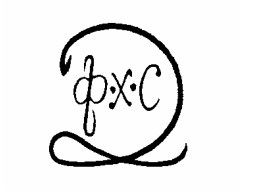

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SODIUM CONCENTRATION IN WATER SAMPLES FROM COAL-FIRED POWER PLANTS

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ABSTRACT

This paper provides findings from the study of total content of sodium (Na) macro-element in environmental water samples around five of the largest coal-fired power plants in the region. Also, pH value of these waters was examined. The concentration of Na was determined by Atomic absorption spectrometry (AAS). The obtained results for the concentration of Na were found to be in range between 8.9 and 61.6 mg/L. In general, the obtained values for Na content were below the recommended maximum permissible limit for drinking water given in the Serbian regulation on the quality of water for human use, as well as European Union (EU) directive and directive of World Health Organization (WHO).

INTRODUCTION

Coal-fired power generation comes with a significant cost to the environment and human health. The water runoff from coal washeries carries pollution loads of metals that contaminate ground water, rivers and lakes, as well as soil during irrigation process and thus affecting flora and fauna [1].

Sodium is an essential element for all animals and some plants, but it also has a vital function in human body for the regulation of blood volume, blood pressure, osmotic equilibrium and pH. Sodium salts are used in water treatment systems to improve pH (sodium hydroxide), for the coagulation of calcium and magnesium to reduce hardness (sodium carbonate), for the addition of fluoride (sodium fluorosilicate) and the ion exchange removal of heavy metals (sodium alumino-silicate or zeolite) [2]. Because of high solubility of most sodium salts in cold water, sodium is an ideal carrier of anions for precipitation of disruptive colloids. Due to of the mentioned above, sodium has recently appeared as a potentially hazardous element and its concentration reaches levels that would be considered unsuitable for many applications.

The coal-fired power plants could be recognized as an additional source of sodium pollution and in this paper an examination of the presence of Na macro-element in the waste water samples around the coal-fired power plants in the Republic of Serbia, as well as the control of its impact on the environment is presented.

EXPERIMENTAL

The sampling of landfill overflow waters, drain and river waters, groundwater as well as drinking water was performed during September and October of 2013 in five coal-fired power plants and their surrounding areas in the Republic of Serbia: "Nikola Tesla A and B" (TENT A, TENT B) - Obrenovac, "Morava" (TE MORAVA) - Svilajnac, "Kolubara" (TE KOLUBARA) - Veliki Crljeni and "Kostolac" (TE KOSTOLAC) - Kostolac. About a liter of each sample was taken to determine the Na content.

Water samples were first analyzed on pH. For pH measurement pH meter (Hanna Instruments, pH/^{0}C Tester pHep4) was used. Calibration of the instrument was carried out by 4, 7 and 10 pH standard solutions.

Before of Na content analysis, the samples are filtered through membrane filter and then acidified with 0.5 % HNO_3 to pH 1. Also, the preparation of the samples for determination of Na involved the addition of the certain concentration of Cs modifier. The stock solution was purchased from Fluka Analytical Sigma Aldrich (Sodium Standard). Multistandard for curve control was purchased from Merck.

The concentration of Na in collected water samples was performed using Atomic absorption spectrometer SensAA (GBC scientific equipment) in which the air-acetylene gas was used. Na content was determined by flame technique. HOLLOW CATHODE lamp (S & J Juniper & Co) was used for the determination of Na at 330.2 nm wavelength.

RESULTS AND DISCUSSION

The results of Na content, as well as the pH values in the analyzed water samples are given in the Table 1.

Table 1. Concentration of macro-element Na and pH value of analyzed water samples

Power plant	Location	Na (mg/L)	pH
TENT A	Landfill overflow water	15.1	8.3
	Drain water at well	17.0	8.4
	Drain water between wells	19.0	8.4
	Sava river upstream	12.8	8.5
	Sava river downstream	16.7	8.5
TENT B	Landfill overflow water	17.6	8.3
	Drain water	21.3	8.0
	Sava river upstream	13.3	8.9
	Sava river downstream	14.0	8.3
TE MORAVA	Landfill overflow water	34.3	12.4
	Drain water	32.8	12.5
	Morava river upstream	20.1	8.7
	Morava river downstream	19.6	9.0
TE KOLUBARA	Landfill overflow water	57.5	7.9
	Drain water	23.0	8.4
	Turija river upstream	26.7	8.3
	Kolubara river downstream	25.9	8.3
	Drinking water	61.6	7.7
TE KOSTOLAC	Landfill overflow water	14.5	8.0
	Landfill drain water	14.8	7.9
	Drain water (Drmno)	13.7	8.1
	Drain groundwater (Ćirikovac)	8.9	5.4

As can be seen from Table 1, all water samples are alkaline (pH values are from 7.7 to 12.5), except for a single sample of drain groundwater from Ćirikovac surface mine which has pH of 5.4. According to regulation on quality and other requirements for natural mineral water, spring water and bottled drinking water, the recommended value for pH is between 6.5 and 9.5 [3]. In addition, the same range is prescribed by EU Directive [4]. The obtained results point out that three pH values were found to be outside of the recommended range, but these investigated water samples are not from water suitable for drinking. For one analyzed drinking water from TE KOLUBARA (pH is 7.7), this criterion is met and it is important.

The concentrations of Na in analyzed samples were in the range from 8.9 to 61.6 mg/L, while the median for analyzed macro-element was 18.3 mg/L. In the Serbian [3] and EU regulations [4,5], as well as directive of WHO [6], the

maximum allowed concentrations of individual elements are prescribed only for drinking waters. The recommended value of Na content by these regulations is 200 mg/L. It can be seen that regulation in Serbia is in accordance with directive of EU and WHO for maximum allowed concentration of Na. Also, the concentrations of Na in water samples analyzed in this paper are less than the above mentioned value, even though all the analyzed water samples were not suitable for drinking. Due to no considerable changes in river upstream and downstream sodium concentration, we can also conclude that coal-fired power plants do not discharge extra sodium concentration into the environment.

CONCLUSION

Sodium has been recently recognized as a potentially hazardous element, because its concentration in rivers and soil reaches levels that would be considered unsuitable, especially for vegetation. The concentration of Na macro-element, as well as pH value in 22 water samples taken around the five coal-fired power plants in the Republic of Serbia are presented in this paper. The only one of analyzed water samples is acidic (pH 5.4), while the rest of the water samples are alkaline (pH values higher than 7.7). Landfill overflow water and drain water from TE MORAVA are extremely alkaline with pH values of 12.4 and 12.5, respectively. Accordingly, the obtained pH values for 19 from 22 analyzed waters meet the limited values according to drinking water regulations. Due to no considerable changes in river upstream and downstream sodium concentration, it can be concluded that coal-fired washeries are not water polluters. Also, the concentrations of Na in analyzed water samples are within the recommendation values by Serbian regulation (below 200 mg/L), as well as EU and WHO directives for drinking water.

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