries that require hospitalization or multiple medical
4	Very Serious	Life-threatening injuries or multiple injuries that require
5	Critical	Death or multiple injuries that pose threat to life

In addition, 5x5 L type risk decision matrix is given in Table 3 and an occupational health risk assessment table is given in Table 4 [1].

Table 3. 5x5 L type risk decision matrix

		SEVERITY				
		Critical (5)	**Very Serious (4)**	**Serious (3)**	**Minor (2)**	**Negligible (1)**
LIKELIHOOD	**Frequent (5)**	Not tolerated (25)	High (20)	High (15)	Moderate (10)	Low (5)
	Moderate (4)	High (20)	High (16)	Moderate (12)	Moderate (8)	Low (4)
	Occasional (3)	High (15)	Moderate (12)	Moderate (9)	Low (6)	Low (3)
	Remote (2)	Moderate (10)	Moderate (8)	Low (6)	Low (4)	Low (2)
	Unlikely (1)	Low (5)	Low (4)	Low (3)	Low (2)	Insignificant (1)

Table 4. The risk assessment table for occupational health

Risk Score	Risk Degree	Actions should be taken to prevent the risk
25	Not tolerated	The process must not be operated until the risk is reduced to an acceptable level. it is necessary to stop single being studied actions. The activities must be canceled if the risk cannot be prevented.
15, 16, 20	Critical	The situation is an emergency or required actions must be taken at the nearest time. The action can be continued under supervision and control if the risk has no dangerous potential
8, 9, 10, 12	Moderate	The required protective actions must be taken to reduce the risk level.
2, 3, 4, 5, 6	Minor (maybe tolerated)	The emergency measure is not needed but the ruling measures must continue.
1	Negligible	Taking precautions is not the priority

3. Results and Discussions

In this risk analysis study, 50 risks are identified. The risks are categorized as high, medium, and low by rating them and are given in Table 5. 30 (60 %) risks with high risk, 18 (18 %) risks with medium risk, and 2 (4 %) risks with low risk have been determined.

Table 5. Frequency of risk grades

Risk Degree	Number of risks	% frequency
High Risk	30	60
Medium Risk	18	36
Low Risk	2	4
Total	**50**	**100**

The found risk scores and the distribution of the number of risks are shown in Figure 2. Considering the risk scores, there is a maximum number of hazards with a risk score of 20.

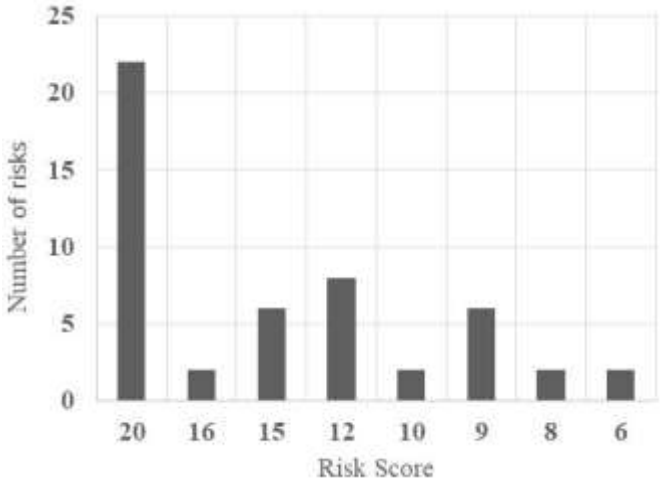

Figure 2. The risk score and number of hazards

The risk score and the number of risks identified as a result of the risk assessment performed are presented in Table 6.

Table 6. The risk score and number of risks

Risk Score	Number of Risks
20	22
16	2
15	6
12	8
10	2
9	6
8	2
6	2

4. Conclusions and Recommendations

In this study, hazards and the risks that may arise from these hazards have been evaluated by using L Type Matrix method in the laboratory. Appropriate (necessary) measures need to be taken to reduce risks with a high degree of risk to an acceptable level.

As a result, risks with a high risk level and a medium risk level should be reduced to a low risk level and made acceptable. Necessary measures are taken into account to eliminate the deficiencies and to provide a healthier and safer laboratory environment.

- Emergency exit plans and emergency escape routes should be determined for emergencies that may occur in the laboratory.
- In case of an emergency that may occur in the laboratory, the necessary information of the emergency teams should be visible in the laboratory.
- Employees should do these emergency drills for emergencies that may occur in the laboratory.
- Employees should know which fire extinguishing equipment should be used according to the type of fire in case of fire. The locations of equipment such as fire extinguishers must be at a height and marked, and annual periodic controls must be carried out by the determined legislation.
- The locations of the equipment in the laboratory should be marked, the users using the equipment should be determined, and the periodic maintenance of this equipment should be done.
- The identification cards of the equipment in the laboratory and the records of who was the last user should be kept regularly.
- Chemical materials should be stored considering their quantities.
- Chemical materials should be used under the control of authorized persons.
- Periodic maintenance of emergency showers and eye showers should be done.
- Contingency plans should be posted in a visible place in the laboratory and regularly updated.
- It should be ensured that laboratory personnel is stored regularly according to their qualifications.
- Appropriate personal protective equipment for the work of the employees in the laboratory should be provided and their use should be ensured.
- Tubes that are likely to burn and explode should be fixed, used, and stored by the legislation.

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Research Article

Depremden Zarar Görebilirlik Boyutunu Etkileyen Faktörlerin Derecelendirilmesi

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Öz

Afetler geniş kapsamlı sosyal, fiziksel ve ekonomik zararlara neden olan insan veya doğa kaynaklı olaylardır. Deprem büyük yıkımlara neden olan maddi ve manevi ciddi zararlar veren en önemli afetlerden biridir. Depremin neden olacağı hasarların belirlenmesi ve hasarları engellemeye yönelik gerekli önlemlerin alınması zarar boyutunun azaltılmasında önemli bir adımdır. Bu çalışmada depremden zarar görebilirliğe etki eden faktörler literatür taraması ve uzman görüşleri ile belirlenir. Ana ve alt başlıklarda belirlenen zarar görebilirliğe etki eden faktörler etki boyut ve ilişkilerine göre açıklanır. Deprem risk planlamasının yapılması ve önlemlerin alınması için faktörlerin öncelik sıralaması yapılır. Öncelik sıralaması depremden önce, deprem sırasında ve depremden sonra olası maddi ve manevi zarar boyutunu en aza indirmede yardımcı olur. Çok kriterli karar verme problemi olarak tanımlanan problemde depremden zarar görebilirliği etki eden faktörler analitik hiyerarşi prosesi (AHP) ile yapılandırılır ve ikili karşılaştırma matrisleri (İKM) ile değerlendirilir. Ana ve alt faktörler ikili karşılaştırılarak faktörlerin öncelik değerleri elde edilir. Yapısal, çevresel ve sosyal ana faktörlerden yapısal faktörlerin önemi ön plana çıkarken sosyal faktörlerden nüfus yoğunluğu dışındaki faktörler sıralamada son sıralarda yer alır. Çevresel faktörlerden faylara uzaklık ve jeolojik yapının önemi vurgulanır. Yapısal faktörler ile çevresel faktörlerin beraber dikkate alınması depremden zarar görme ölçüsünü önemli ölçüde azaltacağı görülür. Depremden zarar görebilirliği azalmak için tüm faktörlerin bütünsel olarak ele alınması gerekliliği dikkat çeker.

Anahtar Kelimeler: Deprem, zarar görebilirlik, ikili karşılaştırma matrisi, analitik hiyerarşi prosesi, öncelik değeri.

Rating of Factors Affecting the Dimension of Vulnerability from Earthquake

Abstract

Disasters are human or natural events that cause massive social, physical, and economic damage. Earthquake is the most important disaster that causes great destruction and causes serious material and moral damage. Identifying the sources of damage to be caused by the earthquake and taking the necessary precautions is an important step in reducing the size of the damage. In this study, the factors affecting vulnerability from earthquakes are determined by a literature review and expert opinions. To make earthquake risk planning and take precautions, the factors are prioritized. In the problem, which is defined as a multi-criteria decision-making problem, the factors affecting vulnerability from earthquakes are structured using the analytical hierarchy process (AHP) and evaluated with pairwise comparison matrices. While the importance of structural factors, which is one of the main structural, environmental, and social factors, comes to the fore, factors other than population density, which is one of the social factors, are at the bottom of the list. The distance from the environmental factors to the faults and the importance of the geological structure are emphasized. It is seen that considering structural and environmental factors together will significantly reduce the extent of damage from earthquakes. It has been pointed out that all factors should be considered holistically to reduce vulnerability to earthquakes.

Keywords: Earthquake, vulnerability, pairwise comparison matrix, analytical hierarchy process, priority value.

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1. Giriş

Deprem maddi ve manevi büyük yıkımlara neden olan önemli bir doğal afettir. Dünya'nın çeşitli bölgelerinde genellikle yer kabuğunun levha sınırlarında meydana gelen depremler gözlemlenir. Öngörülemeyen zaman ve boyutta gerçekleşen depremler büyük afetlere ve insanların savunmasız kalmasına neden olur (Duzgun vd., 2011). Diri fay hatları ile çevrili olan ve nüfusun büyük bir çoğunluğu deprem riski altında olan Türkiye yıl boyunca sismik etkiler altındadır. (AFAD, 2021). Tarihsel yıkımlarla karşılaşmış olan Türkiye'de aletsel dönemde kaydedilen en büyük deprem 1939 yılında 7,9 büyüklüğünde kaydedilen Erzincan depremidir (BDTİM, 2023a). Ayrıca 6 Şubat 2023 tarihinde gerçekleşen Gaziantep-Kahramanmaraş depremleri Türkiye tarihinin en fazla can kaybına neden olan depremleridir. Dörtten büyük her yıl ortalama yaklaşık 50 deprem gerçekleşen Türkiye maddi ve manevi risk tehditleri ile karşı karşıyadır (BDTİM, 2023b). Türkiye için öncelikli bir afet olan deprem farklı kıtalarda ve farklı ülkelerde de insanların yaşamını etkilemektedir. Depremin neden olduğu hasar depremin büyüklüğünün yanı sıra insan ve insan dışı faktörlerden kaynaklı deprem şiddetinin de bir sonucudur. Depremin büyüklüğü depremin açığa çıkardığı enerjinin bir ölçüsü iken depremin şiddeti açığa çıkan bu enerjinin insanlar, çevre ve yapılar üzerindeki etkilerini tanımlar. Örneğin 7.0 ve üzeri büyüklükteki bir depremin şiddeti şu boyutlarda tanımlanır: ahşap yapılar yıkılırken taş yapıların büyük çoğunluğu yıkılır ve demiryolları eğilir (şiddet: X), birkaç yapı dışında tüm yapılar yıkılır, demiryolları bükülür (şiddet: XI) ve bütün yapılar yıkılır, ufuk çizgisi oynak bir yüzeye dönüşür ve nesneler havada uçar (şiddet:XII) [5].

Deprem büyüklüğü ile birlikte ortaya çıkan şiddetin verdiği hasar boyutu insan başta olmak üzere birçok faktör temelinde artar. Artan nüfus yoğunluğu, plansız ve uygun olmayan yapılaşma, deprem konusunda bilinçsizlik, duyarsızlık ve ihmaller zarar boyunun artmasını tetiklemektedir. Ayrıca deprem ile birlikte ortaya çıkan heyelan, yangın, bulaşıcı hastalıklar ve yağma gibi problemlerin yol açacağı afet zinciri deprem acil durum boyutunun artmasına neden olur (Zhou vd., 2015). Deprem afetinin belirsizliği ile yüzleşerek önlemlerin alınması maddi ve manevi zararların boyutunu sınırlamaya yardımcı olacaktır.

Zarar görebilirlik, AFAD (Afet ve Acil Durum Yönetimi Başkanlığı) tarafından "Farklı tür ve büyüklükteki tehlikeler karşısında, insanların ve yaşam çevrelerinin uğrayabileceği fiziksel, toplumsal, ekonomik veya çevresel zarar ve kayıpların ölçüsü" (AFAD, 2023) olarak tanımlanır. Deprem riski kapsamındaki bölgelerin depreme hazırlıklı hale getirilmesinde zarar görebilirlik çalışması önemli bir aşamayı oluşturur. Riskli bölgeler için zarar görebilirlik çalışmalarının yapılması depremin zincir etkilerini düşürmede ve acil durum faaliyetlerini yönlendirmede önemli bir yöntemdir. Zarar görebilirlik değerlendirmesi olası hasar ve kayıpların öngörülmesi ve azaltılmasına yönelik planlamalarda yer alır (Etemadfard & Moradi, 2021). Deprem için zarar görebilirlik çalışması yerleşimlerin mevcut koşullarını değerlendirerek hasar senaryoları oluşturulmasına yardımcı olur. Deprem afetlerinden öngörülen yapı ve insan kayıplarını en aza indirme amaçları zarar görebilirlik çalışmalarının ve bağlı programların geliştirilmesinin önemini vurgular (M. S. Shadmaan & Popy, 2022).

Bu çalışma depremden zarar görebilirlikteki temel unsurlarının ele alınmasını ve bunlar arasında öncelik sıralaması yapılması ile ilgilenir. Literatür taramasından ve uzman görüşlerinden elde edilen zarar görebilirlik kriterlerinin derecelendirilmesi Çok Kriterli Karar Verme (ÇKKV) problemi olarak ele alınır. Zarar görebilirlik faktörlerin karşılaştırmalı değerlendirmesini yapmak ve faktörleri derecelendirmek için ÇKKV yöntem aracı olarak Analitik Hiyerarşi Prosesi (AHP) kullanılır. Doğal afetin zarar verme riskini tanımlayan hasar görebilirlik deprem özelinde nicel ve nitel kriterler dikkate alınarak belirlenir. Bölgeler için yapılan depremden zarar görebilirlik değerlendirmeleri, olası riskleri en aza indirgeme planlamalarında ve haritalandırmada çalışmalarında önemli bir araç olarak başvurulur.

Çalışmada yerel ve küresel boyutta maddi ve manevi ciddi zararlar veren deprem afetine karşı önlemlerin alınması için etkin faktörlerin önceliklendirilmesi amaçlanır. Literatür taraması ve uzman görüşleri ile geliştirilen ana ve alt faktörlerin depremin zarar verebilirliğine etkileri incelenir. Tanımlanan faktörlerin başlık ve sınıflandırmaları ve bunların mevcut koşullarda uzman görüşleri ile yapılan değerlendirmeleri çalışmanın literatüre özgün katkısını oluşturur. Elde edilen sonuçlar ile toplumsal ve yönetsel farkındalık oluşturarak depremin zarar verebilirlik boyutunun azaltılması amaçlanır.

Çalışma şu alt bölümlerden oluşur: Bölüm 2 depremden zarar görebilirliği değerlendirmede temel faktörler hakkında ve faktörlerin derecelendirmesinde başvurulan ÇKKV yönteminden ve AHP karar verme aracından bahseder. Bölüm 3 ana ve alt faktörlerin ikili karşılaştırma ve derecelendirme çalışmalarını açıklar. Sonuç başlığı olan Bölüm 4 elde edilen sonuçlar ve gelecek çalışmalar hakkında bilgi verir.

2. Materyal ve Metot

2.1. Depremden Zarar Görebilirlik Faktörleri

Depremden zarar görebilirlik faktörlerinin belirlenmesi ve tanımlanması risk değerlendirme çalışmaları için önemli bir aşamadır. Ana ve alt başlıklarda belirlenen faktörlerin zarar görebilirlik değerlendirmesindeki etki değerlerini belirlemek için ikili karşılaştırmalar yapılır. İkili karşılaştırmaların doğru yapılabilmesi için faktörlerin tanınması ve anlamlandırılması gerekir. Bu bölümde literatür ve uzman görüşleri ile yapısal, çevresel ve sosyal ana faktörler ve her ana faktör altında dört alt faktör tanımlanır.

2.1.1. Yapısal Faktörler

Farklı dönemlerde oluşan teknik/yapım bilgileri ve coğrafi özellikler kırsal ve kentsel yapıların farklılaşmasına neden olur. Yapıların oluşum özellikleri depremden zarar görebilirlikte en kritik faktörleri kapsamaktadır. Yapısal faktörler için tanımlanan alt faktörler şu şekildedir:

1. Yapı yaşı (Alizadeh, Ngah, vd., 2018; Bahadori vd., 2017; Nazmfar, 2019; M. S. Shadmaan & Popy, 2022): İnşasında kullanılan malzemeye göre yapı elemanlarının zamanla aşınması yapının yaşı ile ifade edilir. Yapının yaşının yüksek olması kullanılan malzemenin ve uygulan inşaat tekniklerin uygunsuzluğunu ve yapının zamanla yorulmuş olduğunu işaret eder. Bu durum yapının depremden hasar görebilirlik düzeyinin aratmasına neden olur. Yapılar 10 yaş altı, 10-30 yaş arası ve 30 yaş üstü olmak üzere üç gruba ayrılabilir. 10 yaş altı yapılar yeni olarak adlandırılırken 10-30 yaş

arası yapılar risk belirsizliği içerirken 30 yaş üstü yapılar yaşlanma ve zamanın teknik yetersizlikleri göz önünde bulundurularak hasar görebilirliği en yüksek grubu oluşturur. Eski yapıların eski yerleşim merkezlerinde bulunması ve bu merkezlerde yoğunlaşmaları yapıların ve bu yerleşimlerdeki kalabalıkların zarar görebilirliğe daha savunmasız olmasına neden olur.

2. Yapı tipi (Armaş, 2012; Bahadori vd., 2017; M. S. Shadmaan & Popy, 2022): Yapının inşasında kullanılan malzemenin özelliği yapı tipini tanımlar. Yapı inşasında kullanılan en yaygın malzemeler beton, çelik, tuğla, demir, kerpiç ve ahşaptır. Kerpiç ve ahşap malzemelerden yapılan yapılar daha az kırılgan özelliktedir. Dayanıklı malzemelerin kullanılması yapının hasar görebilirlik riskini azaltır. Zamanının koşullarında yüksek insan inisiyatifinde, inşaat kurallarına uyulmadan ve eksik denetimde inşa edilen eski yapılarda dayanıklı yapı malzeme ve teknik eksiklikleri görülür. Ayrıca yapı cephe tipi özelliklerinin cam, taş veya tuğla olması hasar görebilirlik riskini etkiler.
3. Kat sayısı (Alizadeh, Hashim, vd., 2018; Alizadeh, Ngah, vd., 2018; Bahadori vd., 2017; Nazmfar, 2019; Shafapourtehrany vd., 2022): Yapıların katsayısı depremden zarar görebilirliği etkileyen önemli bir faktördür. Yapılar katsayısına göre farklı sismik tepkiler gösterir. Kat sayısının artışı ile yapıların sismik kırılganlığı da artar. Yapı teknolojilerindeki gelişmeler yapı dayanımını arttırmasına rağmen katsayısının artışı yapının savunmasızlığı engelleyemez. Ayrıca katsayısının çokluğu nüfus yoğunluğu oluşturması hasar boyutunun yükselmesine ve deprem sonrası faaliyetlerin karmaşıklaşmasına neden olur.
4. Yüzey alanı (Jena vd., 2020; S. Shadmaan & Islam, 2021): Yapının inşa edildiği zemin alanını genişliği yapının zarar görebilirliğini etkiler. Yapı zemin alanının geniş olması yapının zarar görebilirliğini azaltırken zemin alanının dar olması hasar riskini arttırır. Dar alanda yüksek katlı yapılar geniş alanda az katlı yapılardan daha fazla deprem hassasiyetine sahiptir. Yapı malzeme özellikleri zemin alanı genişliğinin etkilerini değiştirir. Örneğin geniş yüzey alanına sahip kerpiç yapılar depremden hasar görebilirliği en yüksek yapılardır.

2.1.2. Çevresel Faktörler

Yapının bulunduğu konum ve çevresinde yer alan özelliklerin depremden zarar görebilirliğe olan etkilerini tanımlar. Bu faktörler deprem sırasında ve deprem sonrasında olası hasarların önlenebilirliği dikkate alınarak tanımlanır. Çevresel faktörler için tanımlanan başlıklar şu şekildedir:

1. Faylara olan uzaklık (Alizadeh, Hashim, vd., 2018; Bahadori vd., 2017; Jena vd., 2020; Nazmfar, 2019): Sismik açıdan risk alanlarından kaçınmak depremden hasar görebilirlikten kaçınmada önemli prosedürler arasındadır. Yapıların faylara olan mesafesi depremden zarar görebilme risklerini etkiler. Faylara olan mesafenin azalması yapısal faktörlere bağlı olarak hassasiyetin değişken artmasına neden olur. Yüksek hassasiyetteki bu bölgelere yakınlık mesken ve ticari yapılaşmalar için uygun görülmemektedir.
2. Jeoloji (Alizadeh, Hashim, vd., 2018; Alizadeh, Ngah, vd., 2018; Jena vd., 2020; Nazmfar, 2019): Sismik faaliyetlere sahip bölgelerin jeoteknik kırılganlığının belirlenmesi olası deprem risklerini derecelendirmeye yardımcı olur. Jeolojik yapı sismik dalgaların yer kabuğu üzerindeki etkileri belirleyici bir role sahiptir. Yapının yer alacağı zeminin toprak ve kaya tipini, eğimini, bileşimini ve su dokusunu içeren jeolojik oluşum türü depremden hasar görebilirliği etkileyen önemli faktördür. Depreme karşı dirençsiz jeolojik oluşumlar yapıların deprem hassasiyetini arttırır. Ayrıca jeolojik özelliklere göre deprem sonrası oluşabilecek zemin sıvılaşması, yüzey ayrışmaları ve heyelanlar depremin hasar boyutunu etkiler.
3. Ulaşım ağı (Alizadeh, Ngah, vd., 2018; Nazmfar, 2019; M. S. Shadmaan & Popy, 2022; Shafapourtehrany vd., 2022): Ulaşım sistemi altyapısı deprem hasarlarına müdahalede ve etkilerini en aza indirmede önemli bir rol oynar. Ulaşım ağları ve ana yolların genişliği deprem zarar görebilirlik yönetiminde önemli bir faktördür. Ulaşım ağının geniş ve açık olması müdahaleleri hızlandırarak depremden hasar görebilirlik boyutunu düşürür. Geniş ve etkin ulaşım ağı, kurtarma operasyonlarının, yardım malzemelerinin iletimi, yaralı nakilleri ve güvenli bölgelere yerleşimlerin hızlı bir şekilde gerçekleşmesini sağlar.
4. Acil servislere (itfaiye, hastane, polis vb.) uzaklık (Armaş, 2012; Bahadori vd., 2017; Rashed & Weeks, 2003; M. S. Shadmaan & Popy, 2022; Shafapourtehrany vd., 2022): Deprem sonrası ortaya çıkan afet yönetiminin gerçekleştirilmesinde, ilk yardım müdahalelerin yapılmasında ve oluşan kaos ortamının kontrol altına alınmasında acil servisler öncül göreve sahiptir. Bu servislere yakınlık yardım ve kurtarma operasyonlarının hızla gerçekleşmesini sağlayarak afetzede sayısını azaltacaktır. Acil servislere yakınlık depremden hasar görebilirlik düzeyini azaltır.

2.1.3. Sosyal Faktörler

Depremden etkilenen toplulukların özellikleri depremden zarar görebilirliklerini etkileyen bir faktördür. Kişilerin fiziksel, zihinsel ve ruhsal özellikleri deprem öncesi, sırası ve sonrası davranışlarını ve depreme maruz kalma boyutlarını belirler. Toplulukların depremden zarar görebilirliklerini etkileyen sosyal faktörler şu şekildedir:

1. Cinsiyet (Armaş, 2012; Rahman vd., 2015; M. S. Shadmaan & Popy, 2022): Cinsiyet farklılığı depremden zarar görebilirliği etkileyen bir faktör olarak görülür. Kadınların yapılarda kalma olasılıklarının yüksek olmasından ve duygusal ve fiziksel özelliklerinin erkeklerden farklı olmasından dolayı depremlerde erkeklerden daha fazla savunmasız oldukları kabul edilir.
2. Eğitim (Alizadeh, Ngah, vd., 2018; Armaş, 2012, 2012; Rahman vd., 2015; M. S. Shadmaan & Popy, 2022):

Eğitim düzeyinin artması deprem başta olmak üzere tüm afetlerde nasıl davranılması gerektiği konusunda bilincin artması ile ilişkilendirilir. Deprem öncesinde, sırasında ve sonrasında yapılması gerekenlerin bilinmesi depremin zarar verebilirlik düzeyini azaltır. Eğitimli insanların varlığı afetlerle başa çıkmada tedbirlerin alınmasında ve uygulanmasında öncü rol üstlenerek toplumsal savunmasızlığı azaltır. Deprem hassasiyeti konusunda toplumsal deprem eğitimi öncelikli olması gerekir. Eğitim düzeyi yalnız başına depremden hasar görebilirliği değiştirmemesine rağmen yüksek eğitimli kişilerin tehlike öngörülerine sahip olma olasılıkları daha yüksektir.

3. Yaş (<14, >65) (Bahadori vd., 2017; Rahman vd., 2015): Yaş, depremden zarar görebilirliği tanımlayan bir kriterdir. Fiziksel yetersizlikler ve bilgi eksiklikleri 14 yaş altı ve 65 yaş üstü bireylerin depremden zarar görme risklerini arttırır. Bu yaş gruplarının yalnız olması zarar görme hassasiyetini arttırırken yaş ve bilgi yeterliliğine sahip bireyler ile beraber olmaları hassasiyeti azaltır.
4. Nüfus yoğunluğu (Alizadeh, Ngah, vd., 2018; Jena vd., 2020; M. S. Shadmaan & Popy, 2022; Shafapourtehrany vd., 2022): Depremden zarar görebilirlik boyutunu etkileyen ve sismik tehlike boyutu hesaplamada kullanılan en önemli faktör nüfus yoğunluğudur. Sismik faaliyetlere maruz kalan kişi sayısının artması zarar görme hassasiyetini de arttırır. Yapı yoğunlaşması ve kat sayısı ile birlikte nüfus yoğunluğunun artması savunmasızlığın artmasına da neden olur. Deprem öncesi riskli bölgelerdeki yoğunluğun yatay mimari ile seyreltilmesi risklerin azalmasını sağlar. Nüfus dağılım bilgilerinin bilinmesi ile deprem sonrası acil müdahale öncelikleri bu bölgelere yapılarak zarar görebilirlik boyutu azaltır.

Yapısal, çevresel ve sosyal ana kriterleri altında ele alınan alt faktörler ile depremden hasar görebilirlik boyutları arasında değerlendirme yapılır. AHP ile ele alınan problemde kriterler ana ve alt kriterler olarak karşılaştırmalı değerlendirilir. Karşılaştırmalı değerlendirmeler bir araya getirilerek faktörlerin öncelik değerleri elde edilir.

2.2. Analitik Hiyerarşi Prosesi (AHP)

Birden fazla kriteri değerlendirerek kriterler arasında önceliklendirme yapmaya amaçlayan çalışma ÇKKV problemi olarak ele alınır. Kriterleri ikili karşılaştırarak daha basit ve doğru değerlendirme imkanı verdiği için AHP yöntemi kullanılır. Bu bölümde AHP yönteminden bahsedilir.

Saaty tarafından geliştirilen AHP (T. L. Saaty, 2008) yaygın olarak soyut özelliklerin değerlendirmesinde başvurulur ve ilgili başlıkları göreceli değerlendirme kolaylığı sunar (Aguarón vd., 2020). En uygun sonucu bulma amacı ile tasarlanan karar verme probleminde alternatifleri ve kriterleri değerlendirir. Çok sayıda alternatif ile çok sayıda kriterin tek boyutta karşılaştırılması zorluğu yerine karmaşık problemler alt boyutlara olmakla beraber en iyi kararın verilmesine de engel olmaktadır (Çoban, 2020). AHP karmaşık problemleri hiyerarşik olarak alt boyutlara indirgeyerek çözme imkanı veren bir yöntemdir. AHP değerlendirme elemanlarını ikili karşılaştırma matrisi (İKM) altında üstünlüklerine göre değerlendirir. Böylece karar vericiye değerlendirme ve derecelendirme kolaylığı sağlar. Değerlendirme elemanları için tanımlanan ikili karşılaştırma matrisi, E şu şekilde tanımlanır (Brunelli, 2018);

$$E = \left(e_{ij}\right)_{m\times m} = \begin{pmatrix} e_{11} & e_{12} & \cdots & e_{1m} \\ e_{21} & e_{22} & & e_{2m} \\ \vdots & & \ddots & \vdots \\ e_{m1} & e_{m2} & \cdots & e_{mm} \end{pmatrix} \quad (1)$$

Önem düzeyi (Tablo 1) temelinde e_ij∈[1/9,9] olmak üzere alternatif i'nin (a_i) alternatif j'ye (a_j) üstünlük derecesini tanımlar (Franek & Kresta, 2014). Ayrıca ikili karşılaştırma değeri elemanların ağırlıkları arasındaki oran için yaklaşık değeri tahmin eder (Gass & Rapcsák, 2004):

$$e_{ij} \approx w_i/w_j \,, \forall i,j \quad (2)$$

$e_{ij} \approx w_i/w_j > 0$ olduğu için $e_{ji} \approx w_j/w_i = 1/e_{ij}$ olmak üzere ikili karşılaştırma matrisi bu şekilde tanımlanabilir. Her eleman kendileri üzerinde eşit üstünlüğe sahip olduğu için $e_{ii} = 1$ olur ve İKM'nin diagonali 1 olarak tanımlanır.

Tablo 1. Saaty'nin tercih ölçeği

Önem	Tercih derecesi
1	Eşit derecede
3	Orta derecede
5	Fazlasıyla
7	Çok fazlasıyla
9	Aşırı derecede
2, 4, 6, 8	Ara dereceler

İkili karşılaştırma matrislerinde eleman ağırlıklarını tahmin etmede özvektör (Gass & Rapcsák, 2004; R. W. Saaty, 1987) ve geometrik ortalama yöntemleri yaygın tercih edilir. Perron-Frobenius özvektör yöntemi (Harker, 1987), ikili karşılaştırma matrisinin (E) gerçek ağırlık vektörü (w) ile çarpımının, ağırlık vektörünün (w) İKM'nin en büyük özdeğeri (λ_{mak}) ile çarpımı arasındaki eşitliğe dayanır.

$$Ew = \lambda_{mak}\, w \quad (3)$$

İKM'de elemanların ikili ele alınması ile yapılan tüm değerlendirmelerin karar verici tarafından tutarlı bilgilerle yapılması beklenir. Karar vericinin değerlendirmelerini tutarlı yapıp yapmadığının değerlendirmesi geçişlilik koşullarının sağlanıp sağlanmadığına bakılarak yapılır (Xu vd., 2018). Tutarlılık indekslerine dayanarak geçişlilik koşullarının geçerliliği ölçülür. Saaty'nin tutarlılık indeksi ve tutarlılık oranı literatürde yaygın kabul gören ve başvurulan bir yöntemdi (Aguarón vd., 2020). Saaty özvektör yöntemine dayanarak İKM'nin $(E_{m\times m})$ en yüksek özdeğerinin (λ_{mak}) İKM boyutuna (m) eşit olması durumunda değerlendirmelerin tam tutarlı olduğu sonucuna varılır. Bu kabule göre λ_{mak} ve m arasındaki ilişkiye dayanarak tanımlanan tutarlılık indeksi,CI şu şekildedir (Bulut vd., 2012):

$$CI(E) = \frac{\lambda_{mak}-m}{m-1} \quad (4)$$

Tutarlılık indeksinin 0'dan farklı değer çıkması durumunda İKM'nin tutarlılığını değerlendirmek için tutarlılık oranı (CR) değerine bakılır (Csató, 2018). Tutarlılık oranı (CR(E)), İKM'nin boyutuna göre tutarlılık indeksinin ilgili boyuta karşılık gelen rassal indekse (RI_n) oranı olarak tanımlanır. Rassal indeks (RI_m), ikili karşılaştırma değerleri [1/9,9] aralığında rastgele üretilen

İKM'lerin tutarlılık indekslerinin ortalamalarının alınması ile hesaplanır.

$$CR(E) = \frac{CI(E)}{RI_m} \quad (5)$$

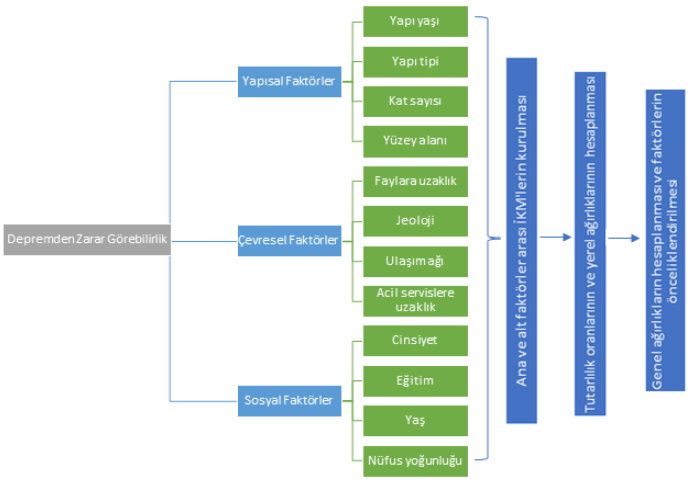
İKM'nin tutarsızlık oranının (CR) 0.1'e küçük ve eşit olması (CR≤0.1) ikili karşılaştırmaların karar verici tarafından yeterince tutarlı olduğu sonucunu işaret eder. Ayrıca Saaty 3 ve 4 boyutlu İKM'lerin CR eşik değerlerini sırası 0.05 ve 0.08 olarak tanımlar (T. L. Saaty, 2008). Alonso ve Lamata tarafından geniş rassal veri seti ile üretilen RI_m değerleri Tablo 2'de gösterilir (Alonso & Lamata, 2006).

Tablo 2. Alonso ve Lamata RI değerleri

m	1	2	3	4	5
RI_m	0	0	0.5247	0.8816	1.1086
m	6	7	8	9	10
RI_m	1.2479	1.3417	1.4057	1.4499	1.4854

3. Faktörlerin Derecelendirilmesi

Depremden zarar görebilirliği etkileyen üç ana ve on iki alt faktör tanımlanır. Sismik riskleri etkileyen faktörlerin derecelendirilmesinde ve önceliklendirilmesinde AHP faydalı bir araç olarak ele alınır. Faktörlerin öncelik değerlerini belirleme amacı ile kriterlerin değerlendirilmesinde kullanılır. AHP değerlendirmesi ile ağırlandırılacak ve önceliklendirilecek kriterler, deprem öncesi ve sonrası afet yönetiminde önem verilmesi gereken başlıkları tanımlar. Farklı fiziksel, çevresel ve sosyal özelliklere sahip bölgeler ilgili faktör yoğunluğuna göre farklı risk boyutlarında tanımlanabilir ve haritalandırılabilir. Depremden zarar görebilirlik derecelendirmesi amacı için geliştirilen AHP yapısı Şekil 1'de gösterilir.



Şekil 1. Depremden zarar görebilirlik değerlendrimesinin AHP gösterimi.

Ana faktörler öncelikli olmak üzere her ana kriter altında tanımlanan alt faktörler için İKM'leri uzman görüşleri ve literatürden elde edilen bilgilere göre geliştirilir. Ana kriterler için tanımlanan İKM Tablo 3'de gösterilir.

Ana ve alt faktörler için yapılan ikili karşılaştırmalı değerlendirmeler İKM ile gösterilir. Bu değerlendirme yapılırken, yapısal faktörler çevresel ve sosyal faktörlere göre daha yüksek puanlanmıştır. Depremden zarar görmede yapılar temel risk potansiyellerine (binanın yaşı, kullanılan malzeme vb.) olduğu için önem düzeyi yüksek tutulmuştur.

Ana kriterlerin ikili karşılaştırmalı değerlendirmesine göre faktörler arasında önemli farklılıklar görünmez (Tablo 3). Öncelik değerlerine göre yapısal faktörler (0,525) zarar görebilirlik için en önemli faktör olarak görünürken en zayıf etkiler sosyal faktörlerden (0,141) beklenir. Yapısal ana faktörünün yüksek öncelik değeri alt faktörlerinin de genel derecelendirme ve sıralamada öne çıkmasını sağlar.

Tablo 3. Zarar görebilirlik ana kriterlerinin İKM

Faktörler	**YF**	**ÇF**	**SF**	**Öncelik Vektörü**
Yapısal Faktörler (YF)	1	2	3	0,525
Çevresel Faktörler (ÇF)	0,5	1	3	0,334
Sosyal Faktörler (SF)	0,33	0,33	1	0,141

Yapısal faktörlerin kendi içinde ikili karşılaştırmasında, yapı yaşı en önemli yapısal faktör olarak ortaya çıkar (Tablo 4). Bina yaşının artması ve özellikle 30 yıl sınırını aşması zarar görebilirlik risklini arttırır. Yapı yaşı ve yapı tipi eşit düzeyde kat sayısı ve yüzey alanında önemli olarak değerlendirilir. Yüzey alanı faktörü yapının yaşı, tipi ve kat sayısından daha az önemsiz olarak görünür (0,137).

Tablo 4. Yapısal faktörler zarar görebilirlik kriterlerinin İKM

Faktörler	**YY**	**YT**	**KS**	**YA**	**Öncelik Vektörü**
Yapı Yaşı (YY)	1	3	2	2	0,420
Yapı Tipi (YT)	0,3	1	2	2	0,248
Kat Sayısı (KS)	0,5	0,5	1	2	0,195
Yüzey Alanı (YA)	0,5	0,5	0,5	1	0,137

Çevresel faktörlerin değerlendirmesinde faylara uzaklık en önemli faktör (0,385) olarak belirlenir (Tablo 5). Faylara uzaklık, tüm çevresel faktörler üzerinde üstün önem düzeyine sahip olup jeoloji ikinci yerel öncelik sıralamasına sahip faktördür. Tüm faktörlerden önemsiz olarak değerlendirilen acil servislere uzaklık faktörü en az öncelik değerine (0,149) sahip olup eşit önem değerine sahip olduğu ulaşım ağı faktörünün öncelik değeri 0,160'dir. Bu sonuçlar depremden zarar görebilirlikte öncül önlemlerin alınması gerekliliğine işaret eder.

Tablo 5. Çevresel faktörler zarar görebilirlik kriterlerinin İKM

Faktörler	**FU**	**J**	**UA**	**ASU**	**Öncelik Vektörü**
Faylara Uzaklık (FU)	1	2	2	2	0,385
Jeoloji (J)	0,5	1	2	3	0,306
Ulaşım Ağı (UA)	0,5	0,5	1	1	0,160
Acil Servislere Uzaklık (ASU)	0,5	0,3	1	1	0,149

Sosyal faktörlerin değerlendirmesinde nüfus yoğunluğu en önemli faktör (0,384) olduğu gözlenir (Tablo 6). Nüfus yoğunluğunun fazla olması zarar görebilirliğin ölçüleri olan can kaybı ve yaralanma sayılarının artırmasına neden olur. En önemli üstünlük derecesi yaş faktörünün cinsiyet faktörü üzerinedir. Cinsiyet faktörü diğer faktörlerden önemsiz konumda olup en düşük öncelik değerine (0,120) sahiptir. Yaş ve eğitim eşit öneme sahip olmalarına rağmen yaş faktörünün öncelik değeri (0,275) eğitim faktörünün öncelik değerinden (0,220) yüksektir.

Tablo 6. Sosyal faktörler zarar görebilirlik kriterlerinin İKM

Faktörler	C	E	Y	NY	Öncelik Vektörü
Cinsiyet (C)	1	0,5	0,25	0,5	0,385
Eğitim (E)	2	1	1	0,5	0,306
Yaş (Y)	4	1	1	0,5	0,160
Nüfus Yoğunluğu (NY)	2	2	2	1	0,149

Alt faktörlerin ana faktör öncelik değerlerine dayanarak yapılan derecelendirme Tablo 7'de gösterilir. Derecelendirme ve sıralamaya göre yapısal faktörler ön plana çıkar. Yapı yaşı genel değerlendirmede en önemli faktör olarak belirlenir. Diğer bir yapısal faktör olan yapı tipi genel önem sıralamasında ikinci sırada yer alır. Yapı tipi zeminin özelliklerine göre değişkenlik göstermesinden dolayı önemli faktörler arasındadır. Yapısal faktörler dışında üçüncü önem sırasında yer alarak öne çıkan çevresel faktör fay hatlarına uzaklık faktörüdür. Dolayısıyla fay hatlarının belirli mesafe uzağına yapılaşmanın yapılması gerekliliği dikkat çeker. Sosyal faktörleri zarar görebilirlik önem sıralamasında son sıralarda yer alırken sırası ile cinsiyet (0,017), eğitim (0,031) ve yaş (0,039) en düşük genel önem değerlerine sahiptir. Cinsiyet, eğitim ve yaşında zarar görebilirlikte önemli olmasına rağmen nüfus yoğunluğu kadar önemli olmadığı görülmektedir.

Tablo 7. Genel öncelik değerleri ve öncelik sıralaması

Ana faktörler	Alt faktörler	Yerel öncelik		Genel öncelik	
		Değerleri	Sırası	Değerleri	Sırası
Yapısal Faktörler (w=0,525)	Yapı yaşı	0,419	1	0,220	1
	Yapı tipi	0,248	2	0,130	2
	Kat sayısı	0,195	3	0,103	4
	Yüzey alanı	0,137	4	0,072	6
Çevresel Faktörler (w=0,334)	Faylara uzaklık	0,385	1	0,129	3
	Jeoloji	0,306	2	0,102	5
	Ulaşım ağı	0,160	3	0,053	8
	Acil servislere uzaklık	0,149	4	0,050	9
Sosyal Faktörler (w=0,142)	Cinsiyet	0,120	4	0,017	12
	Eğitim	0,220	3	0,031	11
	Yaş	0,275	2	0,039	10
	Nüfus yoğunluğu	0,384	1	0,054	7

Genel olarak depremden maddi ve manevi zarar görebilirliği yapısal, çevresel ve sosyal faktörler birbirlerini tamamlayıcı bir yapıda etkiler. Bu çalışmada yapılan karşılaştırmalı değerlendirme ve önceliklendirme hesaplamalarından elde edilen sonuçlar deprem öncesi, sırası ve sonrası maruziyeti etkileyen faktörleri tanımlayarak depremin zararlarını azaltmayı amaçlar. Elde edilen sonuçlar göz önünde bulundurularak deprem afet planlamalarının ve öncelik faaliyetlerinin tanımlanmasına yardımcı olması beklenir.

4. Sonuç

Depremden zarar görebilirlik, depremin neden olduğu tehlikelerin insanlar başta olmak üzere canlı ve cansız çevrelere vereceği zararların ölçüsü olarak tanımlanır. Zarar görebilirliğe neden olan faktörlerin tanımlanması ve bu faktörlere öncelikli önlemlerin alınması zarar ölçüsünün azaltılması katkı sağlayacaktır. Bu çalışma, zarar görebilirlik etkilerini azalmak için kritik faktörlerin literatür taraması ve uzman görüşleri ile tanımlanmasını ve önceliklendirilmesini amaçlar. Zarar görebilirliği etki eden faktörler yapısal, çevresel ve sosyal ana başlıklarında tanımlanır. Yapısal faktörler yapı yaşı, yapı tipi, kat sayısı ve yüzey alanı; çevresel faktörler faylara uzaklık, jeoloji, ulaşım ağı ve acil servislere uzaklık; sosyal faktörler cinsiyet, eğitim, yaş ve nüfus yoğunluğu alt faktörlerinde tanımlanır. Ana faktörleri v ve alt faktörleri ikili karşılıklı değerlendirme imkanı veren AHP yöntemi kullanılır. AHP yöntemi ile faktörler hiyerarşik olarak tanımlanır ve öncelikli ağırlıkları elde edilir.

Ana faktörlerin ikili karşılaştırmalı değerlendirmelerine göre yapısal faktörler depremin zarar verebilirlik boyutunu etkileyen en önemli faktör olarak belirlenir. Yapısal faktörler altında yer alan yapı yağı, yapı tipi ve kat sayısı faktörleri depremin zarar verme ölçüsünü düşürmede öncelikli faktörler olarak sıralanır. Yüzey alanı faktörü en zayıf yapısal faktör olmasına rağmen genel öncelik sıralamasında ön sıralarda yer alır. Bu sonuçlar depreme karşı yapısal önlemlerin alınmasının önemi bir kez daha vurgular. Yapısal faktörlerden sonra gelen en önemli ana faktör çevresel faktör iken en zayıf etkiye sahip ana faktör sosyal faktördür. Faylara uzaklık ve jeolojik yapı çevresel faktörlerin önem öncelik kazanmasına neden olan faktörlerdir. Yapısal özellikler önemli olmasına rağmen fay hatlarına yakın olunması ve uygun olmayan zemin yapısına inşaların yapılması zarar görebilirlik boyutunu arttırması beklenir. Özellikle deprem sonrası zarar ölçüsünü düşürmede ulaşım ağı ve acil servislere uzaklık kritik faktörler olarak öne çıkar. En zayıf ana faktör olan sosyal faktörlerde nüfus yoğunluğunun artması ölüm ve yaralanma riskini arttıracağı için en önemli sosyal risk olarak tanımlanır. Sosyal faktörler özellikle savunmasız bireylerin zarar görebilme durumunu dikkate alır. Genç ve yaşlı bireyler depremden savunma konusunda bilgilendirilmeleri ve toplumsal bilincin sağlanması için genel deprem eğitimlerinin verilmesi de zarar boyutunun azaltılmasına katkı sağlayacağı görülür.

İnsanların ve çevrenin depremden görebileceği maddi ve manevi zararların kaynakları çoklu boyutta ele alınması gereken önemli bir problemdir. Bu çalışmada ele alınan faktörler ve bu faktörler için tanımlanan öncelik sıralamaları toplumsal farkındalığın yaratılmasında ve ulusal deprem planlamasına katkıda bulunması beklenir. Gelecek çalışmalarda ele alınan ana ve alt faktörlerin ayrıntılı genişletilmesi ve başlıkların yeniden tanımlanması planlanır. Bu şekilde genişletilen çalışma ÇKKV problem olarak ele alınarak farklı karar verme araçları ile faktörlerin derecelendirilmesi ve sıralanması yapılabilir. ana sonuçları bu bölümde özetlenmelidir.

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Research Article

Navigating the Challenges of Education Management Best Practices for Improving Student Outcomes

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Abstract

The purpose of this study is to examine the key challenges facing education management and to offer insights into best practices for addressing these challenges. The research investigates the shifting educational landscape and the increasing demand for effective and efficient management of resources, the role of technology in education management, and the importance of leadership in education management. The study was conducted using a comprehensive literature review and analysis of current practices in education management. The findings highlight the need for ongoing professional development, the development of strong partnerships and collaborations, and the implementation of effective data-driven decision-making processes. The results indicate that effective education management requires a deep understanding of the complexities of educational systems and the ability to collaborate effectively with stakeholders. Technology plays a crucial role in improving decision making and supporting resource allocation, while strong leadership skills, a culture of innovation, and a supportive and inclusive work environment are critical to success. In conclusion, this study offers practical strategies for enhancing the quality and effectiveness of educational systems. The findings emphasize the importance of addressing the challenges facing education management in order to ensure that students receive the best possible education and that resources are used efficiently and effectively.

Keywords: Best Practices, Education Management, Leadership, Student Outcomes, Technology.

Eğitim Yönetiminin Zorluklarını Yönetmek: Öğrenme Çıktılarını Geliştirmek İçin Gerçekleştirilen En İyi Uygulamalar

Öz

Bu çalışmanın amacı, eğitim yönetiminin karşılaştığı temel zorlukları incelemek ve bu zorlukların ele alınması için en iyi uygulamalara ilişkin içgörüler sunmaktır. Araştırma, değişen eğitim ortamını ve kaynakların etkin ve verimli yönetimine yönelik artan talebi, eğitim yönetiminde teknolojinin rolünü ve eğitim yönetiminde liderliğin önemini araştırmaktadır. Çalışma, kapsamlı bir literatür taraması ve eğitim yönetimindeki güncel uygulamaların analizi kullanılarak gerçekleştirilmiştir. Bulgular, devam eden mesleki gelişime, güçlü ortaklıkların ve iş birliklerinin geliştirilmesine ve etkili veri odaklı karar alma süreçlerinin uygulanmasına duyulan ihtiyacı vurgulamaktadır. Sonuçlar, etkili eğitim yönetiminin, eğitim sistemlerinin karmaşıklıklarının derinlemesine anlaşılmasını ve paydaşlarla etkili bir şekilde iş birliği yapma yeteneğini gerektirdiğini göstermektedir. Teknoloji, karar vermeyi iyileştirmede ve kaynak tahsisini desteklemede çok önemli bir rol oynarken, güçlü liderlik becerileri, inovasyon kültürü ve destekleyici ve kapsayıcı bir çalışma ortamı başarı için kritik öneme sahiptir. Sonuç olarak, bu çalışma eğitim sistemlerinin kalitesini ve etkinliğini artırmak için pratik stratejiler sunmaktadır. Bulgular, öğrencilerin mümkün olan en iyi eğitimi almalarını ve kaynakların verimli ve etkili bir şekilde kullanılmasını sağlamak için eğitim yönetiminin karşılaştığı zorlukların ele alınmasının önemini vurgulamaktadır.

Anahtar Kelimeler: Eğitim Yönetimi, En İyi Uygulamalar, Liderlik, Öğrenci Çıktıları, Teknoloji.

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1. Introduction

Education management has become an increasingly complex and challenging field in recent years, with a growing emphasis on improving student outcomes and enhancing the overall effectiveness of educational systems. The purpose of this study is to examine the key challenges facing education management and to offer insights into best practices for addressing these challenges. The educational landscape has shifted significantly in recent years, with changing demands from students and the need for effective and efficient management of resources (Xiaodong, Chong, Chenhao, & Shu, 2021). The increasing use of technology in education has also brought new challenges, including the need to effectively incorporate data analytics and artificial intelligence into decision-making processes (Loukis Euripidis , Manolis, & Niki, 2020).

Leadership plays a critical role in education management, as it sets the tone for the overall effectiveness of educational systems. Effective leaders must have strong skills, a culture of innovation, and a supportive and inclusive work environment (Leithwood, Harris, & Hopkins, 2008). Additionally, education management requires a deep understanding of the complexities of educational systems and the ability to collaborate effectively with stakeholders, including teachers, students, and families (Mayo, García-Martín, Rodríguez, & Grande-de-Prado, 2021). To address the challenges facing education management, it is important to understand the current state of the field and to identify best practices for improving student outcomes and enhancing the overall effectiveness of educational systems. This study was conducted using a comprehensive literature review and analysis of current practices in education management (Wilcox, 2021). One of the key challenges facing education management is the need for ongoing professional development. As the demands of the field continue to evolve, education managers must continuously update their skills and knowledge to meet changing needs (Shirley, 2020). This includes staying up-to-date with the latest technologies and data analytics tools, as well as developing strong leadership and collaboration skills (Hallinger & Kulophas, 2020). Another challenge facing education management is the development of strong partnerships and collaborations.

Effective partnerships between schools, communities, and other stakeholders are critical to improving student outcomes and enhancing the overall effectiveness of educational systems (García-Martínez, Montenegro-Rueda, Molina-Fernández, & Fernández-Batanero, 2021). Education managers must work closely with stakeholders to build trust, create shared goals, and establish a culture of collaboration (Shirley, 2020). The implementation of effective data-driven decision making processes is another important challenge facing education management. The use of data analytics and artificial intelligence can help education managers make informed decisions about resource allocation, program design, and student outcomes (Wilcox, 2021). However, the effective use of data requires a deep understanding of data analytics techniques and a commitment to using data to drive decision making (Yu, 2021). Effective education management also requires a strong understanding of the complexities of educational systems. Education managers must be able to navigate the complex policies, regulations, and systems that govern education in order to ensure that resources are used effectively and that student outcomes are improved (Wilcox, 2021). This requires a deep understanding of the context of education and the ability to work effectively with a wide range of stakeholders (Leithwood, Harris, & Hopkins, 2008).

Finally, the role of leadership in education management cannot be overstated. Effective leaders play a critical role in setting the tone for the overall effectiveness of educational systems (Leithwood, Harris, & Hopkins, 2008). They must have strong skills, a culture of innovation, and a supportive and inclusive work environment in order to effectively lead and manage educational systems (Hallinger & Kulophas, 2020). In conclusion, the challenges facing education management are significant and complex. However, by understanding the current state of the field and identifying best practices, education managers can work to improve student outcomes and enhance the overall effectiveness of educational systems. This study provides a comprehensive overview of the challenges facing education management and offers insights into best practices for addressing these challenges. It is essential for education managers to continually develop their skills, build strong partnerships and collaborations, effectively use data analytics, have a deep understanding of the complexities of educational systems, and exhibit strong leadership qualities. With a focus on these key areas, education managers can work towards ensuring that students receive the highest quality education and that educational systems are effective and efficient. In order to understand key factors and best practices for effective education management system, ultimately leading to improved educational outcomes and a successful educational system, questions bellowed were asked below:

RQ1. What are the main challenges facing education management and how can they be addressed effectively?

RQ2. What are the key qualities and skills necessary for effective education management, and how can these be developed and strengthened?

RQ3. How can education managers effectively use data analytics to inform decision-making and improve educational outcomes?

RQ4. What is the impact of partnerships and collaborations on education management and student achievement?

RQ5. How can education leaders exhibit strong leadership qualities to ensure the success of their educational systems?

2. Literature Review

Education management is a complex and multifaceted field that requires a deep understanding of educational systems and the ability to effectively use data analytics, develop partnerships and collaborations, and exhibit strong leadership skills. The literature on education management provides valuable insights into these key aspects of education management, and offers best practices for addressing the challenges facing education managers.

One of the main challenges facing education managers is the need for ongoing professional development. According to Bronwen et al., (2022), effective education management requires a continuous process of learning and improvement, as education systems are continually evolving and changing. Education managers must have a deep understanding of the complexities of educational systems, as well as the ability to adapt and respond to changing circumstances. To develop these skills, education managers need access to ongoing professional development

opportunities that allow them to expand their knowledge and enhance their skills (Boveda & Weinberg, 2022).

The ability to effectively use data analytics is another critical aspect of education management. Da-Hong et al. (2020) notes that education managers must have a strong understanding of data analytics, as well as the ability to effectively use data to inform decision-making and improve educational outcomes. Ifenthaler, (2022) also highlight the importance of data analytics, stating that education managers must have a deep understanding of the data available to them and must be able to use that data to drive improvement. To effectively use data analytics, education managers must be trained in data analysis and interpretation, and they must have access to the necessary tools and resources (Ifenthaler, 2022).

Partnerships and collaborations are also essential for effective education management. Mayger & Hochbein (2020) argue that partnerships and collaborations can help to build trust and strengthen relationships between different stakeholders, including teachers, administrators, and parents. García-Martínez et al. (2021) also emphasize the importance of partnerships and collaborations, stating that these relationships can help to create a shared vision and a sense of shared responsibility for student achievement. Education managers must be skilled in building and maintaining partnerships and collaborations, and must be able to effectively communicate and negotiate with a variety of stakeholders (Boveda & Weinberg, 2022).

Strong leadership is also critical to effective education management. Leithwood et al. (2008) argue that education management requires strong leadership that is capable of inspiring and motivating others. Education managers must exhibit strong leadership qualities, such as the ability to inspire and motivate others, the ability to make tough decisions, and the ability to effectively communicate and engage with a variety of stakeholders (Abate & Adamu, 2022). The literature also provides insights into the importance of effective communication in education management. According to Abate & Adamu (2022), effective communication is critical to creating a shared vision and promoting a culture of collaboration and trust. Education managers must be skilled communicators and must be able to effectively engage with a variety of stakeholders, including teachers, administrators, and parents.

Effective decision-making is also a critical aspect of education management. (Aarkrog & Wahlgren, 2022) It is argued that effective education managers must have the ability to make tough decisions and to use data to inform their decision-making. Education managers must also be able to effectively manage risk, as educational systems are complex and constantly evolving. The use of technology is another important aspect of education management. According to Camarena & Fusi (2022) technology can be a valuable tool for education managers, as it can help to increase efficiency and improve communication and collaboration. Education managers must have a deep understanding of technology and must be able to effectively integrate technology into the educational system to support teaching and learning (Camarena & Fusi, 2022).

Effective financial management is also crucial in education management. Riadi (2021) argue that education managers must have a strong understanding of financial management principles, as well as the ability to effectively allocate resources to support educational programs and initiatives. Education managers must also be able to effectively manage budgets and ensure that resources are being used in an efficient and effective manner (Riadi, 2021). Teacher professional development is another important aspect of education management. Even- Zahav, Widder, & Hazzan, (2022) argues that education managers must provide ongoing professional development opportunities for teachers to enhance their skills and knowledge, and to support their growth as educators. Education managers must also be able to effectively evaluate teacher performance and provide feedback to support teacher improvement (Even- Zahav, Widder, & Hazzan, 2022).

The role of education managers in school reform is also important. Knapp (2020) notes that education managers must play a key role in driving school reform, and must be able to effectively lead and manage change initiatives. Education managers must also be able to effectively engage with teachers, administrators, and other stakeholders to ensure that reforms are effectively implemented and sustained (Knapp, 2020). Additionally, education managers must also understand the political and policy context in which they operate. Education policy and funding decisions can greatly impact the ability of schools to meet their goals and deliver high-quality education to students. Education managers must be able to know about the policy environment and be able to effectively advocate for policies that support the needs of students and schools (Aslan, et al., 2022). Furthermore, education managers must also be able to effectively manage cultural diversity and support students from diverse backgrounds. In an increasingly diverse society, education managers must be able to develop policies and programs that support the academic and social-emotional needs of all students. Finally, it is important for education managers to be knowledgeable about the latest research and advancements in education. Education is constantly evolving, and education managers must be able to stay informed and incorporate new research and innovations into their practice.

In summary, education management is a complex and challenging field that requires a wide range of skills and knowledge. Education managers must be knowledgeable about the educational system, be able to use data analytics, exhibit strong leadership skills, engage in effective communication, make effective decisions, integrate technology, manage finances, support teacher professional development, and drive school reform. They must also understand the political and policy context, effectively manage cultural diversity, and stay informed about the latest research and advancements in education. In conclusion, the literature on education management provides valuable insights into the key aspects of education management and the challenges facing education managers. Effective education management requires a deep understanding of educational systems, the ability to effectively use data analytics, develop partnerships and collaborations, exhibit strong leadership skills, engage in effective communication, make effective decisions, integrate technology, manage finances, support teacher professional development, and drive school reform. Education managers must be skilled and knowledgeable in these areas, and must be committed to ongoing professional development and improvement.

3. Material and Method

This study adopted a mixed-methods research design, which combined qualitative and quantitative data collection and analysis techniques (Tashakkori, Teddlie, & Teddlie, 1998). The purpose of the mixed-methods design was to provide a comprehensive and in-depth understanding of the knowledge, skills, and attitudes of

education managers, and to explore the ways in which education managers develop and improve their knowledge and skills over time.

3.1. Data Collection

The data collection process consisted of two stages: a questionnaire and semi-structured interviews. The questionnaire was designed to gather quantitative data on the knowledge, skills, and attitudes of education managers, and was administered online to a convenience sample of education managers working in schools across the United States. The semi-structured interviews were designed to gather qualitative data on the experiences and perceptions of education managers, and were conducted in person with a purposive sample of education managers who had completed the questionnaire.

The questionnaire consisted of a series of questions that explored the knowledge, skills, and attitudes of education managers. The questions were based on the literature review and were designed to measure the following constructs:

- Knowledge of student learning and development
- Ability to promote a positive school culture and climate
- Development and implementation of effective assessment and accountability systems
- Effective management of school resources and facilities

The questionnaire was pilot-tested with a small group of education managers to ensure that the questions were clear and easy to understand. The pilot test also helped to identify any problems with the questionnaire design, and to refine the questions as necessary. The semi-structured interviews were conducted in person with a purposive sample of education managers who had completed the questionnaire. The interviews were designed to gather qualitative data on the experiences and perceptions of education managers, and to explore the ways in which education managers develop and improve their knowledge and skills over time. The interviews consisted of a series of open-ended questions that were based on the questionnaire data and the literature review. The interviews were audio-recorded and transcribed for analysis.

3.2. Data Analysis

The data collected from the questionnaire and semi-structured interviews were analyzed using both qualitative and quantitative techniques. The questionnaire data were analyzed using descriptive statistics to summarize the responses of education managers. The semi-structured interview data were analyzed using thematic analysis to identify patterns and themes in the data.

3.3. Ethical Considerations

This study was approved by the institutional review board of Fırat University, and all participants provided informed consent prior to participating in the study. The participants were assured of their anonymity and confidentiality, and were informed that their participation was completely voluntary. The data collected were securely stored and analyzed in accordance with the ethical guidelines of the institution.

4. Results and Discussion

The findings of this study provide a comprehensive understanding of the knowledge, skills, and attitudes of education managers, as well as the ways in which they develop and improve their skills over time. The following sections summarize the key findings from the survey and semi-structured interview data.

4.1. Survey Findings

4.1.1. Knowledge of Student Learning and Development

The survey results showed that education managers have a good understanding of student learning and development. Over 90% of the education managers surveyed reported having knowledge of child development theories, and over 80% reported that they use this knowledge to guide their decision-making and to create effective learning environments for students.

4.1.2. Knowledge of Student Learning and Development

The survey results showed that education managers are able to promote a positive school culture and climate. Over 80% of the education managers surveyed reported that they use positive reinforcement and praise to encourage good behavior and to create a positive school culture. Additionally, over 90% reported that they communicate regularly with teachers and staff to promote a positive school culture and to create a sense of teamwork.

4.1.3. Development and Implementation of Assessment and Accountability Systems

The survey results showed that education managers have the ability to develop and implement effective assessment and accountability systems. Over 80% of the education managers surveyed reported that they use data to inform their decision-making and to evaluate the effectiveness of their programs and initiatives. Additionally, over 90% reported that they use performance-based assessments to hold themselves and their staff accountable for student outcomes.

4.1.4. Management of School Resources and Facilities

The survey results showed that education managers are effective at managing school resources and facilities. Over 80% of the education managers surveyed reported that they use data and technology to monitor and manage school resources and facilities, and over 90% reported that they regularly conduct facility assessments to ensure that their schools are safe and well-maintained.

The results of the survey showed that education managers had a high level of knowledge and skills in some areas, such as promoting a positive school culture and climate, but were less confident in other areas, such as the development and implementation of effective assessment and accountability systems. Education managers valued the opportunity to engage in professional learning and development activities, and saw these activities as important for their personal and professional growth.

Different education managers had different preferences for the type of professional development activities they participated in, with some preferring hands-on, practical training sessions, while others preferred workshops and conferences that provided opportunities for networking and collaboration. Overall, the survey results emphasized the need for ongoing training and professional development for education managers.

4.2. Survey Findings

The semi-structured interview results provide deeper insights into the experiences and perceptions of education managers, and the ways in which they develop and improve their knowledge and skills over time. The following are some of the key themes that emerged from the interview data:

4.2.1. Continuous learning

The education managers reported that they engage in continuous learning to improve their knowledge and skills. They reported attending workshops, conferences, and professional development opportunities, and reading research and books related to education management.

4.2.2. Mentorship and collaboration

The education managers reported that they value mentorship and collaboration as a means of developing and improving their knowledge and skills. They reported seeking out experienced education managers as mentors, and collaborating with colleagues and peers to share ideas and best practices.

4.2.3. Mentorship and collaboration

The education managers reported that they engage in regular reflection and self-assessment to improve their knowledge and skills. They reported taking time to reflect on their experiences, and to evaluate the effectiveness of their decision-making and programs.

4.2.4. Mentorship and collaboration

The education managers reported that they use technology to improve their knowledge and skills. They reported using online professional development resources, and using data and technology to monitor and manage school resources and facilities.

The semi-structured interviews provided further insights into the experiences and perceptions of education managers. A number of themes emerged from the interviews, including the importance of ongoing professional development, the challenges of managing school resources, and the need for effective communication and leadership skills. Here are ten quotes from the education managers:

- "Professional development is key to staying current and improving our skills as education managers."
- "Balancing the budget and managing school resources is one of the biggest challenges I face on a daily basis."
- "Good communication skills are essential for building relationships with staff, students, and parents."
- "As an education manager, it's important to have a vision and the leadership skills to bring that vision to life."
- "I believe that promoting a positive school culture and creating a supportive environment for students and staff is one of the most important aspects of my job."
- "Building trust and strong relationships with staff is crucial for effective management and achieving our goals."
- "I think it's important for education managers to stay current on new trends and developments in education and to continuously learn and grow."
- "Assessment and accountability are critical components of effective school management, but they can also be challenging to implement."
- "I believe that hands-on, practical training sessions are the most effective form of professional development for education managers."
- "As an education manager, it's important to have strong interpersonal skills and the ability to build consensus and bring people together to achieve a common goal."

These quotes illustrate the diverse perspectives and experiences of education managers, and highlight the importance of ongoing professional development, effective communication and leadership skills, and the challenges of managing school resources. They emphasize the need for education managers to have a range of knowledge, skills, and attitudes to be effective in their roles.

4. Conclusions and Recommendations

The findings of this study provide new insights into the knowledge, skills, and attitudes of education managers, and the ways in which they develop and improve these over time. The survey results indicated that education managers have a strong understanding of student learning and development, and the importance of promoting a positive school culture and climate. The results also suggest that education managers face challenges in the development and implementation of effective assessment and accountability systems, as well as the effective management of school resources and facilities. The semi-structured interviews provided further insight into these findings, and emphasized the importance of ongoing professional development, effective communication and leadership skills, and the challenges of managing school resources.

The survey results align with previous research that has emphasized the importance of school leaders having a strong understanding of student learning and development (Leithwood et al., 2008). This knowledge is critical for school leaders to create a supportive and effective learning environment for students. The results also suggest that education managers have a strong understanding of the importance of promoting a positive school culture and climate, which has been shown to have a significant impact on student achievement (Özdemir, Gün, & Yirmibeş, 2021).

The results of this study also highlight the challenges that education managers face in the development and implementation of effective assessment and accountability systems. This is consistent with previous research that has identified assessment and accountability as critical components of effective school management, but also noted the challenges of implementing these systems in practice (Boff & Zulianelo, 2021). The semi-structured interviews emphasized the need for education managers to have a strong understanding of assessment and accountability and the skills to effectively implement these systems in their schools.

The results of this study also suggest that education managers face challenges in the effective management of school resources and facilities. This is consistent with previous research that has identified resource and facility management as critical components of effective school management, but also noted the

challenges of managing these resources in practice (Leithwood et al., 2008). The semi-structured interviews emphasized the importance of education managers having the skills to effectively manage school resources and facilities, and to create a supportive and effective learning environment for students. Accordingly, the findings of this study contribute to the understanding of the knowledge, skills, and attitudes of education managers, and the ways in which they develop and improve these over time. The results highlight the importance of ongoing professional development, effective communication and leadership skills, and the challenges of managing school resources. These findings can be used to inform professional development programs for education managers, and to support their continued growth and development as leaders.

The findings of this study have important implications for the education management profession and the training and development of education managers. The study has shown that education managers have a high level of knowledge and skills in some areas, such as promoting a positive school culture and climate, but that they are less confident in other areas, such as the development and implementation of effective assessment and accountability systems. This highlights the need for ongoing training and professional development for education managers, particularly in areas where they lack confidence.

The study has also shown that education managers value the opportunity to engage in professional learning and development activities, and that they see these activities as important for their personal and professional growth. This indicates that education managers are open to the idea of ongoing training and development, and that they are motivated to improve their knowledge and skills over time. The study has also revealed that education managers have different preferences for the type of professional development activities they participate in, and that they value different aspects of these activities. Some education managers prefer hands-on, practical training sessions, while others prefer workshops and conferences that provide opportunities for networking and collaboration. This highlights the importance of offering a variety of professional development options to education managers, to ensure that they can find activities that meet their needs and preferences.

The study aimed to explore the knowledge, skills, and attitudes of education managers, and to identify the ways in which education managers can effectively address the challenges facing the education management profession. The findings of this study have important implications for education managers, policy-makers, and researchers. In answering RQ1, the study found that the main challenges facing education management include limited resources, conflicting stakeholder interests, and increasing accountability pressures. To address these challenges effectively, education managers need to be strategic and innovative in their approach to decision-making, and to develop strong partnerships with other stakeholders in the educational system.

RQ2 highlights the key qualities and skills necessary for effective education management, including strong leadership skills, an understanding of student learning and development, and the ability to promote a positive school culture and climate. To develop and strengthen these skills, education managers need to engage in continuous professional development and seek feedback from stakeholders. RQ3 highlights the importance of data analytics in education management, and the ways in which data analytics can inform decision-making and improve educational outcomes. Education managers need to be proficient in using data analytics to track student progress and identify areas for improvement. RQ4 explores the impact of partnerships and collaborations on education management and student achievement. The study found that strong partnerships between education managers, teachers, and other stakeholders can lead to improved educational outcomes and a more effective educational system. Finally, RQ5 examines the role of strong leadership qualities in ensuring the success of educational systems. The study found that effective education leaders need to be visionary, knowledgeable, and able to effectively communicate their vision to stakeholders. They also need to be able to inspire and motivate their staff, and to create a culture of continuous improvement.

Overall, the findings of this study have important implications for education management, and highlight the need for education managers to be strategic, innovative, and proficient in their approach to decision-making. To be successful, education managers need to be knowledgeable about student learning and development, have strong leadership skills, and be able to use data analytics to inform decision-making and improve educational outcomes. Additionally, education managers need to develop strong partnerships with other stakeholders in the educational system, and exhibit strong leadership qualities to ensure the success of their educational systems.

Future research in this area should focus on exploring the implementation of these findings in real-world educational settings, and on developing evidence-based strategies for education management. In conclusion, this study has provided valuable insights into the knowledge, skills, and attitudes of education managers, and has highlighted the need for ongoing training and professional development for this important group of professionals. The findings of this study will be useful for education management organizations, universities, and other institutions that provide training and support for education managers, and will help to inform the development of new and effective training programs that meet the needs of education managers in the 21st century (Kazu, Kazu & Kuvvetli, 2022).

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Research Article

Forensic Analysis of APT Attacks based on Unsupervised Machine Learning

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Abstract

Advanced Persistent Threat (APT) has become the concern of many enterprise networks. APT can remain unde- tected for a long time span and lead to undesirable consequences such as stealing of sensitive data, broken workflow, and so on. APTs often use evasion techniques to avoid being detected by security systems like Intrusion Detection System (IDS), Security Event Information Management (SIEMs) or firewalls. Also, it makes it difficult to detect the root cause with forensic analysis. Therefore, companies try to identify APTs by defining rules on their IDS. However, besides the time and effort needed to iteratively refine those rules, new attacks cannot be detected. In this paper, we propose a framework to detect and conduct forensic analysis for APTs in HTTP and SMTP traffic. At the heart of the proposed framework is the detection algorithm that is driven by unsupervised machine learning. Experimental results on public datasets demonstrate the effectiveness of the proposed framework with more than 80% detection rate and with less than 5% false-positive rate.

Keywords: Unsupervised Machine Learning, Advanced Persistent Threats (APTs), HTTP, SMTP, Forensic Analysis

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1. Introduction

An Advanced Persistent Threat (APT) is an organized cyber attack by a group of skilled, sophisticated threat actors. [1] [2]. Attackers plan their mission carefully against strategic targets and execute out over a long time window. APTs are highly sophisticated compound attacks involving multiple phases with diverse techniques with zero-day exploits and malware. APT campaigns tend to involve multiple attack vectors as well as multiple access points. Thus, APT attacks are difficult to be identified [3] [4]. Since APTs target critical companies and other governmental organizations, they constitute one of the most serious security challenges [5].

APT exploits a variety of tactics and techniques and a large library of custom and open-source malware. It actually utilizes 13 different tactics defined by MITRE ATT&CK. This includes: reconnaissance, resource development, initial Access, execution, persistence, privilege escalation, credential access, discovery, lateral movement, defense evasion, command and control, collection, and exfiltration. To achieve their objectives, APT attackers use one or more techniques. For instance, APT38 is a North Korean state-sponsored threat group that specializes in financial cyber operations; it has been attributed to the reconnaissance general bureau. Active since at least 2014, APT38 has targeted banks, financial institutions, casinos, cryptocurrency exchanges, SWIFT system endpoints, and ATMs in at least 38 countries worldwide [6].

APTs are detected and prevented in many ways. The most common software or hardware are Security Event Information Management (SEIM) and Intrusion Detection System (IDS). However, when both the APT traffic is indistinguishable from the normal traffic, it becomes extremely difficult to detect such attacks. Furthermore, exploiting evasive techniques allow APT attacks to easily bypass the detection systems [7] [8]. Therefore, exploiting adaptive detection techniques reinforced with deep inspection might be inevitable to properly equip different enterprises with effective detection techniques against APT attacks [9].

HTTP and SMTP malicious traffic are the most common and annoying types of APT attacks. These malicious traffics analogous to genuine SMTP and HTTP traffic. They use the same TCP port 80 for HTTP and 25 for SMTP and respect the SMTP and HTTP messages structure [10] [11]. Thus, detecting such malicious traffic cannot be conducted with simple analysis of ports numbers or thorough inspection of the packet structure. A deep analysis is required to assess the behavior of the entities by combining multiple information such as the number of bytes exchanged, the duration, the time the message was sent, the time the message takes to response, and other related information.

These days most organizations use SEIMs to oversee occasion logs and safeguard their organization from assaults. Nonetheless, composing discovery rules in SIEMs while considering countless measures is no longer imaginable. It raises a concern about the acceptable threshold value to tag a traffic instance as malicious or not. APTs are being executed by gifted assailants, whereas the rate of attacks is controlled to stay undetected for sufficiently long time period.

Machine learning techniques can be effectively exploited in such a complex detection task. There exists two classes of machine learning techniques: supervised and unsupervised methods. Supervised learning (SL) is practiced through feeding the system with a set of input-output examples to infer the needed function for classification. In supervised learning, each example in the training set is a pair consisting of an input vector and the desired output vector [12]. Nonetheless, this approach has two downsides in APT detection application. In the first place, the presentation of the algorithm relies exhaustive preparation of the dataset. An algorithm prepared with a particular arrangement of danger methods probably will not recognize a zero-day attack. An algorithm trained to recognize authentic traffic will be well specific for the association where the preparation dataset has been captured or caught. The subsequent issue is related to the expense of labeling datasets. Countless picture datasets exist because label pictures do not need explicit abilities. In the case of network security, the context is different. Labeling network security traffic must be performed by security specialists, which infers a dramatic expansion to the cost of this undertaking. Unsupervised machine learning algorithms, on the other hand, infer patterns from a dataset without reference to known, or labeled, outcomes and do not need any training [13]. This consequently resolves the two aforementioned drawbacks. However, for the unsupervised class, it is difficult to have the same result and the same accuracy as the supervised method or algorithm achieves.

In this paper, we propose a framework to detect APT attacks for both HTTP and SMTP traffic. We used Splunk which is SIEM to help us to analyze the data and to analyze the collection log from different sources, also, the reason that we used Splunk is that Splunk has the machine learning toolkit that helps us to test our chosen algorithm.

This paper will propose a comprehensive framework driven by unsupervised machine learning detection algorithm, to identify APT attacks for both HTTP and SMTP traffic. Our contributions are summarized as following: an unsupervised machine learning technique, we focus on HTTP and SMTP traffic. The obtained results are further analyzed to conduct forensic analysis. Our contributions are summarized as follows:

- We propose a framework, driven by unsupervised ma- chine learning algorithms to detect abnormal traffic for both HTTP and SMTP packets, through dynamically identifying the lower band, upper band, and outliers with proper choice of statistical measures.

- Three types of unsupervised machine learning algorithms are compared and evaluated in terms of Detection Rate (DR) and False Positive Rate (FPR).
- Combination of different algorithms are tested and evaluated for further enhancement of the results.
- The obtained results are further analyzd to do foreonesic analysis and obtain the attack vector as well as the targeted machines.

The rest of the article is as follows. First, we present the related work. Then, we introduce a background for machine learning algorithms and APT in section **3**. Section **4** describes our proposed algorithm, the dataset, and the comparison of the three unsupervised algorithms. Then we present in section **5** the experimental result and the attack scenario after forensic analysis. Finally, section 6 concludes the article.

2. Related Work

Several techniques have been proposed in the literature to detect generic network intrusions as well as abnormal HTTP and SMTP traffic. This has been conducted using both supervised and unsupervised machine learning.

Leon et al. introduced in [14] a way to deal with anomaly detection based on Unsupervised Niche Clustering (UNC).The UNC is a hereditary niching strategy for clustering, which can decide the number of clusters automatically. The creators describe each predicted cluster using a fuzzy membership function. Also, they utilize the Maximal Density Estimator (MDE) refinement to work on the nature of the arrangement and Principal Component Analysis (PCA) to reduce the complexity of the dataset and further improve the exhibition of the proposed approach. The model has been tested on a public dataset and has shown a detection rate of 99.2% with false alarm rate of 2.2%.

Ibrahim Ghafir et al. proposed in [15] a novel machine learning-based system, namely MLAPT, to detect and predict APT attacks in a holistic approach. The MLAPT consists of three main phases: threat detection, alert correlation, and attack prediction. The MLAPT is able to predict APT in its early steps with a prediction accuracy of 84.8%.

Cho Do Xuan has exploited machine learning to propose a method of detecting APT attacks based on abnormal behaviors of network traffic [16]. In this work, two components are defined: Domain and IP of the abnormal behavior of APT attacks in network traffic. Then, these behaviors are esteemed and classified based on the Random Forest classification algorithm to conclude the behavior of APT attacks.

Thi Quynh Nguyen et al. made a comparison of the performance of four unsupervised machine-learning algorithms [17]: K-means, Gaussian Mixture Model (GMM), Density-Based Spatial Clustering of Applications with Noise (DBSCAN), and Local Outlier Factor (LOF) on the Boss of the SOC Dataset Version 1 (Botsv1). Then they present a technique that merges DBSCAN and K Nearest Neighbor (KNN) to gain 100% detection rate and between 1.6% to 2.3% false-positive rate.

In the work publised in [18], the authors introduced a semi-unsupervised anomaly detection method. They made assumption that during the learning phase (for the captured volume of HTTP traffic), Only a small fraction of the samples is labeled. Their experiments show that the proposed method achieves ratios of true positive and false positive errors below 1%.

Feature selection techniques have been exploited to analyze phishing datasets in the work published in [19]. In this context, information gain, gain ratio, Relief-F, and Recursive Feature Elimination (RFE) for feature selection have been utilized with the aid of diverse machine learning algorithms. The highest scoring classifiers have been then combined to improve the classification accuracy which has reached up to 97.4%.

Although abnormal HTTP and SMTP detection works achieve good detection results, some of them use supervised learning approaches and thus, require a training dataset which is expected to fail in detected zero-day attacks. Although some other approaches have utilized unsupervised ML, they have been applied to small datasets. The adaptation of such approaches on a wider scale is mandatory with the increasing number of APT attacks. Furthermore, most of the core fields those approaches inspect might result in high false positive rate if there are multiple servers in the network, since the proposed classifiers do not distinguish user traffic from the server traffic. Therefore, we propose in this paper a behavioral analysis approach based on probabilistic and distributed statistic algorithms for detecting malicious HTTP and SMTP traffic. We evaluate our proposed approach on public datasets: Botsv1 and Botsv2 datasets of Splunk project.

3. Background

Although translating the aforementioned MITRE ATT&CK tactics into a set of detection rules to be fed into an Intrusion Detection System (IDS) is possible, writing such rules is a very exhaustive as it needs building many highly composite indicators of compromise.

3.1. Advanced Persistent Threats (APTs)

APT attacks mainly aim to mine highly sensitive data through silently establishing a long term presence in a network. APTs generally target businesses and governments with exploiting sophisticated malware [20]. For instance, when studying APT38, the attacker has conducted spearphishing campaigns using malicious email attachments with SMTP protocol. Moreover, the attackers in the APT group encrypt most of their traffic with SSL to hide malicious traffic inside authorized network traffic. After the attacker gets into the network, APT38 has used brute force techniques over HTTP traffic to attempt account access when passwords are unknown or when password hashes are unavailable. Thereafter, APT38 has used a backdoor

with the capability to download and upload files to and from a victim's machine.

Over the years, APT groups have targeted traditional financial institutions, making the targeting of SWIFT systems their specialty. The group targets are geographically diverse, with financial institutions in Africa, Southeast Asia, India, and Latin America [6].

3.2. Machine Learning

As explained before, applying supervised learning algorithms for detecting malicious network traffic raises issues due to the exhaustivity of the training dataset and high labelling cost. There exist, however, many unsupervised anomaly detection algorithms. The core motivation of using unsupervised ML algorithms in this work is to dynamically define the thresholds needed to distinguish malicious traffic from the normal traffic. Otherwise, a threshold has to be set manually, which is more likely to increase the rate of false positives.

In this paper, we utilize two categories of unsupervised ML algorithms to detect APT attacks: Probabilistic-based algorithms and outlier detection- based algorithms.

3.1.1. Probabilistic-based ML Algorithm

This algorithm identifies anomalous events by computing a probability for each event and then detecting unusually small probabilities. The probability is defined as the product of the frequencies of each individual field value in the event. Each data item is treated based on its type as following :

- For categorical fields, the frequency of a value x represents the number of times x occurs divided by the total number of events.
- For numerical fields, we first build a histogram for all the values, then compute the frequency of a value x as the size of the bin in the resultant histogram that contains X divided by the number of events.

3.1.2. Outlier Detection-based ML Algorithm

This algorithm determines values that appear to be extraordinarily higher or lower than the rest of the data. Identified outliers are indicative of interesting, unusual, and possibly dangerous events. This algorithm is compatible with two statistical measurements: Standard deviation and Median absolute deviation.

When a situation violates the expectations for a parameter, it results in an outlier. The steps for utilizing this algorithm is as following [13]:

- Select a numeric field to analyze in the packet.
- Select a statistical measurement to detect outliers. The proper metric is selected based on the distribution of the data to be analyzed as follows:
  - Standard Deviation : This method is appropriate If the data exhibits a normal distribution. Since the standard deviation method centers on the mean, it is more impacted by outliers.
  - Median Absolute Deviation : This method applies a stricter interpretation of outliers than standard deviation because the measurement centers on the median and uses Median Absolute Deviation (MAD) instead of standard deviation.
- Specify the threshold multiplier to identify the outlier envelop.

4. Proposed Approach

The proposed framework for detecting abnormal HTTP and SMTP traffic is driven by two hypotheses, as published in [17]: First, APTs are higky complex attacks perpetrated by experts of highly skilled attackers whose objective is to stay undetected for an extended period of times. Thus, most of the network traffic is genuine. The traffic corresponding to attacks is assumed to be very low (e.g., less than 3% of the traffic at maximum). In other words, if the malicious traffic rate exceeds this presumed rate, it is assumed that traditional detection systems are capable of detecting it. The second hypothesis is related to detecting anomalies without previous knowledge of the network and the traffic. This is translated in the form of detecting outliers. Consequently, the network traffic must be preprocessed to separate the different network services (DNS, HTTP(S), SMTP(S), etc.) before applying outlier detection.

Accodingly, our detection framework is summarized as following (shown in Fig. 1):

1) Categorize the network traffic by service.
2) For each service, apply unsupervised machine learning to detect abnormal traffic. In this context, three algorithms are evaluated: Histogram (probabilistic-based), standard deviation, and medium absolute deviation (outlier-detection based) algorithms (see Fig. 2).
3) Post-analyze the detected values to determine the infected machine and predict the detailed scenario for forensic analysis.

4.1 Chosen Dataset

Both experimentation and the evaluation have been conducted using Botsv1 and Botsv2 datasets from Splunk project [21] [22]. Both datasets are public. Botsv1 dataset contains HTTP-based execution and reconnaissance. On the other hand, Botsv2 contains SMTP-based spear-phishing email or initial access. Thus, our goal for the first dataset is to detect abnormal HTTP traffic which may carry executing and privi- lege escalation data. For the external scenario. Regarding the second version of the dataset, our goal isto detect SMTP traffic which may carry initial access. In this context, it is important to mention that both datasets contain evidence captured during actual computer security incidents, or from realistic lab recreations of security incidents. Both datasets consist of two parts: The original

dataset containing all data, and a much smaller version of the original dataset containing only attack data. The original dataset is available in several formats: compressed, several JSON files by source type, and several CSV files by source type (such as stream: DNS, stream: HTTP, stream: SMTP, etc).

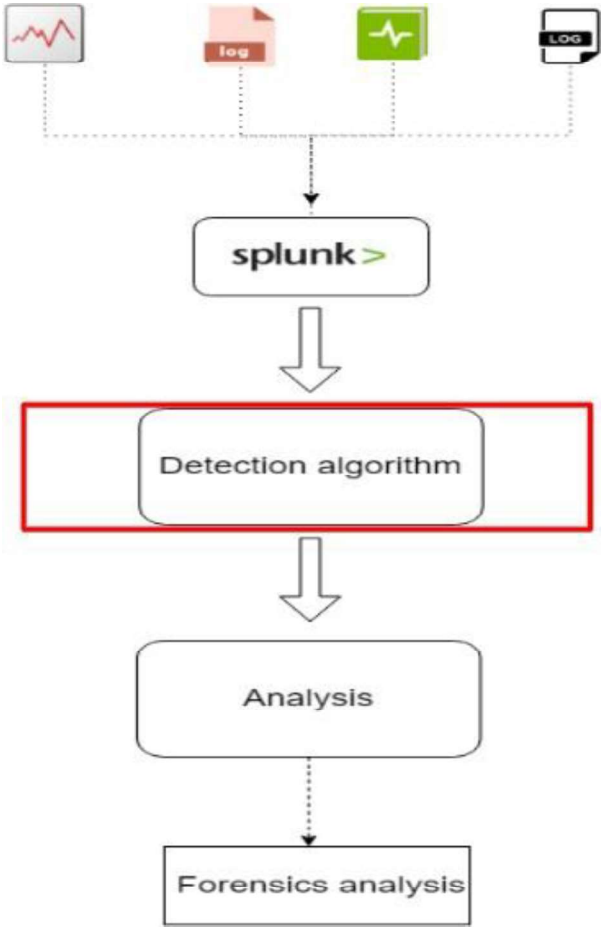

Fig. 1. **Proposed Framework**

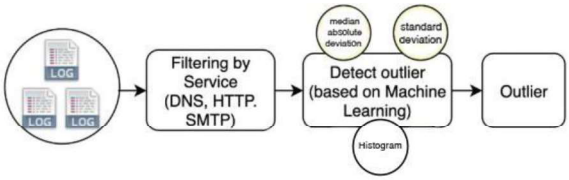

Fig. 2. **Detection Algorithm.**

4.2 Data Preparation

We deal with the datasets as an index, so we compare the original dataset, which contains the normal data with attacker data, and with the attacker dataset to choose the interesting field that changes between the two datasets. The fields of interest are: source IP, destination IP, number of bytes in, number of bytes on, client round trip time (rtt), response acknowledgment time, and the packet size.

After selecting and preparing the features, we label the Botsv1-HTTP dataset using the HTTP-attack logs that allow us to determine which connection is abnormal. The resulting labeled dataset contains 40,035 genuine HTTP connections and 23,435 attack connections. Similarly, we label the Botsv2- SMTP dataset using the SMTP-attack logs that allow us to determine which connection is abnormal. The resulting labeled dataset contains 790,683 genuine SMTP connections and 560,726 attack connections. As we conclude here, at the beginning of the APT group, the first stage will take more than 40% of the traffic. Furthermore, it will be easier than using Command & Control (C& C) server to determine the root cause at first in forensic analysis because if the attacker starts C&C, the mission will be hard to detect it using the all dataset as one bulk.

4.3 Detection Algorithm

The second step of our methodology consists of applying unsupervised ML detection algorithms to identify abnormal traffic. As mentioned before, we apply three algorithms, namely, standard deviation, medium absolute deviation, and histogram.

Once the volume of the fields of interest is obtained for both HTTP and SMTP datasets, we calculate the lower-bound and the upper-bound for standard deviation and medium absolute deviation algorithms. Regarding the histogram algorithm, the summation for each interest feature is computed. For each field of interest, any value outside the lower and upper bounds of the used statistical measure is tagged as an outlier. We use Detection Rate (DR) and the False Positive Rate (FPR) to evaluate the performance of the algorithms. The detection rate is the number of attacks detected by the system divided by the number of attacks in the dataset. The false positive rate is the number of normal connections that are mis-classified as attacks divided by the number of normal connections in the dataset. As consequence, a good algorithm should achieve a high DR value while keeping the FPR low.

4.4 Forensic Analysis

Once the malicious packets are detected by the ML algorithm, each packet is deeply inspected to envision the the scenario of the attack. Such analysis is insightful in deciding whether the attack is internal or external. Furthermore, the source machine for attacks with its intended victims are identified.

5. Experimental Results

All experiments have been conducted using Splunk. First, we try each of the aforementioned fields in the packet to identify the most influencing fields on the classification outcome. So, we found that the volume of client Rount Trip Time (RTT) , response acknowledgement time, and volume of bytes are the core fields to input to the detection algorithm.

5.1 Comparison between ML Algorithms

Table I displays the abnormal HTTP connection of the three algorithms for the dataset. For the Botsv1 dataset, medium absolute deviation yields poor results with DR value of 74% and the FPR of 70%. The DR of the histogram yields better which is 81.3%, and the FPR is about 3%. Regarding, the standard deviation, both DR and FPR are the best result for that dataset, with DR being 90% and FPR being 2.5%. Those results are argued in twofold: (1) The volume of the first dataset is relatively small. (2) The packet size of HTTP is relatively small if compared with SMTP. Consequently, the standard deviation algorithm outperforms others in detecting abnormal traffic.

Table I: DR and FDR Comparison for HTTP

Algorithm	DR	FPR
Histogram	81.3%	3%
Standard Deviation	90%	2%
Median Absolute Deviation	74%	33.4%
Histogram & Standard Deviation	100%	1.7%

In the next step, we try to make a combination of two algorithms to improve the result, which are histogram and standard deviation. Firstly, we calculate the standard deviation, and the output result is inputted to the Histogram. This combination achieves high DR which is 100%, and FPR 1.7%, which is an acceptable value. However, the accuracy of those results is not 100% because the dataset is relatively small.

Figure 3 shows the statistics for the combination algorithm (histogram and standard deviation) when applied to HTTP traffic with the volume of the chosen fields. Also, we indicate whether the traffic is considered to be an outlier or not.

In Botsv1 dataset, it is easy to determine the infected host using the volume of bytes. However, if there are multiple servers, a dramatic increase in the FBR is expected. We solve the multiple server problem by making classification between server and client, by choosing client RTT to make sure that the connection does not start from the server because if the connection starts from it, this means the server is already compromised.

To validate the effectiveness of the algorithms being tested, we use Botsv2 dataset to get a more exact accuracy. Table II displays the abnormal SMTP connection of the three algorithms and the combination of histogram and standard deviation for the dataset. So after applying the histogram and Standard deviation algorithm, the DR is found to be 79%, and the FPR is about 4%. We assume that the reason for this relative degradation in the result is the massive size of traffic. However, the median absolute deviation algorithm outperforms others with 96% DR and 1.2% FPR. Clearly, this algorithm progosses well for massive traffic.

Fig. 4 displays the statistics for median absolute deviation algorithm when applied to SMTP traffic (Botsv2 dataset). Notice that the detected outliers are tagged when a value of 1 is assigned for the Boolean variable is outlier.

We conclude that the reason for the obtained results is attributed to the size of the input data. If we need to obtain high DR with low FPR for a relatively small amount of traffic, a combination of histogram and standard deviation algorithms is utilized. However, median absolute deviation is recommended for massive amount of traffic.

Table II: DR and FDR Comparison for SMTP

Algorithm	DR	FPR
Histogram	77%	10%
Standard Deviation	78%	12.4%
Median Absolute Deviation	96%	1.2%
Histogram & Standard Deviation	79%	4%

5.2 Forensic Analysis

After using the proper machine-learning algorithm, we analyze APT attacks for datasets and show how machine learning helps us envision the scenario more quickly than the traditional way. For the Botsv1 dataset, after analysis and deep inspection of packets according to ML and experiment, we predict all scenarios for this attack as shown in Fig. 5, which is as follows:

At first, the attacker is in the internal network, and he knows the admin machine after doing some reconnaissance. Then the attacker targets the machine using brute force attack to get privilege escalation. After this, the attacker installs Remote Access Terminal (RAT) which poisons a backdoor Trojan that allows the remote attackers to perform various malicious activities on the compromised machine and execute it. At the end, the attacker opens a connection outside the network and closes the internal one.

For SMTP with Botsv2, the attacker tries first to send a phishing email to all companies until an employee reacts to the phishing email. Then the attacker sends spearphishing email by hiding a malicious ZIP file including a back door inside it. Also, the attacker encrypts most of their email traffic with SSL to hide malicious traffic inside authorized network traffic. Fig. 6 shows this scenario.

Both scenarios in the datasets are similar to APT38 which starts at first with a spearphishing email.Once the user executes the ZIP file, the attacker opens a backdoor and starts reconnaissance to know where the admin machine is, after that, it tries to get privilege escalation to be admin. Then it installs a ZIP file in the admin machine to get the root privilege. So, as we see that without machine learning this will take days, even

a month, but if we use machine learning, we can predict all scenarios and get the root cause in less than a day.

6. Conclusions

In this paper, we present an Advanced Persistent Threat (APT) detection framework based on unsupervised machine learning for detecting malicious SMTP and HTTP traffic. We used the logs provided by Splunk and extracted the information to build datasets. We compared the performance of yhree algorithms standard deviation, median absolute deviation, and histogram without sampling (as one block). Combining standard deviation and histogram gave the best result for relatively szmall traffic with 100% DR and 1.7% FPR. For large amount of data, the medium absolute deviation algorithm outperforms others. After detecting the outliers, we analyzed the result to find the root cause of the attack using forensic analysis, which would have taken much more time without using machine learning.

src_ip	sum(bytes)	sum(response_ack_time)	sum(bytes_in)	sum(bytes_out)	absDev	isOutlier	lowerBound	median	medianAbsDev	upperBound
1.160.115.70	58541	208927221	39623	18918	198240461	1	-10512282	10686760	10599521	31885802
1.160.117.198	413794	1521648047	280097	133697	1510961287	1	-10512282	10686760	10599521	31885802
1.160.118.132	244301	922754717	165258	79043	912067957	1	-10512282	10686760	10599521	31885802
1.160.127.3	211215	778302606	143016	68199	767615846	1	-10512282	10686760	10599521	31885802
104.47.32.205	493	299608	204	289	10387152	0	-10512282	10686760	10599521	31885802
104.47.32.208	499	315588	210	289	10371172	0	-10512282	10686760	10599521	31885802
104.47.32.231	500	224675	211	289	10462085	0	-10512282	10686760	10599521	31885802
104.47.32.41	84192	30657317	21764	62428	19970557	0	-10512282	10686760	10599521	31885802
104.47.32.43	107359	61598882	27907	79452	50912122	1	-10512282	10686760	10599521	31885802
104.47.32.45	6321	382220	5995	326	10304540	0	-10512282	10686760	10599521	31885802
104.47.32.47	138446	75496067	113274	25172	64809307	1	-10512282	10686760	10599521	31885802
104.47.32.49	20526	41451091	3032	17494	30764331	1	-10512282	10686760	10599521	31885802
104.47.32.51	1057	537925	464	593	10148835	0	-10512282	10686760	10599521	31885802
104.47.32.56	2916	307833	2612	304	10378927	0	-10512282	10686760	10599521	31885802

Fig 4: Algorithm Statistics for SMTP

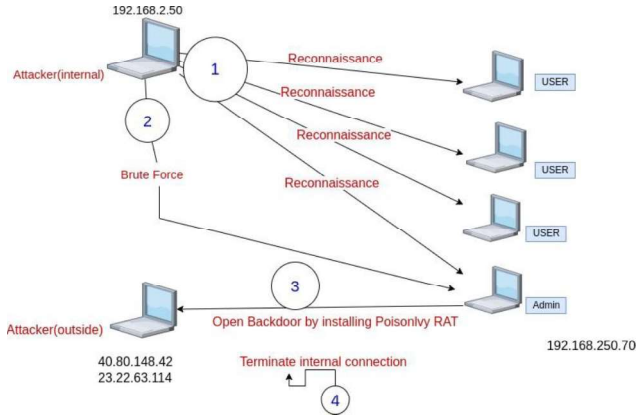

Fig 5: Forensic Analysis for HTTP Scenario

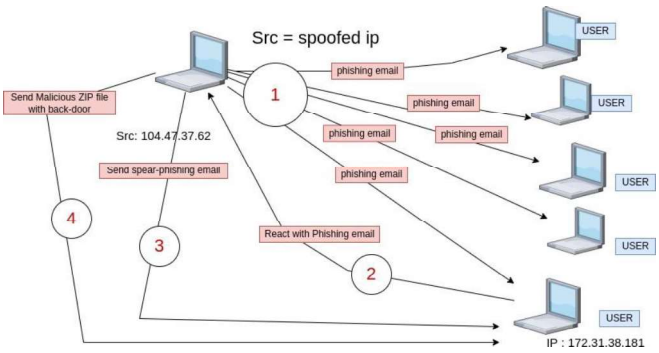

Fig 6: Forensic Analysis for SMT Scenario

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Research Article

Enhancing Deaf and Dumb Collaboration by Video Annotations

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Abstract

Online annotations, which enable information to be added to existing data without altering it, have emerged as a crucial technique for engaging with web pages and user queries. Annotations become a tool for targeted collaboration between users (Annotators) with similar interests when the visibility of annotations is restricted to groups of users. Many strategies have been developed to improve online user conversations and collaboration. Websites are suitable media for that since they enable users to engage in online discussions by adding comments (also known as annotations) to page elements like texts, photos, and videos. There are numerous annotations, including written, spoken, visual, and graphic. Although textual annotations are well-known, users are increasingly adding their own video comments to the HTML web document components to have conversations and exchange ideas. This enables deaf and dumb people to have the chance to participate in online discussions. At the end of the work, we conducted a comprehensive experimental test in order to compute the collaboration percentages between users in which promising results were achieved.

Keywords: Web Annotation, Visible Annotations, Sign Language, Deaf & Dump Collaboration.

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1. Introduction

Expressing one's thoughts and exchanging ideas and experiences with others can be done in several ways. Starting from the traditional ways of communication between people up to the usage of the latest technologies represented in the utilization of the different social network applications [1]. Expressing ideas to others perfectly facilitates their understanding and decreases their confusion regards the issues under discussion. However, conducting online discussions increases people's experiences due to the universal communication between people from different countries, nations, and backgrounds.

Annotating websites has become an increasingly popular method for individuals and organizations to enhance their online experience. By adding annotations to websites, users can provide additional context, insights, and information about the content of a webpage [2]. This helps other users to better understand the content and its relevance, and can also facilitate collaboration and knowledge sharing between them.

Recently, several applications are used to create online annotations of different types and map these annotations to different resources of websites. Textual and vocal online notes are public types of annotations that are used to express one's thoughts in which users are able to create and attach them to any website content like text, images, and videos) [3]. Although the traditional way of creating new annotations is by selecting some website textual contents to attach the created annotations with them, drawing over the website contents some graphical shapes like free drawings, circles, and rectangles becomes a popular way of mapping between website contents and the created annotations [4].

Despite that textual annotations are considered a perfect way in sharing ideas with others, they are limited in expressing emotions which enhances the amount of sharing ideas between online users that vocal annotations can do. The user's voice tone embedded in vocal annotations can substitute a lot of textual words needed to express his/her emotions. Expressing emotions with annotations add extra information and directs others to the points of online discussions and minimizes efforts and time in declaring ideas and feelings [5].

People with disabilities in their speaking or hearing are not able to express their ideas and emotions by vocal annotations. Usually, they communicate using symbols of sign language represented in some actions using their fingers and/or their bodies' gestures. Although some of them can communicate textually, they still have some limitations in expressing their feelings and emotions perfectly using this kind of communication. However, these limitations in communications make it hard for them to conduct online discussions using annotations [6]. Visible annotations are used to better exchange ideas and feelings between people all over the world by attaching digital contents of websites with visible annotations created as video files. Moreover, they can be used by deaf and dumb people in order to participate in some communication over the web. This enables them to involve more in communities and eliminates their feeling of isolated [7]. The ability to have an AI system that translates sign language gestures to spoken language facilitates the ability to conduct communication between deaf and dumb people with others without the need for others to know or learn sign language.

This work is related to enhancing the deaf and dumb users to create visual annotations for digital contents of websites as a way to increase their communication and make it easy for them to exchange their ideas and feelings regards the contents under discussion as well as enhance their involvement in online discussions with other people who are familiar with shared sign language.

The rest of this paper is organized as follows: Previous work is proposed in Section 2. Section 3 discusses the system architecture of the tool while Section 4 is related to Video Annotations Creation and Retrieval of the tool. Section 5 demonstrates the experimental results. Finally, Section 6 concludes this paper.

2. Related Works

Creating different types of annotations and assigning them to different types of digital content can be done these days using several types of annotation tools. Each of which has its own facilities for enhancing the intended collaboration between users. Brat (https://brat.nlplab.org/index.html), doccano (https://doccano.herokuapp.com/), LightTag (,https://www.lighttag.io/) and TagTog (https://www.tagtog.net/) are all examples of text-based annotation tools.

Another well-known practice is annotating internet content by sketching shapes over it. Users are able to annotate certain website contents by drawing shapes over them and adding textual notes to these drawings. Users of these tools exchange these drawings in order to have a debate based on the drawings and their notes. On the web, there are several tools available to improve this form of annotation. Famous tools for this type of annotation include Sketchpad1, Sketch to Web2, and MADCOW[4].

There aren't many tools available online for vocal annotations because of the small number of works in this area. Among them, XODO (https://xodo.uservoice.com/) stands out because it is used to produce audible annotations that can only be appended to PDF files on mobile devices. Use VISITView (https://www.ssec.wisc.edu/visitview/tutorial/img7.html) to record voice annotations solely for educational reasons. The last option is Chrome Audio Capture (https://github.com/arblast/Chrome-AudioCapturer), a Google Extension that enables users to record voice memos independently of some web content. This program is similar to ours in that it is implemented by a Google Chrome extension, but it just functions as a recording tool and does not add vocal annotations to the text of websites.

A possible method of facilitating collaborative sessions around the globe is by using video to provide visual annotations. Here, users can use web-based collaboration strategies by producing their own movies and attaching them to various pieces of online information. The work is yet insufficiently mature and is missing a number of supporting services.

The research done in [8] looked at how to depict professional collaborative learning in dispersed online environments using voice annotations and video clips of practice. The initiative conducted two major studies with experts in learning technologies. The main findings of this research are that various types of video clips can assist the need for professional development. They also felt that integrating artifacts from the practice helped to "base" or anchor a representation in realistic ways for reflective learning. The

subjects acknowledged that watching oneself in video clips was still a somewhat unique experience. According to the study, voice annotations and video clips can be produced quickly. Particularly in fluid, developing fields like the learning technology industry, speed was considered a key asset and regarded as more important than producing a polished result.

The authors of [9] describe a novel architecture and its prototype tool for indexing and retrieving particular voice recordings captured during conversations concerning tangible objects like text documents, images, or 3D models. An ink-dot is used to identify a specific component of an object when it is mentioned, and an image of the dot at a tiny scale is taken to record the information in a database. An index of the recording fragment is simultaneously created and connected to the dot. The associated recording fragment can be retrieved for playing after a dot has been scanned and identified by comparing its microscopic image with the database. To make these tasks easier while the user focused on the conversation, a useful tool has been created. Dot identification's performance tests have produced accurate matches that are authentic. The program successfully supported the building of indexes with dots during speech recordings in demonstrations of a real-world usage scenario, and it accurately played back all the distinct recording fragments connected to the dots.

Despite the existence of the mentioned textual and vocal tools, they are limited in completely expressing the users' emotions represented by body gestures nor introducing a solution for deaf and dumb people to communicate and collaborate online. This work is related to developing a visual-based annotation tool that enables the creation of video annotations (as well as texts) in order to better conduct online communication between users by attaching these annotations to the textual contents of websites. This enables people to better communicate and express their emotions in a better way rather than enabling people with disabilities related to their hearing or speech to better communicate with each other and involve in an online collaboration for selected topics. Moreover, the ability to attach textual tags with annotations makes our tool more fruitful in terms of searching for the most suitable annotations and hence their annotators to better conduct online discussions with the most related topics for users.

3. System Architecture

Adding a translucent overlay on top of an annotated website is all that the concept of annotation on web content entails. The tier where annotations are present is represented by this unseen layer. The utility built in this study follows the web-based client/server architecture. In an HTML web page, users can add their own video annotations to texts, and when they save the page, the relevant data are kept in a special database. According to this technique, the tool is made up of three layers: presentation, processing, and database. The Presentation Layer handles the user-browser interaction in which annotations are submitted, placed as placeholders next to chosen texts, and then saved in the specific database. Between the Presentation and Database levels, the Processing Layer handles the processing required to colour the highlighted text, record the video annotation, and save it as a video file. Last but not least, the Database Layer is concerned with the actual storage of all information pertaining to the created annotations represented in the annotated text, including the URL, the video file, and the annotator-related information. Finally, the Database layer is in charge of retrieving the annotations for a specific person and website. The framework of the tool is shown in Figure 1 below, where the request/reply protocol is utilised for saving and retrieving annotations, respectively.

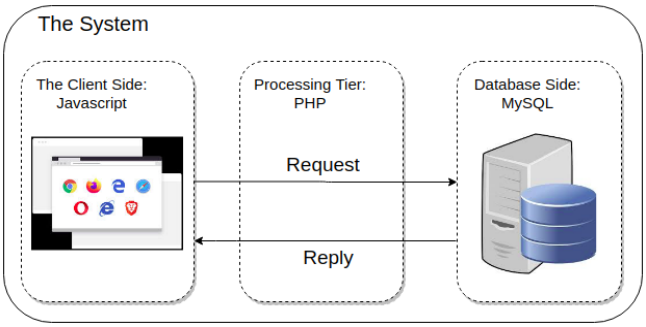

Fig. 1 The tool's architectural layout.

The tool's interaction is implemented via a Google extension. It comprises a series of JavaScript routines that are injected into each visited website in order to execute the functionality of text selection and video annotations recording. The extension also includes user login and account creation functionality.

The database's logical schema is shown in Figure 2 below as an entity-relationship diagram. The User, Video, and Text entities, as well as the entity relationships between them, are represented in the diagram. The text entity is used to preserve information about the annotated text, while the Video entity is used to save information about the video annotation itself. The user entity reflects all properties connected to users.

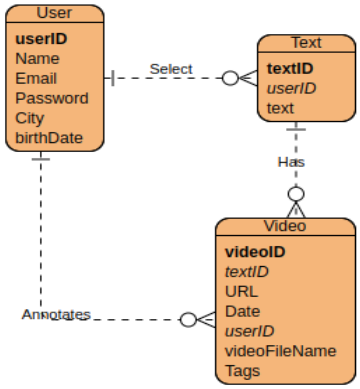

Fig. 2 The Entity Relationship Diagram.

The flow chart for the activity of creating annotations is shown in Figure 3. The action starts when a user chooses some text on a website. This occurs when the JavaScript object for the Browser object calls the *createAnnotation(selectedText)* function. The latter executes the r*ecordVideo()* method on the Video Recorder object, which returns the recorded video saved in the recordedVideo object and returns it to the JavaScript object. The Database object's function *Save(selectedText, recordedVideo, URL)* saves all relevant data in the system's database, and is then called by the JavaScript object. The *Notify()* function alerts the user when the vocal annotation has been successfully created before prompting them.

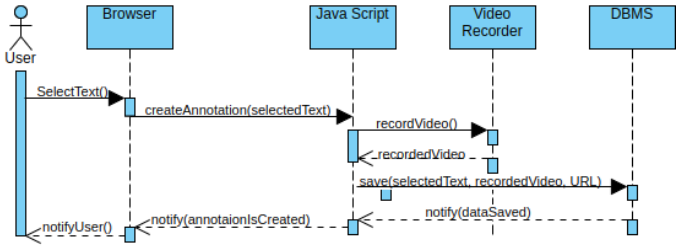

Fig. 3 Video Annotation Creation Sequence Diagram

The video annotation submission and retrieval are both summarised in the following pseudocode piece. The Google Extension is loaded and the aforementioned code is run as soon as the Google Chrome browser opens.

```
while(true){
  // List of Google Extension (GE) embedded listener functions
  GE.onChangeURL() = injectJavaScript(URL);
  GE.onLoadAnnotations() = loadAnnotations(URL);
  GE.onSelectText() = createAnnotation(URL, userID);
  GE.onHighlightTextClicked() = retrieveAnnotations(URL, clickedText);
}
function createAnnotation(URL, userID){
  placeHolder = selectText(selectedText);
  displayPopup(placeHolder, selectedText);
  recordedVideo = recordVideo(recordedFile);
  saveAnnotation(userID, selectedText, recordedVideo, placeHolder, URL);
}
function retrieveAnnotations(URL, clickedText){
  VideoFile Files[];
  popUpWindow = new popUpWindow();
  Files = getAnnotations(URL, clickedText);
  for(i = 0; i < Files.size(); i++)
    popUpWindow.insert(Files[i]);
}
```

By running the listeners mentioned inside the loop, the code keeps iterating in an unending loop. When a logged-in user navigates to a new URL, the listener function *GE.onChangeURL()* is called. This causes the method *injectJavaScript(URL)* to be invoked to inject the appropriate JavaScript code that will be in charge of processing video annotations. When a user clicks the Google Extension to obtain all annotations previously contributed to the current URL by calling listener function *GE.onLoadAnnotations(URL)* that causes the invocation of the function *loadAnnotations()*. This listener function additionally re-highlights all texts that are associated with annotations for the current URL.

When the user selects some text from the current URL, the listener function *GE.onSelectText()* is executed. The method *createAnnotation(URL, userID)* is called when this listener is activated, passing the URL and userID as inputs. The final listener is *GE.onHighlightTextClicked()*, which is called when a user clicks a highlighted text in the active URL. This method calls *retrieveAnnotations (URL, clickedText)* to load all annotations associated with the clickedText.

The annotation creation process begins with the execution of the function *createAnnotation (URL, userID)* begins with the execution of the function *selectText(selectedText)* method that in turn returns the place-holder (the location information of the selected text) and stores it in the variable placeHolder. Upon the selection of some text, The function *displayPopup(placeHolder, selectedText)* inserts the selected text and associated placeHolder information into the pop-window itself. The controls required to construct the video annotation and save it into the database are included in this pop-up window. Figures 4 and 5 depict these contents. After that, the function *recordVideo(recordedFile)* is executed to begin recording the video annotation and upon completion, the recorded file is saved in the variable recordedVideo. The function *saveAnnotation(userID, selectedText, recordedVideo, placeHolder, URL)* is then executed to save all annotation related data inside the dedicated database.

The function *retrieveAnnotations(URL, clickedText)*, which accepts the current URL and the clickedText as inputs, is invoked to retrieve previously submitted annotations. This function generates an empty array of Files of type VideoFile that will be used to store all video files that are associated with the highlighted clicked text. A new pop-up window is then created and saved in the object popUpWindow by calling the constructor *popUpWindow()*. The next step is to call the function *getAnnotations(URL, clickedText)* to retrieve all associated video files, which are then saved in the Files array. The JavaScript code then loops the File array in order to insert the video files inside the pop-up windows created for retrieved annotations to be played back by the users.

4. Video Annotation Creation and Retrieval

After visiting an interesting website, a user can choose some text that matches his or her interest and add a verbal remark to it. The user then selects the system extension icon located in the Google extensions area of the Google Chrome browser which opens a pop-up window containing the selected text as well as a set of options to create and save a video file. After providing a series of optional tags that describe the tenor of the annotation, the user then starts recording his or her own video annotation. The search for annotations will make use of these tags. The program saves the annotation and all associated data in its database when the save button in the pop-up window is clicked. The pop-up window used to construct the annotation is seen in Figures 4 and 5 below, where the Gray-highlighted text is copied from the original webpage to the pop-up window.

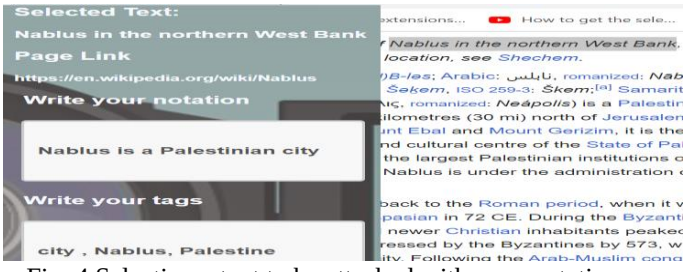

Fig. 4 Selecting a text to be attached with an annotation

The recording process begins when the user clicks the video area and stops when s/he clicks it again. By pressing the Save button, the embedded JavaScript code in the Google extension

communicates with the required PHP code to save the video file in a specific server folder with an automatically generated file name that is saved in the database, linking the saved annotation to the relevant video file. In this case, the name of the video file is saved in the database but the actual video file is saved in a separate server folder. When the video annotation needs to be recovered later, this generates a virtual mapping between the name of the file and the actual file in the server for file retrieval purposes.

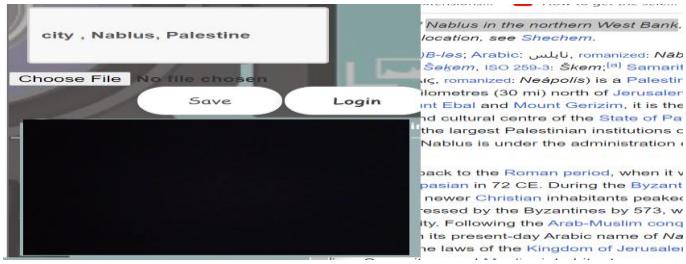

Fig. 5 Recording a video for the created annotation

After logging into their portals, users can view a list of all of their own annotations and filter responses. They have the option to browse the websites related to these annotations and play the video recordings that are associated with them. The way the annotations are shown in some users' portals is seen in Figure 6.

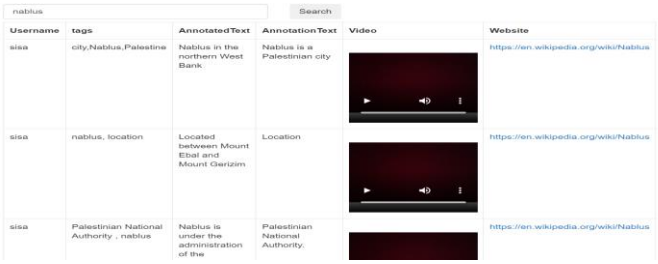

Fig. 6 Searching by tags.

The figure includes the annotated text as well as a collection of all relevant video annotations. However, the figure illustrates the ability to search for annotations by tags in which the users are able to search for some annotations depending on the tags associated with them in order to make it for users to search for the annotations they are interested in. Each annotation includes the video control for the video file it is linked to, as well as information on its owner, and the set of tags that are associated with it. The users have the ability to reply to these annotations by another video annotation giving them the possibility of conducting collaborations between them with respect to some interesting shared topics. Naturally, clicking on any of these annotations will take the user to the website where the corresponding annotation was created. When one of them is clicked, the tool opens the corresponding website and utilises its URL to obtain all annotations related to the website. To allow users to examine all filtered annotations connected to the clickable texts, all texts that were previously selected on that website will be re-highlighted and clickable. On the other hand, a logged-in user can ask the Google Extension to retrieve all annotations provided to this website (if there are any) if they surf a sample previously annotated website. With that request, the tool re-highlighted all annotated texts so that the user can click any of them to open a pop-up menu that contains all clicked text-related annotations. Users of the tool can also look for published annotations of interest using their portals.

5. Experimental Tests

We conducted an experimental test involving 20 participants in order to compare video, vocal and textual annotations. The participants are of two groups, each of which is composed of 10 participants. The members of the first group are people without deaf and dump disabilities, while the members of the other group are. We need to test the amount of collaboration between the members of each group and between the whole members of both groups (for those who practice sign language).

The supervised test lasts for 8 days in which a set of predefined websites are selected for different topics (Sports, Science, Education, Politics, Information Technology).

We divided the test into three apheses for the first group. In the first phase, we asked them to navigate the websites and create textual annotations only. In the second phase, we asked them to create vocal annotations (we asked them to switch off their cameras) while the last phase is done by using video annotations. At the end of the test, we noticed that 235 annotations were submitted (47 textual, 86 vocal, 102 videos), 32 distinct websites were annotated and 3 tags as average per annotation. For the second group, we asked them to submit textual and video annotations only in which the annotations contain sign language. At the end of this test, 135 annotations were submitted (29 textual, 106 videos), and 27 websites were annotated with 2 tags as average per each annotation.

In order to learn the thoughts of the two groups on the experiment and the cooperation acquired through the use of the three types of annotations, the participants of the two groups were requested to complete a questionnaire. The percentages below are computed by taking the average of the percentages gathered from the two groups. There are several questions on the survey, including:

1. What difference does the use of video annotations make in terms of how well participants understand the topics being discussed? reducing time and effort, with almost 75% of respondents choosing to spend less time and effort using video annotations, 15% for vocal and 10% for textual ones.

2. How does employing video annotations for collaboration compare to the other annotation types? Exceptional, Good, and Poor. Percentages computed were 80% for video 11% for vocal and 9% for textual annotations.

3. What degree of tool usefulness is there? Excellent, Very Good, Good, and Acceptable grades. The Percentage values collected were 85% for video, 10% for voice, and 5% for textual annotations.

4. Which is more effective for expressing your emotions in submitted annotations? (Video, voice, and text). We received 90% for video, 7% for voice, and 3% for textual).

5. Which is quicker to annotate? (Video, voice, and text). As speaking and showing body gestures is far faster than talking or writing and requires no manual labour like typing, we received a perfect score for video represented in the percentage 95%, while voice got 3% and 2% goes to textual annotations.

Figure 7 below depicts the previously computed percentages for the 5 questions in which the video annotations perform the other types.

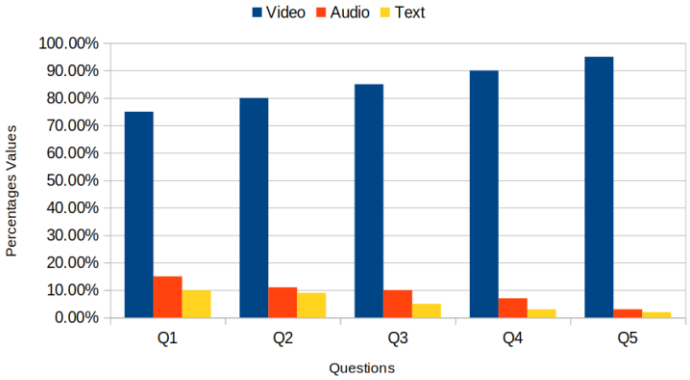

Fig. 7 Percentages values computed for the 5 questions.

6. Conclusion

In this work, a video-based annotation is put into practice and tested. People can hold online conversations utilising video-based annotations to collaborate and talk about topics of interest. For searching purposes, users can add a set of related textual tags to annotations. An experimental test under supervision was carried out, and encouraging outcomes were obtained.

For the next projects, we are planning to improve the search function by adding a video recognition system that allows recognising their signs and converting them to vocal notes in order to better collaborate disables users with others users.

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Research Article

Behaviour-based Manufacturing Control with Soft Computing Techniques

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Abstract

Soft Computing methods have been widely used in recent years to address the challenges posed by disturbances handling and uncertainty management in Manufacturing Execution Systems (MES). The focus of this research paper is on the application of Soft Computing methods for classification problems in Behaviour Based Control.
The paper proposes the use of classification techniques to determine the behavior of a production system. This is an important task as it enables the detection of anomalous behavior and allows for the implementation of appropriate corrective measures. The proposed classification method is based on the use of Neural Networks and Fuzzy logic. Neural Networks are a powerful tool for classification tasks due to their ability to learn from data and make predictions based on patterns. The proposed method uses a feedforward neural network with a single hidden layer to classify the behavior of the production system. The inputs to the network are features extracted from the production system, while the output is the classification result. Fuzzy logic is also used in the proposed classification method to handle uncertainty in the input data. In conclusion, this research paper presents a novel approach to classification problems in Behaviour Based Control using Soft Computing methods. The proposed method shows promising results in handling disturbances and uncertainty in manufacturing systems. Further research in this area could lead to the development of more advanced Soft Computing methods for manufacturing systems, enabling more efficient and effective control and management of production processes

Keywords: Soft Computing, Manufacturing Execution Systems, Behaviour Based Control.

Yumuşak Hesaplama Teknikleri ile Davranış Tabanlı Üretim Kontrolü

Öz

Esnek Hesaplama yöntemleri, Üretim Yürütme Sistemlerinde (MES) bozulmaların ele alınması ve belirsizlik yönetiminin ortaya koyduğu zorlukları ele almak için son yıllarda yaygın olarak kullanılmaktadır. Bu araştırma makalesinin odak noktası, Davranış Tabanlı Kontroldeki sınıflandırma problemlerine yönelik Esnek Hesaplama yöntemlerinin uygulanmasıdır.
Makale, bir üretim sisteminin davranışını belirlemek için sınıflandırma tekniklerinin kullanılmasını önermektedir. Bu, anormal davranışın tespit edilmesini sağladığı ve uygun düzeltici önlemlerin uygulanmasına izin verdiği için önemli bir görevdir. Önerilen sınıflandırma yöntemi, Yapay Sinir Ağları ve Bulanık mantık kullanımına dayanmaktadır. Sinir Ağları, verilerden öğrenme ve kalıplara dayalı tahminler yapma yetenekleri nedeniyle sınıflandırma görevleri için güçlü bir araçtır.

Anahtar Kelimeler: Soft Computing, Manufacturing Execution Systems, Behaviour Based Control.

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1. Introduction

This paper explores potential strategies for managing uncertainty in production processes. The practical model for addressing multi-task, multi-resource problems is nonlinear, as processes are defined by both internal relationships and external constraints. Due to the limited technological intensity of tasks, production bottlenecks, unstable states, and unwanted delays can occur, which may adversely affect production processes.

Process indicators (also known as key performance indicators [1]) are used to evaluate production processes, with the primary objective of fulfilling production orders while adhering to specified constraints [9]. However, this objective can be met at different costs and within varying timeframes. The performance indicators are dependent on predictive planning, scheduling, and allocations. When operating at the margin of overload, systems are prone to bottlenecks and critical processes, which may cause chaotic behavior. Small changes in scheduling can lead to dramatic changes in performance indicators, as stochastic events increase the likelihood of deviations from planned states. Unfortunately, disturbances are often unavoidable in these situations. The most common sources of disturbances of a production system are as follows:

- Tool breakage, interruption of operations.
- Machine breakdown, outage of resources.
- High rejects rate.
- Unexpectedly low production intensity.
- Human errors.
- Material outage, supply chain delays.
- Long set-up times.
- Outage of labour resources.
- High rate of demands.
- Change in the priority of the jobs.
- Appearance of urgent jobs.

1.1. Handling Uncertaınıty in MES

The methods of uncertainty handling at the MES level includes:

1. Develop performance indicators from the local data which allows the global state of whole system to be determined.

2. Identify the most important situations based on the global indicators.

3. Classify the situations into appropriate number of classes to allow interactions to be done in real time.

4. Assess the state of the production and make decision on the behaviour of production control. This defines a Behaviour-Based Control whose interactions are assigned to behaviour classes.

5. Select the appropriate actions based on the selected behaviour. The possible actions and their parameters should be modelled beforehand. The inter-actions should direct the production processes towards a stable, planned state.

6. The interactions affect the whole schedule.

7. Following the interactions new situations arise.

Behaviour-Based Control relies heavily on the possible and permitted interactions between various components. These interactions occur at different hierarchical levels, with corrections initiated in an upward or downward direction. Higher-level corrections may supersede decisions made by lower hierarchical levels, and decisions made at lower levels may even be prohibited. In hierarchical Behaviour-Based Control, new constraints are disseminated from the upper level to the lower level, while the identification of anomalies spreads in a bottom-up direction.

2. Behaviour-Based Control

Behaviour-Based Control (BBC) is an approach to control systems that emphasizes the importance of behavior as the fundamental unit of control. Rather than focusing on specific actions, BBC focuses on defining and regulating the behaviors of individual system components to achieve desired outcomes. This is accomplished by designing the system to exhibit a set of desired behaviors in response to various stimuli or inputs. The interactions between these behaviors, and between the system and its environment, then determine the overall behavior of the system. BBC is often used in complex systems with multiple interacting components, such as robotics or manufacturing, where it can be difficult to explicitly program all possible scenarios. By emphasizing behavior over specific actions, BBC provides a more flexible and adaptable approach to control, enabling systems to respond more effectively to changing conditions and unforeseen events.

2.1. A possible classification of behaviours

Experiments show that a few numbers of classes are favoured in practical applications. For production processes the following general global states are suggested:

- Normal,
- Deviated,
- Critical,
- Dangerous.

Normal state requires no interaction. In deviated situation the process does not go as planned: readiness for delivery is decreasing, jobs late, waste rate increasing, etc. The situation is critical if the original schedule becomes unmaintainable. Usually rescheduling is required. The situation is dangerous if the master production plan becomes unfeasible.

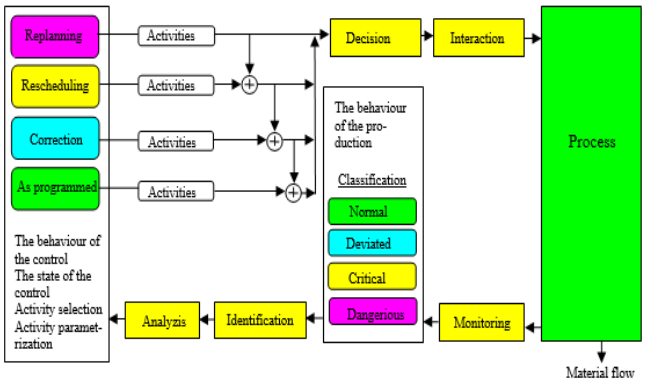

Figure 1. Behaviour based approach in manufacturing control

3. Softcomputing Methods for Classification

3.1. Methods Used

There are several ways to classify the system state into the aforementioned categories. Soft computing methods are widely accepted and used by researchers. In the scope of this research work the following methods were investigated:

- Backpropagation Neural Network,
- Radial Basis Neural Network,
- Probabilistic Neural Network,
- Fuzzy Logic.

A pilot application has been created for each of the methods to evaluate them. The classification problem was inspired by a case study explained in [8].

The Backpropagation Neural Network (BPNN) employs a hard-limit transfer function that is well-suited for classification problems. The decision boundary line at W.p + b = 0 divides the input space into two classification regions, where W represents the weight vector, p represents the input value, and b represents the bias. This study utilized a network with one hidden layer. Since there were four distinct statuses, a binary code was assigned to each status, necessitating two bits at the output. To facilitate learning, the perceptron learning rule algorithm was employed

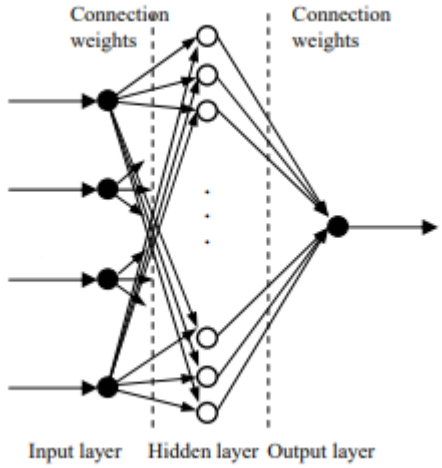

Figure 2. Neural network with single hidden layer

Radial Basis Function Neural Network (RBF) consist of two layers: a hidden radial basis layer and an output linear layer. The first layer determines the distance of an input vector v. If the vector is close to the weight vector of the neuron then the output is close to 1. If the distance between the vectors is greater then the output is close to 0. The higher the output of the neurons of the first layer are the more importance they have in the second layer.

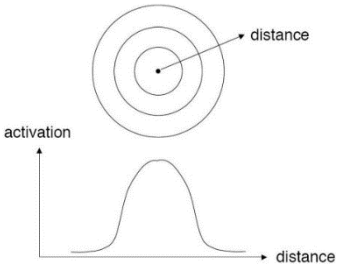

Figure 3. RBN activation **Hata! Başvuru kaynağı bulunamadı.**

Probabilistic networks perform classification where the target variable is categorical value

PNN networks have advantages and disadvantages compared to Multilayer Perceptron networks [3]:

Properties of Probabilistic Neural Networks (PNN):

- PNN is a type of feedforward neural network that performs classification tasks for categorical target variables.
- PNN can be much faster to train than other neural network models like multilayer perceptron (MLP).
- PNN often generates more accurate predictions than MLP networks.
- PNN is relatively insensitive to outliers.
- PNN networks can generate accurate predicted target probability scores.
- PNN networks approach Bayes optimal classification.
- PNN networks require more memory space to store the model.
- PNN networks can be slower than MLP networks when classifying new cases.

The Fuzzy Logic model was configured as follows: The original project involved a large number of input variables, which resulted in performance issues. To address this problem, a two-level hierarchical processing approach was introduced. In the first step, each production order was classified individually, and the statuses were evaluated. Then, the classification of the entire system was performed. The number of rules greatly impacts the computing time, so it was necessary to minimize the number of rules while still classifying the system without ambiguity. During the fuzzy classification process, each rule was evaluated sequentially using the appropriate variables. A rule consisted of NOT, AND, and OR connections, and the variables were inserted into the rule to produce a numeric value between 0 and 1. This value represented the degree of truth or the extent to which a proposition was true.

Some sample rules used in the first pass of fuzzy processing:

1. IF tardiness is small AND machine utilisation rate is big THEN status is normal.
2. IF tardiness is considerable AND machine utilisation rate is big THEN status is deviant.
3. IF quantity is many AND priority is high AND tardiness is considerable THEN category is critical.
4. IF tardiness is considerable AND machine utilisation rate is big THEN status is dangerous.

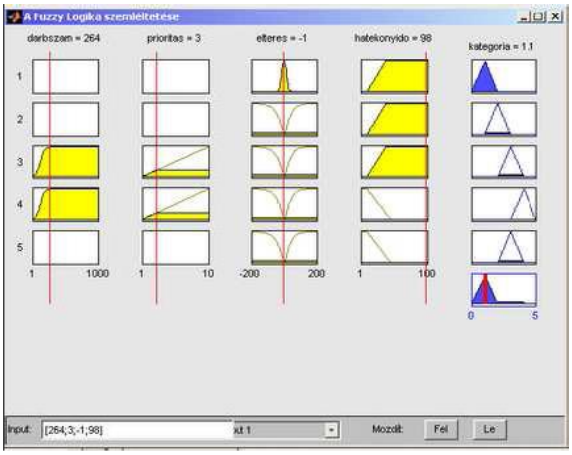

Figure 4. Screenshot of fuzzy classification

In the second processing phase the overall tardiness time was also calculated. The rules used in this phase were as follows:

1. IF status of the ith Product Order POi is normal AND tardiness is negligible THEN status is normal.

2. IF status of POi is deviant AND tardiness is small THEN status is deviant.

3. IF status of POi is critical AND tardiness is observable THEN status is critical.

4. IF status of POi is dangerous AND tardiness is observable THEN status is dangerous

Two kinds of evaluation were applied: the method was tested against the data set used at the learning phase, and then the method was tested against a new data set. (Obviously, fuzzy processing had no learning data set, so that test case was skipped).

BPNN succeeded the learning phase but after certain time it showed no more progress in learning, there was a remaining error. The learning time was considerable.

RBF achieved a very small remaining error and produced better results than BPNN. The learning time was smaller. By increasing the size of the training set the network produced more reliable output.

PNN was characterised by the smaller learning time among the NNs used. By increasing the size of the training set the network produced more reliable output. However, RBF was more reliable.

Fuzzy system was difficult to create good rules. After some experiments the rules were fine tuned. Its performance was behind the NNs. Very likely some more fine tuning is still required.

Some performance data can be found in Table 1.

4. Conclusions and future work

As you can see in Table 1, PNN performed very well on small inputs. However, as the input size was bigger the number of correct classifications decreased. In medium sized problems RBF provided the best result. PNN outperformed other methods in large scale problems. In order to integrate to a MES environment an upcoming task is to execute an Action Generator that selects the suitable actions based on the classification results. This can be achieved through a rule-based system, an expert system, or a neural network. Additionally, the Cockpit Task Management system can also be employed where operators are aided by the classification and other pertinent data.

Table 1. Performance data of NN classifications

Type	Input number	Correct classifications	Goodness (%)
BPNN	100	53	53
RBF	100	23	23
PNN	100	100	100
BPNN	100	51	51
RBF	100	89	89
PNN	400	299	74.7
BPNN	100	52	52
RBF	400	380	95
PNN	800	609	76.1
Fuzzy	100	70	70
Fuzzy	800	544	68

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Research Article

Numerical Solution of Transmission Line PDEs Using Finite Difference

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Abstract

Transmission lines refer to a variety of electrical structures that transfer information or energy typically in the form of carrying electromagnetic waves. Examples of transmission lines include coaxial cables, telephone wires, microstrips, and optical fibers. Understanding the transmission and distribution of the electromagnetic waves across the line is critical for matching the load with the generator to deliver the energy or information with minimum losses. The flow of electromagnetic waves across the line is described based on the voltage and current using Partial Differential Equations (PDEs). In this paper we apply the Central Space Central Time (CSCT) finite difference numerical method to solve the transmission line PDEs. We present the numerical solution of the waveforms and compare it with the analytical solution to evaluate the accuracy of this numerical method in solving the transmission line problem. It is found that the numerical solution of the voltage waveform is very near the analytical result with small error margin. However, while the numerical solution of the current shows the same waveform as the analytical one, there is some quite significant error in the magnitude. The error is found to result from the fact that the waveform of the numerical solution has some phase shift from that of the analytical solution. Adjusting the phase shift of the current waveform results in having good agreement between numerical and analytical results.

Keywords: Transmission line, PDEs, CSCT, finite difference, numerical analysis, stability analysis, electromagnetic waveform.

Sonlu Fark Kullanarak İletim Hattı PDE'lerinin Sayısal Çözümü

Öz

İletim hatları, tipik olarak elektromanyetik dalgalar taşıma biçiminde bilgi veya enerji aktaran çeşitli elektrik yapılarını ifade eder. İletim hatlarına örnek olarak koaksiyel kablolar, telefon kabloları, mikro şeritler ve optik fiberler verilebilir. Elektromanyetik dalgaların hat boyunca iletimini ve dağıtımını anlamak, enerjiyi veya bilgiyi minimum kayıpla iletmek için yükü jeneratörle eşleştirmek için kritik öneme sahiptir. Hat boyunca elektromanyetik dalgaların akışı, Kısmi Diferansiyel Denklemler (PDE'ler) kullanılarak voltaj ve akıma dayalı olarak tanımlanır. Bu yazıda, iletim hattı PDE'lerini çözmek için Merkezi Uzay Merkezi Zaman (CSCT) sonlu farklar sayısal yöntemini uyguluyoruz. Dalga biçimlerinin sayısal çözümünü sunuyoruz ve bu sayısal yöntemin iletim hattı problemini çözmedeki doğruluğunu değerlendirmek için analitik çözümle karşılaştırıyoruz. Gerilim dalga biçiminin sayısal çözümünün, küçük hata payı ile analitik sonuca çok yakın olduğu bulunmuştur. Bununla birlikte, akımın sayısal çözümü analitik olanla aynı dalga biçimini gösterse de, büyüklükte oldukça önemli bazı hatalar vardır.

Hatanın, sayısal çözümün dalga biçiminin analitik çözümden bir miktar faz kaymasına sahip olmasından kaynaklandığı bulunmuştur. Mevcut dalga formunun faz kaymasını ayarlamak, sayısal ve analitik sonuçlar arasında iyi bir uyum sağlar.

Anahtar Kelimeler: İletim hattı, PDE'ler, CSCT, sonlu farklar, sayısal analiz, kararlılık analizi, elektromanyetik dalga formu.

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1. Introduction

The term transmission line is used to refer to a variety of structures that transfer information or energy but here the focus is on the analysis of transmission lines carrying electromagnetic waves. Examples of such transmission lines include coaxial cables, telephone wires, microstrips, and optical fibers (Transmission line theory, 2009) and (Ulaby, 1994). Such transmission lines are used for carrying audio, video, and digital information to TVs, computers, phones, etc. (Korzeniewska, 2019). A transmission line is a two-port network where at one port there is a source sending some type of electromagnetic signal (generator) while at the other port a load is receiving that signal (Davoli, 2018). Understanding the transmission and distribution of the electromagnetic signal across the line is critical for matching the load with the generator to successfully deliver the energy or information with minimum losses. This understanding is also critical for the design of efficient transmission lines in terms of length, size, and materials.

The problem of electromagnetic waves inside transmission lines is typically solved in the complex domain using the notation of phasors. So, the equations describing the transmission line are typically written and solved in phasor notation and not in the usual time domain notation. After solving the problem, the solution is transformed into the time domain notation (Daafouz, 2014). So, it is interesting to approach this problem in a new way that is not explored in the textbooks on circuits and electromagnetics. It is interesting to see how this problem can be solved using numerical methods. This approach can help us see the problem from another perspective. In particular, we can get more insight about the role of boundary conditions and initial conditions in solving partial differential equations (PDEs). This is because in the usual way this problem is solved, the engineer is more concerned with applying the already obtained equations rather than deriving the solution from the fundamental PDEs. Also, we can get to compare the results of our numerical solution with the analytical solution and thus be able to judge the suitability of the numerical method with this type of problems. Simply, the problem is not approached using the typical time domain analytical approach nor the numerical approach and it is interesting to try to apply a relatively unusual numerical technique to solve this problem and compare the numerical solution with the analytical solution to investigate the accuracy of the technique and its suitability for this kind of problems.

In order to analyze the behavior of the electromagnetic wave across the line, an appropriate electric circuit model of the line must be used. As it is well-known, a typical equivalent circuit model of the transmission line has four components: resistance, inductance, conductance, and capacitance (Ulaby, 1994) and (Wang, 2018). They can provide a very accurate model of all transmission lines carrying any form of electromagnetic signals (Ulaby, 1994). R' is the resistance per unit length measured in **Ω**/m. L' is the inductance per unit length measured in H/m. G' is the conductance per unit length measured in S/m. C' is the capacitance per unit length measured in F/m. The values of these parameters are unique characteristics of each transmission line that are determined by the type of the material of the line and its geometry. Based on this model, the propagation of electromagnetic signals along the line can be analyzed.

2. Methodology

Equations (1) and (2) are called the transmission line equations or the telegrapher's equations (Ulaby, 1994). They are coupled linear first-order Partial Differential Equations (PDEs) of voltage and current with respect to time and spatial position. Since the equations have two derivatives with respect to position and two derivatives with respect to time, we need two boundary conditions and two initial conditions to solve the equations. These conditions are determined by the generator supply voltage, the nature of the load, specifically the impedance of the load, and the parameters of the transmission line. So, in order to solve the equations, we have to choose a specific transmission line scenario where the generator and load are known, and the values of the transmission line parameters are given.

$$-\frac{\partial v(z,t)}{\partial z} = R' * i(z,t) + L' * \frac{\partial i(z,t)}{\partial t} \quad (1)$$

$$-\frac{\partial i(z,t)}{\partial z} = G' * v(z,t) + C' * \frac{\partial v(z,t)}{\partial t} \quad (2)$$

We assume that z = 0 at the load and z = l at the generator, where 'l' is the length of the transmission line. Assume for our problem that l = 1 m. Let the generator be connected to a load with negligible impedance, e.g., short-circuited line with Z_L=0 **Ω**, through a transmission line with the following parameters $R' = 10$ **Ω**/m, L'= 1 μH/m, $G' =$ 0.01 S/m, $C' = 1\ pF/m$. Then, we can plug in these values in Equations (1) and (2) to obtain the PDEs that describe this particular transmission line problem. Equations (3) and (4) are the PDEs that we are going to solve numerically.

$$-\frac{\partial v(z,t)}{\partial z} = 10 * i(z,t) + 10^{-6} * \frac{\partial i(z,t)}{\partial t} \quad (3)$$

$$-\frac{\partial i(z,t)}{\partial z} = 0.01 * v(z,t) + 10^{-12} * \frac{\partial v(z,t)}{\partial t} \quad (4)$$

To fully define our problem, assume a typical scenario where the generator generates a sinusoidal source voltage signal given by (note: angles are in degree not radian)

$$v(z,0) = 20 * \sin(10\pi * z) \quad (5)$$

This is our first initial condition for the voltage at t = 0. The frequency of the signal is 1 GHz as can be seen from the source voltage equation. Usually, the phase velocity of electromagnetic waves in media is lower than their wave velocity in vacuum (the speed of light 'c'). So, assume that the phase velocity in this transmission line is equal to 2/3 c. It is always beneficial to calculate the wavelength of the electromagnetic wave and compare it to the length of the transmission line as it turns out to have many connections that help understand the physics of the problem.

$$\lambda = \frac{v}{f} = \frac{\frac{2}{3} * 3 * 10^8}{1 * 10^9} = 0.2\ m \tag{6}$$

So, l = 5λ. Later we will comment on the implication of this relation between the line length and the wavelength. The current boundary condition at the load, voltage boundary condition at the load, and initial current are, respectively,

$$\mathrm{i}(0,\mathrm{t}) = 3.18 * 10^{-3} * \cos(2\pi * 10^9 * \mathrm{t} - 179.91) \tag{7}$$

$$\mathrm{v}(0,\mathrm{t}) = 0 \tag{8}$$

$$\begin{aligned}&\mathrm{i}(\mathrm{z},0)\\ &= 0.00159 * \cos(10\pi * \mathrm{z}\\ &- 179.91\ )\\ &+ 0.00159 * \cos(-10\pi * \mathrm{z} - 179.91)\end{aligned} \tag{9}$$

These equations provide the necessary boundary and initial conditions for the voltage and current that are needed to solve the PDEs. Now, with the PDEs set and initial/ boundary conditions given we can proceed with solving the PDEs numerically. Note that $0 \le \mathrm{z} \le 1$ m and $0 \le \mathrm{t} \le 1$ μs. This time is long enough compared with the frequency and speed of the wave with respect to the length of the transmission line; long enough for the system to have reached steady state and remained in it long enough.

3. Solution and Results

To solve these PDEs numerically, we apply the finite difference method. We use the central difference for both the time derivative and the space derivative (CSCT) so that the error be of second order in both 't' and 'z'. Applying the central difference on the PDEs and rearranging the terms to make them explicit (can be solved explicitly where we solve for the future value at a single node in terms of only past values), we obtain.

$$\mathrm{i}_i^{n+1} = -20 * 10^6 * \Delta t * \mathrm{i}_i^n + \mathrm{i}_i^{n-1} - 10^6 * \frac{\Delta t}{\Delta z} * \mathrm{v}_{i+1}^n + 10^6 * \frac{\Delta t}{\Delta z} * \mathrm{v}_{i-1}^n \tag{10}$$

$$\mathrm{v}_i^{n+1} = -2 * 10^{10} * \Delta t * \mathrm{v}_i^n + \mathrm{v}_i^{n-1} - 10^{12} * \frac{\Delta t}{\Delta z} * \mathrm{i}_{i+1}^n + 10^{12} * \frac{\Delta t}{\Delta z} * \mathrm{i}_{i-1}^n \tag{11}$$

In order to make sure that the PDEs can actually be solved using suitable space/ time discretizations, we have to check the stability of the numerical method for our problem. The method must be either unconditionally stable or conditionally stable. In the second case, we have to choose our discretizations based on the stability conditions so that we can ensure that we obtain a stable solution using our numerical method. Applying Von Neumann stability analysis, the solution is stable if the magnification factor (amplitude at next or current time step over amplitude at previous time step) of the wave amplitude for both the voltage and current at each time step is less than one. That is,

$$\left|\frac{\mathrm{A_i e^{j\omega(n+1)\Delta t}}}{-\frac{2\Delta t \mathrm{R'}}{\mathrm{L'}} * \mathrm{A_i e^{j\omega n\Delta t}}}\right| = \left|\frac{1}{-\frac{2\Delta t \mathrm{R'}}{\mathrm{L'}}}\right| = \frac{\mathrm{L'}}{2\Delta t \mathrm{R'}} < 1 \tag{12}$$

$$\left|\frac{\mathrm{B_i e^{j\omega(n+1)\Delta t}}}{-\frac{2\Delta t \mathrm{G'}}{\mathrm{C'}} * \mathrm{B_i e^{j\omega n\Delta t}}}\right| = \left|\frac{1}{-\frac{2\Delta t \mathrm{G'}}{\mathrm{C'}}}\right| = \frac{\mathrm{C'}}{2\Delta t \mathrm{G'}} < 1 \tag{13}$$

So, the conditions for stability are

$$\frac{\mathrm{L'}}{2\mathrm{R'}} < \Delta t \tag{14}$$

$$\frac{\mathrm{C'}}{2\mathrm{G'}} < \Delta t \tag{15}$$

Plugging in the values we have for the line parameters, $5 * 10^{-8} < \Delta t$, $5 * 10^{-11} < \Delta t$. So, we have to choose Δt to be larger than $5 * 10^{-8}$ for stability. It is noted that the solution is unconditionally stable for any space discretization. That is, the stability does not depend on Δz.

Given that λ = 0.2, our Δz has to be much less than 0.2. Generally, $\Delta z \ll \lambda$, because the wavelength is the characteristic spatial length of the wave, the wave variation in space happens in fractions of λ. So, if our space discretization is equivalent to λ, then we are missing

information on the waveform of the wave. That's the wave is hugely changing within our discretization step. This is obviously not acceptable and will result in failure of the numerical method since the wave would be much varying during our discretization step. So, we can choose $\Delta z = 0.002\lambda = 4*10^{-4}$. Thus, given that the length of the transmission line is $l = 5\lambda$, we have 2500 nodes. For the time discretization, $\Delta t = 6.25 * 10^{-8}$. So, we have 16 time steps in the interval $0 \leq t \leq 1\ \mu s$. To do the actual computations, we make use of MATLAB. We have to develop a MATLAB program that solves the equations for each time step and saves the solution.

The problem can be analytically solved in more than one way, here we used the usual electric circuit solution that makes use of the complex domain and phasors. The main step in the solution is to obtain the impedance of the circuit based on the model and the values of the parameters given before. Then after completing the solution and transforming the results from the complex domain to the real domain, the solution for the voltage and current was obtained as shown in Equations (16) and (17).

$$v(z,t) = 10\,[\,\sin(2\pi * 10^9 * t + 10\pi * z) - \sin(2\pi * 10^9 * t - 10\pi * z)\,] \quad (16)$$

$$i(z,t) = 0.00159\,[\,\cos(2\pi * 10^9 * t + 10\pi * z - 179.91) + \cos(2\pi * 10^9 * t - 10\pi * z - 179.91)\,] \quad (17)$$

Figure 1. Surface plot of the voltage waveform along the transmission line up to t= 10^-7.

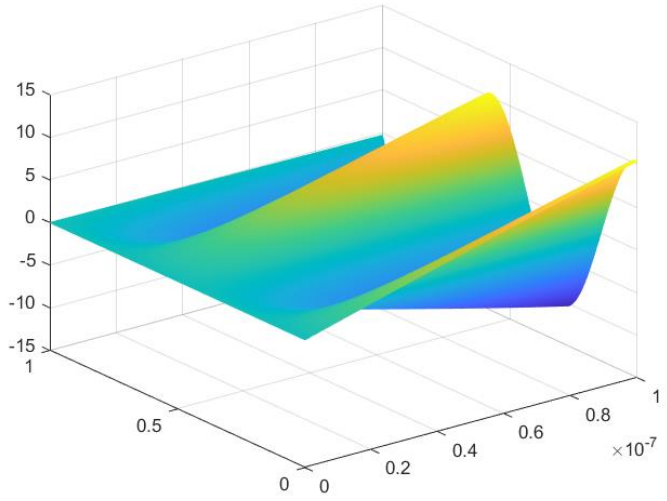


Figure 2. Surface plot of the current waveform.

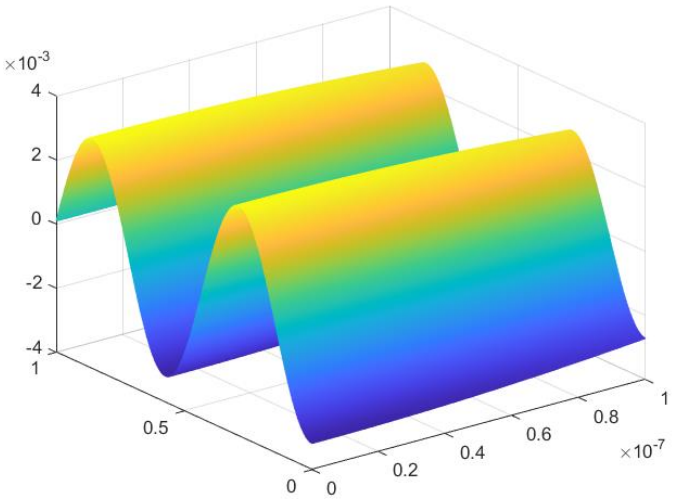
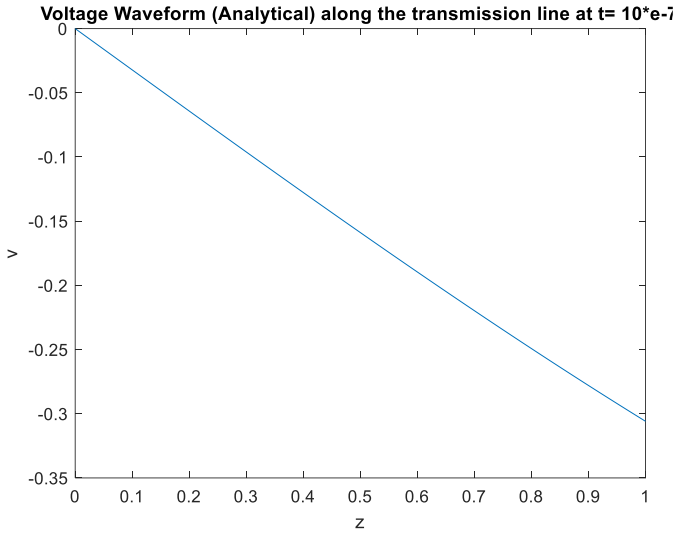


Figure 3. Voltage waveform analytical result and numerical result along the transmission line at t= 10^-7 s.



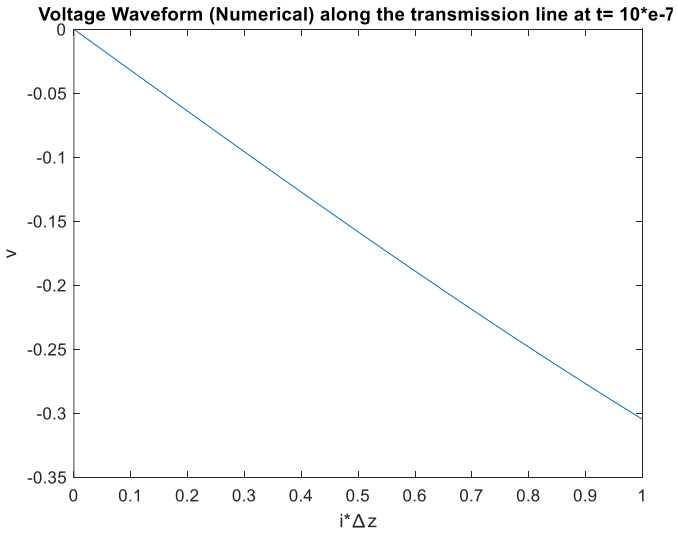


Figure 4. Voltage waveform analytical result and numerical result at the middle of the transmission line.

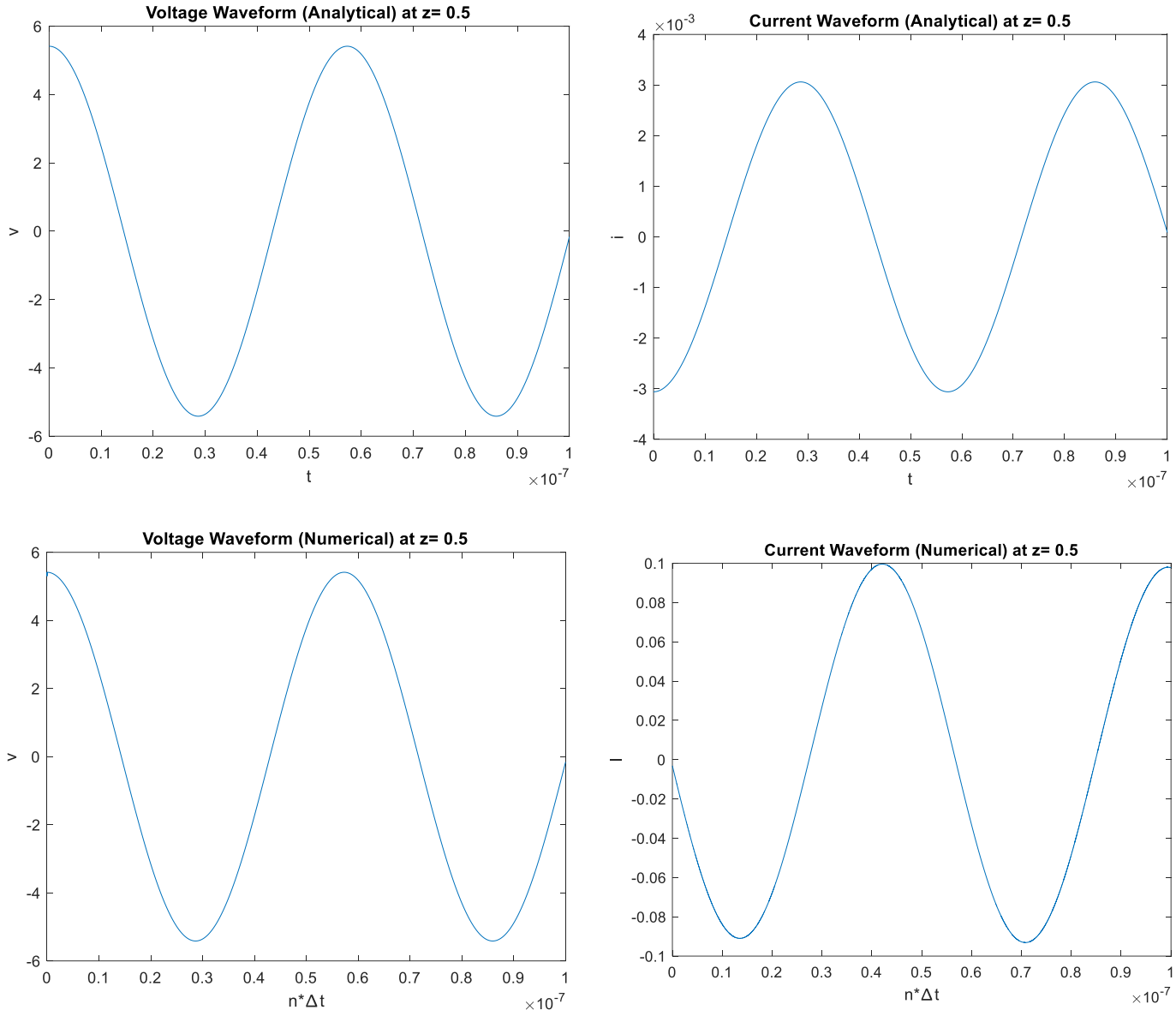


Figure 5. Current waveform analytical result and numerical result at the middle of the transmission line.

4. Conclusion

It can be seen that the numerical solution of the voltage is very near from the analytical result with small error that is hardly visible from the graphs. However, while the numerical solution of the current showed the same waveform as the analytical one, there was quite significant error between the magnitudes of both results. It appears that the waveform of the numerical solution has some phase shift from that of the analytical solution. So, when we compare them we get different magnitudes since we are not accounting for this potential phase shift that may have arose from accumulation of the errors. Adjusting the phase shift of the current waveform results in having good agreement between numerical and analytical results. One challenge is that the execution of the numerical code (the "for" loops in particular) takes a lot of time.

This is because the computations are very extensive since we are talking about roughly 250 million iterations. In fact, if we try to increase the time duration we are solving for by 10 times, Matlab shows an overflow error message that it cannot store the resulting variable. We had to use "single" precision instead of "double" precision for our floating-point variables so that the code be executed withing an acceptable time limit. However, this will come at the expense of accuracy at some point.

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Research Article

The Usage Status of Joetermel Energy in the World, Turkey and Djibouti

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Abstract

In recent years, with the increase in population and the development of technology in the world, the need for energy has been increasing day by day. With the rapid depletion of fossil fuel reserves such as oil, coal and natural gas and the increase in the population, renewable energy sources are gaining importance. Geothermal energy, one of the renewable energy sources, is currently used in various processes such as electricity generation, heating and drying. Geothermal Energy is a clean, cheap and environmentally friendly domestic underground renewable energy source. For this reason, the issue of assessing the situation of direct and indirect production and use of geothermal energy in the world, Turkey and Djibouti has gained importance.

Keywords: Renewable Energy, Geothermal energy, Environmental effects, Usage in Turkey and Djibouti

Joetermal Enerjisinin Dünyada, Turkiye ve Cibuti'deki Kullanım Durumu

Öz

Son yıllarda, dünyada nüfus artması ve teknolojinin gelişmesiyle enerji ihtiyacı her geçen gün artmaktadır. Petrol, kömür ve doğalgaz gibi fosil yakıt rezervlerinin hızla tükenmesi ve nüfusun artması ile yenilenebilir enerji kaynakları önem kazanmaktadır. Yenilenebilir enerji kaynaklarından biri olan jeotermal enerji günümüzde elektrik üretimi, ısıtma ve kurutma gibi çeşitli işlemlerde kullanılmaktadır. Jeotermal Enerji, temiz, ucuz ve çevresel etkileri dostu bir yerli yeraltı yenilenebilir enerji kaynağıdır. Bu sebeple Dünya'da, Türkiye ve Cibuti'deki jeotermal enerjinin doğrudan ve dolaylı üretiminde ve kullanımının durumu değerlendirilmesi konusu önem kazanmıştır.

Anahtar Kelimeler: Yenilenebilir Enerji, Jeotermal Enerji, Çevresel etkiler, Türkiye ve Cibuti'de Kullanımı

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1. Introduction

Energy consumption is an indicator of the level of development of countries so that individuals can lead a comfortable life. Energy needs will represent 80% of energy demand in developing countries at the end of the 21st century (WEC 1993). The increase in energy consumption with the development of population and the increase in technology poses an important problem in Turkey and Djibouti as well as in the rest of the world. In the literature, energy sources are divided into two as conventional energy sources and renewable energy sources. Oil, natural gas, nuclear energy and coal are among the non-renewable energy sources. Renewable energy, on the other hand, refers to an energy source that can maintain its current status in the future as a part of the evolution of nature (Külekçi 2009).

The rapid depletion of fossil fuel resources and the damages they cause to the environment threaten the lives of future generations. Therefore, limited energy resources reserves, population growth, increasing fuel prices, negative effects on the environment and climate change (increasing carbon dioxide emissions) require the use of renewable energy resources within the framework of new energy technologies. Important renewable energy sources are solar energy, geothermal energy, wind energy, biomass (biomass; Biofuel), wave energy and hydrogen energy are used in various processes such as electricity generation, heating and drying. These resources are more advantageous than fossil fuels due to their respect for the environment, reliability and unlimited reserves (Çukurçayır and Sağır 2008).

Geothermal energy originates from the formation of the earth and the radioactive decay of materials at currently uncertain rates (Dye 2012). The high temperature and pressure on Earth causes some rocks to liquefy, and the solid mantle behaves like plastic. This also comes from the upward bending of parts of the mantle as it is lighter than the surrounding rock. Temperatures at the core-mantle boundary can exceed 4000 °C (Lay *et al* 2008).

2. Material and Method

2.1. What is Geothermal Energy

Geothermal energy has the advantage of providing a continuous and regular flow. Also, if solar energy was stored in terrestrial biomass and in fossil energy deposits in the past, geothermal energy has the advantage of hiding a significant stock compared to other renewable energies: 140 million joules are located in the first 5 km of the earth's crust. Therefore, geothermal energy is both a flow energy and a stock energy. Therefore, this situation is also an advantage compared to other renewable energies. As the era of fossil fuels passes in this century, it is clear that no single energy source can assume the role they play. Geothermal energy will be widely used locally and will play an integrative role. For this, it is obvious that geothermal energy will play an important role in this century. Geothermal energy, on the other hand, includes all kinds of indirect or direct benefits obtained from these sources (Kendirli and Çakmak 2009).

Therefore, the work of the geothermal geologist usually consists of thermally suitable zones for searching permeable terrains, allowing high fluid flows in contact with large rock volumes (Bertanı 2015). In geothermal areas, the high temperature of hot rock and groundwater is found in shallower places than in normal areas (Figure 1). The rise of magma towards the crust and therefore heat transport, the heat flow caused by the high temperature difference in the places where the crust Decays, and the groundwater rising to the surface after a depth of several kilometers and heating were among the main reasons for this Syukri (Syukri *et al* 2018).

Historically, there have been two types of geothermal energy: the first is produced by drilling (December 150 to 350 ° C), which responds to the needs of low-temperature heating (45 to 90 ° C), which represents almost half of a country's energy demand, and the second is expanded in a steam turbine, generating electricity (in the range of 150 to 350 ° C) (Varet 2017).

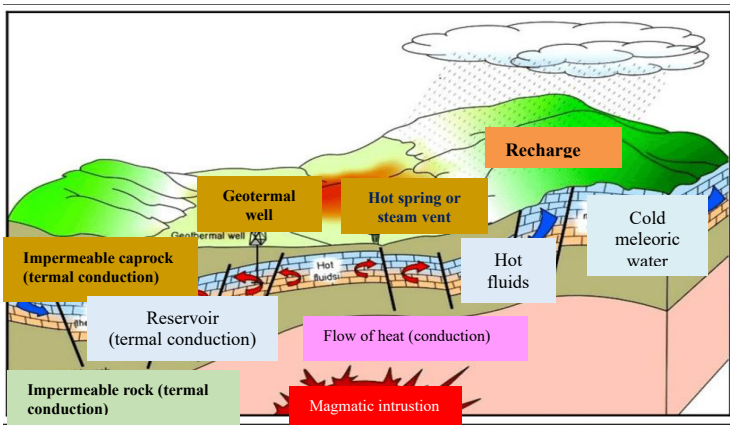

Figure 1. Schematic representation of an ideal geothermal system (Syukri et al 2018).

2.2. The State of Geothermal Energy in The World

This resource, which has been used by the inhabitants of all continents since historical periods for heating and cooking cleaning, health, entertainment and food on a primitive basis, is starting to be used in all countries with geothermal resources in the world.

In 2019, geothermal electricity production in 29 countries around the world is 16,000 MW, and the target is 250,000 MW by 2050. Ranking of the top 5 countries in geothermal electricity production in the world The United States is still the country that produces the most electricity from geothermal sources. Indonesia, the Philippines, Turkey and Kenya have greatly increased their production in recent years (Huttrer 2020). The preliminary country with the most installed geothermal energy production in 2020 is given in Table 1.

The non-geothermal electricity use in the world is 108,000 MW in 2019, which is the equivalent of about 18 million residential heating units. Global geothermal heat production (Review 2015-2020) is given in Table 2.3.

Table 1. The front country with the most installed geothermal energy production in 2020 (Huttrer 2020].

Countries	MWe was founded in 2020
United States Of America	3.700
Indonesia	2.289
Philippine	1.918
Turkey	1.549
Kenya	1.193
Mexico	1.105
New Zealand	1.064
Italy	916

Table 2. Global Thermal Geothermal Production (Lund and Toth 2020)].

Countries	Heat Production (Mwh/Year)
China	123.192.222
United States Of America	42.447.083
Sweden	17.333.333
Turkey	15.162.222
Icleland	9.332.778
Japan	8.534.242
Germany	8.094.067
Finland	6.500.000
France	4.799.899
Canada	4.031.111
Switzerland	4.009.100
Norway	3.500.333

In general, there are direct and indirect uses of geothermal energy. The direct method of use is the oldest geothermal energy. in 2019, the rates of direct use of geothermal in the world (non-electricity), geothermal area heating 74.8% (China, Iceland, Turkey, France and Germany), Spa health use 18% (China, Japan, Turkey, Brazil and Mexico), Greenhouse heating 3.5% (Turkey, China, the Netherlands, Russia and Hungary), Geothermal fishing 1.3% (China, USA, Iceland, Italy and Spain), Industrial use 1.6% (China, New Zealand, Iceland, Russia and Hungary), Cooling snow smelting accounts for 0.2% and the Other 0.2% (Lund and Toth 2020)].

2.3. The State of Geothermal Energy in Djibouti

It is of great importance that the Republic of Djibouti, which is currently experiencing an annual economic growth of 3.5%, uses its potential in renewable energies in order to ensure its economic growth and to save foreign currency. However, the country is experiencing the same energy situation as the sub-Saharan African countries, where energy is abundant but electricity is scarce. 97% of the population's energy needs (mostly urban, more than 85%) are met by oil production imports and 90% of Djibouti households use kerosene as domestic fuel. Electricity usage is very low, about 30%. Only 0.2% of electricity production (with a total installed power of 130 MW) is realized by solar photovoltaic energy, which is a single renewable energy source.

At the geothermal energy level, the potential is technically estimated to be between 350 and 650 MWh. The geo thermic indicators in Figure 2 show that the geothermic fields located in Djibouti are Back, Tadjourah, Gaggadé, Hanlé, Ghoubbet, Arta, Asal and Dora. In these regions, the volcano consists of eruption area (emitting smoke and gas) (Youssouf 2020).

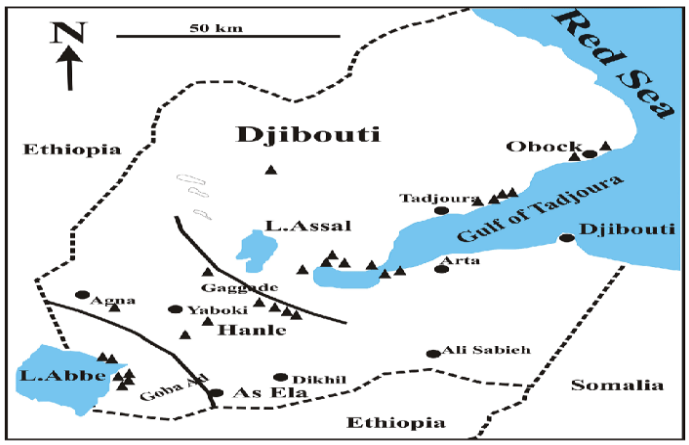

Figure 2. Geothermal sites in Djibouti (Chandrasekharam et al 2014).

There are hot water springs with a temperature of 48 °C in the Tadjourah region and regions with chimneys that emit gas and smoke at a temperature of 38 and 47 °C in the Rouéli region (Figure 3). Here, especially in the Ni'illé region, there are underground waters known as 'hot water springs-hot springs' among the people that come out sideways at the same temperature (Stieltjes 1973).

Figure 3. Korili hot water spring (hot spring) (Berger 2001).

According to the findings of numerous studies conducted by the CNR-CNRS and BRGM institutes, Assal-Ghoubbet, which is undeniably the most active area of the fault fracture, has the highest geothermal resource density. The Assal 1 and Assal 2 drilling experiments recorded high temperatures at depths of up to 345 ° C. Unfortunately, the high salinity of the spring (mineralization ratio of 110 g / l) causes significant deposits in the wells, reducing the likelihood of using the liquid (Youssouf 2020).

2.4 The State of Geothermal Energy in Turkey

The use of geothermal resources is quite common. In these places, the geothermal energy currently produced in Turkey is used for electricity generation, heating (for greenhouses and houses), thermal and health tourism, industrial mineral extraction, fishing, drying and other purposes. Kizildere Power Plant, which was established by the General Directorate of MTA in 1975 and has a power of 0.5 MWe, started the first electricity production in geothermal energy applications.

According to the end of 2021 data, there are 15,854 MWe of installed geothermal energy capacity worldwide, an increase of 246 MW compared to 2020. The USA, Indonesia, Philippines, Turkey and New Zealand are the top 5 countries in the world for geothermal energy electricity generation (Figure 4). Turkey, which has an 11.5 percent share in the global geothermal energy installed capacity, ranks fourth in the world in terms of installed capacity and first in Europe (Richter 2022).

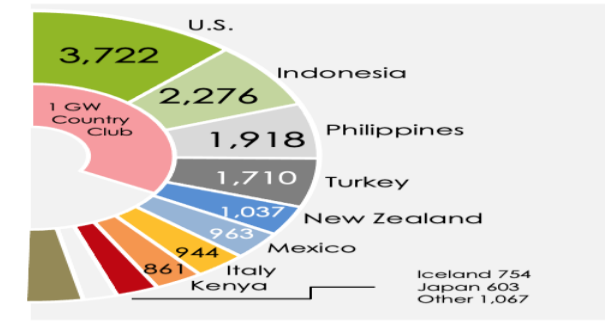

Figure 4 ThinkGeoEnergy Top 10 Geothermal Countries by installed power generation capacity (MWe) in 2021 (Richter 2022)..

While there are more than 600 hot water (geothermal energy) sources in Turkey, some sources have increased this number to 1000. Turkey has the second largest geothermal energy resource in Europe after Italy, and these resources are more concentrated in the Aegean Region in Western Anatolia than in other regions due to the geological structure of the country.

Turkey is located in a region with active tectonic activity. Geothermal resources in the form of natural outlets and at various temperatures are widely distributed throughout Turkey. Geothermal energy is therefore an important renewable energy source for Turkey (Zaim and Çavşi 2018).

Electrical energy is generated using high enthalpy fields (temperatures> 180 ° C). Medium enthalpy sites (70 to 180 ° C) are used for heating houses and greenhouses and other drying processes. Low enthalpy zones benefit from facilities such as swimming pools, balneological baths and fish farms (temperatures from 20 to 70 ° C). Depending on the local conditions and the fluid temperature, geothermal energy sources can be used in many different places. The use of geothermal energy in places close to the fluid source is important in terms of its efficient and cost-effective evaluation. Kizildere (Denizli), Tuzla (Anakkale), Salavatl (Andy), Germencik (Andy) and Einar-Simav (Kütahya) regions of Turkey (Table 3) were excellent for generating electrical energy, classified as high enthalpy locations according to their temperatures (Şimşek 1998).

Turkey is located in a geography where tectonic movements are intense. Turkey There are many geothermal resources scattered all over the world in the form of natural outlets and at different temperatures. Therefore, geothermal energy is an important renewable energy source for Turkey. The areas of use of geothermal energy resources vary greatly depending on the regional conditions and fluid temperature. In order for geothermal energy to be evaluated efficiently and economically, it is necessary to use it in areas close to the source of the fluid.

Geothermal power plants with an installed capacity of 820.86 MW account for 1.58% of Turkey's total installed energy power. As of 2000, the direct use capacity of geothermal energy in the world such as thermalism, cooling, heating has reached 17174 MWT. Turkey, on the other hand, is the 5th in the world thanks to its 820 MWt direct use capacity. it is in the position of the country. With an increase of 246 MW compared to 2020, the total installed geothermal energy production capacity in our country was measured as 15,854 MW at the end of 2021 (Anonymous 2022). In Table 3, the areas where geothermal energy can be produced in Turkey are given.

Table 3. Areas where Geothermal Energy Can be Produced in Turkey (Anonim 2022)

Field Name	Reservoir Temperature (°C)
Germencik, Aydın	232 °C
Kızıldere, Buharkent, Aydın	242 °C
Kurudere, Alaşehir, Manisa	184 °C
Göbekli, Alaşehir, Manisa	182 °C
Tuzla, Çanakkale	174 °C
Salavatlı, Aydın	171 °C
Simav, Kütahya	162 °C
Seferihisar, İzmir	153 °C
Caferbey, Salihli, Manisa	150 °C
Yılmazköy, Aydın	142 °C
Balçova, İzmir	136 °C
Dikili, İzmir	130 °C

3. Results and Discussion

Geothermal resources in the world may supply 8% of the world's electrical energy needs in the near future. Rising oil prices will improve the economics of energy production from supported geothermal systems in the near future and may double electricity production from geothermal systems. The use of low-grade geothermal resources in the world and in Turkey will replace fossil fuels in direct use locally. It will reduce social costs by controlling the use of geothermal resources instead of fossil fuels and controlling CO2 levels. The technically decontamentable geothermal potential of the Republic of Djibouti is currently estimated to be between 350 and 650 MW.

4. Conclusions and Recommendations

On the temporal horizons of technology and social systems, geothermal resources can be seen as renewable because they do not have the same geological lifespan as fossil fuel reserves such as coal, oil and gas. At the same place where the liquid or heat is withdrawn, high enthalpy reservoirs are recovered. In October, heat pump systems can be used to produce truly sustainable food. The environmental impacts of geothermal energy production and direct consumption are typically modest, manageable or negligible. Environmental laws, which may differ from one country to another, should be strictly adhered to. In any case, the effects should be monitored, recorded and, if necessary, mitigated (sometimes for extended periods of time).

In the foreseeable future, geothermal resources may meet 8% of the world's electrical energy requirements. Rising oil prices may soon make supported geothermal energy production more economically viable and perhaps triple electricity production from these systems. Fossil fuels will be replaced by low-grade geothermal resources both globally and in Turkey for local direct use. By limiting CO2 levels, the use of geothermal resources instead of fossil fuels will reduce social costs.

Turkey's energy production seems economically viable and more projects are underway. With the current financial model and heating rates, the economy of central heating systems in Turkey does not look healthy, and given this economic situation, it does not seem realistic to compete with natural gas in the short and medium term. Turkey's geothermal resources seem to be a good place to get process heat. The industry needs to be aware of this scenario and take it into account. The industry has already recognized that it makes economic sense to use Turkey's geothermal resources to heat greenhouses.

The technically Decontamentable geothermal potential of the Republic of Djibouti is currently estimated to be between 350 and 650 MW. The Asal-Ghoubbet plant alone has an economic operational potential of over 150 MW, far beyond the current requirements of the country. During the drilling operations, the exploration of most of the places with geothermal resources was very simple due to the small area of the country. The only remaining task is to move to the operational stage after twenty years of exploration in this area.

The Assal plant is a promising area and the initial 30 MW phase, gradually followed by modular units of 5-10 MW, should be considered near the country's existing plants. The current Iceland project in this region can be completed with an initial capacity of 50 MW, which is expected within the next three years. After completing these tasks, a 5 MW pilot geothermal power plant should be built.

5. Acknowledge

The authors would like to thank the many people who contributed to the country update articles who provided data that is often difficult to find or calculate. In most cases, these numbers had to be estimated by the country update authors or the authors of this article. We hope that our estimates of geothermal capacity and utilization are quite accurate, but we welcome suggestions for changes or corrections. This research was carried out within the scope of the Doctoral program.

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Research Article

Allelopathy effects of essential oils from Juniperus phoenicea L and Artemisia herba-alba on several weedy species

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Abstract

Utilizing allelopathy as a bio rational management tool for natural resources in agroecosytems is a promising approach.the aim of this study was to investigate natural alternatives to chemical pesticides for weed control in agriculture by exploring the allelopathic effects of volatile essential oils (EOs) extracted from selected plant species native to Algeria .
Specifically;we evaluated the allelopathic potential of EOs from Artemisia herba-alba and Juniperus phoenicea L;on the germination and seedling growth of five weed species, including Daucus carota, Ampelodesmos mauritanica, Cynodon dactylon, Poa annua, and Avena fatua. Essential oils were extracted from the aerial parts of the two plants using hydro distillation. The results showed that the essential oils from A.herba-alba were highly effective in inhibiting seed germination of D. carota,P. annua and A.fatua,while the J.phoenicea essential oils suppressed seedling growth in all of the targeted weeds.In particular,a higher concentration of 50 µL/l of the essential oils completely inhibited germination and seedling growth in C. dactylon and A. fatua, and in P. annua at a concentration of 50µL/l. Furthermore, the essential oils from J. phoenicea at a concentration of 500µL/l inhibited seed germination of A. mauritanica, while the essential oils from A. herba-alba at concentrations ranging from 50 to 250µL/l achieved the same effect.The finding suggest that a combination of the essential oils from the two plants species or using Nano emulsion technology ;could be a promising bio-herbicide.

Keywords: Weeds;Essential Oils; Allelopathic potential; Seed germination; *herbicides;*Artemisia herba-alba; Juniperus phoenica L.

Juniperus Phoenicea L ve Artemisia Herba-Alba'nın Esansiyel Yağlarının Bazı Yabani Türler Üzerindeki Alelopatik Etkileri

Öz

Agroekosistemlerde doğal kaynakların biyo-rasyonel yönetimi için alelopatiyi kullanmak umut verici bir yaklaşımdır. Bu çalışmanın amacı, Cezayir'e özgü seçilmiş bitki türlerinden elde edilen uçucu esansiyel yağların (EO'lar) alelopatik etkilerini araştırarak tarımda kimyasal ilaçların yerine doğal alternatifler bulmak için yabani otların kontrolü için doğal yöntemleri incelemektir.
Özellikle; Artemisia herba-alba ve Juniperus phoenicea L'den alınan EO'ların, Daucus carota, Ampelodesmos mauritanica, Cynodon dactylon, Poa annua ve Avena fatua gibi beş yabani türün çimlenme ve tohum çimlenmesi üzerindeki alelopatik potansiyelini değerlendirdik. İki bitkinin havadaki kısımlarından hidro distilasyon kullanarak esansiyel yağlar çıkarıldı. Sonuçlar, A.herba-alba'dan elde edilen esansiyel yağların D. carota, P. annua ve A.fatua'nın tohum çimlenmesini engellemede çok etkili olduğunu, J.phoenicea esansiyel yağlarının ise hedeflenen tüm yabani otların tohum çimlenmesini baskıladığını gösterdi. Özellikle, esansiyel yağların 50 µL / l'lik daha yüksek bir konsantrasyonu, C. dactylon ve A. fatua'nın tohum çimlenmesini ve tohum çimlenmesini tamamen inhibe etti ve P. annua'da 50µL / l'lik bir konsantrasyonda etkili oldu. Ayrıca, J. phoenicea esansiyel yağları, 500µL / l konsantrasyonda A. mauritanica'nın tohum çimlenmesini inhibe ederken, A. herba-alba esansiyel yağları, 50 ila 250µL / l arasındaki konsantrasyonlarda aynı etkiyi elde etti. Bulgular, iki bitki türünden elde edilen esansiyel yağların bir kombinasyonunun umut verici bir biyo-herbisit veya Nano emülsiyon teknolojisi kullanımı için olabileceğini düşündürmektedir.

Anahtar Kelimeler: Yabani otlar; Esansiyel Yağlar; Alelopatik Potansiyel; Tohum Çimlenmesi; Herbisitler; Artemisia herba-alba; Juniperus phoenica L..

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1. Introduction

Synthetic herbicides have been applied in weed management; however, their indiscriminate use has enhanced environmental pollution, human health hazards and weed .resistance [1];and minor weeds becoming dominant

In order to find manipulated and alternative strategies to manage weeds in ago-ecosystems, studies and subsequent test inbioassays ,reported allelochemicals isolate from plants has provided proof for their phytotoxic potential against weed species.use of allelopathy as novel weapons for natural weed suppression.

Plant essential oils (EOs) have been known for their phytotoxicity and for their allelopathic effects on seed germination.

The hypothesis of this study was that some EOs might be suitable for controlling some Mediterranean weeds.

the objective of this study was to evaluate the allelopathic effects of selected volatile EOs from two different plant species on seed germination and seedling growth of fives invasive species.

2. Material and Method

The present experiment aimed at assessing the allelopathic actions of essential oils of Artimisia and Juniperus,on germination and seedling growth of monocotyledon of and dicot weed plants.

2.1. Bioassay

2.1.1. Sample Collection

Artemisia herba-alba,known also as «desert wormwood»or «shih»in Arabic ,is an aromatic and medicinal shub,20to 40cm high,growing wild in arid areas of the Mediterranean bassin.[14]

About,Juniperus species belong to coniferous plants,Juniperus phoenica is an evergreen tree indigenous to the North Africa and belongs to the family Cupressaceae.[13]

Artemisia herba alba and Juniperus phoenica plants were collected in Aurès region at the maturity stage (2022).

The plants left air -dried for 14 days ,then separated into two shoot and leaves parts.

Mature seeds of five weedspecies (Daucus carota, Ampelodesmos mauritanica,Cynodondactylon ,Poa annua,and Avena fatua.) were collected from crop fields;Palm Grove in Tolgua ,Biskra region.

2.1.2. Extraction of the Essential Oils (EOs)

The volatile essential oils (EOs) of Artemisia herba alba and Juniperus phoenica was extracted via steam distillation using a Clevenger-typeaparatus for 300 min using500g,700g of dried aerial part leaves , in 2-L distillation units .The oil were stored in hermetically sealed dark-glass containers and kept at 4°c for further use.

2.1.3. Assay

To prepare an essential oil solution, were formulated as active ingredients with different dose under current study,0.5µL,5µL,25 µL and

50 µL of : Artemisia herba alba ,Juniperus phoenica essential oil were mixed with 100ml of distilled water,the final solutions were shaken to get homogeneous.

Ten seeds of weedspecies and rapeseed were separately placed in 9 cm diameter petri dishes lined with filter paper.

25 ml of each solutions were applied to the petri dishes There were 5 replications of each seed species dishes were incubated in a growth chamber at 24±2°C in the dark for a week after that exposed to ambient temperature of the month Aout at (38 ±2)°C

Germination was determined by counting the number of germinated seeds at 48h intevals till 7days after 15 days,recorded seed germination percentage, shoot length, root length.[3]

3. Results and Discussion

3.1. Seed germination

The essential oil of Artemisia herba alba and of Juniperus phoenica significantly inhibited the seed

germination of 5 weed plants (Daucus carota, Ampelodesmos-mauritanica,Cynodon dactylon ,Poa annua,and Avena fatua.)

The essential oils of Juniperus phoenica have harmful effects on seed germination of weed species (fig1);

Juniperus phoenica's EOs shown to inhibit seeding emergence of weed species Avena fatua,Cynodon dactylon and the lowest values of pourcentage seed gemination was recorded in Daucus carota, Ampelodesmos-mauritanica under 20%.

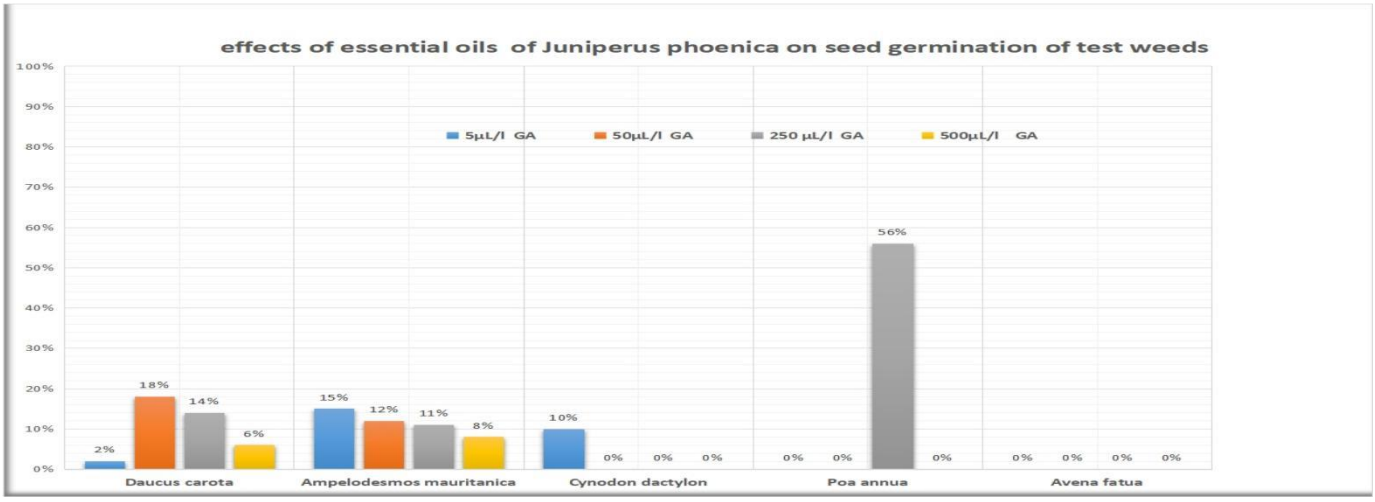


Fig. 1 Effects of essential oils of Juniperus phoenica (GA) on seed germination of test weeds

The data presented in (fig2) weeds germination percentage show the variations in the weeds control of five weeds species at four concentrations of Artemisia alba-herba essential oils

Inhibitory effects of two essentiel oils data presented in (fig3); complete inhibition of Avena fatua seed germination was observed at icreases conentrations essential oil of Juniperus phoenica (GA) and Artemisia herba alba(AM), 100%inhibition of seed germination was observed in Daucus carota,and Poa annua at (5µL/l to 500µL/l)Artemisia herba alba essential oil.

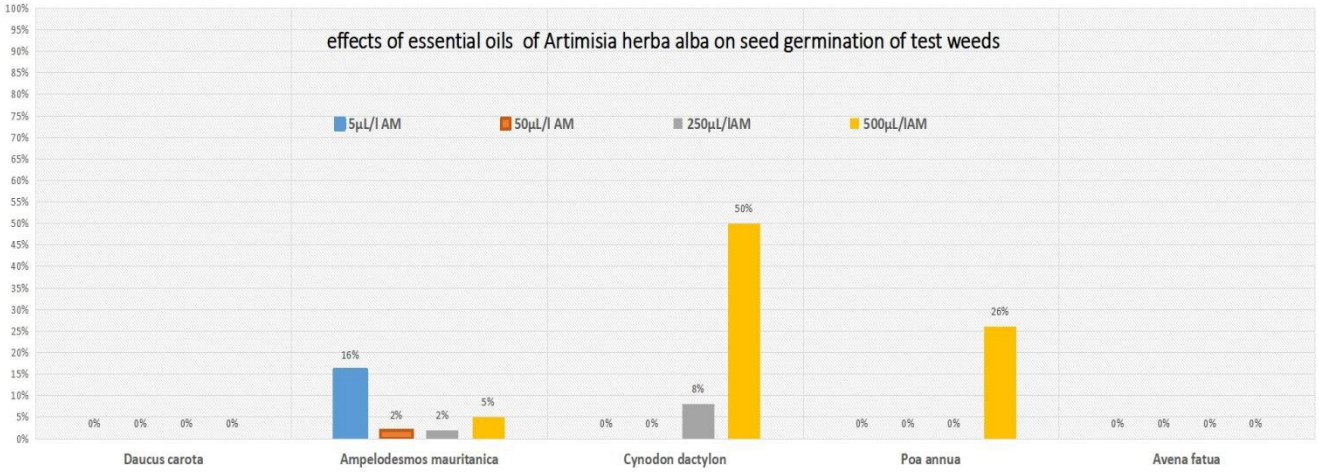


Fig. 2 Effects of essential oils of Artemisia herba alba (AM) on seed germination of test weeds.

As can be seen from the data ,the seed germination of frour targeted weeds was significantly,the complete inhibition of seed germination was observed of Daucus carota and Avena fatua,at higher dose of Artemisia herba alba essential oil more than (50µL/l) decreased the germination of Ampelodesmos mauritanica and for lower concentrations (50 µL/l) of oil ,no germination of treated seeds Cynodondactylon.

Poa annua but at higher concentration more than (50 µL/l) of oil we record increased germination :Poa annua (26%) at (500µL/l),Cynodon dactylon (50%)..

At lower doses of Juniperus phoenica (5µL/l),and at higher concentration (50µL/l) concentration of Juniperus phoenica essential oil treatment,92%,94%,100% inhibition in germination was observed in Daucus carota, Ampelodesmos mauritanica,Cynodon dactylon

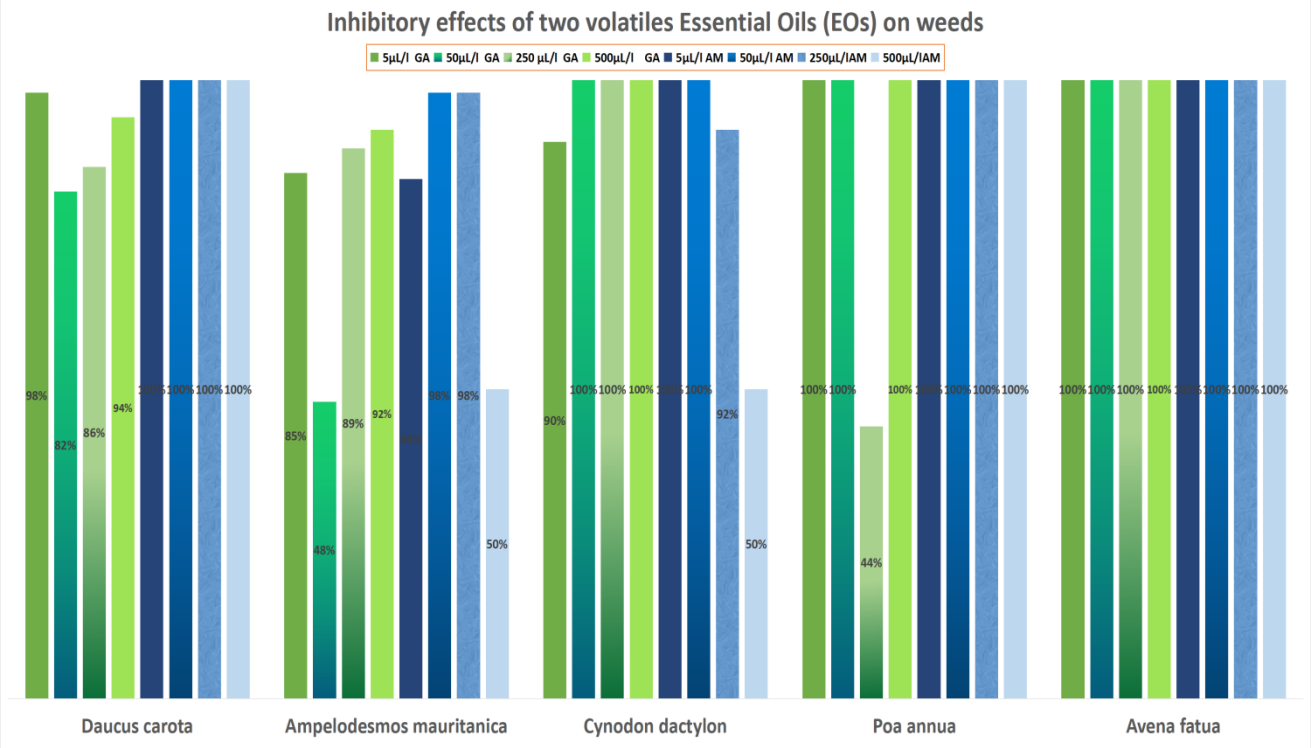


Fig.3 Inhibitory effects of essential oils of Juniperus phoenica (GA) and Artemisia herba alba (AM) on seed germination of test weeds.

3.2. Seedling development

The effects of Essential oils of Artemisia herba alba (AM) and Juniperus phoenica were tested on seedling development(Radicle and shoot length(mm)) of weed species.(fig.4) .

For instance;we found that low concentrations of Juniperus phoenica(5µL/l) had harmful effects on roots and shoot elongation,also increased concentrations of Artimisia herba-alba essential oils (250µL/l-500µL/l) showed suppressor of radicle and shoot growth of the Cynodon dactylon (fig.5) .

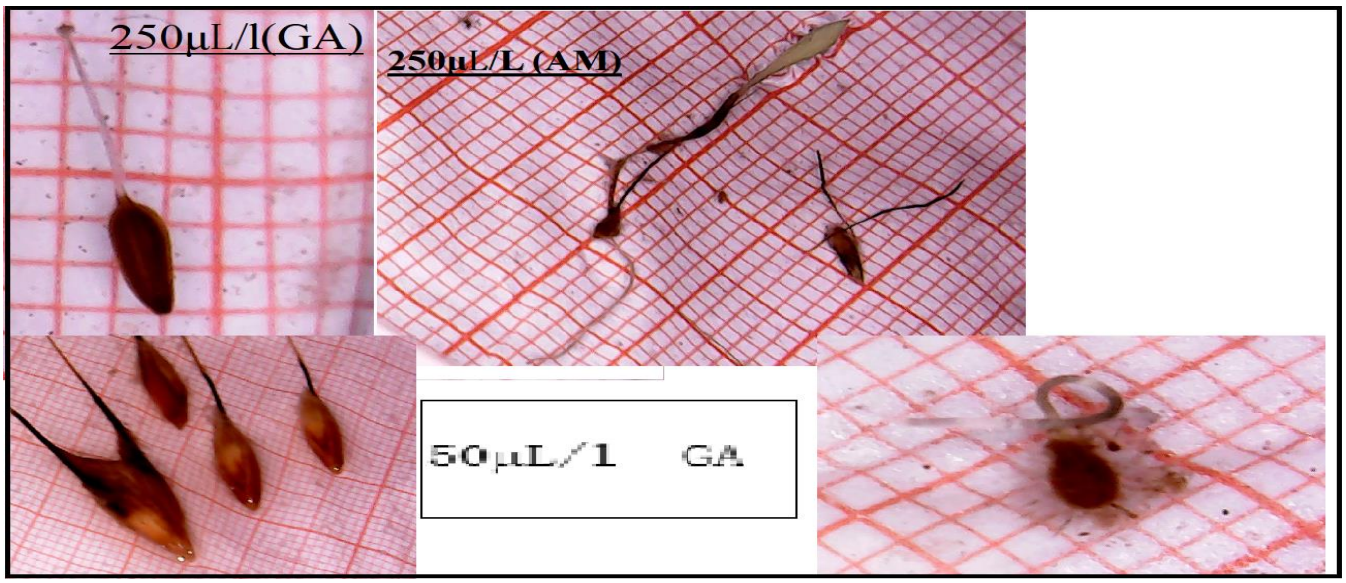


Fig.4 Effects of essential oils of Juniperus phoenica (GA) and Artemisia herba alba (AM) on weed seedling development.

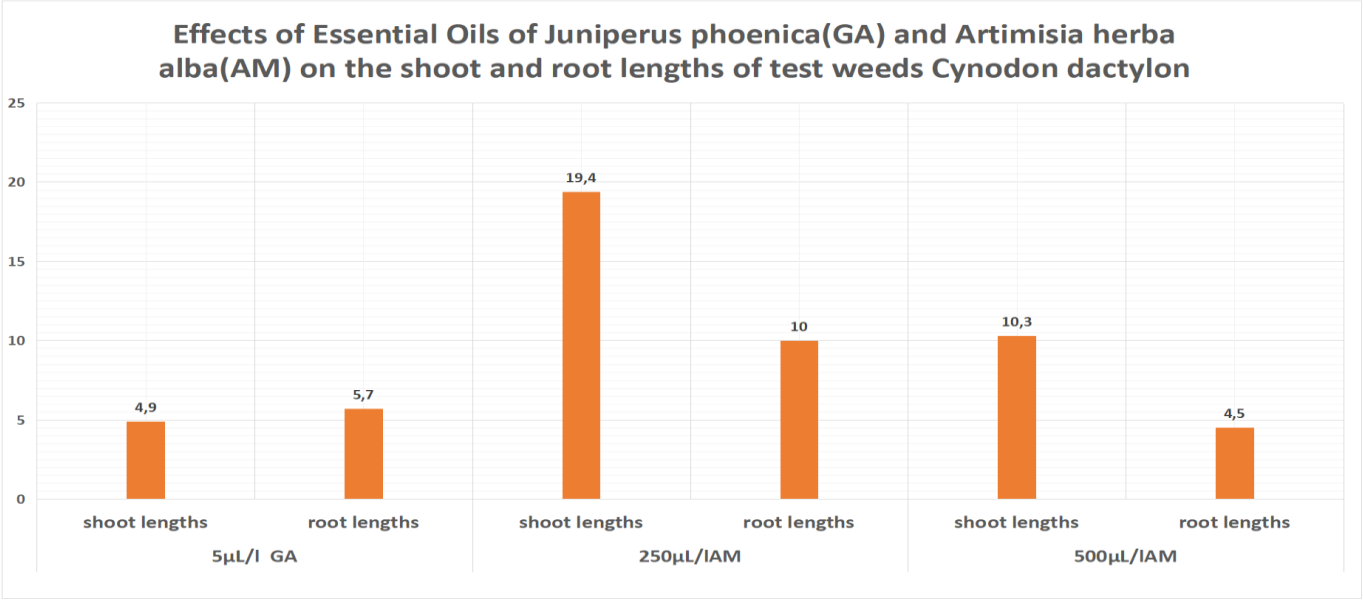


Fig. 5 Effects of essential oils of Juniperus phoenica (GA) and Artemisia herba alba (AM) on seeds development (mm) of test weeds Cynodon dactylon.

We have noticed that seedling grouth of Daucus carota were effected at increases concentrations essential oils of juniperus phoenica, at elongation root lengths stimulated the shoot lenghts showed supressor,vice versa.(fig.6)

Effects of increases concentrations of essentiel oils of Juniperus phoenica(GA) at elongation shoot lengths had decreased for stimulate elongation root of Ampelodesmos mauritanica.but the increases concentrations of essential oils of Artemisia herba-alba effects elongation root and shoot lenghts harmfully.(fig.7)

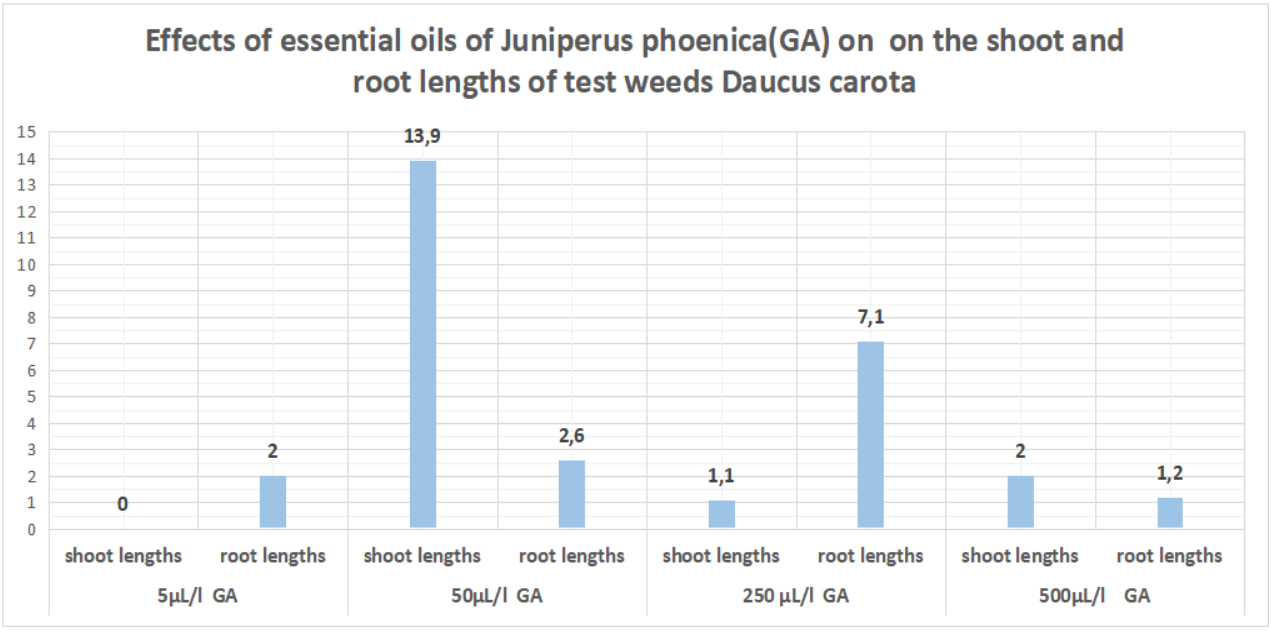
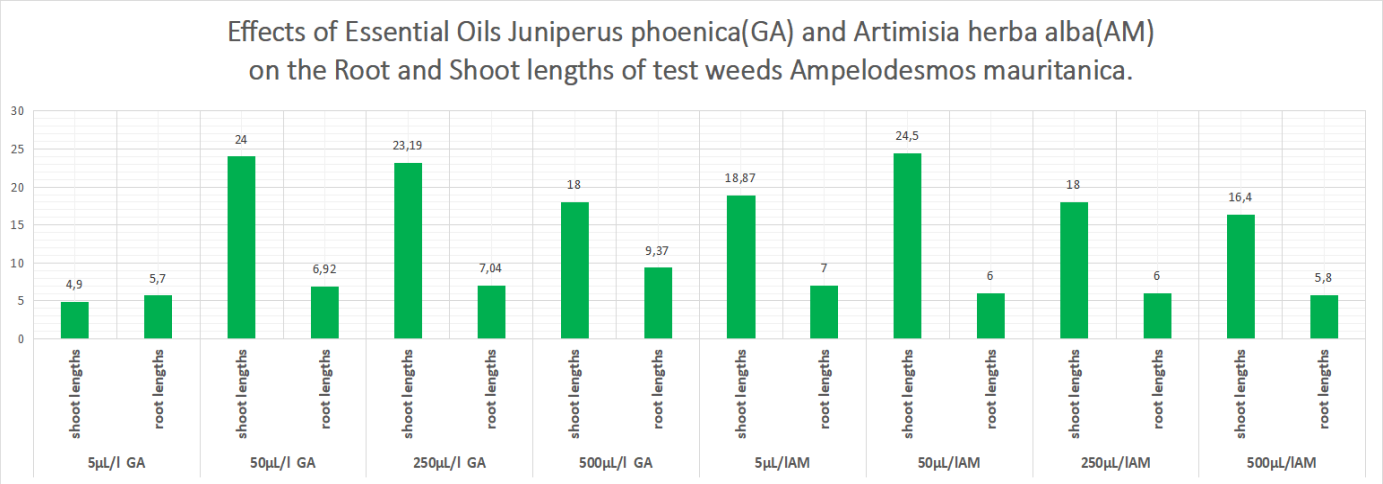


Fig. 6 Effects of essential oils of Juniperus phoenica (GA) on seeds development (mm)of test weeds Caucus carota.

Fig. 7 Effects of essential oils of Juniperus phoenica (GA) and Artemisia herba alba (AM) on seeds development (mm) of test weeds Ampelodesmos mauritanica.



At concentration of essential oil of Juniperus phoenica (250µL/l)and at concentration essential oil of Artemisia herba-alba (500µL/l) stimulated the root elongation without shoot elongation (0mm).(fig.8) .

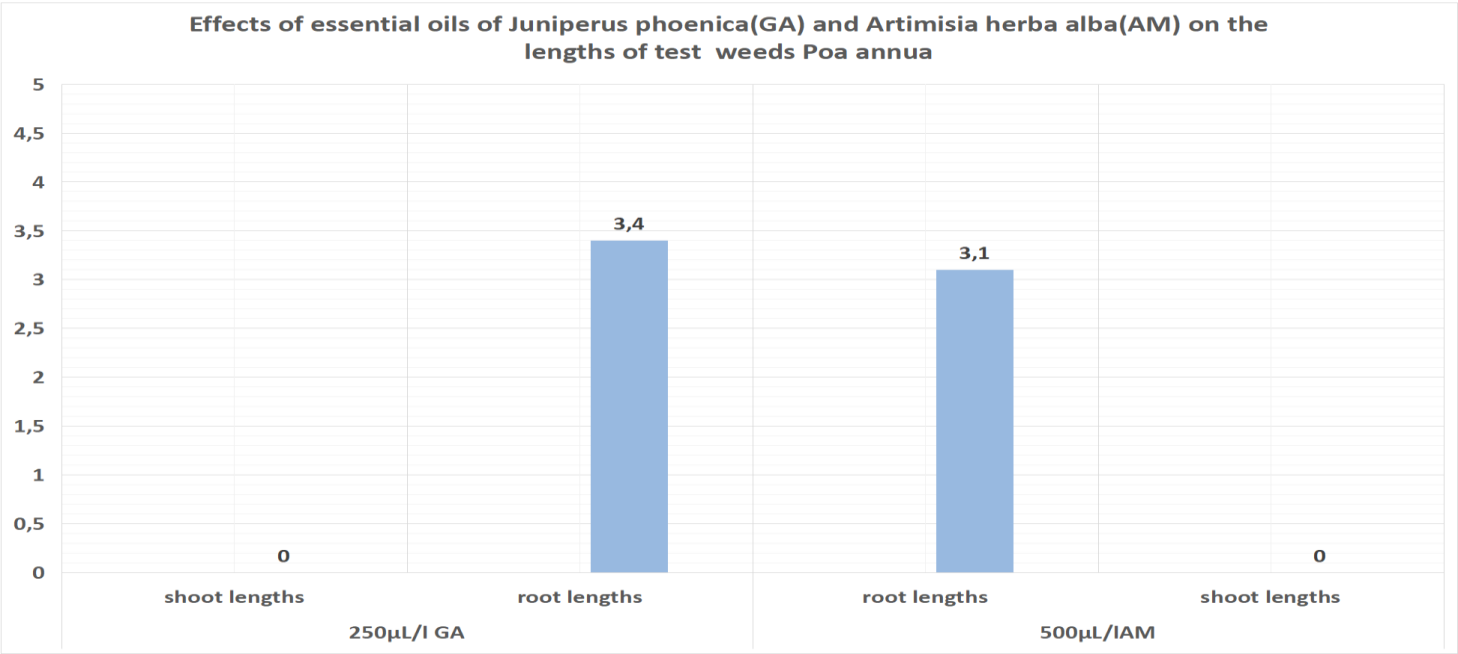


Fig. 8 Effects of essential oils of Juniperus phoenica (GA) and Artemisia herba alba (AM) on seeds development (mm) of test weeds Poa annua.

3.3. Discussion

The literature reports numerous papers on the composition of essential oil from Artemisia herba-alba, originating from different parts of the world [3,1,4]. The analysis of the oils revealed a high degree of polymorphism, leading to the identification of multiple chemotypes [2]. Essential oils from A. herba-alba collected from Morocco, Algeria, and southern Spain showed different compositions [7,2]. In Tunisia, where the climate is semi-arid and arid, the essential oils exhibited varying compositions, with some dominated by a single component such as α-thujone, β-thujone, 1,8-cineole, camphor, chrysanthenone, or trans-sabinyl acetate, while others were characterized by the presence of two or more of these compounds [7,2,4].

Many studies around the world have been performed on the chemical composition of the EOs and extracts of Juniperus species.

Juniperus Oils and extracts contain various chemotypical compounds: from 2,6-dimethyloctane to sesquiterpene skeletons, and flavonoids and biflavonoids, but the main classes identified in almost all Juniperus are mono and sesquiterpenoids and their derivatives .[13,21]

Bouguerra and coworkers found ,The major volatile compounds of Juniperus phoenica.L.,found that pinene, - myrcene and caryophyllene, -cadienene,farnesol and -humulene[16]

There are not many reports on the use of Juniperus phoenica L.essential oils allelopathic effect on seed germination and seedling development. to discuss the resultats,Biotic and abiotic factors must be taken into consideration, exemple The temperature was higher by comparison to other studies because our objectif is study allelopathy potentiel of essential oils in arid areas at weeds species.

Dias et al. (2020), the authors investigate the allelopathic potential of four different monoterpenes on the germination and early growth of maize. The monoterpenes tested were limonene, alpha-pinene, beta-pinene, and 1,8-cineole. The study found that all four monoterpenes had inhibitory effects on the germination and primary root growth of maize, with beta-pinene and 1,8-cineole showing the strongest inhibitory effects. The study also found that the monoterpenes had negative effects on mitochondrial respiration, indicating that they may affect the energy metabolism of the plant.

the study by Taheri et al. (2019) found that essential oils from Juniperus phoenicea L had a significant inhibitory effect on the seed germination and early growth of three weed species, suggesting that they could potentially be used as a natural herbicide for weed control in agricultural fields.

In our study,these results confirmed several studies have reported the volatile essential oil was active against radical elongation;Ilias and coworkers[7]have reported at doses 2.5 µg/mLand 0.25 µg/mLthe essential oil of A.herba alba inhibited the radicle elongation and at high doses of oils tested,the results show stimulatry activity of radicle elongation of radish.Escudero and cowerkers [9]noticed the inhibitory effects of aqueous extract of fresh A.herba-alba shoot and roots of Helianthemum squamatum(L)Dun Cours.

Li with coworkers [11]confirmed that the allelochemicals volatile released from leaves of Artemisia frigida willd and aqueous extracts of leaves and roots,inhibited seed germination and seedling grouwth of 3 dominants species inMongola steppe.

Also Jassbi and coworkers [12]demonstrated that the allelopathy potentiel of Artemisia tridentata at seed germination and seedling growth of the co-existant plant.

According to Dhifi and coworkers, The essentiel oil of Artemisia campestris affected the seed germination at the concentration 100 ppm resulted in an increase of the rate of seed germination of the weed D. carota undergoes a decrease with 1000 ppm and 2000 ppm whereas we noticed an increased germination rate (11.65%) compared to the control (10%) at the 100 ppm concentration.[30]

Abdel-Fattah and coworkers,founded that allelopathic effects can cause both stimulatory and suppressive effects at lower and higher concentrations respectively.[31]

From 4 to 7 days,no seed germination after week we start recording;Our findings were in agreement with those of Dhifi and coworkers;the speed of germination or the time required by D. carota seeds to germinate was also affected. Compared to the control, it increased from 6 to 8 days and from 6 to 11 respectively for the concentrations 1000 ppm and 2000.Daily monitoring of germination is necessary to assess the allelopathic effect, which may not affect the germination itself but rather the germination rate or other process parameters, as stated by Ferreira and Áquila (2000). These changes in germination patterns may impact various factors, such as membrane permeability, DNA transcription, RNA translation, secondary messenger operation, oxygen uptake (phenol), enzyme and receptor conformation, or a combination of these factors. Recent studies have shown that EOs and their constituents can significantly impact root growth and development by inhibiting cell division in growing root tips, interfering with DNA synthesis in growing meristems, inducing oxidative stress, enhancing lipid peroxidation and hydrogen peroxide accumulation, and increasing electrolyte leakage in root tissue. For example, Nishida et al. (2005) reported such effects in their research, while Scrivanti et al. (2003) and Singh et al. (2006) found similar outcomes. These findings suggest that EOs could potentially interfere with several essential cellular processes, leading to various physiological and biochemical alterations.

Therefore, to develop effective and sustainable bio-herbicides based on EOs, it is essential to understand their allelopathic effects thoroughly. This knowledge can help identify the most effective EO chemotypes, optimize their extraction processes, and develop efficient and safe application methods for agricultural and natural ecosystems.

4. Conclusions and Recommendations

The current research findings suggest that essential oil volatiles can impede the germination and initial growth of several weed species, including Daucus carota, Ampelodesmos mauritanica, Cynodon dactylon, Poa annua, and Avena fatua. To enhance our understanding and control of this process, it is imperative to determine the chemical composition of the two essential oils.

The results of current study suggest that alelochemicals in the essential oils of Juniperus phoenica and Aretemisia herba alba as altenative for sustainable weed management.

It is widely accepted that allelopathy can both inhibit and stimulate plant growth. To further explore this phenomenon, we need to investigate the potential bioherbicidal properties of a combination of Juniperus phoenica and Artemisia herba alba oils. This includes evaluating their allelopathic potential as post-emergence bioherbicides under field conditions and determining their effects on non-target weed species and crop agriculture.

More research is needed to fully understand their mechanisms of action and optimize their use in weed management.

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