O 111. THE EFFECT OF CONCENTRATED SOLAR ENERGY ON DRYING OF TREATMENT SLUDGE

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ABSTRACT: Treatment sludge are concentrated wastes including organic or inorganic impurities and resulted from separation process of wastewater treatment plants. Although the sludge is separated by dewatering processes, it contains a large amount of water in its contents. The water content of the non-fluidized sludge cake from the centrifugal dewatering unit varies between 82% and 78% in the Konya wastewater treatment plant. This high-water content in the sludge is a problem that needs to be overcome in the implementation of final disposal or reuse alternatives. It is necessary to increase the solid matter content of the sludge in order to burn, landfilling or to use as fertiliser. Therefore, drying is a mandatory process for these reuse or disposal options. Thermal dryers operated by fossil fuel could be achieve high drying rates, but its cost is disadvantage. Greenhouse type indoor or outdoor drying plants, where the sludge is laid on the floor in a thin layer to benefit from solar energy, have relatively low cost but requires large areas. It is necessary to increase the number of drying options that use the highest level of solar energy. Concentrated solar energy systems are promising alternative to overcome these problems. Parabolic trough types solar collectors where the heat generated at high temperatures is used for industrial application such as production of electricity by steam power. In this study, a mechanism of direct sludge passing through the tube located at the focal point of the parabolic collector was installed to concentrate solar energy on the lower area. The moisture was removed by means of ventilation while the sludge was heated in the metal tube. It was observed that the solid matter content increased from 21% to 64% on a day where the average solar radiation is 1047 W/m^2 and the sludge flow rate of 29 g/min.

Keywords: Treatment sludge, parabolic trough type solar collector, drying, solar energy

1. INTRODUCTION

The produced wastewater of Turkey has been increased from 2.3 billion m^3 (%52 treated) in 2001 to 4.5 billion m^3 (%86 treated) in 2016. Municipalities had 126 treatment plant in 2001 and this number increased to 881 in 2016(Anonim, 2017b; Nas, 2017a). The increase of treated waste water directly increases the amount of sewage sludge. In 2016, about 300000 tons of sludge on dry matter basis was formed in municipalities (Anonim, 2017c). Konya wastewater treatment plant produced 35.000 tons of stabilized sludge cake in 2017. Treatment sludges were applied to 2.7 million m^2 area in Konya for agricultural(Anonim, 2017a). Treatment sludges are often stored on land as regular or irregular in Turkey (İnsel, Arıkan, & Ayol, 2013). Regardless of the disposal method, the sludge cake is reduced in water but the dried product contains at least 70% water. Doubling the sludge dry matter ratio allows the sludge volume decrease to about 50% (Filibeli, 2013). A large reduction in weight and volume of sludge facilitates transport of sludge and increases the possibility of disposal as an additional fuel. Also, the potential for agricultural use increases as the pathogenic activity of dry sludge decreases. Reducing the water content will eliminate the problem of leachate in landfills, thus reducing the impact of disposal on the natural environment (Öztürk, Çallı, Arıkan, & Altınbaş, 2015).

Solar drying in open area or in green house and thermal drying methods have been used in the world as well as Turkey (Öztürk et al., 2015). There are eleven thermal drying and six greenhouse type solar drying plant in Turkey (Nas, 2017b). It is necessary to focus on the low-cost and low-area drying by efficiently using of the solar energy (Hanif et al., 2013). Parabolic trough type solar collectors are mostly used in industrial applications and electricity generation by heating fluids (Kalogirou, 2002). Some applications have been made on the use of heated air for drying the plants by passing air through the

receiving pipe (Karıukı, 2014). However, there is limited study in the literature on the sludge drying with parabolic trough type solar collectors.

2. MATERIALS AND METHODS

The parabolic groove was drawn to the parabola chart that's going to set the reflector to provide heat generation in the desiccant tube (Anonim, 2019). The equation of the parabola focal point is expressed as $f=x^2/4y$ (Elmas, 2019). The parabola curve was drawn with a computer aided design (CAD) program and this curve was used to form the design of the reflector bed. Polished aluminum sheet (Almeco Vega 95100), which reflects high solar radiation and has low absorption rate, is preferred as reflector. The desiccant tube was designed as conveying and mixing the sludge with spiral, to be possible sludge/air inlet and outlet with chimneys, coating with 0.40 mm solar energy selective surface (Almeco tinox) on the outer wall and external glass sheath to prevent heat loss (Figure 1). Drying experiments were conducted in October and November 2018 in Konya waste water treatment plant. Avarage air flow of 360 L/min was applied by an air supplier. The open area of parabolic reflector was 4.3 m^2. Solar radiaton was measured with solar sensor in W/m^2 (Ingenieurbüro Mencke & Tegtmeyer GmbH SiS-01TC-DMM sensor and Victor 86C dijital multimeter). The amount of dry matter of sludge was measured by Ohaus mb45.

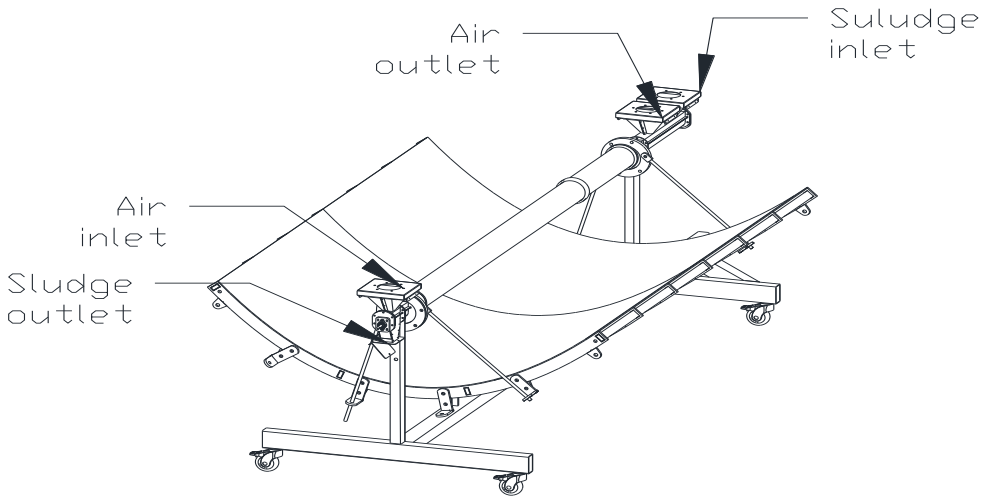

Figure 1. Parabolic trough type solar collector and desiccant tube

3. RESULTS AND DISCUSSION

In the experiment carried out on October 16, where solar radiation was lower than other days, a dry matter (DM) content of 47% was achieved (Table 1). This shows that ventilation plays an effective role in the drying process even if the heat energy is reduced. On October 9, when the weather was generally cloudy; solar radiation and temperatures were lower. Since the weather became completely cloudy in the last fifty minutes of the study, no sun tracking was performed during the last fifty minutes. However, on such a day when the amount of solar energy is fluctuating, the average KM rate doubles compared to the raw sludge. On 1 November, when solar radiation was high; dry matter rate reached to 60% with 28 g/min sludge feed. The solid matter content increased from 18% to 47% on a day where the average solar radiation is 882 W/m^2 and the sludge flow rate of 33 g/min. On another day when the radiation and the flow rate were 1047 W/m^2 and 28.6 g/min, the solids content increased from 21% to 64%.

In the study carried out on the first day of November (Figure 2), the outlet air temperature started to fall from 41.5°C at 11:40 am, although the solar radiation increased, and was measured as 34.6°C at 12:00. This is due to some heat transfer to the sludge supplied to the system at the start of the work. Sludge feeding and sun tracking were finished at 14:00 and 14:20, respectively. After the end of the solar tracking, an increase in the effluent air temperature was observed. This probably due to decreasing of the heat transfer to the sludge over time after the sludge feeding is finished at 14.00, as the sludges left in the system are thrown out.

Table 1. Drying data for trials at different times

		9 October		16 October		1 November	
Sludge amounts (g)		9000		8000		4000	
Flow rate of sludge mass (g/dk)		37,5		33,1		28,6	
Solar radiation (W/m²)	**Min.**	550		469		1032	
	Average	904		882		1047	
	Max.	1086		963		1058	
Influent air temperature (°C) and relative humidity (%)		**°C**	**%**	**°C**	**%**	**°C**	**%**
	Min	23	27	22	37	16	30
	Average	25	31	24	41	20	36
	Max.	26	35	26	47	21	51
Effluent air temperature (°C) and relative humidity (%)	**Min.**	29	35	30	10	31	31
	Average	33	69	35	62	34	55
	Max.	37	86	60	88	42	75
Desiccant tube temperature (°C)	**Min.**	40		40		50	
	Average	68		72		68	
	Max.	78		110		80	
Solid matter of raw sludge (%)		19		18		21	
Solid matter of dried sludge (%)		43		47		64	

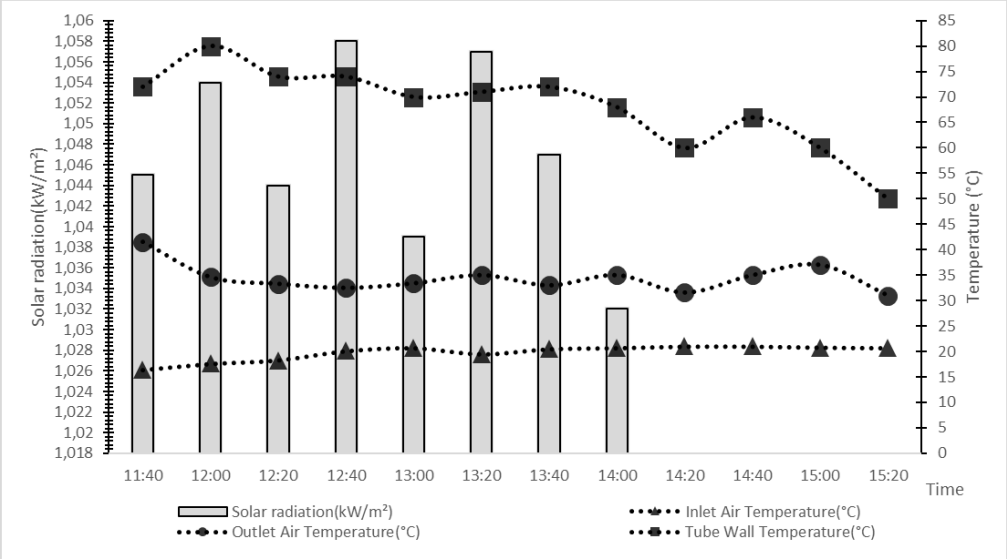

Figure 2. The solar radiation and temperature change on November 1, 2018

4. CONCLUSION

In this study, dry matter of dewatered sludge increased from 21% to 64% in 170 minutes by concentrating of the solar radiation. However, the system can be rapidly affected by changes in solar radiation. It is recommended that the measurements of the solar radiation and air temperature/humidity in desiccant tube may be connected to the automation. Thus, it can be provided that the spiral movement which provides the advancement of the sludge changes depending on the measurements made. It can be dried more amounts of sludge if the drying system would designed using serial collectors or parabolic reflectors having larger area.

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