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Environmental Pollution : Challenges and Remedies

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ABSTRACT

Almost every human activity that results in the degradation or depreciation of the quality of the natural environment is regarded as pollution. Environmental pollution is not a new phenomenon, yet it remains the worlds's greatest problem facing humanity, and the leading environmental causes of morbidity and mortality. In 2015 it was predicted that ill-health caused by pollution accounted for 9 million premature deaths, which is more than three times the number of deaths from malaria, AIDS, and tuberculosis put together (Landrigan et al., 2017). Widespread interference of human related activities have resulted in major problems including environmental pollution, land degradation, global warming/climate change, paucity of potable water supply and biodiversity loss. These issues have directly affected the quality and sustainability of the ecosystems. In addition, these activities have resulted in loss of habitats resulting in mass extinction of species which in itself is a matter of great concern.

Keywords: Morbidity, Sustainability, Tuberculosis, Extinction.

I. INTRODUCTION

Earth is the only celestial body in the universe where life is known to exist and that too with such a huge diversity. Generally, environmental pollution is greater in middle- and low-income countries than in developed countries, possibly due to poverty, poor legislation, and being unaware of pollution forms. It is likely that humans face pollution daily without knowing it or we may have possibly become immune to it in our fast-paced lives (Muralikrishna and Manickam, 2017). As unlikely as it may seem, being unaware of the forms of pollution results in humans performing activities that yield deleterious by-products in forms and quantities that the environment can no longer counterbalance without outright deformation of its system. However, it is now becoming more and more inhabitable for most of the species as indicated by steep decline in diversity of flora and fauna. For instance, deforestation, burning of bushes, dumping of agricultural and household wastes in water bodies, use of chemicals in harvesting aquatic animals, and improper disposal of electronic wastes, all contribute to air, land, and water pollution. More so, as human population density increases, human activities also increase with concomitant increase in the impact on the environment. The impacts are not only on humans but also on other aquatic and terrestrial animals including microorganisms, which because of their abundance and diversity tend to maintain their biogeochemical function necessary for sustaining the ecosystem. The main reasons behind the worsening conditions for life on earth are the anthropogenic activities. The human interference has

resulted in increase in concentration of greenhouse gases (GHGs), climate change, degradation of land, pollution of air water and soil, depletion of non-renewable resources, loss of biodiversity, accumulation of harmful recalcitrant chemicals and several related issues. Since the last few decades the impact of environmental problems has been highlighted at several forums. In 1960s, the United Nations (UN) discussed the environmental costs of growth-centered or conventional development. In the report 'Our Common Future' (known as the Brundtland Commission), released in 1987 by the World Commission on Environment and Development (WCED), it was stated that development is only 'sustainable' if it 'meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987). WCED global agenda was an initiative to work on sustaining the planet for better future. Similarly, the UN Conference on the Environment in Stockholm and on Environment and Development (UNCED) in Rio de Janeiro (1992) accepted that the un-sustained human activities towards environment will cause huge, irreversible damage to life on earth (http://www.un.org/genin fo/bp/envir o.html). The UN Agenda 21 was to promote sustainable development undertaken at the Earth Summit held at Rio de Janeiro. The agenda formed the basis for a "global partnership" to encourage cooperation among nations for sustaining life on earth by protecting the environment while simultaneously resulting in growth. The causes of environmental pollution are not limited to industrialization, urbanization, population growth, exploration, and mining, but also transboundary movement of pollutants from developed to developing countries or vice versa. Transboundary pollution is part of the reason that pollution has remained a global challenge. Through different routes, primarily air and water, pollution that arises in one country may be found wreaking havoc in another, hence no country can afford to be indifferent toward pollution. Also, transboundary movement of nonfunctional electrical and electronic equipment (EEE) from developed to developing countries in the guise of bridging the digital divide is a serious cause of air, water, and soil pollution by toxic metals. Additionally, environmental pollution is triggered by the introduction of harmful materials, such as gaseous pollutants, toxic metals, and particulate matter (PM) into the atmosphere; sewage, industrial effluents, agricultural runoffs, and electronic wastes into water bodies; and activities such as mining, deforestation, landfills, and illegal dumping of refuse that cause soil pollution. With rapid global advancement and an exponential growth rate in the electrical and electronic industries in the 21st century has come a corresponding change in consumer lifestyles, resulting in the generation of a huge amount of end-of-life electronics, known as electronic waste (e-waste) (Kiddee et al., 2013a, 2013b; Li et al., 2015a,b; Perez-Belis et al., 2015; Wang et al., 2013). It has been estimated that approximately 42 million tons (Mt) of e-waste is generated globally per annum (Balde et al., 2015). batteries, and copper for electrical wiring and large amounts of these valuable metals remain after the disposal of e-products (Stevels et al., 2013; Tang et al., 2010a, 2010b, 2010c; Zeng et al., 2013). E-waste contains two major types of substances:e hazardous [(Cd, Cr, Pb, Hg, Chlorofluorocarbon, (PAHs), (PBDEs), (PCDD/Fs)] and non-hazardous (base metals such as Cu, Se, Zn and precious metals such as Ag, Au, and Pt) both types have potential negative environmental impacts (Tsydenova and Bengtsson, 2011; Widmer et al., 2005; Wei et al., 2014; Zeng, 2014; Zhang et al., 2013). The knowledge of the causes and consequences of environmental pollution is paramount, but the cost of inaction in huge. Different physical and chemical approaches have been applied to rid the environment of pollution, but most of them create additional environmental problems and are expensive. To really tackle the pollution caused by continually emerging

recalcitrant pollutants, ecofriendly and economical approaches that generate lesser secondary by-products are being considered in the literature. Of these approaches, microbial bioremediation has received worldwide consideration possibly because restoration of the environment through this means is viable and ecofriendly. Different types of pollution exist, but considerations would be given to the three main types of pollution: air, water, and soil/land pollution.

II. MAJOR TYPES OF POLLUTION

Air Pollution- Air pollution can be defined as the occurrence of chemical compounds in the atmospheric air that are toxic and present at concentrations that may be injurious to animals, vegetation, buildings, and humans. Broadly speaking, air pollution suggests the presence of chemical compounds in the air, which are not present originally but have resulted in the decrease in the quality of air. Air pollution also causes adverse changes in the quality of lives on Earth through global warming and depletion of the ozone layer. Depending on the source, form, and condition under which pollutants are generated, they have differing characteristics, which make their distribution and effects diverse. Common gaseous pollutants are sulfur oxides (especially SO2), nitrogen oxides (including NO and NO2), volatile organic compounds (VOCs), and carbon monoxide (CO). These gaseous pollutants are grouped into primary and secondary pollutants. The primary pollutants (examples are CO, CO2, NO2, and SO2) are the pollutants that are released directly into the atmosphere, usually from domestic, industrial, or transportation sources, while secondary pollutants are gases and particulates that also form in the atmosphere, largely from the primary pollutants. For example, the breakdown of ammonium nitrate aerosols, sulfuric acids, and hydrocarbons result in atmospheric nitrogen oxide gases, atmospheric sulfur, and generation of ozone (O3), respectively. Gaseous pollutants include sulfur compounds such as SO2 and sulfur trioxide; carbon monoxide; nitrogen compounds such as nitric oxide, NO2, and ammonia; organic compounds such as hydrocarbons; volatile organic compounds; polycyclic aromatic hydrocarbons and halogen derivatives such as aldehydes; and odorous substances. Volatile organic compounds are released from burning fuel (gasoline, oil, coal, wood, charcoal, natural gas, and so on); solvents; paints; glues; and other products commonly used at work or at home. Volatile organic compounds include such chemicals as benzene, toluene, methylene chloride, and methyl chloroform. Emissions of nitrogen oxides and hydrocarbons react with sunlight to eventually form another secondary pollutant, ozone, at ground level. Ozone at this level creates health concerns, unlike ozone in the upper atmosphere, which occurs naturally and protects life by filtering out ultraviolet radiation from the sun. Air pollution is caused mainly by the combustion of petroleum products or coal by motor vehicles, industry, and power stations. In some countries, the combustion of wood or agricultural waste is another major source. Motor vehicles emit PM, nitric oxide and NO2 (together referred to as NOx), carbon monoxide, organic compounds, and lead. Lead is a gasoline additive that has been phased out in industrial countries, but some developing countries still use leaded gasoline. Mandating the use of lead-free gasoline is an important intervention in relation to health. It eliminates vehicle-related lead pollution and permits the use of catalytic converters, which reduce emissions of other pollutants. The extent of damage caused by air pollutants primarily depends on their chemical composition such as oxidizing ability, solubility, concentration, and the susceptibility of the affected person or thing. For humans, SO2 gases may damage the skin and upper airways because they are water soluble; whereas O3 and NO2 can penetrate further into the lungs because of their lesser solubility. CO is a colorless, odorless, highly soluble, and nonirritating gas that has higher

affinity to hemoglobin compared to oxygen, thus, it readily passes into the bloodstream to form carboxyhaemoglobin with detrimental effects. PM is usually classified by its size or aerodynamic diameter: PM10 denotes particles,10 mm in diameter; PM2.5 particles are ,2.5 mm in diameter; and PM0.1 particles are ,0.1 mm in diameter. Large particles that are visible as dust can be carried by wind and deposit on buildings, structures, and in human eyes. Several health-damaging pollutants such as polyaromatic hydrocarbons (PAHs) and persistent organic pollutants (POPs) are commonly found in emissions from the incomplete combustion of organic materials. However, these pollutants can bind to PM, travel long distances and deposit on the environment causing serious harm. Thus, air pollution is seen as the most severe of pollution types.

Interventions to Reduce Air Pollution- Reducing air pollution exposure is largely a technical issue. Technologies to reduce pollution at its source are plentiful, as are technologies that reduce pollution by filtering it away from the emission source (end-of-pipe solutions; see, for example, Gwilliam, Kojima, and Johnson 2004). Examples of technologies to reduce air pollution include the use of lead-free gasoline, which allows the use of catalytic converters on vehicles' exhaust systems. Power plants and industrial plants that burn fossil fuels use a variety of filtering methods to reduce particles and scrubbing methods to reduce gases, although no effective method is currently available for the greenhouse gas carbon dioxide. High chimneys dilute pollutants, but the combined input of pollutants from a number of smokestacks can still lead to an overload of pollutants.

Water Pollution- Water pollution comes from both man-made and natural sources. Underground water sources may possess naturally occurring ores that are rich in toxic metals, which leach into water bodies causing pollution. Another major source of drinking water is groundwater, which often has low concentrations of pathogens because the water is filtered during its transit through underground layers of sand, clay, or rocks. However, toxic chemicals such as arsenic and fluoride can be dissolved from the soil or rock layers into groundwater. Direct contamination can also occur from badly designed hazardous waste sites or from industrial sites. In the United States in the 1980s, the government set in motion the Superfund Program, a major investigation and cleanup program to deal with such sites (U.S. Environmental Protection Agency 2000). Instances of high arsenic and lead contamination of groundwater sources are linked to such ores. Also, as noted by Ewuzie et al. (2020), geological formations of different areas largely contribute to the elemental compositions of the water bodies, and as such could be the reason for the elevated concentrations of the elements causing pollution of the water. Anthropogenic sources include contamination due to domestic wastes, insecticides and herbicides, food processing waste, pollutants from livestock operations, VOCs, heavy metals from electronic wastes, chemical waste, and medical wastes. Nutrients in water can result in eutrophication, an outgrowth of plants, and sometimes algae that could result in oxygen reduction leading to more pollution. The use of nitrogen fertilizers can be a problem in areas where agriculture is becoming increasingly intensified. These fertilizers increase the concentration of nitrates in groundwater, leading to high nitrate levels in underground drinking water sources, which can cause methemoglobinemia, the life threatening "blue baby" syndrome, in very young children, which is a significant problem in parts of rural Eastern Europe (Yassi and others 2001). Pesticides and other chemical contaminants that enter waterways through agricultural runoff, stormwater drains, and industrial discharges may persist in the environment for long periods and be transported by water or air over long distances. Some pesticides are applied directly on soil to kill pests in the soil or on the ground. This practice can create seepage to groundwater or runoff to surface waters. Some

pesticides are applied to plants by spraying from a distance—even from airplanes. This practice can create spray drift when the wind carries the materials to nearby waterways. Another major source of industrial water pollution is mining. The grinding of ores and the subsequent processing with water lead to discharges of fine silt with toxic metals into waterways unless proper precautions are taken, such as the use of sedimentation ponds. Lead and zinc ores usually contain the much more toxic cadmium as a minor component. If the cadmium is not retrieved, major water pollution can occur. Mining was the source of most of the widespread cadmium poisoning (Itai-Itai disease) in Japan in 1940–50 (Kjellstrom 1986).

Interventions to Reduce Water Pollution- Water pollution control requires action at all levels of the hierarchical framework. The ideal method to abate diffuse chemical pollution of waterways is to minimize or avoid the use of chemicals for industrial, agricultural, and domestic purposes. Adapting practices such as organic farming and integrated pest management could help protect waterways (Scheierling 1995). Chemical contamination of waterways from industrial emissions could be reduced by cleaner production processes (UNEP 2002). Other interventions include proper treatment of hazardous waste and recycling of chemical containers and discarded products containing chemicals to reduce solid waste buildup and leaching of toxic chemicals into waterways. Changing the pH of wastewater or adding chemicals that flocculate the toxic chemicals so that they settle in sedimentation ponds are common methods.

Soil Pollution- Soil pollution is a worldwide problem that draws its origins from anthropologic and natural sources. Urbanization, industrialization, and food-demand increases have required the use of compounds, substances, and chemical agents, which, over the years, have brought on the dispersion and accumulation of pollutants in the environment. The common pollutants present in the soil are heavy metals, polycyclic aromatic hydrocarbons (PAHs), or pesticides. Pesticides are chemical compounds used to eliminate pests; among them, herbicides are compounds particularly toxic to weeds, and this property is exploited to protect the crops from unwanted plants. Pesticides are used to protect and maximize the yield and quality of crops. The excessive use of these chemicals and their persistence in the environment have generated serious problems, namely pollution of soil, water, and, to a lower extent, air, causing harmful effects to the ecosystem and along the food chain. They are chemical or biological agents, that weaken, incapacitate, and kill pests. Based on the types of targeted pests, the pesticides can be divided into several groups, namely insecticides, herbicides, rodenticides, bactericides, fungicides, and larvicides. When pesticides are used, a part of them remains in the soil, and the accumulation affects the microorganisms living there. Human exposure can occur through the ingestion of pesticide-contaminated water and food, the inhalation of pesticide-contaminated air, and directly from occupational, agricultural, and household use. The pesticides can enter the human body by dermal, oral, eye, and respiratory pathways. The toxicity of pesticides depends on the electronic properties and the structure of the molecule, dosage, and exposure times. Apart from earthquakes, erosion, and other natural disasters that tend to damage the soil, the main sources of soil contamination are industrial and domestic wastes. Some soil pollutants include heavy metals, hydrocarbons, inorganic and organic solvents. Dumping of refuse on open land, waste burning, and inadequate landfills are the major contributors to soil pollution. Fossil fuels from petrochemical plants, petroleum refineries, and power-generating plants also support soil pollution. Petroleum exploration, refining, and distribution through road transport often result to soil pollution. Pollution of land by plastics is beginning to receive global attention due in part to

the toxic nature of the additives used in their production and direct effects plastics have on plants and animals. Plastic litter on land is unpleasant to the eyes, may penetrate into the soil and prevent nutrient uptake by plants, and cause entanglement of terrestrial animals. Pollution of soil does not only result in human health problems but also may modify metabolic processes in plants resulting in reduced crop yields. Pollutants may equally find their way into the food chain through absorption by plants.

Interventions to Reduce Soil Pollution- The residual pesticide concentration present in the soil must be reduced, and effective remediation techniques must be used to do this. An ecofriendly, cost-effective, rather efficient method is bioremediation, which is an alternative to more expensive and toxic approaches, such as chemical and physical methods. In biodegradation, the removal can be achieved by exploiting the microbial activity of microorganisms. The microorganisms, primarily bacteria, or fungi transform pesticides into less complex compounds, CO2, water, oxides, or mineral salts, which can be used as carbon, mineral, and energy source. In these reactions, the enzymes have an important role since they act as catalysts. Several techniques are available for the biodegradation of pesticides, which could develop in aerobic or anaerobic conditions based on types of microorganisms. Moreover, the bioremediation techniques can be divided into three categories depending on where the remediation treatment is done, namely in situ, ex situ, or on-site. In the in situ approach, the treatment is involved in the contaminated zone, and usually, the process is aerobic. The main in situ techniques are natural attenuation, bioaugmentation, biostimulation, bioventing, and biosparging. In the ex situ methods, the contaminated soil is removed from polluted sites and transported to other places for treatment. Bioreactors, composting, landfarming, and biopiles are ex situ treatments. The on-site approach consists of the treatment of polluted soil on the surrounding site, to say the soil is removed from its original position but cleaned up in the neighborhood without any impact due to its transport.

III. CAUSES OF ENVIRONMENTAL POLLUTION

Atmospheric Pollutants- It is due to small particles which are present in air which it reaches to water bodies through rain. It includes carbon dioxide which produced by burning of fossil fuels its quantity is increasing which it combines with water molecules its forms sulphuric acid. Sulphur dioxide produced from volcanoes and industries also combines with water molecules to form sulphuric acid. Sulphur dioxide is also produced by combustion of coal and petroleum products. Similarly Nitrogen dioxide also combines with water to form nitric acid. Particulates also play very important role in effecting water pollution these particulates reach to water bodies through rain.

Urban Storm Water Runoff- It is due to highly populated cities. It comes from homes and office places. In suburban and urban areas pavement and buildings covers much of land surface so whenever there is snow melt or rain the water does not soak into ground. This storm water carries much type of pollutants like dirt, oil, lawn fertilizers and chemicals directly to rivers and streams where they cause water pollution. In the case of natural landscape these pollutants are trapped into pores soil and water is filtered but in cities as water is not able to soak into ground so it wash away all of these pollutant's into water bodies thus polluting them. Moreover this storm water has high speed of flowing which erodes more sediment from embankments of water bodies thus causing water pollution.

Ground Water Pollution- Presently the annual requirement of water globally is around 6000 to 7000 Km^3. When pollutants which are present on ground enter the water bodies under earth they cause ground water pollution. When fecal water containing pathogens reaches under earth it makes it unfit for

drinking. Pathogen polluted ground water may contain viruses, protozoa and bacteria and rarely in some cases helminth eggs. Consumption of this water causes diseases like diarrhoea and cholera. Similarly nitrates also causes ground water pollution causing disease in children called blue baby syndrome in rural population of Bulgaria and Romania. It is observed that when nitrates concentration exceeds above 10 mg/L (10 ppm) in ground water chances of blue baby syndrome increases. Excessive use of nitrate fertilizers can also cause water pollution because very small amount of nitrates is utilized by plants most of it accumulates in soil which later on reaches to ground water by leaching and contaminate it. Ground water polluted with high levels of fluoride causes dental and skeletal problems. Thus, it becomes the need to use the water in much planned way and also, recycling of the water must also be considered.

Chemical Pollutant- It comes from waste of harmful chemicals factories it is a material which is left as a by-product during manufacturing process and it also plays a big role in polluting water bodies. Hazardous chemical waste may be in solid, liquid or in gaseous form. The characteristics which make material hazardous are corrosively, Ignitability, toxicity and reactivity. It started with the start of industrial revolution. Industrial waste chemicals can only be treated by using special waste treatment plants they cannot be treated by sewage treatment plants.

Surface Water Contamination From Mining Operations- Mining activities worldwide mobilize more than 50×109 metric tons of geological material per year, which is similar to the flux of particles transported by rivers from the continents to the sea. Most mining operations trigger significant environmental and social problems as they result in large waste deposits, which are exposed to oxidation by air and weathering by precipitation, and subsequent pollution of water resources. Mining for coal, lignite, building materials, and iron involves the largest mass movements with a significant yield of end products. The extraction of rare metals, such as copper, nickel or gold, however, produces up to 1,000 tons of waste materials per kilogram of pure metal. These massive waste streams are accompanied by problematic geochemical weathering reactions and specific pollutant loads, which are introduced as mining chemicals. Ores, such as coal, iron, and copper, typically contain large fractions of sulfide material; this material is oxidized in contact with air and water and releases sulfuric acid in the form of “acid mine drainage”. Because the sulfur concentrations can reach high proportions (1–20 wt% pyrite in the case of coal), a conservative worldwide estimate assumes that about 20,000 river kilometers and 70,000 ha of lake and reservoir area are seriously damaged by acidic mine effluent. In addition, mining and extraction of precious metals are associated with intense use of chemicals, energy, and water that poses greater pollution hazards and environmental risks. Gold production serves as an illustrative example. As the average ore grade decreased over the past two centuries, chemical extraction either by mercury amalgamation in artisanal gold mining or via the industrial cyanide extraction process became increasingly important. Both reagents are extremely toxic to humans and the environment. Artisanal gold mining with mercury is increasingly practiced by about 13 million miners in 55 countries, such as Brazil, Tanzania, Indonesia, and Vietnam. Traces of gold are dissolved in liquid mercury, which is then removed by heating and evaporation to the atmosphere. Mine workers are thereby directly exposed to hazardous levels of the neurotoxic metal, and the local environmental contamination of water resources can be severe. A review based on detailed case studies in Brazil estimates that more than 100 tons of mercury are discharged into the environment every year, and about 50% of this is mobilized into surface water, where mercury biomagnifies up to 106-fold in predatory fish and then represents a health risk to indigenous populations. At lower gold

concentrations and larger volumes, the cyanide extraction facilitates oxidative leaching of gold as a complex into aqueous solution. Dissolved gold is then adsorbed, and the cyanide solution is recycled. Typically, 700 tons of water and 140 kg of cyanide are required to extract 1 kg of gold. Cyanide blocks the function of iron- and copper-containing enzymes in the respiratory chain of higher organisms. It is acutely toxic to humans at a level of a few 100 mg for an adult person. Fish react at about 1,000 times lower levels and are killed in water containing as little as 50 µg/L of cyanide. Gold mining operations are therefore often associated with spectacular fish kills. Most aquatic organisms were killed along the main stem of the Tisza River in Hungary, and most water supplies were closed when a dam failure at a tailing pond in Romania triggered the release of about 100,000 m3 of cyanide-containing waste in January 2000. More sustainable mining practices require mitigation measures for existing tailings and improved processes and safety procedures for ongoing activities. Highly toxic chemicals, such as cyanide or mercury, should be replaced by less harmful extraction agents, such as halogens or thiourea, or a zero-emission policy should be enforced. Such technical measures should be supplemented by clear international regulations and corporate social responsibility in the mining industry, which is based on open information policies. Although international agreements and practice codes cannot substitute for stronger enforcement of environmental regulations by developing countries, they represent helpful benchmarks for protecting water quality.

IV. REMEDIES

Several remediation methods have been suggested including biological, chemical, and physical methods. However, focus should be on how to nip pollution in the bud so that remediation of the already affected environment would be fast and feasible. Physical methods of soil reclamation do not change the physicochemical properties of the pollutants accumulated in the environment to be cleaned. Chemical methods on the other hand degrade the pollutants accumulated, and further make some changes to their physicochemical properties in order to reduce their ecological hazard. More importantly, biological methods that are based on the biological activity of microorganisms and higher plants have the ability to degrade accumulated pollutants and further lead to their mineralization, immobilization, or removal. Recent studies have also suggested particular areas for research and innovation, which include understanding and reducing plastics use, cleaning-up oceans and beaches, replacement materials, and understanding the impacts on human and animal health. In a nutshell, workshops, conferences, seminars, and use of media can help to educate the public on how to manage and improve on the relationship between human society and the environment in an integrated and sustainable manner.

V. CONCLUSION

Among the types of pollution, air pollution seems to be widely studied and has received greater attention. This could be as a result of increased morbidity and premature mortality rate attributable to air pollution. Developed and developing nations share the burden of pollution, yet the latter suffer it most due to weak legislation, lack of awareness, and poverty. Pollution disproportionately affects the vulnerable groups in middle- and low-income countries. Awareness should be raised on the dangers of pollution and all hands must be on deck to forestall activities that result in environmental pollution so that remediation of an already affected environment becomes realizable. Among the other remediation methods, biological methods that involve the use of microorganisms have been adjudged eco-friendly, cost-effective, and sustainable methods for environmental and human safety.

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