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Methods to Remove the Heavy Metals from the Slurry

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Abstract

The contamination of soil with elements coming from the slurry composition is of a major importance and it is put under strict environmental regulations. Among these elements, the heavy metals are of special concern, considering the serious damages it produces, even at very low concentrations.
This paper presents a study, made on two different samples of slurry, with different heavy metals compositions, that involves three techniques of reducing the heavy metals content. The experiments were done using extraction in static and in dymanic regime, as well as the technique of free flow. As extraction liquids, it was used water, an acid solution and an alkali solution.
The study concludes with an estimation of the efficiency of the three techniques, comparing also the effectiveness of the extraction liquids for both samples of slurry.

Key words: *heavy metals, reduction, slurry, environmental protection*

Introduction

Heavy metals are chemical elements common to all soils and their abundance is of order of percents (%) to parts per million (ppm). It is generally accepted that heavy metals are an inorganic soil compound and it includes electropositive chemical elements with a density higher than 5 kg/m^3 (Fe, Mn, Cu, Zn, Pb, Cd, Cr, Co, Ni, Hg) [1].

The content in soil of these elements can be higher than the maximum limit for concentration and, in this case, they have a damaging effect on the vegetation. By exceeding concentration limits, heavy metals contribute to the inhibition of the natural growth process for plants and, in addition, to the disturbing of the environment functionality [2]. Heavy metals are transported in soil by liquid phases or by the slurry brought to the surface.

The high heavy metals concentrations, as pollution effects, determine, depending on the chemical features of the soil, the adsorption in high amounts in plants. When reaching toxic levels [3], the plants growth is negatively affected and the unwanted implications on other environment factors appear [4].

This paper presents a study [5] that aims to give practical solutions for the reduction of heavy metals in slurries.

Experimental

Static Regime Extraction

The probes of slurry were ground, sorted out (5 mesh) and then placed in contact with the liquid phase: water, chloride acid solution 2,2 %, sodium hydroxide solution 2,2 %,, for 48 hours at a temperature of 30°C. The mixing ratio was: 1g solid probe to 100 ml solution.

The liquid phase was separated from the solid one by centrifugation, and from the clear solution obtained was determined the heavy metals content, using the atomic absorption spectrophotometry (AAS) method.

Dynamic Regime Extraction

It was experimented a method to extract heavy metals from the slurry by controlling the liquid phase, having the solid phase in state of powder (a better contact between the two phases). For this purpose, the mix was submitted to continuos stirring.

Alter 24 hours, the two phases were separated by centrifugation and the liquid phase was analyzed to determine the heavy metals content. The amounts of these elements remained in the solid probes was established by calculations.

Free Flow Extraction

To control the contacting capacity of the two phases (mineral and liquid phase), the extraction liquid was allowed to free flow among the slurry particles.

The dry slurry probe, ground, was put in glass tubes of 2 cm diameter, having a tap at the lower side. The extraction liquid was let to flow freely, and it was collected in a glass. The ratio between the solid amount and the extraction liquid volume was kept constant, 1 g: 1000 ml. The whole volume of colleted liquid was concentrated and brought to a constant volume in a leveled recipient. From the solution obtained so, the heavy metals content was measured by atomic absorption spectrophotometry (AAS). Further calculations helped to determine the quantity of heavy metals remained in the solid medium.

Results

Static Regime Extraction

The results obtained are presented in table 1.

Table 1. Heavy metals content in the slurry decontaminated in static regime.

Extraction fluid	Element, mg/kg											
	Cr		**Cu**		**Zn**		**Cd**		**Pb**		**Ni**	
	D I	D II	D I	D II	D I	D II	D I	D II	D I	D II	D I	D II
Water	180	162	71	57	89	81	9,88	10,2	160	163	88	95
Acid solution	135	148	55	51	68	64	5,61	8,9	151	155	62	82
Alkali solution	161	155	65	54	88	69	7,65	9,2	120	142	79	91

In static regime occurs a different reduction in content for copper, zinc, cadmium, lead and nickel when using an acid solution. Only chrome is easily removed from the slurry by using the sodium hydroxide solution.

Washing with water reduces only partially these chemical elements.

Dynamic Regime Extraction

In table 2 are given the results obtained using this method.

Table 2. Heavy metals content in the slurry decontaminated in dynamic regime

Extraction fluid	**Element, mg/kg**											
	Cr		**Cu**		**Zn**		**Cd**		**Pb**		**Ni**	
	D I	D II	D I	D II	D I	D II	D I	D II	D I	D II	D I	D II
Water	160	153	68	40	81	75	8,92	9,05	150	152	76	80,5
Acid solution	120	99,8	38	29	52	50	4,55	7,25	149	150	51	69
Alkali solution	140	13,8	49	32	79	52	7,54	7,50	110	115	75	78,53

The results analysis ascertain that the reduction of heavy metals from the slurry treated in dynamic regime is stronger than in the slurry treated in static regime, although the contact time was less. The contact favored the extraction of ionic compounds.

Free Flow Extraction

Table 3 shows the results for the experiments using this technique.

Table 3. Heavy metals content in the slurry decontaminated in free flow

Extraction fluid	**Element, mg/kg**											
	Cr		**Cu**		**Zn**		**Cd**		**Pb**		**Ni**	
	D I	D II	D I	D II	D I	D II	D I	D II	D I	D II	D I	D II
Water	179	160	70	52	85	79	9,02	10	162	158	80	85,3
Acid solution	137	135	56	38	69	57	5,03	8,2	154	151	65	74,5
Alkali solution	159	140	66	40	89	61	7,66	8,50	113	128	78	82,5

In this case, the method was applied with difficulty due to the swelling of the clay from the slurry. The free flow of the extraction liquid was slower towards the end of the experiment, sometimes being almost blocked.

Initially, the solids quantities were bigger, as well as the liquid volumes, keeping constant the ratio between them. Because of the difficulties encountered, both solid amount and liquid volume were decreased.
The reducing of heavy metals content using this method was better than in the case of the static regime, but it can only be applied to low amounts of solids.

Table 4. Efficiency estimation on the slurry probe I

Technique	Decrease, %																	
	Cr			**Cu**			**Zn**			**Cd**			**Pb**			**Ni**		
	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3
Static Regime	9,54	32,16	19,09	2,74	24,65	10,95	4,30	26,88	5,37	1,20	43,9	23,50	2,44	7,93	26,83	3,30	31,86	13,18
Dynamic Regime	19,59	39,69	29,64	6,85	54,79	32,87	12,90	44,08	15,05	10,8	54,5	24,6	8,54	9,15	32,52	16,48	43,95	17,58
Free flow	10,05	31,15	20,10	4,11	23,28	9,59	8,60	25,80	4,30	9,8	49,6	23,4	1,22	6,09	31,09	12,06	28,57	14,28

Table 5. Efficiency estimation on the slurry probe II

Technique	Decrease, %																	
	Cr			**Cu**			**Zn**			**Cd**			**Pb**			**Ni**		
	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3
Static Regime	7,43	15,42	11,42	5	15	10	4,70	24,70	18,82	32	40,66	38,66	4,12	8,82	16,47	5,94	18,81	9,90
Dynamic Regime	12,57	42,97	21,14	33,33	51,66	46,67	11,76	41,17	37,64	39,67	51,67	50	10,59	11,76	32,35	20,29	31,68	22,27
Free flow	8,57	22,85	20,0	13,13	36,67	33,33	7,05	32,94	28,23	33,3	45,3	43,3	7,05	11,17	24,70	15,54	26,23	18,31

Efficiency Estimation

The results obtained using these three methods to reduce the content of heavy metals from the slurry can be processed to estimate the efficiency of each proceeding by calculating the percentage of heavy metals reduction on each type of slurry (tables 4 and 5).

In these tables, the notations are as follows:

L_1 represents water;
L_2 - acid solution;
L_3 – alkali solution.

Conclusions

The techniques to reduce the heavy metal content presented in this paper showcast few aspects mentioned in the following.

The dynamic regime technique is more efficient than the one in static regime, under the conditions of using the same slurry/liquid phase ratio and the same temperature.
The use of acid solution to exctract heavy metals like Cu, Cr, Zn, Cd, Ni (less Pb) gave the best results.

In all cases studied, the alkali solution has a better extraction capacity than water.
The concentration of the acid and the alkali solutions used as extraction liquids to reduce the heavy metals content does not imply high costs to apply the proceeding. In addition, the cost of the chemicals used is not high.

The work temperature chosen to apply these content reduction techniques does not require high energy costs. If wanting to enhance the process, the work temperature can be raised.
When choosing the extraction liquid to reduce the content of certain chemical species (heavy metals) from the slurry, a major concern is to avoid formation of non soluble compounds between the ions from the solid medium and the ones from the liquid phase.

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Metode de reducere a conţinutului de metale grele din detritus

Rezumat

Contaminarea solului cu elemente provenite din detritus este de o importanţă majoră şi este supusă unor regulamente de mediu foarte stricte. Printre elementele de interes special se numără metalele grele, având în vedere efectele puternic nocive pe care le are, chiar şi în concentraţii reduse.

Această lucrare prezintă un studiu experimental efectuat pe două probe de detritus, cu diferite compoziţii, în care se folosesc trei tehnici de reducere a conţinutului de metale grele. Experimentele au fost realizate folosind metoda extracţiei în regim static şi dinamic, dar şi tehnica curgerii libere. Ca lichide de extracţie s-au utilizat apa, o soluţie acidă şi o soluţie alcalină.
Studiul realizează o estimare a eficienţei celor trei tehnici, comparând, de asemenea, şi performanţele lichidelor de extracţie pe ambele probe de detritus.