Chapter I
Introduction

Environmental pollution is the release of harmful pollutants into the environment that results in unfavorable alteration. The deterioration of aquatic bodies is termed as pollution of water as a result of addition of pollutants directly or indirectly into aquatic systems without adequate treatment to eliminate unsafe components thereby distressing aquatic life. Water is a very significant input on which mankind survives. It is necessary for both aquatic life and terrestrial life for carrying out different processes by the ecological system of the earth environment is balanced. Lot of environmental inconveniences like production of waste water and its tendency to collect, to treat it and removal in environmental safe way has been caused by urbanization. The wastewater which is allowed to run out without proper treatment, most of the times seeps in the earth and pollutes the underground water or may flow in the naturally present drainage. In India about 75% of surface water is contaminated.
by sewage. Domestic, household and other wastes, is directly dumped into roadside waterbodies, which are washed into ponds and lakes. According to experts, in addition to the unchecked industrial pollution, the rapid pace of urbanization have also contributed to the aquatic pollution in the country (Zingde and Govindan, 2001; Modak, et al., 1990; Prabha and Selvapathy, 1997; Khurshid, et al., 1998; Singare, et al., 2010a; Singare, et al., 2011a; Singare, et al., 2011b; Singare, et al., 2010b; Klean Environmental Consultants Pvt. Ltd, 2004). Toxic pathogens occurring in the sewage harms the animals as a result severe diseases are caused in the animals. Lack of safe drinking water in India has resulted in deaths due to water borne diseases. Microorganisms such fungi, bacteria, viruses, algae, viruses, etc., are present in drainage waste water that leads to epidemic and enormously harm the health of public. The common water borne diseases like cholera, typhoid, polio, dysentery and hepatitis which are infections are caused due polluted drinking water. Thus water pollution the consequence is detrimental not only to specific species but also to the entire biological environment. Pollution in majority of Indian water sources are progressively increasing as a result of the accumulation of contaminants through the environment such as industrial and sewage effluents, organic material, etc. The contamination of natural water bodies will also results in an adverse alteration of water quality. Widespread impact of water pollution causes lowering biodiversity and degradation of aquatic ecosystem. Natural causes such as sedimentation due heavy rains, volcanic eruptions and algae blooms are responsible for worldwide water pollution. The most hazardous water pollutants are microbes whose sources may be construed as natural but a prevalence of their infestation may result from human intrusion in the environment (such as discharge of raw sewage) or over-population. The agricultural activities involving use of fertilizers, pesticides and herbicides are also considered as a major cause of polluting natural water. The environmental pollution due to discharge of industrial effluent has remain a significant issue in developing countries like India. The biggest number of contaminated river and water bodies in India are in Maharashtra state as stated by Central Pollution Control Board (CPCB) report. With the ever increasing pace of industrialization in Maharashtra state of India, the price of industrial development is heavily borne by most of aquatic bodies in the state. Subsequently at the end of each time period the pollution problem leads to serious concern. As a result of this toxic waste has collected thus detiorating soil quality and
water quality. These wastes often contain a wide range of contaminants such as petroleum hydrocarbons, chlorinated hydrocarbons and heavy metals, which are greatly mitigated in Western Countries, but remain a significant issue in developing countries like India. Some of the previous studies in the Arabian Sea have shown that the petroleum hydrocarbons ranged from 1.8 to 11.1mg/L in water, 1.84 to 5.81mg/g dry weight in sediments and 0.33 to 3.67mg/g wet weight in fish (Sengupta, et al., 1993), while the total DDT in zooplankton samples in the Arabian Sea (Shailaja, et al., 1990) varied from 0.083 to 0.563mg/L.

The waste management policies adopted in India cannot cope with the growing industrialisation and urbanization. The water stress in this region can be attributed to extensive development of water intensive agriculture, large scale industrialization and urbanization that exerts unsustainable demand of fresh water. The fast growing urbanization and industrialization with inappropriate planning has resulted in release of drainage and industry effluents into the aquatic bodies.

Heavy metals are the elements which are usually present in fairly small concentrations in water. Heavy metals can be looked upon as a particular group of trace elements which are found to endanger health on entering the food chain through plants and biological life. The elements comprising the heavy metals group are Copper (Cu), Arsenic (As), Lead (Pb), Cadmium (Cd), Zinc (Zn) Chromium (Cr) and Mercury (Hg). The heavy metals have densities greater than 4g/cc when present as metals. The natural aquatic systems are widely infected due to discharge of heavy metals from household, industrial and other human activities (Conacher, et al., 1993; Velez and Montoro, 1998). Untreated or allegedly treated industrial effluents often include inconsistent quantity of heavy metals such as copper, lead, arsenic, nickel, cadmium, zinc, chromium and mercury, having the capacity to infect crops cultivated under such irrigation conditions. These toxic metals not only contaminate the crops but also pose a threat to the aquatic biota (Aghor, 2007; Patil, 2009). The increase in residue levels of heavy metal content in vegetation, water and sediments, thus reduce productivity (Lokhande and Kelkar, 1999) and add to in health risk in case of human beings (Kazi, et al. 2009; Gbaruko, et al., 2008; Ember, 1975; Sunderman, 1959; Cai, 2009; Pokhrel, 2009). There is substantial fear for the human health aspects from the metal cycling in polluted coastal and inland waters which are in vicinity of large population centres. Measurements have been made of pollution due to heavy metals in foreign countries.
However, no remedies have been carried out in India. A broad supervising efforts for a extensive duration is required so that average precipitation of metals and its tendency, \textit{(Johansson and Rasmussen, 1977)}, which is an important factor of the pollution control management can be controlled.

Aquatic ecosystems are affected due to these toxic heavy metals that significantly deplete biodiversity. The ecological equilibrium of the affected environment reveals shocking effects due to heavy metal contamination and has also affected diversity of aquatic organisms species \textit{(Farombi, et al., 2007; Ashraj, 2005)}. The aquatic ecosystems are anticipated to be largely effected as compared to the terrestrial ecosystem in the future due to the deplication of biodiversity \textit{(Sala, et al., 2000)}. The effects of heavy metals on the aquatic life are very apparent and this may enter the food chain through bio magnification and eventually harm the human beings too. The probability of accumulation of heavy metals in bio-systems and the food chain pollution through polluted air, soil and water has blazed \textit{(Aghor, 2007; Patil, 2009; Kumar, 1996)}. The soil is chief origin of heavy metals in vegetable crops from which they are absorbed into roots. Studies have also showed that the fertility of soil and agricultural yield and output is decreased due to existence of toxic metals \textit{(Lokhande and Kelkar, 1999)}. Heavy metals present in inconsistent quantity in the treated sewage water are capable of spoiling crops grown and irrigated with the water. The predicament of water pollution due to these heavy metals has become still worse due to their bio-accumulation and bio-magnification. Awareness of toxic metal pollution is slowly increasing due the increased use of a wide variety of metals in industries and in our daily life. Many of these metals tend to remain in the ecosystem and ultimately move from one layer to the other in the food chain. Among the various toxic pollutants entering in the aquatic environment, the heavy metals are creating more serious environmental problem owing to their non-biodegradable nature, accumulative properties and extended biological half lives. Once the heavy metals enter the environment it not possible to eradicate them totally. Studies show that the aquatic ecosystem in India has significant amount of mercury \textit{(Menon and Mahajan, 2010; Govindswamy, et al., 1998)}. Apart from the mercury, untreated or allegedly treated industrial effluents and sewage water discharged in the water bodies also contains other toxic heavy metals such as arsenic, lead, cadmium, nickel, zinc copper, iron chromium and mercury. Because of their particle
reactivity, metals tend to accumulate in soil/sediments, and, as a result, may persist in the aquatic environment long after their primary source has been removed. Study of heavy metal sources and their accumulation has become a particularly significant issue of today’s research. In hydrosphere, toxic metal concentrations are typically orders of magnitude greater in the sediments as compared to those in overlying waters. These toxic metals may not remain fixed to the sediments permanently, but are exchanged within the sediments as well as the water column via chemical and biological agents both. Behavior of these metals in the coastal marine sediments is largely related to their capacity for complexation with organic matter in truly dissolved, colloidal, macro particulate phases. The ability of the soil and sediments to concentrate metals make them indicators for monitoring purposes and for detecting sources of pollution in the aquatic system. Therefore the analysis of soil and sediments gives clear record of the heavy metal content. (Ward, 1995, Hodson, 1986).

Though the toxic heavy metals can be taken by biological organisms in aquatic environment in form of free metal ions and soluble complexes they also get adsorbed onto particulate matter (Salomons, et al., 1984). The heavy metals adsorbed by sediment material are deposited in estuarine sediments (Sahu, et al., 2009; Weston, et al., 2002) and are also accessible for biological uptake (Lee, et al., 2000; Spooner et al., 2003; Adams, et al., 1992, Maher, et al., 1999). It has been found that the concentrations of metals in sediment are higher than that of water. This may be due to the high alkalinity of the water allowing most metals to precipitate. Thus, the accumulation of heavy metal contaminants in the superficial sediments can provide means of assessing the long term accumulation of trace metal (Kennicutt, et al., 1994; Zanruddin and Shabad, 1998). Bottom sediments consist of particles that have been transported by natural agents from the sites of their origin in a terrestrial environment and deposited on the floor of a river, lake, or ocean. In addition to these particles, bottom sediments will contain materials precipitated from chemical and biological processes. Natural processes responsible for the formation of bottom sediments can be altered by anthropogenic activities. Many man-made materials have entered bodies of water through atmospheric deposition, runoff from land, or direct discharge into the water. Heavy metal contaminated sediments may cause an adverse effect on aquatic organisms. The accumulation of heavy metals results in gradual harm to living organisms thus making careful monitoring of the input, movements and effects of such pollutants necessary.
Heavy metal accumulation in aquatic soils/sediments and in particular biological animal species can have unforeseeable consequences for certain links in the food chain (Pempkowiase, et al., 1999; Chowdhury and Blust, 2002; Clearwater, et al., 2002; Ashworth and Alloway, 2004). Fishes are among the inhabitant that are subjected and cannot get away from the harmful effects of the pollutants and are broadly used to assess the health of aquatic ecosystems (Olaifa, et al., 2004; Dickman and Leung, 1998; Clarkson, 1998). The investigation done on various species of fishes have revealed that heavy metals may change the biochemical parameters and physiological properties in blood and in tissues both (Canli, 1995 and1998; Basa and Rani, 2003; Tort and Torres, 1988). The poisonous effects of heavy metals on biotic life due to bioaccumulation is reviewed (Waqar, 2006; Rasmussen and Anderson, 2000; Adami, et al., 2002; Aucoin, et al., 1999). The organisms create a protection against the toxic effects of necessary and nonessential heavy metals and other xenobiotics that construct deteriorative changes like oxidative strain in the body (Abou EL-Naga, et al., 2005). It is known that metals accumulate on sediment surface in benthic living things, planktonic organisms and other living matter and is enhanced through food chain. The xenobiotic chemicals with poor water solubility are accumulated in the fish body, due to very close contact with the medium that takes the chemicals in solution or suspension and also as fishes have to extort oxygen from the medium by exchanging the large volumes of water through gills. The important sites for absorption of water borne chemicals are the gills, digestive tract and skin. The absorbed chemical is carried by the blood to liver or to the bones. In liver it is stored and then excreted to the bile or further mixed with blood and may probably excreted by gills or kidney and stored in fat tissues. We know that heavy metals have dangerous effects even at places away from the source of pollution as they have the ability of immune, reproductive, nervous and endocrine systems in animals and these effects can be at organ, tissue and cell level (Geeraerts and Belpaire, 2009). Fish are susceptible to acute and chronic environmental changes and they show a classical stress response. This stress influences plasma glucocorticoids and catecholamines. Environmental changes may cause hypoxia, metabolic acidosis and alkalosis, hypotension and hypoglycemia. Gill tissue is an organ having a large surface and separates blood from water in fish and is very susceptible to changes in concentrations of the variables (heavy metals, temperature, pH etc.) in the
environment. These variables affect the structural integrity of the gill and cause morphological changes. For this reason gills are good indicators of water pollution (Bhagwant and Elahee, 2002; Koca, et al., 2005 and 2007). Liver has an significant role in protecting inner homeostasis in vertebrates. The liver being highly dynamic in nature and as it regulates numerous physiological and metabolic activities it is a crucial model for investigation (Segner, 1998). Muscle tissue forms a major part of the body weight of fish when compared to other vertebrates and is also economically valuable. The heavy metals have the great possibility of biomagnifications because of their conservativeness when they are transferred to the humans via the various members of the trophic levels in the food chain. Human beings are affected negatively as a result of their accumulation.

Among the different water bodies, lakes contain a intricate and weak ecosystem, lakes are stagnant they does not have self-cleaning capability and hence gather pollutants. The cumulative effect of these factors leads to eutrophication of a lake resulting in loss of biodiversity and poor water quality. Lakes in industrial zones face added problem of pollution from toxic industrial solid and liquid waste (effluents). This has resulted in the saturation of poisonous contaminants resulting defilement in water quality of water for the past few years. The crisis of pollution along the lakes in India due to accumulation of toxic contaminants has become to cause distress now in most metropolitan towns. Agricultural discharge, industrial and domestic wastes, rainfall pattern, geological configuration and penetration time are some factors affecting the value of soil sediments. The water quality to a great extent influence the public health, it is essential to analyze the pollution level of lake water. Also as the quality of lake sediments very much affect the plants and other biota, it is also required to analyze their physico-chemical factors. Although the cleanup of the lakes has been taken up to save this precious natural resource from depleting, but the present conventional clean up processes are very much expensive and also produce obnoxious waste by-products thereby imposing additional clean up. Extensive research work is carried out previously to study the pollution of different water bodies (Lokhande, et al., 2011b, 2011c, 2011d, Modak, et al., 1990), however relatively less attention has been given to recognize the correlation between pollution load and Physico-chemical properties of sediments (Moundiotiya, et al., 2004; Rajaram, et al., 2008; Prabha, et al., 1997; Sasamal, et al., 2007).
Apart from the pollution of aquatic bodies, air pollution has turned out to be a severe global environmental problem today. It depreciates ecological condition. It is explained as the variation of any atmospheric components that would have been evaluated in absence of human existence. Today’s growing population and increasing urbanization has resulted in sudden increase in number of vehicles (Gaikwad, et al., 2004). The problem posed with vehicles is due to discharge of pollutants (CO$_2$, Pb, SO$_x$, NO$_x$, etc). Release carbon dioxide results acidification of water bodies, and lowers the pH of the earth’s surface water due to dissolution of CO$_2$. The production of greenhouse gases results in global warming affecting ecosystems in several ways. Nitrogen oxides from the air are dissolved in rainwater and absorbed by fertilize land thus changing the composition of ecosystems. Plants are damaged by the smog and mist which obstructs the sunlight required for photosynthesis leading to the development of troposphere ozone. Soil can become barren and inappropriate for plants. Sulfur and nitrogen oxides dissolves in rain water causing acid rain inturn lowers the pH of soil. The environment protection from the undesirable effects of pollution is checked by worldwide nations to regulate pollution control as well as to lessen the bad effects of pollution. Efforts have been taken for restoring environment in India but appearsto be a difficult task (Tripathi, et al., 2007). The increasing population density have caused permanent damage to the environment due to the resulting housing requirements and dense traffic. It is very obvious that automobiles are 60% responsible for air pollution in city. The constantly increasing road traffic is the prime reason. The extent of the air pollution threat is assessed and effective steps are taken, a biological monitoring is also included in components of an urban air quality management along the instrumental air quality monitoring. This will present the necessary information about actual causes of regional pollutant releases.

The sensitive species in plants and animals both are equally effected by of air pollutants at severe level. Plants are very important part of all ecosystems and are affected the most by airborne pollution. Plants are known as the living things with high possibility to accept damages of prevailing air pollution. Since major portion of plant comprises of leaves, they serve as primary receptors for pollutants. As plants are the ecologically essential and air pollutants cause large scale harm to these, hence the sensitivity of the plant receptors was considered before prescribing the standard in Indian air quality management system.
National Forest Policy, 1988 states that forests were ecological necessity for requirements of goods for local populations and wood for industries. The biochemical and morphological status of the plants and their responses has been changed by the air polluted ambient environment in urban area. The effect of auto exhaust pollutants are best studied on plants. Plants which are an important part of all ecosystems play a crucial role in examining and sustaining the ecological balance by cycling gases like CO₂ and O₂. The ambient environment of an urban area may be contaminated with several pollutants such as oxides of sulphur, carbon, nitrogen and heavy metals and the plants growing there would be exposed to one or more pollutants and their different conditions. The direct impact of air pollutants on the plants can be seen on leaves, while the indirect effect can be seen through soil acidification (Steubing, et al., 1989). Acute and chronic symptoms were observed in plant species. Since air pollutants affect seeds germination, flowering and length of pedicles, (Nithamathi and Indira, 2005) the plant species can be used as a biomonitor to assess the effect of air pollution. Plants respond differently to air pollutants. Their sensitivity towards air pollutants is also variable. The plant species which are more sensitive act as biological indicators of air pollution. To evaluate the impact of air pollution, biomonitoring very essential factor. The effects of airborne pollutants are widely observed on the leaves. The plants provide vast leafsurface area for assimilation and collection of air pollutants which minimises pollution extent in the air. (Escobedo, et al., 2008). The response of plants to air pollution in biochemical and physiological aspects can be analysed by determining resistance and susceptibility. The visible and non visible effects of automobile exhaust on road side has been reported. (Nuhoglu, 2005). Their studies on the effect of air pollution have reported the physiological changes in plants before exposing visible harm to leaves (Dohmen, et al., 1990). The investigation have showed gradual loss of chlorophyll resulting in yellow leaves, which may be associated decrease photosynthesis (Woolhouse, 1986). The studies also reported ascorbic acid affected by air pollution (Hoque, et al., 2007) chlorophyll (Flowers, et al., 2007), leaf extract pH (Klumpp, et al., 2000) and relative water content also affected by air pollution (Rao, 2006). These factors have given different results for same species (Han, et al., 1995). The air pollution tolerance index (APTI) calculated by considering all the four parameters have been used for determining tolerance levels in plant (Dwivedi and Tripathi, 2007; Dwivedi, et al., 2008; Yan-Ju and Hui,
The response of plants towards air pollutants was calculated by air pollution tolerance index. The APTI value for the determination of tolerance and sensitivity of plant species was studied by researchers (Agrawal and Tiwari, 1997; Dwivedi and Tripathi, 2007; Liu and Ding, 2008; Dwivedi, et al., 2008). Some researchers have ranked the plant species according to their tolerance to air pollution (Raza and Murthy, 1988; Singh and Rao, 1983). These studies will help in developing greenbelt in pollution loaded areas by selecting tolerant varieties of plant species and thus fighting against the hazard of air pollution. The studies showed that the plants with higher APTI values were tolerant to air pollution. Research should be extended to a greater variety of plant species to overcome the air pollutants.

The present day by day increasing environmental pollution in India in general and Mumbai in particular (Zingde and Govindan, 2001; Singare, et al., 2010a; 2010b; Singare, et al., 2011a; Singare, et al., 2011b; Singare, et al., 2010c; Singare, 2011d; Klean Environmental Consultants, 2004, Modak, et al., 1990; Madhavan and Meenambal, 2010; Rajaram and Das, 2008; Horaginamani and Ravichandran, 2009; Patel and Hina Kousar, 2010; Prabha and Selvapathy, 1997;) have prompted us to carry the systematic and detail study of environmental pollution along the Bhavan’s College campus located at Andheri city of Mumbai, India. The study was performed to understand the aquatic pollution load due to discharge of sewage as well as water effluent from the adjacent chemical laboratories that finds their way in the lake water due to seepage. The study was extended further to understand the air pollution tolerance of different plant species grown along the road side of College campus by comparing their APTI values with those of similar plants species grown in unpolluted area of college botanical garden. It is expected that study will be handy for future planning of air pollution control.

OBJECTIVES

Bhavan’s College established in 1946 is one of the oldest colleges of western suburb of Mumbai. The college is built upon 45 acres (180,000 m²) of land and has a botanical garden and a beautiful lake. Climate is pleasant, with cool winters and hot summers. The weather is dry. The rainfall is moderate. The sewage and waste effluent from the laboratories of adjacent Chemistry Department finds their way in the lake water due to seepage. The laboratory and sewage waste water from the laboratory is the root cause of heavy metals in
the lake hence this lake is perfectly suitable for study of heavy metal concentration. The
release of heavy metals has much apparent impact on water bodies. The more the residue
levels of heavy metal in water, biota and sediments, the less is the production. And more
exposure of human beings to toxic material (Moore and Ramamoorthy, 1984). The present
study on water pollution along Bhavan’s College campus of Andheri, Mumbai was therefore
carried out with following objectives:

I. To produce the pollution load records through regular study as this will help to
execute programmes to estimate the amount of pollution.

II. To analyze toxic heavy metal contents in sediment, water, vegetation and aquatic life
i.e. fish.

III. To obtain Physico-chemical data of waste water discharged in the study area during
the sampling period.

IV. The study was extended further to understand the air pollution tolerance of different
plant species grown along the roadside of College campus by comparing their
values with similar species in unpolluted area of college botanical garden.

HYPOTHESIS

The seepage of discharged sewage and laboratory waste water in Lake of Bhavan’s College
campus has resulted in deterioration of lake water quality. The problem of water pollution
has become still intense due to seepage of waste water containing toxic metals released from
nearby chemical laboratories. The toxic heavy metal thus release has begun to cause major
concern along the lake of Bhavan’s College. Hence for better knowledge of Physico-
chemical properties like pH, alkalinity, biological oxygen demand (B.O.D), chemical oxygen
demand (C.O.D), dissolved oxygen (D.O), total hardness, chlorides, sulphates, conductivity
and total bacterial count and accumulation of heavy metal like Copper (Cu), Lead (Pb), Zinc
(Zn), Calcium (Ca), Chromium (Cr), Cadmium (Cd), Nickel (Ni), Iron (Fe), Mercury (Hg)
and Arsenic (As) in water, sediments, plants and fishes has become predominantly vital
subject of today’s research on pollution measurements. This was tested by using the standard
techniques used in classical and instrumental methods of analysis (ICMR, 1975; Jackson,
1973).
SCOPE OF THE STUDY
The study on pollution status along the Bhavan’s College campus is proposed to be carried out for tenure of one year. The sampling of water and sediment samples will be done daily in morning and evening sessions along different locations of the lake. The samples collected in two sessions for a month will be mixed separately to give gross sample. Such gross samples will be drawn for twelve months. The gross samples collected for twelve months will be analyzed for their heavy metal contents and Physico-chemical properties. It is expected that the results of samples collected for twelve months will provide fluctuations in level of pollutants released during different working days of the college. The study was extended further to study the four physiological and biochemical parameters namely ascorbic acid content (AA), leaf Relative Water Content (RWC), leaf extract pH and total chlorophyll (TCh) in the leaves of four plant species grown along the road side of Bhavan’s College and on that basis to calculate Air Pollution Tolerance Index (APTI) of the plant species. The APTI values so obtained were compared with the APTI values of the same plant species grown in the unpolluted area of college botanical garden. It is expected that these APTI values are significant in understanding the plant-environment interactions and are used for developing of bioindicator groups.

UTILITY OF THE STUDY
Although it is the responsibility of the Central Pollution Control Board (CPCB) to protect and maintain the morality of water bodies according to the Water (Prevention & Control of Pollution) Act 1974 sanctioned by Parliament of India, it is expected that to maintain or restore the water quality at desired level it is important to have monitoring on regular basis. The objective is to give proper image of existing water worth situation and drift in water standard and to make possible the recognition of rising problem and potential precedences. Therefore the present study on pollution status along the Bhavan’s College campus of Andheri city of Mumbai, India, will be useful to satisfy following objectives.

• For logical scheduling of pollution management schemes and their precedence;
• To measure quality and level of pollution management required;
• To assess efficiency of pollution managing methods already in existing;
• To estimate water quality drift over a period of time;
• To recognize the environmental destiny of different pollutants.
• To measure the condition of water for different uses.
• To assess the fitness of water for different uses.