# Table of Contents

1. Introduction 1
   1.1 Introduction 1
   1.2 Oceanic Nitrogen Cycle 4
   1.3 Significance of Nitrogen Biogeochemical Cycling in Arabian Sea 7
   1.4 Previous Work 9
   1.5 Nitrous Oxide cycling 14
   1.6 Geographical Setting 15
   1.7 Climate 17
   1.8 Importance, Objectives and Scope of the Study 18

2. Materials and Methods 22
   2.1 Introduction 22
   2.2 Field Observations 22
      2.2.1 Oceanic Expeditions 22
      2.2.2 Coastal Expeditions Off Goa 23
      2.2.3 Field (Benthic chamber) experiment 23
   2.3 Laboratory (Incubation) Experiments 23
   2.4 Methodology 24
      2.4.1 Experimental
         2.4.1.1 Sampling and Analysis 24
         2.4.1.2 Dissolved oxygen 25
         2.4.1.3 Nutrients 26
            2.4.1.3.1 Nitrite and Nitrate 26
            2.4.1.3.2 Ammonia (NH$_4^+$ + NH$_3$) 27
            2.4.1.3.3 Phosphate 27
         2.4.1.4 Hydrogen sulphide 27
         2.4.1.5 Nitrous oxide 28
         2.4.1.6 Primary Production 29
         2.4.1.7 Chlorophyll $a$ 29
         2.4.1.8 Isotopic Analysis 29
      2.4.2 Computations
         2.4.2.1. Potential Temperature ($\theta$) and Density ($\sigma_0$) 31
         2.4.2.2. Nitrous Oxide Data Processing 31
         2.4.2.3. Air-Sea fluxes of N$_2$O 31
         2.4.2.4 Sedimentary denitrification rates 32

3. Salient features of hydrography 33
   3.1 Upper-Ocean Circulation 33
   3.2 Water Masses 38
### 4. Evolution and Effects of Oxygen-Deficiency Over the West Indian shelf

- **4.1 Introduction**
- **4.2 Significance**
- **4.3 Observations**
- **4.4 Property Distributions along Cross-Shelf Sections**
  - 4.4.1 Off Quilon
  - 4.4.2 Off Cannanore
  - 4.4.3 Off Mangalore
  - 4.4.4 Off Karwar
  - 4.4.5 Off Goa
  - 4.4.6 Off Ratnagiri
  - 4.4.7 Off Mumbai
  - 4.4.8 Cross-Shelf Sections: Summary
- **4.5 Quasi-Time-Series Measurements**
  - 4.5.1 Temperature (Fig. 4.8)
  - 4.5.2 Salinity (Fig. 4.9)
  - 4.5.3 Oxygen (Fig. 4.10)
  - 4.5.4 Hydrogen Sulphide (Fig. 4.11)
  - 4.5.5 Chlorophyll (Fig. 4.12)
- **4.6 Climatology of Oceanographic Variables**
- **4.7 Primary Production**
- **4.8 Pelagic Denitrification Rate over the Shelf**
- **4.9 N₂O Emission to the Atmosphere**
- **4.10 Discussion**
  - 4.10.1 Shallow-Suboxic Zone — Natural Versus Anthropogenic Origin
  - 4.10.2 Cause of Anomalous N₂O Accumulation

### 5. Stoichiometric Relationships and Nitrogen Isotopic Abundance

- **5.1 Introduction**
- **5.2 Pathways of Oxidation of Organic Matter**
  - 5.2.1 Aerobic Respiration
  - 5.2.2 Denitrification
  - 5.2.3 Sulphate Reduction
- **5.3 Significance of the Study**
- **5.4 Methodology**
- **5.5 Results**
- **5.6 Discussion**
- **5.7 Implications for Biogeochemical Cycles**
- **5.8 Isotopic Composition of Nitrate**