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THE POTENTIAL OF AGRICULTURAL RESIDUES IN THE DISTRICTS OF ADANA

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ABSTRACT

The aim of this study was to determine the biomass potential and the energy value, being produced from agricultural residues in Adana province. Adana is a province of Turkey on the Mediterranean Region which is divided into 15 districts. The amounts of residues from the agricultural crops cultivated in Adana province were calculated using production data of crops with Turkish Statistical Institute for the 2018 seasonal years. The annual gross potential of agricultural residues was determined by using residue to product ratio. The energy potential of residues for each districts was calculated by multiplication of the calorific values of agricultural residues with the available residue amount. The total amount of agricultural residues was approximately 1,768.8 kt.year^{-1}. It was found that the total calorific value of the agricultural residues was around 31.48 PJ.year^{-1} for the production period of 2018 in the province. When districts put in order according to the amount of agricultural residues, the top five districts of Adana are Ceyhan (546.1 kt), Yüreğir (350.4 kt), Karataş (214.3 kt), Kozan (164.43 kt) and Seyhan (141.44 kt). The major crops included in the ratio of the total agricultural residues were maize (54.3%), cotton (18.9%), sunflower (11.2%) and citrus (6.3%). Additionally, the data obtained in order to see the distribution of residues more clearly is mapped.

1. INTRODUCTION

Energy is central to economic development, and there is a clear correlation between energy consumption and living standards. Energy sources are split into three categories: fossil fuels, renewable sources and nuclear sources (Karaca, 2015). The valid global energy supply depends heavily on fossil sources (crude oil, lignite, hard coal, natural gas). The World's economies are dependent on crude oil. Fossil fuels are limited resources, collected in few regional areas of the world. This creates a permanent and insecure status of dependency on import of energy for the countries of outside this region.

Conventional biomass plays a considerable role in energy production in Turkey. Wood is used as a major resource for direct cooking and heating in rural areas, but the use of modern biomass for energy production is a rather recent event. Turkey is an agricultural country; moreover, it has significant forestry potential, especially in the Central Anatolia, Çukurova, and Southern Anatolia regions. Even though the main goal is harvesting cereals and other seeds in agriculture, there is a strong wish to reclaim buried agricultural waste. Agricultural waste is a major source of biomass due to its high potential (Karaca and Başçetinçelik, 2014).

Turkey has always been one of the major agricultural countries in the world. The importance of agriculture is increasing for biomass energy is one of the major resources in Turkey. Biomass waste materials can be used in Turkey to provide centralized, medium- and large-scale production of process heat for electricity generation. Electricity generation from biomass has been found to be a promising method in the nearest future in Turkey (Karaca, 2015).

Biomass energy includes agricultural residues, domestic waste, fuelwood, animal waste and other fuel derived from biological sources. Estimation is based on the recoverable energy potential from the main agricultural residues, livestock farming waste, forestry and wood processing residues and domestic waste as given in the

literature. Biomass which comprising mostly wood and dung for heating and cooking is mainly used in rural areas (Başçetinçelik et. al. 2005)

Agricultural residues are defined as a biomass by-product from the agricultural system and include straws, husks, shells, and stalks. These residues can be divided into two groups: crop residues, which remain in the field after harvest including cotton stalk, and agricultural residues, which are the by-products of the industrial processing of crops such as rice husk. (Karaca, 2015)

This study aimed to determine the biomass potential and the energy value, being produced from agricultural residues in Adana province. The major benefits are environmental and relate to the reduction of GHG emissions (since crops are considered CO_2 neutral), conservation of natural resources, and avoidance of fossil fuel consumption. They are complemented by economic benefits (reduction of imported fuel consumption), regional development and investment increase.

2. MATERIAL AND METHODS

Adana Province is a province of Turkey on the Mediterranean Region. Adana province is divided into 15 districts, four of which (Seyhan, Yüreğir, Çukurova and Sarıçam) are included in the municipality of Center district. Other districts include Aladağ, Ceyhan, Feke, İmamoğlu, Karaisalı, Karataş, Kozan, Pozantı, Saimbeyli, Tufanbeyli and Yumurtalık.

Grains and industrial crops have the most important place regarding production area and amount of product in the production of agricultural products of Adana. The province has 486,102 hectares of agricultural land. Field crops constitute 75.7% of the agricultural land and fruit, vegetable and fallow lands constitute the rest. Maize, wheat, cotton, sunflower and groundnut are the prominent products in the province. (TUIK, 2018a)

The amounts of residues from the crops cultivated in Adana province were calculated using production data of crops with Turkish Statistical Institute for the 2018 seasonal years (TUIK, 2018b). The annual gross potential of agricultural residues was determined by using residue to product ratio (RPR) (Table1).

The net potential of residues was determined by using the availability of residues. The availability of residues is unused and completely wastes part of residues (Table1). The available potential of the agricultural residues in each district of Adana was calculated based on the Eq.1.

$$(AAR)_i = (AAP)_i \; x \; (RPR)_i \; x \; (A)_i \qquad (1)$$

where $(AAR)_i$ is the available amount of agricultural residues of i^{th} crop in ton, $(AAP)_i$ the amount of agricultural product in tons or number of tree for pruning wastes, $(RPR)_i$ residue-to product ratio of the i^{th} crop and $(A)_i$ the availability of residues.

The residues are material left over the field after agricultural production. Some agricultural residues have already been used for domestic purposes, heating, animal fodder, bedding. Mainly residues from the production of industrial, agricultural products are left over the field. The species are cotton stalk, maize stalk, sunflower stalk, cereal straw, pruning, etc.

The energy potential of residues for each district was calculated by multiplication of the heating values of a selection of agricultural residues which was taken heating value per each residue (Table 1) with the available residue amount (Eq. 2).

$$(THV)_i = (AAR)_i \; x \; (LHV)_i \qquad (2)$$

where $(THV)_i$ the total heating value of agricultural residues of i^{th} crop in GJ, $(AAR)_i$ is the available amount of agricultural residues of i^{th} crop in tons and $(LHV)_i$ lower heating value of air-dry residues of i^{th} crop in MJ kg^{-1}.

The energy content of the selected products for each district was calculated using the above equations. For each district, the calculated values that the total amount and the total energy potential of agricultural crop residues were mapped using the GIS software. The produced maps were provided to see more clearly in the differences of data among the districts. The mapping can provide the rise of public awareness and policy-makers' reference about these subjects.

Table 1. The ratio of product to residue, availability and heating values of a selection of agricultural crop residues (Başçetinçelik et. al., 2006; Velázquez-Martí et. al., 2013; Karaca, 2015)

Field Crops	Residues	Ratio of Product to Residue (*RPR*)	Availability (*A*) (%)	Heating Value (*LHV*) (MJ/kg)

Wheat	Straw	1.00	15	17.9
Barley	Straw	0.75	15	17.5
Maize	Stalks	1.60	60	18.5
	Cob	0.30	60	18.4
Cotton	Stalks	2.30	60	18.2
	Ginning residues	0.30	80	15.7
Sunflower	Stalks	2.50	60	14.2
Groundnut	Shell	0.40	80	18.4
Fruits Crops				
Olive	Cake	0.40	90	19.7
	Pruning	4*	50	18.1
Walnut	Pruning	10*	50	19.0
Almond	Pruning	7*	80	18.4
Peach	Pruning	8*	80	19.4
Lemon	Pruning	13*	80	17.6
Orange	Pruning	15*	80	17.6
Mandarin	Pruning	13*	80	17.6

* RPR kg/tree

3. RESULTS AND DISCUSSION

The total amount of agricultural residues, including annual crop residues (cereals, maize, cotton, sunflower, groundnuts), perennial residues (tree pruning) and agro-industrial residues (cotton-ginning, seed oil industries, olive oil industries), were calculated to be about 1,768.8 thousand tons in Adana (Table2). Its distribution by the source is field crops (91.95%) and fruit crops (8.05%). Major crops that included in the ratio of the total residue amount are maize (54.3%), cotton (18.9%), sunflower (11.2%), wheat (5.8%) and groundnuts (1.7%). On the other hand, the share of citrus pruning wastes in total agricultural waste is 6.3%.

Table2. The amount of agricultural product and available residues of Adana

Field Crops	Amount of Agricultural Product (*AAP*) (tons)	Residues	Available Residues (*AAR*) (tons)
Wheat	681,905	Straw	102,286
Barley	14,796	Straw	1,665
Maize	842,697	Stalks	808,989
		Cob	151,685
Cotton	206,143	Stalks	284,477
		Ginning	49,474
Sunflower	131,639	Stalks	197,459
Groundnut	94,954	Shell	30,385
Fruits Crops			
Olive	35,900	Cake	12,924
	2,848,927*	Pruning	12,820
Walnut	149,700*	Pruning	749
Almond	277,208*	Pruning	1,552
Peach	508,965*	Pruning	3,257
Lemon	2,416,308*	Pruning	25,130
Oranges	2,818,322*	Pruning	33,820
Mandarin	5,011,632*	Pruning	52,121
TOTAL		**Residues**	**1,768,793**

* Number of trees

When all districts of Adana are aligned according to the amounts of residue, an alignment is as in Table 3. Also, the distribution map of agricultural residues which mapped using a GIS Software for each district was given Figure1.

Table 3. The alignment of districts according to amount of agricultural residues

Districts	Field Crops Residues (tons)	Fruit Crops Residues (tons)	Total Residues (tons)	Share in Total Residues (%)
Aladağ	6,659	387	7,045	0.40
Ceyhan	539,616	6,485	546,101	30.87
Çukurova	18,403	2,955	21,359	1.21
Feke	1,119	243	1,363	0.08
İmamoğlu	72,727	2,413	75,140	4.25
Karaisalı	56,506	5,872	62,377	3.53
Karataş	199,027	15,247	214,274	12.11

Kozan	140,345	24,085	164,430	9.30
Pozantı	80	233	313	0.02
Saimbeyli	1,124	154	1,278	0.07
Sarıçam	78,917	5,059	83,975	4.75
Seyhan	116,768	24,670	141,438	8.00
Tufanbeyli	5,498	267	5,766	0.33
Yumurtalık	88,416	5,113	93,529	5.29
Yüreğir	301,216	49,190	350,406	19.81
TOTAL	**1,626,420**	**142,373**	**1,768,793**	**100.00**

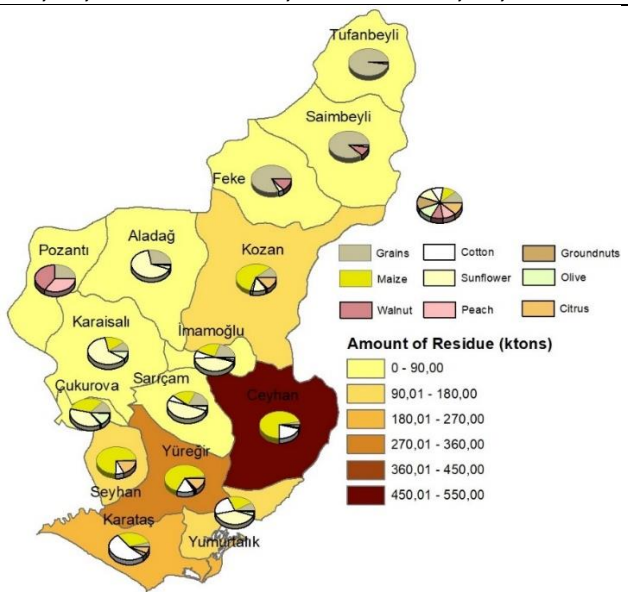

Figure 1. The distribution map of agricultural residues in Adana

30.87% of total residues in Adana were found to originate from the Ceyhan district. Apart from this, also the Yüreğir district is seen to have a high agricultural residue potential (350.4 ktons). It is believed that there will not be a shortage of raw materials for the investment and facilities to be made for obtaining energy from agricultural residues in these two districts.

Table 4. Total heating value of agricultural residues of Adana

Field Crops	Residues	Total Heating Value (*THV*) (GJ)
Wheat	Straw	1,830,915
Barley	Straw	29,130
Maize	Stalks	14,966,299
	Cob	2,791,012
Cotton	Stalks	5,177,488
	Ginning	776,747
Sunflower	Stalks	2,803,911
Groundnut	Shell	559,089
Fruits Crops		
Olive	Cake	254,603
	Pruning	232,045
Walnut	Pruning	14,222
Almond	Pruning	28,564
Peach	Pruning	63,193
Lemon	Pruning	442,281
Orange	Pruning	595,230
Mandarin	Pruning	917,329
TOTAL		**31,482,056**

It was calculated that the total heating value of the agricultural residues was about 31.5 PJ (752 ktoe) for the production period of 2018 in Adana. The heating value of agricultural residues that calculated separately for each product is given in Table 4. The distribution map was given Figure 2.

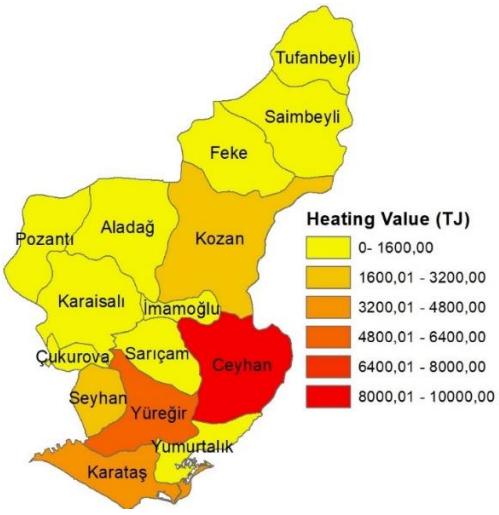

Figure 2. The distribution map of heating value based on agricultural residues in Adana

These maps (Figure1 and 2) showed that the potential of agricultural residues concentrated in the Ceyhan and Yüreğir districts. Especially, it is observed that the type and distribution of residues in Ceyhan district, the distribution of agricultural residues according to heating value is ranked as maize (71.8%), cotton (21.5%) and wheat (2.9%) respectively. In Yüreğir, this ranking consists of maize (65.8%), cotton (16.2%) and citrus pruning (12.7%) respectively. However different crop residues are remarkable in a certain district. Grains (wheat and barley) have a share of 80.3% in Feke, 85.7% Saimbeyli and 95.1% in Tufanbeyli, while in other districts, these distributions are as follows; 51.6% of cotton in Karataş, 55.9% of sunflower in Karaisalı and 75.8% of walnut and almond in Pozantı.

The potential of biomass from agricultural residues was determined in Samsun province. The total biomass potential was determined as 366.6 ktons in the province. (Karaca et. al., 2017).

A study carried out by Karaca and Öztürk (2017) in Osmaniye province indicated that the total biomass potential from agricultural residues was 491 ktons.

Karaca (2018) reported the amount of biomass from agricultural residues was about 380.8 ktons, equivalent to about 6,517.8 TJ of heating value in Balıkesir.

Despite these facts, until now, there has not been any investment in these areas related to agricultural residues, which have a great potential for conversion to energy. However, the results of this study show that such a large potential necessarily has to be evaluated by establishing modern facilities.

4. CONCLUSIONS

This study aimed to determine the distribution of agricultural residues in districts of Adana as given on the map. The importance of this paper is increasing more because Turkey is an energy importing country. Adana is in the second place with a share of 9.1% in Turkey, especially regarding the potential for field crops residues (Karaca, 2015).

The total amount of agricultural residues was approximately 1,768.8 kt. It was found that the total heating value of the agricultural residues was around 31.5 PJ for the production period of 2018. It was determined that this potential concentrate in the Ceyhan, Yüreğir and Karataş districts. It was seen that the majority of agricultural residues originate from field crops. According to the amount of residues of agricultural products, it is listed as, maize (54.3%), cotton (18.9%), sunflower (11.2%), wheat (5.8%) and groundnuts (1.7%).

Although Adana province has a large biomass energy potential, this potential cannot be adequately assessed. In this paper, the produced maps were provided to see more clearly in the differences of data among the districts. The mapping can provide the rise of public awareness, policy-makers' reference and investor's guide about these subjects.

Consequently, agricultural residues are a very attractive choice, since it is economical, sustainable, environmental friendly and a familiar energy source for Adana.

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