CONCLUSION AND FUTURE WORK
4.1. Conclusion

4 fungal types in genus *Aspergillus* and 4 fungal species in genus *Penicillium* were identified using available references in Sri Lanka.

Fungicidal activity of natural herbal oils including cinnamon leaf oil, citronella oil and neem seed oil were studied in detail using above identified fungal types. Significant fungicidal activity was identified in the cinnamon leaf oil over the citronella oil and the neem seed oil, when introducing above oils individually. Therefore only cinnamon leaf oil was introduced into prepared brilliant white exterior emulsion paint. Effects of the cinnamon leaf oil on pH, viscosity, effect to the colour of the paint and effect to the adherence of the binder were studied and it did not alter the above properties of the paint even after aging for three years.

Cinnamon leaf oil does not show mammalian toxicity (dried cinnamon bark is used as food additive). It produces commercially in adequate amounts and the required concentration (3.5 kg of cinnamon leaf oil per 1000 kg of liquid exterior emulsion paint batch) to inhibit the growth of fungi is in cost effective range.

4.2. Future work

1. This work of study should be repeated using all types of fungi, which can grow on dried paint films, different types of paint formula and different colour of paints as a good fungicide should have a broad spectrum.

2. Outdoor exposure test should be done to determine how long cinnamon leaf oil could withstand against the effects of UV light and the effects of intermittent rain on an applied paint film keeping its fungicidal activity.
3. Cinnamon leaf oil consists of around 75 %–85 % of eugenol. Eugenol shows high antibacterial properties. Therefore same type of study can be done using cinnamon leaf as natural bactericide for water-based paints.

4. Anti microbial properties of individual components in three herbal oils should be studied in detail, since individual components might be more successful as natural biocides than raw oils (as in the case of citronella oil and neem seed oil).
REFERENCES


5. Princen L.A. emulsion technology, film forming compositions part iii, North regional research laboratory, peroria, Illinois, p.81-84.


8. Gambini R., Microbiological testing of water paint preservatives, Dow Chemicals Europe S.A.


13. Jerry Tracey, Causes and Prevention of microbial spoilage in high temperature climates, Thor chemicals International, Ramsgate Road, Margate, Kent, CT 9, 4JY, UK.


17. Industrial biocides, Thor chemicals International, Ramsgate Road, Margate, Kent, CT 9, 4JY, UK.


20. Citronella, a literature survey, compiled by Jayasinhge, P., Medicinal and aromatic plant series, No 08, Industrial Technological Institute, Colombo.


22. Upser, F.J., Methods for isolation of bio deterioration of fungi and their subsequent Identification, Department of Defence, Material research laboratories, Cordite Avenue, Maribyrnong, Victoria, 3032, Australia, Hurry, A. Biodegradation Investigation Techniques, P.3.

23. Fankhouser, D.B., Agar overlay technique, Professor of Biology and Chemistry University of Cincinnati, Clermont, Batavia OH 45103.


25. Bambarkar, S. Neem, A vast potential for agrochemicals, McDA Agro pvt Ltd, 9, Kitab Mahal, Dr. D.N. Road, Fort Bombay, 400001.


28. Rukmani, C. Chemical and nutritional evaluation of neem oil, National institute of Nutrition, Indian council of Medical research, Jamai Osmania (ppo), Hyderabad 500007, AP, India.


31. Traxler, R.W., Flannery, W.L., Mechanism of hydrocarbon degradation, department of microbiology, University of Southwestern Louisiana, Lafayette, Louisiana 70501, USA., Biodeterioration of materials, Microbial and applied aspects.
APPENDIX I

Types of bacteria grow in liquid emulsion paints

*Acinetobacter*
*Aerobacter Aerogenes*
*Bacillus megatherium*
*Bacillus ubtilis*
*Enterobacter aeroginosa*
*Escherichia coli*
*Pseudomonas aeruginosa*
*Pseudomonas fluorescens*
*Pseudomonas putida*
*Pseudomonas pyocyanea*
*Salamoneella typhimurium*
*Serratia marcescens*
*Staphylococcus sureus*
*Staphylococcus faecalis*
APPENDIX II

Types of fungi grow on dried paint films

Absidia species
Basidium species
Kloekera species
Aspergillus niger
Aspergillus Sulphureus
Aspergillus Veriscolour
Aspergillus flavus
Candida albicans
Chaelomium albicans
Chaelomium crispalum
Chaelomium globosum
Cladosporium cladosporioides
Cladosporium herbarum
Cladosporium resinae
Coriolus versicolour
Fusarium monoliforme
Fusarium oxysporum
Mucor mucedo
Mucor recomposes
Oidium lactis
Penicillium expansum
Penicillium brevicompactum
Penicillium notatum
Penicillium purpurogenum
Phoma violacea
Rhizopus nigricans
Rhodotorula rubra
Sacharomyces cerevisiae
Sprobolomyces roseus
Stachybotrys atra
Trichophyllum mentagrophytes
Tricoderma viride
Ulocladium atrum
Enumerating fungal spores using improved Neubauer haemocytometer

Structure of haemocytometer is shown in figure 10-(a). The central grid of the haemocytometer (figure 10- (c)) was divided into 25 large squares and each large square was further divided into 16 small squares. The area of the central grid is 1mm$^2$. Therefore area of the small square is equal to 4x10$^{-6}$ cm$^2$. A coverslip is placed on grids (figure 10(a)) before enumerating. Then a drop of fungal suspension is placed on the edge of the coverslip and it runs to the central grid (figure 10(b)). The number of cells lying above at least 80 small squares are now counted (figure 10 (d)) calculated the average number of spores in one small square. By using this procedure spores in a fungal suspension can be enumerated.

Figure 10. Neubauer haemocytometer