# Chapter 6

# Concluding remarks and future directions

## 6.1 Thesis conclusions

Significant findings of the thesis can be summarized as follows.

(a) An efficient photodegradation process was obtained in chapter 3. The details involving the synthesis of DT800 and DT500, characterization and analyses of their physical properties using various investigative instruments and techniques, finally performing photodegradation observations using dyes have been reported in this chapter. The innovative use of diatoms and $TiO_2$ nanostructures for these processes is explained. DT800 is shown to be the best candidate for photodegradation compared to DT500, $DTiO_2$ and diatom frustules. Thus, it has been shown that diatom frustules acting as templates are capable of utilizing a broad range of solar radiation from visible to UV light for very efficient photodegradation processes in combination with proper photocatalysts.

(b) In chapter 4, a simple and highly effective photo-induced bio-reduction process of Ag-NPs incorporated in diatom cells at room temperature under basic conditions was presented. The interaction of diatoms with aqueous salt $AgNO_3$ promoted the formation of NPs in the presence of light. No other external reducing/stabilizing agents are used in this method, only fucoxanthin present in the diatom cells, independent of diatom species, is responsible for the bio-reduction of Ag-NPs in the presence of day light. Presence of protein components in the diatom cells which act as stabilizing agent for Ag-NPs, is revealed by FTIR analysis. This green bio-synthesis of NPs using diatom cells is eco-friendly, worthwhile, energy efficient, harmless to human health, effective, low-cost and has benefits since it leads to large-scale production of NPs easily. Further these biologically synthesized metal NPs show efficient sensing behavior of dissolved ammonia in the 0-100ppm range at ambient temperature.

(c) In chapter 5, interesting properties of diatom frustules were found when incorporated with arsenic compound. Distinct changes were observed in arsenic treated diatom frustules when compared to untreated frustules. EDS analysis confirmed the presence of arsenic in the diatom frustules with 95% silica and 0.33% arsenic. Also change in optical BG from 3.1eV for untreated to 3.5eV for arsenic treated diatom frustules was observed. All these analyses show distinct and different characteristics of diatom frustules when they are treated with arsenic compounds. It can be concluded that diatoms can be used to detect arsenic in water bodies.

## 6.2 Future directions

The work done in this thesis can be extended in many ways. We shall highlight some of the points where these work may lead to,

(a) The as-prepared samples namely DT800 and DT500 could be used as a photocatalyst to control dye pollution in waste water. The photocatalytic behaviour of these materials could be further investigated for several other organic and inorganic dyes.

(b) The green synthesis process, as discussed in this work, could be extended for the synthesis of other NPs like Gold and other important metal NPs etc.

(c) The as-synthesized SND material could be used in sensing of dissolved ammonia using proper technique.

(d) Diatoms could be an efficient material for the detection of arsenic in water bodies.

(e) Semiconductors other than $TiO_2$ could be incorporated in diatom frustules templates to study photocatalytic process.