Review of literature

Modi, (1996). From all the pollution, the most dangerous is the industrial waste which contains a wide variety of organic and inorganic pollutants which includes recalcitrant xenobiotics, and carcinogenic compounds, cyanides, heavy metals and radionuclides.

Pazirandeh, et. al. (1998) The discharge of heavy metals into the environment due to agricultural, industrial and military operations and the effect of the pollution on the ecosystem and human health are matter of concern.

Vieira and Volesky. (2000) Modern industry is to a large degree answerable for contamination of the environment. Lakes, rivers and oceans are being overwhelmed with bacteria and waste matter. Among toxic substances reaching dangerous levels are heavy metals. Metal pollution is a global concern. The levels of metals in all environments including air, water and soil are increasing in some cases to toxic levels. Metals are introduced into the environment from various sources, during mining and refining of metal ores. The rapid expansions of industry and increases in domestic activities in the past century have caused a concomitant increase in the quantities of metals that are being released to the environment.

Roane and Pepper. (2000) The natural recycling of some metals that generally occurs in biogeochemical cycles has been disrupted as a result of the large quantities of metals and pollutants that are currently entering the environment from various sources. Toxic or carcinogenic at high concentration, Copper, Zn, Mn, Fe, Ni, Cd, Cr, Co, Pb and Hg concentration was found in surface water in the Neyveli area.

Khan, et al. (2005) Heavy metal contamination in the natural reservoirs (Peria, Kolakudi, Walaza and Perumal ponds and the Paravannar river) is mainly due to the discharge of untreated mine water, fly ash pond water and effluents from associated industries. Heavy metal analysis of mine water, fly ash pond and industrial effluents and the natural reservoirs reveals that Co, Cr and Hg are above the recommended irrigation water quality standards in 17%, 75% and 100% of the samples, respectively.

Ganga, the most sacred and important river of India, is regarded as the cradle of Indian civilization. About 2506 km of the river stream gives life to twenty-nine cities, seven towns and thousands of villages which are contaminating the river by over 1.3 billion L waste water per day. Among the inorganic contaminants of the river water, heavy metals are getting importance for their non-degradable nature and often accumulate through tropic level causing a deleterious biological effect.
Bruins, et al. (2000) Though some of the metals like Cu, Fe, Mn, Ni and Zn are essential as micronutrients for life processes in plants and microorganisms, while many other metals like Cd, Cr and Pb have no known physiological activity, but they are proved detrimental beyond a certain limit which is very much narrow for some elements like Cd (0.01 mg/L), Pb (0.10 mg/L) and Cu (0.050 mg/L).

Fig 1 Locations of the monitoring stations on river Ganga in west bengal

FAO. (1975) The river water exhibited a slightly alkaline pH and the conductivity apparently increased along the downstream due to the tidal effect of Bay of Bengal. The observed pH of the river water was well within the safe limit for drinking as well as for crop production.
Shah, et.al. (2005) The relative dominance of the heavy metals in water was observed in the following sequence: Fe > Mn > Ni > Cr > Pb > Zn > Cu > Cd. The highest concentrations of most of the heavy metals (Fe, Zn and Cu) at Palta may be due to the discharge of heavy metal loaded industrial waste water. Except for Fe and Mn, the concentrations of other metals in the Ganga water were lower than the observed metal concentrations of the river Bhadra at Karnataka and of the river Purna.

Jain. et al., (2004) The metal pollution in water and sediment of the river Hindon in western Uttar pradesh (India) was assessed for Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn. The metal concentrations in water showed wide temporal variations compared with bed sediment because of variability in water discharge and variations in suspended solid loadings, Santagarh and Atali being the most polluted sites of the river.

Singh, (2001) The Yamuna river sediments collected from Delhi and Agra urban centers, were analyzed for concentration of heavy metals. Total metal contents varied in the following ranges (in mg/kg): Cr (157-817), Mn (515-1015), Fe (28,700-45,300), Co (11.7-28.4), Ni (40-538), Cu (40-1204), Zn (107-1974), Pb (22-856) and Cd (0.50-114.8). In the total heavy metal concentration anthropogenic input contains 70% Cr, 74% Cu, 59% Zn, 45% Pb, 90% Cd in Delhi and 61% Cr, 23% Ni, 71% Cu, 72% Zn, 63% Pb, 94% Cd in Agra. Based on Muller’s geoaccumulation index, the quality of the river sediments can be regarded as being moderately polluted to very highly polluted with Cr, Ni, Cu, Zn, Pb and Cd in the Delhi and Agra urban centers.

Shrivastava, et al.(2003) Shahpuralake, Bhopal (India) receives untreated domestic sewage from residential areas in Bhopal city. The concentration of some of these metals including iron and manganese were within acceptable limits, whereas others including chromium, nickel, zinc and lead were not within acceptable water quality limits. The metals ranged from the non polluted to the heavy pollution.

Golden corridor, Gujarat

Horton, et al., (2006) Valsad, the southernmost district in Gujarat has been known as the fruit basket of Gujarat because of its Mango, Guava, Chikoo, Coconut etc. plantations and for its highly productive rice fields. The district has attracted large investment in chemical industries with formation of Vapi Industrial Estate in 1967, and other chemical and pulp-paper mills in the locality.
Now, the district is known for its industrial development, heavy pollution and diminishing agricultural products. The Gujarat Pollution Control Board started monitoring Bil Khadi after 1995 and even its annual average readings are way beyond its own norms, still nothing is done. The petitions tried to highlight the most serious environmental problems along the 200 km corridor from Vapi (District Valsad, state Gujarat) to Nandesari (District Baroda, state Gujarat) that forms the worst affected segment of the 400 km long 'Golden corridor'. This is where “Paryavaran Suraksha Samiti” has focused attention over the last couple of years and parts of the effluents received by Damanganga, Gujarat are from the common effluent treatment plant and still the river is red, foaming and stinking all the way to the estuary!

V. Shukla et al.,(2009) In Ankleshwar a preliminary survey of a part of the slum colonies showed 55 out of 65 hand pumps and bore wells had yellow to red colored water, some of which were either acidic or smelt of unknown chemicals. Analysis of the samples showed high levels of nitrate and fluoride in the groundwater. Hazardous solid waste has been indiscriminately dumped on open spaces, around water bodies without
any concern about their impact on the local water soil or living organisms. All chemicals are or can be harmful; even the most innocuous of the substances when taken into the body in sufficient quantities, may lead to undesirable, if not distinctly harmful effects. It follows, therefore, that the degree/intensity of the injurious effects produced by a toxicant, is determined by two factors:

1. Concentration of the toxicant at the site of action.
2. Length of exposure of a susceptible site to the toxicant.

In both these factors, the former has given rise to the concept of ‘dose’ and experimental toxicology and the later to the classification of exposures to toxicants as acute, sub acute or sub chronic and chronic types. Several pollutants on single or repeated exposures affect various organs. These are known as the target organs.

Table 1: Common industrial units releasing heavy metals into water bodies.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Common sources</th>
</tr>
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<tbody>
<tr>
<td>Chromium</td>
<td>Chrome plating, petroleum refining, electroplating industry, leather, tanning, textile manufacturing and pulp processing units. It exists in both hexavalent and trivalent forms.</td>
</tr>
<tr>
<td>Nickel</td>
<td>Galvanization, paint and powder, batteries processing units, metal refining and super phosphate fertilizers.</td>
</tr>
<tr>
<td>Lead</td>
<td>Petrol based materials, pesticides, leaded gasoline, and mobile batteries</td>
</tr>
<tr>
<td>Copper</td>
<td>Electroplating industry, plastic industry, metal refining and industrial emissions.</td>
</tr>
<tr>
<td>Zinc</td>
<td>Rubber industries, paints, dyes, wood preservatives and ointments.</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Batteries, electroplating industries, phosphate fertilizers, detergents, refined petroleum products, paint pigments, pesticides, galvanized pipes, plastics, polyvinyl and copper refineries.</td>
</tr>
<tr>
<td>Iron</td>
<td>From metal refining, engine parts.</td>
</tr>
<tr>
<td>Aluminium</td>
<td>Industries preparing insulated wiring, ceramics, automotive parts, aluminum phosphate and pesticides.</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Automobile exhaust/industrial dust, wood preservatives and dyes.</td>
</tr>
<tr>
<td>Mercury</td>
<td>Electric/light bulb, wood preservatives, leather tanning, ointments, thermometers, adhesives and paints.</td>
</tr>
</tbody>
</table>
Parayavarsurkhshasamiti, (2000) The literature survey discussed in the preceding text has shown that the research of Indian scenario, in Gujarat, Ankleshwar along with Vapi is a pollution hot spot and would rank among the dirtier places in the world.

Zayed and Terry, (2003) These areas became most toxic zones due to the industrial waste released by the chemical plants and other industries existing in different cities of Gujarat viz. Ankleshwar, Bharuch Panoli, Vadodara, Valsad, Vapi, Vatva-Ahmedabad. The entire industrial zones are known as Golden Corridor for pollution in Gujarat.

The main aim behind the entire research study was to analyze the existing scenario of metallic pollutant in Golden Corridor, through modern techniques to decrease its toxicity and to define remediation technologies which are easier and cheaper than the existing costly conventional methods.

Asha Lata Singh, Viti, et al., (2003) Metallic chromium and salts are commonly used in industry in a variety of chemical processes. It is used in electroplating industry where it oxidizes electroplated metal surfaces to offer smooth, shiny and clean finishes. Some other products which contain chromium include paints, pigments, inks, fungicides, wood preservatives, rubber ceramics, photography and textiles from where it is discharged into natural water bodies of water and lands. The tanning industry is an especially large contributor of chromium pollution to water resources.


Asha latasingh; Camargo, et al., (2003) However these procedures have disadvantages such as incomplete metal removal, high reagent or energy requirements or generation of toxic sludge and are generally very expensive to operate at low concentrations present in the waste waters hence are not economically feasible.

Nickel is a chemical element with chemical symbol Ni and atomic number 28. It is silver white, hard, malleable, & ductile metal. It is lustrous metal with slight golden tinge. It belongs to the transition metals. It is fairly good conductor of heat & electricity.

Kittle, (1996) Nickel is a nutritionally essential trace metal for at least several animal species, micro-organisms and plants, and therefore either deficiency or toxicity symptoms can occur when, respectively, too little or too much Ni is taken up.
Evgeny, (1997) Pure nickel shows a significant chemical activity that can be observed when nickel is powdered to maximize the exposed surface area on which reaction can occur, but larger pieces of the metal are also slow to react with air at ambient conditions due to the formation of the protective oxide surface.

Fordsmand, (1997.) Nickel and nickel compounds have many industrial and commercial uses, and the progress of industrialization has led to increased emission of pollutants into ecosystems. These facts make it necessary to look for new economic and practical alternative treatment methods. Microbial chromium and selenium removal is gaining wide attention and may provide and efficient as well as economically feasible alternative to the conventional treatment processes.

**Bioremediation:**

**Bioremediation** is a waste management technique that involves the use of organisms to remove or deactivate pollutants from a tainted site. According to the EPA, bioremediation is a “treatment that uses naturally occurring organisms to break down hazardous substances into less toxic or nontoxic substances”. Technologies can be commonly classified as *in situ* or *ex situ*. *In situ* bioremediation involves treating the polluted material at the site, while *ex situ* involves the deletion of the polluted material to be treated elsewhere. Some examples of bioremediation related technologies are phytoremediation, bioventing, bioleaching, land farming, bioreactor, *composting*, bio augmentation, rhizofiltration, and bio stimulation.

Camargo, *et al.*, (2003) The technology of bioremediation using microorganisms to clean and treat impurities in the environment is in use since 600 BC. In ancient times, Romans use to direct wastewater into large pits or tanks outside the city and wastewater treatment was carried out by microbial activities. This was considered to be the unpredicted first start for applying bioremediation.

Environmental regulations were progressively established whereas such a rapid modification trend could not continue without disturbance. Comparing the presentation of various methods applied to clean up the environment from diverse types of pollutants as well as seeking for cheap and justifiable methods leads to advancement of bioremediation technology.
The traditional techniques used till now for remediation used to dig up contaminated materials and remove it to a landfill, or to cap and contain the contaminated areas of a site. The methods have some drawbacks. The first method simply moves the impurity elsewhere which may create substantial risks in the excavation, management, and transport of dangerous material. In addition to it, it is also very difficult and expensive to find new sites for the disposal of the hazardous material. This is only the provisional solution because the contamination remains on site which will increase the cost of monitoring and maintenance of the isolation. Hence keeping all this in view a better method than these traditional methods is to completely terminate the pollutants, or at least to transform them into the harmless substances. Some tools which can be used are high-temperature burning and chemical decomposition. They can be very operational in reducing levels of contamination, but has numerous drawbacks, the main is their technological complexity, high cost in respect of small scale application, also unacceptable by public at large, especially for burning that may increase the contact to pollutants by nearby residents & workers.

Ackerley, et al., (2004) Hence keeping above option in mind, option that offers the possibility to destroy or purify various harmless pollutants using natural genetic activity is Bioremediation. Method is low at cost, low at technology techniques, and also have
high public acceptance and can also be carried out on site. It is not necessary that it is always helpful but methodologies used are not technically complex, only considerable experience and skill may be required to form a plan and to implement a successful bioremediation program. As bioremediation technique seems to be a good alternative to conventional method, technologies research in this field, especially in the United States, rapidly increasing. Bioremediation has been used at a number of sites worldwide, including Europe, with varying degrees of success.

With the increase in use of bioremediation, techniques & expertise are increased and great knowledge is gained. Hence there is no doubt that bioremediation has great potential in dealing with the contamination of certain kinds such soil, water etc. Unfortunately, as this method is not widely used the site owners & regulators are unaware of the principals, techniques, advantages & disadvantages.