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# EVALUATION OF METAL CONCENTRATIONS IN GROUNDWATER NEARBY SOMA COAL-FIRED POWER PLANT, TURKEY

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## Abstract

*Groundwater pollution by metals nearby Soma coal-fired power plant in Turkey was investigated. Coal combustion results in huge ash piles from which metals can originate and migrate to groundwater. Forty samples were collected from water wells nearby the power plant to determine fourteen metals namely, Na, Ca, K, Mg, Al, Ba, Fe, Zn, Cu, Pb, Cr, Cd, Ni, and V. The results were compared with the World Health Organization, the European Community and the Turkish Guidelines for drinking water quality. Iron and zinc concentrations in 5 wells were higher than the EC guidelines. Lead concentrations were less than the three guidelines but were relatively high in 8 wells. The other anthropogenic elements were lower than the three guidelines. Some toxic elements concentrations like lead did not exceed the guidelines, but these metals tend to accumulate and if no action is taken for the disposal of ash, these metals will exceed the guidelines with time. .*

*Soma residents are at risk because they drink the groundwater and use it for irrigation. This water is polluted with Fe and Zn and there are some amounts of the other anthropogenic elements which will accumulate over time. So, correction steps should be taken to overcome the problem of the ash disposal and save the health of the residents.*

***Keywords: metals, coal, power plant, ash piles, groundwater***

## INTRODUCTION

Groundwater pollution, often due to anthropogenic activities is a worldwide problem. Such contamination of groundwater resouces potentially poses a substantial risk to local resource users and to the natural environment. Assessing risk involves identifying the hazard associated with a particular occurrence, action or circumstance and determining the probability of that hazard occurring. There are three categories in recognizing the threat from environmental hazards: hazard to people (e.g. death, disease), hazard to property (e.g. damage or destruction) and hazard to the environment (e.g. loss of biodiversity). As to the nature of pollutants, metals are considered to be very dangerous pollutants to groundwater. They are known to cause serious human health problems and environmental damage. Coal fired power plants are very important source of metals to the environment. In addition to gases and fly ash emitted from these plants, the solid waste (known as the bottom ash) is a major source for metals. Metals such as (Na, K, Ca, Ba, Al, Mg Fe, Cu, Zn, Pb, Cd, Cr, V, and Ni) can have their origin from bottom ash. These metals may migrate to groundwater aquifers and pollute them resulting in a harmful effects to the environment and public health.

The aim of this study was to evaluate the concentrations of these metals in the water wells near by Soma Power Plant, evaluate the environmental impact of the power plant, determine the water quality with respect to the EC and the WHO guidelines and evaluate the possible health risks associated with metal contamination.

## MATERIALS AND METHODS

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Forty groundwater water samples were taken from wells nearby Soma coal-fired power plant. This water is used for drinking and irrigation purposes. Water wells have almost the same depth and the distance from the ash ponds varied from 1 km to about 8 km. Figure 1 shows a map of Soma with the sampling points on it. Samples were collected in 500 ml high density polyethylene bottles. These bottles were washed with distilled water and then soaked in 30% (vol/vol) technical grade nitric acid for twenty four hours. Then, they were filled with 30% (vol/vol) Merck 65% purity nitric acid and left overnight. Bottles were then rinsed with deionised water ten times. This was done to avoid contamination because the concentrations of most metals in groundwater were expected to be in the trace level. Then the pH of the samples was measured. The pH was between 6.7 and 7.2. The samples were then acidified by adding 1% (vol/vol) Merck 65% purity nitric acid. Samples were then stored to be analyzed later.

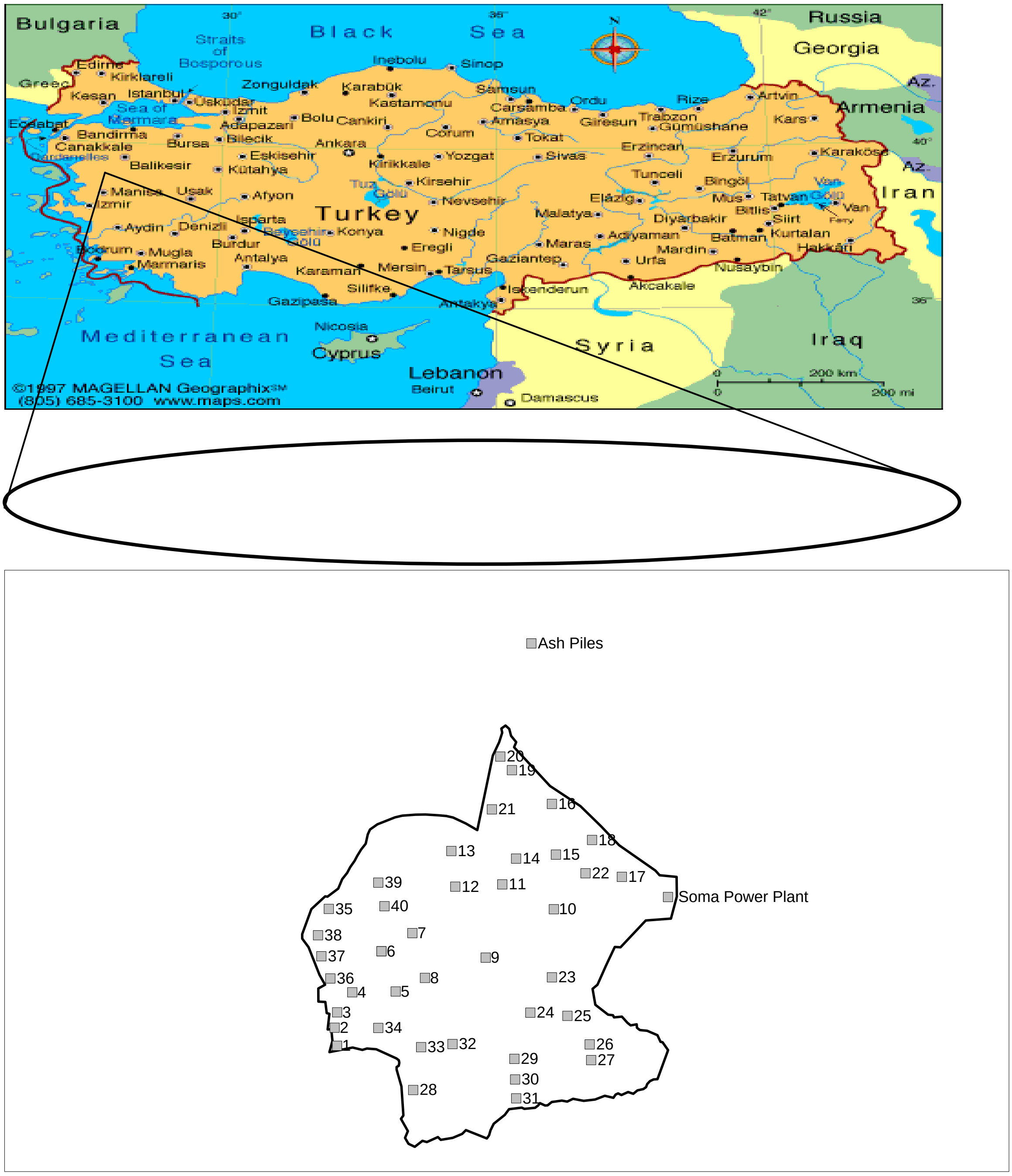

**Fig. 1. Location of the Sampling Sites**

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Collected samples were quantitatively analyzed in the chemistry departments of the Middle East Technical University, Ankara to determine fourteen metals namely, Na, Ca, K, Mg, Al, Ba, Fe, Zn, Cu, Pb, Cr, Cd, Ni, and V. Flame atomic absorption spectrometry was used to determine Mg and Cu. Flame atomic emission spectrometry was used to determine Na, K and Ca. Graphite furnace atomic absorption spectrometry was used to determine Cd, Pb, Ni, V and Cr. Inductively coupled plasma atomic emission spectrometry was used to determine Al, Fe, Zn and Ba. Certified standard reference materials were used to calibrate the instruments before each analysis.

## Results And Discussion

As shown in Table 1, Na, Ca, K and Mg have high concentrations because they are crustal elements. Fe, Zn and Pb are anthropogenic elements, but they show relatively high concentrations. The concentrations obtained were compared with the world Health organization (Who), the European Community (EC) and the Turkish guidelines for drinking water quality. Fe concentrations in 12 wells were higher than the three guidelines. Zn concentrations in 5 wells were higher than the EC guidelines. Pb was less than all guilelines but it was relatively high in 8 wells.The other anthropogenic elements were lower than all guidelines but these metals tend to accumulate and they will exceed the guildlines overtime. Table 2 shows the comparision of the maximum concentrations obtained with the guidelines.

| Well | Na | Ca | K | Mg | Ba | Al | Fe | Zn | Cu | Pb* | Cr* | Cd* | Ni* | V* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 9.00 | 101 | 1.59 | 26.0 | 0.218 | 0.640 | <D.L | <D.L | <D.L | 0.41 | 0.95 | <D.L | 0.77 | 1.94 |
| 2 | 66.0 | 120 | 1.90 | 92.0 | 0.344 | 0.640 | 0.038 | 0.003 | <D.L | 3.38 | 1.74 | <D.L | 3.46 | 3.10 |
| 3 | 36.0 | 79 | 5.11 | 55.0 | 0.233 | 0.660 | 0.320 | 0.117 | 0.024 | 0.082 | 1.11 | <D.L | 3.46 | 14.5 |
| 4 | 35.0 | 120 | 4.64 | 18.0 | 0.153 | 0.640 | 0.41 | 0.027 | 0.026 | 1.48 | 7.31 | <D.L | 2.10 | 2.50 |
| 5 | 38.0 | 207 | 14.30 | 16.0 | 0.220 | 0.630 | 0.183 | 0.000 | 0.034 | 1.31 | 0.83 | <D.L | 1.73 | 2.61 |
| 6 | 49.0 | 174 | 3.52 | 23.0 | 0.251 | 0.413 | 5.869 | 0.210 | 0.049 | 3.79 | 6.42 | 0.10 | 5.10 | 6.50 |
| 7 | 40.0 | 208 | 9.83 | 18.0 | 0.155 | 0.660 | 0.39 | 0.084 | 0.022 | 1.33 | 0.76 | <D.L | 3.33 | <D.L |
| 8 | 43.0 | 263 | 6.54 | 15.0 | 0.183 | 0.720 | 0.482 | 0.029 | <D.L | 1.23 | 0.62 | <D.L | 2.35 | <D.L |
| 9 | 34.0 | 263 | 1.55 | 28.0 | 0.235 | 0.660 | 0.499 | 0.548 | 0.019 | 1.41 | 0.27 | <D.L | 4.57 | <D.L |
| 10 | 13.0 | 255 | 2.43 | 23.0 | 0.116 | 0.610 | <D.L | 0.004 | 0.030 | 1.28 | 1.27 | <D.L | 4.10 | <D.L |
| 11 | 12.0 | 146 | 4.08 | 36.0 | 0.152 | 0.700 | 0.124 | 0.073 | 0.040 | 1.95 | 1.07 | <D.L | 3.83 | 2.83 |
| 12 | 35.0 | 198 | 5.01 | 56.0 | 0.315 | 0.730 | 0.211 | 2.642 | 0.045 | 2.20 | 0.84 | <D.L | 3.33 | 3.72 |
| 13 | 47.0 | 196 | 1.83 | 31.0 | 0.67 | 0.650 | 0.205 | 0.289 | <D.L | 1.77 | 2.38 | <D.L | 3.21 | 2.28 |
| 14 | 46.0 | 251 | 1.38 | 38.0 | 0.235 | 0.890 | 0.271 | 0.172 | <D.L | 0.72 | 2.23 | <D.L | 3.95 | 11.5 |
| 15 | 102 | 257 | 2.73 | 65.0 | 0.190 | 0.660 | 0.197 | 0.038 | <D.L | 1.79 | 1.37 | <D.L | 2.47 | 6.10 |
| 16 | 18.0 | 130 | 1.27 | 57.0 | 0.150 | 0.650 | 1.366 | 2.248 | 0.019 | 4.89 | 6.51 | 0.35 | 2.35 | 10.3 |
| 17 | 27.0 | 179 | 10.74 | 55.0 | 0.063 | 0.640 | 2.502 | 0.129 | 0.027 | 1.66 | 5.25 | <D.L | 1.98 | 12.8 |
| 18 | 32.0 | 250 | 14.89 | 50.0 | 0.111 | 0.620 | 0.085 | 0.922 | 0.032 | 1.36 | 0.67 | 0.17 | 1.98 | 8.83 |
| 19 | 9.0 | 246 | 1.13 | 63.0 | 0.186 | 0.650 | 2.106 | 0.586 | 0.038 | 6.20 | 1.68 | <D.L | 2.59 | 14.5 |
| 20 | 9.0 | 279 | 2.27 | 72.0 | 0.079 | 0.630 | 0.030 | <D.L | 0.040 | 2.64 | 0.73 | <D.L | 3.70 | 8.28 |
| 21 | 6.0 | 194 | 2.74 | 49.0 | 0.280 | 0.680 | 0.186 | 1.618 | 0.051 | 1.07 | 1.80 | 0.11 | 1.98 | 3.72 |
| 22 | 44.0 | 167 | 6.05 | 47.0 | 0.245 | 0.720 | 0.279 | 1.354 | <D.L | 5.20 | 7.82 | 0.20 | 2.35 | 6.28 |
| 23 | 11.0 | 179 | 1.48 | 35.0 | 0.112 | 0.700 | 0.081 | 0.004 | <D.L | <D.L | 0.75 | <D.L | 2.22 | 1.16 |
| 24 | 38.0 | 285 | 0.71 | 65.0 | 0.150 | 0.640 | 0.224 | 0.078 | <D.L | <D.L | 0.81 | 0.10 | 1.60 | 3.28 |
| 25 | 47.0 | 311 | 1.87 | 27.0 | 0.083 | 0.630 | 0.268 | 0.030 | <D.L | <D.L | <D.L | <D.L | 1.98 | 1.39 |
| 26 | 23.0 | 163 | 9.44 | 61.0 | 0.170 | 0.810 | 1.380 | 0.265 | 0.024 | 0.87 | 1.16 | <D.L | 2.84 | 3.17 |
| 27 | 20.0 | 149 | 8.57 | 73.0 | 0.198 | 0.630 | 0.030 | 0.045 | 0.036 | <D.L | 0.56 | <D.L | 4.57 | 1.94 |
| 28 | 26.0 | 317 | 2.19 | 16.0 | 0.054 | 0.630 | <D.L | <D.L | 0.038 | <D.L | <D.L | <D.L | 2.47 | <D.L |
| 29 | 70.0 | 169 | 10.32 | 70.0 | 0.115 | 0.670 | 0.262 | 0.090 | 0.035 | <D.L | 0.76 | <D.L | 2.59 | 0.61 |
| 30 | 30.0 | 172 | 8.17 | 33.0 | 0.212 | 0.760 | 0.964 | 0.147 | 0.039 | 0.31 | 1.27 | <D.L | 5.19 | 1.10 |
| 31 | 18.0 | 157 | 4.13 | 70.0 | 0.73 | 0.950 | 1.882 | 0.391 | <D.L | 4.41 | 2.31 | 0.43 | 3.21 | 1.00 |
| 32 | 16.0 | 175 | 1.87 | 18.0 | 0.222 | 0.640 | 0.038 | 0.013 | <D.L | <D.L | 0.35 | <D.L | 2.47 | <D.L |
| 33 | 19.0 | 286 | 15.41 | 25.0 | 0.105 | 0.640 | 0.066 | 0.024 | <D.L | <D.L | 0.27 | <D.L | 2.59 | 1.00 |
| 34 | 17.0 | 198 | 1.92 | 39.0 | 0.109 | 0.700 | 0.89 | 0.059 | 0.019 | 0.79 | 0.34 | <D.L | 4.20 | <D.L |
| 35 | 11.0 | 202 | 1.74 | 34.0 | 0.133 | 0.790 | 0.413 | 0.133 | <D.L | 0.59 | 0.89 | <D.L | 2.35 | 0.72 |
| 36 | 20.0 | 220 | 1.09 | 40.0 | 0.245 | 0.640 | 0.070 | 0.412 | <D.L | <D.L | 0.59 | <D.L | 2.47 | 2.60 |
| 37 | 15.0 | 153 | 1.09 | 48.0 | 0.135 | 0.750 | 6.728 | 2.632 | 0.412 | 4.13 | 4.48 | 0.24 | 9.26 | 17.52 |
| 38 | 23.0 | 154 | 2.02 | 25.0 | 0.164 | 0.660 | 0.053 | 0.041 | <D.L | <D.L | 0.41 | <D.L | 2.59 | <D.L |
| 39 | 12.0 | 216 | 1.37 | 22.0 | 0.142 | 0.640 | 0.981 | 0.014 | 0.022 | 0.51 | 0.52 | <D.L | 3.95 | <D.L |
| 40 | 27.0 | 152 | 1.73 | 21.0 | 0.153 | 0.630 | <D.L | <D.L | 0.023 | <D.L | <D.L | <D.L | 1.98 | <D.L |

**Table 1. Metal concentrations Found in Water Samples**

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***Units are in µg/l, others are in mg/l. <D.L : Below Detection Limit**

**Table 2. Comparison with Guidelines**

| Element | This Work (Max) | Turkish Guidelines | WHO Guidelines 1993 | EC Guidelines 1980 |
|---|---|---|---|---|
| Na | 102 | _ | _ | _ |
| Ca | 317 | _ | _ | _ |
| K | 15.4 | _ | _ | _ |
| Mg | 92.0 | _ | _ | _ |
| Ba | 0.330 | _ | 2.00 | _ |
| Al | 0.950 | _ | 1.00 | 1.00 |
| Fe | 6.73 | 0.300 | 0.300 | 0.200 |
| Zn | 2.64 | 5.00 | 3.00 | 1.00 |
| Cu* | 50.0 | 1500 | 1000 | 2000 |
| Pb* | 6.20 | 10.0 | 10.0 | 10.0 |
| Cr* | 7.82 | 50.0 | 50.0 | 50.0 |
| Cd* | 0.430 | 5.00 | 3.00 | 5.00 |
| Ni* | 9.26 | 20.0 | 20.0 | 20.0 |
| V* | 17.5 | 50.0 | 50.0 | 50.0 |

*** Units are in µg/l, others are in mg/l**

## CONCLUSION

In this study, forty groundwater samples were collected from water wells near by Soma power plant in order to evaluate the effect of the power plant and the ash piles on the groundwater.

Samples were collected in polyethylene bottles; their pH was measured, acidified and analyzed using FAES, FAAS, GFAAS and ICP-AES, using methods for water analysis.GFAAS gave low detection limits for trace metals and ICP-AES gave low detection limits for Fe, Zn, Al and Ba.

The crustal elements did not show high variations from one well to another, but the anthropogenic elements did. Fe concentrations in 12 wells were higher than the WHO, EC and Turkish guidelines and Zn concentrations in 5 wells were higher than the EC guidelines. Pb concentrations in 8 wells were high but not higher than the guidelines. The other anthropogenic elements were within the guidelines. But, metals tend to accumulate in groundwater and if no action is taken, after some time the concentrations of these metals will exceed the guidelines.

Enrichment factor calculations showed that all the anthropogenic elements were enriched in the North East and North West regions of the sampling area which are close to the ash piles indicating that these elements had originated from the ash piles. So, the anthropogenic metal concentrations decrease as you go away from the ash piles.

Factor analysis calculations showed that one factors was loaded with anthropogenic elements which imply that there is an anthropogenic source for these metals which in this case are the ash piles.

Soma residents are at risk because they drink the groundwater and use it for irrigation. This water is polluted with Fe and Zn and there are some amounts of the other anthropogenic elements which will accumulate over time. So, correction steps should be taken to overcome the problem of the ash disposal and save the health of the residents.

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