Trace element pollution of soils by abandoned gold mine tailings near Potchefstroom, South Africa

by

PAUL-JOHAN AUCAMP

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Supervisor: Prof A van Schalkwyk

Co-Supervisor: Prof MC Laker

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ABSTRACT

The extent to which trace elements from reworked tailings have polluted the underlying soils at the abandoned Machavie Gold Mine was investigated. Material from five tailings dams has been reworked by wind and water erosion and deposited over an area of ± 1,1 km^2 downslope from the tailings impoundments. The tailings deposit varies in thickness between 0,01 m to 1,50 m. The influence of this tailings cover on the underlying soils was investigated by means of a series of test pits from which disturbed samples were retrieved. The investigated soils consist of residual dolomitic soils overlain by colluvial and alluvial soils. The tailings is a source of contamination as it produces trace element-rich acidic leachate from the decomposition of sulphide minerals in the tailings. The average pH of the tailings is very acidic at 3,43. Soluble sulphate salts that have precipitated on the reworked tailings, show high water-soluble concentrations of As, Cd, Co, Cr, Cu, Ni, Pb and Zn. All the soils directly underlying the reworked tailings are affected by the acidic, trace element rich-leachate produced in the tailings. The trace element content of the tailings and soils was compared with the guideline concentrations which indicate that the soils and tailings should be further investigated for As, Co, Cr, Cu and Ni contamination. To assess the degree of contamination in the soils, extractable concentrations of As, Co, Cr, Cu, Ni, Pb and Zn were determined by using NH_4NO_3, which is recommended by various authors as an environmental leaching agent. An ammonium nitrate extractable Zn-equivalent was introduced and used to show that the upper clayey alluvial soils pose a greater threat to plant life than the sandy colluvial soils. The mobility of the trace elements was investigated by determining the percentage of the total element concentration which is extractable with NH_4NO_3. Trace element mobilities increase with lower soil pH values once a pH of 5 is reached.

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SAMEVATTING

Die ondersoek handel oor die mate waartoe grond wat oorlê word deur goudmynslik, deur sekere spoorelemente besoedel word. Die studie area is die geslote Machavie goudmyn wat oos van Potchefstroom, in die Noordwes Provinsie geleë is. In die studie area is 'n gebied van ± 1,1 km^2 besoedel deur wind en water verspreide goudmynslik afkomstig van vyf slikdamme. Die dikte van die slik wissel tussen 0,01 m en 1,50 m. Die invloed van die goudmynslik op die onderliggende gronde is ondersoek deur die grawe van 'n aantal toetsgate waaruit versteurde grondmonsters verkry is. Die gronde in die studie area bestaan uit residuele dolomiet wat oorlê word deur kolluviale en alluviale gronde. Die goudmynslik kan as 'n bron van suur en spoorelementbesoedeling beskou word aangesien die slik 'n gemiddelde pH(water) van 3,43 het, en oplosbare soute wat neergeslaan het op die oppervlakte van die herwerkte slik, hoë water oplosbare konsentrasies van As, Cd, Co, Cr, Cu, Ni, Pb en Zn, bevat. Die meerderheid grond wat oorlê word deur die slik, is geaffekteer deur die slik aangesien die gronde lae pH's het. Die spoorelement inhoud van die gronde is vergelyk met internasionale limiet konsentrasies, en daar is bevind dat die konsentrasies van As, Co, Cr, Cu en Ni in die gronde verder ondersoek moet word. Ammoniumnitraat is gebruik as 'n loginsmiddel om die ekstraheerbare konsentrasies van As, Co, Cr, Cu, Ni, Pb en Zn in die gronde te bepaal. 'n NH_4NO_3 ekstraheerbare Zn-ekwivalent is gebruik om te wys dat die kleierigge alluviale bogrond 'n groter gevaar vir plantlewe inhou as die sanderigge kolluviale bogrond. Die mobiliteit van die spoorelemente is ondersoek deur die persentasie van die totale spoorelement inhoud wat ekstraheerbaar deur NH_4NO_3 is, te bepaal. Daar is bewys dat spoorlement mobilitiet 'n funksie van die pH van die grond is, aangesien hoër spoorelement mobiliteite onder 'n pH van 5 voorkom.

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