1.1 Dye colorant

Dyes are ionizing and aromatic organic compounds which shows an affinity towards the substrate to which it is being applied and imparts the color to the substrate. Dating back to the ancient times, every civilization uses the dyes to impart the color to various substrates including food, fabrics, paints, pharmaceuticals and paper etc. Color gives the appreciability, acceptability, attractiveness to the substrate and finally increases the value and importance which can denote class, economic position and style. Therefore it has long been an important part of society. From the ancient times, dyes were produced individually by harvesting natural plant parts such as bark, root, stem, leaves, flowers and fruits. But after mid-1800s, there is a great progress in the development of different dye techniques and processes. Literature suggests that the first synthetic dye namely aniline dye Mauve was manufactured on a large scale derived from coal tar by Perkins in 1856. However, it has been seen that certain types of cancers were linked to exposure to early aniline type dyes, therefore their use and manufacture was not continued longer (Muir, 1971).

1.2 Textile dyes and Environmental issues

It was assumed that dyes extracted from natural sources must be more environmental friendly and healthier for the consumers. But it was realized that all natural dyes are often neither safer nor more ecologically sound than synthetic dyes. There are many limitations in the use of natural dyes being some of them are difficult to apply, several dyes require the use of mordants, less permanent, less wash and light fast, less color possibilities. Some of the mordants (oxalic acid, chromium, tin, copper, iron and Alum) and dye used are highly toxic viz. Hematein. The process of application of natural dyes requires the large amount of water, heat, energy and time. However, natural dyes are unique and superior in certain case, they are aesthetically pleasing in their intrinsic variation, for making historically accurate costumes, and they form shades which are soft, lustrous and soothing to the human eye. Natural dyes are biodegradable.

With increase in time, the demand for natural dyes also increases which creates pressure on natural resources. Recently it could become difficult to fulfil commercial dye demand which would overwhelm resources. To satisfy the over increasing demand, the sources are being harvested indiscriminately from the wild. Due to anthropogenic activity, there is a rapid depletion of forest, diversity and natural resources. On the other hand, human population is increasing exponentially. It has been calculated that even if 2/3 of the world’s agricultural
land was used to grow only natural dyes, it is merely enough to fulfil the current demand of textile dyes (Chen and Burns, 2006; Kanchana et al., 2013).

During the course of time, as per convenience and availability of business in dyeing organic clothing or yarns interest have switched from natural dyes to synthetic dyes. Now synthetic dyes dominated textile industries being their easy preparation methods, exhibit structural variety, wide color range and readily not susceptible to microbial attacks. They are designed to be wash and light fast thus making them more resistant to environmental factors and increase the durability of the product. Due to lot of advancement in instrumentation and synthetic chemistry, huge numbers of synthetic dyes are available for dyeing textiles. The growing demand challenges the textile industries to produce synthetic dyes that can form different shades and can be obtained in large quantities at affordable cost. Among dyes, azo compounds are the largest and the most diverse group of synthetic dyes. They are widely used in a number of industries such as textile, food, cosmetics, pharmaceuticals and paper printing. These dyes are readily available in almost every color and to the customer.

In India, Dye production was estimated to be around ~200,000 tonnes in the year 2010 and there are more than 10,000 dyes commercially available (Keharia and Madamwar, 2002; Mangal, 2010; Ngieng et al., 2013). During the dyeing and finishing operations in the textile industry, up to 2,00,000 tons of these dyes (10-15%) are lost to effluents every year on account of inefficiency of the dyeing process (Sharma et al., 2009). The release of partially treated and untreated textile dye effluents poses a great environmental concerns in the area and in nearby water streams. It reduces the potability of water and light penetration which effecting the growth of aquatic organisms at large scale. Many of aquatic life forms such as fishes accumulate these synthetic dyes on contact and thus these dyes enters in the food chain ultimately posing risks to human beings (Puvaneswari et al., 2006). Textile dye effluents contain substances known to possess carcinogenic, mutagenic and allergic properties (Kant, 2012). On contact with some of the azo dyes and its oxidation, reduction products leads to many disorders including cancerous disorders in urinary bladder, brain, mouth, oesophagus, liver, gall bladder, stomach and kidneys (Bafana et al., 2009). They have been reported to be allergen causing dermatomes and respiratory diseases (Klemola et al., 2007). Phytotoxicity studies also revealed the toxic nature of textile dyestuff and effluent (Banu and Murugesan, 2013).
1.3 Textile dye effluent treatment

Several efforts have been carried to minimize the threats of textile dyes industry effluents. There are different methods used includes physico-chemical and biological methods. The physico-chemical methods used have advantages as well as limitations which do not make their application feasible and affordable. Membrane filtration methods are costly and were flux declined. It results in membrane fouling, necessitating frequent cleaning and regular replacement of the modules. Coagulation/flocculation can partly remove COD and color from raw wastewater. Equilibrium capacity varies with dyes and adsorbents used in adsorption method which limits its application. Photocatalytic, ozonation and ultrasound enhanced ozonation generates the harmful reactive radicals. Sonication increase decolorization efficiency however, it decreased with an increased dye concentration. Electrolysis requires the high amount of energy. The use of one individual process may often not sufficient to achieve complete decolorization.

Microbial treatments of some textile dyes are reported to produce aromatic amines which are toxic and carcinogenic. However, research studies on biodegradation of dyes have revealed the role of certain microorganisms, plants, fungi and algae in degradation of dyes. Sequential anaerobic-aerobic treatment process based on mixed culture of bacteria was able to biotransform dyestuffs into colorless substituted amine metabolites in the reactor (Sugumar and Sadanandan, 2010). In recent years, there has been extensive research as fungal species require simple medium for growth and release extracellular enzyme which can degrade textile dyes (Bergsten-Torralba et al., 2009). The effectiveness of use of algal system in degradation and decolorization of azo dyes in wastewater effluents had been reported in literature (Clarke and Anliker, 1980; Wang et al., 2007; Ertugrul et al., 2008). In vivo, some aquatic weeds and plants have been reported to degrade textile dyes (Sharma et al., 2005, Kagalkar et al., 2010). In vitro dye decolorization attempts have been made with the help of several angiospermic species (Khandare et al., 2011; Adki et al., 2012; Watharkar et al., 2013). Inspite of all these, till date, there is no effective and economical viable process has been developed for the treatment of textile effluents (Yuan et al., 2006; Watharkar et al., 2013). There is a need to screen the several organisms and to find out the potent organism for the treatment of textile industry effluents by applying conventional and biotechnological approaches. Therefore, in the present investigation the attempts have been made on application of in vivo and in vitro approaches for remediation of textile dyes using some fungal, algal and angiospermic plant species.