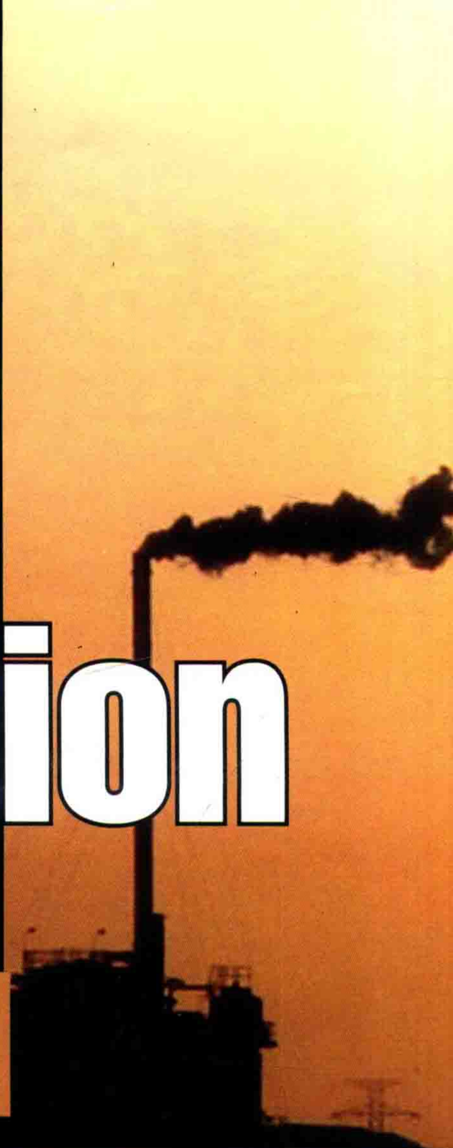
Textile Pollution



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Preface

Environmental pollution by heavy metals such as cadmium, nickel, zinc, lead, copper etc., is accelerated dramatically during the last two decades due to mining, use of agricultural fertilizers, pesticides, traffic emissions, smelting, manufacturing, municipal wastes, industrial effluents and chemicals. Industrial effluents are the waste products include liquid, solid and gaseous waste resulting from industrial processing operation. Liquid waste adversely affect the wastes supply and sewage of towns and cities while a high quantity of water is required for different industrial processes, only a small fraction of it is incorporated in their products, the rest finds its way into the wastewater course. This greatly contributes to the pollution problems to surface water, groundwater, agriculture soil and sediments.

The textile industry provide high economic sources to generate the income and job opportunities to the all strata of human society but the textile industry also play a vital role to deteriorate the surrounding groundwater quality in various manners. The textile effluents have consisting high concentrations of heavy metals, organic pollutants and toxic colours, which may alter the surface water quality of the surrounding environment. Toxic pollutants may percolate down via soil profile and reach in groundwater and agriculture soil through irrigation by wastewater of industrial zone.

The purpose of writing this book is to arrange the available matter and research findings in a comprehensive manner for easy understanding to the research scholars. The book is designed primarily for research scholars providing the fundamental research on the accumulation pathway of heavy metals from industrial effluents to different trophic levels of existing environment in relation to environmental pollution standards and health hazards.

Contents

Chapter 1

Introduction

In the last two decades, the rapid growth of industrialization and urbanization has created negative impacts on the environment. The industrial, municipal and agricultural wastes containing pesticides, insecticides, fertilizers residues, organic pollutants and heavy metals in their effluents have been polluted surface and groundwater. In India, the industrial effluents have contributed a major source of pollution. In the modern industrial era, rapidly growing of industrialization and urbanization has posed adverse impacts on the environment and its all components. Air, soil and water everything on earth surface may changed its quality due to the increasing pollution. Also the underground water resources may affect after a long time by continuous pollution condition.

In modern industrialization period, the most of water resources have affected enormously by seepage, leaching and intermixing of industrial effluents in maximum metropolitan cities and industrial townships. The effluents have consisting high concentrations of heavy metals, organic pollutants and toxic colours, may alter the water quality of the region and ultimately causes the health hazards among livestock and human being.

Water is one of the prime necessities of life. We can hardly live for a few days without water. Water has become an essential commodity for the development of industries and agriculture (Kudesia, 1992). Water is one of the widely distributed and abundant substance found in the nature it covers about 75 per cent of the earth surface therefore earth is sometimes called a "water planet" water is in sea, river, ocean, pond, streams and even in the atmosphere in the form of humidity. Most of the earth surface water is in the sea, the ocean contain about excessive quantities of salts. Fresh water is in lakes, ponds, rivers and steams. Fresh water is also available in the forms of rain, snow, dew etc. The Earth's atmosphere contains 0.02 to 4 per cent water by volume, depending on the location. In addition to providing sources for precipitation, atmospheric water vapors intercept some of the ultraviolet radiation and intercept heat loss from the earth sand redirect part of it to the Earth.

The available natural freshwater resources today are threatened by hazard of pollution particularly rivers are greatly polluted due to release of untreated effluents and waste material from agriculture practices and industries located around water bodies. The poor living conditions of people in settlement around water bodies or rivers, non-availability of treatment from urban areas and negligence of industries for treatment of effluent before release of natural water bodies are the major reason of pollution of Indian rivers and other water bodies like ponds, lakes, etc.

Drinking water are obtained from all sorts of sources, some good, some not well, some bad and some outright dangerous. These are reflected in the health, vitality and longevity of people. Since one gulp water and it is taken straight into the body its cleanliness is vitally important. It should be free from pathogens, it should not contain excessive amount of salts and toxic elements. Scientifically, distilled water is the cleanest, but it is not good drinking water. Water is the mostly used for industrial, municipal and agricultural purpose. The quantity and quality of available water are very important for the purpose of industries. Each industry has its own water requirements and sometimes adequate supply of water may be very suitable for one industry but the same may be dangerous for other. It is therefore, extremely important to take into account the use of water to be carried out and its suitability based on the result of chemical analysis.

1.1 Pollution Aspects

As we know our life depends upon water and man needs water for his drinking and other domestic and industrial processes. With the fast increasing in our industrial civilization, the demand for water is increasing tremendously day-by-day. Although water pollution is an age old problem but in this modern age, the problems like population increase, sewage disposal, industrial waste, radioactive waste etc. have polluted our water resources so much so that about 70 per cent rivers and streams not only in India but of all the countries contain polluted waters (Kudesia, 1992). The industrial effluents and trade waste of pulp and paper, distillery, fertilizer, electroplating, asbestos, silt, alcohol, detergents, steel, tannery, textile, cane sugar, oils, pesticides and herbicides, radioactive wastes etc., play a significant contribution in pollution of water.

In India, the industrial effluents have contributed a major source of pollution. Different industries of the country contribute about 16 per cent of the total wastewater generated. The treatment facilities have been installed in less than one third of the polluting industries (Gopal, 1994). Most of effluent treatment plants (ETP) have not performed physical and chemical treatment processes satisfactory due to economic reasons on commercial scales. Water may pollute by many anthropogenic activities like discharge of household sewage, disposal of various industrial wastes, run off form agricultural fields, acid rain and many other man-made infrastructures and activities. Different types of industries exploit the huge amount of freshwater and discharge wastewater in the form of effluents. These effluents discharged directly into any freshwater body, *viz*. pond, lake, stream or any seasonal drain.

Textile industry is one of the oldest type of industry in India, manufacturing different types of clothes. There are about 850 textile mills established in big cities of India, manufacturing approximately 11000 million meters cloth. Textile industries can be classified into three categories: cotton, woolen and synthetic fibres depending upon the used raw materials. The cotton textile industries are one of the oldest industries in our country having more than 1000 mills mainly located in Mumbai, Surat, Ahmedabad, Coimbatore, Delhi and Kanpur. The woolen mills in the country are mostly located mainly in Amritsar, Bikaner, Ludhiana and Panipat. Synthetic fibre, a comparatively new entry, has become an integral part of the textile industry and is being used to manufacture purely synthetic fabric or is mixed with cotton or wool to manufacture blended fabrics in mills throughout the country (Groff, 1993).

Textile industries in general consume large volume of water of high purity. Consequently, these units discharge large quantities of effluent that normally exhibit polluting characteristics. According to review of available literature the quantity of effluent discharged and quantity of consumed water by woolen units and composite cotton textile industries, always remain high. In the cotton industry, the solid waste generated during processing fibres and spinning amounts to be about 5 per cent of raw cotton weight. In woolen industry, about 4 per cent of the raw wool weight comes out as solid waste prior to and during spinning. Other solid waste generated in the textile industry includes rags, felts, waste piece of cloth and yarns, packaging materials, ash from coal-fired boiler.

As far as the textile mills are concerned boiler feed water should be as soft as possible and should contain least amount of nitrate and organic matter in order to prevent encrustations or corrosion of boilerplates. For the purpose of dyeing water should be free from iron and should posses little hardness only. The consumption of water in dyeing and printing mills is 3,45,000 liters/day.

1.2 Textile Industries

Consumer demand for textiles is ever increasing in the domestic and international market. More cotton textile processing industries are set up at a rapid rate in many Indian cities, the problem of treating wastewater generated at these industries are compounded. Small-scale units cannot afford to have their own treatment facilities because of non-availability of land and skilled manpower to operate it. A common effluent treatment plant (CETP), for the treatment of combined wastewater from a cluster of small scale units is generally designed based on primary and secondary waste treatment system, which involves screening, degreeting, primary clarifier and aerobic biological system.

In the preparation of these raw materials for spinning, weaving and finishing, liquid wastes are produced, the volume and strength of which extend over a wide range, depending not only on the type of fibre being processed but also on the source of raw product, the ultimate use, availability of process water, control of manufacture and other variables.

The textile mills not only add to air pollution by ejecting chimney gases into the atmosphere but also the considerable water pollution by discharging their liquid effluents into various receiving bodies like public sewer, inland surface water like ponds, rivers, *Nallas* or on irrigation land. In fact, major pollution load from the textile mills can be attributed to the liquid effluents from the various wet processing operation like scouring, bleaching, mercerizing, dyeing, etc. amount of composite effluents discharged from the textile mills varies from 1 to 10 million liters per day depending upon quantity of the cloth produced and various manufacturing processes employed. Selection of treatment methods for these wastewaters will be governed by their characters, the policy of regulatory body covering the waters of receiving stream, economics of treatment and present day knowledge of method of purifications.

Textile industries consume substantial volume of water and chemicals in wet processing of textile. Approximately, 40,000 different dyes and pigments are used in the industry and over 7×10^5 tons of these dyes are produced annually worldwide (Zollinger, 1987). It was estimated that 10-15 per cent of the dyes used in textile processing were lost in the effluent during the dying processes (Vaidge and Datye, 1982). These dyes include several structural varieties of dyes, such as acidic, reactive basic, disperse, azo, diazo, anthraquinone-based and metal complex dyes. The only one thing in common among them is the ability to absorb light in the visible region (Wong, 2000). The effluents from dye industries contain high amount of cation, anion, organic pollutants in the form of colour and heavy metals.

Dying is the process of applying to the fabric stock yarn or fabric. The dying is carried out with six different dye classes, vat, direct, developed, napthol, sulphur and aniline black. If aniline and sulphur dye are used, dye wastewater may contain colours, which are extremely difficult to be removed by common waste treatment methods. The water requirement for textile industry is very large for their various processes. The use of water varies from mill to mill and depends on source of water, availability and quantity and quality of fabric produced. To produce one meter of cloth 12-65 liters of water is required, as textile industry requires large volume of water, it releases large amount of wastewater after processing. The main source of wastewaters of textile industry *viz.* preparation of yarn-slashing process waste, textile processing- desizing, kiering, slashing, bleaching, mercerizing, dying and printing waste, washing waste in each step, other waste streams-like cooling water, boiler, house keeping, spills, leaks and sanitary wastes. The quantity of waste discharged from each mill process is very small as compared to the volume of waste generated from the washing and rinsing of cloth. The volume of wastes is highly variable from one mill to another. The pollution load in wastewater posed by textile industry is very high and affects water quality and other environmental components in many ways. These wastes are coloured due to use of dyes and dying aid agents in the different textile processing of material.

1.3 Dyes

Synthetic dyes are major contaminants in textile wastewater and have to be removed before discharging into water bodies or on land. The presence of very small amounts of synthetic dyes in water (less than 1 mg/l for some dyes) is highly visible and affects the aesthetic qualities, water transparency, and gas solubility, in lakes, rivers and other water bodies. The removal of synthetic dyes from wastewater is often more important than the removal of the soluble colourless organic substances, which usually contributes the major fraction of the biochemical oxygen demand. Methods for the removal of the BOD from most effluents are fairly well developed, synthetic dyes, however, are more difficult to be degraded because of their synthetic origin and mainly complex aromatic molecular structures. Such structures are often constructed intentionally to resist fading on exposure to sweat, soap water, light or oxidizing agents (Mckay, 1979) and this renders them more stable and less amenable to biodegradation (Seshadri *et al.*, 1994).

Interest in the pollution potential of textile dyes comes from their possible toxicity and carcinogenicity. This is because many dyes are synthesized from known carcinogens, such as benzidine or their aromatic compounds. Some azo dyes are reported to be reduced in sediments and aquatic environment to form toxic, mutagenic or even carcinogenic aromatic amines among different trophic organisms.

Dye wastewater discharged from textile and dyestuff industries have to be treated due to their impact on the water bodies and growing public concern over their toxicity and carcinogenicity in particular. Dyes usually have synthetic origin and complex aromatic molecular structure. According to their dissociation in an aqueous solution, dye can be classified as (i) Anionic acid, direct and reactive dye (ii) Cationic, basic dye and (iii) Non ionic, dispersive dyes. Dyes such as acid, basics and direct are all water soluble but dispersive dyes have low solubility and colloidal dispersion properties, thus they are agglomerations. Physically, dyes are mostly used in the powder, liquid and pearl or granulate form. Chemically, dyes may be categories as Nitro dyes (napthol yellow), Nitroso dyes (napthol green), Azo dyes (synthetic), Di and triphenol methane dyes, Vat dyes, Anthraquinonoid dyes, Quinoline dyes, Sulphur dyes. Broadly dyes may be classified as direct dyes and developed dyes. Six main classes of dyes for cotton fabric namely vat, direct, developed, napthol, sulphur and aniline black. Many different and complicated molecular structures of dyes make dye water difficult to be treated by conventional biological and physico-chemical processes. About 6,34,900 metric tons of dyes are produce worldwide each year and nearly 10-15 per cent of them are discharged through effluents. Generally conventional biological treatment processes have certain difficulties in degrading those dues causing high COD and colours in the wastewater. A significant portion about 40-70 per cent of COD and colour in textile effluents, are still remaining, and is required an advanced treatment. Studies using physical and chemical processes to further reduce COD and colour in textile wastewater have been intensively reported (Zhang *et al.*, 1994). Developing countries like India and other Asian countries discharge the effluents to the surface water without any treatment or sometimes little treatment due to technological and economical limitations. Colours affect the nature of water, inhibit sunlight penetration and reduce the photosynthetic action. Some of the dyes cause rapid depletion of dissolved oxygen affecting aquatic life adversely. Some of the dyes, especially Benzidine based dyes are toxic and carcinogenic.

Thus, uses of dyes contaminated water without any treatment may cause adverse effect on the health of human beings, domestic animals, wildlife and aquatic environment. So, it is very much essential to treat dye-contaminated wastewater before discharging in to the surface water and develop simple and economical method to treat the stream suitable for developing countries. The conventional methods of removal of dyes using alum, ferric chloride, activated carbon, lime etc. are not economical. Adsorption is a physico-chemical treatment process, which has gained a lot of attraction for the removal of dye from wastewater, since it produces a high quantity treated effluent. The most widely used adsorbent is activated carbon for industrial wastewaters application. But the cost of the activated carbon is high and it increases with its quality. Agricultural solid waste such as coir, pitch, banana pitch, coconut husk, biogas slurry, rice husk, bagasse and paddy straw, saw dust etc. have been investigated for the removal of dye from wastewater.

1.4 Heavy Metals

Heavy metals are chemical elements with a specific gravity that is at least 5 times the specific gravity of water. The specific gravity of water is 1 at 4°C (39°F). Simply stated, specific gravity is a measure of density of a given amount of a solid substance when it is compared to an equal amount of water. Some well-known toxic metallic elements with a specific gravity that is 5 or more times that of water are arsenic, 5.7; cadmium, 8.65; iron, 7.9; lead, 11.34; and mercury, 13.546. In small quantities, certain heavy metals are nutritionally essential for a healthy life. Some of these are referred to as the trace elements (e.g., iron, copper, manganese, and zinc). These elements or some form of them are commonly found naturally in foodstuffs, in fruits and vegetables and in commercially available multivitamin products. Heavy metals are also common in industrial applications such as in the manufacture of pesticides, batteries, alloys, electroplated metal parts, textile dyes, steel and so forth. Twentieth century industrialization has led to an increased exposure to heavy metals for everyone. Certain people suffer a lot due to toxic exposure because of where they live, their occupation, or their lifestyle. Others may be genetically predisposed to heavy metal accumulation due to poor detoxification systems in their bodies.

Heavy metals are usually present in trace amounts in naturally waters but many of them are toxic even at very low concentration. Although many of the metals are essential components of the biological system yet some of these are potentially toxic. Metals such as arsenic, lead, cadmium, nickel, mercury, chromium, cobalt, zinc and selenium are highly toxic even in minor quantity. Increasing quantity of heavy metals in aquatic resources is currently an area of greater concern especially since a large number of industries are discharging their metal containing effluents in to fresh water with out any adequate treatment (Canter, 1987).

Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues. Heavy metals may enter the human body through food, water, air, or absorption through the skin when they come in contact with humans in agriculture and in production of different industrial products, pharmaceutical, biotechnological or residential settings. Industrial exposure accounts for a common route of exposure for adults and children. Ingestion is the most common route of exposure in children. Children may develop toxic levels from the normal hand-to-mouth activity of small children who come in contact with contaminated soil or by actually eating objects that are not food (dirt or paint chips).

Most of the industries discharged their waste directly (without any treatment) into the stream, lakes and oceans as well as in the open land and that contaminate the groundwater. There are number of pollutants like fertilizers, pesticides, heavy metals, which seriously affect human like by entering into the system directly or indirectly through food material. Pollution of environment with heavy metals is a serious problem. Besides causing specific toxicity symptoms, these metals may also contribute to global warming by destroying the atmosphere ozone layer like atmosphere methane, nitrous oxide and sulphur dioxide because of potentially harmful effects on human and animal health, few toxic metals (lead, cadmium, mercury, arsenic, and chromium). It is major concern to ecologist or researcher, because air or water pollution from point and non-point sources may contribute significantly to the load of metals on natural ecosystem (Mani *et al.*, 2005). Environmental contamination and exposure to heavy metals such as mercury, cadmium and lead is a serious growing problem throughout the world. Human exposure to heavy metals has risen dramatically in the last 50 years as a result of an exponential increase in the use of heavy metals in industrial processes and products.

The most common heavy metal pollutants are As, Cd, Cr, Cu, Ni, Pb, and Hg. There are different types of sources of metal pollutants; such as, point sources (localized pollution). The second types of pollutant sources are non-point sources, where pollutants come from dispersed (and often difficult to identify) sources. There are only a few examples of localized metal pollution, like the natural weathering of ore bodies and the little metal particles coming from coal burning power plants via smokestacks in air, water and soils around the factory. The most common metal pollution in freshwater comes from mining operations. They usually use an acid mine drainage system to release heavy metals from ores, because metals are very soluble in an acid solution. After the drainage process, they disperse the acid solution in the groundwater, containing high levels of metals (www.lenntech.com).

Heavy metals are introduced into aquatic system from various anthropogenic sources. Heavy metals constitute a special group of contaminants of aquatic systems and deserve special attention. Since natural degradation processes do not remove metals, they may become enriched in sediments over time. Metal contamination of sediments is an issue of growing concerns worldwide (NRC, 1989). Both natural processes and anthropogenic activities are responsible for introducing metals in to the aquatic system (Nriagu, 1989). Many contaminants discharged into surface waters rapidly become associated with the particulate matter and incorporated in sediments. Metals in aquatic systems become part of the water-sediment system and their distribution is controlled by a dynamic set of physico-chemical interactions and equilibria, largely governed by pH and type of legends and chelating agents, oxidation state of the mineral components and the redox conditions of the system. Metal contaminated sediments may release heavy metals back to the overlying water column and, thus, pose risk to aquatic life and ecosystems. Due to their particle reactivity, heavy metals tend to accumulate in sediment as a result may persist in the environment long after their primary sources have been removed (Forstner and Wittman, 1981).

In the recent years there has been a growing concern with environmental protection. This can be achieved either by decreasing the afflux of pollutants to the environment or by their removal from contaminated media. The former is a feasible choice only for pollutants of anthropogenic origin, whereas, the latter is unavoidable for those of natural origin (Gomez-Serrano *et al.*, 1998). The presence of heavy metals in the aquatic environment has been of great concern to scientists and engineers because of their increased discharge, toxic nature, and other adverse effects on receiving waters.

1.5 Groundwater

Groundwater is used for domestic supply, industries, and agriculture in most part of the world as it is a replenishable resource and has inherent advantage over surface water. There has been a tremendous increase in the demand of fresh water due to growth in population, advanced agriculture practices and industrial usages (Bachmat, 1994). In the last two decades, the rapid growth of industrialization and urbanization has created negative impacts on the environment. Due to industrial, municipal and agricultural wastes containing pesticides, insecticides, fertilizers residues and heavy metals with water; groundwater has been polluted by leaching process of pollutants present in effluents (Sastry and Rathee, 1999).

In Haryana, about 90 per cent of the population of rural areas utilizes groundwater for drinking, washing and other daily uses. But groundwater in Haryana is very saline and large variation in salinity can be observed over a short distance. Water table is also very high. Therefore, scarcity of drinking water is very big problem faced by population of this state. Panipat district of Haryana is well known for the textile industries. A large number of small-scale industries mainly textile printing and textile dying have been established in Panipat city. These industries discharge their effluent openly into pond or other water bodies. The seepage of effluents posed serious threat to the groundwater resources (Groff, 1993). So, groundwater must be managed and protected carefully for the most beneficial use in the future.

Clean groundwater is needed for more than drinking purposes. Agriculture depends highly on groundwater for irrigation; as a large number of groundwater pumps were used for crop irrigation in India. Poor or contaminated groundwater could jeopardize crops and threaten the health of livestock. Groundwater is connected to surface water in the hydrological cycle, and some aquifers actually feed area springs and rivers. Sometimes contamination occurs naturally by mixing the sallow aquifers with other contaminated sources of water table. Saline water from deeper aquifers may reach aquifers that provide water for human beings, livestock and others agricultural activities. Some groundwater may have naturally high levels of nitrates, metals, iron, sulfate, or chloride, all of which provides an odd odor, color, or taste in water. Groundwater contamination has become a major problem in recent decades due to exploring industrialization. Groundwater, as a wide resource for irrigation in most part of country, may contaminate the soil quality by repeated irrigation of agricultural fields. Bed quality of groundwater used in irrigation may alter the characteristics of agriculture soils of the area.