

# **Removal of geosmin and 2-methylisoborneol from Drinking Water Through Biologically Active Sand Filters**

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## **Executive Summary**

This thesis outlines results of a series of studies investigating the removal of two common taste and odour compounds, 2-methylisoborneol (MIB) and geosmin, from drinking water using biologically active sand filtration. A combination of full-, pilot- and laboratory-scale studies were carried out.

A review of long term water quality data from a South Australian water treatment plant indicated that the plant was capable of removing MIB and geosmin to below detection limit without the need for additional treatment. A series of laboratory studies were carried out, validating the theory that the geosmin removal was occurring through biological activity in the rapid gravity filters of the water treatment plant.

Microorganisms capable of geosmin removal were found to be present in the settled water of two South Australian water treatment plants, Morgan and Happy Valley. Laboratory sand column experiments were conducted with these waters and a range of sand media, investigating the effect of biofilm development on MIB and geosmin biodegradation. It was found that the process could produce effective removals, however long start-up periods were often required. A laboratory-scale column utilising new sand fed with Happy Valley settled water took in excess of 300 days before it was capable of removing MIB and geosmin by greater than 80%. Studies on sands with inactivated pre-existing biofilms required much shorter biofilm development periods, from 30 to 40 days. The results of the column studies indicated that a method to encourage sand filters to operate biologically for MIB and geosmin removal would be advantageous. Two methods were studied: pre-ozonation and bacterial inoculation.

Pre-ozonation was carried out at a pilot plant, constructed at the Happy Valley water treatment plant. Additional factors investigated during this study were the length of the biofilm development period and the impact of empty bed contact time (EBCT). Pre-ozonation is often used in tandem with biological filtration to increase the fraction of biodegradable organic matter and in turn increase the biomass activity of the filter. The pilot plant consisted of two sand filters; one fed with settled water and one fed

with pre-ozonated settled water. Pre-ozonation did not enhance the biodegradation of MIB or geosmin. The pre-ozonated column was run for 550 days. Removals of MIB and geosmin were inconsistent throughout the trial. The maximum removal obtained during the study was 80% for MIB and geosmin, at an EBCT of 45 minutes, after 380 days of operation. The settled water column was run for over 650 days. By day 560, the column was able to remove 60% of the influent geosmin and 40% of the influent MIB at an EBCT of 10 minutes, which is close to that used in full-scale plants. Significant effects of empty bed contact time were not noted in the range of 10 to 30 minutes.

Bacterial inoculation studies were carried out at laboratory-scale. The inoculum comprised of a geosmin-degrading consortium of three Gram-negative bacteria previously isolated from the biofilm of the Morgan water treatment plant filter sand. A sand column with a pre-existing biofilm was inoculated with the organisms, achieving 70% removal of geosmin. Inoculation of columns without biofilms gave lower geosmin removals, with an average of 41% removal. These were preliminary studies only, and further work is required.

A biomass activity assay, based on the concentration of adenosine triphosphate (ATP), was developed over the course of the project. This assay was particularly helpful when studying the attachment of the inoculum in the laboratory columns. Other methods to study biomass were flow cytometry to enumerate the water-borne and biofilm associated bacteria, and scanning electron microscopy to obtain a visual observation of the biofilms on various sands.

This work demonstrated the potential of biological sand filtration for MIB and geosmin control. It was shown that long biofilm development periods are evident before effective removal of the compounds can occur. The potential to minimise these long biofilm development periods by inoculation of filters with geosmin degrading organisms was demonstrated.