USE OF BAUXITE REFINING RESIDUE TO REDUCE THE MOBILITY OF HEAVY METALS IN MUNICIPAL WASTE COMPOST

by

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I, Henricus Theodorus Hofstede, declare that this thesis contains original research by the undersigned which has not previously been submitted for a degree at any other university.

Signed,

Henricus Theodorus Hofstede

The following papers of the presented research have been published to date:

Hofstede H. T. and Ho G. E., 1989. The effect of the addition of bauxite refining residue (red mud) on the behaviour of heavy metals in compost, In: *Proceedings of the 7th International Conference on Heavy Metals in the Environment,*, Geneva, pp. 217-220, CEP consultants, UK.

Hofstede H.T. and Ho G. E., 1991. The effect of the addition of bauxite refining residue (red mud) on the behaviour of heavy metals in compost, In: *Trace metals in the environment, vol.1 : Heavy metals in the environment*, J - P Vernet (ed.). Elsevier, Amsterdam, pp. 67 - 94.

Hofstede H. T., Ho G. E., 1992. A modified composting process to reduce the mobility and concentration of heavy metals in organic waste, In: *Proceedings of the 1st National Hazardous and Solid Waste Convention*, Sydney, AWWA & AWMA, pp 62.1-62.10.

Hofstede H. T. Patent on improvement of organic waste treatment processes, 3/9/1992.

Hofstede H. T. and G. E. Ho, 1992. Red mud for production of novel clay - compost from organic waste. In: *Proceedings of the international Bauxite Tailings Workshop*, 2 - 6 november, Perth, Western - Australia, pp. 356 - 365.

Ho G. E., Hofstede H. T. and Liang Q., 1993. Composting of domestic solid waste - fixing of heavy metals. In: *Proceedings of the Tenth National Conference on Waste Management*, Perth, Western - Australia, 3 - 5 March.

Ho G. E., Hofstede H. T. and Liang Q., 1993. Bauxite Tailings (red mud) for heavy metal removal. Waste Management Symposium, RACI, Perth.

Liang Q., Hofstede H. T. and G. E. Ho, 1993. The mobility of heavy metals in clay amended sewage sludge and municipal solid waste compost. In: *Proceedings of the Ninth International conference on heavy metals in the environment*, Toronto. CEP consultants, UK.

Toegewijd aan

mijn ouders en Lucas

Abstract

Use of bauxite refining residue to reduce the mobility of heavy metals in municipal waste compost.

PhD thesis by

Harrie Hofstede

Due to the adverse environmental impact of landfills and the lack of space for nearby population centres an unprecedented interest has developed in waste recycling with the objective to reduce the volume of waste disposed. Generally organic matter represents the largest fraction in the domestic waste stream including food, garden and paper waste.

In the past efforts have been made to process this organic fraction into municipal compost. However contamination of the compost with heavy metals has in many cases resulted in the lack of suitable markets and subsequent closure of compost facilities. A study was undertaken and aimed at reducing the concentration and mobility of heavy metals in municipal compost.

Bauxite refining residue has a high capacity to immobilise metals in soils through precipitation, cation exchange and chemisorption (Fe- and Al- oxides).

The first step in the study was to assess the metal adsorption capacity of red mud by equilibrating red mud with metal solutions. Metal removal from solution proved very high.

Subsequently, the effect of red mud addition to municipal compost was studied in relation to metal mobility. In particular the interaction of metals with the mobile soluble organic fraction, the humic and fulvic acids, was investigated. It was found that most metals remained in the insoluble humin fraction and the metals in solution remained complexed to the soluble organic fraction. Red mud appeared to be able to adsorp fulvic and humic acids and thus indirectly immobilise the metals in solution. Red mud did not appear to be able to transfer metals from the organic fraction to the mineral red mud fraction.

It was hypothesised that, in order for the metals to be adsorped to red mud, the red mud needed to be present in the organic waste prior to composting. Metal adsorption to red mud is a rapid chemical reaction while metal complexation to the organic fraction takes a number of weeks, since it must be sufficiently oxidised to contain functional groups

In order to verify this hypothesis, an installation with seven incubators was developed which allowed composting to be undertaken under computer controlled conditions and monitored for temperature, airflow and carbon dioxide respiration. The incubators were filled with 10 kg of a mixture of grass clippings and sawdust. The first incubator functioned as a control. The contents of the rest of the incubators were spiked with the following metals: Cd, Cr, Cu, Ni, Pb and Zn. In addition the contents of the 3rd - 7th incubators were amended with an increasing percentage of red mud, respectively 10, 20, 25, 30 and 40 % by weight. After the mixture was composted, the metal mobility was reduced by approx. 80 - 99 %, depending on the metal. The mobility was assessed as leachable and plant available in relation to the total metal content. Red mud did not affect the composting process if < 40 % red mud was added.

The next step was to compost municipal organic waste in a pilot plant (capacity 5 m^3) using batches with and without red mud. Mixed waste was collected from 150 households and the glass, metal and plastic fractions were removed by manual sorting. The rest was composted.

The red mud - compost had a relatively lower metal content and a reduced metal mobility compared to compost without red mud. The red mud - compost also had a 300 times higher pH buffer capacity and 90 % less soluble organic matter.

The addition of red mud prior to composting was found to reduce the concentration and mobility of metals in compost, improve the quality of compost as a soil conditioner, increased the resistance of the organic fraction against further breakdown and this process thus adds value to both red mud and organic waste.

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