CONTENTS

LIST OF PUBLICATIONS
LIST OF CONFERENCES
LIST OF TABLES
LIST OF FIGURES
LIST OF PLATES

1. INTRODUCTION    1 - 12
1.1 FLUORIDE IN THE ENVIRONMENT   
   1.1.1 Fluoride in minerals and rocks 1
   1.1.2 Fluoride in soil 2
   1.1.3 Fluoride in vegetation 3
   1.1.4 Fluoride in water 4
   1.1.5 Other pathways 5
1.2 FLUORIDE CHEMISTRY 6
1.3 SCENARIO OF FLUORIDE IN WATER: INDIAN CONTEXT 7
1.4 ALLOWABLE FLUORIDE CONCENTRATIONS IN POTABLE WATER 7
1.5 FLUORIDE RELATED HEALTH EFFECTS: BENEFITS AND RISKS 7
1.6 DEFLUORIDATION TECHNOLOGIES 9
   1.6.1 Defluoridation technologies practised in India 9
1.7 AIMS AND SCOPE OF STUDY 10

2. LITERATURE REVIEW 13 - 32
2.1 SOIL: A COMPLEX ENTITY 13
   2.1.1 Soil Components 13
   2.1.2 Soil Taxonomy 15
   2.1.3 Soils of India 16
2.2 CLAYS: STRUCTURE, CHEMISTRY, CLASSIFICATION AND USES 16
   2.2.2a Kaolinite 18
   2.2.2b Montmorillonite 19
   2.2.2c Illite (Non - expanding smectite) 20
2.3 SORPTION: A HALLMARK IN SOIL RESEARCH 21
2.4 FLUORIDE SORPTION MECHANISM BY SOIL 22
2.5 COLLOIDAL PROPERTIES OF CLAY 23
   2.5.1 Clay water interactions 23
   2.5.2 Nature of acid clays 25
2.6 FLUORIDE ADSORPTION: A REVIEW 26
3. METHODS

3.1 DESCRIPTION OF SAMPLING SITE
3.2 SAMPLE COLLECTION
  3.2.1 Soil of Agra
  3.2.2 Clay minerals
3.3 PRELIMINARY TREATMENT
  3.3.1 Soil of Agra
  3.3.2 Dayalbagh soil
  3.3.3 Clay minerals
  3.3.4 Chemical amendment of silty clay
3.4 PHYSICOCHEMICAL ANALYSIS
  3.4.1 Soil of Agra
  3.4.1a pH
  3.4.1b Soil texture
  3.4.1c Organic carbon
  3.4.1d Electrical conductivity
  3.4.1e Cation exchange capacity
  3.4.1f Soluble ions
  3.4.1g Exchangeable cations
  3.4.1h Surface area
  3.4.2 Clay Minerals
    3.4.2a Montmorillonite (H\(^+\) form)
    3.4.2b Kaolin
    3.4.2c Montmorillonite (Na\(^+\) form)
3.5 SORPTION STUDIES
3.6 ANALYSIS
  3.6.1 Fluoride ion selective electrode
    3.6.1a Theory of operation
    3.6.1b Interference in fluoride analysis
    3.6.1c Measurement
  3.6.2 Atomic absorption spectroscopy
  3.6.3 Molecular absorption spectroscopy
    3.6.3a Aluminium: Eriochrome Cyanine R method
    3.6.3b Silica: Molybdosilicate method
  3.6.4 X - Ray Diffraction (XRD)
    3.6.4a Principle
    3.6.4b Preparation of clay samples for XRD
  3.6.5 Scanning electron microscopy
    3.6.5a Principle
    3.6.5b Clay preparation for SEM
3.7 STATISTICAL ANALYSIS OF DATA
  3.7.1 Correlation
3.7.1a Coefficient of determination ($r^2$) 47
3.7.1b Coefficient of correlation ($r$) 47
3.7.2 Regression 47

4. RESULTS AND DISCUSSION 49 - 69
4.1 GENERAL CONSIDERATION FOR THE CHOICE OF TISAB IN ESTIMATIONS BY ION SELECTIVE ELECTRODE (ISE) 49
4.2 PHYSICO-CHEMICAL ANALYSIS OF SOILS OFagra 52
4.3 SORPTION STUDIES 53
   4.3.1 Composite soil of Agra 53
   4.3.2 Dayalbagh soil 54
      (I) Composite soil 54
   4.3.2 (a) X-Ray Diffraction studies 54
   4.3.2 (b) Sorption studies 54
   4.3.2 (c) Morphology 57
      (II) Soil fractions 57
   4.3.3 Montmorillonite (H+ form) 59
   4.3.3 (a) X-Ray Diffraction studies 59
      (I) At pH ≈ 2 59
      (II) At pH ≈ 4 59
      (III) At pH ≈ 10 60
   4.3.3 (b) Sorption studies 60
   4.3.3 (c) Morphology 62
   4.3.4 Kaolin 63
   4.3.4 (a) X-Ray Diffraction studies 63
   4.3.4 (b) Sorption studies 63
   4.3.4 (c) Morphology 64
   4.3.5 Montmorillonite (Na+ form) 65
   4.3.5 (a) X-Ray Diffraction studies 65
   4.3.5 (b) Sorption studies 65
   4.3.5 (c) Morphology 65
   4.3.6 Chemically amended silty clay fraction 66

5. CONCLUSIONS 70 - 72
REFERENCES i - xvi