REMOVAL OF GEOSMIN AND 2-METHYLISOBORNEOL FROM DRINKING WATER THROUGH BIOLOGICALLY ACTIVE SAND FILTERS

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PhD

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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 conventional 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.

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GLOSSARY

A summary of acronyms used in this thesis is presented below.

ADWG Australian drinking water guidelines

AOC assimilable organic carbon

ATP adenosine triphosphate

BDOC biodegradable dissolved organic carbon

DOC dissolved organic carbon

ES effective size

EBCT empty bed contact time

FCM flow cytometry

HLR hydraulic loading rate

HPSEC high performance size exclusion chromatography

MIB 2-methylisoborneol

NOM natural organic matter

OTC odour threshold concentration

SD standard deviation

SUVA specific UV absorbance

UC uniformity coefficient

WHO World Health Organisation

WTP water treatment plant

TABLE OF CONTENT

EXECUTIVE SUMMARY III

ACKNOWLEDGMENTS V

GLOSSARY VII

1 INTRODUCTION 1

1.1 Problem Statement 2

1.2 Objectives of Research 3

2 LITERATURE REVIEW 4

2.1 Taste and Odour in Drinking Water 5

2.2 MIB and Geosmin 6
2.2.1 Sources of MIB and Geosmin 8
2.2.2 Cyanobacteria 8
2.2.3 Actinomycetes 10

2.3 Treatment of MIB and Geosmin 11
2.3.1 Conventional Treatment Processes 11
2.3.2 Adsorption Processes 13
2.3.3 Oxidation Processes 15

2.4 Biological Processes 16
2.4.1 Biological Degradation of MIB and Geosmin 16
2.4.2 Biodegradation Mechanisms for MIB and Geosmin 18

2.5 Biological Filtration 19
2.5.1 Biological Sand Filtration for MIB and Geosmin Removal 22
2.5.2 Filtration Rate and EBCT 23
2.5.3 Media Sizing 24
2.5.4 Backwashing 24
2.5.5 Ozonation 25
2.5.6 Biomass in Drinking Water Biological Filters 26

2.6 Summary 28

3 MATERIALS AND METHODS 30

3.1 Introduction 31

3.2 Materials and Reagents 31
3.2.1 MIB and Geosmin Stock Solutions 31
3.2.2 Waters 31
3.2.3 Sands 32

3.3 Analytical Methods 33
3.3.1 Dissolved Organic Carbon 33
3.3.2 UV Absorbance 33
3.3.3 MIB and Geosmin Analysis 33
3.3.4 Autoclaving 34
3.3.5 Ozone Residuals 34

3.4 Biomass Analysis 34
3.4.1 Qualitative Analysis - Scanning Electron Microscopy 35
3.4.2 Quantitative Analysis - ATP Assay 36
3.4.3 ATP Assay Method 37
3.4.4 Bacterial Enumeration by Flow Cytometry 38

3.5 Laboratory Methods and Apparatus 39
3.5.1 Bioreactor Studies 39
3.5.2 Laboratory Column Apparatus 39
3.5.3 Biofilm Removal Method 41

4 REMOVAL OF MIB AND GEOSMIN THROUGH BIOLOGICAL SAND FILTRATION - FULL SCALE STUDY WITH LABORATORY VALIDATION 43

4.1 Introduction 44

4.2 Morgan Water Treatment Plant 44
4.2.1 Treatment Plant Overview 44
4.2.2 MIB and Geosmin Removal Through Morgan WTP 46

4.3 Validation by Laboratory Scale Columns 49
4.3.1 Experimental Design 49
4.3.2 Results of Column 1 50
4.3.3 Results of Column 2 52
4.3.4 Results of Column 3 54
4.3.5 Results of Column 4 57

4.4 Confirmation of Biodegradation in Laboratory Column 60
4.4.1 Results of Column 5 60
4.4.2 Results of Column 6 63

4.5 Biomass Analysis 65
4.5.1 Post Chlorinated Backwash Columns 65

4.6 SEM Analysis 68
4.6.1 SEM of Sand Prior to Chlorinated Backwash 68
4.6.2 SEM of Sand During Chlorinated Backwash 69
4.6.3 SEM of Sand After Chlorinated Backwash 70
4.6.4 SEM of Anthracite After Chlorinated Backwash 71

4.7 General Discussion and Conclusions from Chapter 4 73

5 LABORATORY STUDIES ON BIODEGRADATION AND BIOLOGICAL FILTRATION OF MIB AND GEOSMIN 75

5.1 Introduction 76

5.2 MIB and Geosmin Degradation in Reservoir Waters 76
5.2.1 Experimental Design 76

5.3 Results and Discussion on Bioreactors 77
5.3.1 Bacterial Numbers 77
5.3.2 Happy Valley Settled and Reservoir Waters 78
5.3.3 Happy Valley Settled and Ozonated Waters 80
5.3.4 Morgan Settled Water 81
5.3.5 Comparison of Reaction Rates 83

5.4 Overview of Laboratory Column Studies 86
5.4.1 Laboratory Column Experimental Design 86
5.4.2 Experimental Summary 87

5.5 Results and Discussion for Laboratory Columns Using Sand with Established Biofilms 88
5.5.1 Morgan Established Biofilm Column 88
5.5.2 Myponga Established Biofilm Column 91
5.5.3 Biomass Activities on Established Biofilms 94
5.5.4 SEM on Established Biofilm Columns 95

5.6 Results and Discussion for Laboratory Columns Using Sand with Developing Biofilms 97

5.6.1 Morgan Developing Biofilm Column 98
5.6.2 Myponga Developing Biofilm Column 100
5.6.3 Biomass Study on Developing Biofilms 103
5.6.4 Flow Cytometry Study on Developing Biofilm Columns 104

5.7 Results and Discussion for Columns Using Happy Valley Waters 106
5.7.1 Happy Valley Reservoir Water Column 106
5.7.2 Happy Valley Settled Water Column 108
5.7.3 Flow Cytometry Study on Happy Valley Laboratory Columns 111
5.7.4 Biomass Activity on Happy Valley Settled Column 112
5.7.5 SEM on Happy Valley Raw and Settled Columns 113

5.8 General Discussion and Conclusions on Chapter 5 115

6 ENHANCEMENT OF BIOFILTRATION BY SEEDING WITH A CONSORTIUM OF GEOSMIN DEGRADING BACTERIA 117

6.1 Inoculation Studies 118
6.1.1 Experimental Outline for Inoculation Studies 118

6.2 Results and Discussion for Inoculation Trials 121
6.2.1 Inoculation of Pre-existing Biofilm 121
6.2.2 Inoculation of New Sand 124

6.3 General Discussion and Conclusions on Chapter 6 126

7 PILOT STUDY ON BIOLOGICAL SAND FILTRATION FOR MIB AND GEOSMIN REMOVAL – APPARATUS AND METHODS 129

7.1 Introduction to Pilot Plant Trials 130

7.2 Pilot Plant Apparatus and Methods 130
7.2.1 Media 131
7.2.2 Location 134

7.3 Pilot Plant Process Descriptions 135
7.3.1 Settled Water Column 135
7.3.2 Pre-Ozonated Column 135

7.4 General Operational Conditions 136
7.4.1 Charging of the Filter Media 136
7.4.2 Head Loss Monitoring 137
7.4.3 Backwashing 137

7.4.4 MIB and Geosmin Dosing 137
7.4.5 MIB and Geosmin Sampling 138
7.4.6 Ozone Residuals 138

8 PILOT STUDY ON BIOLOGICAL SAND FILTRATION FOR MIB AND GEOSMIN REMOVAL – RESULTS AND DISCUSSION 139

8.1 Introduction 140
8.1.1 Overview of Study 140

8.2 Water Quality Data for Pre-Ozonated Column 143
8.2.1 Ozone Residual 143
8.2.2 DOC and UV Absorbance 144

8.3 Results and Discussion for Pre-Ozonated Column Spiking Trials 146
8.3.1 Pre-ozonated Spiking Trial 1 146
8.3.2 Pre-ozonated Spiking Trials 2, 3 and 4 148
8.3.3 Pre-ozonated Spiking Trial 5 150
8.3.4 Pre-ozonated Spiking Trials 6, 7 and 8 152
8.3.5 Pre-ozonated Spiking Trial 9 155
8.3.6 Pre-ozonated Spiking Trial 10 157

8.4 Water Quality Data for Settled Water Column 159
8.4.1 DOC and UV Absorbance 159

8.5 Results and Discussion for Settled Water Column Spiking Trials 161
8.5.1 Settled Water Spiking Trial 1 161
8.5.2 Settled Water Spiking Trials 2, 3 and 4 163
8.5.3 Settled Water Spiking Trials 5, 6, 7 and 8 165
8.5.4 Settled Water Spiking Trial 9 167
8.5.5 Settled Water Spiking Trial 10 169
8.5.6 Settled Water Spiking Trial 11 171
8.5.7 Settled Column Spiking Trial 12 and 13 173

8.6 Biofilm Study 175
8.6.1 Flow Cytometry on Biofilms 175
8.6.2 Biomass Activity 176
8.6.3 SEM on Pilot Plant Sand 177

8.7 Filter Run Times and Turbidities 182

8.8 Summary of Results 184
8.8.1 DOC Removals 184

8.8.2 MIB and Geosmin Removals 186

8.9 Conclusions on Chapter 8 191

9 CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER WORK 192

9.1 Summary and Conclusions 193

9.2 General Discussion and Recommendations for Future Research 194

9.2.1 Recommendations for Further Work 196

10 REFERENCES 197

APPENDIX A: DEVELOPMENT OF ATP METHOD 208

LIST OF TABLES

Table 2-1: Properties of MIB and geosmin (Pirbazari *et al.* 1992; Young *et al.* 1996). 7
Table 2-2: A Selection of Cyanobacterial Species Responsible for MIB and Geosmin Production. 10
Table 2-3: Conventional slow sand and rapid gravity sand filtration design parameters (adapted from (Rachwal *et al.* 1996). 13
Table 2-4: MIB and geosmin degrading bacteria (adapted from (Ho *et al.* 2006)). 17
Table 2-5: Studies on biofiltration of MIB and geosmin with alternative media. 21
Table 3-1: Water Quality Parameters. 32
Table 3-2: Summary of Filter Sand Properties. 33
Table 3-3: Laboratory Column Apparatus Characteristics. 40
Table 3-4: Laboratory Column Filtration Rates. 41
Table 4-1: Filter Characteristics of Morgan WTP. 45
Table 4-2: Laboratory columns containing Morgan filter media. 49
Table 5-1: Biodegradation rate constants from bioreactors 85
Table 5-2: Bacterial numbers on developing biofilm columns. 104
Table 6-1: Inoculum Concentrations for Laboratory Seeding Studies. 120
Table 7-1: Pilot Plant Dimensions. 132
Table 7-2: Pilot Plant Filtration Rates. 132
Table 8-1: Overview of spiking trials. (*) indicates first and last pre-ozonated spikes. 142

LIST OF FIGURES

Figure 2-1: Physical structures of geosmin and MIB. 7
Figure 2-2 : *Anabaena circinalis* scum on the Torrens Lake, South Australia. Photos courtesy of Australian Water Quality Centre. 9
Figure 2-3: An example of the conventional drinking water treatment process. 11
Figure 3-1: Schematic of Laboratory Columns. 40
Figure 4-1: Morgan WTP schematic. 44
Figure 4-2: Geosmin concentrations (ng L^{-1}) in Morgan WTP, 2000 – 20007. 48
Figure 4-3: MIB concentrations (ng L^{-1}) in Morgan WTP, 1997 – 2007. 48
Figure 4-4: MIB concentrations (ng L^{-1}) through non-chlorinated laboratory column (figure adapted from (Bock 2006)). 50
Figure 4-5: Geosmin concentrations (ng L^{-1}) through non-chlorinated backwash laboratory column (figure adapted from (Bock 2006)). 51
Figure 4-6: Percentage MIB and geosmin removals through non-chlorinated backwash laboratory column (figure adapted from (Bock 2006)). 51
Figure 4-7 : MIB concentrations (ng L^{-1}) through chlorinated backwash laboratory column. 52
Figure 4-8: Geosmin concentrations (ng L^{-1}) through chlorinated backwash laboratory column. 53
Figure 4-9: Percentage MIB and geosmin removals through chlorinated backwash laboratory column. 53
Figure 4-10: MIB concentrations (ng L^{-1}) through post chlorinated backwash laboratory column. 55
Figure 4-11: Geosmin concentrations (ng L^{-1}) through post chlorinated backwash laboratory column. 56
Figure 4-12: Percentage MIB and geosmin removals through post chlorinated backwash laboratory column. 56
Figure 4-13: MIB concentrations (ng L^{-1}) through anthracite post chlorinated backwash laboratory column. 58
Figure 4-14: Geosmin concentrations (ng L^{-1}) through anthracite post chlorinated backwash laboratory column. 58
Figure 4-15: Percentage removals of MIB and geosmin through anthracite post chlorinated backwash laboratory column. 59
Figure 4-16: MIB concentrations (ng L^{-1}) through autoclaved Morgan sand laboratory column (see Figure 4-18 for EBCT details) (adapted from (Bock 2006)). 61
Figure 4-17: Geosmin concentrations (ng L^{-1}) through autoclaved Morgan sand laboratory column (see Figure 4-18 for EBCT details) (adapted from (Bock 2006)). 62
Figure 4-18: Percent removals of MIB and geosmin through autoclaved Morgan sand laboratory column (adapted from (Bock 2006)). 62

Figure 4-19: MIB concentrations (ng L^{-1}) through autoclaved anthracite laboratory column. Circled data points indicate 5 minute EBCT. 63
Figure 4-20: Geosmin concentrations (ng L^{-1}) through autoclaved anthracite laboratory column. Circled data points indicate 5 minute EBCT. 64
Figure 4-21: Percentage removals of MIB and geosmin through autoclaved anthracite laboratory column. Circled data points indicate 5 minute EBCT. 64
Figure 4-22: Biomass activity of post chlorinated backwash sand (nmol ATP per unit filter volume). Error bars indicate standard deviations from triplicate analysis. 65
Figure 4-23: Biomass activity of post chlorinated backwash anthracite (nmol ATP per unit filter volume). Error bars indicate standard deviations from triplicate analysis. 66
Figure 4-24: SEM image of sand prior to chlorinated backwash, scan 1. 68
Figure 4-25: SEM image of sand prior to chlorinated backwash, scan 2. 69
Figure 4-26: SEM image of sand during chlorinated backwash, scan 1. 69
Figure 4-27: SEM image of sand during chlorinated backwash, scan 2. 70
Figure 4-28: SEM image of sand post chlorinated backwash, scan 1. 70
Figure 4-29: SEM image of sand post chlorinated backwash, scan 2. 71
Figure 4-30: SEM image of anthracite, scan 1. 71
Figure 4-31: SEM image of anthracite, scan 2. 72
Figure 4-32: SEM image of anthracite, scan 3. 72
Figure 5-1: Active bacteria in waters as measured by flow cytometry (cells ml^{-1}). 77
Figure 5-2: MIB concentrations (ng L^{-1}) in Happy Valley waters - Trial 1. 79
Figure 5-3: Geosmin concentrations (ng L^{-1}) in Happy Valley waters - Trial 1. 79
Figure 5-4: MIB concentrations (ng L^{-1}) in Happy Valley settled and ozonated Happy Valley settled water. 80
Figure 5-5: Geosmin concentrations (ng L^{-1}) in Happy Valley settled and ozonated Happy Valley settled water. 81
Figure 5-6: MIB concentrations (ng L^{-1}) in Morgan settled water. 82
Figure 5-7: Geosmin concentrations (ng L^{-1}) in Morgan settled water. 82
Figure 5-8: Modelling of pseudo-first-order geosmin decay in bioreactors. 84
Figure 5-9: Modelling of pseudo-first-order MIB decay in bioreactor. (+6) Indicates the lag period observed prior to commencement of biodegradation. 85
Figure 5-10: MIB concentrations (ng L^{-1}) through established Morgan sand laboratory column. 89
Figure 5-11: Geosmin concentrations (ng L-1) through established Morgan sand laboratory column. 89
Figure 5-12: Percent MIB and Geosmin removed in established Morgan sand laboratory column. 90
Figure 5-13: MIB concentration (ng L^{-1}) through Myponga sand/Morgan settled water laboratory column. 92
Figure 5-14: Geosmin concentration (ng L^{-1}) through Myponga sand/Morgan settled water laboratory column. 92

Figure 5-15: Percent MIB and geosmin removed through Myponga sand/Morgan settled water laboratory column. 93
Figure 5-16: Biomass activity of established biofilm columns (nmol ATP per unit filter media). Error bars indicate standard deviations from triplicate analysis. 94
Figure 5-17: SEM image of Myponga sand with established biofilm, scan 1. 95
Figure 5-18: SEM image of Myponga sand with established biofilm, scan 2. 95
Figure 5-19: SEM image of Myponga sand with established biofilm, scan 3. 96
Figure 5-20: (a) Morgan sand with biofilm removed (b) Myponga sand with biofilm removed. 97
Figure 5-21: MIB concentrations (ng L^{-1}) though cleaned Morgan sand laboratory column. 98
Figure 5-22: Geosmin concentrations (ng L^{-1}) though cleaned Morgan sand laboratory column. 99
Figure 5-23: Percent removals of MIB and geosmin though cleaned Morgan sand laboratory column. 99
Figure 5-24: MIB concentrations (ng L^{-1}) through cleaned Myponga sand laboratory column. 101
Figure 5-25: Geosmin concentrations (ng L^{-1}) through cleaned Myponga sand laboratory column. 101
Figure 5-26: Percent removals through cleaned Myponga sand laboratory column. 102
Figure 5-27: Biomass activities on developing biofilm columns (nmol ATP per unit filter volume). Error bars indicate standard deviations from triplicate analysis. 103
Figure 5-28: MIB concentrations (ng L^{-1}) through Happy Valley reservoir water laboratory column. 107
Figure 5-29: Geosmin concentrations (ng L^{-1}) through Happy Valley reservoir water laboratory column. 107
Figure 5-30: Percentage removals of MIB and geosmin through Happy Valley reservoir water laboratory column. 108
Figure 5-31: MIB concentrations (ng L^{-1}) through Happy Valley settled water laboratory column. Figure indicates period of ammonia backwashing. Circled data points indicate 5 minute EBCT. 109
Figure 5-32: Geosmin concentrations (ng L^{-1}) through Happy Valley settled water laboratory column. Figure indicates period of ammonia backwashing. Circled data points indicate 5 minute EBCT. 110
Figure 5-33: Percent removals of MIB and geosmin through Happy Valley settled water column. Figure indicates period of ammonia backwashing. Circled data points indicate 5 minute EBCT. 110
Figure 5-34: Flow cytometry study on Happy Valley columns (cells ml^{-1}). Error bars indicate standard deviation from duplicate measurements. 111
Figure 5-35: Biomass activities on Happy Valley settled water column (nmol ATP per unit filter volume). Error bars indicate standard deviations from triplicate analysis. 112

Figure 5-36: SEM image of Happy Valley raw column, sand 1. 113
Figure 5-37: SEM image of Happy Valley raw column, scan 2. 113
Figure 5-38: SEM image of Happy Valley settled column, scan 1. 114
Figure 5-39: SEM image of Happy Valley settled column, scan 2. 114
Figure 6-1: Apparatus for laboratory column inoculation trials. Dashed line indicates temporary recirculation system. 119
Figure 6-2: Percentage geosmin removals in pre-existing biofilm inoculation studies. 121
Figure 6-3: Percentage MIB removals in pre-existing biofilm inoculation studies. 122
Figure 6-4: Biomass activities in pre-existing biofilm inoculation study (nmol ATP per unit filter volume). Error bars indicate standard deviation from triplicate analysis. 123
Figure 6-5: Percentage geosmin removal in virgin sand inoculation study. 124
Figure 6-6: Percentage MIB removals in virgin sand inoculation study. 125
Figure 6-7: Biomass activities in virgin sand inoculation study (nmol ATP per unit filter volume). Error bars indicate standard deviation from triplicate analysis. 126
Figure 7-1: Photograph of Pilot Plant. 131
Figure 7-2: Photograph of ozone generation unit. 132
Figure 7-4: Geosmin levels (ng L^{-1}) in Happy Valley WTP. 134
Figure 8-1: Happy Valley WTP water temperature (data courtesy United Water International). 141
Figure 8-2: Pilot Plant Ozone Residuals. 143
Figure 8-3: DOC of pre-ozonated column. 144
Figure 8-4: UV absorbance of pre-ozonated column. 145
Figure 8-5: MIB concentrations (ng L^{-1}) through pre-ozonated column, spike 1. 146
Figure 8-6: Geosmin concentrations (ng L^{-1}) through pre-ozonated column, spike 1. 147
Figure 8-7: Percent removals of MIB and geosmin through pre-ozonated column, spike 1. 147
Figure 8-8: MIB concentrations (ng L^{-1}) through pre-ozonated column, spikes 2, 3 and 4. 148
Figure 8-9: Geosmin concentrations (ng L^{-1}) through pre-ozonated column, spikes 2, 3 and 4. 149
Figure 8-10: Percent removals of MIB and geosmin through pre-ozonated column, spikes 2, 3 and 4. 149
Figure 8-11: MIB concentrations (ng L^{-1}) through pre-ozonated column, spike 5. 151
Figure 8-12: Geosmin concentrations (ng L^{-1}) through pre-ozonated column, spike 5. 151
Figure 8-13: Percent removals of MIB and geosmin through pre-ozonated column, spike 5. 152
Figure 8-14: MIB concentrations (ng L^{-1}) through pre-ozonated column, spikes 6, 7 and 8. 153
Figure 8-15: Geosmin concentrations (ng L^{-1}) through pre-ozonated column, spikes 6, 7 and 8. 153

Figure 8-16: Percent removal of MIB and geosmin through pre-ozonated column, spikes 6, 7 and 8. 154
Figure 8-17: MIB concentrations (ng L^{-1}) through pre-ozonated column, spike 9. 155
Figure 8-18: Geosmin concentrations (ng L^{-1}) through pre-ozonated column, spike 9. 156
Figure 8-19: Percentage removal of MIB and geosmin through pre-ozonated column, spike 9. 156
Figure 8-20: MIB concentrations (ng L^{-1}) through pre-ozonated column, spike 10. 157
Figure 8-21: Geosmin concentrations (ng L^{-1}) through pre-ozonated column, spike 10. 158
Figure 8-22: Percent removal of MIB and geosmin through pre-ozonated column, spike 10. 158
Figure 8-23: DOC of settled water column. 159
Figure 8-24: UV absorbance of settled water column. 160
Figure 8-25: MIB concentrations (ng L^{-1}) through in settled water column, spike 1. 161
Figure 8-26: Geosmin concentrations (ng L^{-1}) through settled water column, spike 1. 162
Figure 8-27: Percent concentrations (ng L^{-1}) through settled water column, spike 1. 162
Figure 8-28: MIB concentrations (ng L^{-1}) through settled water column, spikes 2, 3 and 4. 163
Figure 8-29: Geosmin concentrations (ng L^{-1}) through settled water column, spikes 2, 3 and 4. 164
Figure 8-30: Percent removal of MIB and geosmin through settled water column, spikes 2, 3 and 4. 164
Figure 8-31: MIB concentrations (ng L^{-1}) through settled water column, spikes 5, 6, 7 and 8. 165
Figure 8-32: Geosmin concentrations (ng L^{-1}) through settled water column, spikes 5, 6, 7 and 8. 166
Figure 8-33: Percent removal of MIB and geosmin through settled water column, spikes 5, 6, 7 and 8. 166
Figure 8-34: MIB concentrations (ng L^{-1}) through settled water column, spike 9. 167
Figure 8-35: Geosmin concentrations (ng L^{-1}) through settled water column, spike 9. 168
Figure 8-36: Percentage removal of MIB and geosmin through settled water column, spike 9. 168
Figure 8-37: MIB concentrations (ng L^{-1}) through settled water column, spike 10. 169
Figure 8-38: Geosmin concentrations (ng L^{-1}) through settled water column, spike 10. 170
Figure 8-39: Percentage removal of MIB and geosmin through settled water column, spike 10. 170
Figure 8-40: MIB concentrations (ng L^{-1}) through settled water column, spike 11. 171
Figure 8-41: Geosmin concentrations (ng L^{-1}) through settled water column, spike 11. 172
Figure 8-42: Percentage removal of MIB and geosmin through settled column, spike 11. 172
Figure 8-43: MIB concentrations (ng L^{-1}) through settled water column, spikes 12 and 13. 173

Figure 8-44: Geosmin concentrations (ng L^{-1}) through settled water column, spikes 12 and 13. 174
Figure 8-45: Percentage removal of MIB and geosmin through settled water column, spikes 12 and 13. 174
Figure 8-46: Biomass levels on sand media by flow cytometry. SW indicates sand taken from settled water column; Pre-O3 indicates sand taken from pre-ozonated column. 175
Figure 8-47: Biomass activity on pilot plant sand (nmol ATP per until filter volume). Error bars indicate standard deviations from triplicate analysis. 176
Figure 8-48: SEM image of Virgin Pilot Plant sand, scan 1. 177
Figure 8-49: SEM image of Virgin Pilot Plant sand, scan 2. 178
Figure 8-50: SEM image of pre-ozonated column sand, scan 1. 178
Figure 8-51: SEM image of pre-ozonated column sand, scan 2. 179
Figure 8-52: SEM image of pre-ozonated column sand, scan 3. 179
Figure 8-53: SEM image of settled water column sand, scan 1. 180
Figure 8-54: SEM image of settled water column, scan 2. 180
Figure 8-55: SEM image of settled water column, scan 3. 181
Figure 8-56: Pre-ozonated column turbidities (NTU). Dotted line indicates ADWG value. 183
Figure 8-57: Settled water column turbidities (NTU). Dotted line indicates ADWG value. 183
Figure 8-58: Percentage DOC removed in pilot plant trials. 185
Figure 8-59: Box plot of MIB pilot plant data over total spike period. 187
Figure 8-60: Box plot of geosmin removal over total spike period. 188
Figure 8-61: Box plot of MIB removals over two time periods. 189
Figure 8-62: Box plot of geosmin removals over two time periods. 189
Figure 8-63: Box plots of settled water column, spikes 11 to 13. 190