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Industrial pollution and its impacts on ecosystem: A Review

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INTRODUCTION

The environment consists of both biotic and abiotic components and interaction for living organism community developed a sound ecosystem which provide benefits to the living organism. The researcher's findings showed that excess concentration of industrial pollutants may produce toxic effects on ecosystem. It creates unfavorable conditions for existence and development of living organisms. All organisms are mainly affected directly or indirectly due to environment pollution resulting due to rapid industrialization, technological advancement and geometrically increases in human population since las couple of years very rapidly a regional and global level.

Environmental pollution by industrial revolution is a major problem facing the world today and there is an increasing awareness of the fact that a clean environment is necessary for better health of living organisms. Environmental pollution is an unfavorable alteration of our surroundings brought about particularly by the industrial revolution. Industrial projects have a profound influence on society and the environment not only in terms of benefits but also in risks and hazards. Man has been paying the cost of destruction he has produced in his environment and in natural process throughout the centuries. It is exact to say that the industrial revolution of the 19th century is mainly responsible for environmental pollution. This environmental pollution added by different industries is causing a great threat to human, animals as well as to plants and formed Industrial pollution.

Developments of new technologies and anthropogenic activities have affected environmental quality in a lot of ways. The harmful effects on the natural environment and health of living organisms are resulting from man lack of awareness. As industrial wastes are disposed into the environment with no proper monitoring and management, which become hazardous for living organisms. Industrial wastes disposed into air, water and soil, mostly without proper treatment can cause severe health impacts of air, water and soil pollution, which cause hazards to living organisms found in such disposal sites (World Bank, 1992). Increases in developmental technology in developed industries, different chemicals have become a vital matter for human development. An important use of chemicals is to control different agricultural pests. On one hand use of these chemicals shows the positive influence on agricultural products while, on the other hand, toxic chemicals show harmful effects to the environment and damage human health. Hence, water, air and soil pollution affecting

natural environment, plant growth and other living organisms, including human health has become an important environmental issue (Ahmed-Fariz et al., 2009) especially in industrial area. The environment is composed of air, water, land, plants and animals. All these constituents are interdependent on one another and maintain a balance in nature. Sometime this balance is lost due to various reasons, one of them is the environmental pollution, which take place mainly through different types of industries.

MAJOR INDUSTRIAL POLLUTANTS

Environmental pollution by different types of industries occurs in different forms but can usually be thought of as gaseous and particulate pollutants that are discharged from different industries and become part of the earth's atmosphere. The gaseous pollutants of industrial polluted environment consist of sulfur dioxide (SO_2), different oxides of nitrogen (NO_x), ozone (O_3), carbon monoxide (CO), hydrogen sulfide (H_2S), hydrogen fluoride (HF) and diverse gaseous forms of metals. Such contaminants are released from large industrial estates such as fossil fuel fired power plants, smelters, industrial boilers, petroleum refineries and manufacturing facilities as well as from different industrial units. These are toxic substances which cause damage to environmental balance, can cause injury to living organisms, producing respiratory diseases and reduce visibility. Different contaminants occur as toxic substances in the crust of earth or biosphere and anthropogenic activities such as mining, industry, agriculture and other such activities support their release into the environment, leading to toxicity (Fargasova, 1994). Air pollutants can directly or indirectly affect plants via leaves or soil and water acidification respectively (Steubing et al., 1989). It has been reported that most plants show physiological and ecological changes before exhibiting visible damage to leaves (Doen et al., 1990).

The most diffuse and harmful pollutants in industrial area are sulfur dioxide (SO_2), nitrogen oxides (NOx), carbon mono oxide (CO), troposphere ozone (O_3) and heavy metals, as well as suspended particulate matter. Various air pollutants are identified as phytotoxic agents. Phytotoxicity of sulphur dioxide (SO_2) has been recognized for about a century (Godzik and Sienkiewicz, 1990) effects of ozone (O_3) for more than 30 years (Miller, 1983), acidic precipitation for almost 20 years (Likens et al., 1979), and effects of elevated levels of nitrogen compounds, nitrogen oxides (NO_X) and ammonia (NH_3) in the last decade (Nihlgard, 1985). Importance of other pollutants such as peroxyacetyl nitrate (PAN) (Su et al., 2006), fluorides 20 or heavy metals has also been recognized (Unsworth and Harrison, 1985).

Suspended particles can often reduce the amount of sunlight, disrupting the growth of photosynthetic plants and microorganisms. Industrial pollution is a serious problem affecting the quality of other environmental resources as well as the human-made structures and services in the area. Polluted air of industrial area can harm resources in different manners depending on the toxicity of the pollutant, environmental conditions and the nature or depending sensitivity of resources. The effects of air pollution on vegetation became a matter of great concern in 1890s when Sulphur dioxide was first recognized as a phytotoxicant (Treshow, 1970). Since then many airborne compounds have been characterized as phytotoxic, among them are hydrogen fluoride (HF), ozone (O_3), peroxyacetyl nitrate (PAN) and nitrogen dioxide (NO_2). Fisher et al., (1936) reviewed and reported that sulphur dioxide increased the sulphur content of vegetation in the upper Columbia River valley at a distance of about 54 miles from the trial smelter. Most of the suspended industrial atmospheric pollutants finally fall down and settle on the ground surface, causing soil and water pollution. The similarly industrial pollutants also come back to soil when polluted water is used for irrigation. The increased rate of industrialization also created the problem of water pollution. Hence the ground water, which is considered safe from pollution becomes contaminated with lead, cyanides, mercury, solvent and hydrocarbon compound, hospital and pharmaceutical industrial wastes.

Pakistan is one of the developing countries, which is being threatened by environment relaxed issues; likewise, water, air and soil pollution through unrolled industrial effluents, household sewage, saline drainage water, dust and dirt etc. It has been investigated that about 9,000 million gallons of waste water are being daily liberated into different water sources from different industrial estates (Salaam et al., 1993). National Conservation Strategy (N.C.S.) reported that about 40% of deaths are concerned to water borne diseases. Industrial waste water contains different toxic chemicals. It is important to note that most industries have been started without any

suitable planning and waste treatment plants. These just discharged untreated toxic waste into nearby drains, canals or rivers. In Pakistan very low quantity of fresh water available this is estimated as 172 billion cubic meters (Ahmed, 1988). The industrial polluted waste water is being used for irrigation in urban and sub-urban lands. This untreated water has long been practiced in many parts of the world as a result of plant nutrients and lack of transportation and services of safe disposal. The urban agriculture soils of Pakistan, especially in large cities, as in Karachi are often irrigated with different toxic industrial effluents for growing vegetables (Ibrahim and Salman, 1992). The farmer's use these toxic effluents as a supply of irrigation and nutrients (Ghafoor et al., 1994) while, administrators believe these effluents as a viable practice for disposal. Even the well-planned capital city of Pakistan, Islamabad also needs suitable managements of effluents in its industrial units and the different toxic industrial and slaughterhouse wastes are discharged in river Soan (Mian et al., 1998). These wastes may consist of hazardous, toxic materials, chemical compounds and organic material. The frequent direct release of these unwanted toxic materials in excess in the surroundings from industries brings the failure of self-cleaning mechanism of the environment (Nawaz *et al.,* 2006).

The acceleration of exploitation has been increasing at a high rate and in non-judicious manner during the past few decades especially with the advent of industrial revolution. Industrialization has provided humanity with materials and social benefits (Rai et al., 2011). It has also brought in its wake up many unwanted substances and social problems. One of these problems is the degradation of the environment. These environmental problems are becoming threats to the very existence of the living beings. The environment upon which our life is most dependent, has fallen victim of pollution brought by man himself through unplanned and unscientific urbanization, industrialization and mineral exploitation.

Much of the 20th century witnessed an increasing trend in urbanization in developing countries. While urbanization can be a stimulus of development, in the process many cities in Asia, Africa, the Near East and Latin America are facing two challenges of pollution and congestion. In 1960, less than 22% of developing world's population was urban and the proportion increased to 34% by 1990. The projections are that 50% of the global population will be urban by 2020 (Ashmore, 2005). The general state of the environment, including air quality, is deteriorating in many cities of the developing countries.

Environmental pollution, mainly due to the gaseous emission of industries, thermal power station, automobiles and the domestic combustion, is causing a number of problems and deformities in living beings, particularly in metropolitan cities like Karachi. These pollutants caused injury and damage to plants and plant parts in a number of ways (Ghouse and Saquib 1986; Yunus and Iqbal, 1996; Iqbal et al., 2000; Saquib 2008, 2009; Iqbal et al., 2010; Shafiq, 2002; Shafiq and Iqbal, 2012; Shafiq et al., 2019; Iqbal et al., 2020; Kabir et al., 2020)

The extent of injury depends on the concentration of gases, fumigation frequency, duration of exposure and the prevailing environmental condition (Thomas and Hendricks, 1956). The effects of pollutants may be synergistic, additive or antagonistic depending upon environmental factors and the species involved (Tingey and Reinert, 1975). These pollutants caused serious setbacks to the morphology and physiology of plants.

Industrial pollution resulting from industrial revolution is a constant threat to humanity. Numerous researchers have described the damages to vegetation caused by industrial effluents (Camplin, 2001; Yasir, 2003; Clemente et al., 2005). Pakistan is a developing country and the major cities like Karachi, Lahore, Faisalabad and Hyderabad are suffering from environmental pollution problems. So in many cities of Pakistan, particularly in Karachi industrial effluents released by textile, fertilizers, tanneries, cement, vegetable oils, paints, oil refineries, soap, sugar and smelters industries having high concentration of toxic metals are being disposed into open urban drains (Chaudry et al., 1998). Afterwards, they are commonly used either for growing vegetable crops in the urban areas or drained into fresh water bodies (rivers) without receiving any treatment and ultimately become incorporated into the Arabian sea, an international water body. Hence the uptake of these toxic heavy metals by aquatic flora and fauna, including migratory birds make it a problem of international concern.

Pollution due to discharge of industrial waste has become a serious problem in most of the industrial areas of Pakistan. Usage of effluents not only prevents the environmental pollution but also serves as an additional potential source of liquid fertileness, as it contains organic, inorganic

compound and trace metals to plants (Jayakumar, 2013). That is why ecologists have started to think of various remedial measures that the waste of yesterday could become a useful product of today with reference to pollution. Rapid industrialization for sustaining economic stability, is leading to the pollution of the environment. It is the right time to discuss our environment where we live in is amenable for the healthy life. Irrespective of all the positive aspects, pollution has become a major environmental problem.

Agricultural development is the basic economic activity of the developing countries which provides food for human sustenance and employment for the growing population (Jayakumar, 2013). Though there are various negative aspects and arguments which are contradictory, it is our responsibility to make the industrial effluents to be beneficial to the society and to make the impact of industrial effluents on plants to be beneficial.

Worldwide biosphere has been severely contaminated by metals through natural weathering processes and anthropogenic activities. The high amount of lead, copper and zinc were detected, which influenced the composition of plant communities in the area (Qamar-uz-Zaman and Iqbal, 1994). Heavy metals are natural constituent of the lithosphere, whose geochemical cycles and biochemical balances have been drastically altered by human activity (Sebastiani et al., 2004).

The plants growing in an industrial polluted environment can accumulate heavy metals at high concentration causing serious risk to plants and human health when consumed (Alloway, 1990; Vousta et al., 1996; Akinola and Ekiyoyo, 2006). Moreover, heavy metals are dangerous because they tend to bioaccumulate in plants and animals causing deleterious effects, bioconcentrate in the food chain or attack specific organs in the body (Chatterjee and Chatterjee, 2000).

HEAVY METAL POLLUTION

The occurrence of different pollutants, especially heavy metals in industrial effluents and wastes is of great interest because they are mostly present at considerable levels and if discharged into surface waters can have toxic effects on the ecosystem and public health. The determination of total heavy metal concentrations cannot give helpful information about the risks of accumulation, translocation and the toxic actions of the metals in the environment (Luoma, 1989; Sims and Sklin, 1991; Hsu and Lo, 2001). The metals present in industrial wastes are often distributed in diverse operationally defined geochemical phases, such as carbonates and total organic carbon (T.O.C.), which have different binding capability with different metals and have distinct impacts on the metal bioavailability and its transportation within the environment (Tessier and Campbell, 1987; Bryan and Langston, 1992; Coquery and Wekbourn, 1999). In an industrial area, the acid volatile sulfide is a main factor in affecting the bioavailability, accumulation and transportation of most divalent metals having a high attraction with sulfide (Di-Toro et al.,1990; Ankley et al., 1996; U.S.E.P.A., 2001). It is required to know the physical and chemical characteristics of any industrial waste before their removal and mostly their composition, both in terms of total contents and the quantity that is strongly effective for living organisms.

The pollution due to heavy metals place human health at risk (Ilyasova and Schwartz, 2005) and it is responsible for a number of environmental problems, which includes the decrease of microbial activities, soil fertility and crop yields. The annual toxicity of all the mobilized metals exceeds the total combined toxicity of all radioactive and organic residues generated in the same period (Nriagu and Pacyna, 1988). Pollution by heavy metals normally coincides with the increase in industrialization of a given region and becomes more severe when there are neither controls nor adequate environmental norms (Pilon-Smits, 2005).

Discharges of industrial residues that contain Cd, Cr, Cu and Pb constitute a potential risk to aquatic life, animals and humans, due to the contamination of air, soil sediments, vegetation and water (Yang et al., 2005). These metallic elements, either isolated or in a group, are commonly used in industrial processes of diverse sectors like paper and cellulose, petrochemicals, chemical products, fertilizers, oil refining, steel production, non-iron metals, spare parts of vehicles, plain glass and cement, textile and leather products and the manufacture of other devices (Sanita-di-Toppi and Gabrielli, 1999). According to Patra et al., (2004), plants that grow in environments contaminated with traces of metals show strategies of escape or tolerance to metal toxicity that have been selected during evolution. Several plant species have developed tolerance to metals in a relatively short period of about thirty years (Hall, 2002).

In Karachi's untreated wastewater from industrial estates is being discharged into the

Layri and Malir rivers, which fall into the Arabian Sea. Such wastes are exerting a serious threat to the aquatic environment. A significant percentage of the marine pollution can occur when the import and export industries ship their supplies through Karachi Port. The environmental pollution of such industries is affecting the ecosystem because different factory effluents are untreated and discharged directly into the port area. In 1991 Pakistan National Environmental Plan (P.N.E.P.) suggested three main coastal industries situated near the port with the biggest volume of different effluents include steel mill, power plants and refineries. It was also reported that different industrial estates are depositing more toxic effects on the marine habitat. Toxic heavy metals are being accumulated in the aquatic living organisms. The accumulation of toxic heavy metals (Cd, Co, Cr, Cu, Ni, Pb and Zn) in the flora and fauna of coastal area of Karachi, especially higher in aquatic organism (Mastoi et al., 2008). Some of aquatic life is infected with lead, which if taken up by humans through seafood, has been linked to different dangerous diseases. Marine flora mostly comprises mangroves which can also be disturbed by industrial pollution. In Pakistan mangroves occur mostly in the Indus deltaic region along a few areas of Balochistan Coast and Sindh Coast. Pakistan is depending on these mangroves to sustain the ecological balance as mangrove leaf litter can act as a major source of different nutrients, habitat to different community of invertebrates, birds, fish, reptiles and commercially important shrimp species try to find shelter in mangroves for one stage of their life cycles.

In today's world air pollution does not need any introduction. Pollution is invariably associated with environmental degradation. There does not seem to be any life form not affected by air pollution. The definition says "any abnormal increases or decrease in the concentration of the normal components of the atmosphere is known as air pollution" (Mudakavi, 2010). Due to an increasing number of industries, vehicular exhaust and decreasing plant cover coping with the increasing human population, ambient air is becoming heavily polluted day by day. Air pollution has a detrimental effect on nearly all phases of our lives including health effects like eye irritation, Skin irritation, headache, sneezing, coughing, suffocation, chest pain, breathing problems etc. and welfare effects on vegetation, soil, water, man-made materials, climate and visibility. In plants, air pollutants lead to stunted growth, altered biochemical compositions and less productivity (Chakraborty et al., 2009). It also imparts leaf injury and causes change in stomatal movements and thus the rate of photosynthesis.

Water is the elixir of life without which no biota could survive in the biosphere. The industrial growth in Pakistan, though solving economic problem, also add up to environmental pollution as waste water effluents from tanneries discharged into water bodies deteriorating the water quality (Faisal and Husnain, 2004). Soluble minerals in polluted water actually enhance the salinity problems close to several industries (Davidson, 2000).

Different types of toxic pollutants are being deposited directly on the soil as sewage, industrial effluents and chemical fertilizers. Many organic and inorganic substances are present in different industrial effluents. Such pollutants, mostly remain attached in the soil and are not easily available to plants. These pollutants can not affect the metabolic reactions of plants; however, they affect different soil properties. The industrial pollutants affect the mineral structure, soil pH, total dissolved salts, soil texture and exchangeable nutrients, etc. of the top soil and thus indirectly affect the plants. The pH of the industrial area soil is disturbed, making soil either acidic or alkaline. Various degradable and non-degradable pollutants accumulate in industrial soil up to toxic levels in plants. In highly polluted industrial soils and plants absorb, accumulate and translocate toxic substances in their different parts. Acidic or low pH of soil affects functions of microbes, mainly of decomposers as a result of which decomposition process of organic matter and consequently the nutrient cycles are reduced in the soil. Industry proliferates parallel to urbanization but increased industrialization produced industrial effluent which is hazardous for the environment if not treated (Ahmad et al., 2012).

CONCLUSION

A clean environment is necessary for the better health of living organisms. Therefore, our environment must be protected as environmental issues has top priority in the developed countries of the world. Research papers and review survey may be consulted to solve the problem. No doubt, national efforts to deal with this increasing problem are under way in many major cities of Pakistan, but such efforts must be strengthened. There is a need to bring about improvements in the environmental conditions by means of more

plantations because plant acts as a pollutant sink. More plantations would be helpful in reducing the burden of pollutants from the immediate environment. There is also a need for enforcement of regulations to control environmental pollution. Public participation, nongovernmental organization and civic agencies of the government require a collective approach towards this solution. Continuous pollution monitoring for one or more pollutant is an absolute necessity for completing a diagnosis of pollutant level in the air, water and soil environment. More importantly, a network of monitoring stations throughout the world will be helpful to measure the current pollutant level. Accumulation of air monitoring data will provide the criteria needed for establishing air quality standards. The very nature of industrial pollutant (especially heavy metals) must be analyzed and nature of harmful effect be clearly understood. There is a need to examine the toxic pollutants present in air, water and soil, which would be helpful in formulating the strategy to control or at least minimize the pollution.

In Pakistan, the state of the environment in major urban cities center is not good due to air, water and soil pollution. The damage to the environment has been increased considerably since last couple of decades very rapidly. The numbers of species are reducing and majority of native plants are disappearing for the use of food, fiber or medicine, pharmaceutical and industrial raw materials.

CONFLICT OF INTEREST

The authors declared that no conflict of interest exist among all authors.

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AUTHOR CONTRIBUTIONS

MK designed the article. UH surveyed the literature, gathered information from the scientific papers, search engines and MSdraft the review. MZI., and ZRF critically reviewed the article.

REFERENCES

Ahmad I, Akhtar MJ, Zahir ZA, Jamil A. 2012. Effect of cadmium on seed germination and seedling growth of four wheat (*Triticum aestivum* L.) Cultivars. *Pak. J. of Bot.* 44: 1569-1574.

Ahmed K. 1988. Removal of toxic substances by anaerobic waste stabilized pond. Sci. Technol. and Develop. 7: 45-51.

Ahmed-Fariz M, Zuhairi W, Raihan T, Rahim S. 2009. Ground and soil vulnerability in the largest basin Malaysia. European J. of Scientific Res. 27: 628-635.

Akinola MO, Ekiyoyo TA. 2006. Accumulation of lead, cadmium and chromium in some plants cultivated along the bank of river Ribila at Odonla area of Ikorodu, Lagos state, Nigeria. J. of Environ. Biol. 27: 597-599.

Alloway BJ. 1990. Heavy metal in soils. 2nd ed. Glasglow Blackie and Son Publishers, England, pp. 339.

Ankley GT, Di-Toro DM, Hansen DJ, Berry WJ. 1996. Technical basis and proposal for deriving sediment quality criteria for metals. Environ. Toxicol. and Chem. 15: 2056-2066.

Ashmore MR. 2005. Assessing the future global impacts of ozone on vegetation. Plant, Cell & Environ. 28: 949-964.

Bryan GW, Langston WJ. 1992. Bioavailability, accumulation and effects of heavy metals in sediments with special reference to United Kingdom estuaries. Rev. of Environ. Pollut. 76: 89-131.

Camplin WC. 2001. Effect of paper and pulp factory of Indonesia on the growth and yield potential of cereal crops. Environ. Pollut. 33: 324-331.

Chakraborty S, Solanki R, Dave J, Rana S, Kumar RN, Bhattacharya T. 2009. Effect of airborne fly ash deposition on morphology and biochemical parameters of *Medicago sativa* L. and *Brassica juncea*. Res. in Environ. and Life Sci. 2: 13-16.

Chatterjee J, Chatterjee C. 2000. Phytotoxicity of chromium, cobalt and copper in cauliflower. Environ. Pollut. 109: 69-74.

Chaudry MA, Ahmad S, Malik MT. 1998.

Supported liquid membrane technique applicability for removal of chromium from tannery wastes. Waste Mangmnt, 17: 211-218.

Clemente R, Walker DJ, Bernal MP. 2005. Uptake of heavy metals and As by *Brassica juncea* grown in a contaminated soil in Analcollar (Spain): The effect of soil amendments. Environ. Pollut. 138: 46-58.

Coquery M, Wekbourn PM. 1999. The relationship between metal concentration and organic matter in sediments and metal concentration in the aquatic macrophyte *Eriocaulon septangulare*. Water Res. 29: 2094-2102.

Davidson AP. 2000. Soil salinity, a major constraint to irrigated agriculture in the Punjab region of Pakistan: Contributing factors and strategies for amelioration. American J. of Alternative Agri.15: 154-159.

Di-Toro DM, Mahony JD, Hansen DJ, Scott KJ, Hicks MB, Mayr SM, Redmond MS. 1990. Toxicity of cadmium in sediments: the role of acid volatile sulfide. Environ. Toxi. and Chem. 9: 1487-1502.

Doen GP, Kopper A, Langebartels C. 1990. Biochemical response of Norway Spruce (*Picea abies* L.) towards 14-months exposure to Ozone and acid mist, effect on amino acid, glutathione and polyamine titers. Environ. Pollut. 64: 375-383.

Faisal M, Husnain S. 2004. Microbial conversion of Cr (iv) into Cr (iii) in industrial effluent. Afr. J. of Biotech. 3: 610-617.

Fargasova A. 1994. Effect of Pb, Cd, Hg, As and Cr on germination and root growth of *Sinapis alba* seeds, Bulletin of Environ. Contamination and Toxico, 52: 452-456.

Fisher DF, Coldsworthy MC, Griffin SW. 1936. The accumulation of sulphur in foliage exposed to smelter fumes. Statement to Canadian Agentt, department of Agricultural appendix. 4,7 pp. 570-635.

Ghafoor A, Rauf A, Arif M, Muzaffar V. 1994. Chemical composition of effluents from different industries of the Faisalabad city. Pak. J. of Agri. Res. 31: 367-369.

Ghouse AKM, Saquib M. 1986. Growth responses of some weeds of an agroecosystem to air pollution. Acta Botanica Indica,14: 234-235.

Godzik S, Sienkiewicz J. 1990. Air pollution and forest health in central Europe: Poland, Czechoslovakia, and the German Democratic Republic. In: Grodzinski, W., Cowling, E.B. and Breymeyer, A.I. (eds.). Ecological risks perspectives from Poland and the United States. National academy press, Washington, D.C, pp. 155-170.

Hall JL. 2002. Cellular mechanisms for heavy metal detoxification and tolerance. J. of Exp. Bot. 53: 1-11.

Hsu JH, Lo SL. 2001. Effect of composting on characterization and leaching of copper, manganese, and zinc from swine manure. Environ. Pollut. 114: 119-127.

Ibrahim M, Salman S. 1992. Chemical composition of Faisalabad city sewage effluent. Nitrogen, phosphorus and potassium contents. J. of Agri. Res. 30: 381-390.

Ilyasova D, Schwartz GG. 2005. Cadmium and renal cancer. Toxicol. and App. Pharmacology, 207: 179-186.

Iqbal M, Srivastava PS, Siddiqi TO. 2000. Anthropogenic stresses in the environment and their consequences. In: *Environmental Hazards:* Plants and People. (eds.) Iqbal, M., P.S. Srivastava and T.O. Siddiqi. CBS Publishers, New Delhi, pp. 1-37.

Iqbal MZ, Jilani A, Shafiq M, Kabir M, Farooqi ZR. 2020. Seasonal variations in some soil characteristics on urban area of Karachi. *Bioscience,* 17(2):786-792.

Iqbal MZ, Nighat F, Khan PR. 2010. Photosynthetic, metabolic and growth responses of *Triumfetta rhomboidea* to coal-smoke pollution at different stages of plant ontogeny. J. of Plant Interactions,5: 11-19.

Jayakumar K. 2013. Influence of pharmaceutical effluents on seedling vigour, dry matter production of horse gram (*Dolichos biflorus*. L.). Int. J. of Modern Plant & Animal Sci. 1: 58-66.

Kabir M, Iqbal MZ, Shafiq M, Farooqi ZR, Um E Habiba 2020. The effects of different soils types on seedling growth of *Gliricidia sepium* (Jacquin) Kunth ex Walp. (Fabaceae). *Bioscience,* 17(2):832-841.

Likens GE, Wright RF, Galloway JN, Butler J. 1979. Acid rain. Scientific American, 241: 43-51.

Luoma SN. 1989. Can we determine the biological availability of sediment-bound trace elements? Hydrobiologia, 176-177: 379-396.

Mastoi GM, Shah GS, Khuhawar MY. 2008. Assessment of water quality of Manchar Lake in Sindh (Pakistan).Environ. Monit. and Assess.141: 287-296.

Mian Z, Ahmad T, Rashid A. 1998. Accumulation of heavy metals in water of river Soan due to effluents, in industrial area. Proceedings of

the argoenviron-98: internationalsymposium, May 25-30, NIAB Faisalabad, Pakistan, pp. 1-4.

Miller PR. 1983. Ozone effects in the San Bernardino National Forest. Air pollution and the productivity of the forest, symposium proceedings, Pennsylvania State University Press, State College, P.A., pp. 161-197.

Mudakavi JR. 2010. Principles of practices of air pollution control and analysis. I.K. International publishing house Pvt. Ltd. New Delhi, India, pp. 8-10.

Nawaz S, Ali SM, Yasmin A. 2006. Effects of industrial effluents on seed germination and early growth of *Cicer arientum*. J. of Bioscience, 6: 49-54.

Nihlgard B. 1985. The ammonium hypothesis - an additional explanation to the forest dieback in Europe. *Ambio,* 14: 2-8.

Nriagu JO, Pacyna JM. 1988. Quantitative assessment of worldwide contamination of air, water and soils by trace metals. *Nature*, 333: 134-139.

Patra M, Bhowmik N, Bandopadhyay B, Sharma A. 2004. Comparison of mercury, lead and arsenic with respect to genotoxic effects on plant systems and the development of genetic tolerance. Environ. and Exp. Bot. 52: 199-223.

Pilon-Smits E. 2005. Phytoremediation. Annual Rev. of Plant Biol. 56: 15-39.

Qamar-Uz-Zaman, Iqbal MZ. 1994. Vegetation pattern along the sewage effluents channels of Malir River, Karachi. Turk. J. of Bot.18: 425-430.

Rai R, Rajput M, Agrawal M, Agrawal SB. 2011. Gaseous air pollutants: A review on current and future trends of emissions and impact on agriculture. J. of Scientific Res. 55: 77-102.

Salaam A., Ali M, Chatta AM, Zaman QU. 1993. Growth performance of culture exotic silver carp (*Hypophthalmicthys molitrix*) under semi-intensive farming: An ecological approach. Acta Sci. 3: 89-100.

Sanita-di-Toppi L, Gabrielli R. 1999. Response to cadmium in higher plants. Environ. and Exp. Bot. 41: 105-130.

Saquib M. 2008. Effect of coal smoke pollution on the biomass and chlorophyll pigments of *Brassica juncea*. Ecoprint*,* 15:1-6.

Saquib M. 2009. Root growth responses of *Melilotus indicus* (L.) All. to air pollution. Ecoprint, 16: 29-34.

Sebastiani L, Scebba F, Tognetti R. 2004. Heavy metal accumulation and growth responses in poplar clones Eridano (*Populus deltoides* x *maximowiczii*) and I-214 (*P*.x *euramericana*) exposed to industrial waste. Environ. and Exp. Bot. 52: 79-88.

Shafiq M. 2002. Investigation into the effects of automobile pollutants on growth and metal contents of some roadside plants. Ph.D. dissertation. Department of Botany, University of Karachi, Karachi, Pakistan, pp. 99.

Shafiq M, Iqbal MZ. 2012. Impact of Automobile Pollutants on Plants. Lambert Academic Publishing GmbH & Co. KG Heinrich-Böcking-Str. 6-8,66121, Saarbrü- cken, Germany. 132 pp.

Shafiq M, Iqbal MZ, Kabir M, Farooqi ZR. 2019. Poison Land. "Vegetation of disturbed and polluted areas in Pakistan". Strategic book publishing & rights agency, U.S.A. 173 pp.

Sims JT, Sklin J. 1991. Chemical fractionation and plant uptake of heavy metals in soils amended with composted sewage sludge. J. of Environ. Qual. 20: 387-395.

Steubing L, Fangmeire A, Both R. 1989. Effects of SO_2, NO_2 and O_3 on pollution development and morphological and physiological parameters of native herb layer species in beech forest. Environ. Pollut. 58: 281-302.

Su YC, Ho CL, Wang EI, Chang ST. 2006. Antifungal activities and chemical compositions of essential oils from leaves of four eucalyptus. Taiwan Journal for Science*,* 21: 49-61.

Tessier A, Campbell PGC. 1987. Partitioning of trace metals in sediments: relationship with bioavailability. Hydrobiologia, 149: 43-52.

Thomas MD, Hendricks RH. 1956. Effect of air pollution on plants. In: Air pollution hand book. (eds.) Magil, P.L., F.R. Holden and C. Ackley. McGraw-Hill Book Company, New York, Toronto, London, pp. 223-278.

Tingey DT, Reinert RA. 1975. The effect of ozone and sulphur dioxide singly and in combination on plant growth. Environ. Pollut.9: 117-125.

Treshow M. 1970. Ozone damage to plants. Environ. Pollut. 1: 55-61.

U.S.E.P.A. (United State Environmental Protection Agency) 2001. Methods for collection, storage and manipulation of sediments for chemical and toxicological analyses. Technical manual (EPA-823-B-01-002). U.S. Environmental Protection Agency, Office of Water Washington, DC. pp. 16.

Unsworth MH, Harrison RM. 1985. Is lead killing

German forests? Nature, 317: 674.
Vousta D, Grimanins A, Samara C. 1996. Trace elements in vegetables grown in an industrial area in relation to soil and air particulate matter. Environ. Pollut. 94: 325-335.
World Bank. 1992. World development report 1992.Development and the environment. New York. Oxford University Press, pp. 435-440.
Yang X, Feng Y, He Z, Stoffella PJ. 2005. Molecular mechanisms of heavy metal hyperaccumulation and phytoremediation. J. of Trace Element in Medicinal Biol. 18: 339-353.
Yasir M. 2003. Waste water and its effect on some crops. Water, Air, & Soil Pollut. 3: 32-36.
Yunus M, Iqbal M. 1996. Plant responses to air pollution. John Wiley, Chichester, pp. 545.