Journal of the Serbian Chemical Society
JSCS-info@shd.org.rs • www.shd.org.rs/JSCS
J. Serb. Chem. Soc. *84* (5) 527–530 (2019)
JSCS–5205
UDC 662.613.11–032.35+66.046.58:
628.1.033+54.061
Note

NOTE

The impact of coal ash and slag dump on the quality of surface and ground waters – A case study

IVANA ĆIPRANIĆ[1], RADMILA MARKOVIĆ[2]*, STEFAN ĐORĐIEVSKI[2], ZORAN STEVANOVIĆ[2] and MARIJA STEVANOVIĆ[3]

[1]*University of Montenegro, Faculty of Civil Engineering, Bulevar Džordža Vašingtona bb, 81000 Podgorica, Montenegro,* [2]*Mining and Metallurgy Institute Bor, Zeleni bulevar 35, 19210 Bor, Serbia and* [3]*JP EPS, EPS Jagodina, 7. jula 62, 35000 Jagodina, Serbia*

(Received 29 January, accepted 4 February 2019)

Abstract: This paper presents the assessment of the impact of coal ash and slag from the "Maljevac" dump on the quality of water of Paleški Creek, Montenegro. The obtained results confirm the negative influence of surface and groundwater from the dump on the water from the Paleški Creek. The results obtained by testing of the water samples, collected from Paleški Creek upstream of the dump, indicate that the water is qualified to be used for drinking, after simple physical treatment and disinfection. The results obtained for the water samples collected from the Paleški creek downstream from the dump indicate that the water could be safe for drinking only after the treatment that requires an intensive physical, chemical and biological processing, including some extended treatment.

Keywords: coal ash; coal slag; water quality.

INTRODUCTION

Although the material from ash and slag dumps may be used in the construction industry,[1] the largest amount of this material is stored in dumps, where leaching of the elements with toxic effects occurs.[2] Such dumps pose a serious threat to the surrounding soil, surface and groundwater[3] as well as to aquatic ecosystems.[4] The ash produced from coal combustion is regarded globally as the waste which presents a serious health risk[5] and which must be treated in an adequate manner.

In order to provide sufficient space for the disposal of coal combustion by-products, ash and slag, generated at Pljevlja Thermal Power Plant, the earthen dam "Maljevac" was built in 1982 in the riverbed of Paleški Creek, approx-

* Corresponding author. E-mail: radmila.markovic@irmbor.co.rs
https://doi.org/10.2298/JSC190129012C

Available on line at www.shd.org.rs/JSCS/
(CC) 2019 SCS.

imately 7 km from the town of Pljevlja, Montenegro. At the time it was the common practice to dispose of ash and slag waste directly onto the soil surface, without setting up any protection layers. Hence, the waste material has been stored directly onto soil in the riverbed of Paleški Creek for decades.

The aim of this paper is to determine the impact of coal ash and slag dump of a thermal power plant on the quality of ground and surface water. The impact evaluation is based on the investigations carried out in the area of the coal ash and slag dump "Maljevac" of the thermal power plant in Pljevlja (Montenegro).

RESULTS AND DISCUSSION

For the purpose of examining the effects of dumps on the surface water quality, the analysis of water in Paleški Creek was conducted as the dump directly influences the water of that stream (leachate from the dump is discharged into the stream). The water samples were collected upstream and downstream of the dump. The results of the water samples testing are presented in Table I. The sampling points are marked in Fig. S-1 of the Supplementary material to this paper.

TABLE I. The results of the chemical and physical analyses of Paleški Creek, surface water samples from the dump, and groundwater samples collected from the boreholes on the dam

Parameter	Unit	Sampling point				
		PW-1	PW-2	SW-3	SW-4	GW-5
pH	–	7.5–7.8	10.7–10.96	11.8–12.2	7.3–7.45	5.84–6.02
κ	μS/cm	390–430	863.5–980	11395–11500	1950–2250	2400–2920
Fe	mg/l	0.087–0.11	0.047–0.15	0.001–0.121	0.001–0.21	89–229.1
Al	mg/l	0.017–0.21	1.35–3.72	0.3–0.51	0.014–0.11	2.01–18.34
Ca	mg/l	85.7–101.2	366.2–400.5	1100–1370	130–284.1	330–447.3
Na	mg/l	2.08–5	19.67–48	12.3–15.83	36–80	18.35–44.92
Zn	mg/l	0.007–0.008	0.099–1.35	0.007–0.05	0.006–0.02	0.526–1.38
Mg	mg/l	6.55–8.32	0.59–2.4	11.89–16.4	68–107.92	216.4–324
Mn	mg/l	0.004–0.021	0.028–0.045	0.008–0.0135	3.54–0.777	7.67–11.34
P_2O_5	mg/l	0.24–0.45	0.059–0.09	0.055–0.09	0.006–0.099	0.071–0.15
K_2O	mg/l	0.78–1.3	239.4–320	24–61.36	16.78	8.3–10.55
PAH	mg/l	< 0.000005	< 0.000005	0.000008	0.00042	0.00091
PCB	mg/l	< 0.000002	< 0.000002	0.000002	0.000002	0.000002
Nitrates	mg/l	3.81–8.33	1.99–5.42	5.32–8.29	2.82–3.25	35.2–42
Nitrites	mg/l	0.008–0.010	0.015–0.199	0.520	0.090	0.077–0.09
Sulphates	mg/l	–	82	18.35–36.3	88–193	363–450
Phenols	mg/l	0.019	0.0008	0.061	0.0005	0.0005
Cd	mg/l	–	–	–	0.003–0.02	0.02–0.018
As	mg/l	–	–	–	–	0.08–0.1

The results obtained by the testing of the water samples collected from Paleški Creek, upstream of the dump, indicate that the water of the stream is qualified as clear spring water.

(CC) 2019 SCS.

Paleški creek downstream of the dump is characterized by a large number of the water quality parameters that are above the permissible limits (in Montenegro, determined by the directive[6]): pH value, electrolytic conductivity, the content of sulphates, calcium, sodium, cyanide, etc. The water collected from Paleški Creek upstream of the dump is classified as "A_1" category, while the one collected downstream of the dump is classified as "A_3" category. According to the directive[6], the category "A_1" refers to the waters which can be used for drinking after simple physical treatment and disinfection. On the other hand, the category "A_3" encompasses the water that could be safe for drinking only after the treatment requiring an intensive physical, chemical and biological processing, including extended disinfection and chlorination, coagulation, flocculation, decantation, filtration, activated carbon adsorption as well as disinfection with ozone and chlorine.

The groundwater samples were surveyed from the two boreholes drilled in the body of the dam and in its plinth. Based on the pH values presented in Table I, it is noted that the mean value ranges from neutral to mildly acidic. Even though the pH value of water near the surface is basic, the obtained mean value results from the fact that the dam was constructed of marly clay aterial considered acidic. Electrolytic conductivity is increased. The elevated concentrations of calcium, magnesium, potassium, sodium, cadmium and sulphates are registered. The elevated concentration of Ca is a result of calcium oxide dissolution from the coal ash. In addition, there are traces of arsenic within the borehole in the plinth of the dam. The core of the problem is closely related to the solubility of the ash components in water. In terms of the pollution control of ground waters, the SO_4^{2-} are the most significant as it does not bind tightly to the soil. Due to this feature, sulphates can be used as "tracers", *i.e.*, it would be possible to determine the pollution level of ground water from the dump by means of tracking the ions.[7]

The water samples at the dump were collected from one point at the very surface of the dump. Based on the obtained results it is concluded that these samples are characterized by increased the electrolytic conductivity. Moreover, the pH value is alkaline. The pH value of the water from boreholes depends on the depth of the borehole. The minimal and the maximal concentrations from Table I are similar, which indicates that there is a constant inflow of wastewater.

CONCLUSION

The impact of the coal ash and the slag dump of the thermal power plant on the quality of surface and groundwater is exceedingly harmful. The quality parameters of the surface water samples (pH value, electrolytic conductivity, the content of sulphates, calcium, sodium, etc.) are above the permissible limits. The groundwater in the vicinity of the dump is characterized by the increased elec-

(CC) 2019 SCS.

trolytic conductivity, high concentrations of zinc, sulphates, calcium, magnesium, potassium, sodium, cadmium, etc. The harmful effects of the dump on the quality of surface and groundwater should be eliminated in these cases (when the dump was built directly on the ground, without necessary protection) by means of employing the adequate measures of remediation and recultivation. In addition, the material should be removed and used in making concrete and concrete blocks (used in construction industry) as well as for other industrial purposes.

И З В О Д

УТИЦАЈ ДЕПОНИЈЕ УГЉЕНОГ ПЕПЕЛА И ШЉАКЕ НА КВАЛИТЕТ ПОВРШИНСКИХ И ПОДЗЕМНИХ ВОДА – СТУДИЈА СЛУЧАЈА

ИВАНА ЋИПРАНИЋ[1], РАДМИЛА МАРКОВИЋ[2], СТЕФАН ЂОРЂИЕВСКИ[2], ЗОРАН СТЕВАНОВИЋ[2] и МАРИЈА СТЕВАНОВИЋ[3]

[1]Универзитет Црне Горе, Грађевински факултет, Булевар Џорџа Вашингтона бб, 81000 Подгорица, Црна Гора, [2]Институт за рударство и металургију Бор, Зелени булевар 35, 19210 Бор и [3]ЈП ЕПС, ЕПС Јагодина, 7. јула 62, 35000 Јагодина

У раду је приказан утицај угљеног пепела и шљаке са депоније Маљевац на квалитет воде Палешког потока у Црној Гори. Добијени резултати потврђују негативан утицај површинске и подземне воде са одлагалишта на воду Палешког потока. Резултати добијени испитивањем узорака вода узетих из Палешког потока узводно од одлагалишта указују да се вода квалификује као вода која се може користити за пиће након једноставног физичког третмана и дезинфекције. Резултати добијени за узорке вода који су сакупљени из Палешког потока низводно од одлагалишта указују да би вода могла бити безбедна за пиће само након третмана који захтева интензивну физичку, хемијску и биолошку обраду, укључујући продужени третман.

(Примљено 29. јануара, прихваћено 4. фебруара 2019)

REFERENCES

1. J. Camilleri, M. Sammut, F. E. Montesin, *Waste Manage.* **26** (2006) 853 (https://doi.org/10.1016/j.wasman.2005.11.022)
2. Y. S. Shim, S. W. Rhee, W. K. Lee, *Waste Manage.* **25** (2005) 473 (https://doi.org/10.1016/j.wasman.2005.03.002)
3. A. Popovic, D. S Dordevic, *Energy Sources, A* **31** (2009) 1553-1560 (https://doi.org/10.1080/15567030802094003)
4. V. Pandey, Z. Usmani, A. Chandra, R. K. Mishr, V. Kumar, *Chem. Ecol.* **33** (2017) 777 (https://doi.org/10.1080/02757540.2017.1376663))
5. B. Gottlieb, S. G. Gilbert, L.G. Evans, *Coal Ash-The toxic threat to our health and environment, A Report from Physicians For Social Responsibility and Earthjustice*, Physicians for Social Responsibility, Washington, DC, 2010 (https://www.psr.org/wp-content/uploads/2018/05/coal-ash.pdf)
6. *Classification and Categorization of Surface and Renewable Water*, in Official Gazette of Montenegro, No.2/07, Government of the Republic of Montenegro, Podgorica, 2007
7. M. Vemić, R. Vemić, in *Proceedings of III Consultation C Ko Cigre*, 3-16.05.2013, Przno, Montenegro, 2013.

(CC) 2019 SCS.