Chapter

Gypsum/Desulfurization Fly Ash/Activated Shale Char/Claystone of Şırnak with Popped Biochar Composite Granules as Fire Inhibitor for Fire Hazard Risk in Forest Management

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Abstract

Chemical hydrate analysis using gypsum and lime solution was carried out for dehydration of ashes in heavy heat and fire conditions. The 20–50 g pasted popped char samples soaked at higher temperatures of 750 and 500°C showed higher dehydration and heat sorption capacities and became increasingly nonlinear isotherm due to loss of ash surface on granule sites and dehydrogenation. However, this sorption of popped char was slower than other materials such as expanded clay, because microwave permittivity was attributed to their pore differences in solute molarities and sorption mechanisms. Inhibition of hydrate and CO_2 source cooling flame was tested in our research to avoid the spread of forest fires into live bushes and forest areas due to distribution of hot flame of wind. The prospects were designed for construction of materials, such as bubbled gas, for arresting house fires. The similar materials can be produced using bio-waste materials and by-products of construction wastes or forest soil filling. In this study, porous limestone and porous anhydrite metalized stone absorbed the bubbled balls with microwave melted recycling anhydrite metalized powders covering the surface to avoid combustion. In this investigation, the recrystallized gypsum and powdered limestone were reroasted in microwave to melt anhydrite with the porous cores and basalt granules and even the bubbling of anhydrite metalized granules. The fillers finished was used for fire arrestor powder and soil, absorbing heat of fire which were determined as metalized coal carbon-rich forest soil were investigated for arrestor on floor test and deterioration of soil and heat sorption were calculated, respectively. For this purpose, heat resistance, heat sorption, and soil combustion experiments were conducted. As defined, the test results were conducted by comparing metal powders with high heat. The production flow sheet and advantageous process parameters using recycling coal shale and anhydrite gypsum microwave processing parameters were defined. To recrystallize anhydrite metalized carbon limestone, the composite balls of marls having the relation between composite rock formation and discontinuity at production have been established.

Keywords: microwave, metalized anhydrite-porous rock, composite balls, earthquake wave sorption, bulk elastic behavior

1. Introduction

In order to protect the environment with rich bioresources for life, the nature needs to take real precautions and humans should reduce the source of greenhouse gases. The wild bushes, forests, and nature are highly needed for human life with increasing population. The energy consumption needs alternative clean and renewable energy sources. The bushes and forest fires have become important research topics in order to take precautions on time in this century. This mobile production of the fire inhibitor unit project was critical in forest soil mixture of biomass-based waste and garbage and clean, renewable, and sustainable alternative inhibitor source.

The consumption of natural resources in inhibitor production is increasing parallel to the construction materials for inhibiting fire at house needs today. The production of low-thermal-value waste bio carbon resources is limited in terms of quantities. It enables the evaluation of biotechnological byproducts related to waste management over food processing technology with advanced technological incineration systems. Environmental norms allow the production of the necessary waste fuels such as waste oil as fuel, that is, compatible with biogas production, biopyrolysis or gasification became the high-cost benefaction. In Turkey, the forest fire and the filler production form bioresources rather attracted so critical significance on even less intensive areas of Eastern Anatolia and Southeastern Anatolia region, especially in the low populated steep mountains and high plateaus such as the provinces of Şırnak, Hakkari, and the surrounding steep mountains forest areas, the production of bio resources for production forest fire inhibitor soils and humus soils from waste bio resources for cleaner nature and renewable bio energy production by means of mobile units using incineration or pyrolysis method will provide the development of the South-East Anatolian region and also the industrial development and diversification will increase [1–5].

Flexible and regional targets for a mobile solid waste incineration from an environmental and economic perspective are:

- The 3 ton/hour mobile plant where the waste sorting process is performed for inhibitor soil, and material production resources were processed to acquire secondary materials to be evaluated.

Waste type	Waste statistics		
	Heat value, kJ/kg	Country, actual million ton/year	Eastern Anatolian region, actual 1000 tons/year
Textile, rubber, plastics	18,200	0.6	2.1
Wood, cardboard, paper	17,600	2.4	1.6
Organic municipal waste	13,500	2.2	29
Animal waste	13,500	1.9	21
Forestry and agricultural biomass	18,500	2.8	63
Total	18,000	9.9	116.7

Table 1.
Total amount of municipal waste divided into actual values in Turkey and Eastern Anatolian Region in 2012.

- Biological treatment or carbonization units of biomass and conversion to compost, which are a market value or energy production by producing inhibitors by mixing and treatment.

- Reduction of the amount of waste to be sent to regular storage by thermal treatment systems, making it inert and obtaining energy.

- Reduction of landfill and use of forest fills for inhibiting reclamation and at least the reduction of forest fire as given in **Table 1** [5], and **Figure 2** shows the forest management methods in the elimination of forest fires in the country.

2. Forest fire management

2.1 Forest fires

The rainforests in Amazon still burned many years at a record rate: Brazil experienced more than 76,000 fires in 2019, whereas the total was about 40,000 in 2018. About 10,000 of this year's fires shown in **Figure 1** resulted in catastrophic devastation of fire smoke caused by harsh weather conditions. **Figure 1** shows every fire that unwillingly flamed in central South America since August 2019.

In Amazon, most of the fires were started by farmers and loggers and caused by human facts for industrial or agricultural purposes. However, forest fire caused harsh climate change, which increased flaming and widening fire devastation.

There were more than 76,000 fires in Brazil so far this year, but the issue has not changed any human urbanization, and other parts of South America were burning too.

Global Forest Watch, an organization sponsored by the World Resources Institute, monitors forests and tracks fires using satellite data. The group reported more than 109,000 fire alerts in Brazil between August 13, 2019, but the map of current blazes shows fires in many other regions as well, as shown in **Figure 1**. So far this year, Brazil's neighbor, Bolivia, has experienced more than 17,400 fires. Paraguay, to the south, has had just fewer than 10,000, and Colombia, to the north, 14,000. Venezuela had experienced the second-highest number of fires of 26,500 in 2019: that was one-third of Brazil's forest fire totally.

Australia had one of the most fires on earth, and bushfires form part of the natural cycle of its landscapes. However, the dry weather and high summer

Figure 1.
Part of the Amazon jungle burning near the city of Novo Progresso, Brazil, on 23 August. Nacho Doce/Reuters.

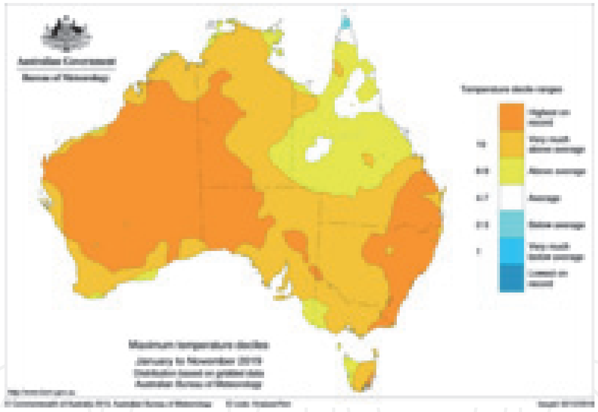

Figure 2.
Maximum temperature deciles.

temperature factors such as high climate risk trends, weather patterns, and vegetation management by humans may not contribute to the intensity of hard seasons as seen in **Figure 2**, and the most destructive fires in Australian history preceded by extreme high temperatures, low relative humidity, and strong winds on last November 2019, which combine to create ideal conditions for the rapid spread of fire. Forest experts and land management accepted that severely below average fuel moisture attributed to record-breaking temperatures and drought, accompanied by severe fire weather, is the primary cause of the 2019 Australian bushfire. The devastating flames were likely to have been exacerbated by long-term trends of warmer and dryer weather over the Australian land mass. Nonetheless, the political nature of many of the crisis and its associated issues has also resulted in the circulation of large amounts of disinformation regarding the causes of the fire activity, to the neglect of credible scientific research, expert opinion, and previous government inquiries, as shown in **Figures 3–5**. The precautious methods were prepared regarding forest land urban interface mapping, showing fire fuel risk and temperature risk on mapping as in **Figure 5**.

2.2 Fuel management

The spatial distribution of tree and bush was considered in the fire management models. The forest plantation characteristics such as land, thermal, physical, and chemical properties of tree elements were constructed. Fuel data of forest were a powerful source of knowledge used for software enabling representation of any

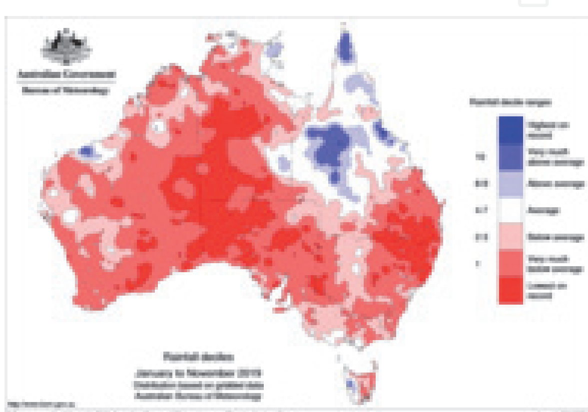

Figure 3.
Rainfall deciles, from January to November 2019.

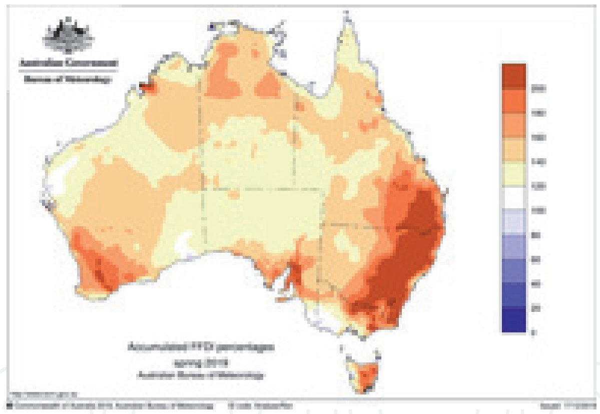

Figure 4.
Forest Fire Danger Index (FFDI), Spring 2019.

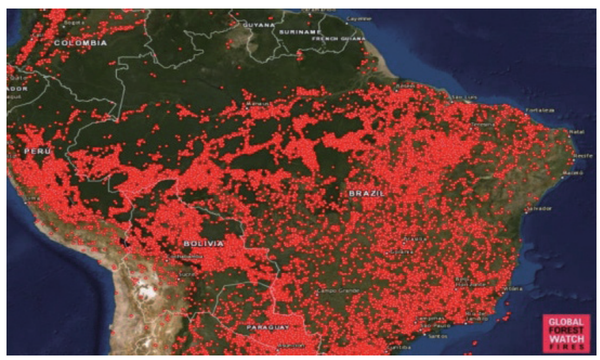

Figure 5.
Forest fires on the Amazon region in Global Forest Watch map.

vegetation community in the landscape, simultaneously integrating the required attributes for running complex fire simulation in the background.

GPS and phone to phone was always provided safe control on internet connection, a touch-screen, and a camera remote control improved extinguishing period following the stages shown in **Figure 6**.

Fire fight commander and team led by the fire extinguishing method following discussion with expert field operators reported a major concern about the visibility on the screen of such weather tools emergency station stage for an observation cam device and available in a field operating car.

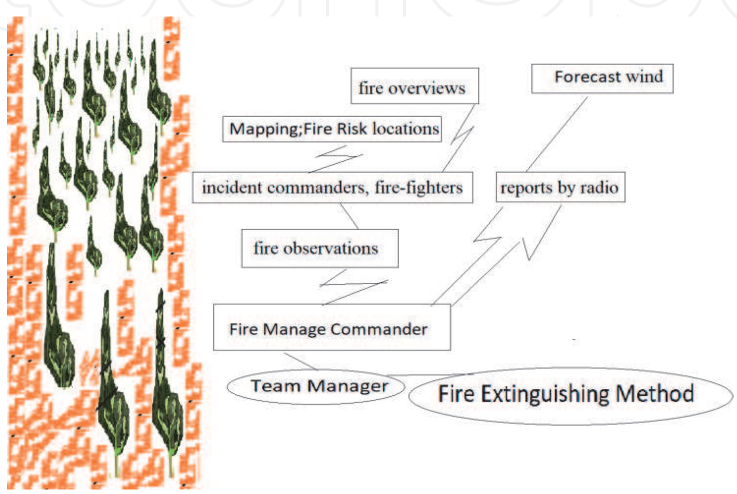

Figure 6.
Fire fight commander and team over the fire reports and weather conditions.

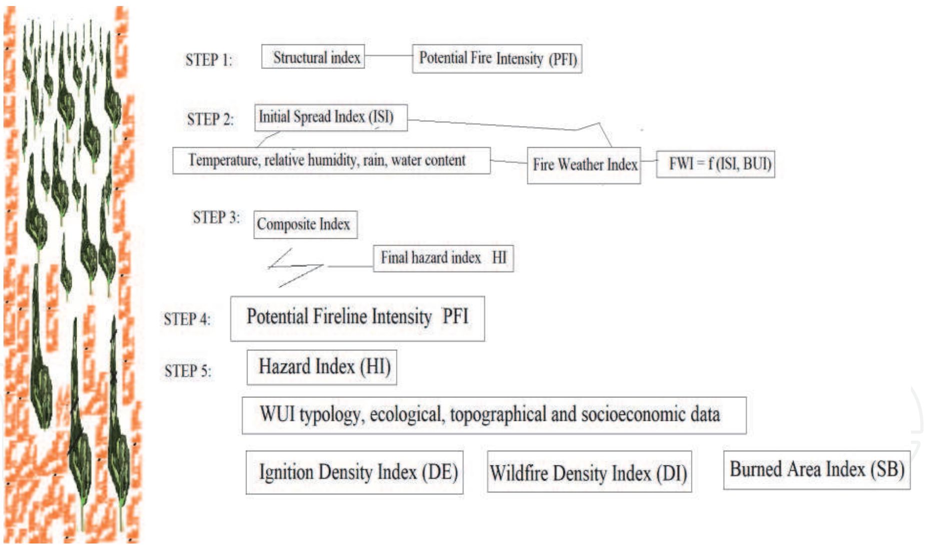

Figure 7.
The organized fire team work that included the extinguishing plan and method is followed by team on risk mapping and data logging.

The data entailing simulation of vegetation growth with and without fire was also shown from risk factors, and the assessment of the wild-land fire risk was calculated on map. It is organized on five step risk parameters as shown in **Figure 7**:

The fire management software made a map over fuel risk and extinguishing system and put the information related to weather and climate conditions together. The forest fire showed risk parameters made available outstanding feedback from forest fire managers within the fire as shown in **Figures 8** and **9**.

2.3 Main tools for fire management

The forest plantation and dry matter characteristics regarding wet land, thermal, and climate risks, physical and chemical properties of tree elements covered the reporting previously in order to eliminate the fuel potential risks. The reported high risk areas contained the parameters such as fire ecology and wet land; fire risk distribution; forest ecology of local plant species; fire land management risk; monitoring and assessment of fire areas; fire weather conditions; wind; and extinguishing plan.

The methods were practiced at the following stages:

- Fire ignition patterns for control flame of forest fire.
- Case studies: detailed assessments on selected management risks.
- Prescribed burning practice (extensive training): at least 5 days of burning.

2.4 Extinguishing by slurry mud or foam

The flame of fire on sites could be inhibited by foaming agent mixed water pouring or muddy water pouring by plane carriers that used effectively on extinguishing work and fire management in urban interface or forest urbanization intercontact area, mainly found in various regions all over the world. In Şırnak, the lightweight materials may be evaluated and investigated for fire flame inhibitor in this study such as: Altered Limestone (Şırnak Center), Marly Limestone (Şırnak Center), Marl (Şırnak Center), Cizre White Porous Limestone (Şırnak Cizre),

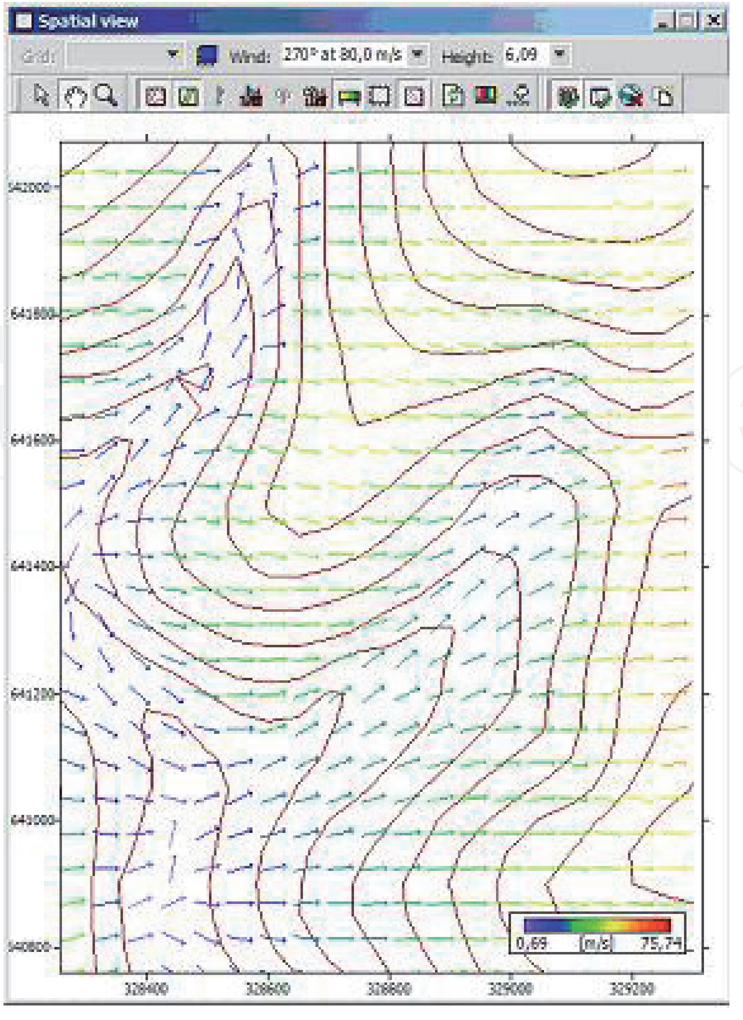

Figure 8.
Forest Fire Flame Danger Index, 2019.

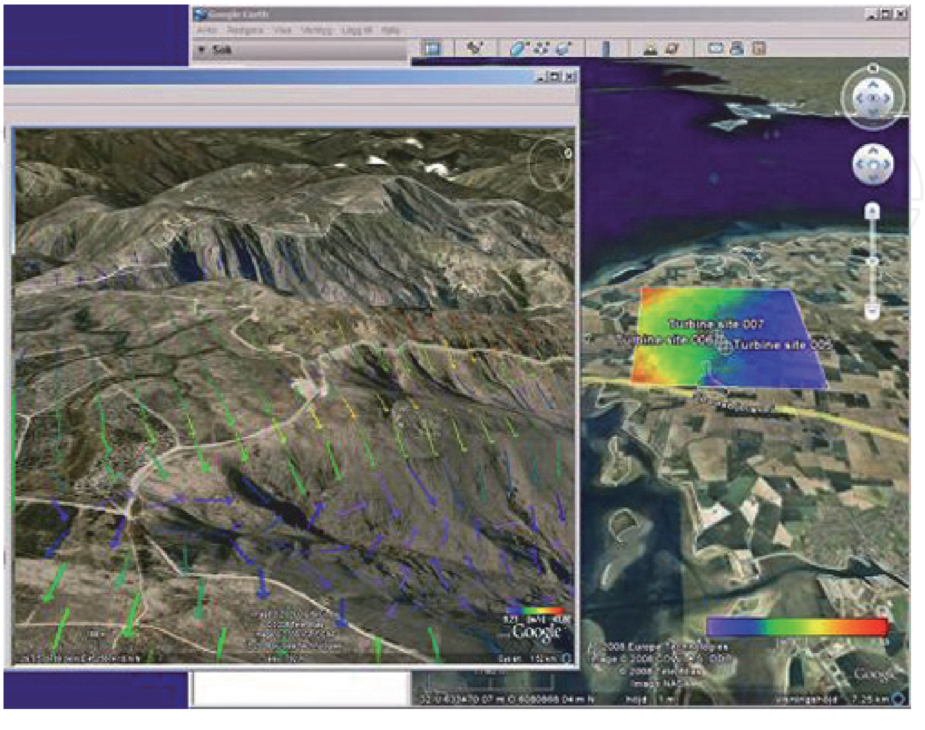

Figure 9.
Forest Fire Urbanization Wind Danger Index, 2019.

Porous Limestone (Cizre Stream), Volcanic Cinder, Midyat Limestone, and Şırnak Coal Mine Waste Marly Shale.

The light porous limestone and marl of Şırnak province can be used as concrete aggregates due to lightweight strength. However, this region consisted of brownish-yellow limestone formations, heterogeneous and carbonates containing 30–45% weight decrease and carbon dioxide dissociation at flame temperature of fire at 800°C regarding dissociation kinetics as extinguisher water slurries.

The various local industrial wastes were used as extinguishing work of fly ash materials [1–3]. Fly ashes of desulfurization units like gypsum are defined as extinguishing slurry materials that inhibiting flaming properties of forest fire but have binding hydrate properties that are finely ground and dissociated chemically with alkali hydrates at flame temperature and providing moisture flame environments [6]. Fly ash provided rain water hydrated soil, low permeability capturing rain water, controlling the lightweight material, dust easily inhibiting dry leafs and woods, and the sulfate effect on soil for humus [5]. It is estimated that there are 600 million tons of fly ash in the world today, but only 10% of it is evaluated in concrete and as filler in road pavement covering technology [7]. Fly ash has a wide range of uses in concrete because of lowering cost of concrete, saving energy, and reducing environmental problems [8]. Use of fly ash in extinguisher fire inhibitor slurry mixtures; decreasing the combustion of wood and light weight flying matters in certain proportions, the use of fly ash instead of granule decreasing the oxygen take up or transfer into high heat flame [9]. The effects of fly ash on the mechanical properties of pavement were studied extensively. In this study, the effects of Silopi fly ash as filler additive on hot combustion chamber for decreasing combustion heat of coal were determined. In this study, the effect of amount of ash replaced to fine gypsum amount, change on flame inhibition ability, oxygen take-up ability, and lightweight slurry density of water mixture at 10–20% weight was determined.

The weight ratio of lightweight limestone, shale, marly shale, and fly ash greatly affected the water content in inhibiting filler material significantly. Bottom aerated combustion of fuel matter in the forest peat and flaming radiated fire development could be inhibited by the stone matters of the fuel flaming styles as shown in **Figures 10** and **11**.

This fire extinguishing work prepared model risk patterns as shown in **Figure 10** by fire hazard maps, on a daily basis, by combining fuel models, forest area topography, soil conditions, and dynamic factors such as wind direction, air wind speed, air temperature, relative humidity, and fuel moisture content, as shown in **Figures 12** and **13**.

The parameters regarding fire features improved the control implemented recently as follows:

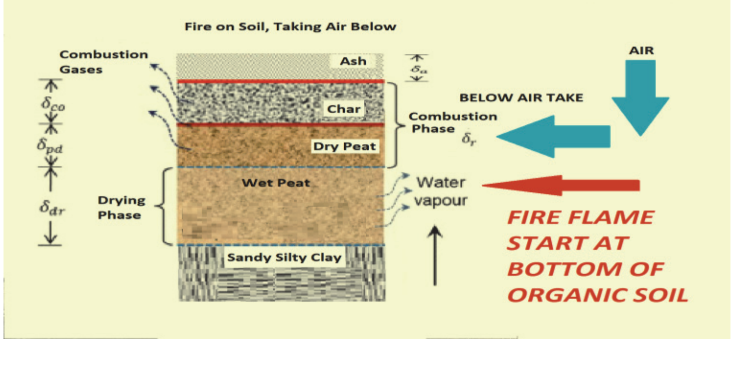

Figure 10.
Forest fire movement with below fired peat with high planted organic soil.

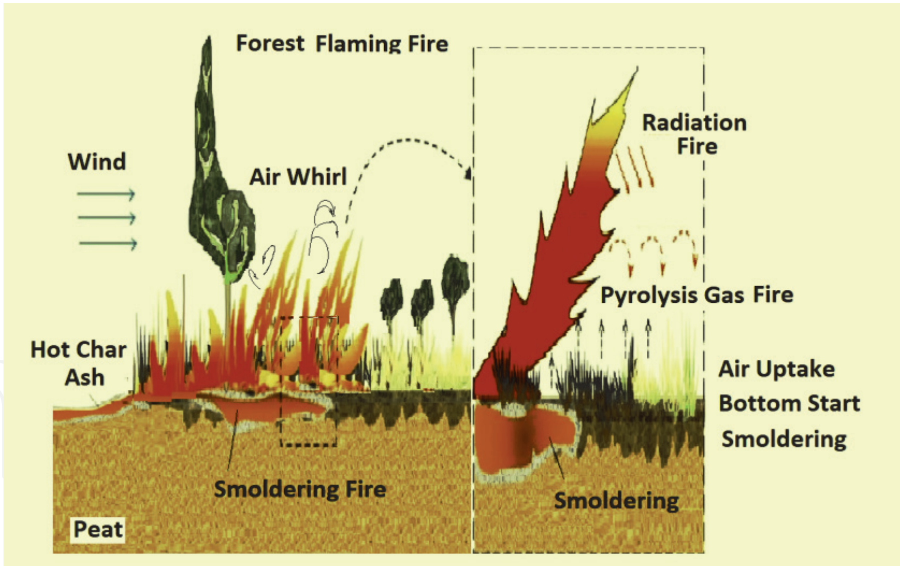

Figure 11.
Forest fire movement with below ignited forest fire, peat with high planted organic soil as happening in Amazon and Indonesian Rain Forests.

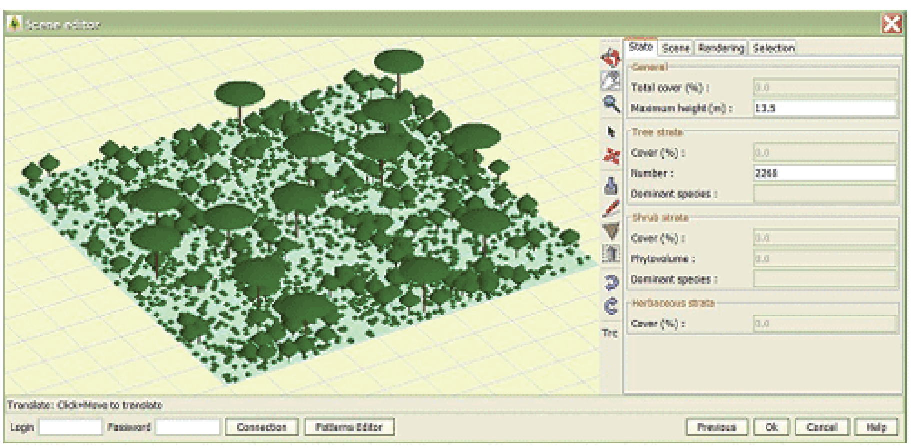

Figure 12.
Software used in forest fire risk management with dry peat or aggregated banning soil, fuel management, and fire risks.

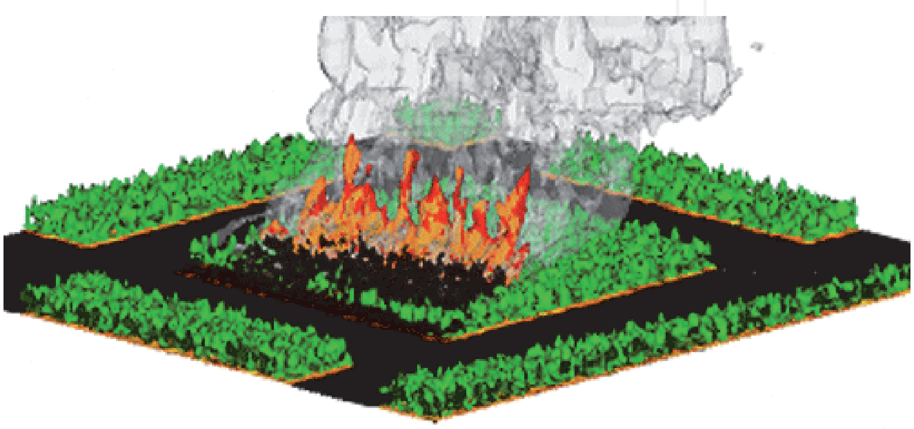

Figure 13.
Forest fire movement with below fired peat with high planted organic soil, fire fuel model.

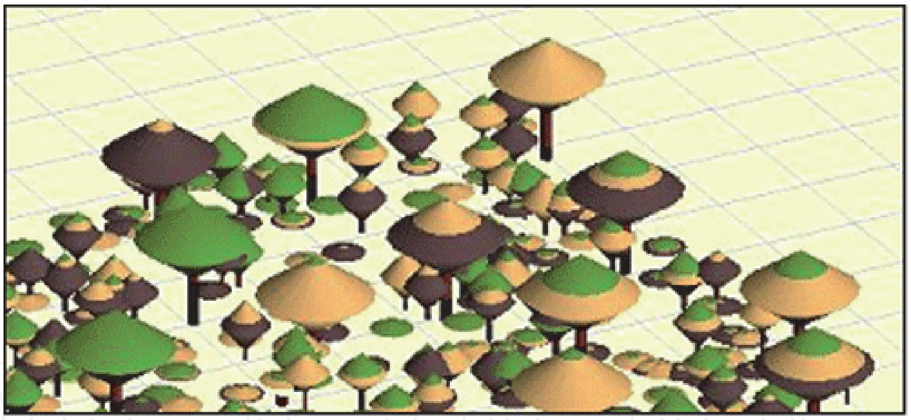

Figure 14.
Dry fuel source, forest fire movement risk with below fired peat soil, and visualization of fire risks on dry fuel matters.

- fuel matter balance dry matter and decayed matters over wet matter forest fuel data (**Figure 14**);
- the dry matter removal and manipulating a vegetation matter;
- the fuel source data for fire model simulations; and
- the environmental risk mapping and mapping over the base of urbanization and impacts at fire as shown in **Figures 10** and **12**.

2.5 Inhibitors as activated clays and hydrated clay matters

There are hydrated layers mainly in clay minerals and lattice layers associated with the inner layer hydrates and the metal oxide with clay lateral surfaces. The water molecules in the spheres surrounding the exchangeable cations are exchange degree of polarization of the alkali metal cation and the surface silanol groups (Si-OH) resulting from the breakage of the Si-O-Si bonds in the tetrahedral layer, in the exchange of the Al^{3+} and Mg^{2+} cations in the octahedral layer, and the Si^{4+} and Al^{3+} and Fe^{3+} cations in the tetrahedral layer as shown in **Figure 5**, associated with metal atoms on the crystal edges. The oxygen planes in the space between the plates act as a pair of electrons [9].

The increasing demand of clay utilization for advanced material technology and the limited reserves of high quality bentonites push the researchers and the operators/producers to evaluate the lower quality calcium and mixed shales for the of hydrates in fire inhibition use. The technological properties of fly ashes, however, can be upgraded by the application of hydrating and activating acids. Mostly, wet concentration methods such as decantation, cycloning, and centrifuging have been applying and water quality and ion type/amount which the water carries becomes more important to control the further activation process since clays carry the releasable and exchangeable cations on interlayers which interact with ions in water. **Table 2** comprised the inhibiting values over extinguishing manner of flame.

In this study, the effect of water quality (ion type and amount in water) was subjected to the concentration and further alkali activation tests with mixed type shale, asphaltite deposits in Şırnak. The water slurries including different salts namely $CaCl_2.2H_2O$ foaming and $AlCl_3.6H_2O$ foaming were used as fire inhibition media in concentration by mixing and agitation. The effect of water quality on concentration and alkali activation was declared based on pH, viscosity, solid ratio, and size.

Inhibitor type	Waste inhibitors			
	25-T_d heat calcination value, kJ/kg	T_d temperature, °C	Hydrate weight, %	Carbonate weight, %
Talc	38,200	613	10.6	2.1
Montmorillonite	27,600	456	12.4	1.6
Zeolite	33,500	565	12.2	2.9
Bentonite	23,500	430	11.9	2.1
Fly ash	18,500	425	12.8	6.3
Gypsum	18,000	250	19.9	0.7
Limestone	59,900	815		42
Marly shale	45,400	845	11	22

Table 2.
Total inhibiting values in Eastern Anatolian region in Turkey.

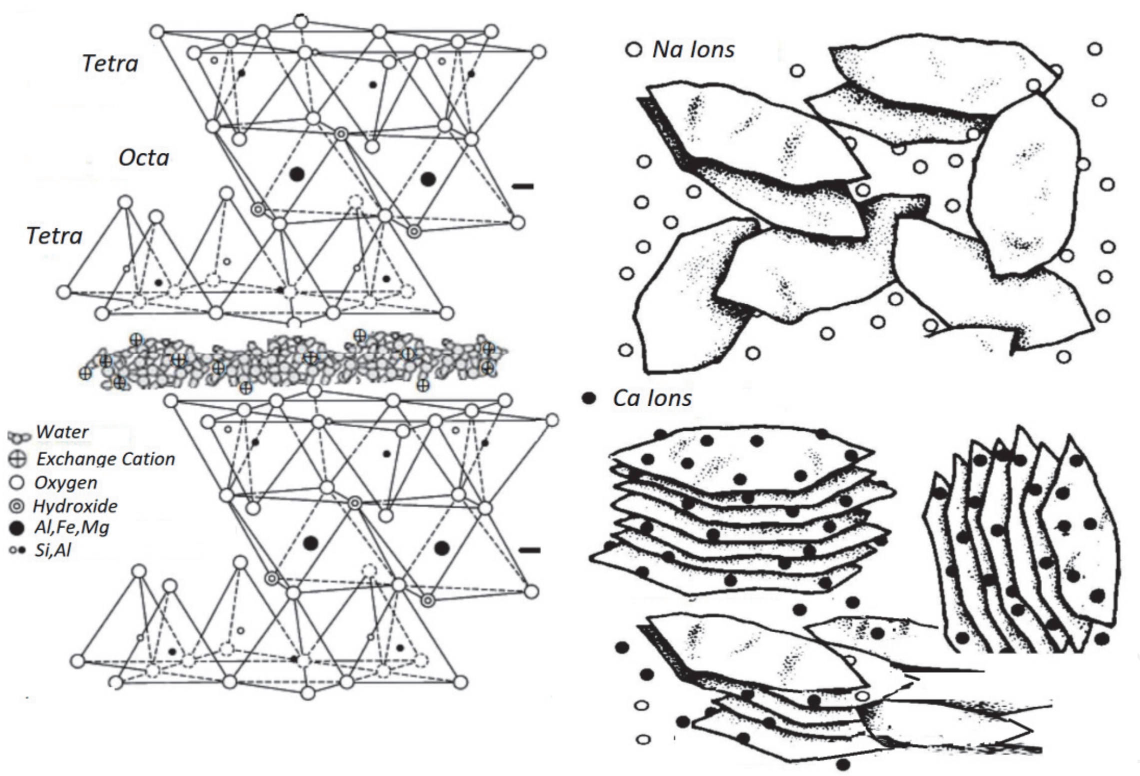

Figure 15.
Shale clay structure, Şırnak resource in Turkey regarding hydrate.

Şırnak shale contained marly carbonates over 45% providing carbonates with the clay minerals of the smectite group, shows colloidal properties when mixed with water, and its properties such as water are due to the three-layered crystal structure (**Figure 15**) [9].

2.6 The methods used ın forest fire management

The investigation of water resources and logging in the Şırnak, Mardin, and Batman provinces was effectively carried out, and construction debris is widely distributed in the forest area to protect urbanization from fire near village location.

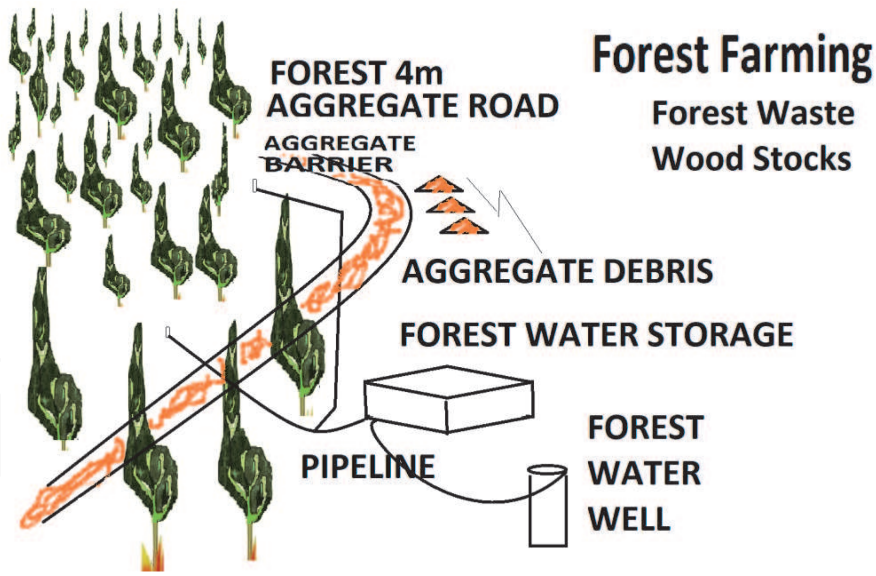

Figure 16.
Total amount of municipal waste for forest management in Turkey and Eastern Anatolian Region in fly ash use of Şırnak Asphaltite.

Figure 16 shows the methods used mainly in construction of water pools for both farming and extinguishing of local forest areas. Inhibitor aggregates roads and high amount of fly ash as municipal waste for forest fire management in Turkey. In Eastern Anatolian Region, high amount of inhibitor waste was used for forest fire inhibition over 120,000 tons fine aggregate as gypsum and ash material with Şırnak Asphaltite wastes and construction debris.

2.6.1 Hydrate sorption matter

The large specific surface area inhibiting fire flame could be water content and evaporation heat of used in industrial foamed water extinguishing purposes as natural materials. Hydrated liquid absorbents and solid adsorbents generally used fly ash matters of desulfurization unit contained mainly gypsum hydrates. It can be classified as waste *group is one of fly ash minerals or* inhibiting filler for flame and more with foamed matter base with sponged stones and hydrated minerals such as containing 85% montmorillonite, is an aluminum hydrosilicate with a colloidal property. When mixed with water, density of a few solid swelling bentonite is about 2.6 g/cm^3.

Shale clay is calcium in many countries clay is a general name of Al Mg silicate hydrates and the main hydrate content of which montmorillonite can change mainly cation and be defined as clay with Ca;. Attapulgite, 2MgSi8O20 (OH2) 4 (OH) The palygorskite expressed by the formula $4H_2O$ an aqueous magnesium, aluminum Silicate. Sepiolite is 6 Mg 9 Si 12 O 30 (OH) 4 6H 2 O group is aqueous Mg silicate. In these minerals channel-shaped pores water bound to crystal structure with molecules. The shale clays contained in this group is micropore and channels and large surface area over 11% due to the possession of various substances inhibitors and high adsorbing capacities.

3. Materials and methods

Wood straw and oak wood char composite type fuel was used as combustion flame test. The fly ash used in the experiments was put into 30 cm dish plate half at half wit fuel content obtained from the Şırnak inhibitor lightweight filler at fine size at 0.1 mm and the chemical composition of the fly ash and inhibitors are given in **Tables 3** and **4** regarding flaming combustion and adsorption matter [10–13].

Reaction heat adsorption:

$$E = kA \log Kp^{RT} \tag{1}$$

$$\text{Cellulose } C + O_2 \rightarrow CO_2 \tag{2}$$

$$\text{Cellulose } 2C + O_2 \rightarrow 2CO \tag{3}$$

The materials of fly ash as inhibitor and popped carbon as shale of Şırnak asphaltite from waste material of Şırnak evaluated in forest fire control as shown in **Table 5**.

In this study, the specific unit weights are given in **Table 6**. Degree of hydrate or carbonate inhibiting ability rates of the filler was determined by evaluating the 3-ton briquetting compression test results (**Table 5**). Combustion weight TGA tests showed higher burning inhibition ability for the Şırnak fly ash and gypsum mixture at 30/70 weight rate so that they gave higher advantageous effect on compaction of road pavement.

In ASTM standards [5], the amount of mixing pine wood and lightweight inhibiting filler rates was taken, however at the amount of wood and porous aggre-

Reaction	log A[log (s)]	E [kJ/mol]	[kJ/kg]
(1) Hemicellulose	16.32	186	0
(1) Cellulose	19.44	242	0
(1) Lignin	8.98	107	0
(2) Hemicellulose	11.42	145	−20
(3) Hemicellulose	15.93	202.4	255
(2) Cellulose	10.11	150.5	−20
(3) Cellulose	14.52	196.5	255
(2) Lignin	6.89	111.4	−20
(3) Lignin	9.18	143.8	255

Table 3.
Kinetic constants used in a-priori modeling, following Bellan's kinetic scheme [6, 10].

Property	Units	Value
Thermal conductivity k	W/m K	0.13
Density ρ	kg/m^3	490
Specific heat capacity c_p	J/kg K	2300
Surface emissivity ϵ	—	0.95
Thermal conductivity of char k_{char}	W/m K	0.08
Density of char ρ_{char}	kg/m^3	330
Specific heat capacity of char	J/kg K	1100

Table 4.
A-priori modeling parameters for wood, taken from Ref. [6].

Components	Şırnak fly ash	Şırnak mid ash
SiO_2	39.71	20.71
Al_2O_3	10.53	10.53
Fe_2O_3	6.62	4.62
S + A + F	68.6	68.6
CaO	16.56	26.56
MgO	3.41	12.41
SO_4	3.02	11.02
K_2O	2.44	2.44
Na_2O	0.55	0.55
Ignition loss	5.74	14.74
Free CaO	4.13	12.13
React. SiO_2	21.12	14.12
React. CaO	8.72	2.72

Table 5.
Seyitömer and Şırnak Silopi fly ash chemical compositions and aggregate compliance with standard values ASTM C616.

Inhibitor Type	Size, mm	25 min	40 min	50 min	60 min	Density	1.1	1.2	1.3
Şırnak shale	−0.15	88	87	85	80	1.55	36	47	52
	−0.5 + 0.15	88	87	85	80	1.55	36	47	52
	−1 + 0.5	88	87	85	80	1.55	36	47	52
Sırnak marly shale	−0.15	78	77	75	80	1.65	36	47	52
	−0.5 + 0.15	78	77	75	70	1.65	36	47	52
	−1 + 0.5	78	77	75	70	165	36	47	52
Şırnak porous limestone	−0.15	75	74	85	70	1.45	36	47	52
	−0.5 + 0.15	75	74	72	66	1.45	36	47	52
	−1 + 0.5	75	74	72	66	1.45	36	47	52
Şırnak gypsum	−0.15	48	47	72	66	1.55	36	47	52
	−0.5 + 0.15	48	47	85	80	1.55	36	47	52
	−1 + 0.5	48	47	85	80	1.55	36	47	52
Şırnak shale 50%+	−0.15	58	57	85	80	1.55	36	47	52
Şırnak gypsum 50%	−0.5 + 0.15	58	57	85	80	1.55	36	47	52
	−1 + 0.5	58	57	85	80	1.55	36	47	52
Sırnak marly shale 50%+	−0.15	68	67	85	80	1.55	36	47	52
Şırnak gypsum 50%	−0.5 + 0.15	68	67	85	80	1.55	36	47	52
	−1 + 0.5	68	67	85	80	1.55	36	47	52
Şırnak porous limestone 50%+	−0.15	68	67	85	80	1.55	36	47	52
Şırnak gypsum 50%	−0.5 + 0.15	68	67	85	80	1.55	36	47	52
	−1 + 0.5	68	67	85	80	1.55	36	47	52
Şırnak shale 30%+	−0.15	59	57	85	80	1.55	36	47	52
Şırnak gypsum 70%	−0.5 + 0.15	59	57	85	80	1.55	36	47	52

Inhibitor Type	Size, mm	25 min	40 min	50 min	60 min	Density	1.1	1.2	1.3
	−1 + 0.5	59	57	85	80	1.55	36	47	52
Şırnak shale 70%+	−0.15	73	74	85	80	1.55	36	47	52
Şırnak gypsum 30%	−0.5 + 0.15	73	74	85	80	1.55	36	47	52
	−1 + 0.5	73	74	85	80	1.55	36	47	52

Table 6.
Şırnak inhibitor material properties and slurries and aggregate time 50% fuel flame weight with standard values ASTM C6167.

Inhibitor with fly ash type	Size, mm	25 min	40 min	50 min	60 min	Density	1.1	1.2	1.3
Şırnak shale + fly ash	−0.15	73	74	85	80	1.55	36	47	52
	−0.5 + 0.15	73	74	85	80	1.55	36	47	52
	−1 + 0.5	73	74	85	80	1.55	36	47	52
Sırnak marly shale + fly ash	−0.15	73	74	85	80	1.55	36	47	52
	−0.5 + 0.15	73	74	85	80	1.55	36	47	52
	−1 + 0.5	73	74	85	80	1.55	36	47	52
Şırnak porous limestone + fly ash	−0.15	73	74	85	80	1.55	36	47	52
	−0.5 + 0.15	73	74	85	80	1.55	36	47	52
	−1 + 0.5	73	74	85	80	1.55	36	47	52
Şırnak gypsum + fly ash	−0.15	73	74	85	80	1.55	36	47	52
	−0.5 + 0.15	73	74	85	80	1.55	36	47	52
	−1 + 0.5	73	74	85	80	1.55	36	47	52
Şırnak shale 50%+	−0.15	73	74	85	80	1.55	36	47	52
Şırnak gypsum 50% + fly ash	−0.5 + 0.15	73	74	85	80	1.55	36	47	52
	−1 + 0.5	73	74	85	80	1.55	36	47	52
Sırnak marly shale 50%+	−0.15	73	74	85	80	1.55	36	47	52
Şırnak gypsum 50% + fly ash	−0.5 + 0.15	73	74	85	80	1.55	36	47	52
	−1 + 0,5	73	74	85	80	1.55	36	47	52
Şırnak porous limestone 50%+	−0.15	73	74	85	80	1.55	36	47	52
Şırnak gypsum 50%	−0.5 + 0.15	73	74	85	80	1.55	36	47	52
	−1 + 0.5	96	1						
Şırnak shale 30%+	−0.15	73	74	85	80	1.55	36	47	52
Şırnak gypsum 70% + fly ash	−0.5 + 0.15	73	74	85	80	1.55	36	47	52
	−1 + 0.5	94	0.2						
Şırnak shale 70%+	−0.15	73	74	85	80	1.55	36	47	52
Şırnak gypsum 30% + fly ash	−0.5 + 0.15	73	74	85	80	1.55	36	47	52
	−1 + 0.5	94	0.2						

Table 7.
Seyitömer and Sirnak Silopi fly ash chemical compositions and aggregate compliance with standard values ASTM C616.

gate content, amounts of mixture components used in forest fire extinguishing mixture covers used for this experimentation are given in **Tables 6** and 7.

3.1 Gypsum/desulfurization fly ash

Gypsum is generally used as construction material: manufacture of wallboard, cement, plaster of Paris, soil conditioning, and a hardening retarder in portland cement. Varieties of gypsum known as "satin spar" and "alabaster" are used for a variety of ornamental purposes; however, their softening and impurity limit their durability (**Table 8**).

The inhibitor compositions of Şırnak location were determined by means of standard methods. The inhibitor materials were ground by vibration milling to −0.1 mm. Inhibitor samples of the Şırnak aggregate rocks from masonary plants

Chemical classification	**Hydrous sulfate, $CaSO_4.2H_2O$, 98.3%**
Color	Clear, colorless, white
Streak	White
Luster	Vitreous, sugary
Diaphaneity	Transparent to translucent
Cleavage	Perfect
Mohs hardness	2
Specific gravity	2.3
Diagnostic properties	Cleavage, specific gravity, low hardness
Chemical composition	Hydrous calcium sulfate, $CaSO_4.2H_2O$
Crystal system	Monoclinic
Uses	Used to manufacture dry wall, plaster, and joint compound. An agricultural soil treatment and fire inhibitor.

Table 8.
Physical properties of gypsum of Şırnak.

Component	**Siirt Limestone**	**Hasankeyf Limestone**	**Mardin Limestone**	**Şırnak Porous Limestone**	**Marly Shale**
SiO_2	3.53	5.42	14.14	2.12	38.53
Al_2O_3	2.23	5.43	4.61	1.71	14.61
Fe_2O_3	1.59	2.48	334	0.58	7.59
CaO	41.48	34.23	39.18	45.22	19.48
MgO	2.20	12.28	4.68	7.41	3.28
K_2O	0.1	1.83	3.12	0.40	2.51
Na_2O	0.3	1.24	1.71	0.21	0.35
Ignition Loss	36.19	24.11	25.43	48.04	13.09
SO_3	0.22	0.31	0.20	0.02	0.32

Table 9.
The chemical analysis of lightweight inhibiting slurry fillers of Şırnak Province, lightweight limestone, marl, and shale.

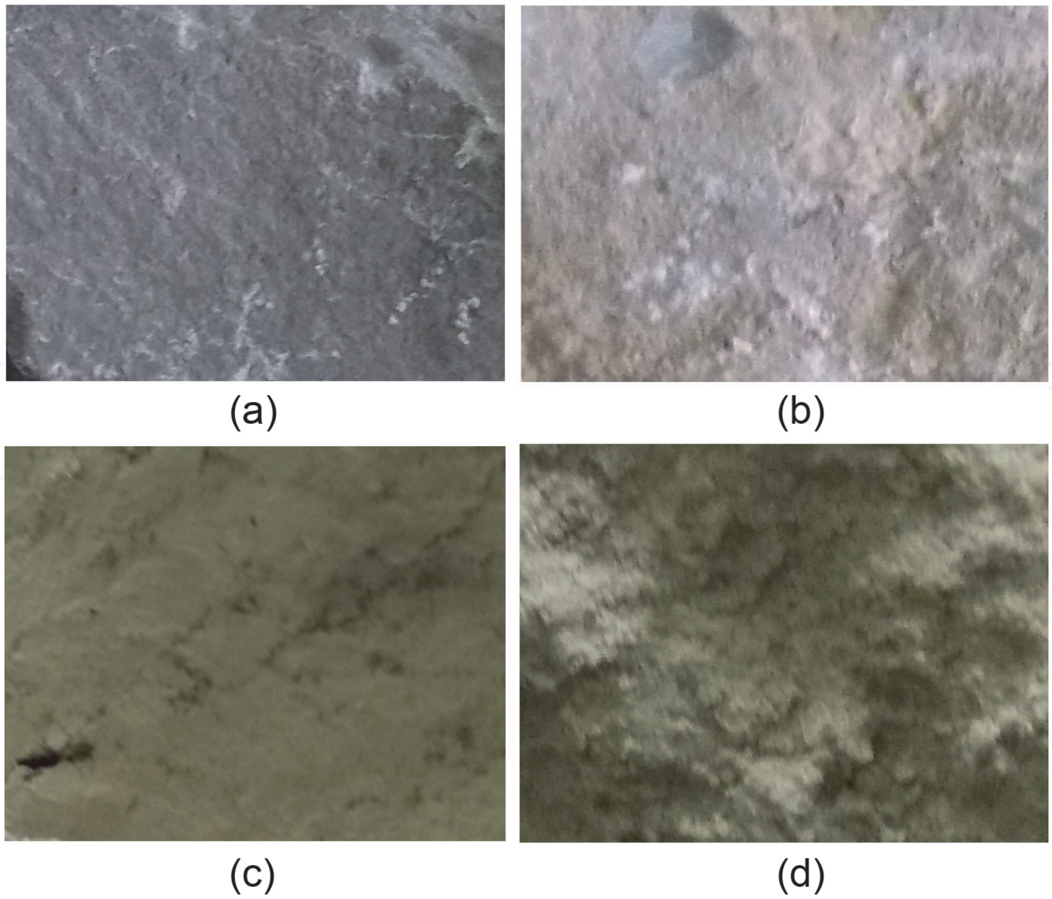

Figure 17.
(a) Marly shale, (b) Mardin limestone, (c) porous Hasankeyf limestone, and (d) the Siirt limestone.

provided in the Mardin, Batman, and Şırnak province in the experiments were given in **Table 9**. The amount of marly shale and porous silty limestone was efficient in fire inhibition reducing flame.

Prior to the preparation of the bright section, a liquid yellow epoxy resin was impregnated with the samples in a medium vacuum. This resin penetrates into the pores and makes the pores appear easier under the microscope (**Figure 17**).

4. Results and discussions

4.1 Flame inhibitor/extinguisher source: gypsum/fly ash/light shale

Mobile solid waste management included incineration of municipal wastes for thermal energy need and following landfill. However, the fire inhibitor soil production technologies from recycling, composting of waste became one method with other feasible mobile units of humus and agro soil production. In this studied case, the classified waste products were tested for inhibitor construction material, and fire inhibitor soil must be able to be developed for forest management and fire control and be aware that the inhibitor materials and composite products to be obtained from them must be processed by the gypsum or fly ash. These plaster sources widely used in construction and markets are also likely to be sensitive to the quality and quantity of the supply. The distribution of fly ash and biomass wastes in Şırnak province is shown in **Table 10**.

Mobile waste management is flexible in terms of design, compliance, and operation, and it needs to be able to adapt to existing social, economic, and

Component%	Şırnak Gypsum	Şırnak fly ash
SiO_2	1.44	21.48
Al_2O_3	1.12	13.10
Fe_2O_3	0.51	7.52
CaO	34.41	18.48
MgO	0.08	4.20
K_2O	0.10	2.61
Na_2O	0.05	1.95
Ignition loss	21.9	1.92
SO_3	26.22	0.32

Table 10.
Chemical compositions of the studied inhibiting fillers for forest fire extinguishing.

environmental conditions in the best way possible. Mobile/integrated systems including such waste inhibitor production and solid waste management units provide the flexibility to direct waste to other treatment systems as much feasible and waste sources of inhibitor soils provided even humus source of forest soil by protection natural conditions change (**Figure 1**).

The mobile solid waste inhibitor system should also be planned on a large scale in the regional base. The need for a range of waste disposal options can be envisaged as a reason for the large-scale plan to benefit from the demand and scale economics of recycled materials, compost, or energy at a certain quality and quantity [7–9, 14–17].

Mobile solid waste incineration can be successfully applied in areas with populations less than 500,000, depending on their work in various applications. The combustion system to be applied in this measure is also the amount of waste that depends on the nature and characteristics. The basic operations are mainly as follows:

4.1.1 Şırnak asphaltite: activated shale char/claystone

The scope of this fire inhibiting material production was filling material based porous solid heat absorption matter, for which the study was aimed metallization Şırnak asphaltite char as soil, fire arrestor source. In order to evaluate Şırnak asphaltite fine and other local limestones and gypsum for fire arrestor instead of construction material. The common burning of matter and metalized resources within the special fire arms is designed and proposed by providing legal and institutional, economic and environmental impact assessment. However, the use of Şırnak asphaltite and biomass source to develop materials against fire and tests of combustion weight change with standard flame and burning tests in laboratory ASTM D1373.

This situation of fire extinguishing matter was considered as metalized char instead of energy sources for better competitive. The fire management materials and safety market was caused additional policy tools needing to emphasize that EU and safety policy and law by environmental concerns drawn from Turkey. According to the potential policy instruments included the country determined the specified safety deviation from the materials fire inhibiting methods and guarantees to domestic targets including sustainable energy sources. The domestic forest potential and fire management regarding gross wood consumption had a certain share on concern to forest fire target (below 10%) should be management on high risk policy and legislation. The fire legislations reported from bio resources in renewable energy production and electric power for heating comprised separate but integrated objectives. These policies and laws only for biomass separate, but can also include an integrated target. All use of renewable sources in the EU target of achieving 12% market share for the biomass should be increased up to 300%. Regarding forest management at high risk fields in Turkey, appropriate potential control instruments and methods included forest fuel control and distribution to public-private sector and fire extinguishing lorry rods, construction ways, observation stations, aggregate road used in easy transport to high fuel risk zones, flexible loans, low interest loans, property first operating subsidies and/or grants and related service for consumers willing to use discounts as well as other financial support mechanisms. A potential wood market instrument of state was not required to support loans on forest management forever.

4.2 Inhibitor soil source as Şırnak asphaltite in Şırnak Province

The fluidized bed combusting of Şırnak asphaltite is producing 415 MW thermal power plant of CİNER in Silopi for electricity in compliance with the addition of limestone at the weight rate of 25% to the fluidized bed boiler on environmental norms to cut SO_x of low quality coal with 46% ash and 7% total sulfur combustion. The high ash of low quality types of coals was unfeasible in combustion systems and energy production facilities. The low quality coals are needed in inhibitor construction material production and mortar materials or pavement in road, and material technology provided also enables the production of liquid and gaseous mixing byproducts of fly ash and flue gas as fire inhibitor [15]. However, agricultural waste materials and humus chemical nature of them require a variety of mixing methods for soil amendments. For this purpose, alternative renewable energy resources need to process them to provide the basic information required in the laboratory and on pilot scale. The methods use feasible process in fire inhibitor materials, waste biomass, and metalized derivative shale chars as fly ash in the local area. So, significant design works for Shale char need to obtain as the char derivatives from the wastes as available fire inhibitor resources (**Figure 18**).

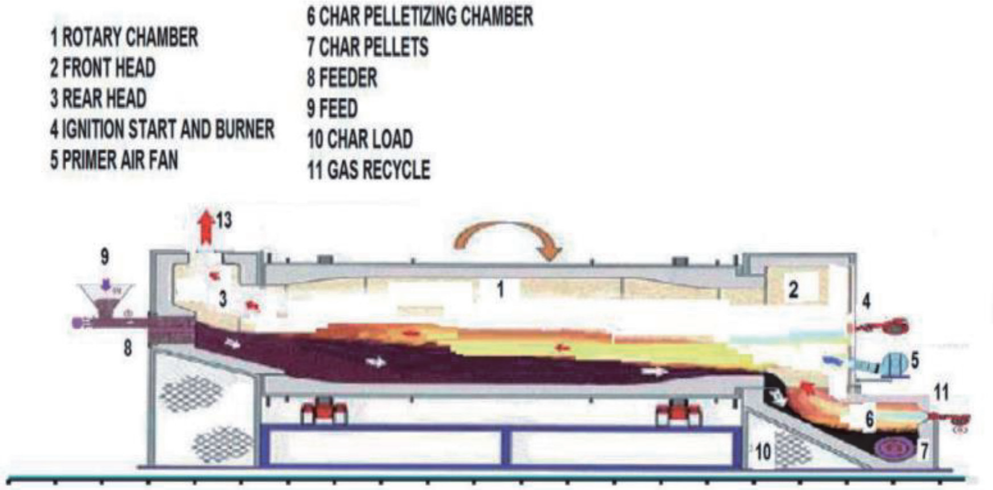

Figure 18.
Emission control with ESF, combustion with Şırnak chalk, limestone, and fly ash at weight rate of 25%, in Şırnak thermal station.

4.3 Fire inhibitor granule/sand/soil: mobile unit for waste carbonization-metalized char carbonization in Şirnak

In this study, porous limestone and porous anhydrite metalized stone absorbed the bubbled balls with microwave melted recycling anhydrite metalized powders covering the surface to avoid combustion. In this investigation, the recrystallized gypsum and powdered limestone were reroasted in microwave to melt anhydrite with the porous cores and basalt granules and even the bubbling of anhydrite metalized granules. The products finished was used for fire arrestor powder and soil, absorbing heat of fire which were determined as metalized coal carbon rich forest soil were investigated for arrestor on floor test and deterioration of soil and heat sorption were calculated, respectively. For this purpose, heat resistance, heat sorption, and soil combustion experiments were conducted. As defined, the test results were conducted by comparing metal powders with high heat. The production flow sheet and process advantageous parameters using recycling coal shale and anhydrite gypsum microwave processing parameters were defined. To recrystallize anhydrite metalized carbon limestone, the composite balls of marls having the relation between composite rock formation and discontinuity at production have been established.

In the tests, the Şırnak asphaltite sample was used as shown in **Figure 19**, and the reduction of the coal samples was shown in melt anhydrite fractions. The chemical melt anhydrite temperature was continuously weighed, and the metalized carbonization analysis was carried out in the bath microwave oven. The test results are shown in **Figure 3** for biomass pellets and coal sample. As shown in the figure, the effect of addition is determined in combustion experiments, the heat absorption as hydrated/dehydrated gypsum, the reactor temperature was 500°C and metalized

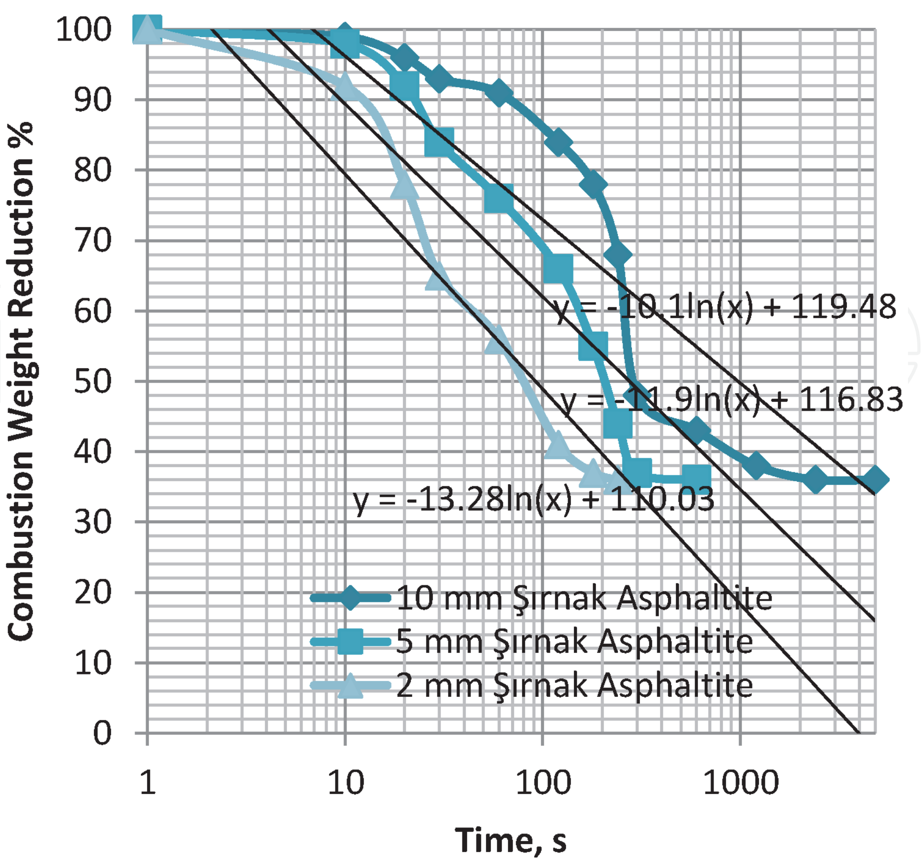

Figure 19.
TGA weight decrease during experimental flame combustion.

anhydrite only 10% metalized coal carbon soil pellet and slaked pores expanded in microwave treatment. The metalized carbonization weight ratio was varied to 750°C, and waste carbon samples were analyzed for heat hold-up by burning.

4.4 Microwave radiated metallized sponge char production

Porous compost production by char was managed in pilot systems using retort combustion systems that are adaptable to flexible and variable fuels in need of low quality fuel. In real applications, char waste fuel qualities were not be fully metalized in a variety of fluid and grate combustion systems. However, environmental effects were reduced due to semi-burning. Burning biowaste or Şırnak asphaltite slime in the fluidized bed manufactured by ALFA Company, combustion and energy production were developed within the scope of char and combustion wastes to char [6, 18, 19]. Char production systems in the integrated solid waste management can provide energetic energy production with biogas plant. The combustion inhibition or flame inhibitor porous char granules occurred on the coarse sized material is shown in **Figure 16** and flame model in **Figures 20** and **21**.

Mobile plant carbonization system with the following design produces integrated energy with the biogas plant (**Figure 2**):

- separation of metal waste and pet wastes;
- classification of biological wastes and drying and storage in pools;
- biogas anaerobic conversion of bio wastes;
- mobile combustion; and
- energy production.

Integrated solid waste incineration is evaluated as more advantageous in some countries. Mobile systems, however, provide economic benefits in the areas of low population density in our country and in cities. The separation of metals from scrap or recycling from household waste has often been an expensive cost step. However,

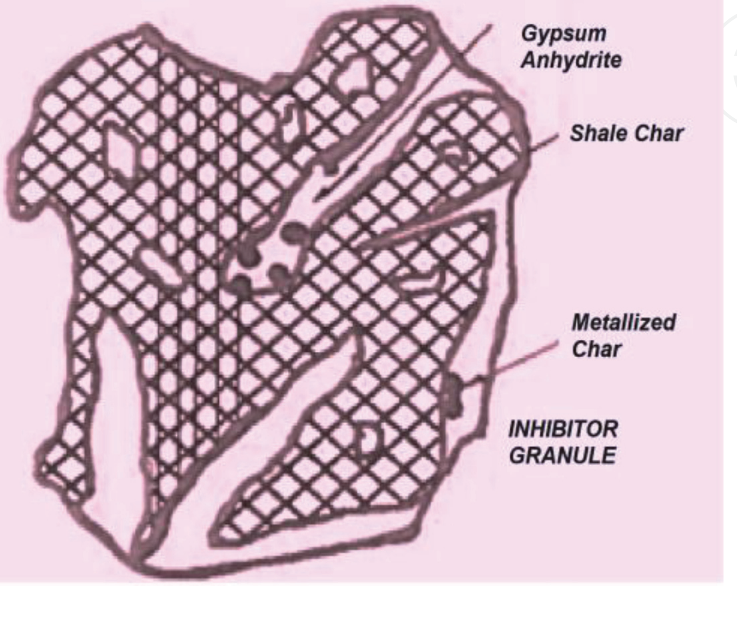

Figure 20.
Integrated fluidized bed biogas and solid waste incineration.

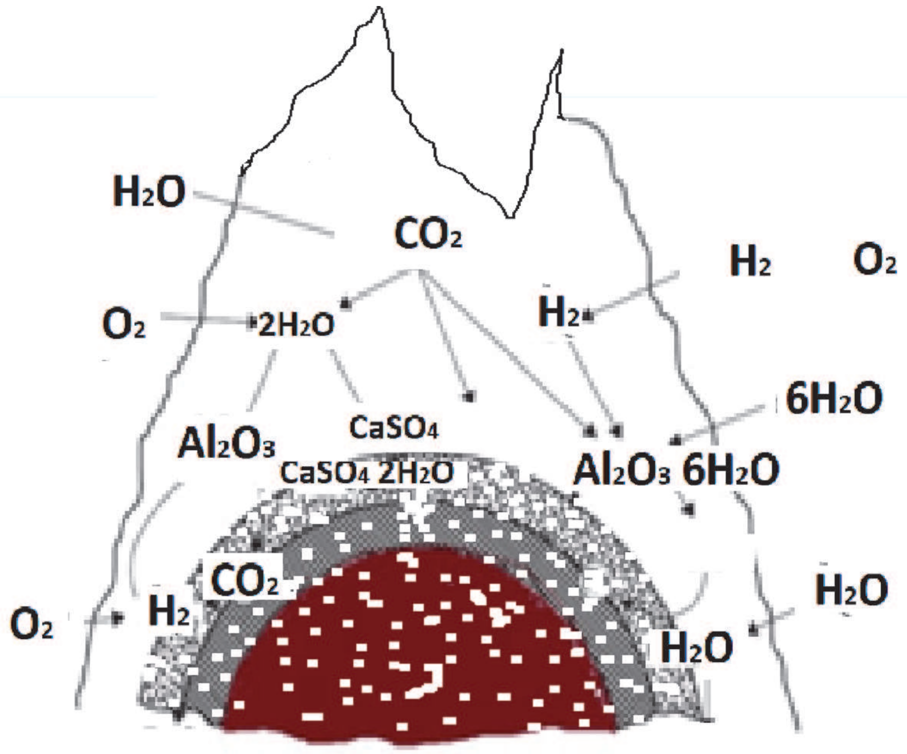

Figure 21.
Inhibitor flame solid waste incineration model on fire.

with the acquisition of biosolid wastes from the domestic source of the waste, the incineration system has been made feasible.

The conductive heat values could be determined by calorimetric studies regarding equations below:

4.5 Porosity and matrix content

The microwave metalized char led to relatively low heat conductivity of mass heat conduction of 53%. After application of recycling of waste asphaltite slime, the pyrolysis char extraction increased to about 11.7%. The char extraction from the waste samples in the conventional furnace at 600 and 700°C yielded values of 15 and 17% low heat conductive char products, respectively.

Microwave metalized char work could be integrated into such a system in order to make pretreatment faster and more economical. The proposed process that includes even microwave pyrolysis circuit was retorted for conducting heat by microwave oven. The test results in this study were given by TGA burning weight decrease of oak and fire inhibitor addition at half weight rate in the dish pot in TGA are shown in **Figures 22** and **23**. The granule composting was obtained by briquetting method under microwave radiation as permittivity loss and heat absorbance as temperature change are shown in **Figures 24** and **25**.

TGA weight decrease during experimental flame combustion results is shown in **Figure 5**.

4.6 Stone type

The problems of water collection in dry climates and hard hot conditions of the water storage pools became advantageous for the production of muddy slurry preparations. The inhibiting slime coal matter such as coal ash particles had a property of noncombusting and low-heat conducting rate than fines; thus, temperature control during fire combustion could be avoided. Additionally, there will be

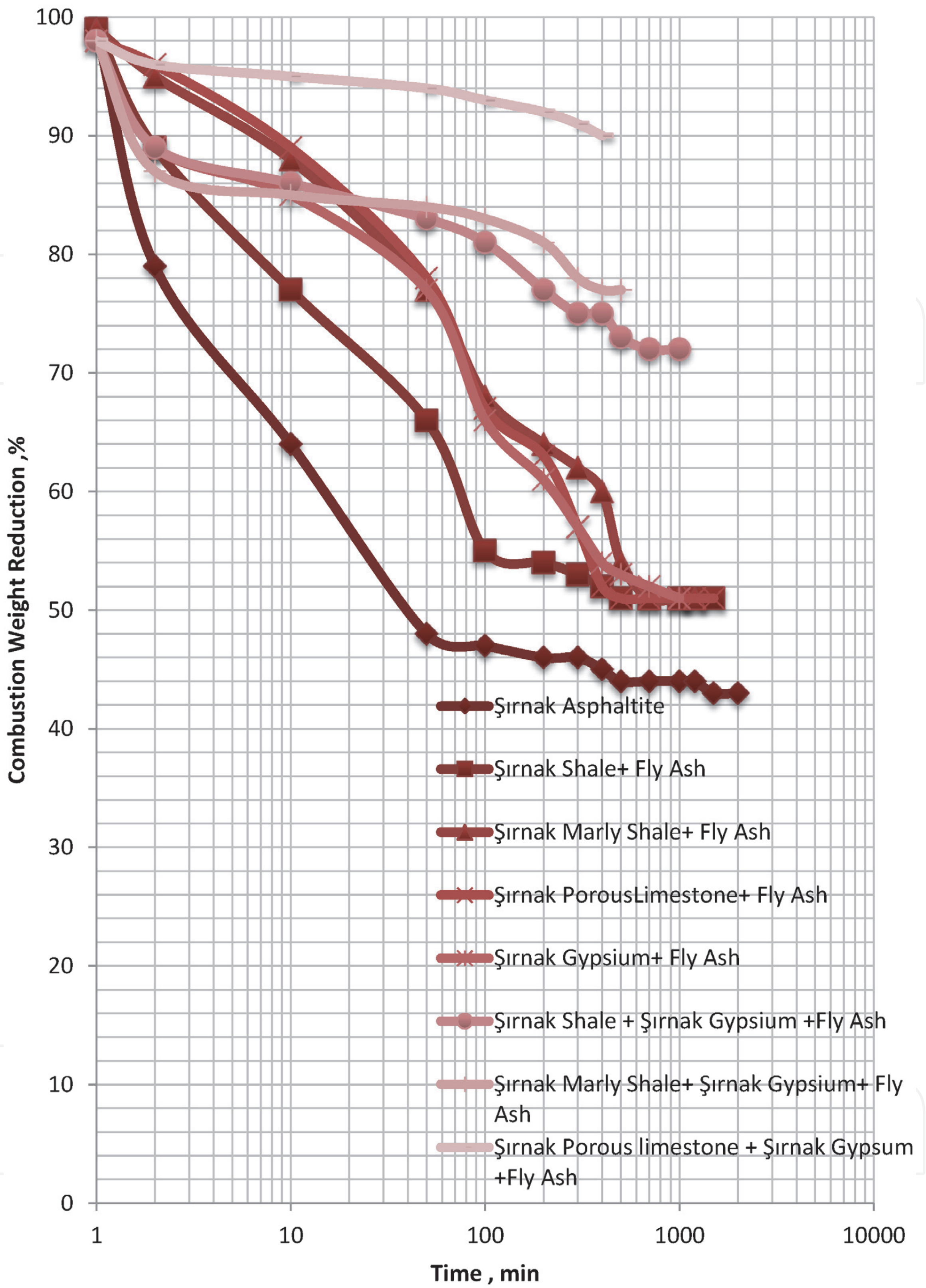

Figure 22.
TGA weight decrease during experimental flame combustion by fly ash, Şırnak shale, limestone and Şırnak gypsum.

fly ash dust that may control during flaming by the high-specific surface area over 12–22 m^2/g and low heat conduction for complete combustion by microwave metalizing char. The carbonaceous matter in the gypsum compost adsorbed much flame heat. The most important matter was the metalized char carbon and waste slime carbon. The constituents of the inhibiting source carbon were amorphous metalized inertia.

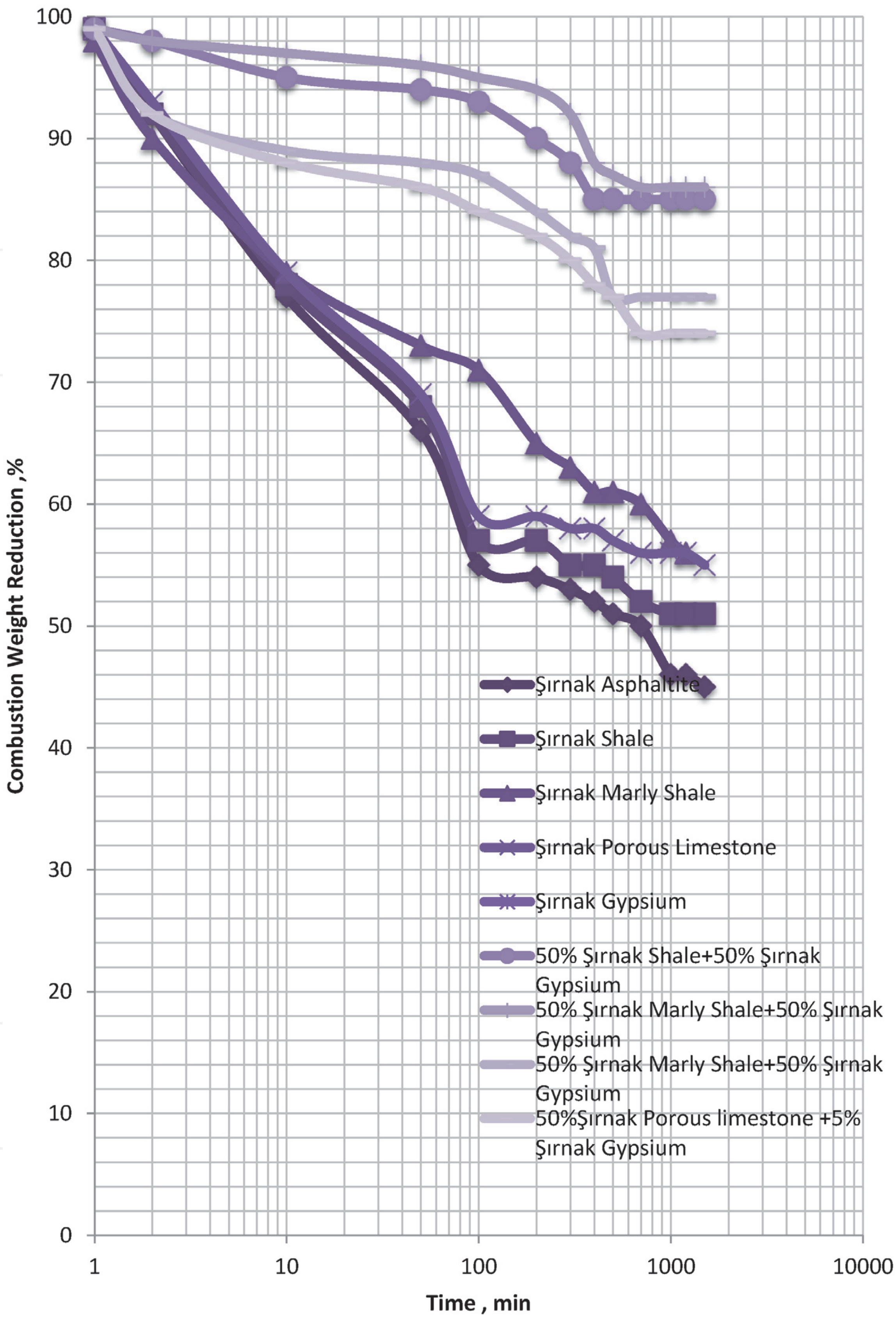

Figure 23.
TGA weight decrease during experimental flame combustion by Şırnak shale, porous limestone and Şırnak gypsum.

Such limestones containing limonite and iron hydroxides provided the inhibitor hydrate in flame extinguishing with microwave pretreatment to break down the matrix of the oxides and metal hydrated matters or passivity the carbonaceous matter before calcinations by heat absorption. The methods included hydrating, pressure hydration, metalized char lining, and flame inhibiting gaseous matter

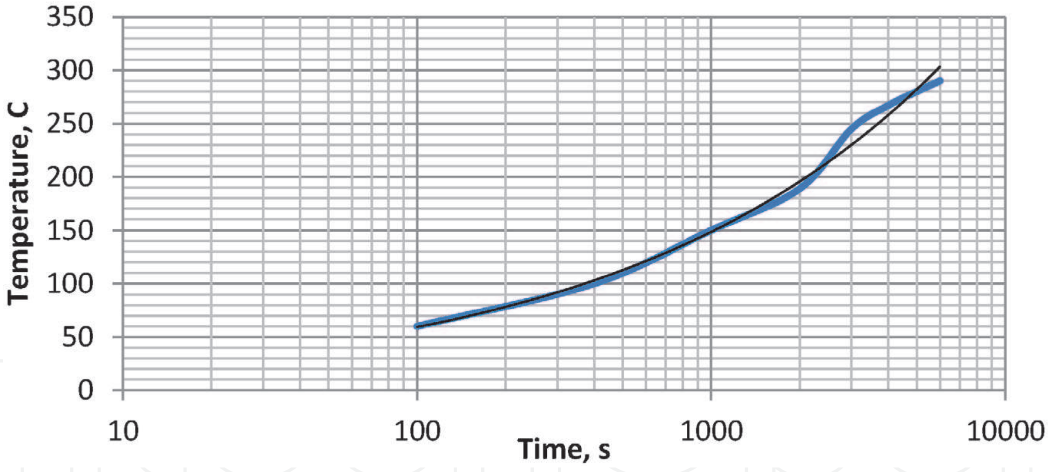

Figure 24.
Time effect of metalized char processing time on briquetted matter by temperature in microwave char metallization.

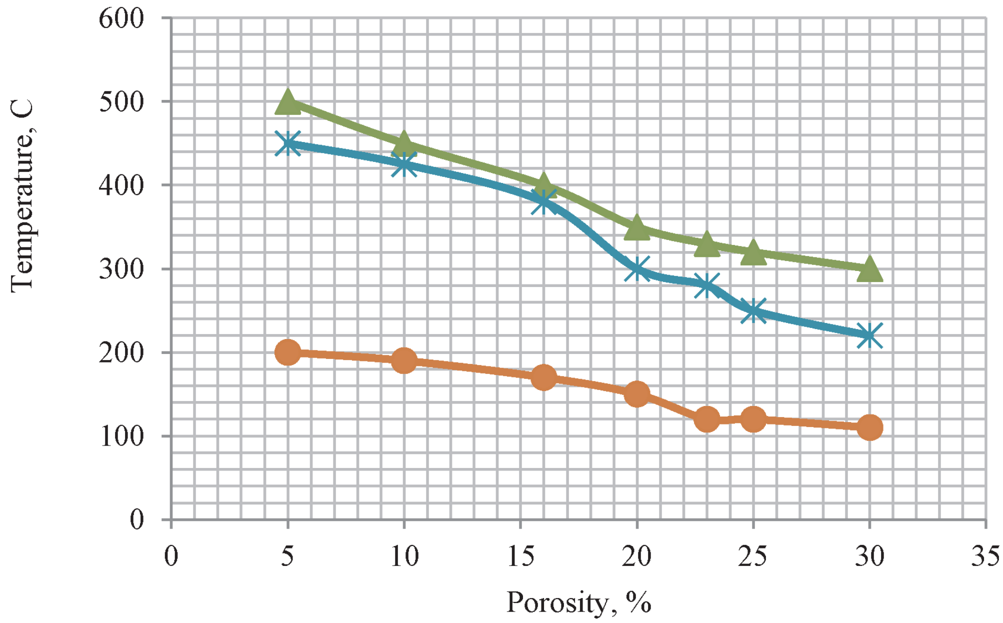

Figure 25.
Porosity effect on temperature in microwave char metalizing.

output of waste. Microwaves could be utilized as an alternative source of energy for hydrate treatment of composts in some of the unit operations such as porous metalized carbon and metal oxides known to be very good microwave absorbers, and they rapidly and selectively inhibited heated flame matters. In the present study, the microwave pyrolysis of a coal sample with coal pyrite and copper pyrite was investigated. The porous limestone was very responsive to microwave heating, and this resulted in almost semi-reactive porous matter for calcination and in some cases active porous compost of the material as shown in **Figure 20**.

The changes in the heat absorbing behavior of the limestone were monitored, and the optimum conditions for metalized char pyrolysis rate were established as shown in **Figure 24**.

Eight hundred powered microwave radiation over the 10 g powder samples reached a temperature of about 500°C in metalized calcination of compost, while the 10 g sample reached temperature long time to about 500°C. Generally, in laboratory scale microwave metalizing, the sample temperature increases with sample mass. In contrast to conventional heating, in microwave systems, the heat is generated internally, and thus, the metalized product porous mass covered heat loss from the sample. There were porosity and density factor that controlled the flame inhibiting weight decrease by fire heating behavior. For samples with a relatively low mass, the high surface area to volume ratio restricted the flame power. The rate of temperature rises, and the maximum attainable temperature could be inhibited by slurry composts. As a result, the conductivity at soil peat values was relatively low, and the soil sample was effectively coupled with inhibition of the fire dish. On the other hand, for the same cross-sectional area of the clay pot, as the sample mass depth was increased, there was a reduction in the surface area to inhibition volume ratio, and this reduced the inhibition matter in fire loss from the bottom, leading to a higher flame and fire temperature. Additionally, as Pot dish depth mass decreased, there was more efficient inhibition on fuel material to reduce interaction with the fire field.

5. Conclusions

The inhibitor granules and water granule slurries at lightweight matter resulted in successive heat absorption in the flame plasma, and the composite granules of gypsum in the bubble composite form were so effective. The shale hydrated was also effective with metalized carbon content and hydrate content.

The microwave radiation metallization of char showed heat absorption in the flame increasing process time and sample mass in the flame. Due to the heat decrease response of the composite gypsum to carbon, low slurry densities of 1.2 and 1.3 kg/lt were found to be suitable for inhibition flaming as higher densities resulted in bubbling and foaming of the metalized char/anhydrite. The waste metalized char/shale/anhydrite weight rates after radiation route in microwave were over 25%, and the bubbling route was continued in the flaming fire period of wood to those obtained by conventional heating. The main advantages of microwave melting were that both the total flaming heat rates conducted to metalized char gypsum surface equally disseminated pores, and the cooled bubbling over cooling rates was higher, and the specific energy area of solid matters in flame was lower than in fly ash composite granule.

Şırnak porous limestones containing 20% porosity and the high gypsum content discarded as sponge stone from aggregate stocks swept to waste products. Şırnak produces the porous gypsum stones by construction stone product about 50,000 tons per annum for swept to waste broken stone wall matter to dispose, Siirt and Şırnak porous limestone was not also evaluated. Those waste stone products both should mainly be evaluated as fire inhibitor material as sponge isolator stone. Those must be evaluated in terms of high valuable metal contents emitting heat conduction and radiation. In this study, samples were subjected to microwave melting of metalized anhydrite shale tailings, fly ash, and subsequently pelletized and subjected to microwave bubbling briquetting over stone surface blocking to clusters. Porous limestone sand, fine waste of porous limestone were wide advantageous in filer raw material sequence in the region containing disseminated distribution of low and high quality cementing limestones. The porous limestones over 50–70% were produced by filler construction or isolation stones processed at least 100,000 tons waste. Every year about a few million tons of limestones could be used as waste fire inhibitor or extinguishing material. The granule in a particle size of these wastes usually occurs below 10 mm in size, which may be advantageous for the evaluation of shock wave şolator composite stone production. The evaluation of those waste sources in sponge composite iron stone block production was prompted as chemical properties in the microwave process, and feasible production of sponge composite iron stone was managed in this study.

Abbreviations

A	*pre-exponential factor* [s^{-1}]
c_p	*specific heat capacity* [J/kg K]
E	*activation energy* [kJ/mol]
heat of pyrolysis	[J/kg]
h_c	convective heat transfer coefficient [W/m^2 K]
k	thermal conductivity [W/m K]
L	depth of the sample [mm]
heat flux	[kW/m^2]
R	*universal gas constant* [J/mol K]
T	temperature [°C]
t	time [s]
Y	mass fraction
z	depth into the sample [m]
ε	*emissivity*
κ	radiative absorption coefficient [m^{-1}]
reaction rate per unit volume	[kg/m^3 s]
ρ	density [kg/m^3]
σ	*Stefan-Boltzmann constant* [J/K]
0	initial
e	external
d	destruction
g	gas
i	condensed-phase species index
ig	at ignition
r	in-depth radiation
s	solid

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