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ENVIRONMENTAL MONITORING OF FLY ASH STORAGE SITE, NW TURKEY

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ABSTRACT

The 18 Mart Can thermal power plant, built in 2006, produces energy using low-quality lignite reserves in the Can basin, NW Turkey. The amount of fly ash produced by this thermal power plant, which is the first plant to operate using the fluidized bed combustion technology in Turkey, is almost half a million tons per year. This study aims to determine the environmental effects of the 18 Mart Can thermal power plant fly ash storage site. The ash storage site was examined using 2007 Digital Globe satellite image with 50 cm resolution, and 2013, 2016, and 2017 CNES/Airbus satellite images. The total surface of the ash storage site was calculated as 21.6 hectares in March 2007, 72.1 hectares in December 2013, 89.9 hectares in November 2016, and 93.7 hectares in June 2017. Fly ash is stored directly in an ash pond in the form of wet slurry. Fly ash contains many metals (such as As, Zn, Cu and Pb) some of which are of environmental concern. Batch leaching test was performed to determine the leach of selected metals from fly ash. Manganese showed maximum leachability. As a result, the storage site is likely to adversely affect the environment due to its areal increase over the years and the toxic metals in fly ash.

Keywords: Environmental monitoring, fly ash, leaching test, satellite images, thermal power plant.

1. INTRODUCTION

Coal fly ash, an industrial by-product, is derived from coal combustion in thermal power plants. It is one of the most complex anthropogenic materials, and its improper disposal can cause water and soil pollution, disrupt ecological cycles and pose environmental hazards (Yao et al., 2015). According to the Turkish Statistical Institute (2013), 13 million tons fly ash was stored in fly ash storage sites in 2012 and this amount is expected to reach 50 million tons per year by 2020. The 18 Mart Can thermal power plant is located in the province of Canakkale within the Can coal basin, NW Turkey (Figure 1). Coal mining has been in operation since the 1980s in the Can basin. Low calorific value and high sulphur content coal is extracted in the Can coal basin by General Directorate of Turkish Lignites, as well as a number of private mining companies (Sanliyuksel Yucel and Ileri, 2018). The 18 Mart Can thermal power plant, in operation since 2006, is the first power plant in Turkey utilizing fluidized bed combustion technology. The annual average lignite requirement of this plant is 1.82 million tons (Baba et al., 2010). The 18 Mart Can thermal power plant produces almost half a million tons of fly ash every year. In this study, the aim was to determine the environmental effects of 18 Mart Can thermal power plant fly ash storage site.

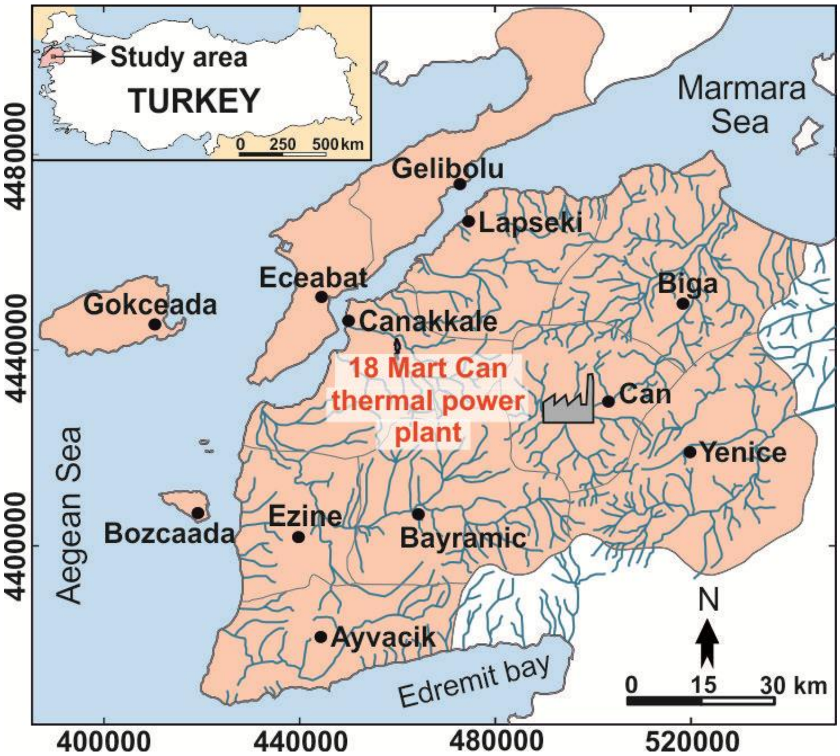

Figure 1. Location map of 18 Mart Can Thermal Power Plant.

2. MATERIALS AND METHODS

To calculate the areal change in the fly ash storage site over the years, satellite images from different years and ArcGIS 10.3 software was used. Satellite images were transformed to Universal Transverse Mercator (UTM) projection World Geodetic System (WGS 84) datum Zone 35 coordinate system with the ArcGIS 10.3 software. Fly ash storage areas were calculated using a DigitalGlobe image dated 15 March 2007 and CNES/Airbus satellite images dated 4 August 2013, 17 November 2016 and 27 June 2017. The satellite images were digitised with the ArcGIS 10.3 software and the area and perimeter of the ash storage site were calculated.

Batch leaching tests were conducted to determine the leach of selected metals (Al, Co, Cu, Fe, Mn, Ni, Pb and Zn) from fly ash at ambient temperature. Ten grams of fly ash was mixed with 100 mL pure water and was agitated at 40 rpm using an orbital shaker for 24 hours contact time. At the end of mixing, pH and EC values of the suspension were measured with a multi-parameter device (WTW 340i) and then fly ash was separated from suspension by filtration through a 0.45 μm membrane filter. The residual concentrations of the metal ions in the supernatant were determined using the inductively coupled plasma-optical emission spectrometry technique (ICP-OES) at Canakkale Onsekiz Mart University Science and Technology Application and Research Center. Each test was repeated at least three times. The percentage error for the experiment was lower than ±5%.

3. RESULTS AND DISCUSSION

The mineralogical, physical and chemical properties of fly ash depend on the nature of coal, conditions of combustion, type of emission control devices and storage and handling methods (Jala and Goyal, 2006; Haynes, 2009). The mineralogical composition of 18 Mart Can thermal power plant fly ash consists of anhydrite, quartz, hematite, cristobalite, lime, calcite, feldspar and magnetite (Sanliyuksel Yucel, 2017). The chemical composition of the fly ash contains 32.24% SiO_2, 20.73% Al_2O_3, 5.57% Fe_2O_3, 0.97% Na_2O, 0.55% MgO, 0.13% MnO and 21.51% CaO and 5.1% LOI (Sanliyuksel Yucel, 2017). Classification of fly ashes was performed using the ASTM C618 standard guidelines (ASTM, 2015). The standard classifies fly ashes into two classifications, Class-F and Class-C. The fly ash is classified as Class-C which have sum of $SiO_2+Al_2O_3+Fe_2O_3$ less than 70 wt.% with maximum LOI of 6 wt.% and are supposed to have cementitious properties in addition to pozzolanic. The particle size distribution of the fly ash ranges between 1.28 and 211 μm. Carbon and sulphur content of fly ash is 1.18 and 4.91 %, respectively. Metal content of fly ash were determined the following in the order As (445 ppm) > Ba (305 ppm) > Zn (67 ppm) > Cu (32 ppm) > Pb (27 ppm) > Co (21 ppm) > Ni (15 ppm). Generally, fly ash particles have an irregular, porous and rarely spherical microscopic structure in scanning electron microscope images (Sanliyuksel Yucel, 2017). The paste pH of fly ash is measured 12.16 when mixed with deionized water 1:2 (solid:solution ratio) at the end of 24 hour.

Batch leaching tests are important in predicting the environmental impacts associated with the disposal into fly ash pond (Ugurlu, 2004). The pH of the leachate (11.8) was strongly alkaline (Table 1). Electrical conductivity of the leachate was measured as 1.95 mS/cm. Leachate metal concentrations were determined to have the following order Mn> Al> Ni> Pb> Fe> Zn> Co> Cu. Mn showed maximum leachability. The leaching of selected metals was low for the studied fly ash. The low metal leaching due to high pH resulted in low contamination of the leachate.

Table 1. Batch leaching test results.

pH	**EC**	**Al**	**Co**	**Cu**	**Fe**	**Ni**	**Pb**	**Mn**	**Zn**
-	mS/cm	mg/L							
11.8	1.95	0.16	0.04	0.03	0.08	0.12	0.09	0.84	0.05

The variation in the area and perimeter of the fly ash storage site through the years is shown in Table 2. The total surface of ash storage site was calculated as 21.6 hectares in March 2007, 72.1 hectares in December 2013, 89.9 hectares in November 2016, and 93.7 hectares in June 2017 (Figure 2). At the end of 10 years, the area of the fly ash storage site increased by 334% while the perimeter increased by 47%. Fly ash is stored directly in an ash pond in the form of wet slurry. As a result, the storage site is likely to adversely affect the environment due to its areal increase over the years and the toxic metals in fly ash.

Table 2. The variation in the area and perimeter of the fly ash storage site through the years.

Date	**Satellite**	**Spatial Resolution**	**Area (ha)**	**Perimeter (km)**
3/15/2007	DigitalGlobe	50 cm x 50 cm	21.6	3.6
8/4/2013	CNES/Airbus	50 cm x 50 cm	72.1	5.1
11/17/2016	CNES/Airbus	50 cm x 50 cm	89.9	5.2
6/27/2017	CNES/Airbus	50 cm x 50 cm	93.7	5.3

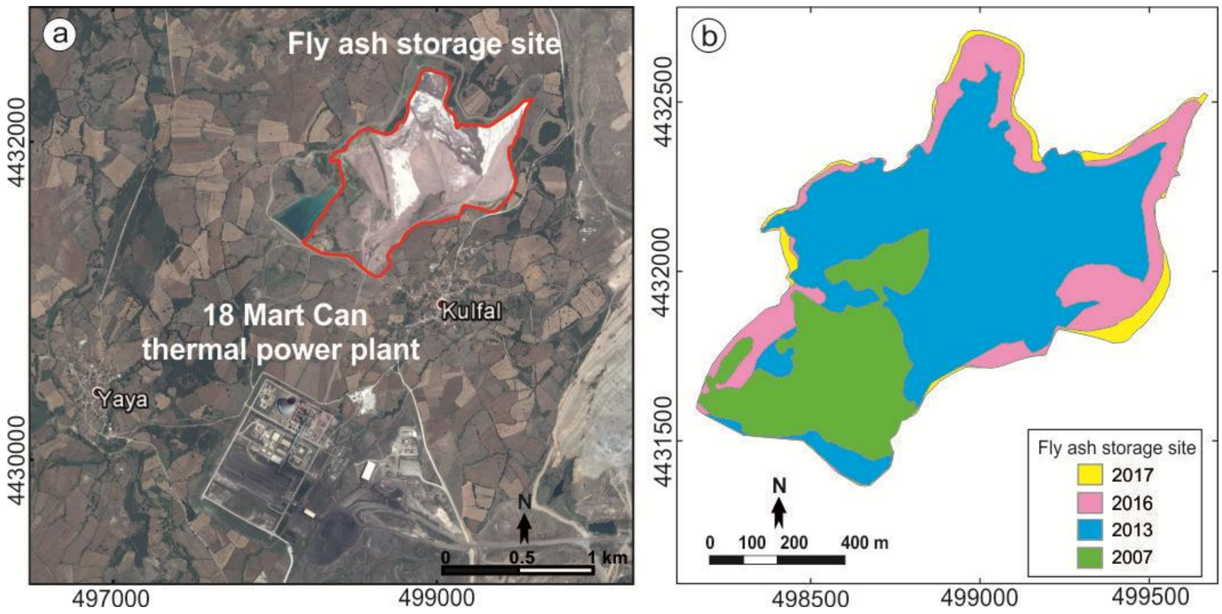

Figure 2a. 2017 year Google earth satellite image from 18 Mart Can Thermal Power Plant **b.** Areal change of fly ash storage site in time period.

4. CONCLUSION

Fly ash contains many metals (such as As, Zn, Cu and Pb) some of which are of environmental concern. The arsenic concentration of fly ash is high (445 ppm). The ash storage site is likely to adversely affect the environment due to its areal increase over the years and the toxic metals in fly ash. Although leaching of selected metals was low for the studied fly ash, it is recommended that continuous monitoring of metal concentration in water sources and soil around the thermal power plant be performed. Fly ash utilization can be evaluated for different sectors (e.g. cement manufacturing, reclamation of abandoned mine sites and/or agricultural land).

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