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Preface

Modern age environmental problems are arising from the extreme desire of the modern human population for more efficient and comfortable life. To amplify the quality of life is coupled with the industrial revolution and pollutant generation. Since the beginning of the nineteenth century, rapid industrialization and urbanization has produced huge amounts of waste materials, thereby creating an extra burden to our environment. Every year, the global pollutant budget is increasing multiple fold by means of natural (e.g. natural release of methane gasses, volcano eruption, acid rain, rock weathering and releasing toxic metals) as well as anthropogenic activities (domestic waste, carbon emission from fossil fuel burning in automobile and energy generation, radioactive materials from nuclear reactors, polycyclic aromatic compounds from oil industries and other xenobiotic compounds, heavy metals). Environment pollution is a worldwide issue and its capability to affect the human health is great. It is unavoidable and influences somehow almost everybody and everything. Exposure of human to pollution is accepted to be more intense now than at any other time in human existence. Pollution can be made by human exercises as well as by natural forces. Human exercises adversely affect the environment directly or indirectly. Undoubtedly extreme level of pollution is causing a lot of harm to human and animal health, plants and trees, as well as the wider environment. Developmental activities, for example, transportation, manufacturing and construction, exhaust the natural resources as well as produce a large amount of wastes that contaminate water, air and soil and lead to global warming and acid rains. Improperly treated or untreated waste is a noteworthy reason for contamination of waterways and environmental degradation creating problem to health and crop productivity. Increasing globalization has also negative impact on environment. Due to increasing globalization, consumption of products has increased that leads to an increase in the production of goods, which in turn puts burden on the environment. Therefore, an important challenge in the present times is to supply the sufficient energy per person to the increasing world population. Today, this energy supply principally relies on fossil fuels that have numerous

shortcomings, like emission of greenhouse gasses, effect of environmental change and the exhaustion of these assets. So, we have to think for alternate sources of energy that are renewable as well as sustainable. Renewable energy, for instance, hydro energy, wind energy, geothermal energy, solar energy or bioenergy, might be important energy sources in the future. Bioenergy is renewable energy from organic material (biomass).

An extensive number of technologies exist for generating bioenergy, heat and power, like biogas digesters, large-scale biomass gasification plants, microbial fuel cell for bioelectricity, etc. Producing energy from biomass can be cost competitive. Bioenergy is the main renewable source that can supplant fossil fuels and can be used in the production of electricity, heat and fuels for transport. Bioenergy is now making a generous contribution to meet worldwide energy demand. This contribution can be extended fundamentally in the future, giving reduction in emission of greenhouse gasses and other natural advantages and in addition adding to energy security, giving chances to social and financial improvement in rural areas and improving the resource and waste management.

For sustainable development, promotion of greater access to bioenergy is essential. Bioenergy has a definite contribution to make to sustainable development as with other potentially interesting renewable energy sources. Bioenergy can possibly be modernized around the world. Bioenergy contributes to all essential components of the nation or local development, economic growth, energy security, environmental security, food security, income and employment generation, poverty alleviation, etc., and it can increase access of poor people to improved types of energy. Attention on bioenergy production is increasing and the trend will continue.

A number of studies have been conducted and reported in the literature, but they are not sufficient to cope with the growing problems of pollution and clean energy supply. Thus, there is an urgent need to develop new, innovative and wise strategies to control pollution in a sustainable manner along with the generation of energy. This book deals with several current issues relating to environmental problems and further focusses on newer technologies (e.g. bioelectrochemical systems) for the generation of renewable and sustainable energy.

We are highly grateful to our internationally renowned contributor from different countries for providing their reliable, progressive and cutting-edge scientific information to accomplish this book. All chapters in this book are well illustrated with appropriately arranged images and tables and enriched with most recent references of related literature. A generous support provided by the authority of Center of Excellence in Environmental Studies (King Abdulaziz University) and research scientists who have contributed in the designing of this book is highly acknowledged. We are undeniably very thankful to our family members for their constant support during the period of book preparation. We highly appreciate the great efforts of book publishing team at Springer Nature, who always replied promptly with solution of queries during the whole book project. Finally, this book may have some basic mistake, printing errors and inaccuracies for which

we feel regret in anticipation. However, if found out at any stage, we will certainly try to improve them in the subsequent print/edition. Readers are most welcome to provide critical analysis and suggestions related to the content presented in this book.

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Chapter 1
Chemical Contaminants for Soil, Air and Aquatic Ecosystem

Tesfalem Weldeslassie, Huma Naz, Balwant Singh, and Mohammad Oves

Abstract Chemicals from fossil fuel use, domestic and industrial waste products, mining and agriculture contaminate air, water and soil. Contaminant chemicals may have considerable implications for human health and safety, welfare and the value of nature. Air contaminants include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), nitrogen oxides (NO_x), hydrofluorocarbons (HFC_s), perfluorocarbons (PFC_s) and sulphur hexafluoride (SF_6). These gases brings climate change by increasing the temperature of the earth's atmosphere and oceans. Climate change is responsible for unpredictable changes in precipitation, rising sea level and extreme climate events. Air contamination can be controlled by passing a law against harmful chemicals production, introducing special devices that reduce green houses gases, and making use of alternative sources of energy. Major water contaminants include sewages, petroleum products (like polychlorinated biphenyls), nitrates, insecticides, sediments and excess organic matters. Harmful chemicals may reach water bodies from outlet of pipes in industries; leakage of pipe line or storage tanks, mining operations, improper application of fertilizers and pesticides in agricultural fields and some leakage from ships. Water contaminants inflict vital body organs, nervous systems, and cause different types of cancers and cardiovascular effects. Soil contamination is caused by dispersion of toxic compounds, acidification, salinization and sodification, enhanced soil erosion, chemical fertilizers, pesticides, fungicides, and the accumulation of heavy metals and other inorganic contaminants. Like air and water contaminants, soil contaminants, if they enter into our body, are also causative agents of many diseases. There are many

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tangible mechanisms to control soil contaminants such as landfills, incineration or burning, composting and recycling.

Keywords Contaminant chemicals • Contamination control • Contaminant sources • Impacts and implications

1.1 Introduction

Environment is the physical (non-living and living) surroundings of human society. Interactions between society and the environment are inevitable. These interactions include the effects of society on the environment and the value of the environment for society (Fig. 1.1).

Environmental problem, most of the time, is caused as a result of the disturbance of the interactions between society and the environment. Such disturbance may have several impacts such as air, water and soil contaminations. In turn, these environmental impacts will have diverse implications for human society, including implications for human health and safety, welfare and the value of nature. Pollution, contamination of earth's environment, afflicts not only the health of human but the quality of life along with the ecosystems (IPCC 2014). Thomas (2012) and IPCC (2014) clearly stated that it is out of question to say the cause for relentless rise of global warming is the consequences of human-induced increases in heat-trapping gases. Nowadays there is no a question on the credibility and maturity of climate science (Carlton et al. 2015). The reason why climate change is dreadfull is its vital power to shape the human planet in a different way so that life becomes very hard. Industrial activities may have environmental impact on water contamination due to disposal of heavy metals such as mercury, lead, copper and selenium and this contaminated water will have implications for human health, for example after ingesting or dermal contact with contaminated soil (Hannah et al. 2009). The risk of climate related impacts is becoming more greater for those disadvantaged societies in any country (IPCC 2014). Many people could understand the negative impacts of air and soil contaminations on human's health, but that of soil is still not fully understood (Science Communication Unit 2013). However, many studies agreed that increased level of soil contaminants affect soil chemisty, microbial activities and health of the animals and plants living in the soil significantly (Hannah et al. 2009; Science Communication Unit 2013).

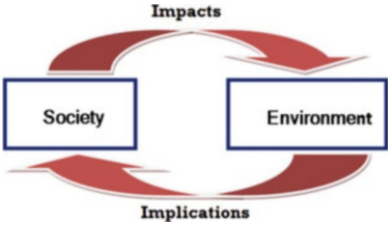

Fig. 1.1 Interactions between society and environment

Environmental problems can be assessed at global or continental or local level (WHO 1982). Global problems include environmental problems caused by pollutants that usually stay in the environment for a long time, and that are transported over long distances. People focus more on atmospheric pollutants as they have large-scale and long-term effects. It does not matter where on earth the emissions take place, because the pollutants spread into earth's entire atmosphere within a few years, while the effects may last for decades or centuries (GISS 2017). Therefore, global problems, for example climate change and stratospheric ozone depletion, are international problems that need urgent global solutions.

Continental problems are caused by pollutants that are transported at a continental scale. These problems are international and need to be solved at the continental level. Continental problems include acidification, eutrophication; tropospheric ozone; dispersion of toxic compounds and the like.

The impact of local environmental problems is limited to more or less the location where the causes of these problems are found. Therefore, these problems need local solutions. Local problems include heavy metals, waste production and disposal, excess use of agricultural chemicals (fertilizers and pesticides), domestic wastes and industrial effulients.

Pollutants can be categorized into biodegradable and non-degradable. Biodegradable pollutants are those materials that are decomposable simply by natural phenomena. They may pose a problem if their rate of addition is greater than their rate of decomposition. The second types of pollutants are those of non-degradable. Non-degradable pollutants decompose at a rate more slowly than their decomposition so that it is needless to say that their removal from the environment is very difficult if not impossible.

1.2 Air Contaminants

Many human activities including fossil fuel use, industry, mining and agriculture are sources of air pollution. Emissions of green house gases (GHG) like carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC_s), perfluorocarbons (PFC_s) and sulphur hexafluoride (SF_6) affect the radiative balance of the atmosphere (so-called radiative forcing). As a result of the radiative forcing, the temperature of the earth's atmosphere is increasing and the climate is being changed. Climate change means occurrence of abnormal precipitation events and rise of sea level. In addition, weather patterns will become less predictable and the incidence of extreme climate events, such as storms, floods, and droughts, will increase. Climate scientists clearly understand the suitation may reach to the level whre nature and human society may not be capable of responding rapidly enough to these changes.

According to IPCC (2006), many processes in the ecosystem are definitely affected by management of land use which will directly affect fluxes of GHGs, to mention some of them are combustion, respiration photosynthesis, enteric

fermentation, decomposition and nitrification or denitrification.Within these processes carbon, sulphur and nitrogen are exposed to complex transformations. Biological (activity of microorganisms, plants, and animals) and physical processes (combustion, leaching, and run-off) involve in the transformation of these elements. Troposphere, 16 km wide atmospheric layer, is frequented with continuous change of climatic variables due to change in the fluxes of GHGs. Almost all local and global pollutions are observed in this layer.

The common air pollutants inside any house can be mentioned as tobacco smoke, invisible radioactive gas, radon, synthetic chemicals of carpets and tools, pesticides and chemicals that are used in cleaning household. It is realized that the most harmful component of air pollution is the polluted air inside the homes and buildings as in one way it is hardly identified and on the other way people particularly children, without recognizing the pollution, spend most of their time being exposed to polluted air (Moya et al. 2004). For example, many people suffer from a lung disease known as asbestosis. The main cause of this disease is airborne fibers of asbestos. Asbestos which are easily accessible in every house are used in insulation of many electrical tools. If there is a lack of appropriate air ventilation inside the house, it is possible that pollutants may concentrate to the level much higher than outside. Hence, the pollutants may threaten the life of many residents of a house at one go. Equipments which can cause unanticipated accumulation of air pollutants are heaters which lack efficient and proper vents.

1.2.1 Major Air Contaminants and Their Sources

IPCC (2014) reported that CO_2, carbon monoxide (CO), nitrogen oxides NO_x, sulphur dioxide (SO_2), and tiny solid particles-including lead from gasoline additives-called particulates are the main known results of anthropogenic GHGs emisions. Human's injudicious and continuous use of resources like burning coal and oil (fossil fuels) to obtain energy for operating industries, fabrics and vehicles, incarnation of domestic wastes, agricultural processes, is referred as the firsthand and unparalleled sources of the major air contaminants. May be sometimes air pollutants can be the outcomes of natural occurring forest fires, aerosols, volcanic ash and the list is many.

Carbon Dioxide It the is one of the most important heat traping gas. Climate scientists show that the major cause of greenhouse effect is high concentration of CO_2 in the atmosphere. Greenhouse effect is the causative agent of global warming, increase of global temperate. Comparing with other air contaminants in terms of its abundance, CO_2 holds the first level. It constantly circulates in the environment through a variety of natural processes known as the carbon cycle. CO_2, released from respiration of animals, combustion or oxidation of fossil fuels including gasoline, coal, manure, soil organic matter, dead organic matter, fermentation of sugars, chemical decomposition of carbonates and urea, and eruptions of volcanoes.

Oxidation of soil organic matter provides energy for the soil organisms. CO_2, the product of respiration, is released into the atmosphere. But it is also removed from atmosphere as it is absorbed into water bodies and by plants by the processes of photosynthesis, conversion of CO_2 and water into simple sugars using the energy of light. However, deforestation, human activity that leads to creation of bare land by cutting trees mercilessly, tremendously reduces the processes of photosynthesis which is the ultimate increase the concentration of CO_2 in the atmosphere. It plays many roles in domestic uses like manufacture of washing soda, baking soda, and effervescence of carbonated beverages. It also helps as fire extinguisher, refrigerant and anesthesia.

With advancement of new technologies the life of human being has been improved drastically. Paradoxically, an increase in concentration of CO_2 in the atmosphere due to human activities is becoming much faster than its removal, which can not be imagined with normal human mind. The problem is becoming more severe due to the ability of CO_2 to stay for more than tens of century in the atmosphere without being disposed naturally. If you look at the history of the concentration of CO_2 in the atmosphere, there were only about 280 ppm molecules of CO_2 before industrial revolution began in the mid 1700s (Michael and Schneider 2009). However, in 2017 the concentration was risen up to 406 ppm due to global wide spread of industrial sectors and increased consumption of fossil fuel for vehicle transportation and electricity generation (GISS 2017).

Methane (CH_4) and Other Volatile Organic Chemicals CH_4 also known as natural gas is emitted from livestock enteric fermentation, from manure management systems, and largely from rice cultivation. About 43% of the emission of CH_4 into the atmosphere is from natural wet lands and paddy fields (Wild 1993). Mining of coal and other fossil fuels also some times aggravate the emission of methane particularly during their production and transportation. Methane also is emitted from decomposition of garbage in landfills, solid waste disposal sites and household products. Comparing CH_4 with CO_2 in terms concentration in the atmosphere, CO_2 is far greater than CH_4. However, the problem with CH_4 is that because it stays in the atmosphere for longer period of time than CO_2. CH_4 is more effective in rising atmospheric temperature as it traps heat more efficiently than CO_2. If we compare CH_4 with CO_2, for example, molecule of CH_4 is nearly 30 times more efficient at trapping infrared radiation radiated from the earth's surface than a molecule of CO_2.

People use CH_4 mainly as a source of fuel energy by burning it. But it has also wide application in different industries to produce different types of chemicals. In kitchens it helps to heat furnaces, stoves, heaters etc. Industries which produce construction materials also use natural gas in large amount to burn wooden materials. Food and glass processing factories also use natural gas to get heat. CH_4 is also very essential for generating chemicals, called petrochemicals, which can be employed for manufacturing commodities that can be used to enrich soil fertilities, to make plastic materials and drugs.

Volatile organic chemicals (VOCs) come in to the atmosphere due to lack of inefficient burning of fossil oils. Volatile organic compounds (VOCs) include organic compounds like ethylene, propylene, benzene, or styrene. VOC_S evaporate at a relatively low temperature and contribute to air pollution.

Nitrous Oxide and Nitric Oxide N_2O has a long residence time in the atmosphere of about 150 years. It absorbs infrared radiation but because of its low concentration it has only a small effect on global warming. Because of its long residence time it has, however, more serious effects in the stratosphere where it reacts with excited atomic oxygen to give nitric oxide, NO, which destroys ozone.

Soil temperature and water content affect the production of N_2O after application of ammonium nitrate as fertilizer. N_2O is produced mainly by the biological reduction of nitrate, a process known as denitrification. Most of the time, this process occurs under anaerobic conditions. It takes place most rapidly when the soil is warm and contains readily decomposed organic matter. Microorganisms use NO^-_3 instead of O_2 as an electron acceptor, producing NO, N_2O and N_2. Many studies indicate that the highest values of N_2O are from irrigated and fertilized soils high in organic matter (Havlin et al. 2005).

Carbon Monoxide CO enters into the atmosphere from industrial activities and from vehicles which consume fossil oil. If the concentration of CO in the atmosphere is greater than 10 mgm^{-3} over 8 h or 40 mgm^{-3} over 1 h, it will be dreadful for health (Engelking 2009). As the concentration of CO in the atmosphere increases, oxygen will not reach the lungs adequately so that the accident of asphyxia, death due to failure of blood to be oxygenated in the lungs. During the time when CO is inhaled, it is immediately assimilated with haemoglobin in the blood so that no more adsorption of oxygen, asphyxiation. Children/infants are more vulnerable to the poisonousness of CO in a given confined environment (WHO 2005). Formation of CO is prevailed if there is incomplete of burning of fossil fuels. In fact it is difficult to get a situation free of CO even with the presence of excess oxygen. Almost all moving vehicles are the main producers of these poisonous gases.

CO is very fatal to life; even 1% may lead death in less than min. The major sources of CO are urban industries, automobile exhaust and cigarette smoke. The main symptoms of this poisoning include headache, nausea, or fatigue, followed by unconsciousness and finally death. An automobile engine, leaking furnace and fuel gas are the main sources of CO.

Sulphur Dioxide SO_2 emits to atmosphere from generators and from oil or coal mining containing sulphuric acids. Nowadays, it becomes a common experience to have the incident of acid rain as their industries deposit huge amount of SO_2 to the atmosphere. If the maximum concentration of sulphuric acid is greater than 80 μgm^{-3} over a year or 365 μgm^{-3} over 24 h, it is detrimental to the life of human being (Engelking 2009).

Particulate Matter Particulate matter, collection of individual particles, may also be the cause of air pollution. Its composition differs from place to place depending

on the type of industrial processes, type of vehicles, method of incineration and type of heat and power generation. Generally, it composes of carbon, nitrates, sulphates, and many harmful metals including lead, copper, iron, and zinc (Engelking 2009). The health standard recommends below 50 μgm^{-3} over a year or 150 μgm^{-3} for 24 h.

Nitrogen Dioxide NO_2 contributes to contamination of air after reacting with hydrocarbons and sunlight to form photochemical oxidants. There are many ways which lead the accumulation of NO_2 in the atmosphere. To mention some of them are improper application of fertilizers, use of nitric acid, operation of all types of generators, during mobility of vehicles and make use of explosives to break rocks and others. Acceptable level of this gas is less 100 μgm^{-3} over a year (Engelking 2009).

Ozone O_3 is formed in the lower part of the atmosphere as a result of a reaction among nitrogen oxides, hydrocarbons and sunlight. That is NO_x and VOCs may affect the chemical composition of the air in such a way that O_3 is formed under the influence of sunlight in the troposphere. O_3 is toxic at low concentrations for many organisms and may cause damage to vegetation and crops. In addition it may cause health problems to humans. According to WHO air quality guideline (2005) concentration of O_3 in the air should not be greater than 120 μgm^{-3} with in 8 h duration of exposure.

Chlorofluorocarbons (CFC_s) These types of compounds are derived from industrial by-products. Increased concentrations of CFCs and halons in the atmosphere are the major causes of stratospheric O_3 depletion. Because O_3 is a natural "filter" for ultraviolet (UV) radiation from the sun, O_3 depletion may result in increased UV-radiation, which in turn may increase risks for skin cancer and disturbances of ecosystems. People have used these compounds as a cooling agent, blowing agent, cleaning agent, aerosol propellant and fire extinguishers. Many studies realized that O_3 is being severely attacked by different pollutants. CFCs are among the pollutants which are responsible for the attack of O_3 layer. CFC molecules are virtually durable until they reach the stratosphere. But when they reach in the stratosphere, they are broken by intense UV radation and chlorine atoms will result in. Subsequently, these atoms react with O_3 to break the bond between oxygen atoms. Finally, the absorbing power of the O_3 for UV-B will be reduced tremendously and the earth will be then liable to direcr UV radiation. During the reaction the chlorine remains unchanged and hundreds of thousands of O_3 molecules can be destroyed by a single chlorine atom, reacting again and again. Some reports indicate that pollutants like N_2O from fertilizers and methyl bromide from pesticide also attack atmospheric O_3. In the Montreal Protocol on substances, countries agreed to stop using CFC_s to avoid O_3 layer depletion by this chemical. Even the use of hydrochloroflurocarbons ($HCFC_s$) will be abolished in the coming decades completely.

Waste The main sources of air contamination due to wastes are landfills, incineration and composting. Incineration and composting may result in emissions of

pollutants to the environment. Possible solutions are waste prevention, recycling and making more efficient use of resources.

1.2.2 Consequences of Air Contaminants

Air pollution occurs inside laboratories, technical schools, rooms and offices, in cities, across continents, and even globally (WHO 2005). Increasing the concentration of contaminating substances in the atmosphere, air pollution, not only afflicts human health but environment and quality of life as well. Particularly, air contaminants affect the health of human being. Major problems associated with air pollution are cancer and respiratory systems. Also, all living organisms together with their ecosystems are the main victims of these harmful pollutants. Some air pollutants (oxides) combine with water vapour and return to earth in the form of acid rain and snow, which corrode statues and buildings, damage crops and forests, and make lakes and streams unsuitable for fish and other plant and animal life.

Pollution is feared to cause ineffective atmosphere to reflect dangerous radiations (UV-B from the sun). At the same time the atmosphere acts as barrier so that no way of escaping of heat in to the atmosphere. Therefore, the absorbed heat in the atmosphere increases dramatically. As the result the average temperature of the globe increases so that the global warming phenomenon prevails. It is belived that sudden rise of sea level, wide spread of contagious diseases etc will prevail due to global warming.

A mixture of smoke and fog forms a smog which causes irritation in eyes, throat and lungs as well as it damages plants. Smog containing O_3 in the lower atmosphere is poison which can damage any living thing and spoil artifacts and statures. The Parthenon temple in Athens, Greece, and the Taj Mahal in Agra, India are some of the victims of smog acids. Environmental officials measure O_3 to determine the severity of smog. With increasing the level of O_3, pollutants like CO intends to increase so that the condition going on even more worse.

Smog also has the potential to spoil the beautifulness of cities and towns. All outdoor activities are becoming unpleasant and their efficiencies are highly affected. It becomes harsher for those who have respiratory, headache and heart problems. Some times smog can be fatal to mass death due to high concentration of CO. For example, in 1952 about 4000 people were killed in Landon due to incidence of thick smog (Ware et al. 1981).

Air pollution is not restricted only at regional level but expands to effect globally. The stratosphere, a zone of O_3, which is between 16 and 50 km above sea level, is the most liable atmospheric layer to air contaminants.This lever saves the earth from penetration of UV-B. If these radiations reach the earth surface, definitely, they will damage the genetic molecule (DNA) of any living cell. This problem then can impose cancer in human being. Thus, we can say that O_3 layer is the saver of the whole lives of our planet.

According to the report of IPCC (2006), if the control measures of air contaminants are not implemented on the ground, there is high possibility that a rise of global temperature between 1.4 and 4.8°C and sea level between 20 and 88 cm will be occurred by the year 2100. If the sea level rises by this magnitude, costal cities will be part of the sea, high social crisis will occur, and spread of communicable diseases will be beyond control.

1.2.3 Control of Air Contamination

For controlling air contamination, a law should be passed against those responsible for polluting materials and activities. However, the law will not be practical unless it clearly specify type and level of these harmful substances.Though there are many ways of specification of air contaminants, the common one is just sampling ambient air and testing it for the presence of the pollutants. Generally, materials like lead, CO, SO_2, NO_x, O_3, VOCs, particulate and other polluting materials. Efforts are needed to publicise and enforce acceptable population standards.Then, investigation of the existing and the newly entering pollutants in the atmosphere will be carried smoothly.

It is the best strategy to control air contamination by decreasing the emission of pollutants locally and globally. However, once the pollutants are formed the contaminants should be controlled using special devices. These are fixed in any vehicle (as catalytic converter) and industrial plants (as filters and scrubbers). The function of catalytic converter is to reduce the harmfulness of the gasses. Protecting air pollution is much more feasible than cleaning the polluted air. Many attempts have been made to achieve clear air. For example let's take the case of gasoline. It has been tried to formulate many times to burn it without polluting the air. Another way is using alternative sources of energy like electricity, solar energy, wind energy etc. for automobiles. Improvement has been made in the design of buildings so that to utilize the sun during cold times and shade and breezes during hot time in stead of using artificial heating and cooling. If more people use public transportation rather driving individually, the number of automobiles will be reduced significantly. Special buildings equipped with proper ventilation should be constructed to avoid indoor pollution. Smoking in public rooms must be prohibited. Never use asbestos in insulation. Construction of tight foundations avoids seeping of pollutants into buildings.

1.3 Water Contaminant Chemicals

Water has unparalleled necessity to all lives existing in the human planet. But contaminated water resources such as streams, lakes, underground water, bays, or oceans by chemicals are harmful to living things. Pollution even makes streams,

lakes, and coastal waters unpleasant to look at, to smell, and to swim in. Water pollutants can be in the forms of chemical, biological, or physical materials.The ultimate consequence of these materials is to degrade the quality of water. In this chapter more focus is given on chemical pollutants of aquatic ecosystem.

1.3.1 Types and Sources of Chemical Contaminants

There are two types of sources of water contaminants. These are point pollution and non point pollution. Point pollution is the type of pollution in which the sources of chemical contaminants are clearly identifiable. An example of point pollution includes factories, processing plants etc. But non point pollution is the second type of pollution in which the sources of chemical contaminants are not easily identifiable. Generally, the main cause for water pollutants is thought to be human activities. Chemical may reach water bodies from outlet of pipes in industries, leakage of pipe line or storage tanks. Mining operations is also responsible for significant water pollution either through the use of chemical contaminants during ores processing in the mining area or through leaching of water through chemical rich rocks. Large amounts of sewage are produced in cities and carried to water bodies either through canals and flowing streams or other mechanisms. Chemical pollutants are also produced in industries, agricultural sources like pastures, ranches, feedlots etc. The major source of sea pollutants includes processing plant and mining activities in the adjacent shorelines, offshore oil platforms, some leakage from ships etc. Plastics are the most harmful materials to marine animals if thrown and swallowed.

Significant oil is added to oceans during the flushing of tanks. There are other sources of water pollution. The outlet of a given chimney transfer chemicals, for example SO_2, from the plant to the atmosphere. As SO_2 in the air starts to mix with moisture in the atmosphere, sulphuric acid is produced and rain to the earth. This acid will get a way to reach the water bodies by runoff and then it will harm many animals living in the water bodies or drinking from that water. The materials in the garbage may be toxin so that during raining times the toxic substances can be carried with percolating water and hence pollution of underground water will be there.

In agricultural fields, nutrients like nitrates and phosphates from applied fertilizers and sewages are carried into rivers, streams and lakes. This leads to the formation of eutrophication which causes the death of many fish and other aquatic lives. Runoff also sometimes carries toxic algae like *Pfiesteria piscicida* and pesticides together with industrial wastes into water bodies. Fine sediment which has been carried by soil erosion is also responsible for the killing of mass aquatic lives.

Petroleum Products People use crude oil to produce chemicals which are used for many purposes such as lubrication activities, fuel energy, plastics and others. As a

result of improper use and handling of these chemicals, however, they reach water bodies and reduce the quality of water. To mention some of human activities which lead to water contamination are leakage from perforated pipeline system, above and underground oil containers, vehicles, ships and others. Almost all oil products are lethal if they taken by animals in large amount. Polychlorinated biphenyls (PCBs) are harmful substances that contaminate water bodies.

Pesticides The chemical agents called pesticides include herbicides (for weed control), insecticides (for insects control), and fungicides (for fungus control). Chemicals used to kill unwanted animals and plants, for instance on farms or in suburban yards, may be collected by rainwater runoff and carried into streams, especially if these substances are applied too lavishly. Some of these chemicals are biodegradable and quickly decay into harmless or less harmful forms, while others are non-biodegradable and remain dangerous for a long time.When animals consume plants that have been treated with certain non-biodegradable chemicals, such as chlordane and dichlorodiphenyltrichloroethane (DDT), these chemicals are absorbed into the tissues or organs of the animals. When other animals feed on these contaminated animals, the chemicals are passed up the food chain. With each step up the food chain, the concentration of the pollutant increases. This process is called biomagnification. An excess of glyphosphate, a widely used ingredient in herbicides, kills susceptible beneficial insects that prey on insect pests, and it is extremely toxic to fish.

Nitrates Use of uncontrolled pesticides and fertilizers in the farm area contaminate drinking water supplies with nitrates. The NO_3^- ion, being negatively charged, is not adsorbed by most soils. It remains in the soil solution until it is either taken up by plant roots or leached out of the soil in drainage water, or denitrified. Nitrate analysis of drinking water are reported as concentrations of nitrate in milligrams per litre, or the amount of nitrogen possessed by nitrate (NO_3^-N) in milligrams per litre. The most recent guideline from the European Commission set the 'Maximum Admissible Level' for nitrate in drinking water to be 50 g of NO_3 per litre of water. The health risk from nitrate in drinking water free of faecal contamination is very small.

Heavy Metalloids Lead, mercury, copper, and selenium are some of the harmful heavy metals. They pollute water bodies if they get the way from their sources like mining, factories and industries, vehicles and parent materials having these chemicals (Oves et al. 2016). Animals can acquire these heavy metals from plants and other animals which already consumed these chemicals.

Hazardous Waste Generally, hazardous wastes are categorized into toxic, reactive, corrosive, and flammable. Most of the time the materials can reach the water bodies due to lack of appropriate storage or treatment. The wastes can get into the water by oil spills or any other mechanisms. Or animals can also be victims of these wastes if they scavenge polluted dead or alive organisms. Animals can also be toxic by their nature if they are eaten by other animals.

Excess Organic Matter Excess application of fertilizers, organic matter and other nutrients can get a way to pollute water. These leads to the high growth of algae and aquatic plants which when die in the water leads to prevalence of high decomposition processes- eutrophication phenomena, depletion of oxygen to a deadly level. Eutrophication causes many deaths of oxygen dependent organisms like fish and others. Pollutants used to promote plant growth on farms and in gardens, may find their way into water. Landfills may result in landscape deterioration, and pollutants may leach from the landfills to the groundwater.

Sediment In the absence of good vegetation cover and appropriate soil water conservation measures too many soil particles are discharged into water bodies from agricultural lands, mining areas and roads. This sediment may impose water contamination not only because of having high nutrient matter but it may be laden with harmful contaminants. Wildlife living in wells, lakes, rivers and streams are extremely vulnerable to contaminant chemicals. Pollutants that reach sea may kill and disturb aquatic ecosystem. Though the oceans are vast, but they are vulnerable to pollution. Polluted water is not only responsible for health problems for humans but cause the deaths of unimaginable amount of wildlife.

1.3.2 Consequences of Water Contamination

Human beings at the top of food chains may, as a result of these chemical concentrations, suffers cancers, reproductive problems, and death. High intake of water and food contaminated with high concentration of nitrates can lead to methemoglobinemia or blue baby syndrome in infants, a potentially lethal form of anemia. This disease is not caused by nitrate but by nitrite, produced in the gastro-intestinal tract by nitrate-reducing organisms. Highly consumption of nitrate also leads to gastric cancer.

Like pesticides and herbicides heavy metals can result in long-term health problems as they reach high levels in the body. That is, if humans eat crops and vegetables, which already absorbed cadmium excessively from organic fertilizers particularly sewages, can lead to the damage of essential body organs. Consumption of Lead is also responsible for mental retardation (Morgan 2013). Fish and shellfish harvested from polluted waters may be unsafe to eat. People who ingest polluted water can become ill, and, with prolonged exposure, may develop cancers or bear children with birth defects. Industrial pollutants that run into streams, rivers, or lakes can have serious effects on wildlife, plants and humans.

A change in the nutrient status in soils and sediments may have an effect on species distribution in terrestrial and aquatic ecosystems; increased nitrate levels in ground water may result in toxic nitrate levels in drinking water, health hazards. Eutrophication is one of the common consequences of water contaminated with nutrients. It is an enrichment of lake, river and sea waters with nutrients (such as nitrogen, phosphorous and sulphur) that increase the growth of aquatic plants. It is

due to agricultural and industrial activities underlying losses of nitrogen, sulphur and phosphorus to the environment. That is, though it is a natural process, but it is accentuated by human activities like discharge of industrial wastewaters, sewage effluent, runoff, leaching from heavily fertilized or manured agricultural land and deposition from atmosphere. Eutrophication is always underway if the levels of nitrogen and phosphorus in natural ecosystems and groundwater have increased.

There are some events in which acid rain or acid snow can have disturbance of the aquatic ecosystems. Moreover, spilled oil from ship and industries in coastal waters may cause the poisoning of fish and the loss of feathers and furs. If the animals swallow the chemicals in large amount, there is high possibility of death.

1.3.3 Control of Water Contamination

Governments, policy makers, and managers should give priority to reduce water contaminants coming from eroded soils, agricultural chemicals and wastes, pesticides and excessive fertilizers. Increasing vegetative covers help being as barriers against to those harmful chemicals which come along with eroded soils. To reduce the amount of sediments, well planned soil and water conservation should be implemented in the water shed and along the river banks. Farmers and foresters should work to stabilize the banks of rivers and streams by increasing the vegetation cover. Farmers should be aware of not tilling their land up and down along the slope to reduce the accumulation of sediments in water bodies. Animals should be confined in a certain places so that their wastes can be controlled and treated conveniently. If possible wet land area should be reserved to help for retaining sediments and nutrients.

1.4 Soil Contaminants

Wild (1993) defined soil pollution in his book as a build-up of toxic chemical compounds, salts, pathogens (disease-causing organisms), or radioactive materials that can affect plant and animal life. Soil is a mixture of mineral, plant, and animal materials that form during a long process that may take thousands of years. It is the growing house of plants and microorganisms. These living things get their nutrients with the help of chemical processes. Shortly soil is a source of food for most living things and without which agricultural production is impossible. Therefore, the chemical situations like pH, structure of organic compounds and minerals, soil ventilation system, and liquid phase affect the growth of plants and organisms living in the soil (Havlin et al. 2005).