THE IMMOBILIZATION OF COPPER FROM WASTE PRINTING DEVELOPER SLUDGE

Savka Adamović[1], Miljana Prica[1], Đurđa Kerkez[2], Jelena Tričković[2], Snežana Maletić[2], Dragan Adamović[1], Milica Velimirović[3]

[1]University of Novi Sad, Faculty of Technical Sciences, Trg Dositeja Obradovica 6, 21000 Novi Sad, Serbia
[2]University of Novi Sad, Faculty of Sciences, Trg Dositeja Obradovica 3, 21000 Novi Sad, Serbia
[3]University of Vienna, Department of Environmental Geosciences, Althanstrasse 14 UZAII,1090 Vienna, Austria
e-mail: miljana@uns.ac.rs

Abstract
The electrocoagulation (EC) treatment of the waste printing developer in laboratory conditions was produced the sludge with a high amount of copper. The solidification/stabilization (S/S) treatment of electrocoagulation sludge (ECS) has been conducted with four immobilization agents: Portland cement, calx, bentonite, and local clay. The efficiency of the S/S treatment was monitored by applying standard German (DIN 38414-4) leaching test. The characterization of ECS in terms of its toxicity was evaluated by comparing the copper concentration levels in the leaching solution with maximum allowed concentrations according to current regulations.

Key words:electrocoagulation, waste printing developer, sludge, copper, solidification/stabilization

Introduction

The term solidification/stabilization (S/S) is used for describing a wide specter of techniques for the transformation of waste into forms that are less harmful to the environment [1].
Stabilization refers to a procedure of applying different additives and/or binders, its principal goal being transforming the dangerous waste constituents into a less toxic, soluble and/or moveable form. This is achieved via chemical and/or physical processes. One of the more common stabilization methods implies adding a chemical agent that decreases the solubility of dangerous waste constituents, in that way significantly reducing their leaching into the environment [2].
Solidification implies the application of additives and binders that transform waste into a solid form that does not contain free liquid. Usually, the main goal of solidification is the transformation of waste into a form that is easier to manage and dispose of, while at the same time minimizing its harmful potential by reducing the surface of the waste that comes into contact with the environment. A chemical reaction is not implied. Besides that, a solidified waste lowers the risk of particle dissipation while managing, keeping, transporting, and disposing. Also, solidification contributes to the heightening of waste solidity and the lowering of permeability when compared to the untreated waste. The solid form gotten through solidification can be in the shape of a monolith block or solid pellets (balls) [3].
The amount and the composition of the printing waste depends on the the raw materials used, the process techniques applied and the properties to be achieved [4]. The waste printing materials are most often not geochemically stable and safe to the environment. It is generally thought that the highest potential risk comes exactly from the leaching of soluble waste pollutants when they come into contact with water. In order to successfully evaluate the potential risks of waste to

human health and the environment, it is necessary to conduct leaching tests. The main goals of the leaching tests are [5]: (i) classification of hazardous and non-hazardous waste; (ii) the assessment of the leaching potential of waste pollutants in environmental conditions; (iii) the simulation of conditions which facilitate leaching; (iv) getting samples that represent the quality of leaching water originating on landfills; (v) the assessment of the waste treatment efficacy; (vi) identification of a suitable scenario of waste management; (vii) determining the kinetic parameters for pollutant transport modeling.

During the EC treatment of the offset printing effluents the sludge with removed metals is formed as a byproduct. To solve the problem of the disposal of sludge formed after the EC treatment of the waste printing developer, the S/S treatment with Portland cement, calx, bentonite, and local clay as immobilization agents was applied.

Experimental

The electrocoagulation treatment of the waste printing developer

For the batch EC reactor, a borosilicate glass was used (250 ml in volume) with 220 ml of the waste printing developer. The EC treatment was conducted with four Fe electrodes placed at a distance of 0.5 cm. The external electrodes were connected to the DC power supply (DF 1730LCD) with constant current density of 8 mA/cm^2 during the operational time of 60 minutes [6]. A balanced stirring of the EC-treated waste printing developer was achieved by using a magnetic stirrer (IKA color squid). The sludge obtained was separated from the liquid phase by membrane filtration and dried to constant mass at 105^{o}C.

The characterization of the electrocoagulation sludge

The characterization of sludge of the EC-treated waste printing developer was conducted according to the pseudo-total content of heavy metals. The pseudo-total content of heavy metals in the sludge was determined by acidic digestion according to the ISO 11466:1995 method [7]. The samples obtained were analyzed by applying the AAS flame technique (Perkin Elmer AAnalyst™ 700) in accordance with the standard EPA 7000B procedure [8]. Also, the sludge characterization included the initial performance of the standard German leaching test on a raw sample of the EC-treated waste printing developer in order to determine its character.

The characterization of immobilization agents

The chemical composition of immobilization agents (Portland cement (PC), calx (C), bentonite (B), and local clay (LC)) for the S/S treatment of ECS is shown in Table 1.

Table 1. The chemical composition of immobilization agents

Compounds	Composition (%wt)			
	PC	C	B	LC
SiO_2	23.40	-	58.90	55.70
Al_2O_3	6.12	-	22.70	14.91
Fe_2O_3	3.21	-	4.83	5.78
MgO	1.01	-	1.40	2.86
CaO	63.20	99.00	1.85	5.90
K_2O	0.54	-	0.24	-
Na_2O	0.12	-	0.12	0.83
SO_3	1.18	-	-	0.22
TiO_2	-	-	-	0.80
Ignition loss	1.40	-	10.60	10.58

The S/S mixture

The S/S mixtures were created by mixing the dried ECS with immobilization agents in the ratio of 50 to 50. To the homogenized S/S mixtures an optimal content of deionized water was added according to the ASTM D1557-00 procedure [9]. Then, the S/S mixtures were placed into inert plastic bags to be stored in for 28 days at room temperature (23±2^{o}C).

Standard German leaching test

For the DIN 38414-4 leaching test, the samples of the S/S mixture was fragmented to particles smaller than 2 cm in size. Deionized water was used as an extraction fluid, and the leaching was conducted during 24 hours on a continuous stirrer. The ratio of liquid to solid was 10 to 1 (l kg^{-1}). DIN 38414-4 leaching test corresponds to the EN 12457/2 test, prescribed by the decision of the European Council [10] as a standard leaching test for determining general characteristics of waste materials and sludge. Also, DIN 38414-4 leaching test is used in Serbian Regulation on categories, evaluation and classification of waste [11].

Results and discussion

The results show the presence in ECS of iron and copper in mass concentrations of 455570 and 351 mg kg^{-1}, respectively. For the classification and characterization of the sludge of the EC-treated waste printing developer as waste, the iron and copper values were compared to the maximum allowed concentration values prescribed by the EPA 658/09 [12]. The iron value was not defined, whereas the value of copper exceeds the border value of 60 mg kg^{-1} prescribed by the EPA 658/09, which determines the tested sludge of EC-treated wasteprinting developer as hazardous waste that has to be treated before being disposed.

Table 2. The concentrations of copper leached from the S/S mixtures of ECS with immobilization agents according to the DIN 38414-4 test

Sample	Concentration 10^{-2}(mg kg)
ECS	772
ECS50B50	467
ECS50LC50	463
ECS50C50	236
ECS50PC50	79
A*	200
B*	5000 - 10000
LAGA Z2*	200
A* - Maximum allowed concentration of waste defined as **inert** L/S=10 (L/kg), [11]	
B* - Maximum allowed concentration of waste defined as **non-hazardous** L/S=10 (L/kg), [11]	
Z2* - The cupper recommended value of usage [13]	

The concentrations of copper leached from the ECS and the stabilized S/S mixtures (ECS50PC50, ECS50C50, ECS50B50, ECS50LC50) by DIN 38414-4 leaching tests are shown in Tables 2. The results of the DIN 38414-4 test of copper leaching from the ECS and the S/S mixture of the waste printing developer sludge and immobilization agents were interpreted by using the national regulation on testing and classification of waste into inert, non-hazardous and hazardous [11] as well as based on the values prescribed for waste by the European Union [10]. The results obtained show that the ECS as well as the S/S mixture of the ECS and immobilization agents can be characterized as non-hazardous waste according to the national regulation on testing and classification of waste into inert, non-hazardous and hazardous. Only the S/S mixture of the ECF sludge and Portland cement (M50PC50) can be defined as inert waste. Also, M50PC50 mixture based on the LAGA criteria prescribed by the German state task-force for waste management [13] fulfills the prescribed value and may be used.

Conclusion

According to the DIN 38414-4 test it can be concluded that the ESC and S/S mixtures of the ECS and immobilization agents are not dangerous and can be safely disposed into the environment. If the S/S treatment is observed from the economic aspect, the fact is that it can be efficiently executed even with non-commercial clay.

References

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