Effects of Forest Fires on Water Sources

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Abstract

Environmental pollution is the most important factor concerning destruction of water, soil and air ecosystems in the world. Water sources are one of the areas mostly affected by environmental pollution. It is required to obtain sustainable and accurate data concerning water quality so that qualifications, areal and temporal change of water sources can be understood. Quality of water sources from water basins consisting of forest lands might deteriorate due to natural disasters, forestry activities and use of forest lands for recreation purposes. Quality of water from forests which are not destructed or deteriorated due to natural disasters is generally quite high. Even though forest fires are favorable for the health of forests in the long term, they affect water quality of streams, lakes and rivers in water basins negatively. Researches reveal that forest fires or incineration of production waste in forests result in increase of chemical element amount on the soil surface. Certain amount of such elements remain dissolved, while others reach water sources through sediments. It is identified that N, P, K, Mg, Na, Ca, Mn, Cl and HCO_3 concentrations increase 2 to 100 times in these sources. According to statistical data of the last 25 years, 2070 (on the average) forest fires occured and 11245 ha forest area is burned every year in our country. These forest fires result in pollution of water sources in addition to major environmental effects.

Keywords — forest fire, water quality, water pollution

1 Introduction

The negative impact of forest fires, which can occur due to various reasons, cannot be limited only to the relevant country or region, because forests are the common property of the world and they have a very important place in the global ecosystem and climate system. Therefore, it is a fact that forest fires seen in one place have negative impacts in a global dimension. Inarguably, much greater loss of life and property occurs at the location of fire, together with the greater problems occurring in the economic and social dimensions.

Despite all financial and technological investments against forest fires, the most important reason for failure in preventing forest fires is suggested to be the wrong policies regarding forest fires. For many years, the efforts to completely keep the forests free from fires have been unsuccessful. Today, it is finally understood that forest administration and fire suppression can be accomplished only when the forest organizations and the people living in the area start living in a harmony with the forests, and adapt to the risks of fire in the same way the plants do [1].

Another reason for the increase in forest fires occurring recently in the world is indicated, as the overall temperature increase in the world due to global climate change. Accordingly, over the course of time the increase in the duration and intensity of warm and arid periods may also increase the frequency and severity of forest fires [2].

2 Forest Fires in Turkey and in the World

In the world and in Turkey forest fires are at the top of the factors that pose a threat for the forests. As is known, Turkey is located in the Mediterranean climate zone. Forest fires are unavoidable in this zone. Approximately 4 million hectares of forest area are exposed to fire each year throughout the world, whereas in the Mediterranean zone, this figure is approximately 550 thousand hectares [3].

The coastal strip in our country, which begins in Hatay and extends all the way to Istanbul, passing from the Mediterranean and Aegean coasts, constitutes the most risky area for forest fires. When we analyze Turkey's forests in terms of their degree of sensitivity to forest fires, the areas that have first-degree fire sensitivity constitute 7,182,051 hectares, whereas the areas with second-degree fire sensitivity constitute 5,091,788 hectares. According to this data, 12 million hectares of forest area, which corresponds to the approximately 57% of our forest areas, are very sensitive to fire (Figure 1).

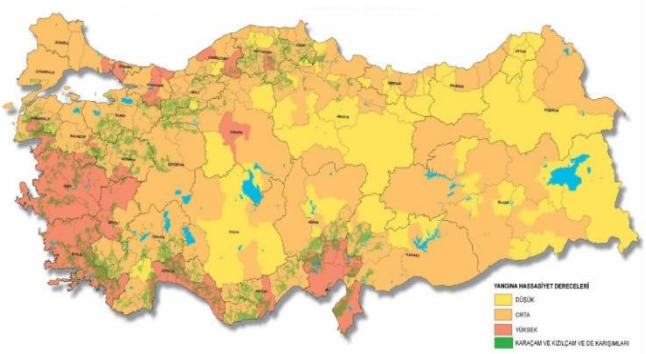

Figure 1. *Distribution of Forest in Turkey According to their Fire Sensitivity Degrees[4].*

Upon the examination of the statistical data pertaining to the last 25 years, it can be understood that in Turkey, approximately 2,070 forest fires occur annually and 11,245 hectares of forest area are damaged by fire. When we examine the fires that occurred in 2013, it can be seen that 86.2% of these fires resulted from negligence and unknown causes (Table1, Figure 2).

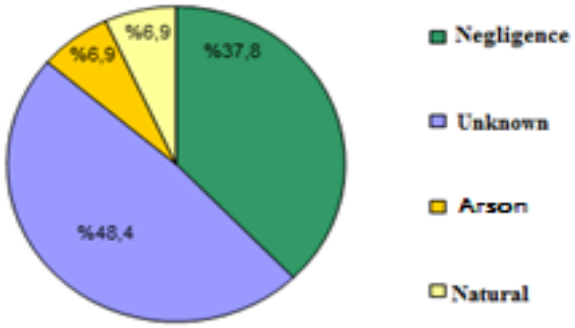

Figure 2. *Distribution of the Causes of Forest Fires in 2013*

The volume of the world's total water is 1.4 billion km^3. Ninety-seven point five percent of this water is comprised of the salty waters of the seas and oceans. Only the remaining 2.5% is fresh water supply that is available for a variety of purposes. Ninety percent of these already limited fresh water supplies are located in the poles and underground; therefore, from these figures it can be seen that the fresh water suitable for the use of mankind is very scarce.

The economically usable capacity of Turkey's rivers is annually 95 billion m^3, and 48.1 m^3 of these stem from forest areas. In that case, 50.53 % of Turkey's usable surface water output is produced by the forest areas in Turkey. In other words, at least 50% of Turkey's usable surface flow reaches the rivers from the forest areas, which cover approximately 25% of the country [5]. Fires occurring in these areas cause our water resources to be largely polluted, in addition to causing other large environmental impacts.

3 Impacts of Forest Fires on Ecosystems

In addition to the direct impacts of forest fires, which have become a growing threat, on the trees, they also have some positive or negative impacts on the forest soil, flora and fauna, wildlife, and water resources. Today, numerous studies are conducted on forest fires by various disciplines and through various topics. However, these studies require many years of observation and data analyses to reach accurate conclusions.

The fires greatly affect the flora and fauna in the fire area. Different types of forest fires have different effects on various animal species and habitats. In addition to the migration and destruction of the habitat caused by fires, they also have direct lethal effects on wildlife. Furthermore, after the fire, the arrival of another species to the burned area is an undesirable

situation for the wildlife.

Other damages caused by forest fires in our country can be listed as follows:

- The contamination of water resources adversely affects all living species, primarily humans.
- The habitats of species living in forest are changed.
- The number and frequency of natural disasters increase upon the termination of soil's living and nonliving elements.
- Erosion and flooding occur in the most striking manner.
- Disruption of the carbon/oxygen balance causes variations in the climate.
- The ecological balance is disrupted.
- Tourism is negatively affected.
- The number of recreation areas decline.

Table 1. *Forest areas that burned due to forest fires in Turkey between 1986 and 2013; the number of fires and their causes (6)*

			Cause of the fire exit							
	Burnt area	**Fire number**	**Arson**		**Negligence**		**Natural**		**Unknown**	
	Hektare	Number	Number	Hektare	Number	Hektare	Number	Hektare	Number	Hektare
1988	18 210	1 372	-	-	-	-	-	-	-	-
1989	13 099	1 633	-	-	-	-	-	-	-	-
1990	13 742	1 750	-	-	-	-	-	-	-	-
1991	8 081	1 481	-	-	-	-	-	-	-	-
1992	12 232	2 117	-	-	-	-	-	-	-	-
1993	15 393	2 545	-	-	-	-	-	-	-	-
1994	30 828	3 239	-	-	-	-	-	-	-	-
1995	7 676	1 770	-	-	-	-	-	-	-	-
1996	14 922	1 645	-	-	-	-	-	-	-	-
1997	6 317	1 339	193	923	696	3 389	78	37	372	1 968
1998	6 764	1 932	249	1 655	1 163	3 713	53	20	467	1 376
1999	5 804	2 075	279	1 926	1 151	2 808	203	126	442	944
2000	26 353	2 353	410	4 417	1 384	19 017	132	167	427	2 752
2001	7 394	2 631	251	651	1 629	4 247	188	735	563	1 761
2002	8 514	1 471	218	509	809	7 287	181	261	263	457
2003	6 644	2 177	258	665	1 317	4 520	120	694	482	765
2004	4 876	1 762	242	748	1 033	3 093	128	233	359	802
2005	2 821	1 530	272	402	867	2 084	140	48	251	288
2006	7 762	2 227	166	206	1 315	5 873	330	543	416	1 139
2007	11 664	2 829	292	1 705	1 642	7 994	407	243	488	1 722
2008	29 749	2 135	377	797	1 018	26 283	330	699	410	1 970
2009	4 679	1 793	231	792	884	3 082	333	105	345	700
2010	3 317	1 861	146	526	861	1 851	281	69	573	871
2011	3 612	1 954	153	283	1 067	2 368	130	39	604	922
2012	10 454	2 450	197	1 615	936	5 780	373	334	944	2 725
2013	11 456	3 755	260	1 478	1 419	4 051	258	138	1 818	5 789

4 Water Quality

The broadest areas affected by environmental pollution are water resources. In order to obtain a good understanding of areal/spatial and temporal changes in water resource characteristics, it is necessary to have to hand data indicating the quality of water, which should be gathered on a continuous basis. In this way, it will be much easier to assess the condi-

tions of water resources and to develop solutions should problems occur [7]. For the assessment of water quality data, each parameter has been defined in a separate regulation and standard. A comparison of water quality parameters obtained in the field with limit values set according to those standards leads to a conclusion as to whether the water is fit for its intended purpose of usage. Making such an assessment for each and every parameter may reveal that the water under examination is usable for some parameters, but unusable for others. [8].

4.1 Effects Forest Fire on Water Quality

Environmental pollution is one of the primary factors with regard to the damage that occurs to the world's present soil and air ecosystems. Water resources are one of the areas that is affected the most from environmental pollution. In order to understand the spatial and temporal change of the characteristics of water resources, sound data revealing the water quality must be obtained in a continuous manner.

In general, a significant portion of the drinkable water is supplied from forest basins. The quality of the water resources stemming from basins formed in forest areas can deteriorate due to natural disasters, various forestry activities, and due to the use of basin's forest areas for recreational purposes. The quality of the water supplied from the forests that are not damaged or destructed by any natural disaster is generally very good [9].

The best way to prevent water pollution arising from forest fires is undoubtedly to create an adequate fire prevention system. On the other hand, in areas where forest fires occur, the burnt forest area should be replaced with vegetation cover without delay. To accomplish this, seeds of annual herbaceous plants and fast-growing tree species suitable for the area must be sown; therefore, the area must be reforested as soon as possible. In such greening activities sometimes no-slope terraces, reformative forms, and other engineering structures are used; however, it has been found that planting barley in narrow lanes in the direction of contour lines is the most effective method for controlling the sediment transport during the prolonged and heavy rains in the scrub areas where the vegetation is destroyed due to fire [10].

Research has proven that an increase occurs in the amount of chemical elements in the soil surface as a result of forest fires or due to the burning of production wastes at the forests. Some of these elements reach the water resources in dissolved form, and some reach via sediments. It has been found that N, P, K, Mg, Na, Ca, Mn, Cl, and HCO_3 concentrations in these resources increase 2 to 100 times [11]. Here, it can be seen once again that the addition of large amounts of chemicals into rivers can be controlled to some extent through the prevention of fires, and via restricting the burning of production waste/trimming cuts as much as possible; in short, through the avoidance of practices that reduce the soil's infiltration capacity.

After forest fires, a significant reduction occurs in the soil's wetting properties and therefore in its infiltration capacity; due to this reason, soil erosion during heavy rains in such regions is higher than other areas. In addition, in the burned areas where the soil has resistance to wetting, the slow movement of soil on the surface also increases, in the form of "dry friction". This situation stems from the fact that the soil, which has lost its wetting properties, is less condensed compared to the wetable soil with weak cohesion.

Studies show that the forest soil that has lost its wettability due to fire has been made to recover and regain its wettability by the sprinkling of specific chemical materials. For example, it has been reported that alkylpolyoxyethylene ethanol that is sprinkled on burnt soil has yielded successful results and that it is effective for at least one year [12].

5 Conclusions

With regard to the rainfall water (175 billion m^3) that falls in the forest ecosystems in Turkey, the mentioned rainfall's course in the forest and from there to the sub-basins varies according to the climate, topographical structure, vegetation, and soil and land use types in the location of the forest. With regard to the rainfall water that falls in the forest, it can be stated that approximately 15% of it re-evaporates after being retained by the forest's cover and soil surface at the time of rainfall; approximately 30% of it re-evaporates upon being absorbed by the plant roots inside soil during its movement inside the soil; and with respect to approximately 55% of the remaining water, some portion of it supplies the soil water and underground water upon its movement in soil, and some portion of it supplies the aboveground water resources through surface flow. These data indicate that forests significantly supply the underground and aboveground water resources.

The hydrological function of the forests can be defined as enabling the continuous movement of the water formed from rainfall that falls on forest ecosystems, with appropriate quality and quantity, to the resources such as soil, streams, freshwater lakes, ponds, and dams. Until today, flood and soil erosions have occurred in some parts of Turkey, and desertification

and drought in some parts of it. Global climate change is expected to further increase these deficiencies. Therefore, by taking forest fires into account, Turkey shall focus more on hydrological function in order to make a greater contribution to the sustainability management of water resources; and its application techniques in forestry development must be also be improved (13).

Water is our most important asset for sustainable living. Limitations are being imposed within the framework of regulations for the protection of water quality. Studies are being conducted in our country for forest fires and their impact on water quality. In addition to developing management models against fires, water quality monitoring, and immediate prevention planning must be carried out.

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