Sources of manganese in the residue from a water treatment plant

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ABSTRACT

Disposal of water treatment residue (WTR), the by-product from the production of potable water, has traditionally been to landfill. The shortage of suitable landfill sites has led to the proposal that WTR be applied to land. Such disposal is only possible if the WTR contains no toxic elements that may contaminate soil, water or vegetation. Previous studies have shown that most WTRs in South Africa contain a high concentration of Mn, which was assumed to be from the drinking water treatment chemicals. This study investigated this assumption at one water treatment plant (WTP) in KwaZulu-Natal. Chemical analysis of drinking water treatment chemicals and a mass balance for Mn at the WTP showed that the main source of Mn was brown lime (added during the treatment process), although the raw water also added appreciable amounts of Mn to the WTR due to the volume of water treated. The concentration of Mn in the organic polymers, bentonite, ferric chloride, ferric sulphate and alum was negligible or very low. It is unlikely that the cost increase associated with changing from brown lime to white lime could be justified, given that the environmental impact of Mn is unclear and is generally not considered to be a problem internationally. Different ecosystems will respond differently to Mn loading and deriving a single, national, maximum permissible level for Mn within a WTR to permit land application is thus difficult and inappropriate.

Keywords: drinking water treatment chemicals, land application, manganese, water treatment residue

INTRODUCTION

One of the principal objectives of potable water treatment is purification by removal of suspended solids and dissolved matter (e.g. clay, fine particulate matter, organic and inorganic components, algae, bacteria and viruses) from the raw water. At a conventional water treatment plant (WTP), the suspended solids are removed in clarifiers and sand filters, after prior coagulation with long-chain polymers, addition of flocculation agents such as bentonite and polyacrylamide, and pH correction utilising lime, sodium hydroxide or soda ash. Filter wash-water contains suspended matter removed by the filters. In South Africa, this waste by-product from the clarifiers and wash-water (here termed water treatment residue (WTR) to distinguish it from wastewater sludge) has historically either been disposed of by release into the nearest watercourse, into evaporation ponds or, after partial dewatering, to landfill. Due to high evaporation rates and the perceived availability of land in South Africa (though this availability is decreasing close to urban areas), the use of evaporating ponds is often favoured, while the direct disposal of WTR to watercourses is now illegal (National Water Act (NWA); Act No. 36 of 1998).

Internationally, techniques for disposal of WTR have included direct discharge to a watercourse, disposal to sanitary landfills, and co-disposal with municipal sewage (Elliot and Dempsey, 1991). In South Africa, the reason for the previous popularity of landfills was that, with environmental concerns being of low priority, landfill constituted a convenient method of waste disposal. Since 1994, however, South Africa has seen the closure of numerous landfill sites for both social and environmental reasons. With increasing transport costs to the nearest acceptable landfill, land disposal systems are becoming more popular for the ultimate disposal of WTRs, with a view to make use of their possible beneficial aspects (Basta, 2000). Elliot and Dempsey (1991 p. 126) define land treatment as 'the controlled spreading of sludge onto or incorporation into the surface layer of soil to stabilise, degrade and immobilise sludge constituents'. Furthermore, land application systems may be engineered to favourably modify soil properties and recycle valuable components of the applied waste (Overcash and Pal, 1979).

Hughes et al. (2005), in an extensive study, detailed the effect of land application of WTR for South African conditions. This study concluded that land application of WTRs is safe and is likely to have no negative impacts on soils, vegetation or groundwater even at very high disposal rates that are unlikely to occur in the field (Hughes et al., 2005). In a follow-up risk assessment, Hughes et al. (2007) recommended that WTR be reclassified to allow its disposal under a general authorisation (NWA, Act 36 of 1998) with consideration being given to the nature of the WTR to determine any potential negative impacts the material may have if applied to land. These studies suggested that a possible area of concern was the elevated manganese (Mn) concentration found in WTRs collected from a large number of WTPs in South Africa. This concern was also highlighted by Novak et al. (2007) who found that soil incubated with a WTR released Mn after 60 days. They concluded that slight soil acidification and reducing conditions were the cause. Furthermore, the raw water was treated with potassium permanganate which would have contributed Mn to the WTR.

Manganese is often perceived as a toxic heavy metal and its presence in the environment at elevated levels may be potentially lethal (Kabata-Pendias and Pendias, 2001). However, Mn

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