EXECUTIVE SUMMARY

The project on Marine Ecotoxicology studies aim to determine the safe limits of chemicals like Copper, Cadmium and Mercury and High Speed diesel oil for Coastal waters of Chennai and Pulicat lake. The laboratory toxicity tests were conducted under continuous flow through method. The Median Lethal Concentration (LC_{50}) and chronic toxicity values were used to derive the safe limits expressed in the form of water quality criteria. LC_{50} value was determined after 96 hrs of exposure and chronic effects were determined based on long term continuous exposure on pre-determined concentrations. A review of literature concerning toxicity studies has been made on marine organisms such as phytoplankton (including diatoms), zooplankton, shrimps, molluscs and fin-fishes exposed to Cadmium, Copper, Lead, Mercury, Zinc and petroleum hydrocarbons were described.

Adoption of Water Quality Criteria based on Ecotoxicoloical studies is widely practiced in other countries. The Water Quality Criteria prescribed by United States Environmental Protection Agency (USEPA), Australian and New Zealand Environment and Conservation Council (ANZECC) and European Economic Commission are based on ecotoxicity data on a limited to wide range of organisms. The USEPA National recommended Water Quality Criteria for Copper, Lead, Mercury and Cadmium are based on acute (4.8, 210, 1.8 and 42.0 μg/L) and chronic effects (3.1, 8.1, 0.94 and 9.3 μg/L), respectively. The ANZECC have formulated trigger values (i.e.a list of indicator values in the form of numerical concentration limits recommended to support or maintain a designated water use) derived from short-term acute toxicity data (from tests $\leq$ 96 h duration) by applying acute-chronic conversion factors and the trigger values are 1.3, 4.4, 0.4, 5.5 and 1-100 mg/l for Copper, Lead, Mercury, Cadmium, and diesel oil, respectively for 95% level of protection. European Commission have prescribed water quality standards for ecosystem which include coastal waters, estuaries and the safe limits for Copper, Lead, Mercury and Cadmium are 5.0, 25.0, 0.3 and 2.5 μg/L respectively. The Government of India, Ministry of Environment & Forests has prescribed Water quality Standards for different uses of coastal waters in the form of Primary Water Quality Criteria for Seawater specified to determine its suitability for a particular purpose.

The present ecotoxicological programme of ICMAM Project Directorate, Ministry of Earth Sciences (MoES), have used one of the mostly accepted technique of Continuous Flow through system which simulates near natural conditions for marine organisms exposed to various toxicants and derived the Sea water quality criteria.

The results of acute toxicity studies under continuous flow through method using marine organisms like tiger prawn (*Peneaus monodon*), green mussel (*Perna viridis)*, the fin fishes, crescent perch (*Therapon jarbua)* and striped mullet (*Mugil cephalus)* indicated that all the species were more sensitive to Mercury than Copper and Cadmium. It is evident that acute response of the marine organisms to toxicants may be the size as well as species specific. The chronic value of mercury exposed to the larval stages (Post larvae) of tiger prawn of *P. monodon* was 7.2 μg/l and the fish fingerlings of *T. jarbua*, *M. cephalus* and green mussel *P. virids* were 31.26, 33.8 and 11.36 μg/l respectively. However, the chronic effects of copper on the green mussel and fingerlings of *T.jarbua*, *M.cephalus,* post larvae of tiger prawn *P. monodon* and green mussel *P.virids* were found to be 479.8 567.3, 107.3 17.7 and μg/l respectively. The chronic effects of cadmium for the above species were found to be 229.5, 243.0, 145.2 and 231.2 μg/l respectively.

Further, the sea water quality criteria adopted by USEPA contain two expressions of allowable magnitude: a CMC to protect against acute (short-term) effects, which is an estimate of the highest concentration of a chemical exposed to marine organisms briefly without causing unacceptable effects and a CCC to protect against Chronic (long-term effects) i.e. an estimate of the highest concentration of a chemical exposed to marine organisms indefinitely without causing unacceptable effects. USEPA guidelines suggested the method for deriving SWQC for chronic effects which require a Final Chronic Value (FCV) i.e. a calculated estimate of the concentration of a test chemical such that 95% of the species (with which acceptable chronic toxicity tests have been conducted on the chemical) have higher Species Mean Chronic Values (SMCV); or the SMCV of an important and/or critical species, if the SMCV is lower than the calculated estimate.

The methodology involve calculation of Species Mean Acute (SMAV) value by considering the mean of the acute values of 3 repetitive flow through tests of each species

viz. 6 different species (for diatoms, copepod - static renewal tests used- green mussel, prawn, and fish fingerlings) and order them from high to low. A set of ranks ® was assigned to the SMAVs from `1' for the lowest to `N' for the highest. The cumulative probability, `P' for each SMAV was calculated as R/ (N + 1). Using the formula, the data on selected SMAVs, the FAVs were calculated for the individual toxicants viz., cadmium, copper and mercury. However by adopting the USEPA guidelines the Final Acute value (FAV) for Cu^{++} Hg^{++} and Cd^{++} were found to be 15.6, 0.96, 35.8 μg/l respectively.

The methodology for deriving Criterion Continuous Concentration (CCC) involve the data from the acute and chronic value of each species, the acute-chronic ratio was calculated. The acute-chronic ratio is basically the inverse of application factor and it was derived by dividing the geometric mean of all acceptable flow through acute tests by the chronic value from the tests conducted under identical conditions. The acute and chronic values for 4 species were used to derive Species Mean Acute-Chronic Ratio (SMACR). From each SMACR the geometric mean of all species was calculated and the resulting value of Final Acute-Chronic ratio (FACR) was derived. The Criterion Continuous Concentration (CCC) is more relevant since it refers to the environment rather than the Criterion Maximum Concentration (CMC) which refers to the toxicity of effluent (i.e. the chemicals), hence the CCC was considered as the Sea Water Quality Criteria and the calculated values of CCC for Cu^{++} Hg^{++} and Cd^{++}, were found to be 3.03, 0.18, 2.49 μg/l respectively. Based on the above CCC, the following Sea water Quality Criteria for Copper, Mercury and Cadmium has been suggested for SW I (Ecologically Sensitive Areas). SW II (Bathing, Contact water sports and Commercial fishing) and SW III (Industrial cooling, recreation and aesthetics) classification of Primary Water Quality Criteria for coastal uses after adding the background concentartion.

Metal	**Calculated CCC values (μg/l)**	**Background concentration of metals at Ennore (from 2003-07 data)**	**CCC values (μg/l) proposed for SW I, II & SW III (after adding background concentration of the metals)**
Copper	3.03	6.0 – 13.0	16.03
Mercury	0.18	0.9 – 2.8	2.98
Cadmium	2.49	1.6 – 7.3	9.79