International Meeting on Soil Fertility Land Management and Agroclimatology. Turkey, 2008. p: 997-1005

Research on Pollution Caused by Thermal Power Plants in Muğla

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ABSTRACT

The paper studies the heavy metal pollution caused by Gökova (210 MWx3), Yeniköy (210 MWx2) and Yatagan (210 MWx3) Thermal Power Plants in Mugla. For this purpose, the heavy metal level of the leave and soil samples taken in each season from olives is stated. The minimum heavy metal level is found in Yatagan, and the maximum in Yeniköy. The heavy metal level of the soil samples generally increases in autumn. The level of the leave samples has generally its highest levels in winter. Because Lignite includes low calorie and high sulphur and ash and especially Yatagan becomes demoded, the pollution continues to pose a serious threat in the precinct.

INTRODUCTION

Thermal Power Plants produce energy by ignited fossil fuels such as coal, petrol or gas. The 60 percent of World electricity production is supplied by fossil fuels. Thermal Power Plants contribute the country's 60 percent of energy production. Yatagan (3*210 MW), Yeniköy (2*210 MW) and Kemerköy (Gökova) (3*210 MW) Thermal Power Plants all of which have 1680 MW power of Thermal Power Plants with 10.794 MW power which are settled in the country and regularly produce electricity for the national power allocation system are in Mugla.

Considering the importance of the tourist receipts for our developing country, the importance of electricity production for the precinct, which has an intensive tourism potential, is apparent. However, at the same time it cannot be ignored that the precinct has foremost *Pinus brutia* Ten. and *Pinus pinea* L. forests, a quite rich forest potential, and a high agricultural production potential. This prosperity is in jeopardy. In precinct, olive (*Olea europea* L.) is harvest vegetation raised intensively and from which oil is produced. Due to the fact that lignite used in Thermal Power Plants is burnt in elevated temperatures, several heavy metals in the lignite turns into ash. Some of the ashes accrue with un-burnt organic matter while most of the ashes are moved through chimney with hot gases and it is released to the atmosphere. Forests and vegetation around Thermal Power Plants are negatively influenced long terms by heavy metal particulates and ashes. The heavy metal content directly related to the increase in the ash level of the coal used as an energy resource changes from source to source. The ash ratio produced by Yatagan Thermal Power Plant which uses Yatagan-Eskihisar lignite including % 20-27 ash and has 3 working units is stated as 1-1.4 million tone/year.

The anatomic and morphological changes on vegetation because of air pollution have been studied in many researches. According to a study executed in Mugla Yatagan Thermal Power Plant region, the scrub which constitutes the forest substratum is preserved whereas red pines which constitute the upper crust of the forest are destroyed by the pollution caused by Thermal Power Plant and forest area which gets dry is 3047 acres (Nuhoğlu et. al.1996). The observations done in the same region for 22 years shows that the width of the pines rings has decreased annually about 07-28 mm. (Tolunay, 2003). The pollution caused by Thermal Power Plants damaged not only aboveground but also the subterranean waters. In a research which studies the effect of Mugla Yatagan Thermal Power Plant on aboveground and subterranean waters, it is reported that Ca_2^+, Cd_2^+, Pb_2^+ and Sb_2^+ metals in water samples taken from 2 barrage, 5 surface and 21 ground water are above the boundary value (Baba et. al., 2003). Another study reports that the effects of the ashes from Yatagan Thermal Power Plant are geochemistrically evaluated and it is required to create precautions and a detailed program to prevent soil contamination in the region intensively affected by ashes (Baba, 2003). In a study to determine some features of fly ash and heavy metal contents from Soma and Tuncbilek Thermal Power Plants, it is stated that the environmental problems caused by the lignite which is used as a fuel in Thermal Power Plants are not only the result of gas emission but also the problem of fly ash storage. The main problem about fly ash results from the heavy metal remains in fly ash storage. The important point in the study is when fly ash comes together with water, it can be resolved. So that it can cause soil pollution (Baba and Kaya, 2004). Some prominent features of lignite coal used as a fuel in certain Thermal Power Plants settled in Turkey and its heavy metal content is examined. It is found that lignite used in Çayırhan, Seyitömer, Tunçbilek, Orhaneli, Soma, Yatagan, Yeniköy, Elbistan, Kangal and Çatalagzi plants contains high moisture (% 14-47), high ash (% 23-64) and % 0.4-4.8 sulphur. It is reported that energy level of lignite is about 1370-4980 kcal/kg. It is noted that coals have such minerals as not only clay but also quartz, feldspat, calcite, dolomite, pyrite and gyps. In addition to these, it contains siderite, aragonite, and zealot. It is also reported that coals are rich in Cr, Cs, Mo, Ni, Rb, Th, U and V metals and according to As, Co, Cu and Mn, coals excess the global standards (Karayigit et. al. 2000).

Considering the environmental reasons mentioned above and the electricity production of our country, this study aims to search the effects of 3 Thermal Power Plants settled in Mugla on soil and vegetation. In this study, pervasively growing olive orchard is used as a material. Each season, leave and soil samples are taken from the olives around each of 3 Thermal Power Plants. In all the leave and soil samples, there are 9 heavy metals (Fe, Cu, Mn, Zn, Ni, Cd, Pb, Co, Cr) and the results are examined.

MATERIAL and METHOD

The research materials are made of the leave and soil samples taken each season from the olive plantations around Gökova (Kemerköy), Yeniköy and Yatagan Thermal Power Plants in Mugla.

After soil samples are turned into air dry in laboratory, they become ready for analyzing process by being sieved in a fine sieve (2 mm) (Jackson, 1967). In the soil samples, heavy metals and certain trace elements (Fe, Zn, Mn, Cu, Cd, Co, Cr, Ni, Pb) king water (HNO_3+HCl) are found by extraction method in Atomic Absorption Spectrometer (AAS) (Kick et al., 1980).

Leave samples taken from young olive trees around each of the 3 Thermal Power Plants are brought to laboratory in freezing compartments. After they are turned into air dry in 65 ^{o}C, they are ground and analyzable (Kacar,1972). After heavy metals and certain trace elements (Fe, Zn, Mn, Cu, Cd, Co, Cr, Ni, Pb) in the leave samples are turned in to ashes in 550 ^{o}C by dry-blowing method. They are found in vegetation samples extracting with 2N HCl by Atomic Absorption Spectrometer (AAS) (Isaac and Kerber, 1969; Kacar, 1984).

RESULT and DISCUSSION

The Heavy Metal Levels in the Soil Samples taken from Olive Plantations around Gökova, Yeniköy and Yatagan Thermal Power Plants

The heavy metal levels in the soil samples taken from olive plantations around Gökova, Yeniköy and Yatagan Thermal Power Plants are defined and average results are shown in the Table 1.

Table 1. The heavy metal levels in the soil samples taken from olive plantations around Gökova, Yeniköy and Yatagan Thermal Power Plants

Plants	Fe (%)	Zn	Mn	Cu	Cd	Co	Cr	Ni	Pb
Gökova	1.9	87.4	544.7	24.6	0.90	17.6	50.7	66.3	23.3
Yeniköy	2.2	84.0	560.0	25.3	1.12	24.2	44.7	65.6	29.8
Yatagan	1.7	75.9	487.7	22.4	0.98	16.8	35.8	42.4	33.7
Average	**1.9**	**82.4**	**530.8**	**24.1**	**1.00**	**19.5**	**43.7**	**58.1**	**28.9**

The findings in Table 1 are in rapport with many researchers' findings. All the metals examined (except for nickel) are in normal boundaries. Saatçı et al. (1988) in Izmir Hakerlerler et al. (1992) in Harran Plain, Scheffer ve Schachtschabel (1989) in Germany have found total iron value in these lands is min. % 0.5, max. % 5.0. Kloke (1980) and Pendias and Pendias (1984) see 70-400 mg kg^{-1} Zn ve 1500-3000 mg kg^{-1} Mn concentration as criterion on lands. Kloke (1980) ve Pendias ve Pendias (1984) finds 60-125 mg kg^{-1} as boundary level for Cu, 0.01-2.00 mg kg^{-1} as normal boundary and 3-8 mg kg^{-1} as critical boundary for Cd. They also find 25-50 mg kg^{-1} as critical boundary for Co. Shacklette et al. (1971) finds about 37 mg kg^{-1} Cr in 863 soil samples. Cr and Pb value of soil on which olive is raised has the same critical values Kloke (1980) ve Pendias ve Pendias (1984) gives. Ure and Berrow (1982) find that the average concentration of Ni is 93 mg kg^{-1}, proposing Nickel pollution. Considering Kloke (1980)'s 50 mg kg^{-1} Ni concentration, it is apparent that Gökova and Yeniköy Thermal Power Plants' soil is polluted by Ni.

In soil samples taken from olive orchard around each of the 3 Thermal Power Plants, the lowest heavy metal level (Fe, Zn, Mn, Cu, Co, Cr ve Ni) is around Yatagan Thermal Power Plant. The highest is around Gökova (Zn, Mn, Cr, and Ni) and Yeniköy (Fe, Cu, Co, Cr). Especially Mn, Cr and Pb vary more than any other elements. According to .the heavy metal criterion given by Kloke (1980), it is found that only Gökova and Yeniköy's soil are polluted by Ni (Ni>50 mg kg^{-1}).

Table 2. The heavy metal levels in the soil samples taken from olive plantations around Gökova, Yeniköy and Yatagan Thermal Power Plants in different seasons (mg kg^{-1})

Seasons	**Plants**	**Fe (%)**	**Zn**	**Mn**	**Cu**	**Cd**	**Co**	**Cr**	**Ni**	**Pb**
Spring	Gökova	1.7	94.7	554.7	21.8	0.38	13.8	40.5	47.9	11.4
	Yeniköy	2.5	77.4	606.0	15.6	0.62	20.2	33.6	52.1	17.9
	Yatagan	1.7	73.3	451.4	16.6	0.90	12.3	16.5	34.7	18.8
Spring Average		**2.0**	**81.8**	**537.4**	**18.0**	**0.63**	**15.4**	**30.2**	**44.9**	**16.0**
Summer	Gökova	1.4	59.7	485.9	21.1	0.76	15.6	68.5	72.8	24.4
	Yeniköy	1.6	54.3	479.4	18.3	1.18	26.8	84.4	74.6	34.7
	Yatagan	1.4	57.2	446.8	18.3	1.34	15.2	77.4	46.6	31.2
Summer Average		**1.5**	**57.1**	**470.7**	**19.2**	**1.10**	**19.2**	**76.8**	**64.6**	**30.1**
Autumn	Gökova	2.5	94.0	701.4	34.1	1.27	25.1	45.3	81.9	29.7
	Yeniköy	2.5	100.8	604.4	44.7	1.70	34.8	36.0	58.0	36.8
	Yatagan	2.0	76.1	624.4	36.2	0.86	25.4	24.2	50.9	35.6
Autumn Average		**2.3**	**90.3**	**643.4**	**38.3**	**1.28**	**28.4**	**35.2**	**63.6**	**34.0**
Winter	Gökova	2.1	101.1	436.9	21.4	1.19	15.9	48.4	62.5	27.6
	Yeniköy	2.2	103.5	550.3	22.6	0.98	15.0	24.9	77.8	29.8
	Yatagan	1.7	97.1	428.0	18.6	0.81	14.2	25.0	37.3	49.4
Winter Average		**2.0**	**100.6**	**471.7**	**20.9**	**0.99**	**15.1**	**32.8**	**59.2**	**35.6**

The result of analysis of the soil samples taken from olive plantations around Gökova, Yeniköy and Yatagan Thermal Power Plants in different seasons are shown in Table 2. The total soluable metal contents of soil samples taken from olive plantations around Gökova, Yeniköy and Yatagan Thermal Power Plants in different seasons are compared by seasons. It is found in soil samples that: Fe is the lowest in summer, the highest in autumn. Zn is the lowest in summer, the highest in winter. Mn is the lowest in winter, the highest in autumn. Cu is the lowest in spring, the highest in autumn. Cd is the lowest in spring, the highest in autumn. Co is the lowest in winter, the highest in autumn. Pb is the lowest in spring, the highest in winter. Cr is the lowest in spring, the highest in summer. the values of the soil samples taken during seasons are report with the values given by Bowen (1979), Kloke (1980), Pendias and Pendias (1984), Scheffer and Schachtschabel (1989), Hakerlerler et al. (1992)'

By total Ni values, the lowest Ni value is found in spring, the highest in summer. The total Ni value in GAP (South East Anatolia Project) region is found 60.23-111.37 mg kg^1 (Hakerlerler et al., 1992). Therefore, considering Kloke (1980)'s 50 mg kg^{-1} total Ni value, it is realized that the lands around Yeniköy and Gökova Thermal Power Plants are polluted by Ni in all 3 seasons except for spring. The lowest heavy metal level of the soil samples taken from the olive plantations is generally found in spring (Cu, Cd, Cr, Ni and Pb), the highest is in autumn (Cu, Cd, Cr, Ni ve Pb) .

The Heavy Metal Levels in the Leave Samples taken from Olive Plantations around Gökova, Yeniköy and Yatagan Thermal Power Plants

The heavy metal levels in the leave samples taken from olive plantations around Gökova, Yeniköy and Yatagan Thermal Power Plants are defined and average results are shown in the Table 3.

Table 3 The heavy metal levels in the leave samples taken from olive plantations around Gökova, Yeniköy and Yatagan Thermal Power Plants (mg kg^{-1})

Plants	**Fe**	**Zn**	**Mn**	**Cu**	**Cd**	**Co**	**Cr**	**Ni**	**Pb**
Gökova	263.4	22.8	47.9	7.0	0.30	2.1	1.8	3.6	6.3
Yeniköy	221.1	22.1	38.9	7.1	0.27	2.0	2.3	4.4	9.9
Yatagan	240.3	20.9	39.2	6.7	0.26	2.4	2.1	3.7	8.7
Average	**241.6**	**21.9**	**42.0**	**6.9**	**0.28**	**2.2**	**2.0**	**3.9**	**8.3**

The findings given in table are in rapport with many researchers' findings. Bouat (1971) states that 460 mg kg^{-1} Fe, 84 mg kg^{-1} Zn, 164 mg kg^{-1} Mn and 78 mg kg^{-1} Cu levels are high for olive leaves. In leave samples taken from olive plantations near the fertilizer factory, Hakerlerler and Höfner (1984) finds 1800-8875 mg kg^{-1} Fe, 23-38 mg kg^{-1} Mn, 0.5 mg kg^{-1} Cd, 2.8-11.5 mg kg^{-1} Cr, 6.3-16.0 mg kg^{-1} Ni, 13-88 mg kg^{-1} Pb. Scheffer ve Schaektschakel (1989) finds 0.04-0.5 mg kg^{-1} Cd, 0.1-1.0 mg kg^{-1} Cr, < 3 mg kg^{-1} Ni ve 0.1-6.0 mg kg^{-1} Pb concentration in normal boundaries. In addition, our findings for Cu are in rapport with the values given by Chapman (1966), for Cd with the values given by Kloke (1973) and Bowen (1979). The metals in leave samples Fe, Zn, Mn, Cu, Cd, and Co are in normal boundaries. However, Cr, Ni and Pb metals are in high limit. It can be concluded that lignite used in Thermal Power Plants may profusely include these metals. Sauerbeck (1982) states that the concentration level of Cr which may have toxic effect on vegetation is 1-2 mg kg^{-1} Cr. According to this level, it can be inferred that there is Cr pollution around Yeniköy and Yatagan Thermal Power Plants. Bowen (1979) notes that the normal Ni concentration level is 0.02-5.0 mg kg-1 whereas Schaffer and Schachtschabel (1989) note that it is 3 mg kg^{-1}**.** Considering these levels**,** there is Ni pollution not only around each of the 3 Thermal Power Plants but also in each Thermal Power Plant. According to Sauerbeck (1982), the critical lead concentration level is 10-20 mg kg^{-1} Pb for vegetation. Considering 10 mg kg lead concentration level, there is a Pb pollution danger around Yeniköy and Yatagan Thermal Power Plants. The lowest heavy metal level of the leave samples taken from olive plantations around each of 3 Thermal Power Plants are equally shared by elements. The highest heavy metal level is found in the olive leaves taken from Gökova (Fe, Zn, Mn and Cd) and Yeniköy (Cu, Cr, Ni and Pb) Thermal Power Plants precinct.

Table 4. The heavy metal levels of the leave samples taken from olive plantations around Gökova, Yeniköy and Yatagan Thermal Power Plants in different seasons. (mg kg^{-1}).

Season	Plants	Fe	Zn	Mn	Cu	Cd	Co	Cr	Ni	Pb
Spring	Gökova	196.2	5.6	30.7	3.4	0.21	1.2	0.8	2.7	2.8
	Yeniköy	191.3	7.0	31.8	3.7	0.19	1.0	0.7	2.5	2.8
	Yatagan	219.6	8.3	34.9	4.2	0.21	1.4	0.9	2.8	3.3
Spring Average		**202.4**	**6.9**	**32.5**	**3.8**	**0.20**	**1.2**	**0.8**	**2.7**	**3.0**
Summer	Gökova	249.4	19.0	33.3	5.0	0.26	1.1	3.0	2.3	11.3
	Yeniköy	148.9	15.6	30.4	5.7	0.24	1.7	4.3	3.4	13.3
	Yatagan	144.8	15.5	31.1	5.6	0.19	2.0	4.3	2.9	10.3
Summer Average		**181.0**	**16.7**	**31.6**	**5.4**	**0.23**	**1.6**	**3.8**	**2.8**	**11.7**
Autumn	Gökova	229.8	27.1	52.5	8.0	0.30	3.6	0.8	3.3	4.4
	Yeniköy	158.5	25.5	39.7	7.6	0.33	3.6	0.6	5.3	4.9
	Yatagan	175.9	21.1	29.8	7.5	0.27	3.7	0.8	3.4	4.3
Autumn average		**188.0**	**24.5**	**40.7**	**7.7**	**0.30**	**3.6**	**0.8**	**4.0**	**4.5**
Winter	Gökova	378.4	39.4	75.2	11.6	0.45	2.4	2.7	6.4	6.5
	Yeniköy	385.6	40.2	53.7	11.4	0.34	1.7	3.5	6.6	18.7
	Yatagan	420.9	38.9	60.9	9.6	0.36	2.5	2.4	5.7	16.8
Winter Average		**394.9**	**39.5**	**63.3**	**10.9**	**0.38**	**2.2**	**2.8**	**6.2**	**14.0**

The heavy metal levels of leave samples taken from olive plantations in different seasons are shown in Table 4 by seasons. As it is seen in table, the level of Fe is lowest in summer, the highest in winter. The level of Cr is lowest in spring and autumn, the highest in summer. The level of Zn, Mn, Cu, Cd, Co, Ni and Pb is the lowest in spring, the highest in winter. The reason why metals appear mostly in wintertime can be the increasing necessity of heating and electricity energy causing Thermal Power Plants to overwork. According to Bouat (1971), the heavy metal level of olive leaves is high. The level of Fe is 460 mg kg^{-1}, Zn is 84 mg kg^{-1}, Mn is 164 mg kg^{-1} and Cu is 78 mg $kg^{-1.}$ Hakerlerler and Höfner (1984) finds 1800-8875 mg kg^{-1} Fe, 23-38 mg kg^{-1} Mn, 88-313 mg kg^{-1} Cu, 0.5 mg kg^{-1} Cd, 2.8-11.5 mg kg^{-1} Cr, 6.3-16.0 mg kg^{-1} Ni and 13-88 mg kg^{-1} Pb in the leave samples taken from fertilizer factory precinct. Apart from these values, Reuter and Robinson (1986) finds the level of Zn is 10-30 mg kg^{-1} and the level of Mn is 20 mg $kg.^{-1}$ Chapman (1966) gives the value of 5-19 mg kg^{-1} for Cu. Kloke (1973) ve Bowen (1979) gives min-max value of 0.1-3.0 mg kg^{-1} for Cd. Macnicol ve Beckett (1985)' min level of Co is 4 mg $kg.^{-1}$ Considering these values, Fe, Zn, Mn, Cu, Cd and Co levels of the leave samples are in normal boundaries. According to Macnicol and Beckett (1985), the

Cr concentration level which causes %10 loss of efficiency on vegetation is 2-18 mg kg^{-1}. For Sauerbeck (1982), the Cr concentration level which has toxic effect on vegetation is 1-2 mg $kg.^{-1.}$ Referring to 2 mg kg^{-1} Cr concentration, it can be proposed that there is Cr pollution on leave samples. For Ni (Nickel), Schaffer and Schabel (1989) find its level below 3 mg kg^{-1} Bowen (1979) finds it normally between 0.02 mg kg^{-1} and ^{5} mg kg^{-1} on the leave samples. Considering 5 mg kg^{-1} Ni concentration, there is Ni pollution in wintertime. Bowen (1979) notes that there is 0.2-20.0 mg kg^{-1} Pb on vegetation while Sauerbeck (1982) notes that the critical lead concentration on vegetation is 10-20 mg kg^{-1} Pb. As it is stated, considering 10 mg kg^{-1}' lead concentration, it is acceptable that there is a Pb pollution in summertime and wintertime. To examine the heavy metal pollution level of soil and vegetation caused by Thermal Power Plants in Gökova, Yeniköy and Yatagan in Mugla, soil and leave samples are taken around Thermal Power Plants and examined. The results are given below: It is notable in the soil samples taken from the olive plantations around Gökova, Yeniköy and Yatagan Thermal Power Plants that some of the average heavy metal concentrations (Fe, Zn, Cd, Co and Ni) are alike while some (Mn, Cu, Cr and Pb) vary.

The lowest heavy metal level in olive plantations is found in Yatagan (Fe, Zn, Mn, Cu, Co, Cr, Ni) and the highest is found in Yeniköy (Fe, Mn, Cu, Cd, Co). The average of Mn, Cr and Pb varies more than any other elements. Ni level in olive plantations in Gökova and Yeniköy (>50 mg kg^{-1} Ni) is the evidence of Ni pollution. The lowest heavy metal level (Cu, Cd, Cr, Ni ve Pb) of soil samples taken from olive plantations in different seasons is generally found in spring and the highest (Fe, Mn, Cu, Cd, Co) in autumn. The highest levels of heavy metal on olive leaves are generally found in the samples taken from Gökova and Yeniköy. The Cr, Ni and Pb levels are especially found in leave samples taken around Yatagan and Yeniköy Thermal Power Plants and these levels are found in little-high limit. The lowest heavy metal levels of the leave samples taken around Thermal Power Plants in different seasons are generally found in the samples (Zn, Cu, Cd, Co, Ni and Pb) taken in springtime and the highest heavy metal levels are generally found in the samples (Fe, Zn, Mn, Cu, Cd, Ni and Pb) taken in wintertime.

ACKNOWLEDGMENTS

This Paper is a part of outcome report of research project supported by Muğla University with the issue of "An Investigation on the Pollution Sources from Thermal Power Plants in Muğla Region".

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