Endosulfan (1,2,3,4,7,7 hexachlorobicyclo-2,2,1-heptene-2,3-bishydroxy methane-5,6-sulfite) is a pesticide belonging to the organochlorine group of pesticides. Endosulfan is a persistent pesticide which is ubiquitously in environment mainly in soil and water. Less solubility of endosulfate makes it less bioavailable and is adsorbed to soil particles leading to its persistence. The toxicity of endosulfate may also decelerate the biodegradation of their parent compound. Many microbes are capable of utilizing endosulfan and other pesticides in an optimized laboratory condition and showed higher efficiency. However, when they are brought to field condition there was considerable reduction in their performance. One main reason attributed is lesser bioavailability and the toxicity of other organic compounds to microbes. Soil microbial community may be altered due to soil characteristics. A study addressing those limitations in the field is needed for successful bioremediation of pesticide contaminated site. Hence, the present study targets to enhance the bioavailability of soil bound endosulfan and some other pesticide residues using microbial catalysts to solublize the soil sorbed pesticide residues and thereby enhance its biodegradation.

Endosulfan degrading mixed bacterial culture capable of utilizing endosulfan as a sole carbon source and degrade 82% of \( \alpha \) and 76% of \( \beta \) endosulfan in five days was enriched form pesticide contaminated soil collected from pesticide contaminated site. Sixty bacterial strains were
isolated from this enriched mixed bacterial culture and were screened for endosulfan degradation and biosurfactant production. Among the screened isolates which degraded endosulfan, 4 isolates produced biosurfactant and were capable of solubilizing endosulfan with an emulsification index ranging from 40-50%. Among the screened isolates, 10 isolates which showed maximum endosulfan degradation were further checked for degradation of endosulfate, a major metabolite of endosulfan. ES-7, ES-33, ES-34, ES-36, ES-38, ES-45, and ES-47 utilized endosulfate and degradation of endosulfate ranged from 74-99%. These seven bacterial strains were then formulated into consortia (A to I) with three isolates in various combination of biosurfactant and non biosurfactant producers. Consortium G was formulated with non biosurfactant producing bacteria.

Among the nine consortia, B & F were able to degrade 80% and 81% of α endosulfan, 81% and 83% of β endosulfan respectively. Among the biosurfactant producing consortia, F showed faster degradation with dechlorination, and hence for the soil microcosm study consortium F was used for enhancing bioavailability and G as a representative for non-biosurfactant producing bacterial consortium.

Biodegradation of endosulfan in different layers of soil by consortium F and G were carried out by simulating the soil profile in a soil reactor to confirm the efficiency of consortium F in enhancing the bioavailability of endosulfan in soil. In all the layers, the percent degradation of endosulfan (98% both isomers) was similar. Among the different layers,
the biodegradation was comparatively slow in the bottom layer (43% \( \alpha \) and 11% \( \beta \)). Among the two consortia used, the degradation rate of endosulfan was high in the case of consortium F in all the layers of soil. Hence, for the further study the consortium F was used as the microbial catalyst. Effect of pH 8.0 on biodegradation of endosulfan I soil was also studied. At pH 7 a maximum degradation of 95% \( \alpha \) endosulfan and 91% \( \beta \) endosulfan was observed on 30\(^{th}\) day of incubation whereas at pH 8, degradation of \( \alpha \) endosulfan and \( \beta \) endosulfan was 98% and 95% respectively.

Biodegradation of endosulfan along with other commonly used pesticide chlorpyrifos and cypermethrin was studied in different layers of soil. Study revealed that the consortium was able to utilize 80 to 90% of endosulfan and chlorpyrifos in 30 days in the three layers of soil whereas percent degradation of cypermethrin was 65-90.

Bioremediation of pesticide contaminated agricultural soil was carried out to check whether the consortium F was able to utilize the soil sorbed endosulfan and other pesticide residue. Qualitative and quantitative analysis of the pesticides in surface (0-15 cm) and subsurface (15-30 cm, 30-40 cm) soil collected from Pakam Village of Thiruvallur District, Tamilnadu, India revealed the presence of pesticides like endosulfan isomers (\( \alpha \), \( \beta \)), endosulfate, alpha benzene hexachloride (BHC), gamma BHC, cyhalothrin, alpha hexachlorocyclo hexane (HCH), hexachlorocyclo benzene (HCB), op-DDE and chlordane isomers. In all the control soil layers degradation rate was less and residues of endosulfan isomers were present at
the end of 30th day in all the soil layers. Complete removal of endosulfan and other pesticides were observed in reactor inoculated with F. In the control reactor endosulfan residues were detected in all the layers however, degradation was approximately 50 to 70% in surface soil, 30-40% in subsurface and bottom soil.

16S rRNA sequence of the ES-34 and ES-36 showed 100% coverage and 99% homology with *Bordetella petrii*, ES-47 showed 100% coverage and 98% homology with *Achromobacter xylooxidans*. Even though the strain ES-34 and ES-36 showed close homology with *Bordetella petrii* multiple sequence alignment, and DNA Finger printing by BOX & ERIC PCR of the Genomic DNA of isolates revealed that ES-34 and ES-36 are similar strains with type variation.

Survival of introduced bacterial strains during various biodegradation studies in soil is confirmed by quantification of DNA extracted from soil, DGGE, specific primer based PCR amplification of the DNA extracted from soil and its detection by agarose gel electrophoresis. The study revealed that biosurfactant producing bacterial consortium was able to enhance the bioavailability of pesticides in soil with simultaneous biodegradation. From the study, it can be concluded that bioaugumentation of pesticide contaminated soil with biosurfactant producing bacterial strains capable of surviving in subsurface soil environment can enhance the bioremediation process.