Bioeconomy in Agricultural Conference

Available residues and potential utilization of biochar in farm-lands for Turkey

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Torrefaction

Thermo-chemical

- Pyrolysis
- Gasification
- Combustion

Slow pyrolysis

TORREFACTION

Approximately at 300°C

Bio-chemical

- Alcohol Fermentation
- Anaerobic Fermentetion

Physico-chemical

- Trans-esterification
- Pelletization

Torrefaction

Source: Stela drying Technology

- By-product of other thermal processes

  Drying/Grindability/Long term storage

Source: NSW DPI - Sugarcane Trials

- Soil amendment

  Useable carbon source

- Alternative fuel to coal

  %30 Higher volumetric energy density

Source: Newspaper of Turkey

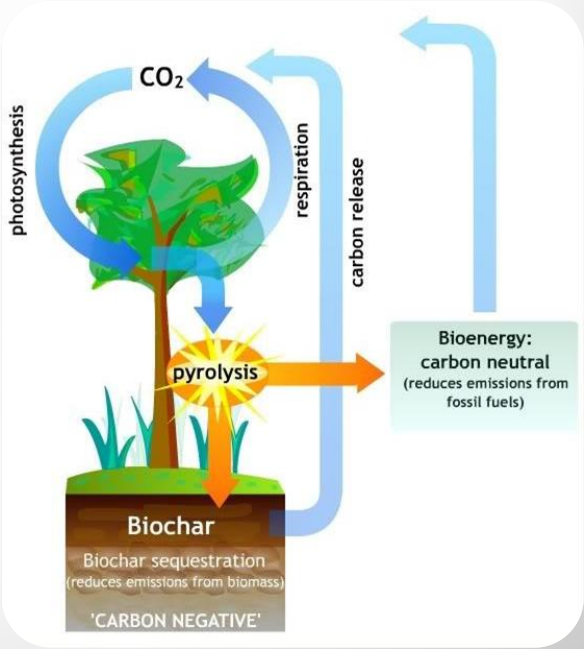
Important Reason For Utilization in Short Term

- A key technology

  to reach a 50% CO_2-eq. emission reduction in the energy sector by 2050 compared to 2005 levels

- Systems are carbon negative

  by transforming the carbon in biomass into stable carbon structures in biochar which can remain sequestered in soils for hundreds and even thousands of years.



Field Application in Australia

- Biochar produced from poultry litter at 450°C and 550°C
- Application to radish production in soil quality of a hardsetting Chromosol (Alfisol)
- ✓ The yield increased, compared with the unamended control field from 42% at 10 t/ha to 96% at 50 t/ha of biochar application

- Sweet corn 59 days after sowing (8 Feb 2008)
- Field trial growing corn in a ferrosol amended with different rates of agrichar.
- ✓ resulted in 35 tonnes of fresh corn produced, compared to 16 tonnes of fresh corn with no agrichar.

0 t/ha Agrichar

50 t/ha Agrichar

Source: Chan et al., 2008; NSW Department of Primary Industries, Best Energy

Yield Increases Based On Different Crops

TYPE OF CROP	AUTHORS	LOCATION	TYPE OF SOILS	QUANTITY of BIOCHAR (t/ha)	YIELD INCREASES (%)
Rice	Asai et al.	Houay-Khot, Nord du Laos	upland	8	70%
Rice	Steiner et al.	Manuas, Brésil	xanthic ferralsol / laterite	11	73%
Rice	Masulili et al.	Sungai Kakap, Indonesia	acid sulphate soil	10	93%
Sugarcane	Chen et al.	Okinawa, Japan	shimajiri maji (clay)	7,2	78%
Tomato	Effah et al.	Kade, Ghana	forest ochrosol	7	177%
Cotton	Reddy	Midjil Mandal, Andrha Pradesh, India	alkaline	3,75	100%
Cabbage	Carter et al.	Siam Reap, Cambodia	sandy acidic	100	750%
Maize	Major et al.	Llanos Orientales, Colombia	savanna oxisol	8 20	71% 140%
Maize	Kimetu et al.	Vihiga, western Kenya	highly degraded ultisol	6	71%
Peanut	Islami et al.	Malang, Indonesia	clay loam	15	54%
Cowpea	Tagoe et al.	Gifu, Japan	sandy loam	-	146%
Onion	Pro-Natura	Senegal	-	10	50%
Wheat	Van Zwietan	NSW, Australia	ferralsol	15	170%
Wheat	Vaccari et al.	Postoia, Italy	silty loam	30	33%
Canola	Pervej-Ahmed et al.	Saskatchewan, Canada	brown loam soil	1	20%
Barley	Gathorne-Hardy et al.	United Kingdom	light soil	20	43%

Source: http://www.pronatura.org/?page_id=521&lang=en

Soil Effect of Biochar

- Inorganic contaminants can be absorbed to biochar surfaces because of their large surface area and cation exchange capacity.

- It may cause a direct risk for soil biota.
  - ✓ For long term use, the stability of biochar in soil must be investigated and the interactions between biochar and soil biota unambiguously identified.

Source: Beesley et al., 2011, Lehmann et al. 2011; Mynott, 2014

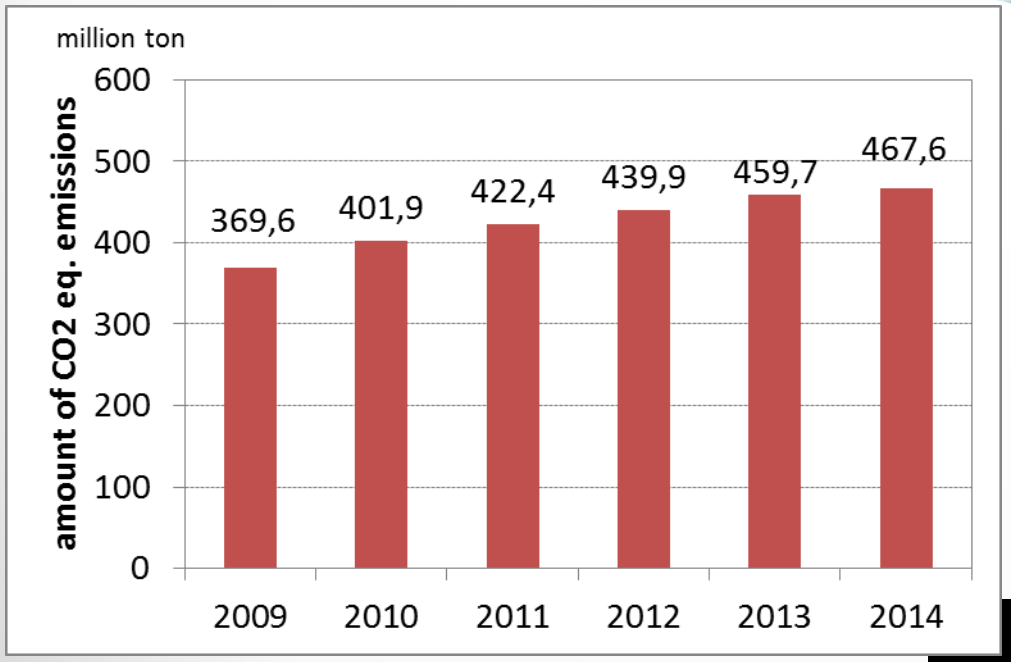
Biochar Standards

	EBC standard	IBI standard
Carbon Content	C >50% (db)	minimum<10% Class 1: ≥60 Class 2: ≥30% and <60% Class 3: ≥10% and <30%
H/C_{org} and O/C_{org}	<0.7 and <0.4	<0.7
Heavy metal As, Cd, Cr, Co, Cu, Ni, Pb, Hg, Mo, Se, Zn, B [mg/kg_{db}]	basic: Cd< 1,5; Cr < 90; Cu < 100; Pb < 150; Hg < 1; Ni< 50; Zn< 400 premium: Cd< 1; Cr < 80; Cu < 100; Pb < 120; Hg < 1; Ni< 30; Zn< 400	As 13 – 100; Cd 1,4 – 39; Cr 93 – 1200; Co34 – 100; Cu 143 – 6000; Pb 121 – 300; Hg 1 – 17; Mo5 – 75; Ni 47 – 420; Se 2 – 200; Zn416 – 7400; B Declaration
PAH (EPA)	basic: <12 mg/kg_{db} premium: <4 mg/kg_{db}	6 – 300 mg/kg_{db}
pH Value	<10	Declaration
BET Surface Area	>150 m^2/g_{db}	Declaration
PCB, Dioxins/Furans	<0,2 mg/kg_{db} <20 ng/kg	<0,2 mg/kg_{db} <17ng/kg

Total N, nutrients, electrical conductivity, Volatile matter, bulk density, moisture etc.

Source: http://www.european-biochar.org/biochar/media/doc/IBI-EBC.pdf

CO_2 eq. emissions of Turkey



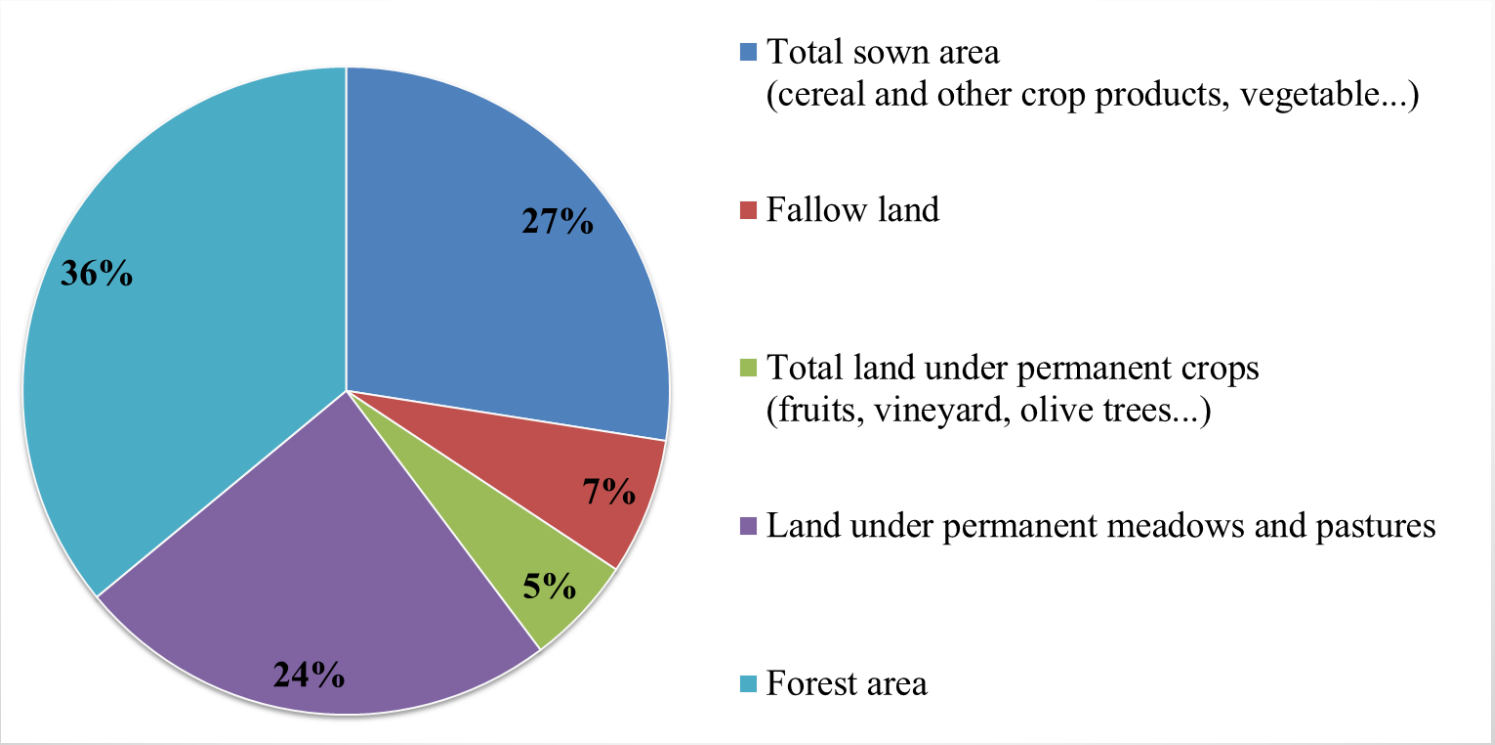
CO2 eq. emission distribution

Sector	2009	2014
Energy	% 75,3	%72,5
Industrial process	%8,6	%13,4
Agriculture	%6,9	%10,6
Waste	% 9,2	%3,5

Source: Turkish Statistical Institute

Distribution of Agricultural Land

- In 2015, the total utilized agricultural land and forest area in Turkey was 60,244 thousand hectares.

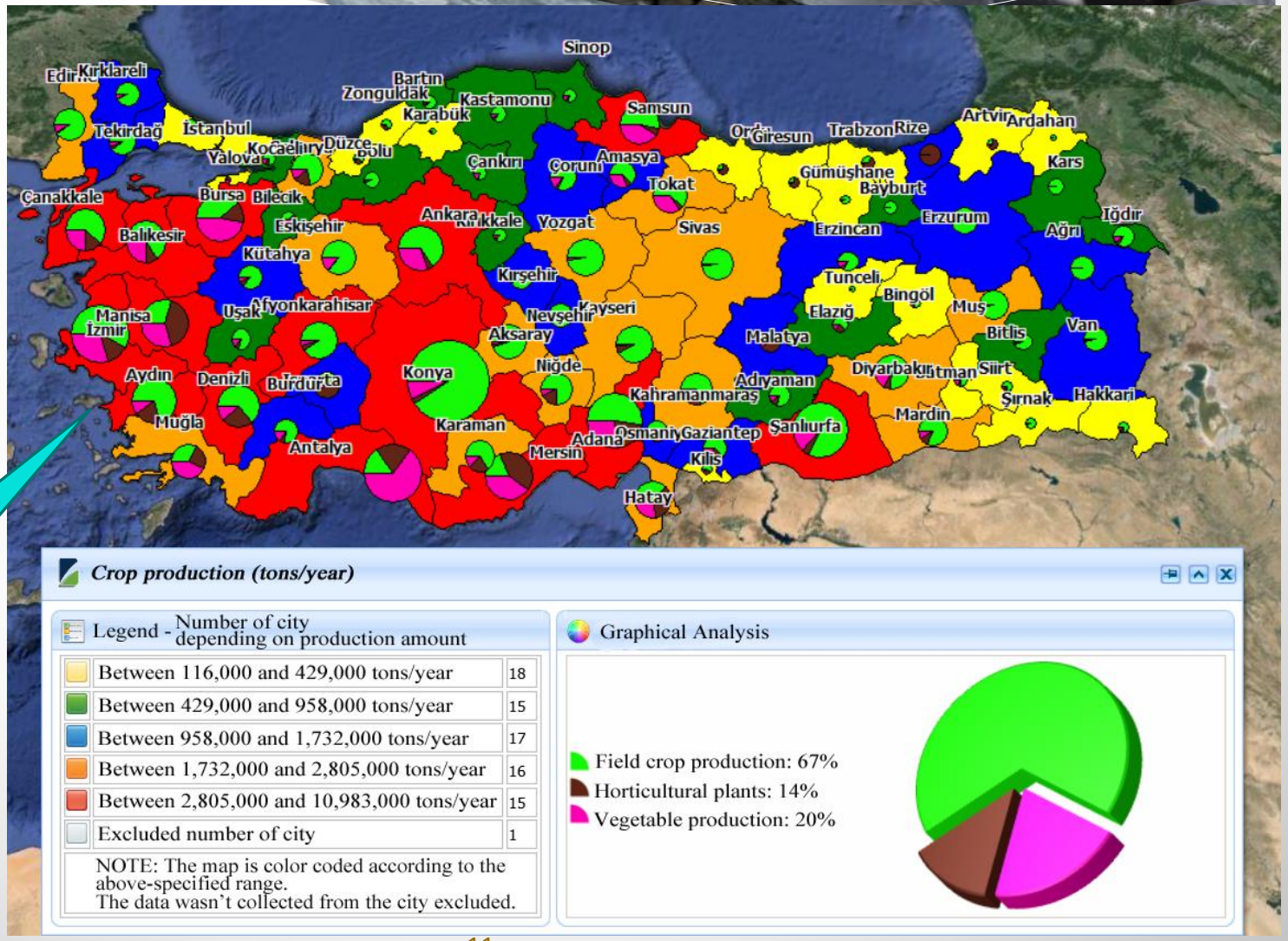


Source: Turkish Statistical Institute

Distribution of Crop Production

Wheat
Vicia
Medicago sativa
Sainfoin
Barley
Potato
Sunflower

Cotton
Tobacco
along the coastline



Source: Ministry of Energy and Natural Resources - Turkish Biomass Energy Potential Map

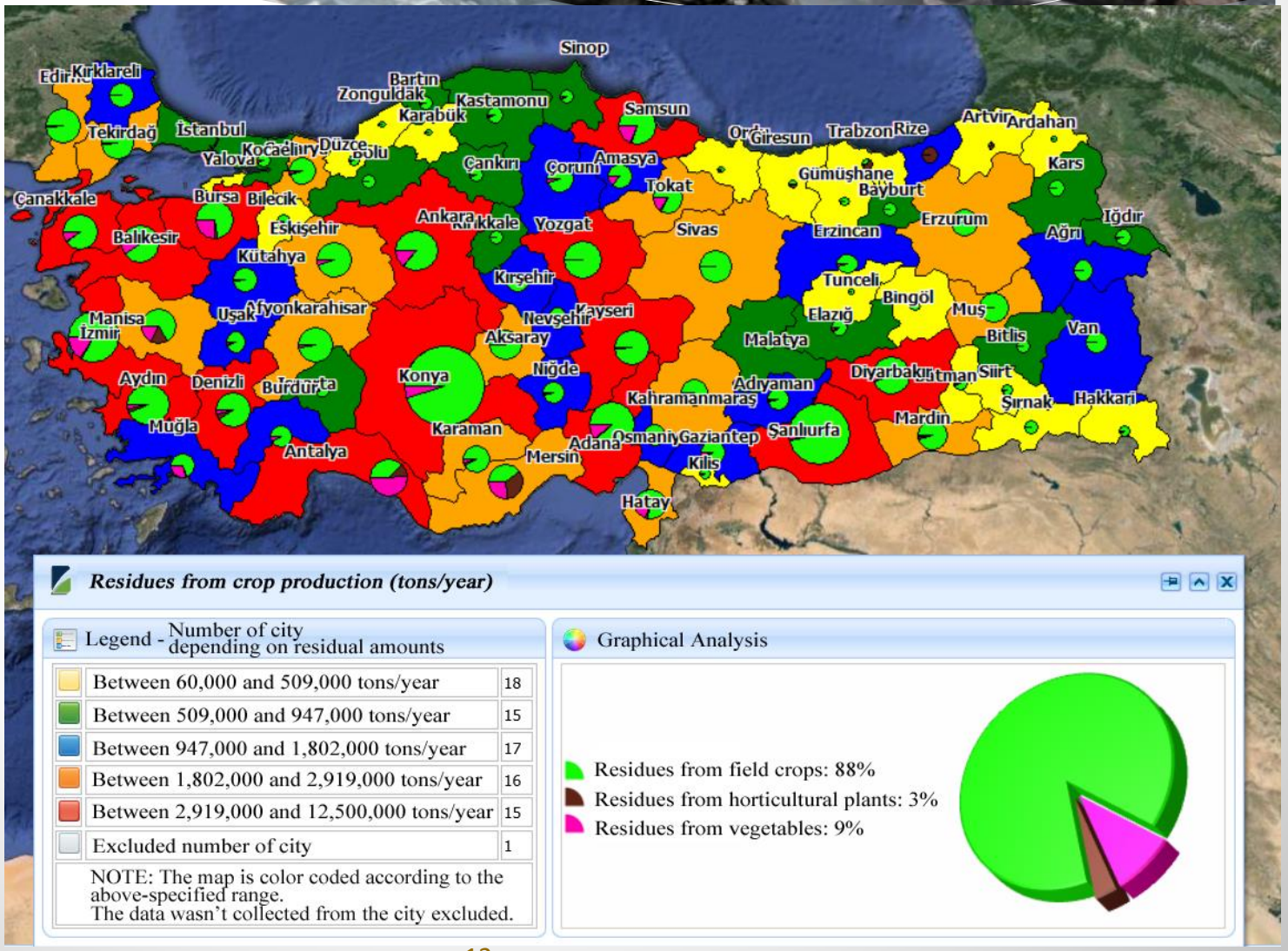
Distribution of Residues from Crop Production

Total amount of residues: 142 million ton/year in 2015

Its energy content : 669 million GJ

Wheat
Barley
Cotton stalk
Corn stalk

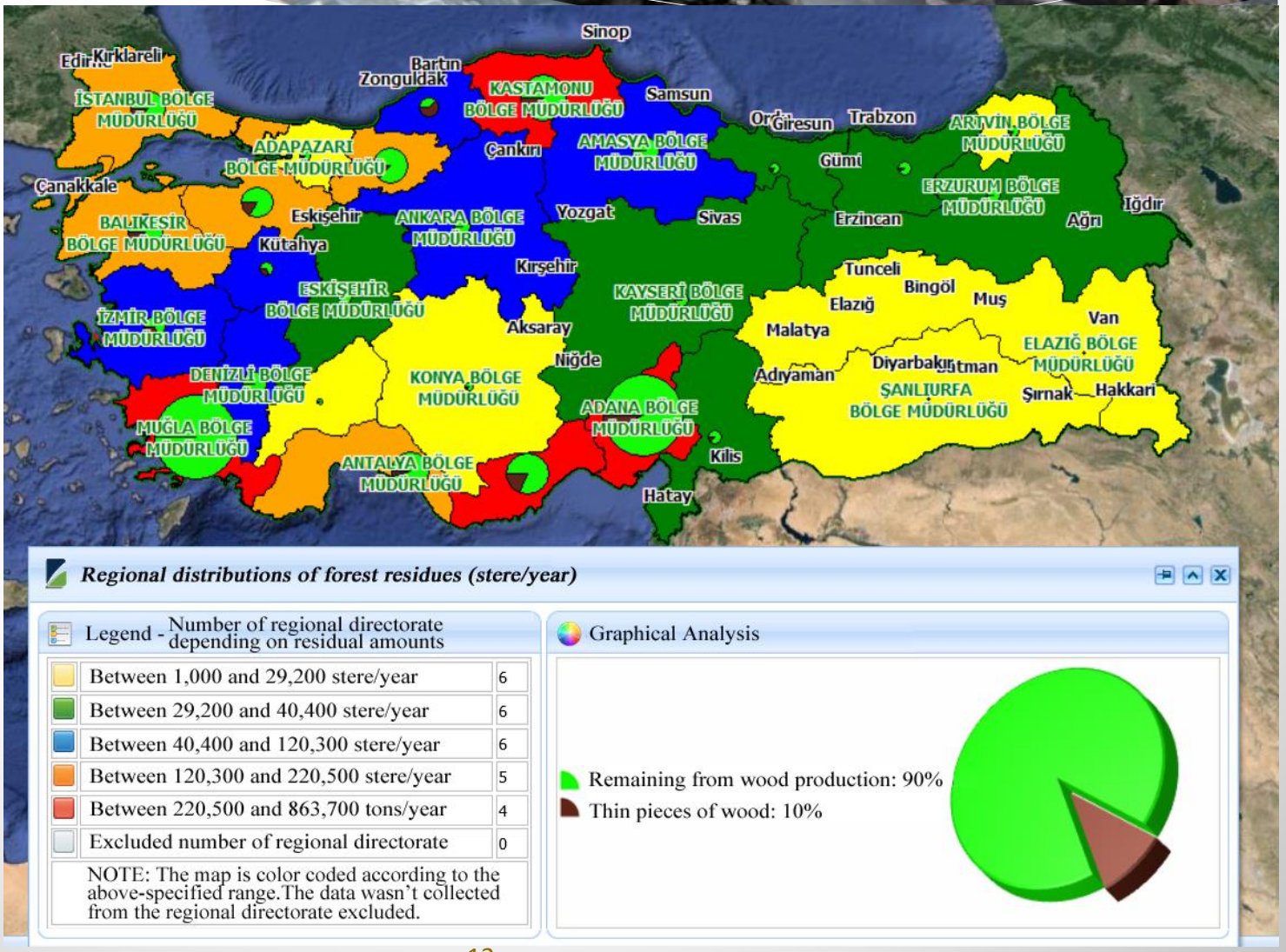
Residues from fruit production: 75 million GJ 56% hazelnut %30 olive tree residues



Source: Ministry of Energy and Natural Resources - Turkish Biomass Energy Potential Map

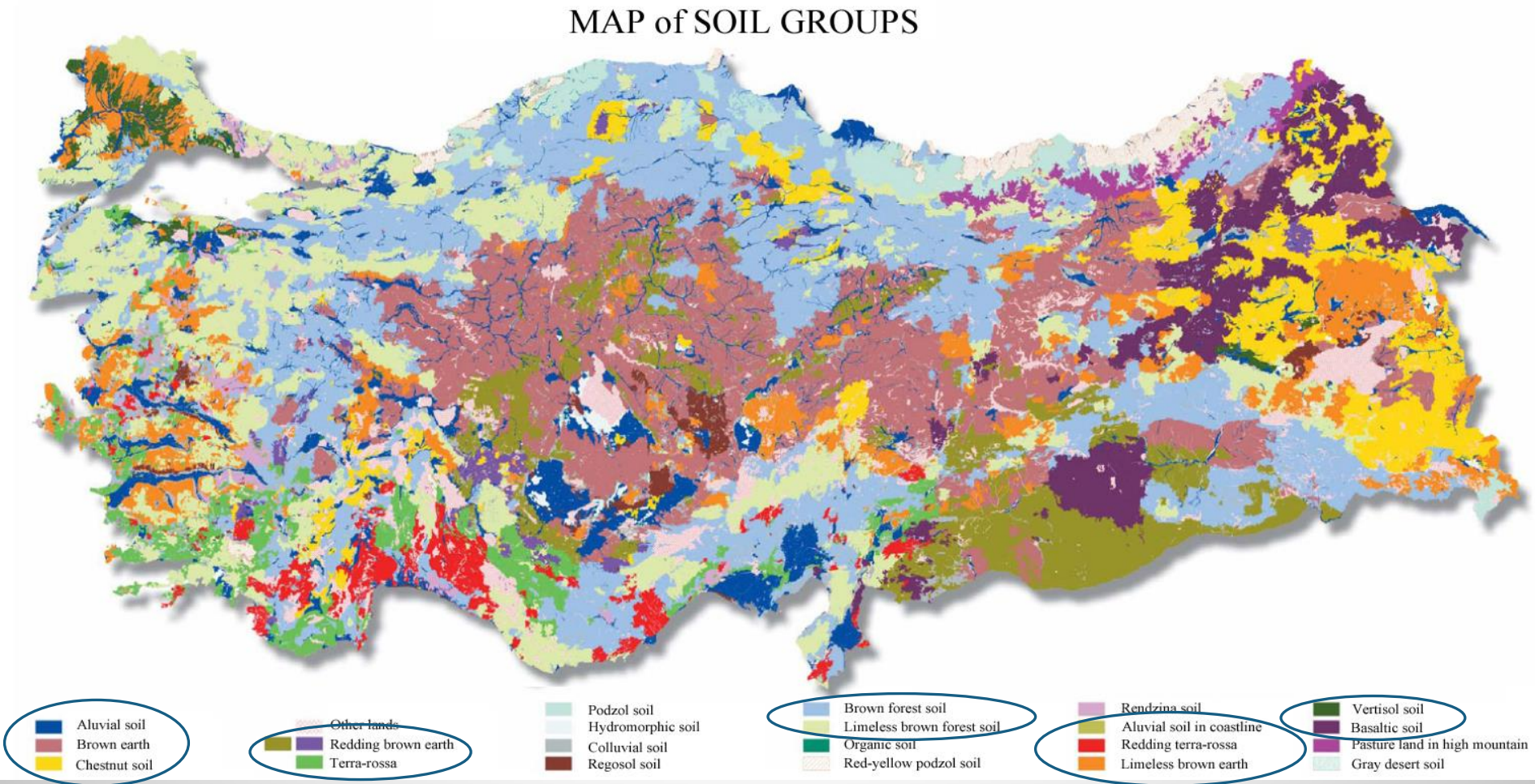
Regional Distributions of Forest Residues

Its energy content : 35,7 million GJ



Source: Ministry of Energy and Natural Resources - Turkish Biomass Energy Potential Map

The Large Soil Groups Present

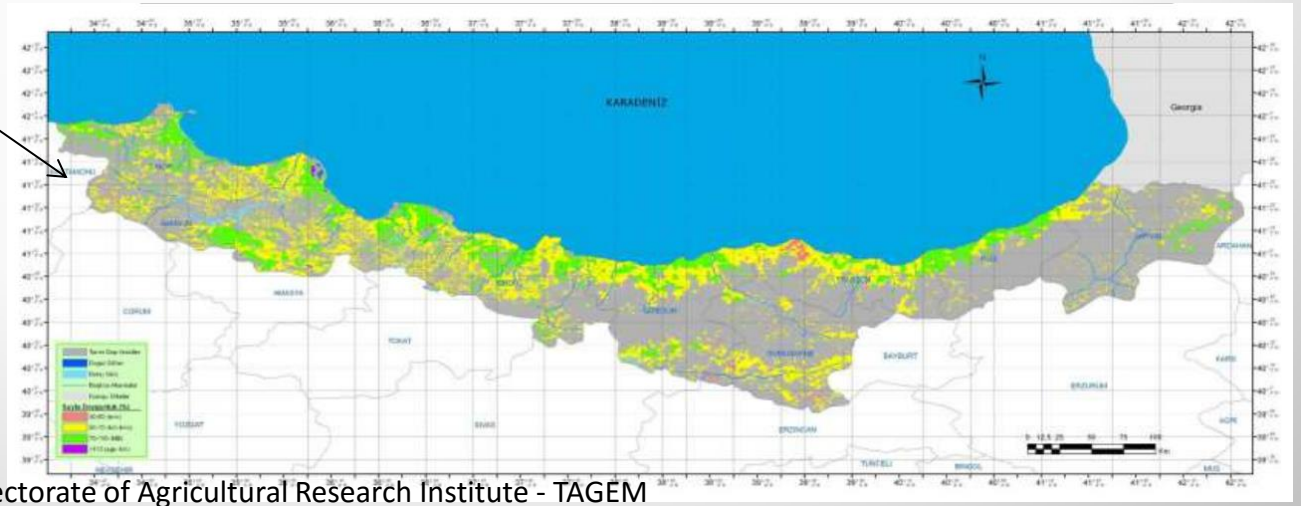


- Alfisol, Molisol, Aridisol, Verdisol, Entisol and Histosol

Source: https://cografyabilim.wordpress.com/tag/turkiye-buyuk-toprak-gruplari-harita-resmi/

Survey and Mapping Studies

- Current maps cover the large soil groups and they are not adequate for scientific studies due to their high error rate.
- New maps should be created by detailed soil surveys using current technology
- Since 2002, the General Directorate of Rural Services has been conducting a project named the “Soil Database of Turkey” in order to improve the knowledge about the soil taxonomy of Turkey.
- Central and eastern Black Sea region was completed.



Source: Ozyazici et al., 2013; Black Sea Directorate of Agricultural Research Institute - TAGEM

Central and Eastern Black Sea Region

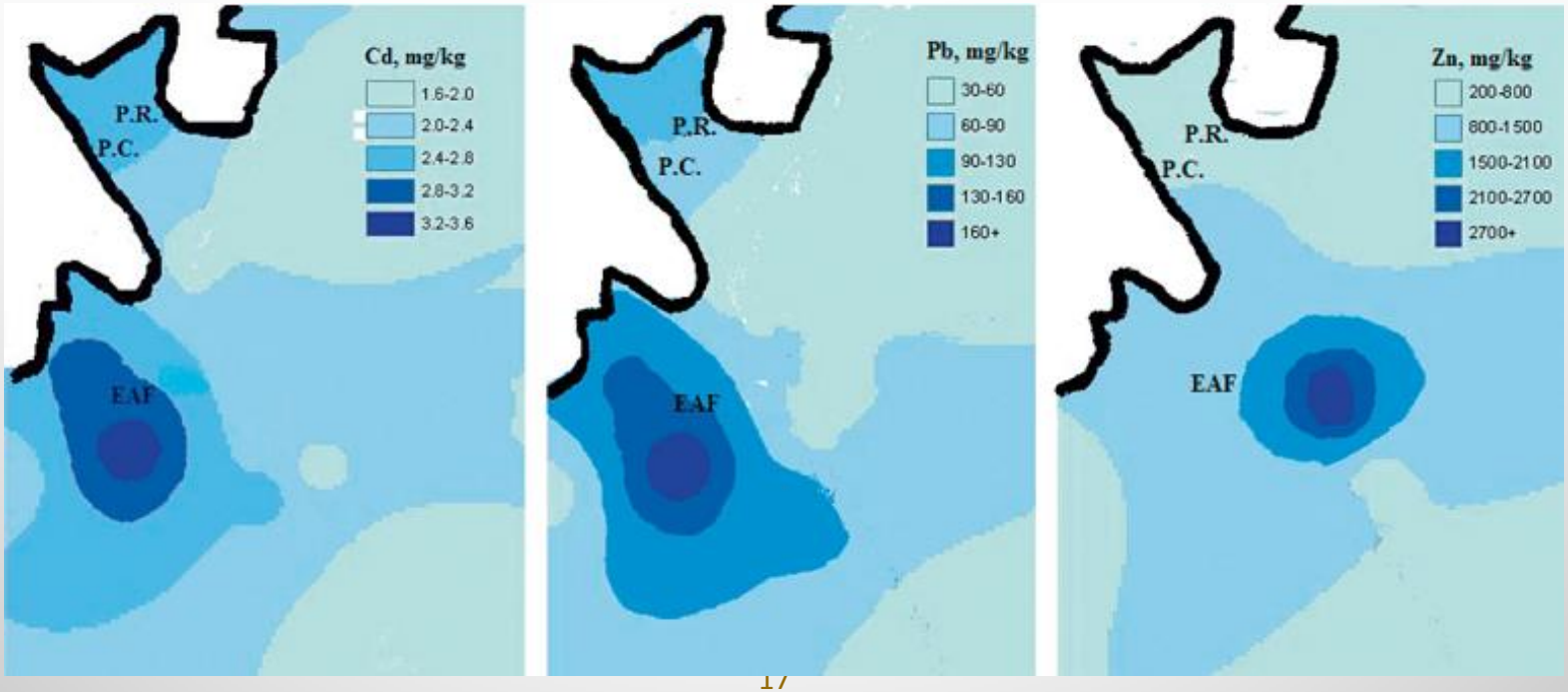
- 26% of the soil texture : clay loam soil
- 22% of it : clay soil
- pH value: neutral at a rate of 30% and slightly alkaline at a rate of 24%
- Medium levels of organic material were detected in soils that had lower salinity and lime contents.
- The arable soils were rich in terms of ***nitrogen*** but ***insufficient*** in available ***phosphorus***.

- Other regional soil survey and mapping projects are in progress

Source: Ozyazici et al., 2013; Black Sea Directorate of Agricultural Research Institute - TAGEM

Soil Pollution of Aegean Region

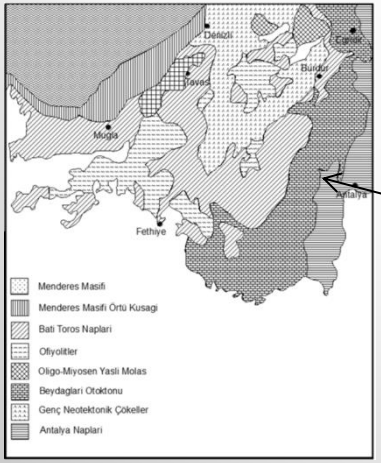
- The chemical compositions of urban, industrial, agricultural, and rural top-soils in Izmir city.
- High concentrations of lead (Pb), zinc (Zn) and cadmium (Cd) in soil samples were found because of iron-steel producers situated in the north of Izmir.

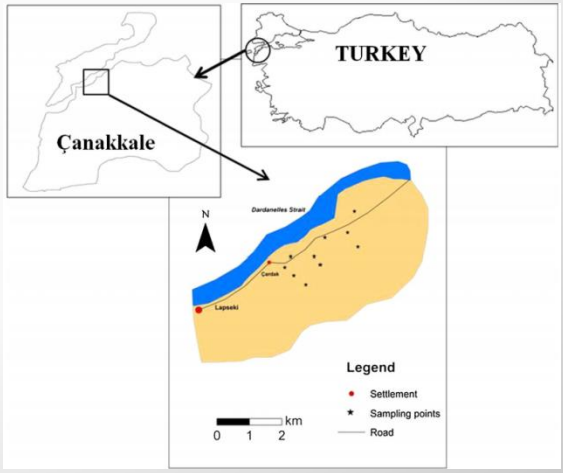


Source: Yatkin and Bayram, 2011

Soil Pollution of Other Regions

- **Southwestern Anatolia region:** The concentration of Cr was found to be 20 times higher than the acceptable limit for Turkey. Besides Cr, the concentrations of cobalt (Co) and Ni were also found to be higher than the acceptable limits.
- **Marmara region:** Cd, which has high environmental risk, was much more mobile in greenhouse samples than field samples.





Source: Sungur et al., 2016; Yalcin et al., 2016

Conclusion

- The sum of lands under permanent crops, meadows, pastures and fallow land, was higher than the total sown area. These lands should be evaluated to increase the agricultural efficiency of Turkey.
- Although the arable lands of Turkey prevail in seven regions, total crop production seems to be focused in southern, western and central Anatolia.
- Compared to total crop production, the ratio of field crop production was substantially higher than that of other crop types.

Conclusion

- Potential Biochar raw materials:
  - ✓ The residues of wheat, barley, corn and cotton stalk, olive tree, forest and hazelnuts
- Hazelnut residues found at the coastline of the Black Sea region
- Cotton stalk and olive tree residues in the Aegean and Mediterranean regions
- Wheat, barley, corn stalk and forest residues could be suitable in all regions as well.
- If the half of forest residues alone is used in torrefaction, 430,000 t/year biochar and its energy of 12.5 million GJ/year could be obtained approximately.

Conclusion

- It is clear that there are different soil types in the arable lands of Turkey and therefore soil survey and mapping studies should be performed in detail using current technologies.
- It is foreseen that biochar, produced from selected residues, would be able to amend the soil texture of Turkey, if used together with fertilizer.
- Moreover, farmers would not need to rest the soil for a period of time before re-cultivation and consequently, the ratio of fallow lands would be reduced in Turkey.
- The utilization of biochar in these soils would help to protect food crops from some pollutants (such as heavy metals).
- On the other hand, biochar can be used as commercial fuel and could support farmers by providing them as an additional income.

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