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INVESTIGATION OF RADIOACTIVE CONTENT OF MANISA-SOMA AND ISTANBUL-AGACLI COALS (TURKEY)

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Abstract. Coal, the world's most abundant, most accessible and most versatile source of fossil energy was brought to the forefront of the global energy scene by the industrial revolution of the 19th century. Like any fossil fuel, coal is associated with naturally occurring radioactive materials. This is due to their U, Th, and K content. This certainly has radiological implications not only for the miners but also for the immediate environment of the mines and the users. In this study, the radioactive elements in Manisa-Soma and Istanbul-Agacli coals and their ashes were studied. In the experimental section, the coal and thermal power plant ashes which were taken from Manisa-Soma were used. Sieve, moisture, ash, calorific value, volatile amount, total carbon, total sulphur, major element and radioactive element analysis of the samples were carried out. The float and sink analyse and flotation tests were carried out on the samples which were taken from Manisa-Soma and Istanbul-Agacli. Thus, radioactive elements changes and moving mechanisms were investigated with coal preparation and burning methods. Furthermore, the pre-investigation of the assessment of the thermal power plant ashes was carried out with the experiments on the ash samples, which were taken from the Soma thermal power plant.

keywords: coal, radioactive elements, coal properies

1. General information

Social and technological development changes are in direct proportion to the amount of energy that is consumed. As a result of the fast growth of world population, the consumed energy naturally increases alongside. Especially, the fact that population growth of Turkey is higher than the worldwide average means that the requirement for energy will increase more every day. In 2008, petroleum has the highest share in energy consumption in Turkey with 32.8%, which is followed by natural gas with 30.4%, coal with 28% and the remaining 10% is occupied by renewable resources including hydraulic (Teias, 2008).

A clean environment is needed for a healthy life and energy is needed for a comfortable life, which requires utilisation of resources by minimising their impact.

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The fact that even ashes of burned coal is usable is an important point both for economic benefit and environmental impact, and this may only be possible due to proper features of coal. When coal is burnt in thermal power stations, toxic trace elements in the coal like As, Cd, Ga, Ge, Pb, Sb, Se, Sn, Mo, Ti and Zn, which have the potential of contaminating, are transferred to the waste products (cinder, ash and gas). Volatile ashes containing many poisonous elements may be collected in ash collection pools under furnaces or as piles. Because soluble metal ions and compounds may leak from the ash pools or piles, then have the potential to contaminate soil, surface and underground water. Then, severe environmental problems may occur (Karayiğit et al., 2000; Perçinel, 2000; Esenlik, 2005; Tuna et al., 2005).

When coal is combusted, toxic trace elements like arsenic (As), cadmium (Cd), lead (Pb), antimony (Sb), selenium (Se), stannum (Sn) and zinc (Zn) are transferred to waste products like cinder, ash and gases. When the waste products are disposed contained poisonous (toxic) trace elements may be conveyed to the atmosphere, earth surface and oceans. These elements may be seriously threatening for living organisms by creating environmental, and health problems when the waste products are washed with rain and these elements are carried away with underground water to the soil, and surface and underground waters (Baba, 2001; Ateşok, 2004; Demir, 2009).

Some of the human diseases occurring near thermal power plants, due to the toxic elements spread in the neighbourhood are given below (Perçinel, 2000):

As: Anaemia, nausea, renal symptoms, ulcer, skin and pulmonary cancer, defective births.

Be: Malfunction of respiration and lymph, lungs, spleen and kidneys, carcinogenic effects.

Cd: Lung emphysema and fibrosis, kidney diseases, cardiovascular effects, carcinogenic effects.

Hg: Nervous and kidney damages, cardiovascular effects, birth problems.

Mn: Respiratory problems.

Ni: Skin and intestinal diseases, carcinogenic effects.

Pb: Anaemia, nervous and cardiovascular problems, delayed growth, gastric and intestinal problems, carcinogenic effects, birth problems.

Se: Gastric and intestinal nausea, pulmonary and splenic damages, anaemia, cancer, teratogenic effects.

V: Acute and chronic respiratory malfunction (Perçinel, 2000).

Radon gas forms in the area in which ashes of the thermal power plant collect (ash chambers) reach the air. Even if these ashes are buried in soil, radon gas infiltrates through the pores of the soil and blends in the air. Radon gas may transform into polonium and active lead in 3.8 days. Therefore, piles of ash emit radioactivity. Perhaps the most critical material that is disposed through the chimneys is uranium, that is contained in lignite and released during combustion to spread around. Uranium is also a serious problem (Özyurt, 2006).

1.1. Major and trace elements contained in coal and coal ash

C, H, O, N and S contained in the structure of coal, contents of which are generally higher than 1000 ppm, form the organic matrix and they are called major elements. Al, Fe, Mg, As, Zn, Cu, F, Th, V etc. with a concentration that is generally less than 1000 ppm are called trace elements in coal (Ateşok, 2004; Özyurt, 2006). There are some elements in coal which are inorganic, which may form inorganic or organometalic compounds, and which may be recovered if they are at an economic level. In the sediments containing coal layers and in coal formations, Ge, Ga, U and Cu may be found at economic levels. Coal also contains toxic trace elements like Be, Mo, V, Zn, W, Co, Cd, As, Pb, Se, and Cr, which are contaminants (Kural, 1998; Özyurt, 2006; Demir, 2009; Demir and Kurşun, 2010).

During combustion of coal, trace elements such as Pb, Cu, Zn, V, As and Th become volatile and concentrate in the furnace ash (Özyurt, 2006; Riley, 2008; Demir, 2009; Demir and Kurşun, 2010). When coals are combusted at high temperatures, their molecular structure is demolished, and an important portion of Cl and F is disposed into air as gases together with smoke (Özyurt, 2006). When coal dust is combusted in thermal power plants, carbon, nitrogen and sulphur contained in the coal structure oxidise and transform into carbon oxide (CO_x), nitrogen oxide (NO_x) and sulphur oxide (SO_x). Some water vapour forms during this transformation, too. Whereas cinder is collected under combustion furnaces, volatile ashes are caught by electro-filters and some are transported with the chimney gas. Researches show that trace elements mostly collect on volatile ashes (Karayiğit et al., 2000; Özyurt, 2006).

In thermal power plants that use coal, combustion in the furnaces occurs at around 900-1400°C depending on the type of coal. Coal pieces heat up in the furnace, vaporizable materials convert into gases and combustion occurs. Minerals disintegrate and melt under heat, start decomposing and agglomerate (Kural, 1998; Özyurt, 2006).

Hg, As, Se, Ni, Pb, Ce are Zn mostly related to sulphide minerals and organic substances. Combination (formation) of coal minerals or organic substances with trace elements may seriously affect vaporisation limit and consequently its ratio in the chimney gas disposed by the plant. Trace elements detected in chimney gases are mostly associated to sulphide minerals (Riley, 2008; Shah et al., 2008).

During combustion of coal, some trace elements contained in coal like As, Cd, Ga, Ge, Pb, Sr, Mo, Zn, Ba transfer to the waste products (cinder, ash and gases). Especially fly ashes of such wastes produce very convenient media for adhesion of elements in liquids and gases because they have clayish structure, endure high temperatures and have large surface area (Özyurt, 2006; Demir, 2009; Demir and Kurşun, 2010).

2. Findings

2.1. Results of particle size analysis

Coal samples collected from the site for the research were crashed in the laboratory type jaw crusher and roll crusher in Istanbul University, Mining Engineering

Department, Mineral Processing Laboratory, and then applied dry particle size analysis to study particle size distribution.

Particle size curves were drawn according to the particle size analysis performed using 8 mm, 4 mm, 2 mm, 1 mm and 0.5 mm laboratory type Retsch brand stainless steel sieves of square section and d_{80} particle dimensions were calculated.

Figure 1 shows particle size curves drawn according to the results of particle size analysis made after crashing of coal samples collected from Manisa-Soma and İstanbul-Agacli region in roll crusher. As the curves show, d_{80} of roll crusher outputs of Manisa – Soma and Istanbul-Agacli coals are 5.4 mm and 5.9 mm, respectively.

Figure 2 shows particle size curve of the coal samples collected from Manisa-Soma and Istanbul-Agacli Region, which were used in float and sink experiments, according to the results of particle size analysis. The curves show that d_{80} of Manisa-Soma and Istanbul-Agacli coals are 1900 µm and 2100 µm, respectively.

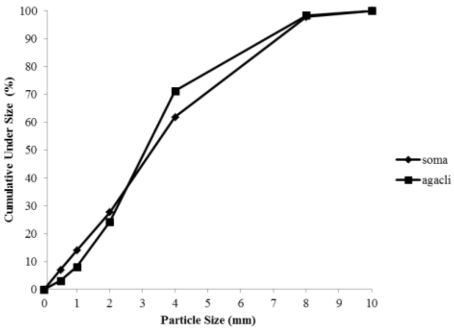

Fig. 1. Manisa-Soma and Istanbul-Agacli particle size distribution after roll crushing

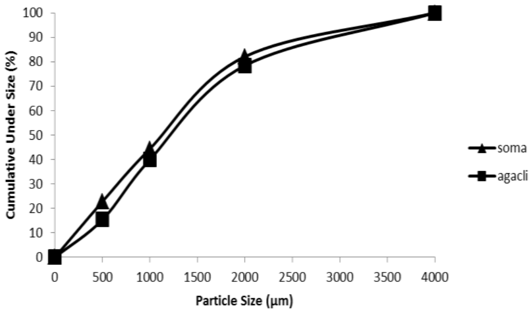

Fig. 2. Particle size curves of “float and sink experiments” samples of Manisa-Soma and Istanbul-Agacli coals

2.2. Results of Proximate and Ultimate Chemical Analysis

Ash samples and coal samples collected for the study were brought to the Mineral Processing Laboratory of Istanbul University, and humidity, ash, density, volatile matter, total sulphur and thermal value analyses were made on these samples. Evaluation and interpretation of the chemical analysis results of the coal and ash samples are summarised below.

Humidity. Coal samples collected from the TKI (Turkish Coal Enterprises) Ege Lignite Enterprises (Manisa-Soma) for the study were brought to the Mineral Processing Laboratory of Istanbul University, and total humidity analysis was made on these samples. Analysis was made according to standard TS 690 ISO 598 (Method-C). Total humidity analysis was made after bringing samples to the laboratory in closed nylon bags without losing time. Due to the high temperature at electro-filters, humidity values of ash samples are mostly almost zero.

Figure 3 shows the percentage curves of the humidity that is lost in time when coal samples collected from Manisa-Soma and Istanbul-Agacli region are heated in drying oven at 105ºC. It was calculated that coal samples collected from Manisa-Soma and Istanbul-Agacli contain 15.49% and 31.75% humidity, respectively. The analyses show that almost entire humidity contained in the samples may be removed in 3 hours for Manisa-Soma coal samples and 5 hours for Istanbul-Agacli coal samples.

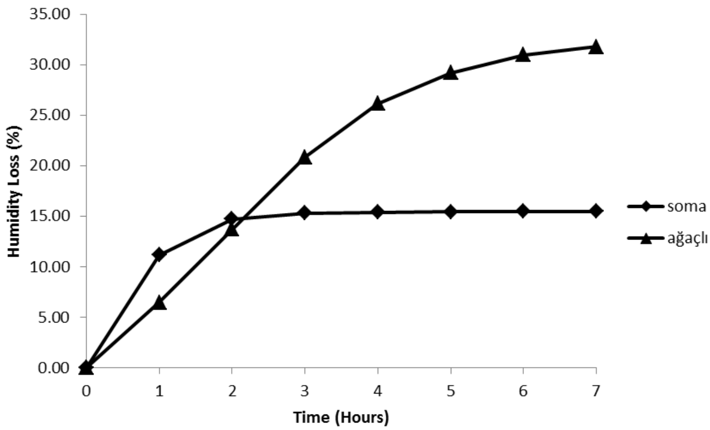

Fig. 3: Graphic of humidity loss (%) as a function of time (hours) for Manisa-Soma and Istanbul-Agacli coals

Volatile Matter. It was observed that volatile matter content of ash samples is lower than coals'. Whereas, Manisa-Soma coal sample contains 31.32% volatile matter, its thermal power plant ashes contain 1.2% because of the unburned coal pieces. Agacli sample contains 57.27% volatile matter.

Ash. Ash analyses of the coal samples within the study were realised in Istanbul University, Department of Mine Engineering, Mineral Processing Laboratory. According to the results of this analysis, coals collected from Manisa – Soma region are coals with high ash ratio.

Theoretically, ash content of waste products formed as the result of combustion in thermal power plants (volatile ash and bottom ash) must be 100%. However, depending on characteristics of combusted coal and conditions of combustion systems, it is always possible to find some unburned coal remnants in these wastes. As a matter of fact, Manisa – Soma thermal power plant ash contains 1.2% unburned pieces.

Total Sulphur. Dry base total sulphur contents of thermal Power Plant ash and coal samples collected for the study in air were analysed by Acme Analytical Laboratories Ltd. in Canada. Leco carbon sulphur device was used in total sulphur analysis (Acme, 2009).

When coals used in Manisa-Soma thermal power plant and ashes formed by combustion are examined for total sulphur contents, it is observed that a little portion is disposed into the air by burning and the rest is concentrated in ash.

Thermal Value. Upper thermal values and lower thermal values of the coal samples were analysed in the Environment and Fuel Analysis Laboratory approved by TÜRKAK belonging to Istanbul Metropolitan Municipality, Department of Environmental Protection & Development. IKA C7000 device was used for thermal value analyses.

Density Analysis. Density analysis with a pycnometer was performed to determine densities of the coal samples collected for the study and to compare optimum sorting density used in float and sink experiments. Density Analysis was performed in Istanbul University, Department of Mine Engineering, Ore Preparation and Concentration Laboratory. TS ISO 5072 Brown Coal and Lignite – Assessment of Real and Apparent Relative Density standard was utilized in the analysis method.

The heavy mediums used in float and sink experiments of Soma and Agacli coals were selected as 1.6 and 1.3 g/cm^3, respectively.

Elementary Analyses. Elementary Analyses of the coal samples collected for the study were performed in Advanced Analyses Laboratory of Istanbul University. Based on the air dried elementary analysis results of the analysed samples are given in Table 2.

Table 1. Based on the air dried chemical analysis results of Istanbul-Agacli, Manisa- Soma coal samples and Manisa- Soma power plant ash samples

Sample	Amount of volatile substances (%)	Ash Content (%)	Total sulphur content (%)	Upper thermal value (Kcal/kg)	Lower thermal value (Kcal/kg)	Density (g/cm^3)
İstanbul-Agacli	57.27	8.12	1.37	4742	4499	1.301
Manisa-Soma coal	31.32	35.88	0.67	2942	2761	1.553
Manisa-Soma ash	1.2	98.80	1.26			

Table 2. Based on the air dried elementary analysis results of Istanbul-Agacli, Manisa-Soma coal samples

	C, %	H, %	N, %	S, %
İstanbul - Agacli	48.19	4.92	0.36	0.56
Manisa – Soma	43.13	2.75	0.42	0.28

Methods used in elementary analyses are explained below:

1DX Analysis. In 1DX analysis, 0.5g of the sample is leached with royal water heated up to 95ºC (Aqua Regia in Latin; it is generally obtained by mixing one third concentrated hydrochloric acid and nitric acid) and the solution placed in ICP-MS device to read the values (Acme, 2009).

Elements detected by 1DX analysis are: Mo, Cu, Pb, Zn, Ni, As, Cd, Sb, Bi, Ag, Au, Hg, Tl, Se.

Leco TOT/C and TOT/S analysis. Total C and Total S analyses are performed with Leco carbon sulphur device (Acme, 2009).

4A Analysis. In 4A analysis, 0.2g coal and ash samples are applied lithium metaborate/tetraborate fusion and decomposed with diluted nitric acid, and then major oxides they contained were detected with the ICP-ES device (Acme, 2009).

Minerals that are analysed with 4A are: SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, P_2O_5, MnO, Cr_2O_3.

4B Analysis. In 4B analysis, 0.2g coal and ash samples are applied lithium metaborate/tetraborate fusion and decomposed with diluted nitric acid, and then rare soil elements and refractor elements they contained were detected with the ICP-MS device. In addition, 0.5g samples were decomposed in royal water, and precious metals and base metals were detected with ICP-MS (Acme, 2009).

Elements that are analysed with 4B are (nitric acid and ICP-MS): Ba, Be Co, Cs, Ga, Hf, Nb, Rb, Sc, Sn, Sr, Ta, Th, U, V, W, Y, Zr, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu.

Elements that are analysed with 4B are (Royal Water and ICP-MS): Au, Ag, As, Bi, Cd, Cu, Hg, Mo, Ni, Pb, Sb, Se, Tl, Zn.

Combustible efficiency analysis. It is used in interpretation of combustible efficiency washing performance. Combustible efficiency has been calculated with the formulae as below (Ateşok, 2004):

$$\text{Combustible Efficiency} = \frac{(100-c)(t-f)}{(100-f)(t-c)}100, \tag{1}$$

where, t represents waste schist ash %, f raw coal ash %, c clean coal ash %.

Float and sink experiments. Trace element analysis results of the products obtained from float and sink experiments are given in Attachments 1 and 3.

Combustible efficiencies of samples according to the float and sink experiment results are given in Table 3.

Combustible efficiencies of the flotation experiment results are given in Table 4.

Table 3. Combustible efficiencies of the coal samples that floated and sank in float and sink experiments

Float and Sink (-4mm+0,5mm)	Quantity,%	ΣC Content,%	Ash, %	Combustible Efficiency,%
Soma +1,6 floating	47.51	63.35	9.90	66.76
Soma -1,6 sinking	52.49	15.37	59.40	33.24
Soma feed	100.00	38.17	35.88	100.00
Agacli +1,3 floating	68.06	58.86	7.90	68.23
Agacli -1,3 sinking	31.94	57.28	8.60	31.77
Agacli feed	100.00	58.36	8.12	100.00

Table 4. Combustible efficiencies of the floating and sinking coal samples in flotation results

Flotation, (-0,5mm)	Quantity, %	ΣC Content, %	Ash, %	Combustible Efficiency, %
Soma floating	61.21	31.44	45.70	61.12
Soma sinking	38.79	30.81	45.50	38.88
Soma feed	100.00	31.20	45.62	100.00
Agacli floating	49.93	60.27	7.30	50.01
Agacli sinking	50.07	59.59	7.60	49.99
Agacli feed	100.00	59.93	7.45	100.00

Combustible efficiencies according to total coal dressing works, in which results of float and sink experiments and flotation experiments are evaluated together, are given in Table 5.

Table 5. Combustible efficiencies of floating and sinking coals in total after coal dressing processes

Total Coal Dressing (-4mm)	Quantity, %	ΣC Content, %	Σ Ash, %	Σ Combustible Efficiency, %
Soma ΣFloating	50.92	53.80	45.70	50.83
Soma ΣSinking	49.08	18.41	45.50	49.17
Soma ΣFeed	100.00	36.43	45.60	100.00
Agacli ΣFloating	65.44	59.02	7.30	65.51
Agacli ΣSinking	34.56	57.76	7.60	34.49
Agacli ΣFeed	100.00	58.58	7.40	100.00

Flotation Experiments. Trace element analysis results of the products obtained by flotation experiments performed in the study are given in Appendices 1 and 3.

Combustible efficiencies of Manisa – Soma coal is low because it is high ash coal and lignite flotation is difficult.

Trace element analysis results of Manisa Soma Coal, Ash and Thermal Power Plant Ash, are given in Appendix 2. Trace element analysis results of İstanbul Agacli Coal and Ash are given in Appendix 3.

3. Conclusions

Because Manisa-Soma lignite is low in thermal value, they can only be used in thermal power plants. It has been observed that trace element sedimentations settling in coal during geological formation of the area is higher than worldwide coal average.

In the Float and Sink Experiments performed on Manisa-Soma coal, which has a relative density of 1.553 g/cm^3, $ZnCl_2$ solution of 1.6 g/cm^3 density has been used. It has been calculated that it is very easy to sort at this density, 47.51% of the coal feed with 35.88% ash content floats, and floating coal contains 9.90% ash and sinking coal contains 59.40% ash. When sorting is made at 1.6 g/cm^3 density, combustible efficiency of floating coals has been calculated to be 66.76%.

As a result of flotation experiments applied on Manisa-Soma coal, it has been found that 61.21% of the coal feed with 45.62% ash content floats, and floating coal contains 45.70% ash and sinking coal contains 45.50% ash. At the end of flotation, it has been calculated that combustible efficiency of floating coal is 61.12%.

It has been aimed to obtain a total coal preparation conclusion by combining the results of float and sink experiment and flotation experiment. According to these results, total floating ratio of the coal with 45.60% total ash content is 50.92% and ash content is 45.70%. Total combustible efficiency has been calculated to be 50.83%.

According to the major and trace element results of the Float and Sink Experiment made on Manisa-Soma coal, whereas radioactive element content of Th is 3.26 ppm in the feeding coal, it is 1.00ppm in floating coal and 5.30 ppm in sinking coal. Furthermore, when post-combustion ashes of these coals are examined, the value found in Floating Coal ash is 12.40 ppm, in Sinking Coal ash 8.80ppm and in Unsorted Coal ash 8.20 ppm respectively. This shows that Th element collects in the sinking part after coal dressing, and gets concentrated in the ash after combustion. In the same way, when the samples are analysed in respect to U element, the values are 7.19 ppm in Unsorted Coal, 7.40 ppm in the floating part and 7.00 ppm in the sinking part after float and sink experiment. When they are analysed with respect to ash, the value is 11.50 ppm in the feeding coal ash, and they concentrate in Floating Coal ash as 72.60 ppm and 12.1 ppm in Sinking Coal ash.

When samples are analysed with respect to air polluting elements, it was observed that As, Co and Mn concentrated in floating coals, Be, Cd, Hg and Ni concentrated in the ashes of these coals, and Se concentrated in sinking coal and its ash.

Th and U values for Soma run-of-mine coal samples are 5.70 ppm and 8.30 ppm, respectively. Th and U values for Soma coal samples were determined as 8.20 ppm and 11.50 ppm respectively according to the results of ash test. Th and U values were observed as 26.20 ppm and 26.50 ppm respectively in Soma thermal power plant ashes.

Because Istanbul-Agacli lignite is low in thermal value, they can only be used in thermal power plants. It was observed that the trace element sedimentations settling in coal during geological formation of the area is higher than worldwide coal average.

In the Float and Sink Experiments performed on Istanbul-Agacli coal, which has a relative density of 1.301 g/cm^3, $ZnCl_2$ solution of 1.3 g/cm^3 density was used. It was calculated that it is very easy to sort at this density, 68.06% of the coal feed with 8.12% ash content floats, and floating coal contains 7.90% ash and sinking coal contains 8.60% ash. When sorting is made at 1.3 g/cm^3 density, combustible efficiency of floating coals was calculated to be 68.23%.

After the flotation experiments applied on Istanbul-Agacli coal samples, it has been found that 49.93% of the coal feed with 7.45% ash content floats, and floating coal contains 7.30% ash and sinking coal contains 7.60% ash. At the end of the flotation, it was calculated that the combustible efficiency of floating coal is 50.01%.

The aim of this study was to obtain a total coal preparation conclusion by combining the results of float and sink experiments and flotation experiments. According to these results, total floating ratio of the coal with 7.40% total ash content is 64.44% and ash content is 7.30%. Total combustible efficiency was calculated as 65.51%.

According to the major and trace element results of the Float and Sink Experiment made on Istanbul-Agacli coal, whereas the radioactive element content of Th is 3.05 ppm in the feeding coal, it is 2.60 ppm in floating coal and 4.00ppm in sinking coal. Furthermore, when post-combustion ashes of these coals are examined, the value found in Floating Coal ash is 32.30 ppm, in Sinking Coal ash 36.00 ppm and in Unsorted Coal ash 43.40 ppm. This shows that Th element collects in the sinking part after coal dressing, and gets concentrated in the ash after combustion. In the same way, when the samples are analysed in respect to U element, the values are1.16 ppm in Unsorted Coal, 0.90 ppm in the floating part and 1.70 ppm in the sinking part after float and sink experiment. When they are analysed with respect to ash, the value is 11.60 ppm in the feeding coal ash, and they concentrate in Floating Coal ash as 13.70 ppm and 13.4 ppm in Sinking Coal ash.

When samples were analysed with respect to air polluting elements, it was observed that As, Co and Mn were concentrated in floating coals, Be, Cd, Hg and Ni were concentrated in the ashes of these coals, and Se was concentrated in sinking coal and its ash.

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Appendix 1. Analysis results and average trace elements table for Manisa Soma coal

		Method Analyte Unit MDL	4A-4B SiO2 % 0.01	4A-4B Al2O3 % 0.01	4A-4B Fe2O3 % 0.04	4A-4B MgO % 0.01	4A-4B CaO % 0.01	4A-4B Na2O % 0.01	4A-4B K2O % 0.01	4A-4B TiO2 % 0.01	4A-4B P2O5 % 0.01	4A-4B MnO % 0.01	4A-4B Cr2O3 % 0.002	4A-4B Sc ppm 1	4A-4B Ba ppm 1	4A-4B Be ppm 1	4A-4B Co ppm 0.2	4A-4B Cs ppm 0.1
Float and Sink Coal	Soma -4+0.5mm +1.60 Floating	Coal	1.71	1.05	0.49	0.23	3.23	0.06	0.07	0.05	0.03	<0.01	0.00	<1	113.00	<1	1.10	2.80
	Soma -4+0.5mm -1.60 Sinking	Coal	21.81	6.01	3.02	1.11	21.78	0.11	0.65	0.16	0.08	0.04	0.00	6.00	196.00	1.00	2.50	9.50
Float and Sink Ashes	Soma -4+0.5mm +1.60 Floating Ash	Ash	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	1239.00	5.00	16.80	5.10
	Soma -4+0.5mm -1.60 Sinking Ash	Ash	32.00	10.34	5.56	1.74	33.79	0.26	1.02	0.28	0.13	0.07	0.008	11.00	350.00	<1	4.80	14.70
Unsorted Coal	Soma Unsorted Coal	Coal	17.91	7.26	2.33	0.84	13.08	0.11	0.77	0.20	0.08	0.03	0.005	6.00	250.00	<1	3.30	10.40
Unsorted Coal Ashes	Soma Unsorted Coal Ashes	Ash	21.06	8.70	2.51	2.47	58.14	0.23	0.98	0.30	0.19	0.06	0.007	7.00	425.00	<1	6.80	13.80
Flotation	Soma -0.5mm Floating	Coal	19.49	8.69	2.09	0.86	13.15	0.14	0.89	0.24	0.07	0.02	0.009	7.00	298.00	<1	3.50	10.70
	Soma -0.5mm Sinking	Coal	17.99	7.01	2.95	0.90	15.33	0.18	0.73	0.20	0.08	0.04	0.005	7.00	287.00	<1	3.20	9.00
Flotation Ashes	Soma -0.5mm Floating Ash	Ash	41.37	17.88	4.43	1.77	26.50	0.32	1.93	0.51	0.16	0.05	0.013	15.00	604.00	2.00	7.90	21.10
	Soma -0.5mm Sinking Ash	Ash	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	584.00	3.00	7.20	18.90
World Average*		Coal												1.00	200.00	2.00	5.00	1.00
Lowest		Coal												1.00	20.00	0.10	0.50	0.30
Highest		Coal												10.00	1000.00	15.00	30.00	5.00
Turkey Average		Coal														1.00	9.40	
Lowest		Coal	0.67	0.07	0.26	0.04	0.06	0.01	0.01	0.01	0.01	0.01				0.20	1.00	
Highest		Coal	28.27	12.00	12.57	3.17	14.08	2.34	1.85	0.57	0.24	0.07				7.00	55.00	

*Swaine (1990)

		Method Analyte Unit MDL	4A-4B Ga ppm 0.5	4A-4B Hf ppm 0.1	4A-4B Nb ppm 0.1	4A-4B Rb ppm 0.1	4A-4B Sn ppm 1	4A-4B Sr ppm 0.5	4A-4B Ta ppm 0.1	4A-4B V ppm 8	4A-4B Th ppm 0.2	4A-4B U ppm 0.1	4A-4B W ppm 0.5	4A-4B Zr ppm 0.1	4A-4B Y ppm 0.1	4A-4B La ppm 0.1	4A-4B Ce ppm 0.1	4A-4B Pr ppm 0.02
Float and Sink Coal	Soma -4+0.5mm +1.60 Floating	Coal	2.10	0.30	2.00	4.40	<1	77.40	<0.10	51.00	1.00	7.40	<0.5	13.90	1.80	2.10	4.00	0.47
	Soma -4+0.5mm -1.60 Sinking	Coal	6.60	1.10	3.30	37.90	<1	135.10	0.20	45.00	5.30	7.00	0.80	37.80	9.50	11.80	22.40	2.68
Float and Sink Ashes	Soma -4+0.5mm +1.60 Floating Ash	Ash	18.30	4.80	24.70	8.90	4.00	753.00	1.00	617.00	12.40	72.60	4.90	163.70	21.30	24.10	43.00	5.19
	Soma -4+0.5mm -1.60 Sinking Ash	Ash	10.50	2.00	6.20	58.90	3.00	231.10	0.40	83.00	8.80	12.10	1.40	65.50	18.80	21.50	41.60	4.98
Unsorted Coal	Soma Unsorted Coal	Coal	7.70	1.40	4.80	41.20	1.00	152.40	0.40	74.00	5.70	8.30	0.70	44.90	9.10	13.70	25.10	3.01
Unsorted Coal Ashes	Soma Unsorted Coal Ashes	Ash	8.80	1.90	6.30	48.40	2.00	426.40	0.40	75.00	8.20	11.50	0.90	68.10	13.10	18.80	35.00	4.14
Flotation	Soma -0.5mm Floating	Coal	8.70	1.60	5.00	47.60	<1	179.20	0.40	72.00	7.10	9.00	0.60	53.70	9.50	14.80	28.30	3.36
	Soma -0.5mm Sinking	Coal	7.90	1.40	4.40	39.40	2.00	180.70	0.30	66.00	5.70	8.60	0.80	43.90	9.20	13.00	24.10	2.94
Flotation Ashes	Soma -0.5mm Floating Ash	Ash	19.00	3.50	10.50	100.90	3.00	362.10	0.80	155.00	14.30	17.90	1.60	118.20	19.90	30.20	56.90	6.81
	Soma -0.5mm Sinking Ash	Ash	15.10	2.80	8.90	79.10	2.00	350.80	0.70	132.00	12.60	17.70	1.30	93.20	19.00	27.60	51.10	6.06
World Average*		Coal	5.00	1.00	5.00	40.00	2.00	200.00	0.20	40.00	4.00	2.00	1.00	50.00		10.00	20.00	
Lowest		Coal	1.00	0.40	1.00	2.00	1.00	15.00	0.10	2.00	0.50	0.50	0.50	5.00	2.00	1.00	2.00	1.00
Highest		Coal	20.00	5.00	20.00	50.00	10.00	500.00	1.00	100.00	10.00	10.00	5.00	200.00	50.00	40.00	70.00	10.00
Turkey Average		Coal								87.00	6.00	13.00						
Lowest		Coal								6.00	1.00	0.40						
Highest		Coal								287.00	29.00	132.00						

*Swaine (1990)

		Method	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	2A Leco	2ALeco	4A-4B	4A-4B
		Analyte	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	TOT/C	TOT/S	LOI	Sum
		Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	%	%	%
		MDL	0.3	0.05	0.02	0.05	0.01	0.05	0.02	0.03	0.01	0.05	0.01	0.02	0.02	-5.1	0.01
Float and Sink Coal	Soma -4+0.5mm +1.60 Floating	Coal	1.80	0.32	0.07	0.31	0.06	0.27	0.07	0.18	0.03	0.21	0.03	63.35	0.70	90.10	97.00
	Soma -4+0.5mm -1.60 Sinking	Coal	10.00	2.02	0.48	1.83	0.28	1.50	0.31	0.85	0.14	0.96	0.15	15.37	0.65	40.60	95.41
Float and Sink Ashes	Soma -4+0.5mm +1.60 Floating Ash	Ash	20.40	3.78	0.92	3.72	0.63	3.54	0.65	2.12	0.27	2.13	0.36	N.A.	N.A.	N.A.	N.A.
	Soma -4+0.5mm -1.60 Sinking Ash	Ash	20.00	3.76	0.89	3.29	0.55	3.02	0.62	1.81	0.30	1.82	0.28	0.22	1.18	7.30	92.48
Unsorted Coal	Soma Unsorted Coal	Coal	11.60	2.07	0.47	1.67	0.28	1.48	0.30	0.93	0.14	0.95	0.15	33.93	0.75	57.30	99.89
Unsorted Coal Ashes	Soma Unsorted Coal Ashes	Ash	16.40	2.85	0.62	2.33	0.39	2.16	0.43	1.32	0.20	1.34	0.19	0.97	0.73	5.20	99.81
Flotation	Soma -0.5mm Floating	Coal	12.40	2.08	0.49	1.84	0.30	1.64	0.33	0.99	0.16	1.00	0.16	31.44	0.76	54.30	99.90
	Soma -0.5mm Sinking	Coal	10.50	1.91	0.46	1.63	0.27	1.57	0.31	0.98	0.15	0.93	0.15	30.81	0.81	54.50	99.88
Flotation Ashes	Soma -0.5mm Floating Ash	Ash	25.00	4.64	0.99	3.77	0.61	3.49	0.67	2.12	0.32	2.18	0.33	1.49	1.52	4.80	99.77
	Soma -0.5mm Sinking Ash	Ash	23.20	4.25	0.99	3.67	0.57	3.31	0.63	1.97	0.31	2.03	0.30	N.A.	N.A.	N.A.	N.A.
World Average*		Coal	10.00	2.00	0.50							1.00					
Lowest		Coal	3.00	0.50	0.10	0.40	0.10	0.50	0.10	0.50	0.50	0.30	0.03				
Highest		Coal	30.00	6.00	2.00	4.00	1.00	4.00	2.00	3.00	3.00	3.00	1.00				
Turkey Average		Coal															
Lowest		Coal															
Highest		Coal															

*Swaine (1990)

		Method	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX
		Analyte	Mo	Cu	Pb	As	Cd	Sb	Bi	Ag	Au	Hg	Tl	Se	Ni
		Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppm
		MDL	0.1	0.1	0.1	0.5	0.1	0.1	0.1	0.1	0.5	0.01	0.1	0.5	0.1
Float and Sink Coal	Soma -4+0.5mm +1.60 Floating	Coal	0.70	9.50	3.90	20.90	0.10	0.10	<0.10	<0.10	<0.50	0.06	0.70	0.80	7.60
	Soma -4+0.5mm -1.60 Sinking	Coal	0.50	15.00	8.90	66.60	0.30	<0.10	0.10	<0.10	0.70	0.06	0.90	2.80	7.10
Float and Sink Ashes	Soma -4+0.5mm +1.60 Floating Ash	Ash	12.00	61.00	5.50	219.00	0.90	1.70	0.40	<0.10	8.30	<0.01	<0.10	2.10	54.20
	Soma -4+0.5mm -1.60 Sinking Ash	Ash	1.40	21.80	10.40	102.30	0.50	0.20	0.30	<0.10	<0.50	<0.01	0.10	3.10	15.20
Unsorted Coal	Soma Unsorted Coal	Coal	0.60	18.90	8.60	52.00	0.20	0.20	0.20	<0.10	<0.50	0.07	<0.10	0.70	9.40
Unsorted Coal Ashes	Soma Unsorted Coal Ashes	Ash	1.60	20.80	16.40	58.90	0.30	0.10	0.20	<0.10	1.00	<0.01	0.20	1.10	21.50
Flotation	Soma -0.5mm Floating	Coal	0.70	21.90	10.60	46.90	0.30	0.20	0.20	<0.10	<0.50	0.08	<0.10	0.60	12.10
	Soma -0.5mm Sinking	Coal	0.90	21.10	10.40	56.10	0.20	0.20	0.20	<0.10	<0.50	0.10	<0.10	0.60	13.20
Flotation Ashes	Soma -0.5mm Floating Ash	Ash	2.10	45.50	16.80	99.50	<0.10	0.30	<0.10	<0.10	0.90	<0.01	0.50	1.70	29.70
	Soma -0.5mm Sinking Ash	Ash	2.20	42.20	16.90	114.40	0.10	0.30	<0.10	<0.10	<0.50	<0.01	0.30	1.50	25.30
World Average*		Coal	3.00	15.00	20.00	10.00	0.50	1.50						1.00	20.00
Lowest		Coal	0.10	0.50	2.00	0.50	0.10	0.10	2.00			0.02	0.20	0.20	0.50
Highest		Coal	10.00	50.00	80.00	80.00	3.00	10.00	20.00			1.00	1.00	10	50.00
Turkey Average		Coal			12.00	53.00	1.00					0.10		2.00	126.00
Lowest		Coal			0.10	2.00	0.01					0.03		0.10	3.00
Highest		Coal			286.00	686.00	45.00					0.70		26.00	1700.00

*Swaine (1990)

Appendix 2. Trace element analysis results of Manisa Soma coal, ash and Thermal Power Plant ash

	Method	4A-4B		4A-4B		4A-4B		4A-4B		4A-4B		4A-4B		4A-4B	
	Analyte	SiO2	Si	Al2O3	Al	Fe2O3	Fe	MgO	Mg	CaO	Ca	Na2O	Na	K2O	K
	Unit	%	(%)	%	(%)	%	(%)	%	(%)	%	(%)	%	(%)	%	(%)
	MDL	0.01		0.01		0.04		0.01		0.01		0.01		0.01	
Soma (-4mm) Coal	Coal	17.91	8.37	7.26	3.84	2.33	1.63	0.84	0.51	13.08	9.35	0.11	0.08	0.77	0.64
Soma (-4mm) Coal Ash	Ash	21.06	9.85	8.70	4.61	2.51	1.76	2.47	1.49	58.14	41.56	0.23	0.17	0.98	0.81
Soma Thermal Power Plant Ash	Ash	44.97	21.02	21.25	11.25	4.10	2.87	1.67	1.01	23.67	16.92	0.54	0.40	1.29	1.07

	Method	4A-4B		4A-4B		4A-4B		4A-4B		4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B
	Analyte	TiO2	Ti	P2O5	P	MnO	Mn	Cr2O3	Cr	Ni	Sc	Ba	Be	Co	Cs
	Unit	%	(%)	%	(%)	%	(%)	%	(%)	ppm	ppm	ppm	ppm	ppm	ppm
	MDL	0.01		0.01		0.01		0.002		20	1	1	1	0.2	0.1
Soma (-4mm) Coal	Coal	0.20	0.12	0.08	0.03	0.030	0.023	0.005	0.003	<20	6.00	250.00	<1	3.30	10.40
Soma (-4mm) Coal Ash	Ash	0.30	0.18	0.19	0.08	0.060	0.046	0.007	0.005	27.00	7.00	425.00	<1	6.80	13.80
Soma Thermal Power Plant Ash	Ash	0.73	0.44	0.22	0.10	0.04	0.031	0.02	0.010	37.40	15.00	893.00	3.00	15.20	25.10

	Method	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B
	Analyte	Ga	Hf	Nb	Rb	Sn	Sr	Ta	Th	U	V	W	Zr	La	Ce
	Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	MDL	0.5	0.1	0.1	0.1	1	0.5	0.1	0.2	0.1	8	0.5	0.1	0.1	0.1
Soma (-4mm) Coal	Coal	7.70	1.40	4.80	41.20	1.00	173.60	0.40	5.70	8.30	74.00	0.70	44.90	13.70	25.10
Soma (-4mm) Coal Ash	Ash	8.80	1.90	6.30	48.40	2.00	426.40	0.40	8.20	11.50	75.00	0.90	68.10	18.80	35.00
Soma Thermal Power Plant Ash	Ash	22.60	4.00	20.30	94.80	3.00	381.10	1.50	26.20	26.50	275.00	3.80	167.60	50.90	95.40

	Method	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	1DX	1DX
	Analyte	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Mo	Cu
	Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	MDL	0.02	0.3	0.05	0.02	0.05	0.01	0.05	0.02	0.03	0.01	0.05	0.01	0.1	0.1
Soma (-4mm) Coal	Coal	3.01	11.60	2.07	0.47	1.67	0.28	1.48	0.30	0.93	0.14	173.60	0.15	0.60	18.90
Soma (-4mm) Coal Ash	Ash	4.14	16.40	2.85	0.62	2.33	0.39	2.16	0.43	1.32	0.20	1.34	0.19	1.60	20.80
Soma Thermal Power Plant Ash	Ash	10.58	39.50	7.30	1.53	6.52	0.96	5.26	1.11	3.05	0.46	3.34	0.48	2.40	29.20

	Method	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	2ALeco	2ALeco	
	Analyte	Pb	Zn	As	Cd	Sb	Bi	Ag	Au	Hg	Tl	Se	TOT/C	TOT/S	Ash
	Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	%	%	%
	MDL	0.1	1	0.5	0.1	0.1	0.1	0.1	0.5	0.01	0.1	0.5	0.02	0.02	
Soma (-4mm) Coal	Coal	8.60	28.00	52.00	0.20	0.20	0.20	<0.1	<0.5	0.07	<0.1	0.70	33.93	0.75	42.70
Soma (-4mm) Coal Ash	Ash	16.40	38.00	58.90	0.30	0.10	0.20	<0.1	1.00	<0.01	0.20	1.10	0.97	0.73	94.80
Soma Thermal Power Plant Ash	Ash	25.00	81.00	144.90	1.60	0.40	0.70	<0.1	<0.5	0.02	0.30	2.20	0.71	1.26	98.80

Appendix 3. Analysis results and average trace elements table for Istanbul Agacli coal

		Method / Analyte / Unit / MDL	4A-4B SiO_2 % 0,01	4A-4B AI_2O_3 % 0,01	4A-4B Fe_2O_3 % 0,04	4A-4B MgO % 0,01	4A-4B CaO % 0,01	4A-4B Na_2O % 0,01	4A-4B K_2O % 0,01	4A-4B TiO_2 % 0,01	4A-4B P_2O_5 % 0,01	4A-4B MnO % 0,01	4A-4B Cr_2O_3 % 0,002	4A-4B Sc ppm 1	4A-4B Ba ppm 1	4A-4B Be ppm 1	4A-4B Co ppm 0,2	4A-4B Cs ppm 0,1
Float and Sink Coal	Agacli -4+0.5mm +1.30 Floating	Coal	0.42	0.70	1.10	0.28	2.08	0.08	0.01	<0,01	<0,01	<0,01	0.00	1.00	47.00	2.00	2.10	<0.10
	Agacli -4+0.5mm -1.30 Sinking	Coal	1.35	1.20	1.33	0.25	1.82	0.09	0.05	0.04	<0,01	<0,01	0.00	2.00	46.00	2.00	1.80	0.30
Float and Sink Ashes	Agacli -4+0.5mm +1.30 Floating Ash	Ash	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	610.00	21.00	34.60	0.30
	Agacli -4+0.5mm -1.30 Sinking Ash	Ash	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	460.00	10.00	19.70	1.20
Unsorted Coal	Agacli Unsorted Coal	Coal	0.87	0.94	1.22	0.31	2.17	0.09	0.02	0.02	0.04	0.01	<0.002	2.00	57.00	2.00	2.60	0.20
Unsorted Coal Ashes	Agacli Unsorted Coal Ashes	Ash	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	609.00	17.00	36.60	0.90
Flotation	Agacli -0.5mm Floating	Coal	1.28	1.26	1.56	0.34	2.56	0.09	0.04	0.03	0.01	0.01	0.002	3.00	63.00	2.00	2.70	0.30
	Agacli -0.5mm Sinking	Coal	1.20	1.15	1.41	0.31	2.38	0.11	0.03	0.03	0.04	0.01	0.004	3.00	61.00	2.00	2.30	0.20
Flotation Ashes	Agacli -0.5mm Floating Ash	Ash	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	654.00	15.00	27.70	2.00
	Agacli -0.5mm Sinking Ash	Ash	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	659.00	13.00	26.30	2.30
World Average*		Coal												1.00	200.00	2.00	5.00	1.00
Lowest		Coal												1.00	20.00	0.10	0.50	0.30
Highest		Coal												10.00	1000.00	15.00	30.00	5.00
Turkey Average		Coal														1.00	9.40	
Lowest		Coal	0.67	0.07	0.26	0.04	0.06	0.01	0.01	0.01	0.01	0.01				0.20	1.00	
Highest		Coal	28.27	12.00	12.57	3.17	14.08	2.34	1.85	0.57	0.24	0.07				7.00	55.00	

*Swaine (1990)

		Method / Analyte / Unit / MDL	4A-4B Ga ppm 0,5	4A-4B Hf ppm 0,1	4A-4B Nb ppm 0,1	4A-4B Rb ppm 0,1	4A-4B Sn ppm 1	4A-4B Sr ppm 0,5	4A-4B Ta ppm 0,1	4A-4B V ppm 8	4A-4B Th ppm 0,2	4A-4B U ppm 0,1	4A-4B W ppm 0,5	4A-4B Zr ppm 0,1	4A-4B Y ppm 0,1	4A-4B La ppm 0,1	4A-4B Ce ppm 0,1	4A-4B Pr ppm 0,02
Float and Sink Coal	Agacli -4+0.5mm +1.30 Floating	Coal	2.60	0.30	0.80	0.10	<1	462.70	<0.10	11.00	2.60	0.90	1.20	9.70	6.50	1.90	4.80	0.55
	Agacli -4+0.5mm -1.30 Sinking	Coal	3.30	0.40	2.50	1.90	<1	373.10	<0.10	16.00	4.00	1.70	1.30	14.60	7.20	4.10	9.00	1.01
Float and Sink Ashes	Agacli -4+0.5mm +1.30 Floating Ash	Ash	27.10	3.20	13.90	2.10	12.00	5672.00	0.40	259.00	32.30	13.70	14.40	113.00	91.90	24.90	56.90	7.42
	Agacli -4+0.5mm -1.30 Sinking Ash	Ash	28.00	4.40	20.50	10.00	3.00	3435.00	1.00	202.00	36.00	13.40	11.90	148.80	60.30	32.10	71.30	7.89
Unsorted Coal	Agacli Unsorted Coal	Coal	2.60	0.30	1.60	0.90	1.00	445.50	<0.10	47.00	3.60	1.30	1.10	11.00	6.80	3.10	6.20	0.81
Unsorted Coal Ashes	Agacli Unsorted Coal Ashes	Ash	22.10	3.70	11.10	7.20	7.00	5792.00	0.70	227.00	43.40	11.60	10.50	140.60	91.80	43.30	95.60	11.03
Flotation	Agacli -0.5mm Floating	Coal	2.80	0.40	2.00	1.10	<1	491.40	<0.10	21.00	4.00	1.50	1.10	14.50	7.70	3.70	7.90	0.95
	Agacli -0.5mm Sinking	Coal	2.50	0.40	1.80	1.10	<1	476.70	<0.10	35.00	3.90	1.30	0.90	13.80	7.10	3.50	7.50	0.88
Flotation Ashes	Agacli -0.5mm Floating Ash	Ash	28.40	4.80	18.60	8.40	2.00	4744.00	0.80	219.00	38.60	15.40	11.10	153.30	79.60	35.80	78.50	9.18
	Agacli -0.5mm Sinking Ash	Ash	28.90	4.20	19.00	8.80	2.00	4746.00	0.80	225.00	36.80	15.70	10.90	147.90	78.80	35.70	77.40	8.93
World Average*		Coal	5.00	1.00	5.00	40.00	2.00	200.00	0.20	40.00	4.00	2.00	1.00	50.00		10.00	20.00	
Lowest		Coal	1.00	0.40	1.00	2.00	1.00	15.00	0.10	2.00	0.50	0.50	0.50	5.00	2.00	1.00	2.00	1.00
Highest		Coal	20.00	5.00	20.00	50.00	10.00	500.00	1.00	100.00	10.00	10.00	5.00	200.00	50.00	40.00	70.00	10.00
Turkey Average		Coal								87.00	6.00	13.00						
Lowest		Coal								6.00	1.00	0.40						
Highest		Coal								287.00	29.00	132.00						

*Swaine (1990)

		Method / Analyte / Unit / MDL	4A-4B Nd ppm 0,3	4A-4B Sm ppm 0,05	4A-4B Eu ppm 0,02	4A-4B Gd ppm 0,05	4A-4B Tb ppm 0,01	4A-4B Dy ppm 0,05	4A-4B Ho ppm 0,02	4A-4B Er ppm 0,03	4A-4B Tm ppm 0,01	4A-4B Yb ppm 0,05	4A-4B Lu ppm 0,01	2A Leco TOT/C % 0,02	2ALeco TOT/S % 0,02	4A-4B LOI % -5,1	4A-4B Sum % 0,01
Float and Sink Coal	Agacli -4+0.5mm +1.30 Floating	Coal	2.60	0.58	0.19	0.78	0.13	0.79	0.18	0.51	0.07	0.49	0.07	58.86	1.18	92.10	96.75
	Agacli -4+0.5mm -1.30 Sinking	Coal	3.60	0.95	0.22	0.95	0.15	0.93	0.22	0.60	0.10	0.54	0.09	57.28	1.77	91.40	97.56
Float and Sink Ashes	Agacli -4+0.5mm +1.30 Floating Ash	Ash	32.80	7.99	2.48	9.72	1.81	10.52	2.46	6.80	1.00	6.33	1.09	N.A.	N.A.	N.A.	N.A.
	Agacli -4+0.5mm -1.30 Sinking Ash	Ash	32.20	6.64	1.81	7.13	1.21	6.94	1.58	4.80	0.72	4.41	0.64	N.A.	N.A.	N.A.	N.A.
Unsorted Coal	Agacli Unsorted Coal	Coal	2.80	0.67	0.28	0.90	0.21	0.86	0.21	0.63	0.14	0.58	0.14	59.36	1.19	93.20	98.91
Unsorted Coal Ashes	Agacli Unsorted Coal Ashes	Ash	45.30	10.02	2.72	11.12	1.85	10.92	2.39	6.60	0.87	5.84	0.89	N.A.	N.A.	N.A.	N.A.
Flotation	Agacli -0.5mm Floating	Coal	4.10	0.87	0.23	0.93	0.16	1.05	0.22	0.62	0.09	0.58	0.08	60.27	1.18	92.70	99.92
	Agacli -0.5mm Sinking	Coal	3.80	0.85	0.21	0.94	0.15	1.04	0.21	0.62	0.09	0.51	0.07	59.59	1.49	92.40	99.06
Flotation Ashes	Agacli -0.5mm Floating Ash	Ash	38.60	8.47	2.33	9.41	1.55	9.66	2.07	6.53	0.92	5.54	0.83	N.A.	N.A.	N.A.	N.A.
	Agacli -0.5mm Sinking Ash	Ash	37.40	8.26	2.31	9.26	1.54	9.36	2.06	6.23	0.92	5.48	0.82	N.A.	N.A.	N.A.	N.A.
World Average*		Coal	10.00	2.00	0.50							1.00					
Lowest		Coal	3.00	0.50	0.10	0.40	0.10	0.50	0.10	0.50	0.50	0.30	0.03				
Highest		Coal	30.00	6.00	2.00	4.00	1.00	4.00	2.00	3.00	3.00	3.00	1.00				
Turkey Average		Coal															
Lowest		Coal															
Highest		Coal															

*Swaine (1990)

		Method / Analyte / Unit / MDL	1DX Mo ppm 0,1	1DX Cu ppm 0,1	1DX Pb ppm 0,1	1DX As ppm 0,5	1DX Cd ppm 0,1	1DX Sb ppm 0,1	1DX Bi ppm 0,1	1DX Ag ppm 0,1	1DX Au ppb 0,5	1DX Hg ppm 0,01	1DX Tl ppm 0,1	1DX Se ppm 0,5	1DX Ni ppm 0,1
Float and Sink Coal	Agacli -4+0.5mm +1.30 Floating	Coal	0.50	7.10	3.00	28.90	<0.10	0.10	<0.10	<0.10	<0.50	0.04	2.40	1.20	12.80
	Agacli -4+0.5mm -1.30 Sinking	Coal	0.70	10.20	6.80	32.50	<0.10	0.20	0.10	<0.10	<0.50	0.05	2.70	1.50	13.40
Float and Sink Ashes	Agacli -4+0.5mm +1.30 Floating Ash	Ash	10.70	82.70	0.60	307.20	<0.10	2.10	<0.10	0.10	8.10	<0.01	<0.10	2.70	119.80
	Agacli -4+0.5mm -1.30 Sinking Ash	Ash	7.40	105.30	5.90	235.60	0.50	1.50	<0.10	0.10	<0.50	<0.01	<0.10	4.90	94.30
Unsorted Coal	Agacli Unsorted Coal	Coal	0.50	10.70	5.30	30.90	<0.10	0.20	0.10	<0.10	0.60	0.05	<0.10	1.00	14.00
Unsorted Coal Ashes	Agacli Unsorted Coal Ashes	Ash	7.60	75.10	27.40	311.70	0.10	1.30	0.30	0.20	2.50	<0.01	<0.10	0.90	130.40
Flotation	Agacli -0.5mm Floating	Coal	0.60	15.20	6.60	30.30	<0.10	0.20	0.10	<0.10	<0.50	0.05	<0.10	1.10	16.20
	Agacli -0.5mm Sinking	Coal	0.50	14.00	7.40	29.00	<0.10	0.20	0.10	<0.10	<0.50	0.06	0.10	0.90	15.20
Flotation Ashes	Agacli -0.5mm Floating Ash	Ash	10.00	162.00	22.60	312.80	<0.10	2.40	<0.10	0.30	3.20	<0.01	0.50	3.50	136.70
	Agacli -0.5mm Sinking Ash	Ash	9.90	135.10	21.80	310.60	0.40	2.60	<0.10	0.30	1.10	<0.01	0.40	3.90	136.60
World Average*		Coal	3.00	15.00	20.00	10.00	0.50	1.50						1.00	20.00
Lowest		Coal	0.10	0.50	2.00	0.50	0.10	0.10	2.00			0.02	0,20	0.20	0.50
Highest		Coal	10.00	50.00	80.00	80.00	3.00	10.00	20.00			1.00	1.00	10.00	50.00
Turkey Average		Coal			12.00	53.00	1.00					0.10		2.00	126.00
Lowest		Coal			0.10	2.00	0.01					0.03		0.10	3.00
Highest		Coal			286.00	686.00	45.00					0.70		26.00	1700.00

*Swaine (1990)