CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Human activity generates enormous amount of waste materials. Such materials are disposed through various methods amounting to components of environmental pollution. Pollution is defined as an undesirable change in physical, chemical and biological characteristics of air, water or soil that may be harmful to human and other lives. Pollution has become a major hazard for the nature. Immense development in the field of science and technology made man to violate the rules of the Nature. Man made industries play a major role in contaminating the nature (Hodges et al 1973).

1.2 POLLUTION

Pollution is the discharge of toxic materials into the environment that becomes harmful to the human health and ecosystem. Pollution started from prehistoric times when man created the first fires. According to an article of 1983 in a journal, Science; "soot found on ceilings of prehistoric caves provides ample evidence of the high levels of pollution that was associated with inadequate ventilation of open fires” (Spengler et al 1983). Pollution causes disturbances in an ecosystem, which may manifest themselves into a chain of adverse reactions, often very complex in nature. Based on the nature, pollution may be of four types namely,
1. Air Pollution
2. Water Pollution
3. Soil pollution or soil contamination
4. Noise Pollution

1.3 HAZARDS OF POLLUTION

Health of human and other lives may be affected either directly or indirectly by soil contamination or pollution. The chemical pollutants are diverse in nature which may originate from industrial, commercial, agricultural and radioactive wastes. They may be solvents, heavy metals, minerals, nitrogenous substances, dyes, pigments, biocides, organic compounds and radioactive substances. Chemical pollutants do not only affect the human health, but also has indirect effect of accumulating when aquatic life is consumed by humankind (Brij 1999). The overview of main health effects on humans from pollution is shown in Figure 1.1.

![Health effects of pollution](image)

**Figure 1.1 Main health effects on humans from pollution**
Adverse air quality can kill many organisms including humans. Ozone pollution can cause respiratory disease, cardiovascular disease, throat inflammation, chest pain, and congestion. Water pollution causes death mostly due to contamination of drinking water by untreated sewage in developing countries.

Oil spills can cause skin irritations and rashes. Noise pollution induces hearing loss, high blood pressure, stress, and sleep disturbance. Mercury has been linked to developmental deficits in children and neurologic symptoms. Older people are majorly exposed to diseases induced by air pollution. Those with heart or lung disorders are under additional risk. Children and infants are also at serious risk. Lead and other heavy metals have been shown to cause neurological problems. Chemical and radioactive substances can cause cancer and as well as birth defects.

Pollution has been found to be present widely in the environment. There are a number of effects of this:

- Carbon dioxide emissions cause ocean acidification, the decrease in the pH of oceans continues as CO$_2$ is dissolved.
- The emission of greenhouse gases leads to global warming which affects ecosystems in many ways.
- Smog and haze can reduce the amount of sunlight received by plants to carry out photosynthesis and leads to the production of tropospheric ozone which damages plants.
- Sulfur dioxide and nitrogen oxides can cause acid rain which lowers the pH value of soil.
- Soil can become infertile and unsuitable for plants. This will affect other organisms in the food web.
1.4 AIR POLLUTION

Air pollution refers to the introduction of chemicals, particulates or biological materials into the atmosphere that cause discomfort, disease, or death to humans, damage other living organisms such as food crops, or damage the natural environment or built environment.

Exposure to urban air pollution is one of several environmental and public health concerns currently confronting the World's population (Bickerstaff & Walker 2001). Several studies have established an association between air pollution and health effects (Leem et al 2006; Pope 2007). Exposure to air pollution leads to adverse health effects ranging from respiratory illness to chronic illness such as cancer, adverse pregnancy outcomes and premature death.

A substance in the air that can be harmful to humans and the environment is known as an air pollutant. Pollutants can be in the form of solid particles, liquid droplets, or gases. In addition, they may be natural or man-made. Pollutants can be classified as primary or secondary. Usually, primary pollutants are directly produced from a process, such as ash from a volcanic eruption, the carbon monoxide gas from a motor vehicle exhaust or sulphur dioxide released from factories. Secondary pollutants are not emitted directly. Rather, they form in the air when primary pollutants react or interact. An important example of a secondary pollutant is ground level ozone, one of the many secondary pollutants that make up photochemical smog. Some pollutants may be both primary and secondary: that is, they are both emitted directly and formed from other primary pollutants like Sulphur oxides, Nitrogen oxides, carbon monoxide, volatile organic compounds, toxic metals, particulates, chlorofluorocarbons, radioactive pollutants and so on (Vallero 2008).
1.5 NOISE POLLUTION

Noise pollution is displeasing or excessive noise that may disrupt the activity or balance of human or animal life. The word noise is cognate with the Latin word nausea, which means disgust or discomfort. The source of most noise worldwide is essentially caused by motor vehicles, aircrafts, trains, and machines. Outdoor noise is summarized by the word environmental noise. Poor urban planning may give rise to noise pollution, since side-by-side industrial and residential buildings can result in noise pollution in the residential areas. Excessive exposure to noise might be considered a health risk in that noise may contribute to the development and aggravation of stress-related conditions such as high blood pressure, coronary disease, ulcers, colitis, and migraine headaches (Sheng et al 2011). High noise levels can contribute to cardiovascular effects in humans, a rise in blood pressure, and an increase in stress and vasoconstriction, and an increased incidence of coronary artery disease. In animals, noise can increase the risk of death by altering predator or prey detection and avoidance, interfere with reproduction and navigation, and contribute to permanent hearing loss.

Noise can have a detrimental effect on wild animals, increasing the risk of death by changing the delicate balance in predator or prey detection and avoidance, and interfering with the use of the sounds in communication, especially in relation to reproduction and in navigation. Acoustic overexposure can lead to temporary or permanent loss of hearing.

1.6 WATER POLLUTION

Water pollution is described as the condition of bodies that contain various elements in it. Water is identified as pure water, clean and contaminated based on the elements contained in it. Pollution occurs when pollutants affect the quality of the water involved. Contamination includes...
any form of environmental changes caused by human action that ultimately produce negative effects (Hodges 1973). Water is called polluted only when it is not able to be used for what one wants it to be used. Water pollution has many causes and characteristics.

Contamination problems vary from region to region, are influenced by climate, population density, intensity of the industrial and agricultural activities. The specific contaminants leading to pollution in water include a wide spectrum of chemicals, pathogens, and physical or sensory changes such as elevated temperature and discoloration. While many of the chemicals and substances that are regulated may be naturally occurring; the concentration is often the key in determining what is a natural component of water, and what is a contaminant. High concentrations of naturally occurring substances can have negative impacts on aquatic flora and fauna.

Many of the chemical substances are toxic. Pathogens can produce waterborne diseases in either human or animal hosts. Alteration of water's physical chemistry includes acidity (change in pH), electrical conductivity, temperature, and eutrophication. Eutrophication is an increase in the concentration of chemical nutrients in an ecosystem to an extent that increases in the primary productivity of the ecosystem.

1.7 SOIL CONTAMINATION

Mining operations and industrial activities are causing serious damage to terrestrial and aquatic environments and are a main source of environmental pollution. In many cases, these activities have led to the major pollution and contamination problems that are found today. Organic substances and heavy metals can be present for extended periods in soils, groundwater, lakes or stream bed sediments. Also, these pollutants in soils and sediments have a direct impact on aquatic systems and water quality,
particularly in areas subjected to severe contamination. These contaminants in high concentrations are considered to affect wildlife, causing eggshell thinning, tumors and other deformities. Elevated concentrations of pollutants in aquatic environments and soils are known to endanger ecosystems and introduce a potential risk to human health. Lead and some heavy metals (e.g., As, Cd, Cu, Zn) in high concentrations have an adverse effect on human health, causing profound biochemical changes in the body and affecting the central nervous system (Saint-Laurent et al 2010).

Soil contamination is the presence of man-made chemicals and other alteration in the natural soil environment. This type of contamination typically arises from the rupture of underground tanks, application of pesticides, and percolation of contaminated surface water to subsurface strata, leaching from landfills, direct discharge of industrial wastes to the soil. The most common chemicals are petroleum hydrocarbons, solvents, pesticides, heavy metals like lead, iron etc. Occurrence of this phenomenon is correlated with amount of chemical usage and degree of industrialization. The concern over soil contamination originates from both primary and secondary contamination of water supplies.

Soil contamination or soil pollution is caused by the presence of xenobiotic (man-made) chemicals or other alteration in the natural soil environment. It is typically caused by industrial activity, agricultural chemicals, or improper disposal of waste. The most common chemicals involved are petroleum hydrocarbons, polynuclear aromatic hydrocarbons, solvents, pesticides, lead, and other heavy metals. Contamination is correlated with the degree of industrialization and intensity of chemical usage.

The role of heavy and trace elements in the soil system is increasingly becoming an issue of global concern at private as well as governmental levels, especially as soil constitutes a crucial component of
rural and urban environments. Agricultural soil contamination with heavy metals through repeated use of untreated or poorly treated wastewater from industrial establishments and application of chemical fertilizers and pesticides is one of the most severe ecological problems in Bangladesh. Although some trace elements are essential in plant nutrition, plants growing in the close vicinity of industrial areas display increased concentration of heavy metals, serving in many cases as biomonitor of pollution loads (Mingorance et al 2007). Heavy metals and trace elements are also a matter of concern due to their non biodegradable nature and long biological half-lives. Wastewater from industries or other sources carries appreciable amounts of toxic heavy metals such as Cd, Cu, Zn, Cr, Ni, Pb and Mn in surface soil which create a problem for safe rational utilization of agricultural soil (Luo et al 2012). Contaminants typically alter plant metabolism, often causing reduction in crop yields. This has a secondary effect upon soil conservation, since the languishing crops cannot shield the Earth's soil from erosion. Some of these chemical contaminants have long half-lives and in other cases, derivative chemicals are formed from decay of primary soil contaminants.

Soil usually acts as a protective barrier for more sensitive media such as water and organisms by filtering, decomposing, neutralizing or storing contaminants. Hence, it substantially reduces their bioavailability. The purifying ability of soil depends on its contents in organic matter, carbonates, and Fe-Mn oxyhydroxides, as well as on its clay content and mineralogical composition, cation exchange capacity, pH, texture, permeability and microbial activity. Therefore, the purifying power of soil has a limit for each substance. If this limit is exceeded, the soil becomes contaminated (Cheng et al 2001).
Soil contamination can be caused by:

- Application of pesticides and fertilizers
- Industries and Mining
- Oil and fuel dumping
- Disposal of coal ash
- Leaching from landfills
- Drainage of contaminated surface water into the soil

1.8 IMPACT OF INDUSTRIALIZATION ON THE ENVIRONMENT

Chemical and metallurgical industries are the most important sources of heavy metals in the environment (Cortes et al 2003). Rapid industrialization and the global economic changes contribute to existing environmental challenges. Human activities have an impact on the overall quality of the environment due to greenhouse gas emissions and the release of complex chemical pollutants into the air, water and land. On the other hand, the diversity and complexity of synthetic chemicals have increased substantially since the industrial revolution. Similarly, both the volume and variety of pollutants that are released into the environment have equally increased in recent decades. In regulating the distribution of these pollutants, various government agencies have established standards for controlled emissions as well as the application of biocides in agriculture (Wan 1994; Arfsten et al 1996). However, these pollutants usually occur in nature as complex mixtures that are prone to impacts of environmental factors, thereby contributing to their bioavailability, toxicity and elimination of exposed
organisms. Some of the newly emerging pollutants, including 22 nanoparticles are generally recalcitrant and take a longer time to undergo transformation or complete degradation. Ecological health is commonly used to predict the consequences of human exposure to potentially harmful chemical pollutants. Given the recent advancement in science, new ways of looking at the global threats from potentially harmful pollutants have continued to evolve. There is increasing interest in assessing the adverse effects under realistic environmental scenarios.

In recent years, the issue of environmental quality and its effect on people’s health and well-being have gained importance in academic research. The pollution associated with particular industrial sites can have negative effects on health of individuals who live nearby residential areas. Beyond the awareness of residents about the cause-effect relationship between pollution and specific diseases, the potential exposure to contaminants contributes to undermine citizens’ welfare and quality of life. Consequently, the risk assessment in populations exposed to these hazards is an essential element in understanding health and welfare of citizens, and that assessment has not received adequate attention in the literature. Moreover, proper management of environmental risks is critical, especially if we consider the potential for effective mitigation of psychosocial effects through the environmental (risk assessment) policy process (Lopez-Navarro et al 2013). As Cutchin et al (2008) suggest, “Active industrial sites, particularly those producing petrochemical products, are associated with increased stress and self-reported illness, psychosocial anxiety and distress and often translate physiological stress into a wide range of effects on health and well-being”.

1.9 ANALYTICAL METHODS FOR STUDIES ON POLLUTION

There is a growing necessity for the pollution control and the methods to assist as diagnostic tool for determining the degree of pollution. There are various methods like Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES), Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES), Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS), Atomic Absorption Spectroscopy (AAS), Flame Photometry, Fourier Transform Raman Spectroscopy (FT-Raman), Fourier Transform Infrared spectroscopy (FT-IR), Thermal analysis, X-ray diffraction (XRD), Scanning Electron Microscopy-Energy Dispersive X-ray (SEM-EDX), X-ray Fluorescence Spectroscopy (XRF), Mossbauer spectroscopy, Magnetic studies etc.

Infrared spectroscopy is the oldest and most commonly used method for identifying either organic or inorganic chemicals providing specific information on molecular structure, chemical bonding and molecular environment (Simonescu 2012). X-ray diffraction analysis is the best and easily available technique for the identification and semi-quantification of all minerals present in the clay. The utility of scanning electron microscopy, combined with energy dispersive spectroscopy of surface texture to decipher different sedimentary elements has now been very well established (Marathe 2012). X-ray fluorescence (XRF) allows determination of elemental concentration in samples of various forms and nature. Thermal Analysis is used for the material characterization in pollution studies. Physico-chemical analysis of soil involves the measurement of various physical properties through a study of the relation between the physical properties of soil and its composition.
1.10 LOCATION OF STUDY AREA

Tirumalarajanpattinam is a census town and commune in Karaikal District of Puducherry State, India. Tirumalarajanpattinam is situated at a distance of 6 kilometers in the south of Karaikal Municipality. Geographic coordinates: 10.8678° N, 79.8283° E.

The hot and moisture climate supports thorny and xerophytic vegetation. The area has dry summer from March to June and monsoon season prevails from October to mid-December. The average temperature is around 30°C, with high humidity. Due to proximity to the sea, the climate remains humid throughout the year.

An industrial zone is located in the South side of Tirumalarajanpattinam shore. River Piravidayanaru is flowing in East-Westerly direction across this industrial area to confluence in the Bay of Bengal.

There are more than 30 industries with products namely, fertilizers, chemicals, petrochemicals, smelters and metal processing. A major port is engaged in chemical shipments and a thermal power station is located in the neighborhood. The location of sampling area at Tirumalarajanpattinam, Karaikal are shown in Figures 1.2 and 1.3.
Figure 1.2 Location of Karaikal
Figure 1.3 Location of sampling area at Tirumalarajanpattinam, Karaikal

1.11 OBJECTIVE OF THE RESEARCH

The rapid pace of industrialization has made soil ecosystem as one of the worst hit victims. It is the time to recognize that the economic and social development depend on the protection of the environment and reduction of human and industrial impact. Environmental problems like, soil contaminations pose major threats to human safety, health and productivity. The need to take actions to sustain soil is pressing and challenging. There is a growing necessity for the pollution monitoring and hence, for the methods to assist as diagnostic tools for determining the degree of pollution. Soil is one of the important and valuable resources of the Nature. All living beings are
directly and indirectly dependent on soil for day to day needs and 95% of the human food is derived from the earth.

Thirty six soil samples were collected from the above industrial area with standard procedure and subsequently subjected to various spectrometric and analytical methods for the assessment of contamination.

The present work deals with various techniques like; FT-IR, WD-XRF, XRD, SEM-EDX, TG-DTA and Physico-Chemical methods, which are necessary to give the possible explanation for the contamination of soils in and around Tirumalarajanpattinam, Karaikal.

The objective of investigations and their results has been presented in the text of this Thesis which has been organized into eight chapters as follows:

- Chapter 1. To give basic knowledge about the sources of pollution, types of pollution and its adverse effects.

- Chapter 2. To find the physico-chemical parameters of soils and to discuss the results.

- Chapter 3. To analyse quantitatively on elements, like aluminium, calcium, chlorine, iron, iodine, potassium, magnesium, sodium, lead, silicon, titanium and zinc in soils using Wavelength dispersive-X-ray fluorescence spectroscopy (WD-XRF) and to discuss the results.

- Chapter 4. To identify and quantify the majority chemical constituents of soils by using FT-IR spectral study.
• Chapter 5. To identify the minerals of soil with Powder X-ray Diffraction (XRD) analysis and to discuss on results.

• Chapter 6. To identify the elemental status of soils and also to study their morphology using Scanning Electron Microscopy with Energy Dispersive X-ray (SEM with EDX) method.

• Chapter 7. To carry out thermal analysis of soils, using thermo gravimetric analysis (TGA) and differential thermal analysis (DTA) and to calculate the mass loss, to confirm chemical constituents of soil.

• Chapter 8. To summarise the Thesis and to give conclusion of the research.