Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 6 Issue 11, November - 2019

Analysis Of Various Construction Materials Used In Turkey With Wavelength Dispersive X-Ray Fluorescence Spectrometer

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***Abstract*— In this study, the chemical content of 22 different building materials used in Turkey measured with Wavelength Dispersive X-Ray Fluorescence Spectrometry (WDXRFS). In the analysis of building materials, mainly C, N, O, Si and Ca elements were observed. Also, oxide compounds such as CO_2, Al_2O_3, SiO_2, and CaO were detected in abundance. The results obtained are evaluated both physically and in terms of construction and environmental engineering and aimed to increase the quality of life autso, experimental setup and sample preparation method used in the study are presented.**

Keywords—Construction material analysis; Wavelength Dispersıve X-Ray Fluorescence Spectrometer; Building material

I. INTRODUCTION

The building is an artificial environment created to meet the needs of living things. The material choices in this building are very important. Because living things spend most of their time in these structures. The building materials wrong chosen for the design of work and living areas cause adverse effects on psychology and health. The psychological effect of building materials is usually related to the surface properties of the material (color, shape, gloss, surface contamination, hardness, softness, air-gas, etc.) permeability. These psychological effects emerge as laziness, pessimism, stress, irritability [1]. In parallel with the rapid increase in the population, housing demands are increasing day by day. It is not known exactly how to affect the health of the living of these products, which are shown to be glamorous, attractive and useful to the user. There are many different studies in the literature on building and building materials. The natural radioactivity has been measured using Natural Gamma-ray Spectroscopy (NGS), The Neutron Activation Analysis (NAA), and WDXRF, which were used for the analysis of Iraqi cement for its major, minor and trace elements [2]. The Ca, Fe, P, Ti, S, Si have determined in Iraqi cement by using WDXRF [3]. In their work has been investigated, the safety and environmental effect of decorative moldings made of expanded polystyrene (EPS) [4]. The chemical composition of construction materials (gas concrete, cement, sand, bricks, roofing tiles, marble, lime, and gypsum) has been determined using energy dispersive X-ray fluorescence (EDXRF) spectrometry [5]. The linear attenuation coefficients have been measured using EDXRF for various construction materials used in Turkey [6]. The elemental composition of three different Iranian cement has been determined by using WDXRF and INAA (Instrumental Neutron Activation Analysis) [7].

In this study, chemical content of construction materials (strength of 28 daily pressure: 32.5-42.5 and 52.5 MPa Cement, Adobe, Black Cement, Brick, Briquette, Clay, Exterior Paint, Joint Filler, Hardboard, Laminate Flooring, Lime, Marble, MDF (Medium Density Fiberboard), Oil Paint, Plaster Sand, PVC (Polyvinyl Chloride), Satin Plaster, Tile Adhesive, White Cement, Ytong) have been determined by using WDXRFS. According to the literature, the experimental data inadequate for chemical analysis of construction materials. The aim of this work is to complete this lack of literature and create a basis for other studies. However, it is aimed to consciously construct and use construction materials with the knowledge of the chemical content of building materials.

II. EXPERIMENTAL PROCEDURE

A. Preparation of Sample

In this study, different building materials are used. These materials are strength of 28 daily pressure: 32.5-42.5 and 52.5 MPa Cement, Adobe, Black Cement, Brick, Briquette, Clay, Exterior Paint, Joint Filler, Hardboard, Laminate Flooring, Lime, Marble, MDF (Medium Density Fiberboard), Oil Paint, Plaster Sand, PVC (Polyvinyl Chloride), Satin Plaster, Tile Adhesive, White Cement, Ytong. Since some of these materials are in the form of mass, they are milled by using a grinder. After grinding, the samples were pressed at 5-ton pressure. All the pressed samples were pelletized to a diameter of 1.3 cm. These materials are weighed with scales having a precision of 10^{-5} grams. The mass of all samples is 0.2 grams. Counting time is 3600 seconds.

B. Wavelength Dispersive X-Ray Fluorescence Spectrometer

The various construction materials used in Turkey were analyzed by using Wavelength Dispersive X-Ray Fluorescence Spectrometer of ZSX 1000 of Rigaku firm. This system has the ability to analyze the energy range of 0.1-5.9 keV. Additionally, it is the counting time 10-4000 s, counting rate $5x10^3$ s^{-1} and the detection limits in 1000 seconds around (ng, mg, g^{-1}). The schematically arrangement of the WDXRFS used

in the present work is shown in Fig. 1. Schematic design of the WDXRFS.

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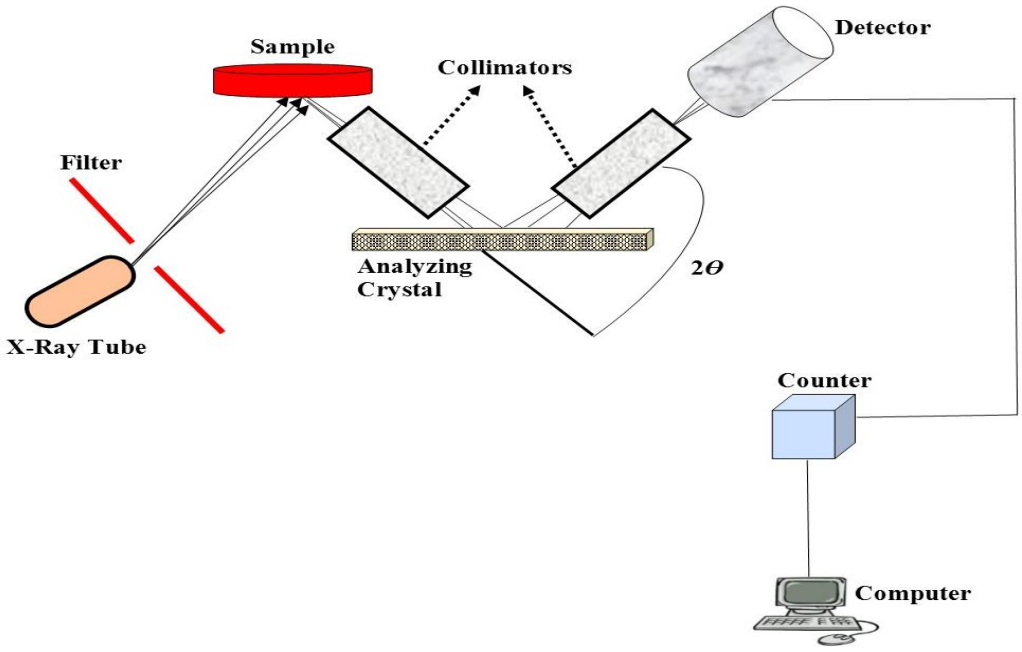

Fig. 1. Schematic design of the WDXRFS

III. RESULTS AND DISCUSSION

Construction is one of the main sectors in the world. Our country has a large and strong construction sector. Turkey is an important manufacturer of basic building materials such as cement, marble, pipe, timber, MDF, hardboard, brick, plastic and aluminum profiles, paint, ytong, ceramic tile [5]. Examination of elements concentrations of these materials will help to assess their suitability as building materials. Because the Turkish standards and regulations related to the detailed chemical composition of currently widely used building materials have not been established. Because of this, our study was performed chemical analyses of some building materials used in Turkey by using WDXRFS.

A representative WDXRF spectrum for Adobe and clay is shown in Figure 2-3. The elemental and compound content of 22 different building materials is shown in Table 1-2. It is observed from Tables 1-2 that heavy metals such as Cr, Mn, Fe, Zn, Ni, Pd, and Zr. The heavy metal term is used for metals with a density greater than 5 g / cm^3 in terms of physical properties. This group includes more than 60 metals including lead, cadmium, chromium, iron, cobalt, copper, nickel, mercury and zinc [8]. Heavy metals are taken to the organism by mouth, respiration, and skin, and they accumulate in the body and affect human health considerably. For example; according to National Committee for Clinical Laboratory Standards (NCCLS), zinc (Zn) element is one of the essential trace elements necessary for humans or animals [9]. In biological systems are found only as Zn^{+2}. It is an element found in air, soil, water, and food, which is abundant in minerals. It is used for coating iron and other metals, in alloy manufacturing, white paint production, ceramics, rubber industry, fertilizers, and healthcare. The general problems observed in excessive zinc intake in humans are; decreased appetite and immune system activity, late healing of wounds and excessive hypersensitivity, elevated cholesterol [10].

Also, It is observed from Tables 1-2 that the oxide compounds such as CO_2, Al_2O_3, SiO_2, and CaO. The main chemical components of cement, clay, duralite, grouting, briquette and marble are SiO_2 and CaO. The chemical constituents of the samples such as Adobe, sand, ytong, and brick were determined as SiO_2 and Al_2O_3. Since the raw materials of bricks and Adobe are similar, the chemical composition of these materials is almost similar.

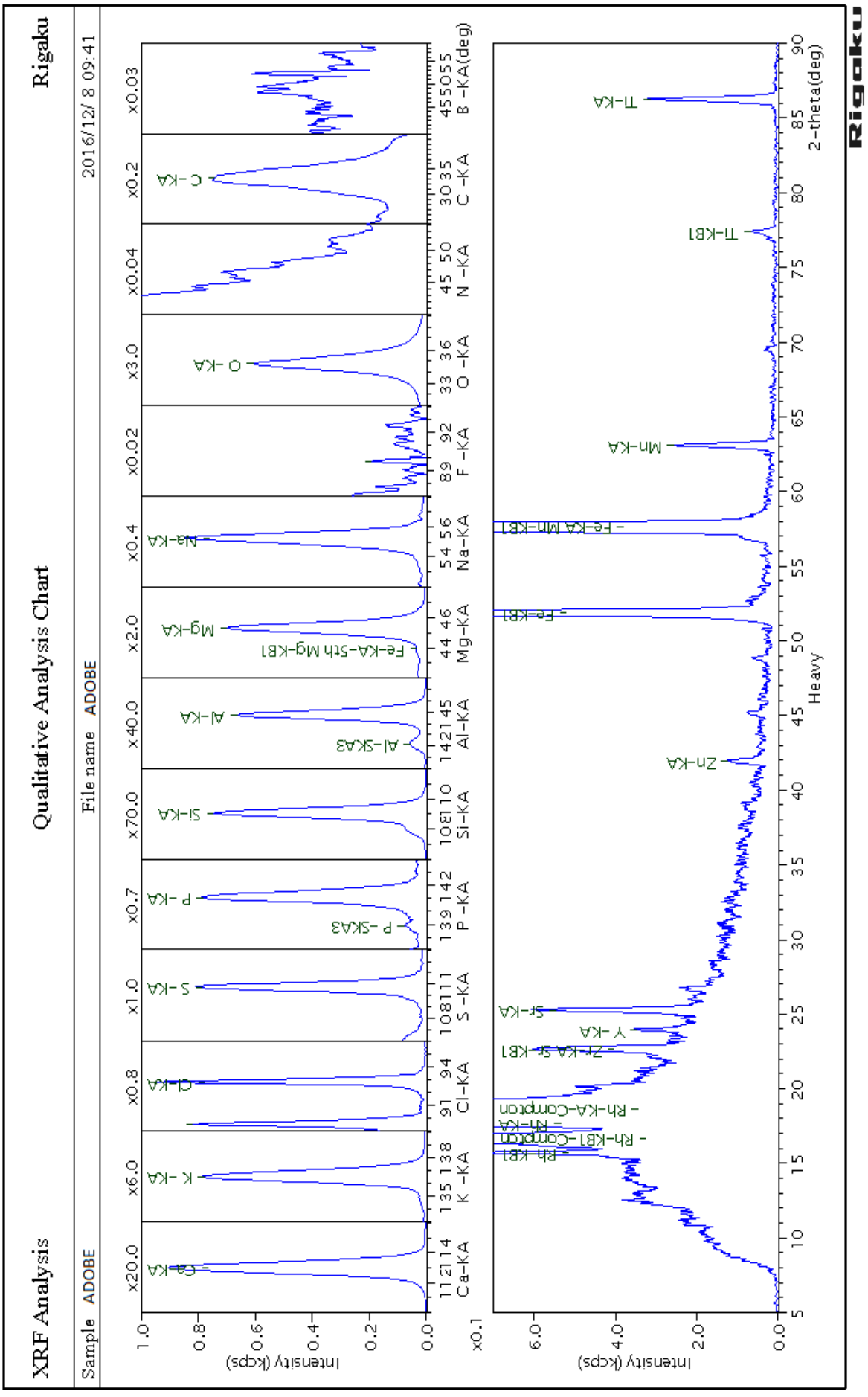

Fig. 2. Representative WDXRF Spectrum for Adobe

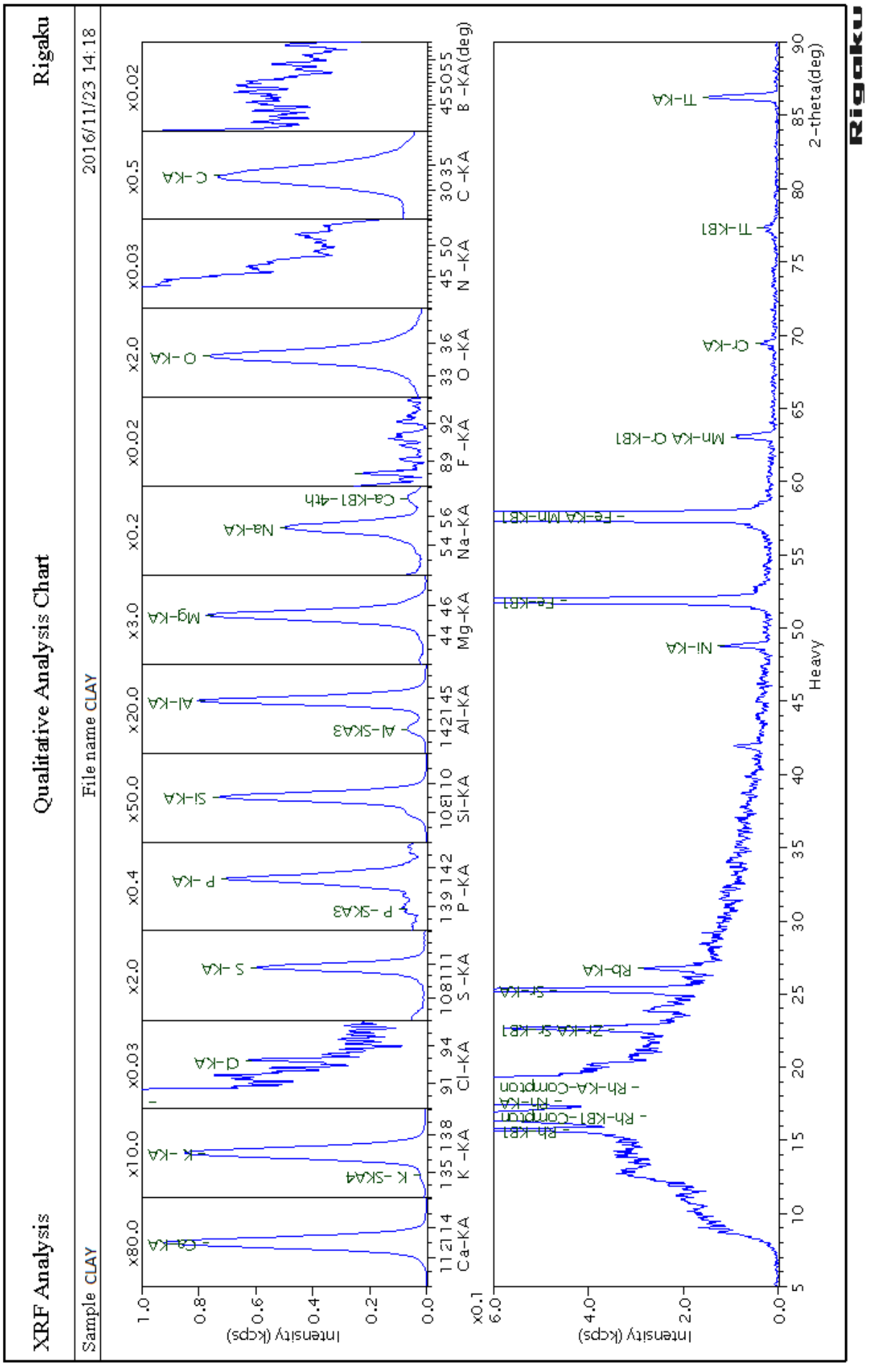

Fig. 3. Representative WDXRF Spectrum for Clay

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Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 6 Issue 11, November - 2019

TABLE 1. The elemental content of 22 different building materials

	32.5 MPa cement	42.5 MPa cement	52.5 MPa cement	Adobe	Black cement	Brick	Briquette	Clay	Exterior paint	Joint filler	Hardboard
Elements	**Percentage(%) value**										
B	1.5109	-	-	-	-	-	-	-	-	-	-
C	7.4586	5.4592	3.9530	3.0943	7.8193	3.4287	7.7439	6.7743	7.4692	10.8732	57.7816
N	-	-	-	-	-	-	-	-	-	-	-
O	44.3181	44.0904	41.2830	50.4789	43.4020	45.6712	50.9633	51.8546	46.5655	44.1334	28.5039
F	-	-	-	-	-	-	-	-	-	0.7403	-
Na	0.1933	0.2251	0.2498	1.3171	0.1757	1.0846	0.6269	0.3684	0.3714	0.1170	0.0427
Mg	1.3225	1.4382	0.7971	2.1397	1.2979	5.1194	2.0292	3.3731	0.5427	0.4210	0.1858
Al	2.1599	2.1785	1.9538	9.5414	3.0255	10.2663	4.8033	5.4591	1.0707	0.6374	0.0161
Si	6.8929	7.1084	8.2056	23.6359	7.0440	25.3842	13.8824	13.8235	3.9171	2.5564	0.2595
P	0.0327	0.0338	0.0351	0.1244	0.0317	0.0677	0.0748	0.0456	0.0121	0.0139	0.0135
S	1.2087	1.4630	1.6060	0.2199	1.2997	0.2586	0.4769	0.2347	0.5179	0.5039	0.0493
Cl	-	-	-	1.0385	0.0141	-	-	0.0108	0.0219	-	0.0433
K	0.6001	0.6021	0.2768	1.1297	0.6187	1.4332	0.3418	1.4803	0.3230	0.1059	0.0135
Ca	33.4081	36.4248	41.5354	4.5677	34.3049	3.6458	16.6191	14.8296	39.0963	39.8423	11.9240
Ti	0.0899	0.0605	-	0.3227	0.0796	0.3273	0.2333	0.1652	-	-	0.7689
Cr	-	0.0138	-	-	0.0174	0.0225	-	0.0123	-	-	-
Mn	0.0230	0.0144	-	0.0673	0.0124	0.1311	0.0557	0.0235	-	-	-
Fe	0.7356	0.8512	0.0786	2.3063	0.8039	3.1101	2.1376	1.5201	0.0766	0.0328	0.3958
Ni	0.0075	0.0079	-	-	0.0106	0.0294	-	0.0107	0.0059	0.0133	-
Cu	-	-	-	-	-	0.0057	-	-	-	-	-
Zn	-	-	-	0.0054	-	0.0059	0.0040	-	-	-	-
As	-	-	-	-	-	-	-	-	-	-	-
Rb	-	-	-	-	-	-	-	0.0027	-	-	-
Sr	0.0259	0.0286	0.0257	0.0067	0.0266	0.0067	0.0066	0.0089	0.0097	0.0093	0.0019
Y	-	-	-	0.0017	-	-	-	-	-	-	-
Zr	-	-	-	0.0025	-	0.0018	0.0013	0.0024	-	-	-
Pd	0.0129	-	-	-	0.0162	-	-	-	-	-	-

TABLE 1.-Continued

	Laminate flooring	Lime	Marble	MDF	Oil paint	Plaster sand	PVC	Satin plaster	Tile adhesive	White cement	Ytong
Elements	**Percentage(%) value**										
B	-	-	-	1.2077	-	-	-	3.6258	-	-	-
C	38.1284	5.1166	14.4394	35.7832	15.0453	4.3236	97.6292	3.5213	8.0551	7.9402	5.5386
N	47.9861	-	-	45.8779	-	-	-	-	-	-	-
O	12.7327	43.9950	45.7182	13.3530	46.5116	48.1601	2.1628	44.8974	44.7296	42.3127	50.1458
F	-	-	-	-	-	-	-	-	-	1.5991	-
Na	0.0583	0.0339	0.0653	0.1504	0.0946	1.1676	-	-	0.1819	0.3266	1.2145
Mg	0.0089	0.3418	0.7118	0.0925	0.7248	2.7510	0.0246	0.5342	1.0520	0.5722	0.5191
Al	0.0302	0.1723	-	0.4276	0.1636	8.9470	-	-	1.5679	1.3774	6.1883
Si	0.0125	0.1970	0.5164	0.5763	0.1068	23.3830	0.0400	0.0885	5.5162	5.7058	23.3355
P	0.0066	0.0102	0.0098	0.0757	0.0376	0.0972	0.0061	0.0036	0.0284	0.0167	0.0195
S	0.0744	0.5881	0.0280	0.1587	0.0256	0.1149	0.0036	18.9142	1.1220	1.2106	0.3605
Cl	0.0330	-	0.0154	0.1917	0.0165	0.0936	0.0035	0.0134	0.0211	-	0.0415
K	0.0054	0.0334	0.0453	0.0426	0.0074	1.3690	-	0.0082	0.4793	0.4600	3.5959
Ca	0.0184	49.4442	38.3294	0.0456	35.7873	6.4485	0.0069	28.3481	36.4661	38.3786	8.2597
Ti	0.9018	-	-	1.9955	1.4583	0.3591	0.1195	-	0.0741	-	0.0766
Cr	-	-	-	-	-	0.0310	-	-	-	-	0.0109
Mn	-	0.0185	0.0251	-	-	0.0710	-	-	0.0202	-	0.0173
Fe	0.0021	0.0358	0.0874	0.0165	0.0110	2.6517	0.0016	0.0133	0.6430	0.0627	0.6434
Ni	-	-	-	-	-	0.0064	-	-	0.0082	0.0297	-
Cu	-	-	-	-	-	0.0044	-	-	-	-	-
Zn	0.0012	-	-	-	-	0.0071	-	-	0.0040	-	-
As	-	-	-	-	-	0.0033	-	-	-	-	-
Rb	-	-	-	-	-	-	-	-	-	-	0.0057
Sr	-	0.0132	0.0082	-	0.0062	0.0062	-	0.0320	0.0253	0.0064	0.0061
Y	-	-	-	-	-	0.0019	-	-	0.0055	-	-
Zr	-	-	-	-	0.0033	0.0024	-	-	-	0.0012	0.0072
Pd	-	-	-	0.0049	-	-	0.0022	-	-	-	0.0140

TABLE 2. The compound content of 22 different building materials

	32.5 MPa cement	42.5 MPa cement	52.5 MPa cement	Adobe	Black cement	Brick	Briquette	Clay	Exterior paint	Joint filler	Hardboard
Compounds	Percentage(%) value										
B_2O_3	4.8446	-	-	-	-	-	-	-	-	-	-
CO_2	26.6181	20.0910	14.4816	11.4561	28.0147	11.6242	28.3878	25.4561	27.7557	39.1142	93.8045
Na_2O	0.2508	0.3059	0.3367	1.7885	0.2283	1.3894	0.8452	0.5084	0.5170	0.1511	0.0229
MgO	2.1079	2.4043	1.3212	3.5771	2.0719	8.0109	3.3657	5.7344	0.9301	0.6681	0.1230
Al_2O_3	3.9118	4.1522	3.6900	18.1987	5.4898	18.0590	9.0799	10.6140	2.0936	1.1513	0.0122
SiO_2	14.0884	15.3516	17.5450	51.1698	14.4108	49.6127	29.7204	30.5827	8.6877	5.2186	0.2216
P_2O_5	0.0712	0.0783	0.0805	0.2896	0.0690	0.1381	0.1715	0.1089	0.0289	0.0302	0.0122
SO_3	2.8598	3.6940	4.0073	0.5577	3.0789	0.5745	1.1922	0.6112	1.3469	1.1950	0.0487
K_2O	0.6805	0.7345	0.3331	1.3834	0.7024	1.5300	0.4123	1.8648	0.4075	0.1203	0.0062
CaO	43.4040	51.7582	58.0621	6.5021	44.6626	4.4977	23.2870	21.8150	58.0703	51.5734	5.3687
TiO_2	0.1359	0.1031	-	0.5485	0.1206	0.4769	0.3898	0.2930	-	-	0.2578
Cr_2O_3	-	0.0207	-	-	0.0231	0.0287	-	0.0192	-	-	-
MnO	0.0268	0.0190	-	0.0886	0.0145	0.1469	0.0720	0.0323	-	-	-
Fe_2O_3	0.9505	1.2427	0.1122	3.3641	1.0423	3.8576	3.0615	2.3162	0.1189	0.0421	0.1048
NiO	0.0086	0.0102	-	-	0.0122	0.0321	-	0.0146	0.0082	0.0151	-
CuO	-	-	-	-	-	0.0061	-	-	-	-	-
ZnO	-	-	-	0.0069	-	0.0063	0.0049	-	-	-	-
As_2O_3	-	-	-	-	-	-	-	-	-	-	-
Rb_2O	-	-	-	-	-	-	-	0.0031	-	-	-
SrO	0.0276	0.0345	0.0303	0.0081	0.0285	0.0068	0.0079	0.0112	0.0125	0.0098	0.0004
Y_2O_3	-	-	-	0.0022	-	-	-	-	-	-	-
ZrO_2	-	-	-	0.0035	-	0.0022	0.0018	0.0034	-	-	-
PdO	0.0135	-	-	-	0.0169	-	-	-	-	-	-

Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 6 Issue 11, November - 2019

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TABLE 2.-Continued

Compounds	Laminate flooring	Lime	Marble	MDF	Oil paint	Plaster sand	PVC	Satin plaster	Tile adhesive	White cement	Ytong
	Percentage(%) value										
B_2O_3	-	-	-	2.3598	-	-	-	11.5177	-	-	-
CO_2	82.9890	18.8541	50.9044	77.2680	52.8251	15.2362	99.8921	11.9219	29.3107	28.6391	19.9049
Na_2O	0.0464	0.0487	0.0811	0.1281	0.1170	1.5296	-	-	0.2419	0.4268	1.6125
MgO	0.0088	0.6051	1.0859	0.0976	1.1005	4.4185	0.0112	0.8138	1.7201	0.9188	0.8465
Al_2O_3	0.0345	0.3482	-	0.5175	0.2824	16.2890	-	-	2.9193	2.5166	11.4793
SiO_2	0.0163	0.4514	1.0129	0.7878	0.2084	47.7422	0.0243	0.1722	11.6164	11.7776	48.7875
P_2O_5	0.0092	0.0251	0.0206	0.1100	0.0784	0.2098	0.0040	0.0074	0.0640	0.0367	0.0433
SO_3	0.1143	1.5786	0.0639	0.2513	0.0581	0.2700	0.0026	42.1338	2.7508	2.8993	0.8724
K_2O	0.0040	0.0437	0.0493	0.0323	0.0080	1.5482	-	0.0084	0.5655	0.5285	4.1904
CaO	0.0159	77.9380	46.6311	0.0399	43.3033	8.4412	0.0029	33.3677	49.7087	50.5771	11.1442
TiO_2	0.9070	-	-	1.9872	1.9815	0.5561	0.0606	-	0.1193	-	0.1227
Cr_2O_3	-	-	-	-	-	0.0420	-	-	-	-	0.0153
MnO	-	0.0282	0.0266	-	-	0.0848	-	-	0.0251	-	0.0215
Fe_2O_3	0.0016	0.0605	0.1021	0.0123	0.0127	3.5076	0.0007	0.0152	0.8869	0.0826	0.8817
NiO	-	-	-	-	-	0.0075	-	-	0.0100	0.0348	-
CuO	-	-	-	-	-	0.0051	-	-	-	-	-
ZnO	0.0008	-	-	-	-	0.0081	-	-	0.0048	-	-
As_2O_3	-	-	-	-	-	0.0040	-	-	-	-	-
Rb_2O	-	-	-	-	-	-	-	-	-	-	0.0059
SrO	-	0.0185	0.0079	-	0.0059	0.0067	-	0.0302	0.0289	0.0070	0.0069
Y_2O_3	-	-	-	-	-	0.0022	-	-	0.0068	-	-
ZrO_2	-	-	-	-	0.0037	0.0030	-	-	-	0.0015	0.0093
PdO	-	-	-	0.0028	-	-	0.0006	-	-	-	0.0155

IV. CONCLUSIONS

In this work, chemical content of 22 different building materials (strength of 28 daily pressure: 32.5-42.5 and 52.5 MPa Cement, Adobe, Black Cement, Brick, Briquette, Clay, Exterior Paint, Joint Filler, Hardboard, Laminate Flooring, Lime, Marble, MDF (Medium Density Fiberboard), Oil Paint, Plaster Sand, PVC (Polyvinyl Chloride), Satin Plaster, Tile Adhesive, White Cement, Ytong) have been determined by using WDXRFS. In the analysis of building materials, mainly C, N, O, Si and Ca elements were observed. Also, oxide compounds such as CO_2, Al_2O_3, SiO_2, and CaO were detected in abundance. Knowing the positive or negative effects of building materials and avoiding their negative effects is very important in terms of living healthy. Thanks to this work, people will be aware of the materials that harm them and will be conscious of using the building materials. It will also have an important effect on the creation of the database for the building materials that are planned to be used.

ACKNOWLEDGMENTS

This work was supported by the Atatürk University Scientific Research Projects Fund, Project No: 2016/168.

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