List of Tables

Chapter I

Table 1.1 Species specificity of tri-organotin compounds.
Table-1.2 Marked Tributyltin effected areas in the world
Table 1.3 Chemical characteristics of organotin compounds.
Table 1.4 Internal fate (accumulation and excretion) of tributyltin compounds in various organisms.
Table 1.5 Tributyltin resistant bacteria and their TBTC tolerance limits

Chapter III

Table 3.1 Physico-chemical characteristics of environmental (water & sediment) samples.
Table- 3.2 Total viable count of bacteria in environmental (water and sediment) samples.
Table 3.3 Screening of organotin tolerant marine bacterial isolates.
Table- 3.4 Morphological and biochemical characteristics of organotin tolerant marine bacterial isolate.
Table 3.5 Most Heavy Metal Polluted Sites in India.
Table-3.6 LD_{50} values of TBTC tolerant bacterial isolates to different heavy metals.
Table 3.7 Antibiotic resistance of all organotin tolerant bacterial isolates.

Chapter IV

Table 4.1 Chemical analysis of EPS produced by Alcaligenes sp. 2-6 in ZMB and MSM supplemented with 1 mM, 2 mM and 5 mM TBTC.
LIST OF FIGURES

CHAPTER I

Fig. 1.1  Marine fouling on ship surfaces without TBTC coating.
Fig. 1.2  Removal of TBT coated paint in seawater due to hydrolysis.
Fig. 1.3  Female dogwhelk (*Nucella lapillus*) showing severe imposex stage.
Fig. 1.4  Structural formulas of major tributyltin compounds.
Fig. 1.5  Major Applications of organotin compounds.
Fig. 1.6  Fate of organotin compounds in the environment.
Fig. 1.7  Heterolytic cleavage of organotins.
Fig. 1.8  Biological degradation of organotins.
Fig. 1.9  A model for the biogeochemical cycling of organotins in the marine environment.

CHAPTER III

Fig. 3.1  Geographical location of sampling sites.
Fig. 3.2  Growth of TBTC resistant bacterial isolates on zobell marine agar.
Fig. 3.3  Phase contrast and Scanning electron (Isolate S3) microscopic view of organotin tolerant marine bacterial isolates S1, S2, S3, Sd and Sp.
Fig. 3.4  Taxonomic phenogram of highly potent Tributyltin chloride resistant marine bacterial isolates S3 and Sd.
Fig. 3.5  TBTC tolerance limits of all marine bacterial isolates
Fig. 3.6  Temperature optima for the growth of TBTC tolerant marine bacterial isolates.
Fig. 3.7  Comparative growth of all TBTC tolerant marine bacterial isolates at 28°C.
Fig. 3.8  pH optima for the growth of TBTC tolerant marine bacterial isolates.
Fig. 3.9  Comparative growth of all TBTC tolerant marine bacterial isolates at different pH.
Fig. 3.26  Growth behaviour of *Alcaligenes* sp. swo (strain Sd) in NB with varying concentrations of TBTC.

Fig. 3.27  Growth behaviour of *Alcaligenes* sp. swo (strain Sd) in MSM with varying concentrations of TBTC.

Fig. 3.28  Growth behaviour of *Pseudomonas fluorescens* (strain Sp) in ZMB with varying concentrations of TBTC.

Fig. 3.29  Growth behaviour of *Pseudomonas fluorescens* (strain Sp) in LB with varying concentrations of TBTC.

Fig. 3.30  Growth behaviour of *Pseudomonas fluorescens* (strain Sp) in NB with varying concentrations of TBTC.

Fig. 3.31  Growth behaviour of *Pseudomonas fluorescens* (strain Sp) in MSM with varying concentrations of TBTC.

Fig. 3.32  Percent survival of *Flavobacterium balustinum* (strain S1) in selected heavy metals (Hg, Cd and As).

Fig. 3.33  Percent survival of *Vibrio harveyi* (strain S2) in selected heavy metals (Hg, Cd and As).

Fig. 3.34  Percent survival of *Alcaligenes* sp. 2-6 (strain S3) in selected heavy metals (Hg, Cd and As).

Fig. 3.35  Percent survival of *Alcaligenes* sp. swo (strain Sd) in selected heavy metals (Hg, Cd and As).

Fig. 3.36  Percent survival of *Pseudomonas fluorescens* (strain Sp) in selected heavy metals (Hg, Cd and As).

**CHAPTER IV**

Fig. 4.1  Growth behaviour of *Alcaligenes* sp.2-6 in MSM with 3% glucose and varying concentrations of TBTC.

Fig. 4.2  Growth (Total Protein content) of *Alcaligenes* sp.2-6 in MSM with 3% glucose and varying concentrations of TBTC.

Fig. 4.3  Growth behaviour of *Alcaligenes* sp.2-6 in MSM with 2.5% glycerol and varying concentrations of TBTC.

Fig. 4.4  Growth (Total Protein content) of *Alcaligenes* sp.2-6 in MSM with 2.5% glycerol and varying concentrations of TBTC.

Fig. 4.5  Growth behaviour of *Alcaligenes* sp.2-6 in MSM with 2%
Fig. 3.10 Salinity optima for the growth of TBTC tolerant marine bacterial isolates.

Fig. 3.11 Comparative growth of all TBTC tolerant marine bacterial isolates different salinity.

Fig. 3.12 Growth behaviour of *Flavobacterium balustinum* (strain S1) in ZMB with varying concentrations of TBTC.

Fig. 3.13 Growth behaviour of *Flavobacterium balustinum* (strain S1) in NB with varying concentrations of TBTC.

Fig. 3.14 Growth behaviour of *Flavobacterium balustinum* (strain S1) in LB with varying concentrations of TBTC.

Fig. 3.15 Growth behaviour of *Flavobacterium balustinum* (strain S1) in MSM with varying concentrations of TBTC.

Fig. 3.16 Growth behaviour of *Vibrio harveyi* (strain S2) in ZMB with varying concentrations of TBTC.

Fig. 3.17 Growth behaviour of *Vibrio harveyi* (strain S2) in LB with varying concentrations of TBTC.

Fig. 3.18 Growth behaviour of *Vibrio harveyi* (strain S2) in NB with varying concentrations of TBTC.

Fig. 3.19 Growth behaviour of *Vibrio harveyi* (strain S2) in MSM with varying concentrations of TBTC.

Fig. 3.20 Growth behaviour of *Alcaligenes* sp. 2-6 (strain S3) in ZMB with varying concentrations of TBTC.

Fig. 3.21 Growth behaviour of *Alcaligenes* sp. 2-6 (strain S3) in LB with varying concentrations of TBTC.

Fig. 3.22 Growth behaviour of *Alcaligenes* sp. 2-6 (strain S3) in NB with varying concentrations of TBTC.

Fig. 3.23 Growth behaviour of *Alcaligenes* sp. 2-6 (strain S3) in MSM with varying concentrations of TBTC.

Fig. 3.24 Growth behaviour of *Alcaligenes* sp. swo (strain Sd) in ZMB with varying concentrations of TBTC.

Fig. 3.25 Growth behaviour of *Alcaligenes* sp. swo (strain Sd) in LB with varying concentrations of TBTC.
succinate and varying concentrations of TBTC.

Fig. 4.6 Growth (Total Protein content) of *Alcaligenes* sp.2-6 in MSM with 2% succinate and varying concentrations of TBTC.

Fig. 4.7 Growth behaviour of *Alcaligenes* sp.2-6 in MSM with 0.07% ethanol and varying concentrations of TBTC.

Fig. 4.8 Growth (Total Protein content) of *Alcaligenes* sp.2-6 in MSM with 0.07% ethanol and varying concentrations of TBTC.

Fig. 4.9 Growth behaviour of *Alcaligenes* sp.2-6 in MSM with 0.07% ethanol, 0.07% ethanol + 5 mM TBTC and 5 mM TBTC (Crude).

Fig. 4.10 TBTC utilization and growth by *Alcaligenes* sp.2-6, *Pseudomonas aeruginosa* PAO1 and *Pseudomonas aeruginosa* USS25W in MSM.

Fig. 4.11 Effect of thiol (B-mercapto ethanol) and chelating agent (EDTA-Na$_2$) on amelioration of TBT toxicity to *Alcaligenes* sp.2-6.

Fig. 4.12 Effect of thiol and EDTA-Na$_2$ on TBTC toxicity of *Alcaligenes* sp.2-6 in MSM.

Fig. 4.13 Growth and EPS production by *Alcaligenes* sp.2-6 in ZMB.

Fig. 4.14 Growth and EPS production by *Alcaligenes* sp.2-6 in ZMB+1 mM TBTC.

Fig. 4.15 Growth and EPS production by *Alcaligenes* sp.2-6 in ZMB+2 mM TBTC.

Fig. 4.16 Growth and EPS production by *Alcaligenes* sp.2-6 in ZMB+5 mM TBTC.

Fig. 4.17 Growth and EPS production by *Alcaligenes* sp.2-6 in MSM+1 mM TBTC.

Fig. 4.18 Growth and EPS production by *Alcaligenes* sp.2-6 in MSM+2 mM TBTC.

Fig. 4.19 Growth and EPS production by *Alcaligenes* sp.2-6 in MSM+5 mM TBTC.

Fig. 4.20 EPS produced by *Alcaligenes* sp.2-6 in ZMB with varying concentrations of TBTC at 48 hrs of incubation.

Fig. 4.21 EPS produced by *Alcaligenes* sp.2-6 in MSM with varying concentrations of TBTC at 48 hrs of incubation.
Fig. 4.22  EPS produced by *Alcaligenes* sp.2-6 in ZMB with varying concentrations of TBTC at 96 hrs of incubation.

Fig. 4.23  FTIR scan of EPS produced by *Alcaligenes* sp. 2-6 in ZMB.

Fig. 4.24  FTIR scan of EPS produced by *Alcaligenes* sp. 2-6 in MSM+5 mM TBTC.

Fig. 4.25  Spectrophotometric scan of pigment produced by *Alcaligenes* sp.2-6 grown in ZMB with out TBTC.

Fig. 4.26  Spectrophotometric scan of pigment produced by *Alcaligenes* sp.2-6 grown in MSM with 1 mM, 2 mM and 5 mM TBTC.

Fig. 4.27  Spectrofluorimetric scan of pigment produced by *Alcaligenes* sp.2-6 grown in MSM with 5 mM TBTC.

Fig. 4.28  Spectrophotometric scan of chloroform extract of cell pellet of *Alcaligenes* sp. 2-6 obtained after 0, 24, 48 and 72 hrs of incubation.

Fig. 4.29  Spectrophotometric scan of chloroform extract of cell pellet of *Alcaligenes* sp. 2-6 obtained after 4 days, 1, 2 and 3 weeks of incubation.

Fig. 4.30  Spectrophotometric scan of chloroform extract of cell pellet of *Alcaligenes* sp.2-6 grown in MSM+5mM TBTC after 1, 2 and 3 weeks.

Fig. 4.31  Spectrophotometric scan of chloroform extract of cell pellet of *Alcaligenes* sp.2-6 grown in MSM+5mM TBTC after 45 days of incubation.

Fig. 4.32  Spectrophotometric scan of chloroform extract of cell pellet of *Alcaligenes* sp.2-6 grown in MSM+7mM DBT after 4, 6 and 9 days.

Fig. 4.33  TBTC degradation profile of *Alcaligenes* sp.2-6 after 21 and 45 days of incubation.

Fig. 4.34  TBTC degradation profile of *Alcaligenes* sp.2-6 after 45 days of incubation.

Fig. 4.35  DBT degradation profile of *Alcaligenes* sp.2-6 after 6 and 9 days of incubation.

Fig. 4.36  Growth (Total Protein content) of *Alcaligenes* sp.2-6 in ZMB with varying concentrations of TBTC.

Fig. 4.37  Growth (Total Protein content) of *Alcaligenes* sp.2-6 in MSM with varying concentrations of TBTC.
Fig. 4.38  Growth (Total Protein content) of *Alcaligenes* sp.2-6 in ZMB with varying concentrations of DBT.

Fig. 4.39  Growth (Total Protein content) of *Alcaligenes* sp.2-6 in MSM with varying concentrations of DBT.

Fig. 4.40  Protein profile (SDS-PAGE) of *Alcaligenes* sp. 2-6 grown in ZMB, MSM with 2 mM, 5 mM TBTC and 5 mM , 7 mM DBT respectively.

**CHAPTER V**

Fig. 5.1  Plasmid profile of *Alcaligenes* sp. 2-6.

Fig. 5.2  Restriction mapping and Agarose gel electrophoresis of Plasmid DNA of *Alcaligenes* sp. 2-6.

Fig-5.3  Percent survival of *Alcaligenes* sp.2-6 in acridine orange.

Fig. 5.4  Acridine orange curing of plasmid DNA of *Alcaligenes* sp. 2-6.

Fig. 5.5  PCR analysis of genomic DNA to find our tbtB gene.