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Mardin TCDD Şenyurt historical station building material characterization and conservation suggestions

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Abstract

There are three main railway lines in Turkey built by the Baghdad Railway Company, one of which runs from Ankara to Mardin. On this line, there is a station structure built at eight different points in the province of Mardin. Şenyurt station is the largest station building among these eight station buildings on the Mardin railway line. The railways built between Şenyurt and Mardin played an important role in the economic and commercial development of the area and met the military needs of the Republican period. However, due to the social events that took place in Turkey in 2014, train services have not been organized on the Mardin railway route since then. TCDD Şenyurt Station Historical Station Building, which has been in the region for more than a century, contains intangible cultural values as well as tangible values. Today, the building is idle and there are various material deteriorations in the structure. In this context, the aim of the study is to characterize the material of the TCDD Şenyurt Station Building in Mardin province and to present conservation suggestions for the structure. Observational detection and experimental analysis methods were used in the study. As a result of the study, the content of the production material of the building, the binder, aggregate, the quality of the additives, their ratios, the state of protection and the sources of the problem were determined. The most important problem identified in the results of the study is the detection of Chloride and Sulphate salts in various amounts in the samples. The sulfate and the chlorine salts detected in the samples are thought to originate from the Portland cement used for repair purposes in almost all parts of the building.

1. Introduction

Most of the world's cultural heritage building stock consists of stone-built structures. However, due to various climatic and human-induced effects, material deterioration in stone structures continues to increase over the years [1-6]. In this context, it is a necessity in all geographical regions to analyze and document historical stone structures and to develop conservation proposals [7-12]. The historical building under investigation should first be visually inspected, followed by a thorough examination and photographing of the deterioration. In order to identify the materials and select the appropriate materials during the restoration phase, the samples taken from the structure should be analyzed extensively experimentally [13-17]. The materials to be used in the repair should be selected according to these analysis results and recommended in accordance with the original material [18-23].

In the selection of materials used in the restoration of a historical building; It is necessary to use materials that comply with the physical and chemical properties of the original material, give similar reactions to heat, humidity and atmospheric conditions, and whose colors and textures are in harmony with the original materials [24-28].

The literature explains that petrographic, archaeometric and various experimental analyzes provide useful data on the nature of building materials and can help select compatible materials for restoration work. Restorations carried out without adequate experimental analysis led to the use of new materials that are incompatible with and architecturally similar to the original building materials in historical buildings [29-32]. It is emphasized by various studies in the literature that this situation is one of the factors that threaten our cultural heritage in many countries around the world [33- 39].

In the literature, it was suggested that the local material used in that region in different geographical areas, which was stated as a necessity before conservation interventions, should be investigated with experimental analyzes. Within the scope of the study, the material properties and problems of a historical stone structure, which has been in existence for more than a century in Mardin, which is a historical region, will be investigated by experimental analysis methods. The Mardin TCDD Şenyurt Station Historical Station Building, which will be examined, is a valuable structure in terms of keeping the intangible cultural values alive as well as the tangible values of the region. Today, the building is idle and there are various material deteriorations in the structure. The aim of the study is to characterize the material of the TCDD Şenyurt Station Building in Mardin province and to present conservation suggestions for the structure. When the literature was examined, no study on the material properties of the building and material analysis giving detailed information on this subject could be found. The study is important in terms of filling this gap in the literature. Chemicals (loss of glow, acid treatment, spot tests) were carried out on natural stone, mortar and plaster samples taken from the building. Physical (size distribution analysis of aggregates by sieve, types and approximate ratios) analyzes were made. With petrography analysis, mineral contents of thin sections were examined with polarizing microscope, and general tissue properties were examined from bright thick sections under stereo microscope. As a result of the study, the content of the production material of the building, the binder, aggregate, the quality of the additives, their ratios, the state of protection and the sources of the problem were determined. In addition, the results obtained with on-site visual inspections were evaluated, and suggestions for repair and conservation were given.

2. Study area

TCDD Şenyurt Station is located in Kızıltepe district of Mardin province. The building is located in Şenyurt District (Figure 1), within the scope of the 6th Regional Directorate of TCDD.

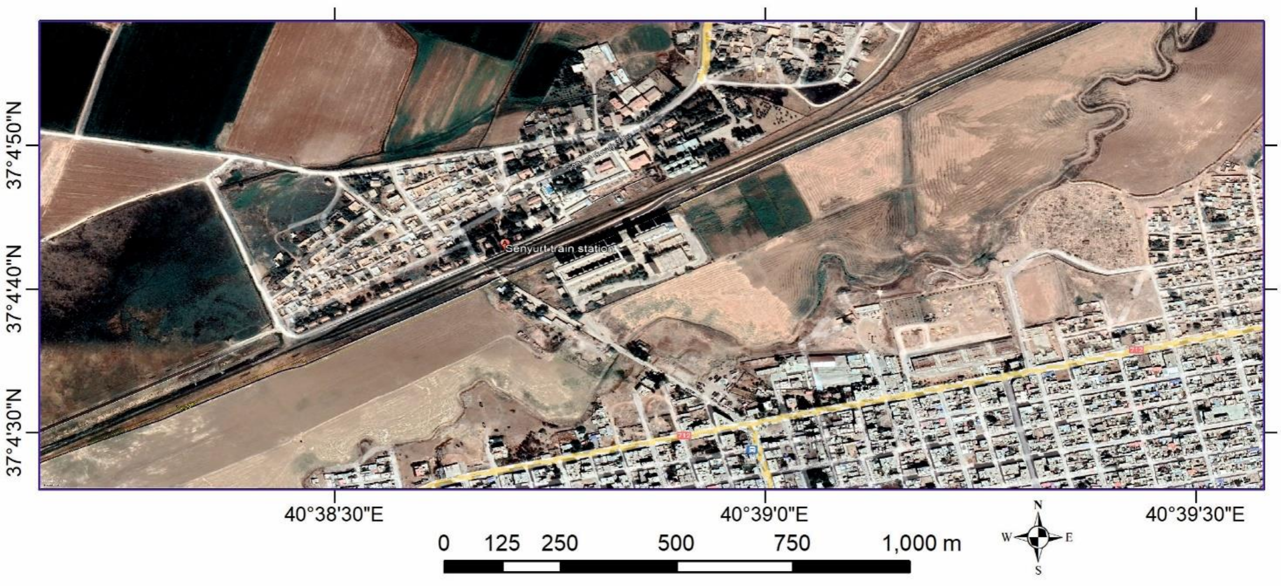

Figure 1. Location map of the study area

There are three main railway lines built by the Baghdad Railway Company in Turkey, and the first main secondary line is the Haydarpaşa-Ankara line. The second one passes from Ankara to Erzurum, through Yozgat, Sivas and Erzincan. The third main line starts from Ankara and extends to Kayseri, Malatya, Diyarbakır and Mardin. On this line, there is a station structure built at eight different points in the province of Mardin. However, only four of them have survived to the present day.

The Mardin railway line was not actively used by the regular army and militia during the national struggle. Therefore, this line has been nationalized due to security concerns of foreign-operated lines and the fact that the regions it passes continue to receive services for their own economic interests. In this context, the lines between Şenyurt and Mardin were transferred to the state in 1949. The railways built between Şenyurt and Mardin played an important role in the economic and commercial development of the area. These lines met the military needs of the republican period. Since only freight is transported on the Şenyurt-Mardin branch line, the last stop of the passengers arriving in Mardin on the main line is Şenyurt station. Şenyurt station is the largest station building among these eight station buildings on the Mardin railway line. Şenyurt Train Station is the main station of the Mardin Railway and contains steam engine maintenance and service warehouses, offices, locomotive maintenance warehouses. And the regional directorate of the movement was located here in the past. However, since 1978, the road branch chief was moved to Ceylanpınar and the road section chief was moved to Mardin Station, while the station chief continued to serve in Şenyurt. The other named units were closed (Ceylanpınar Railway Maintenance Directorate Archive). Table 1 shows the current operational status of the TCDD Şenyurt Station station building, which was built within the scope of the Baghdad Railway Project [40].

Table 1. Number of Passangers Carried on Main Line Routes Between 2004-2014

Date	Şenyurt-Mardin	Date	Şenyurt-Mardin
2004	1.724	**2010**	5.477
2005	1.501	**2011**	5.159
2007	1.517	**2012**	5.293
2008	3.478	**2013**	2.871
2009	4.911	**2014**	-

Due to the war and diplomatic crisis that broke out between Iran, Iraq and Syria in 1980, a train connection between Turkey and Iraq could not be organized until the beginning of the 2000s. Finally, the transportation services that started in 2004 continued regularly until 2014, and the passenger services that started in 2005 were canceled in 2013 and the demand for the next year disappeared. Various social events took place in Turkey on October 6-7, 2014, after a terrorist organization attacked the city of Ayn-el Arab, just across the Turkish border. For this reason, train services have not been organized on the Mardin railway route from that date to the present. Therefore, the building is idle today [40].

Located in the Kızıltepe district of Şenyurt, Şenyurt station building is surrounded by 3 meters high walls on all four sides. There is a water press and a tower in the courtyard of the building. The building has been in this area for over a hundred years. The building shows a wide variety of material deterioration and needs an urgent restoration intervention (Figure 2).

Figure 2. Images from Şenyurt Station Historical Station Building

3. Method

Before proceeding to the repair phase of historical buildings, first of all, samples of mortar and material, which constitute a representative sample, were taken from the monument. Analyzes/experiments were made on three samples (one natural stone, 1 mortar and 1 plaster sample) taken from Mardin TCDD Şenyurt Station Historical Station Building. In the study, chemicals (loss of glow, acid treatment, spot tests) were carried out on natural stone, mortar and plaster samples taken from the building. Physical (size distribution analysis of aggregates by sieve, types and approximate ratios) analyzes were made. With petrography analysis, mineral contents of thin sections were examined with polarizing microscope, and general tissue properties were examined from bright thick sections under stereo microscope. In addition, the results obtained with on-site visual inspections were evaluated, and suggestions for repair and conservation were given.

3.1. Obtain Samples

The locations of three samples (one natural stone, 1 mortar and 1 plaster sample) collected from Mardin TCDD Şenyurt Station Historical Station Building are summarized in Figure 3-5.

Sample 1 is a dark beige-gray mortar sample taken from the exterior wall of the building (Figure 3). Sample 2 is a whitish-beige plaster sample taken from the wall surface in the interior of the building (Figure 4). Sample 3 is a cream colored natural stone sample taken from the exterior of the building (Figure 5).

(a) (b) (c)

Figure 3. Sample 1 **3a)** General view **3b)** General Location **3c)** Detail Location

(a) (b) (c)

Figure 4. Sample 2 **4a)** General view **4b)** General Location **4c)** Detail Location

(a) (b) (c)

Figure 5. Sample 3 **5a)** General view **5b)** General Location **5c)** Detail Location

4. Results

In the restoration materials used in the interventions, the original materials used in the building should be considered, and in order to choose a compatible restoration material, the physical, chemical and mechanical behavior of the repair material should be compared with the original ones. In this context, the findings of the analyzes were interpreted by comparing them with each other.

4.1. Loss of Glow, Acid Treatment and Size Distribution Analysis of Aggregates by Sieve

With the loss of glow analysis (calcination), the percentage losses of substances such as calcium carbonate ($CaCO_3$), which are calculated by utilizing the loss of moisture, organic matter and carbon dioxide (CO_2) in the material, are determined. In the case of acid loss, after the material reacts with hydrochloric acid, the loss (carbonate, etc. reacting with acid) and the remainder are determined. By looking at the losses and residuals of the calcination and acid loss processes (silicate materials that do not react with acid, etc.), the quality, binder and silicate aggregates of the material are determined in line with these results. For this purpose, the acid loss and glow loss values of the samples were compared. The ratio of silicate aggregates remaining undecomposed as a result of acid treatment with the calcination (heat loss) test performed at 105 ± 5 °C, 550 ± 5 °C and 1050 ± 5 °C of the samples and without reacting with acid, and the particle size distributions of these aggregates are given in Table 2. Sieve analysis is an analysis that is used to determine the quality and proportions of the aggregates contained in the samples and is made after the acid loss analysis (Table 2).

Table 2. Heating and Acid Loss and Sieve Analysis

Sample No	**Loss of Glow** (%)			**Acid Treatment** (%)		**Size Distribution Analysis of Aggregates by Sieve** (%)									
	105 C°	550 C°	$CaCO_3$	Loss	Retained	>8.00 mm	>5.6 mm	>4.0 mm	>2.0 mm	>1.0 mm	>500µ	>250µ	>125µ	>63µ	< 63µ
1	0,68	2,56	17,07	20,31	79,69	0,00	0,00	0,00	15,75	22,30	25,38	15,30	9,87	1,15	10,25
2	0,61	2,30	15,37	38,45	61,55	0,00	0,00	0,00	0,00	24,80	22,84	18,40	12,30	12,43	9,23
3		*		99,55	0,45					*					

*As it is a natural stone sample, the relevant analysis was not carried out

4.2.Salt, Protein-Oil and Conductivity Analysis

Simple spot tests were carried out in the laboratory in order to determine the qualities and amounts of water-soluble salts (chloride, sulfate, carbonate and nitrate salts) in the samples taken, and to understand whether additives such as saponifiable oil and protein were added. According to the test results; It is thought that the Chloride (Cl^-) and Sulphate (SO_4^{-2}) salts found in various amounts in the samples originate from cementitious building materials. Carbonate (CO_3^{-2}), nitrate (NO_3^-) salt and protein and saponifiable oil were not detected in any of the samples (Table 3).

Table 3. Water soluble salts and organic matter analysis

Sample No	(Cl^-)	(SO_4^{-2})	(CO_3^{-2})	(NO_3^-)	Conductivity	Salt Amount (%)	Protein	Oil
1	+	+	-	-	857	5,06	-	-
2	+	+	-	-	985	5,81	-	-
3								

-:absence; +:small amount; ++:present +++:abundant ++++: excessive amount

4.3. Petrographic Analysis

For petrography analysis, firstly the samples were epoxied, then coarse and thin sections were prepared for the necessary ones, polarizing microscope (double nicol) mineral contents were examined from the thin sections prepared, and the general tissue properties were examined under the stereo microscope from the shiny thick sections. In the petrographic analysis, the binder type of mortar and plaster type materials, aggregate size and properties, and the general mineral and texture properties of natural stones and their types are given. Sample 1, which was examined under a stereo microscope, resulted in the analysis results; The aggregates of the sample, whose binder is 150-200 doses of Portland cement with approximately 10% lime added, were determined as quartz sea sand with 2 mm sieve size. Sample 2 examined under a stereo microscope; It has been determined that the aggregates of the sample, whose binder is approximately 50 doses of Portland added lime, are sand in 1 mm sieve size. Sample 3 examined under a Stereo Microscope and Polarizing Microscope; It was determined as cream-beige colored, spary-micritic limestone with abundant voids and organic impurities, which is thought to belong to the quarries in the region (Figure 6).

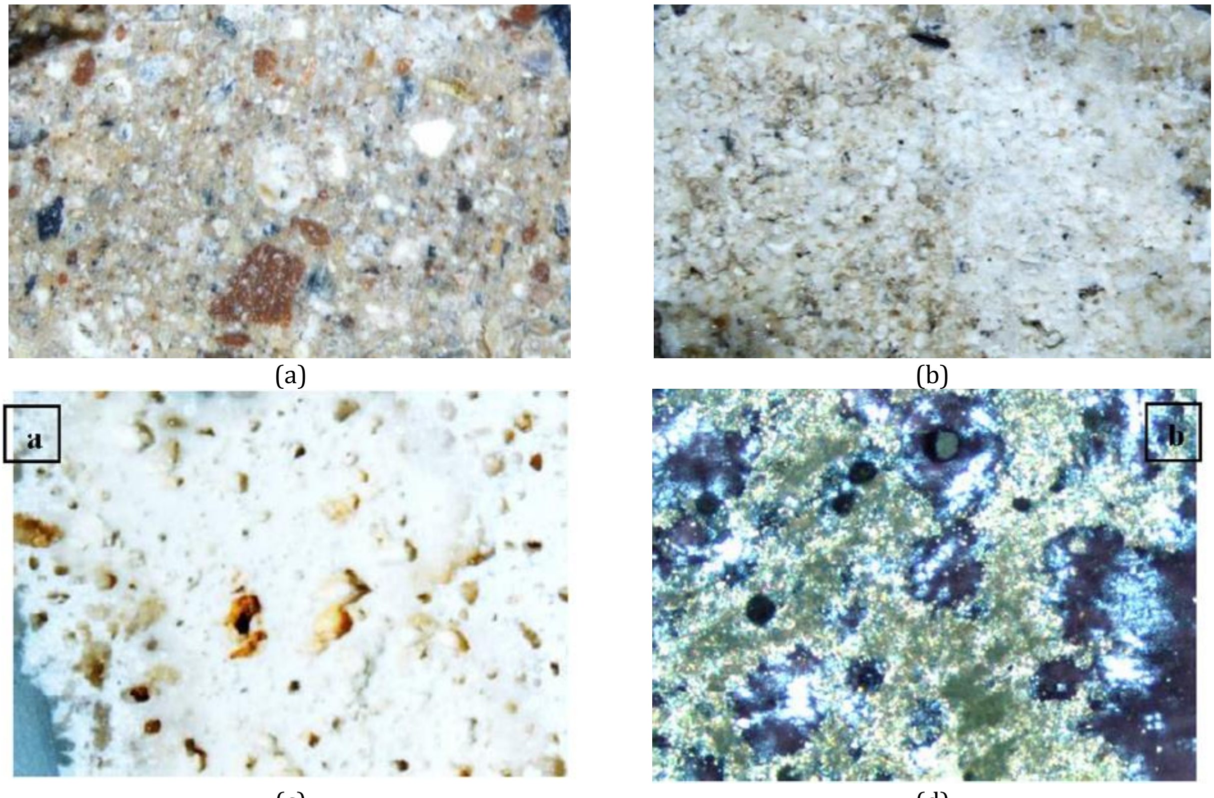

Figure 6. Stereo Microscope/ Polarizing Microscope Images of Samples
a) Sample 1/Stereo Microscope General Tissue b) Sample 1/Stereo Microscope General Tissue
c) Sample 3/Stereo Microscope General Tissue d) Sample 3/Polarizing Microscope General Tissue

5. Discussion

The aim of the study is to characterize the material of the TCDD Şenyurt Station Building in Mardin province and to present conservation suggestions for the structure. When the literature was examined, no study on the material properties of the building and a material analysis that gave detailed information on this subject could not be found. The study is important in terms of closing this gap in the literature. Observational detection and experimental analysis methods were used in the study.

According to the results obtained from petrographic analysis; Sample 1 examined under a stereo microscope; The aggregates of the sample, whose binder is 150-200 doses of Portland cement with approximately 10% lime added, were determined as quartz sea sand with 2 mm sieve size. Example 2 examined under a stereo microscope; It has been determined that the aggregates of the sample, whose binder is approximately 50 doses of Portland added lime, are sand in 1 mm sieve size. Sample 3 examined under a stereo microscope and polarizing microscope; It has been identified as cream-beige colored spiri-micritic limestone with abundant voids and organic impurities, which is thought to belong to the quarries in the region. The results of these analyzes confirm that the minerals that make up the rocks and the texture formed by these minerals, the weathering and weathering of the minerals can be determined by petrographic analysis.

Acid loss and loss of heat loss tests performed on the mortar samples showed that lime was used as a binder in these samples (Table 2). Simple spot tests were carried out in the laboratory in order to determine the qualities and amounts of water-soluble salts (chloride, sulfate, carbonate and nitrate salts) in the samples taken, and to understand whether additives such as saponifiable oil and protein were added. According to the test results; Chloride (Cl^-) and Sulphate (SO_4^{-2}) salts were found in various amounts in the samples. Air pollution is the main source of sulfates and seawater contains sulfates. Sulphate salt can also result from carbonated materials exposed to air pollution, repairs or the type of binder. Sulphate salt; Substances with chemical and abrasive properties, which are carried to the surface of the building elements by the effect of humidity, wind and temperature, can cause deterioration and serious destruction on the facades of the building. In addition, these salts can be mixed into structures by capillary methods close to agricultural lands. Chlorine salts are found in sea water and building materials used for repair purposes such as cement. The chlorine (Cl) salts detected in the samples are thought to originate from the Portland cement used for repair purposes in almost all parts of the building. This is because the sodium and potassium carbonates produced by cement alone or by reacting with chemical salts in the soil form other water-soluble carbonates, primarily chlorine (Cl) and various other salts.

In the results of the study, carbonate (CO_3^{-2}), nitrate (NO_3^-) salt and protein and saponifiable oil were not detected in any of the samples (Table 4). The purpose of protein and oil tests is to determine whether protein and / or oil-based substances are used in the applications made to the material and to determine the quality of the binder, preservative and strengthener to be applied in the protection-repair study. The presence of the protein varies according to the type of sample. Presence of protein detected in mortar or plaster samples; It is usually caused by protein-based additives in the material such as eggs, blood, casein, tow, plant fibers, animal hair. No organic additives (vegetables, straw, tow, etc.) were detected in the aggregate structure of the mortar samples. No protein or fat content was found in the mortar samples. In addition, it shows that the reason why the CaCO3 ratio in the mortar taken from the building is almost non-existent, is that this mortar was a repair mortar made for this structure in the later period and that the composition of the mortar was a mortar consisting of soil additives.

Determining the causes of material problems with the analyzes used as a result of the study; supports the fact that the experimental characterization of materials detected in various studies in the literature is an important tool for examining the deterioration and deterioration effects on stone [29- 39].

6. Conclusion

Mardin TCDD Şenyurt Historical Station Building, which has been in existence in the region for more than a century, is a valuable structure in terms of keeping the intangible cultural values alive as well as the tangible values of the region. However, today, the building has been exposed to various material deterioration and is in danger of extinction. In this context, in order to provide resources for experts in future restoration interventions on the structure, experiments and analysis studies were carried out to determine the material characterization and problems of the structure. Chemicals (loss of glow, acid treatment, spot tests) were carried out on natural stone, mortar and plaster samples taken from the building. Physical (size distribution analysis of aggregates by sieve, types and approximate ratios) analyzes were made. With petrography analysis, mineral contents of thin sections were examined with polarizing microscope, and general tissue properties were examined from bright thick sections under stereo microscope. As a result of the study, the content of the production material of the building, the quality and proportions of binders, aggregates and additives, the state of protection and the sources of problems were determined. In this context, recommendations for repair and conservation are explained below.

According to the results obtained from petrographic analysis; Example 1 examined under a stereo microscope; The aggregates of the sample, whose binder is 150-200 doses of Portland cement with approximately 10% lime added, were determined as quartz sea sand with 2 mm sieve size. Example 2 examined under a stereo microscope; It has been determined that the aggregates of the sample, whose binder is approximately 50 doses of Portland added lime, are sand in 1 mm sieve size. Sample 3 examined under a stereo microscope and polarizing microscope; It has been identified as cream-beige colored spiri-micritic limestone with abundant voids and organic impurities, which is thought to belong to the quarries in the region. In this context, it is necessary to use mortar, plaster and stones, which have properties similar to the original material specified in the building, during the restoration phase.

The most important problem identified in the results of the study; Chloride (Cl^-) and Sulphate (SO_4^{-2}) salts were detected in various amounts in the samples. The sulfate salt and the chlorine (Cl) salts detected in the samples are thought to originate from the Portland cement used for repair purposes in almost all parts of the building. It has been determined in our analyzes that the architectural texture of the building has been largely destroyed by the use of cement instead of hydraulic lime in the restoration works. The use of cement mortar is irreversible. When cement mortar is used, it leaves cracks where water can enter, and its resistance increases with humidity. Due to the water-soluble salts, it contains, cement mortar causes deterioration and blooms in all kinds of porous materials and especially in limestone-based stones. The sodium and potassium carbonate formed during the firing of the cement react on their own or with the chemical salts originating from the soil to form water-soluble carbonates and introduce extra salts into the wall structure. Also emerging are sodium potassium sulfate, chloride and nitrates etc. salts, together with the pre-existing ones, cause stone deterioration by flowering or scaling under suitable atmospheric conditions [41].

In this context, it is recommended to monitor the building by establishing a sustainable conservation program on a platform such as HBIM for future studies. Today, the detection of material deterioration can be detected with technological tools such as terrestrial laser scanning and UAV. It is recommended to create a data set by including the data obtained from these technological tools in the HBIM platform. Thus, it is hoped that faulty repairs and other human-induced material deterioration such as cement application can be prevented [42-48].

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Author contributions

Lale Karataş: Conceptualization, Methodology, Writing-Original draft preparation **Tahir Ateş:** Writing-Original draft preparation, Visualization **Aydın Alptekin:** Data curation, Writing-Original draft preparation, Validation. **Murat Yakar:** Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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