CHAPTER 1

Introduction

The rapid increase in anthropogenic activity and industrial development along the coastal region has resulted in elevated concentration of toxic agents in the environment, affecting the health of marine ecosystem (Sarkar et al., 2014). Of all the ecosystems, estuarine and coastal regions are greatly affected by high degree of contaminations from various sources and are considered as the primary sink for pollutants. Pollutants may accumulate through point sources like a single sewage pipe or factory wastewater outfall, or it can arise from a variety of geographic points otherwise called as non-point sources (river runoff, agriculture, livestock, urban runoff, automobiles, to name a few). Pollutants entering into the oceans are mostly diluted; however, the organisms living in the oceans tend to concentrate the pollutants into their body by various mechanisms, like adsorption, absorption, ingestion etc. Residues of the pollutants (both organic and inorganic) contaminate the coastal seas and accumulate in the body compartments of marine organisms. Concentration of these toxic residues magnifies at the higher trophic level through food chain (biomagnification) and hence express their toxicity at all trophic levels. Usually the pollutants exceeding threshold limits combined with environmental variables such as temperature, salinity, pH, dissolved oxygen, hydrogen sulphide etc. give stress to the organisms living in these environment.

Some of the major contaminants prevalent in the sea are persistent organochlorine (OC) pesticides (DDTs, HCHs, aldrin dieldrin, endrin), polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), planar halogenated aromatic hydrocarbons (PHAHs), and toxic elements such as lead (Pb), mercury (Hg), cadmium (Cd) and arsenic (As). Many of these pollutants are chemical carcinogens and mutagens with the capacity to cause various types of DNA damage. Benzo(a)pyrene, a representative PAH is reported to be converted at cellular level to chemically reactive oxygen species, diol-epoxide (BaPDE) which can form stable adduct with DNA resulting into DNA strand breaks (Pisoni et al., 2004). Benzo[k]fluoranthene is another PAH, that is listed in pollutant list (US EPA, 2009) by United States Environmental Protection Agency (US EPA). It is
also among the several PAHs which are possibly carcinogenic to humans (IARC, 2015). PAHs and their metabolites interact with DNA and form DNA adducts. PAH activation process also generates reactive oxygen species (ROS) that can induce genotoxic damage by modifying integrity of DNA (Gauthier et al., 2014). The occurrence of single strand breaks can be induced in various ways such as chemical induction during excision repair, interaction with DNA-intercalating agents, degradation due to autolysis or disruption, formation of alkali labile sites, interstrand cross links, DNA-protein cross (DPC) links. Moreover, significant DNA damage can occur due to interaction of alkylating agents with DNA at multiple sites.

Aquatic ecosystem is an important source for food for human and it plays an essential role in human health. Consumption of aquatic organism exposed to toxicants can cause health risk to human. Gastropods are an important source of food for many fishes and birds and play a very important role in aquatic food chain. They have limited ability to metabolize xenobiotics and thus are prone to accumulate high concentrations of hydrocarbons (Zheng et al., 2012). In recent years gastropods have received great attention from ecotoxicologists, thanks to the discovery of imposex. As regards the study region is concerned, Goa is one of the most famous tourism destination in the world situated on the west coast of India with a flourishing hotel industry supported by the rich catches of prawns, fishes, crabs, clams and snails etc. Along with increased number of industrial units, shipping, mining and tourism activities keep the living organisms in the coastal region under constant stress. Several investigations have reported that the trace metals in the marine environment can cause serious damage to physiological status of various species of marine organisms at the molecular level with long-term effects on entire communities (Desai et al., 2010; Sarkar et al., 2011).

Biomonitoring of marine organisms has become necessary to study the effect of these toxic pollutants on the marine environment. In order to assess the impact of environmental stress on the health of the marine environment, the quality and the status of marine life especially in coastal areas, it is of urgent necessity to look for reliable tools to express the effects of anthropogenic activities on biological systems. The condition of environmental health of a marine ecosystem cannot always be diagnosed by only chemical analysis of the water, as it does not provide any information in regard to the physiological status
of the organisms exposed to marine pollutants. It only indicates that there might be some undesirable biological effects which may be of great concern, and therefore, studies of biological effects will give us a better understanding of the potential impact on ecosystems.

In this context, biomarkers play a significant role by measuring the biological response of living organisms in response to their exposure to variety of pollutants. They are an important tool to detect exposure and adverse effects of anthropogenic or natural contaminants on aquatic organisms. Some biomarkers are specific to chemicals or group of chemicals while other are non-specific and induces upon exposure to broad range of pollutants. Thus the impact of these pollutants on the health of the marine organisms can be observed by the detection of DNA damage using Comet assay (Singh et al., 1988), inhibition of acetyl cholinesterase (AChE) activity (Sarkar et al., 2006), Glutathione S-transferase (GST) activity (Habig et al., 1974), Catalase activity (Sinha, 1972), and lipid peroxidation (LPO) (Desai et al., 2010). In view of complexity of contaminants, the use of multi-biomarker has become an increasingly popular tool to study the environmental impact assessment in terms of causative effects on organism health. Combinations of biomarkers yield a complicated and vast amount of data which is hard to interpret. In the recent years there has been many reports on application of integrated biomarker response (IBR) in clams (Tankoua et al., 2013; Barda et al., 2014), mussels (Pain-Devin et al., 2014; Turja et al., 2014), fishes (Xie et al., 2014; Zheng et al., 2014), and crabs (Ben-Khedher et al., 2013; Rodrigues et al., 2014).

In view of the continuing problem of environmental contamination by various types of toxic pollutants, it has become an urgent need of the hour to assess the state of pollution of the coastal environment and the ecotoxicological impact on the health of the marine ecosystem. For our study we have selected three species of gastropods i.e. *Nerita chamaeleon*, *Planaxis sulcatus* and *Morula granulata*. These three gastropod species were selected because (i) they are widely distributed along the Goa coast and can be found throughout the year (ii) they can be easily collected from the intertidal rocks scattered along the coast, (iii) they are easy to culture and laboratory studies can be easily conducted, (iv) they reflect changes in pollution status of marine environment, (v) they have been widely used as a sentinel species for ecotoxicological studies, (vi) they represent
diverse feeding behavior (P. sulcatus and N. chamaeleon are herbivore, and M. granulata is a carnivore), (vii) these three species are diverse in their habitat (P. sulcatus is mostly found exposed in the rocks, N. chamaeleon is commonly observed in rocks submerged in water, whereas M. granulata is seen in oyster beds)

The objectives of this study are as follows:

1. To identify the hot spot of pollution along the coastal region of Goa
2. To identify the sentinel species of marine gastropods for marine pollution studies;
3. To assess the impact of genotoxicants on the integrity of DNA in marine gastropods as a biomarker of genotoxic pollution
4. To assess the variation in Acetylcholinesterase activity in marine gastropods as a biomarker of neurotoxic contaminants
5. To assess the oxidative stress of pollution in terms of superoxide dismutase activity, Glutathione S-transferase activity, Catalase activity and lipid peroxidation
6. To assess the variation of physico-chemical parameters of the coastal water and their impact on the variation in DNA integrity