Mild steel is the most commonly used engineering material of construction in many of the industries. It undergoes corrosion causing huge losses to the economy of any country. In India, the economic losses due to corrosion is around 2-4% of the Gross National Product which works out to a whopping figure of Rs.24,000 crores for the year 1996-1997.

Corrosion of metals in oxygenated aqueous environment is an electrochemical phenomenon in which the metal ions go into solution (anodic reaction), leaving electrons that combine with oxygen to produce hydroxyl ions (cathodic reaction). Corrosion also takes place in anaerobic environments, in which oxygen is replaced by hydrogen ions or water as cathodic reactants. The involvement of microorganisms in metallic corrosion has lead to the question of how the biological agents affect the corrosion process and whether they are able to modify the electrochemical nature of the corrosion.

Bio corrosion or Microbial corrosion or Microbiologically influenced corrosion (MIC) is defined as an electrochemical process where microorganisms are able to initiate, facilitate or accelerate the corrosion reaction. When microorganisms are present in the environment, they produce diverse effects due to their interaction with the environment surrounding the metal surface. As this interaction is very intense, it can be expected that microbial participation in corrosion will be marked by enhanced damage to the metal. Till 1995, it was believed that wherever microorganisms are present at more than $10^4$ cfu/gm, the environment become aggressive. Even though organisms like sulphate reducing bacteria, acid producing bacteria and iron and manganese oxidising/depositing bacteria are generally found to enhance
the corrosion process, there are a host of other microorganisms which can confer corrosion protection under various conditions. So far, not much work has been reported in this regard. Also the mechanistic aspects of corrosion inhibition by bacteria has not been given much attention in literature. Scanning the literature for information reveals the availability of only limited knowledge on inhibition of corrosion by bacteria. Now several researchers are working in this area, but the information on the role of natural biofilm and the influence of individual pure bacterial cultures on corrosion inhibition process are still lacking.

Therefore in the present investigation, an in depth study has been undertaken to identify and investigate the microorganisms which inhibit corrosion and the mechanism of corrosion inhibition by bacterial species. As a prelude to this investigation, the existing knowledge about the microbiologically induced corrosion has been scanned and more than 150 relevant references have been cited. An overview on the subject is presented in Chapter I.

Chapter II deals with the earlier studies carried out on "corrosion inhibition by microorganisms". Only a few papers have been published in this area. Various models proposed with respect to the corrosion inhibition through biofilm covered metal surface have been discussed. And the discrepancies in the existing research are also focused. It is found that only a few bacterial species so far have been subjected to corrosion inhibition studies. Most of the researchers have used pure cultures received from culture collection centres for corrosion inhibition studies leaving a vast scope for further investigation. In the present study, microorganisms have been isolated from the natural biofilm and they have been employed for corrosion inhibition studies.
The objectives of the present work is presented in Chapter III. The primary objective of the present investigation is to propose a more convincing model for corrosion inhibition by bacterial biofilms. Towards this end, the approach will be isolation and identification of pioneering micro organisms that can colonize on mild steel, subsequently the electrochemical behaviour of the isolated bacterial species will be evaluated.

Chapter IV briefly discusses the methodology adopted and the experiments carried out with the aim of understanding the mechanism of corrosion inhibition. The biofilm formed on mild steel was characterized and identified by various biochemical tests (more than 75 tests). The corrosion inhibition studies were carried out using conventional methods like weight loss and potential measurements. Electrochemical behaviour of the isolated bacterial species was studied by employing polarization studies and AC impedance spectroscopic method. The type and pattern of surface film formed on the steel with various bacterial species were characterized by making use of X-ray diffraction (XRD) and Fourier transform infrared spectroscopic (FTIR) studies. The composition of extracellular polymeric substances of various bacterial species were also characterized by using sophisticated techniques like Gas chromatography (GC). The pattern of bacterial attachment and the surface topography of the metal surface along with various bacterial species were examined under Scanning electron microscope (SEM). The contour mapping of the extracellular polymeric matrix of various bacterial species were also analysed by Fourier transform infrared microscopy (FTIRM).

The results are discussed in Chapter V. The weight loss studies revealed that to some extent the natural biofilm itself inhibits the corrosion. Moreover the natural biofilm tends to
shift the open circuit potential towards positive direction with time. The polarization studies also reveal that the corrosion current in presence of natural biofilm is less than that of the control system. The $R_{ct}$ values calculated from impedance studies of the natural biofilm are also high compared to control system.

In the present investigation as many as 65 isolates have been isolated a predominant eleven bacterial species such as *Alcaligenes* sp, *Pseudomonas* sp, *Chromobacterium* sp, *Vibrio* sp, *Bacillus* sp, *Acinetobacter* sp, *Brochothrix* sp, *Kurthia* sp, *Actinomycetes* sp, *Micrococcus* sp, and *Staphylococcus* sp were subjected to detailed investigation.

The performance grading of the eleven bacterial species was evaluated based on the durability factor. The durability factor is in three distinct ranges. *Bacillus* sp, *Micrococcus* sp, *Pseudomonas* sp, *Actinomycetes* sp and *Kurthia* sp show a durability factor in the range of 5.7 to 7. *Staphylococcus* sp, *Acinetobacter* sp, *Alcaligenes* sp and *Vibrio* sp show a durability factor in the range of 8 to 9.4. *Brochothrix* sp and *Chromobacterium* sp show a highest durability factor of 13.42.

The polarization measurements of eleven bacterial species indicate that the bacterial species shift the open circuit potential in more negative side upto three days later tends to move in the positive direction. The $B_a$ and $B_c$ values decreases with time where as sterile control system it increases with time. Moreover the polarization is low leading to lower corrosion current density.
The $R_{ct}$ values of most of the isolates ranging from 2700 to 25000 ohm.cm$^2$. The resistance values vary from organism to organism. The pH and Dissolved oxygen content decreases with time.

The nature of film formed on the metal surface was characterized by XRD and FTIR spectroscopy. The XRD data reveals that the biofilm is amorphous in nature.

The FTIR spectroscopic studies revealed that the biofilm shows a distinct peaks which corresponds to the functional groups of fatty acids, amino acids and polysaccharides. Probably the bacterial secreted products are mainly organic in nature which bind with the metal surface and form organometallic complexes.

The chemical composition of extra cellular polymer matrix released by the microorganisms are characterized and the results are correlated with the electrochemical studies. The contour mapping of the biofilm of selected bacterial species was compared with control system.

The Scanning electron microscopy of various bacterial species show that there is no pits observed in presence of these species. Besides, the biopolymer matrix was found to uniformly cover the entire steel surface. The morphology of various bacterial species were also visualised.

When considering this microbial mechanism of corrosion inhibition, it must be highlighted that bacterial metabolism induces complex modifications of the environment, not only through changes in pH, but also through oxygen consumption and production of
metabolites, and cellular lyses compounds. Based on the present investigation a model has been proposed for bacterial attachment and inhibition of corrosion.

Chapter VI presents the elaborate discussion of the results and are compared to earlier reported values.

Thus this investigation has led to a fresh understanding of the corrosion inhibition of mild steel by various bacterial species. In this context, the present investigation has immense potentials in opening up new vistas for further research.