Energy Education Science and Technology Part A: Energy Science and Research
2012 Volume (issues) **28(2):** 1151-1158

Statistical analysis of soil heavy metals of Istanbul children playgrounds

Namik Ak[1,*], Emre Eroglu[2], Ibrahim Guney[3]

[1]*Sirnak University, Energy Systems Engineering, Sirnak, Turkey*
[2]*Mathematics Department, Gebze Institute of Technology, Kocaeli, Turkey*
[3]*Istanbul Sabahattin Zaim University, Istanbul, Turkey*

Received: 23 February 2011; accepted: 29 July 2011

Abstract

In this study, collected urban soil samples have been collected in different sites of Istanbul. The soil samples have been analyzed and Al, Ca, Mg, K, Zn, Pb, Cu, Ni, Co, Cr, V, Cd, Na levels have been measured. Following the analysis, mathematical approach and statistical modeling have been used in order to assess the levels of heavy metals. Furthermore, new original data concerning the levels of heavy metals have been utilized as well. The collected data have been analyzed by means of correlation-regression, general linear model.

Keywords: Heavy metals; Children playgrounds; Factor analysis; Statistical model

1. Introduction

Accumulated heavy metals in soil and effect of human healthy were studied in the last decades. We were extracted substantial results in these studies. Lead accumulated particularly have motivated studying researchers in this area. Analysis of soils from 61 urban sites in Shenyang have indicated accumulation of lead in soil and necessity of reduction of soil lead metal concentration in industrial area, public parks, kindergarten playground, and commercial area [1]. Lead contaminated house dust is a main source of lead exposure for urban children [2-5]. Especially for children, a lead remains is a serious health problem [6, 7]. In contemporary studies about street dust have focused on elemental concentrations and source identification [8-11]. Heavy metals could contaminate to soil different instruments. One of the major instruments is vehicle emission [12-14]. According to Wang, the lead accumulated in soil mainly comes from industry point source and automobile exhaust [1].

Lead accumulated is not the one hazard for human healthy. Some results have distinguished about heavy metals in soil of Istanbul. According to the results of the concentration at 14 main areas and 22 different sample points within this area, the average concentration of heavy metals was determined to be 211.88 mg/kg for lead, 208.49 mg/kg for

*Corresponding author. Tel.: +90-486-216-8245; fax: +90-486-216-3285.
E-mail address: dr.akhoca@gmail.com (N. Ak).

copper, 397.90 mg/kg for manganese, 520.81 mg/kg for zinc, 1.91 mg/kg for cadmium and 31.52 mg/kg for nickel. According to the heavy metals concentration in the E-5 street dust sample, concentrations of Pb, Cu, Zn and Cd were higher than the maximum concentration of corresponding elements in soil except for nickel and manganese concentration. The high Pb, Cu and Zn concentrations show that there is heavy metal pollution at the sampling points [15]. Collected road dust samples from urban areas of Shanghai are high proportion of inhalable, thoracic and respirable particles, generally [16]. Based on the metal concentrations, nearly all the concentrations of the determined metals in urban soils, urban road dusts and agricultural soils in the cities of China are higher than their background values [17]. In research, the soil samples were collected and analyzing these samples were gained original results. On the other hand differ from, heavy metals in the soil were investigated and statistical analysis were performed for assessing results [18-20].

Solid waste incineration generates solid residues, such as bottom ash and air pollution control residues. Besides a high content of inorganic metal compounds, incineration residues also contain abundant carbon compounds deriving from incomplete combustion, unburned organic matter and carbon compounds formed during the incineration process [21-28].

In this study, were collected urban soil samples in different sites of Istanbul. The soil samples were analyzed that measured Al, Ca, Mg, K, Zn, Pb, Cu, Ni, Co, Cr, V, Cd, Na levels. After the analysis the levels of heavy metals, were introduced mathematical approach and statistical modeling. It was utilized that *original* and *new* data about levels of heavy metals. Data have been analyzed by means of correlation-regression, general linear model and cluster analysis methods. We obtained regression equations and cluster dendograms.

2. Method and materials

2. 1. Study area and measurement periods

With a population around 12,6 million, Istanbul is the most populous and the biggest area having urban properties. Being a metropolitan city, Istanbul is Turkey's cultural and fiscal center as well. The city in the north-western part (41°N and 29°E) of Turkey, is located on the Bosphorus Strait. Having some traffic problems, Istanbul hosts considerable industrial activities. However, unplanned urbanization, gradual decline in the number of green areas and construction of the high buildings have negative impact on air circulation. As a result of this, some parts of Istanbul are exposed to higher air pollution during the cold months of March and October [19].

In this study, 5 playgrounds located in various areas with respect to traffic flow in Besiktaş, Beyoglu, Sisli districts have been chosen. 1. playground is located on the main street (Yildiz, Barbaros Avenue and IETT office) having dense traffic; 2. on the coastal area where effects of the sea and strait could be detected beside traffic density (Courtyard of Molla Celebi Mosque, Kabatas and Beyoglu); 3. on the both sides of the main street having traffic density (Abide-i Hurriyet, Okmeydani-E5, Caglayan-Sisli); 4. in a resort area covered with woods and far from traffic (Yildiz Korusu, Besiktas); 5. an area among crowded settlements far from traffic (Abbasaga, Besiktas).

Playgrounds, secure and well-protected spots whis are not exposed to cases of theft, sabotage, arson and etc. have been chosen and 'air quality measuring cabins' were settled there. The map on table 1 shows the locations of these playgrounds (their cabins/stations). Stations are seen to be close to each other, which provides a proper measuring and not cause any meteorological and climatological problems. 18 day-measurement periods have been carried out in each station successively. Therefore, the measurement in 5 playgrounds have been completed in 3 months (1 period), or in a season. This work covers the measurement results in a time of 3 periods (3 seasons) between March 1 and December 1 [20].

2. 2. Element analysis

0.2-0.5 gram of homogenously mixed samples were put into the teflon containers in their dry forms. 9ml pure HNO_3. 3 ml HCl. and 2 ml HF were added for soil while this was 8 ml pure HNO_3 for plants (and diluted HNO_3 for tissues). Then teflon containers were capped and placed in a microwave owen. The heat was gradually increased to 185 °C. The container was kept at this heat for 20 minutes. after which Teflon containers were taken out and contents were decanted to 50 ml HDPE volumetric flasks. where they were complemented to 50 ml volume by addition of ultra pure water. Now it was ready for heavy metal analysis at ICP-OES. The elemental heavy metal analysis of the collected soil samples have been carried out by Perkinelmer brand model (Optima 7000 DV) ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometer).

At ICP. sample collected through autosampler is transferred to nebulizer and there it was mixed with argon gas to become aerosol. After that it comes to be plasm state at about 600-700°K. The 'Torch' where the plasm is constituted is composed of 2 nested quartz canals. Aragon is injected via two outside canals while sample and aragon are injected together through small inside canals. The sample sprayed along with aragon through the injector is brought into a form of a plasm after being induced with a RF (Radio Frequency) signal applied to metal coil on the side of the area. Emissions from the hot spot in the mid of the plasm are used for the analysis.

5 standarts and 1 blank are prepared in order to constitute the calibration curve. Consentration of the standards are as follows:

STD 1	10 ppb
STD 2	25 ppb
STD 3	50 ppb
STD 4	100 ppb
STD 5	250 ppb

In order to operate the device its software program is turned on. Ensuing values are entered via a special method. Recommended reading (plasma view) for low concentrations (ppb levels) is axial. This option is also entered into the method. A sample info is created to state the locations of the samples in Autosampler. Before the calibration process. the standard of highest concentration is viewed as a sample and peak correction is made accordingly. After that blank and standards are viewed and the calibration curve is drawn. Correlation coefficient is expected to have three or four 9's for the sensitivity of the calibration. Samples are placed in the autosampler. Sample flow is 1.5 ml/dk. The device begins to read the sample 45 seconds after the sample flow. It makes 3 readings for each sample and gives the result as the average of the three in terms of µg/L. Plasm speed is 17L/m. Nebulizer speed is 0.55 L/m. Washing is carried out and washing period is 45 seconds.

3. Statistical approach

The collected urban soil samples affected by several anthropogenic sources (mining, metal factory, traffic emissions) were collected in Istanbul, Turkey. The Al, Ca, Mg, K, Zn, Pb, Cu, Ni, Co, Cr, V, Cd, Na levels have been measured. Factor analysis was used to check the associations between the total metal contents in soil and grass, as well as between the levels of the different sequential fractions and the total content in grass.

Solids were sampled by a probe (10mm ID) that was bent at the end in the vertical direction, which allowed sampling of either the down-flowing or up-flowing suspension. During measurements, solids were spurted out at different locations of the riser cross-section.

It consists of two main cluster. The first cluster is formed variables Cr, V, Cu, Ni, Co, Pb, Cd, Zn, Mg. The second cluster consists of two main clusters. The first of these Al and Ca the other sub cluster is K and Na variables.

Table 1. Descriptive analysis

	Minimum	Maximum	Mean	Standard Deviation	Skewness	Kurtosis
Al	3707.00	33770.00	11473.3143	6289.21199	1.595	3.292
Ca	1314.00	39090.00	15483.6857	7426.88796	565	1.589
Mg	315.30	3045.00	1014.7200	558.39067	1.537	3.803
K	8318.00	25360.00	14665.2286	5108.22648	697	-949
Zn	81.57	242.40	154.2546	44.26941	78	-699
Pb	18.26	73.20	33.9909	14.92336	985	-5
Cu	3.18	57.68	25.7971	14.90887	104	-725
Ni	1.12	59.51	31.4787	15.08591	-218	-873
Co	0.18	36.87	16.9482	9.21040	46	-887
Cr	1.10	102.00	61.6849	26.90605	-471	-714
V	3.40	115.00	60.9646	32.17604	-181	-1.236
Cd	1.21	2.07	1.5090	0.17609	1.072	2.260
Na	3905.00	19020.00	10312.0286	4422.77641	174	-1.120

Table 2. Pearson's correlation matrix for the metal concentrations

Correlations

		Al	Ca	Mg	K	Zn	Pb	Cu	Ni	Co	Cr	V	Cd	Na
Al	Pearson Correlation	1	0.804**	0.575**	-0.211	0.246	0.319	0.195	0.216	0.276	0.165	0.255	0.634**	-0.281
	Sig. (2-tailed)		0.000	0.000	0.225	0.154	0.062	0.260	0.214	0.109	0.345	0.140	0.000	0.102
Ca	Pearson Correlation	0.804**	1	0.706**	-0.318	0.181	0.152	0.154	0.267	0.235	0.158	0.181	0.462**	-0.358*
	Sig. (2-tailed)	0		0.000	0.063	0.297	0.383	0.377	0.121	0.174	0.364	0.297	0.005	0.035
Mg	Pearson Correlation	0.575**	0.706**	1	-0.381*	0.194	0.217	0.209	0.273	0.155	0.228	0.277	-0.042	0.121
	Sig. (2-tailed)	0	0.000		0.024	0.263	0.210	0.228	0.112	0.375	0.188	0.107	0.811	0.487
K	Pearson Correlation	-211	-0.318	-0.381*	1	-0.775**	-0.542**	-0.817**	-0.748**	-0.717**	-0.765**	-0.802**	-0.120	0.255
	Sig. (2-tailed)	225	0.063	0.024		0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.493	0.139
Zn	Pearson Correlation	246	0.181	0.194	-0.775**	1	0.574**	0.889**	0.797**	0.793**	0.791**	0.823**	0.270	-0.180
	Sig. (2-tailed)	154	0.297	0.263	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.117	0.301
Pb	Pearson Correlation	319	0.152	0.217	-0.542**	0.574**	1	0.535**	0.515**	0.636**	0.583**	0.706**	0.161	-0.142
	Sig. (2-tailed)	62	0.383	0.210	0.001	0.000		0.001	0.002	0.000	0.000	0.000	0.354	0.415
Cu	Pearson Correlation	195	0.154	0.209	-0.817**	0.889**	0.535**	1	0.848**	0.721**	0.829**	0.815**	0.191	-0.081
	Sig. (2-tailed)	0.260	0.377	0.228	0.000	0.000	0.001		0.000	0.000	0.000	0.000	0.271	0.644
Ni	Pearson Correlation	0.216	0.267	0.273	-0.748**	0.797**	0.515**	0.848**	1	0.874**	0.961**	0.913**	0.081	-0.022
	Sig. (2-tailed)	0.214	0.121	0.112	0.000	0.000	0.002	0.000		0.000	0.000	0.000	0.645	0.902
Co	Pearson Correlation	0.276	0.235	0.155	-0.717**	0.793**	0.636**	0.721**	0.874**	1	0.882**	0.922**	0.196	-0.253
	Sig. (2-tailed)	0.109	0.174	0.375	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.260	0.143
Cr	Pearson Correlation	0.165	0.158	0.228	-0.765**	0.791**	0.583**	0.829**	0.961**	0.882**	1	0.965**	0.003	-0.008
	Sig. (2-tailed)	0.345	0.364	0.188	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.987	0.965
V	Pearson Correlation	0.255	0.181	0.277	-0.802**	0.823**	0.706**	0.815**	0.913**	0.922**	0.965**	1	0.044	-0.064
	Sig. (2-tailed)	0.140	0.297	0.107	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.801	0.713
Cd	Pearson Correlation	0.634**	0.462**	-0.042	-0.120	0.270	0.161	0.191	0.081	0.196	0.003	0.044	1	-0.584**
	Sig. (2-tailed)	0.000	0.005	0.811	0.493	0.117	0.354	0.271	0.645	0.260	0.987	0.801		0.000
Na	Pearson Correlation	-0.281	-0.358*	0.121	0.255	-0.180	-0.142	-0.081	-0.022	-0.253	-0.008	-0.064	-0.584**	1
	Sig. (2-tailed)	0.102	0.035	0.487	0.139	0.301	0.415	0.644	0.902	0.143	0.965	0.713	0.000	

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

The first 4-axis describes %88.062 change. The first one describes %52.309. the second one describes %19.302. the third one describes %11.478 and the fourth one describes %4.972.

When the factor analysis method implement, the first two-main axis describes % 71.611. %49.167 from the first one and %22.444 from the second one along total change.

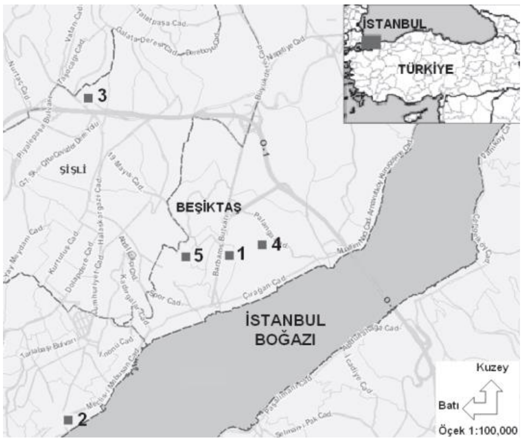

Fig. 1. Locations of the playgrounds and particular substance in Istanbul playgrounds

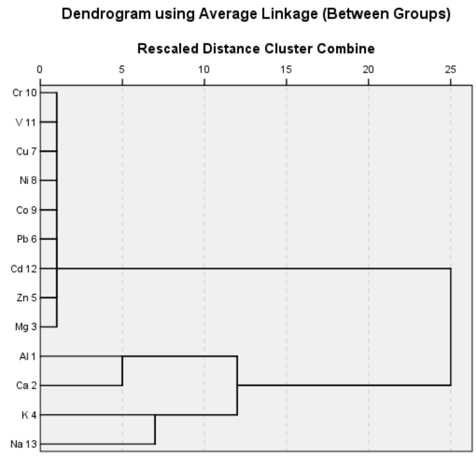

Fig. 2. Dendogram of hierarchical cluster analysis of heavy metal concentrations in soils of İstanbul.

Table 3. Principal component analysis

Communalities													
	Al	Ca	Mg	K	Zn	Pb	Cu	Ni	Co	Cr	V	Cd	Na
Initial	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Extraction	0.833	0.817	0.336	0.755	0.808	0.489	0.817	0.886	0.837	0.929	0.952	0.546	0.305

Extraction Method: Principal Component Analysis.

Table 4. Total variance

Total Variance Explained

Component		Initial Eigenvalues			Extraction Sums of Squared Loadings	
		Total	% of Variance	Cumulative (%)	Total	% of Variance
Dimension	1	6.800	52.309	52.309	6.800	52.309
	2	2.509	19.302	71.611	2.509	19.302
	3	1.492	11.478	83.090		
	4	0.646	4.972	88.062		
	5	0.574	4.414	92.476		
	6	0.440	3.388	95.864		
	7	0.160	1.229	97.094		
	8	0.127	0.978	98.071		
	9	0.106	0.816	98.887		
	10	0.073	0.562	99.449		
	11	0.050	0.385	99.834		
	12	0.016	0.120	99.955		
	13	0.006	0.045	100.000		

Extraction Method: Principal Component Analysis.

Table 5. Total variance

Total Variance Explained

Component		Extraction Sums of Squared Loadings	Rotation Sums of Squared Loadings		
		Cumulative %	Total	% of Variance	Cumulative %
Dimension	1	52.309	6.392	49.167	49.167
	2	71.611	2.918	22.444	71.611

Extraction Method: Principal Component Analysis.

Table 6. Principal components analysis

		Al	Ca	Mg	K	Zn	Pb	Cu	Ni	Co	Cr	V	Cd	N
Component	1	0.140	0.116	0.221	-0.841	0.884	0.672	0.899	0.937	0.898	0.964	0.972	0.027	-0.044
	2	0.902	0.896	0.536	-0.218	0.165	0.193	0.094	0.091	0.172	0.005	0.081	0.738	-0.551

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

The first 2-main axis which explains %70 total variance is:

Y = 0.140*Al + 0.116*Ca + 0.221*Mg - 0.841*K + 0.884*Zn + 0.672*Pb + 0.899*Cu + 0.937*Ni + 0.898*Co + 0.964*Cr+0.972*V + 0.027*Cd-0.044*Na

Y_2= 0.902*Al+0.896*Ca+0.536*Mg-0.218*K +0.165*Zn +0.193*Pb + 0.094*Cu + 0.091*Ni +0.172*Co+ 0.005*Cr+0.081*V+0.738*Cd-551*Na

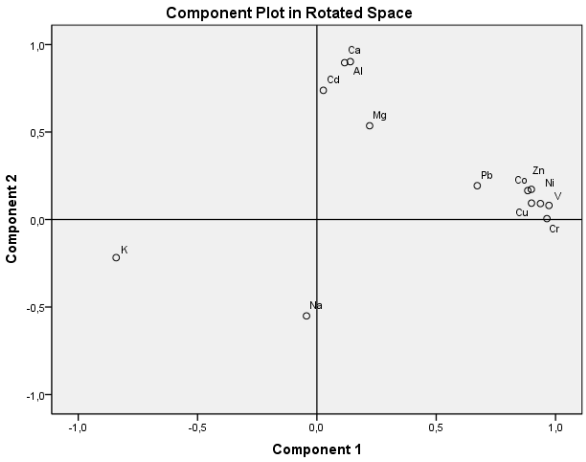

Fig. 3. Factor loadings for two factor solutions.

Variables distinguish two–main axis. The first one is Ca, Cd, Al, Mg, Na and the second one is Pb, Co, Zn, Cu, V, Cr, K, Na and K elements scatter the negative axis for stability.

4. Conclusion

In statistical analysis based on environmental pollution variables are obtained descriptive analysis of variables, correlation matrix and dendogram of hierarchical cluster. In result of multivariable statistics is observed interaction among variables. The variables are introduced two-main axis in R^2 space and they are observed to lie ±x and ±y axis. Pb, Co, Zn, Ni, Cu, V, Cr and K scatter in ±x axis. Mg, Cd, Al, Ca and Na scatter in±y.

Polluting heavy metals are sourced from automobiles. Automobiles spread heavy metals kindergarten playground soil via air and the soil absorbs them. This statistical analysis elaborates property of heavy metals. For example Na and K alkali metals have the same property with each other; Al, Mg, Cr, Ni and Cu soil alkali metals as well.

Acknowledgement

In this study, it was benefited from this project with number of 108Y173 that TUBITAK-CAYDAG supported.

References

[1] Ren HM, Wang JD, Zhang XL Assessment of soil lead exposure in children in Shenyang, China. Environ Pollut 2006;144:327–335.
[2] Duggan MJ, Inskip MJ. Childhood exposure to lead in surface dust and soil: a community health problem. Public Health Rev 1985;13:1–54.
[3] Lanphear BP, Weitzman M, Winter NL, Tanner M, Yakir B, Eberly S, Emond M, Matte TD. Lead contaminated house dust and urban children's blood lead levels. Am J Public Health 1996;86:1416–1421.
[4] Lanphear BP, Burgoon DA, Rust SW, Eberly S, Galke W. Environmental exposure to lead and urban children's blood lead levels. Environ Res Section A 1998;76:120–130.
[5] Lanphear BP, Matte TD, Rogers J, Clickner RP, Dietz B, Bornschein RL, Succop P, Mahaffey KR, Dixon S, Galke W, Rabinowitz M, Farfel M, Rohde C, Schwartz J, Ashley P, Jacobs DE. The contribution of lead-contaminated house dust and residential soil to children's blood lead levels. Environ Res Section A 1998;79:51–68.
[6] Melman ST, Nimeh JW, Anbar RD. Prevalence of elevated blood lead levels in an inner-city pediatric clinic population. Environ Health Perspec 1998;106:655–658.
[7] Pirkle JL, Kaufmann RB, Brody DJ, Hickman T, Gunter EW, Paschal DC. Exposure of the U.S. population to lead 1991-1994. Environ Health Perspec 1998;106:745–750.
[8] Ferguson JE, Kim N. Trace elements in street and house dusts source and speciation. Sci Total Environ 1991;100:125–50.
[9] De Miguel E, Llamas JF, Chacón E, Berg T, Larssen S, Royset O, Vadset M. Origin and patterns of distribution of trace elements in street dust: unleaded petrol and urban lead. Atmos Environ 1997;31:2733–2740.
[10] Naqerotte SM, Day JP. Lead concentrations and isotope ratios in street dust determined by electrothermal atomic absorption spectrometry and inductively coupled plasma mass spectrometry. Analyst 1998;123:59–62.
[11] De Miguel E, Iribarren I, Chacón E, Ordóñez A, Charlesworth S. Riskbased evaluation of the exposure of children to trace elements in playgrounds in Madrid (Spain). Chemosphere 2007;66:505–513.
[12] Harrison RM, Laxen DPH, Wilson SJ. Chemical association of lead, cadmium, copper and zinc in street dust and roadside soil. Environ Sci Technol 1981;15:1378–83.
[13] Gibson MG, Farmer JG. Multi-step chemical extraction of heavy metals from urban soils. Environ Pollut B 1986;11:117–135.
[14] Soyhan B, Demir G, Barlas H, Bayat C. Traffic originated heavy metal pollution in Istanbul E5 highway. Air Pollution Control National Symposium, Izmir, Turkey, 1999 [In Turkish].
[15] Sezgin N, Ozcan HK, Demir G, Nemlioglu S, Bayat C. Determination of heavy metal concentrations in street dusts in Istanbul E-5 highway. Environ Int 2003;29:979–985.
[16] Shi G, Chen Z, Bi C, Wang L, Teng J, Li Y, Xu S. A comparative study of health risk of potentially toxic metals in urban and suburban road dust in the most populated city of China. Atmos Environ 2011;45:764–771.
[17] Binggan W and Linsheng Y. A review of heavy metal contaminations in urban soils, urban road dusts and agricultural soils from China. Microchem J 2010;94:99–107.
[18] Chen TB, Zheng YM, Lei M, Huang ZC, Wu HT, Chen H, Fan KK, Yu K, Wu X, Tian QZ. Assessment of heavy metal pollution in surface soils of urban parks in Beijing, China. Chemosphere 2005;60:542–551.
[19] Karaca F, Alagha O, Erturk F. Statistical characterization of atmospheric PM10 and PM2.5 cocentrations at a non-impacted suburban site of Istanbul, Turkey. Chemosphere 2005;59:1183–1190.
[20] Ozdemir H, Borucu G, Demir G , Yigit S, Ak N. Istanbul'daki cocuk oyun parklarinda partikul madde (PM2,5 ve PM10) kirliliginin incelenmesi. Ekoloji 2010;77:72-79 [in Turkish].
[21] Demirbas B. Biomass business and operating. Energy Educ Sci Technol Part A 2010;26:37–47.
[22] Oztas F. The effects of educational gains of vocational school of health students on their environmental attitudes. Energy Educ Sci Technol Part B 2010;2:147–159.

[23] Dikmenli M, Cardak O, Oztas F, Yakisan M. High school students' images of an environmental scientist. Energy Educ Sci Technol Part B 2010;2:187–210.
[24] Balat H. Prospects of biofuels for a sustainable energy future: A critical assessment. Energy Educ Sci Technol Part A 2010;24:85–111.
[25] Sahin Y. Environmental impacts of biofuels. Energy Educ Sci Technol Part A 2011;26:129–142.
[26] Demirbas A. Energy issues in energy education. Energy Educ Sci Technol Part A 2011;27:209–220.
[27] Kilic FC. Recent renewable energy developments, studies, incentives in Turkey. Energy Educ Sci Technol Part A 2011;28:37–54.
[28] Cetin M. The emission of characteristics LPG-ethanol blend as a fuel in a SI Engine. Energy Educ Sci Technol Part A 2011;28:151–160.