INTRODUCTION

1.1 Background

Environment is a common asset of each one and not the property of any individual. Therefore, it is the joint responsibility of all to conserve, protect and improve the environment. Today, world is facing the impacts of environmental imbalance in the form of different problems like pollution of air, water and soil, loss of biodiversity, global warming, climate change, ozone layer depletion and other many more natural calamities. All these environmental concerns have been emerged out from human activities and attracted attention of the entire human community in recent years.

In affluent sections of our country, the depletion of resources, destruction of ecosystems and degradation of environment are more. Such destructions are to fulfill the increased needs and habits of westernized consumerist ideas. Though development is the need of the time, it should be well planned and carefully implemented. While achieving the process of development, we should also consider the availability and regeneration ability of natural resources. Otherwise, the present development will prove to be harmful for the coming new generations. The current pattern of development should be changed in such a way that there will be reduction in the adverse impacts of human activities on the stock of existing natural resources. The nature of development should support all existing people now and who are likely to live in future will be able to enjoy a good, satisfactory and quality life.

Human society need to understand issues related to current pattern of development, role of individual, society and government to maintain the environmental balance. It is not only the responsibility of government. It is the joint responsibility of every citizen as individual, students, businessman, industrialist and politician including every common man living in the country and who wish for the betterment of environment. Quality environment is not possible without environmental awareness. For creating awareness about environment, firm goals
are essential which are to be properly decided. The goals should transform the understanding and knowledge in peoples about our environment, environment associated problems and commitment to work individually and collectively towards finding and implementing the solutions for environmental problems. Environmental awareness and development should go hand in hand to provide good quality life for the people to live. It will also bring the welfare of all living beings with prosperity. All sections of society will get benefited. They will get educated, wisely civilized and develop their moral and mental abilities for healthy future with and sustainable development.

Rapid urbanization and industrialization has resulted in increased number of vehicles. Harmful air pollutants from various human activities including industries and vehicles put stress on environment and challenge the assimilative capacity of the environment. Today, the world has crossed the 6 billion mark of human population. If the present rate is continued, it would be doubled in next 35 years. The ultimate effect of increase in population is increase in air pollution. The pollutants like CO₂, CO, SO₂, H₂S, NO and NO₂ are some of the common air pollutants emitting from industrial stack which contain dust, carbon, metals and other solids and some radioactive materials. Automobile exhaust releases the poisonous gases like CO and NOx and hydrocarbons in addition to leaded gas and particulate lead as a result of incomplete combustion, ultimately NOx are responsible for photochemical smog.

The air pollution is excessive concentration of foreign matter in air. It adversely affects the well being of individuals or causes damage to property. Different contaminants enter the atmosphere through natural and manmade processes. These contaminants interact with living organisms and create toxic impacts and various diseases. Contaminants such as dust, gas, odor, smoke etc in atmosphere in specific quantities and characteristics with specific duration are found to be injurious to plant and animal including human beings.

Vegetation affects local and regional air quality by altering the urban atmospheric environment. The trees grown in urban area affect the air quality in
terms of reduction in air temperature, removal of air pollutants, energy effects on buildings and emission of volatile organic compounds. Trees absorb harmful air pollutants, primarily through the uptake by means of leaf stomata. The responses of plants to air pollutants provide a low cost monitoring and control method for gaseous pollutants. The proper selection of suitable tree species with suitable plant characteristics is important in this context. Scientists have suggested many of the plant parameter for biomonitoring of air pollution. These parameters include foliar injury, membrane permeability, ascorbic acid content, chlorophyll content; relative water content and leaf extract pH value. Nowadays, urban air pollution has become a serious environmental problem in many cities including Aurangabad. Trees in city area are facing the adverse impacts of air pollution.

Trees naturally cleanse the atmosphere by absorbing gases and some particulate matter through leaves and act as a pollutant-trapping device. Trees can be classified according to their sensitivity and tolerance towards air pollutants. Sensitive plant species are suggested to act as bio-indicators. Levels of air pollution tolerance vary from species to species, depending on the capacity of plants to withstand the effect of pollutants. In urban atmosphere various unspecified pollutants are present. It is not possible to evaluate plant responses based on a single parameter.

To study the biological effects on plants the method of biomonitoring using selective tree species is advisable which was selected in present investigation with respect to air pollution. The study was planned to measure different parameters of plants, record periodically, quantify and correlate with the level of pollutants. In the present investigation, plant response indicating different parameters were used in determining the Air Pollution Tolerance Indices (APTI) of selective tree species.

The information gained during the present study is helpful for the researchers, environmentalists, landscape architects and urban planners and those who have roles in dealing with the environment to have more ideas in developing design criteria. Thus, they will have the tools to design a safer urban environment and a better quality of life for human beings.
1.2 Aurangabad region- At a glance

1.2.1 Geography

Aurangabad is situated on the banks of the river Kham and tributaries of the Godavari River. The city is surrounded by hills of the Vindhya ranges and the river Kham passes through it. It is one of the famous cities in the country due to its famous tourism spots like Biwi ka Makbara and Panchakki. The caves of the Ajanta and the Ellora are close to Aurangabad (Technical Report, MPCB, 2010). There are few caves in and around of Aurangabad. The city is located on the latitude of 19°53'50" N and longitude of 75°22'46" E at the mean sea level is 512 m. Aurangabad sits in a strategic position on the Deccan Plateau. The city stands in the Dudhana valley between Lakendora range on the north and Satara hills on the south. The valley has a general breadth of about 10 miles is open towards the east, but on the west, the northern range deflects and curves in towards the city sending a spur close upon its suburbs. Along the centre it deepens. Thus city occupies very uneven ground (Env. Status Report, 2009).

1.2.2 History of the city

Aurangabad was founded in 1610 A.D. by Malik Ambar, the Prime Minister of Murtaza Nizam Shah of Ahmadnagar on the site of a village called Khadki. He made it his capital and the men of his army raised their dwellings around it. Within a decade, Khadki grew into a populous and imposing city. Malik Ambar cherished strong love and ability for architecture. Aurangabad was Ambar's architectural achievement and creation. The Municipal Council of Aurangabad was established in 1936 (www.en.wikipedia.org). Aurangabad has developed as a centre of culture and learning since ancient time. The city has an important place on the tourist map of the world due to its rich heritage. Aurangabad is the only district of India having two world heritage monuments to its credit. The city is surrounded with an amazing monument, like the rock-cut temples in the mountain of Ellora and Ajanta, forts such as the one at Daulatabad as well as mosques. The Aurangabad Caves, Pithalkhora Caves, the religious places in the district like Paithan, Daulatabad (Deogiri Fort) and Bibi-Ka-Maqbara are of great pride. In Aurangabad
there are 54 gates, out of 54 gates only 13 have survived over the period of time. The important and architecturally most appealing gates include Delhi Gate, kala Darwaza, Makia Gate, Paithan gate and Rangeen Darwaza (www.wikitravel.org).

1.2.3 Population

The trend of urbanization has been increasing steadily for decades in India. Today, about 27% of the total population of the country lived in urban area. The urban population in Maharashtra is about 42%. The Aurangabad district has population of about 28.97 lacks of the total. The district spreads over an area of 10100 sq. km. The urban population of the district is 37 % of the total population. This is above the national urban rate and slightly less than the states urban growth rate. The population of Aurangabad as per the 2011 census is 11, 71,260 persons, among which males are 6 lacks and 10 thousand 303. Out of them, about 4 lacks 97 thousand 330 are literate. Total of female population is about 5 lacks 60 thousand 952 among, of which 83 thousand 881 are literate (Daily Lokmat, 2011). The population of Aurangabad as per the 2001 census was 8, 73,311 persons. It was 4, 87,025 persons for the year 1991. The population of the city has grown rapidly from 1961 to 1981. The growth rate was highest in 1981(District Census 2011). This was due to the industrial development at waluj which attracted lot of people for employment. The growth rate decreased from 1981 to 1991 and has again increased in the last decade. The density of the city as per the 2001 census population is 6300 persons/sq.km.

Due to rapid industrialization, Aurangabad city has changed drastically. The industrial clusters of MIDC and CIDCO helped lot for this development. The increasing industrialization in the Aurangabad region has led to the growth of urban population. During the decade of 1981 to 1991, the city Aurangabad was the fastest growing city in Asia. The decadal growth of the city is 79.32 %. The population growth indicates the increasing trend over the last three decades (Env. Status Report, 2009).
1.2.4 Industrial Growth

Aurangabad has all three types of industries small, medium and large. These industries are divided into three types, viz. red, orange and green. The red types of industries include 49 large scale, 56 medium and 84 small scale industries. The orange type of industries include 8 large, 19 medium and 258 small scale industries while Green type of industries include 3 large, 61 medium and 964 small scale industries. The industrial policy of the state encourages industries in underdeveloped areas of the state. This helped the establishment of industries in Aurangabad. The Maharashtra Industrial Development Corporation of Maharashtra established industrial estates at Chikalthana, Waluj and Shendra. The industries include Automobile, pharmaceutical, breweries, distilleries and engineering sectors. Industrial structure of Aurangabad district is fairly diversified. It is the most promising district in the region for industrial growth and therefore offers scope for almost all industry groups.

In addition to that, the district possesses development potential for specific industries like food, fruits, and vegetable processing, dairy, tourism, poultry, cattle breeding, sheep/goat rearing, gum, lac, oil mills, cold storage, cotton ginning and pressing, vanaspati, bidi, khandsary, solvent extraction, sugar and its by-products, alcohol, coir-strings, forged hand tools, small tools, industrial and scientific instruments, paper, hardboards, fibre boards, chip boards, packaging, basic drugs, industrial machinery, packaging, electrical goods, electronic items and engineering and automobile ancillaries (Env. Status Report, 2009).

A. Aurangabad Industrial Area: Aurangabad MIDC was established in the year 1963 developing a small area (34 Ha.) near the Aurangabad railway station. The area today is well developed. The major industrial units in this area are Nirlep Industries, Pricision Engineers, Mahavir Paper Products, Ajantha Tiles and Marathwada Spun Pipe Industries.

B. Chikalthana industrial area: MIDC established Chikalthana as an industrial base in the year 1970 with a planned area of 724 Ha. The Chikalthana industrial
area was established in 1965 with a total area of 719.68 hectares. Today, this industrial estate has several companies including Wockhardt, Maharashtra Distilleries Ltd., Lupin, Indo German Tool Room, Greeves, Cosmo Films, Hindustan Lever Ltd., HMT, Dagerfost and NRB.

C. Waluj industrial area: Waluj industrial area is located at the distance of 10 kms from Aurangabad city with a planned area of 1,563 Ha and established in 1982. The area has got sufficient water supply scheme with a capacity of 72,000 cubic meters a day and has a 132 KVA substation. The major industrial units at Waluj are Bajaj Auto, Colgate-Palmolive, Ceat Tyres, Wipro, Kenstar, Garware, Wockhardt, Foster, Sterlite Industries Ltd., Franke, and Johnson & Johnson.

D. Shendra Industrial Area: Shendra is the third industrial estate near Aurangabad having an area of 927 hectares. It is located on the Aurangabad -Jalna-Nagpur State highway. It is 8 km away from the Aurangabad airport and 19 kms from the Aurangabad Railway Station. The Skoda has established its unit at Shendra.

E. Chitegaon Industrial area: The Videocon has established a big industrial area at Chitegaon along Paithan road. It is near about 15 km away from the city.

1.2.5 Geology and soil

The entire area of Aurangabad is covered by the Deccan Trap lava flows of Upper Cretaceous to Lower Eocene age (www.wikitravel.org). The volcanic rocks have given rise to red as well as black cotton soils. Major part of the city has deep black soil derived from the trap rocks with certain variations due to varied exposure. A mixture of tachlite and black soil is encountered in the eastern parts together with sandy soil along river banks. Most of the hill tops are bare or covered by coarse gravel while the low lying area accumulates clay and loam.

The city of Aurangabad is situated on basic igneous volcano rocks of upper cretaceous to lower Eocene (about 120 million years before to 60 million years before.) age which are well known as Deccan Traps in geological literature. There are mainly two types of rocks in this area. They are i) Compact basalt, which is almost free from gas cavities but contains three sets of cooling joints (two vertical and one horizontal) and ii) amygdaloidal basalt, which is almost free from cooling
joints but contain gas cavities filled by secondary minerals such as quartz zeolites and calcites. In the area of Aurangabad Municipal area, there is more black cotton soil. Sometimes, during weathering process of basalt, lime (calcium carbonate) is also formed. This lime gets deposited in the soil in the form of partials imparting dirty white colour to soil. Such soil is called as kunkar soil. Kunkar soil is dominantly observed in Garkheda area and in some parts of Padampura and Karnapura (Env. Status Report, 2009).

1.2.6 Groundwater Geology

Aurangabad city is situated on the bank of Kham river and sukhana river which are tributaries of Godvari river, but not the perennial rivers. In fact, there is no perennial river in the nearby area of Aurangabad city. In past, therefore, groundwater contributed as major source of water to the native population of Aurangabad city. There are hills on almost all sides of Aurangabad and the topography of the city is bowl shaped. This topography in collaboration with deep weathering helped to improve groundwater potential of this area. The dykes present in these areas acted as barriers for the movement of groundwater and played important role in confining groundwater to this area only. Thus, the areas around Bibika Makbara, Garkheda, Karnapura, and Khadkeshwar have good groundwater potentials. Some of such rich groundwater aquifers were successfully identified and tapped in historic times. The area behind Dr. B. A. Marathwada University and near Shahanoormiya Darga areas are among these. The water was collected in wells and was supplied through pipe lines to the city. This historic public water supply schemes are known as ‘Nahar’. Panchakki nahar, Shahanoormiya Darga nahar, are the examples of this kind. These nahars are the sites of attraction of tourists and subject matter for study of the students of environmental science, geology and civil engineering (Env. Status Report, 2009).

1.2.7 Climate

The weather of Aurangabad city is dry and moderately extreme. Temperature of Aurangabad city varies between 09°C to 41.8°C. The average day temperature ranges from 27.7°C to 38.0°C while it falls between 26.9°C to 20.0
0°C during night times. Similarly, summer and winter temperature also varies greatly. The highest temperature during summer day is about 42.2 0°C while the lowest temperature during winter nights can be about 8.0 0°C. The highest maximum temperature ever recorded was 46 °C (114 °F) on 25 May 1905. The lowest recorded temperature was 2 °C (36 °F) on 2 February 1911. Relative humidity is extremely low for major period of the year (between 35 to 50%) while it is highest (85%) during monsoon. The average relative humidity is 17% (www.wikitravel.org). The rainy season starts from June and lasts up to the end of September which is followed by a sultry period from about the end of September to the middle of November. The average relative humidity during monsoon period of time is 40%. The winter season commences from the October and lasts up to the end of January followed by a dry hot summer from February to June. Summers are in general full of gusty winds. The normal average rainfall is about 72.50 cm, but is rather variable from year to year. The major amount of South West Monsoon precipitation is received on the West Coast of India due to the Sahyadris and only a small amount escapes through high hills, which is received by the Deccan Plateau (Env. Status Report, 2009).

1.2.8 Flora and fauna

The climate of Aurangabad city is generally hot and dry and receives low rainfall. Some parts of Aurangabad city have good fertile land with stable climate, because of which the Aurangabad city shows ample bio-diversity. Due to the lack of adequate rainfall, vegetation cover shows its diversified nature. Aurangabad district covers more forest area than the other districts in Marathwada region. There are teak, sandalwood, anjan, moh, tembhurni, ain and other kinds of trees in these forests.

In Aurangabad district, Gautala is a well known wildlife sanctuary along with Jayakwadi as famous bird sanctuary (www.wikitravel.org). Thorny scrub forests are having major trees like bor, babul, aloe-voera etc. A variety of wild animals can be seen in these regions, more specifically in forests. These include the wild boars, foxes, hares etc. Leopards are seen but rarely. There are many monkeys
and Baboons in the Aurangabad city and adjoining area. The major agricultural crops are cotton, oil seeds, bajra, jowar, groundnut, wheat, safflower and irrigated crops like sugarcane which is one of the important irrigated crops. The other irrigated crops like grapes, bananas, sweet limes and ranges etc. are also grown in the soils of the Aurangabad. In the soil of Aurangabad variety of vegetables like brinjals, tomatoes, onions, potatoes and leafy vegetables are grown. The Godavari is the main river in the Marathwada region (Env. Status Report, 2009).

1.2.9 Forest

The Aurangabad district has an area of 345.25 sq. miles under the forests which make 5.35 per cent of the total geographical area of the district against an average of 17.56 per cent for Maharashtra. The forest area is under the control of forest department. The forest area in the Aurangabad division is 4 per cent of the total area. The division has reserved forests covering the area of 309.75 sq. miles. Protected forest area is 86.33 sq. miles and unprotected forest area is 18.76 sq. miles. The forests are mostly barren due to excessive grazing and pressure of population except in Kannad and Ajanta ranges. The forests are scattered all over the district in small patches. They fall in the southern dry deciduous forests type. Major tree species found in the forest is teak which covers considerable portions of Kannad and Fardapur ranges. Another important tree species is anjan which is predominantly found in parts of Fardapur range. The other important tree species found in the forests are dhauda, salai, char, chandan, mohi, tembru, kandol, khair, mhowa, palas and ain. The forests have also extensive adjoining grassy areas. The species of grass found are kusal, paonyh and sheda. The grasses found in the adjoining areas of forests are sfia and motia varieties of rosha (Env. Status Report, 2009).

Forest Types: The main forest type of this division corresponds to "Group 4-A Southern Indian Tropical Dry Deciduous Forests". They are primarily mixed forests consisting of a variety of species. The occurrence of these species is considerably influenced by biotic interferences and management practices. The
species occurring in these forests can be enlisted as follows in the descending order of their incidence and commercial importance.


It is difficult to classify these forests into distinct sub-types but the forests can be recognized into the following categories for the convenience of management. This classification is adopted from Env. Status Report (2009) and the current working plan implemented in the district.

**A. Dry teak type:** The species found being teak in varying proportion with *dhavra, ain, salai, char* etc.

**B. Mixed miscellaneous type:** Occurring on inferior locations, the species are *salai, dhavra, moyen* etc.

**C. Anjan type:** Almost pure occurring along Satmala foot hills facing Khandesh.

**D. Thorny scrub type:** It is more or less a regressed subtype where overwood has been completely removed and due to excessive grazing only thorny species such as *karwand, henkal, amoni, ghaneri*, etc.

**E. Grass lands:** These are well protected commercial *kurans* used mainly for fodder grass which is sold on cutting terms, the main species being *sheda, marvel, kunda, paonya, rosha, kusali* etc.
1.2.10 Roads and Transport

There is a well established network of roads in Aurangabad city area. Public transport system in Aurangabad mainly comprises of train, bus, Auto Rickshaws and taxi. The State Transport (ST) authority runs the city bus service.

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Table-1.1: Number of vehicles registered in Aurangabad city till April 2011 (RTO, 2011).

More number of vehicles has resulted in traffic conjunctins and other problems in certain areas the major concern in traffic is increasing number of road accidents and rise in city air pollution.