



Environmental Pollution and Pollutants on the Ecosystem: A Review.

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Abstract

One of the greatest problems that the world is facing today is that of environmental pollution, increasing with every passing year and causing grave and irreparable damage to the earth. Pollutants emerge from various anthropogenic sources in ecosystem and are distributed throughout environmental matrices. There are different types of pollutant e.g. heavy metal, pesticides, industrial compounds, personal care products, poisonous gases and PAHs. These pollutants may be mobile and persistent in water, air, soil and sediments even at low concentrations. Pollution must be taken seriously, as it has a negative effect on natural elements that are an absolute need for life to exist on earth, such as water and air. For these reasons, the purpose of this publication is to explain types of pollutions and the effects of the pollutants on the ecosystem.

Keywords: Ecosystem, Pesticide, PAHs, Pollution, Pollutants

INTRODUCTION

In the last decades, there has been an increasing global worry over the public health impacts attributed to environmental pollution. It was the industrial revolution that gave birth to environmental pollution as we realize it today. Populations of developing countries are particularly vulnerable to toxic pollution resulting from industrial processes. In recent years, people have been exposed to different types of compounds with broad spectrum due to the rapidly developing technology [1]. Technology has brought us clear simplicity, and thousands of substances produced in different areas are up on the market every year [2]. It has been shown that global production of anthropogenic chemicals increased from 1 million to 400 millions tons per each year between 1930 and 2000 [3]. Statistics reported by EURO-STAT that, over 50% of the total production of chemicals is represented by environmentally harmful substances between 2002 and 2011. It is important that over 70% of these chemicals are significant with environmental impact [4, 5].

Over recent decades, the world has exposed the adverse consequences of uncontrolled development of multiple human activities in, for example, urbanisation, transport, industry and agriculture. The increase in living standards and higher consumer demand have amplified pollution of water with a variety of chemicals, leachates, nutrients, oil spills, among others, of the air with, for example, CO₂, SO₂, NO_x and other greenhouse gases and particulate matter, and of the soil due to the disposal of hazardous wastes, sludge, spreading of pesticides, as well as the use of dis-posable or non-biodegradable materials and the lack of proper facilities for waste [5, 6].

Pollution is the introduction of contaminants into the environments that cause discomfort or harm to other living organisms or damage the environment, which can come in the form of chemical substances or energy, such as light, heat, or noise. Pollutants can be naturally occurring substances but are considered contaminants when in excess of the natural levels. Santos divided pollutants into biodegradable and

nonbiodegradable ones. Biodegradable pollutants can be broken down and processed by living organisms, including phosphates, organic waste products, and inorganic salts. Nonbiodegradable pollutants cannot be decomposed by living organisms and therefore persist in the ecosphere for extremely long periods of time. They contain plastics, metals, pesticides, glass and radioactive isotopes [1, 7].

There has been heightening awareness and concern about the persistence and biological effects of anthropogenic contaminants ever since Rachel Carson's book *Silent Spring* was published [8, 9]. Some forms of pollution exert a destructive effect on plants, animals, humans and wildlife by impairing or killing the health of their individuals [10, 11]. Environmental pollution has started with the appearance of humans. When *Homo sapiens* lighted fire, its smoke proved to be the first environmental pollution [12]. Pollution has increased dramatically in recent years and effected all living organisms negatively in the world.

This review focuses primarily on pollution of ecosystems and aims to address some key features of anthropogenic pollutants, in particular air, water and soil pollutants as well as pesticides, PAHs and heavy metals.

History of Anthropogenic Pollution

Anthropogenic pollution is not new-humans have contributed to the environmental burden since they learned to control fire [13]. Walls of caves are covered by thick layers of soot many thousand years ago. Hence, it is supposed that breathing of cavemen was difficult due to the smoke. Additionally their eyes irritated in the closed room. Lungs of mummified bodies from the Palaeolithic era are often black [12, 14]. In the early times, environmental pollution was responsible for several kinds of illnesses. Human excrement might have been the first pollution of the environment. Bowel bacterium living in the human body, such as the *Escherichia coli*, might have got from faeces to springs, which might have infected the early humans. This environmental pollution has been the reason of millions' illnesses even recently [12, 15]. Dust pollution also appeared in the early times. According to

the assumption of Janssens, in the New Stone Age in stone mines, people who carved flint from limestone day by day might have suffered from silicosis. The reason of it was that they breathed stone powder all the day [15].

The people were concentrated in cities with industrial revolution and resulted in increased pollution of the air, as a result of the burning of fossil fuels, and of rivers, with organic pollutants in the form of sewage [16]. Moreover, traffic increased air pollution of cities [14]. New substances of many classes, including halogenated organic compounds, alkyl phenols, polycyclic aromatic hydrocarbons (PAHs) and phthalates were manufactured for use domestically and in industry, agriculture. Therefore, these chemicals inevitably were released into the environment [17].

The old pollutants clearly had adverse effects on wildlife populations and human health but we are only now beginning to understand the effects of the new pollutants. Their effects may be equally, or more, harmful [18].

Types of Emerging Pollutants and Adverse Effects

Air Pollution

Various industrial, transport and other pollution sources release a number of specific and common pollutants such as a oxides of sulfur, carbon, halogen gases, nitrogen, toxic heavy metals, oxidants, volatile hydrocarbons and ozone, to name a few. Many of these pollutants, even if released in small quantities, persist in the environment and can build up to high levels. Many others undergo transformation and are converted into more dangerous forms than the parent compounds. Exposure to high concentration of toxic substances induces specific acute toxicities, whereas long term level of exposure causes chronic toxicity [11].

The sensitivity of health impact of pollution depends on kind of pollution and pollutant, degree of exposure, presence of interaction chemicals, species, age, physiology and nutrition of the exposed population [11, 19].

Presently the lower part of the atmosphere is known as "air" and is formed by mainly oxygen, nitrogen and other gases, trace gases and particles. The energy consumption and technical evolution related to these sources is one main cause of the man made pollution. This pollution causes modification of the air quality. The four major groups of gaseous air pollutants by historical importance, concentration, and overall effects on plants, animals and humans are, oxides of nitrogen (NO_x : NO , NO_2), carbon dioxide (CO_2), sulphur dioxide (SO_2) and ozone (O_3). Sulphur dioxide and nitric oxide (NO) are primary pollutants – they are emitted directly from sources. The most important groups of anthropogenic air pollution sources are defined by industrial processed, transportation, residential heating systems and agricultural systems [20].

Tropospheric ozone is one of the world's most important regional-scale air pollutants carrying risks to both vegetation and human health [21]. Ozone is a secondary pollutant, formed from the precursors volatile organic compounds (VOCs) including methane and nitrogen oxides (NO_x). At present ecosystems, particularly forest systems, act as a net sink of ozone. However, this effect is decreased by deforestation, which reduces canopy uptake, and replacement of forests with agriculture, which increases nitrogen oxide emissions from soil [22]. Ozone is also of great importance for climate regulation. In addition to its role as a greenhouse gas, ozone may also have large effects on climate regulation services in

terrestrial ecosystems. Although there are large uncertainties in the analysis, it is likely that the physiological effect of ozone on vegetation will also limit carbon sequestration by plants and thus counterbalance any increased carbon sequestration caused by CO_2 fertilisation [23].

Acid rain is primarily caused by the release of nitrogen and sulfur into the atmosphere as a result of coal and oil combustion by power plants vehicles and machines. The hazards posed by acid rain were first recognized in late 1970's. The acid rain increases acidity of aquatic ecosystem, leading to poor performance of fish species. The modern animal production results in disposal of large amount of unprocessed manure, which through emissions produces ammonia. Ammonia is hazardous to both animals and humans disturbs ecological balance and produces acid rain [24].

Ammonia can have significant effects on a large range of sensitive ecosystems through both increased acidification and nitrogen deposition. It also has human health impacts, acting as a precursor for secondary inorganic aerosols. Emissions of ammonia affect services in both terrestrial and aquatic ecosystems [25].

Although there are natural sources, production of sulphur dioxide (SO_2) is overwhelmingly anthropogenic with combustion of fossil fuels by coal-fired power stations being the most important sector [26]. Although sulphur deposition as SO_x (dry deposition as SO_2 and wet deposition as SO_4) can cause a reduction in both plant growth and yield it may act as a fertiliser in low sulphur ecosystems. Acidification is another major impact of sulphur deposition in both aquatic and terrestrial ecosystems [25].

Water Pollution

Emerging organic contaminants (ECs) are compounds now being found in groundwater from agricultural, urban sources that were previously not detectable, or thought to be significant. ECs include pesticides and degradates, water treatment byproducts, industrial compounds, pharmaceuticals, fragrances, personal care products, food additives, flame retardants and surfactants, engineered nanomaterials as well as 'life-style' compounds such as caffeine and nicotine. ECs may have adverse effects on human health and aquatic ecosystems [27, 28]. In the last few decades there has been a growing interest in the occurrence of these contaminants in the aquatic and terrestrial environment, their potential toxicity and their environmental fate even at low concentrations [29]. The pollutions of groundwater is a growing concern and relatively poorly understood compared to other freshwater resources [28, 30].

To date, the occurrence of ECs has been much better characterised in surface water and wastewater environments than in groundwater resources [30]. Wastewaters are the main sources of ECs in the environment and surface waters therefore contain the greatest loads of ECs. Wastewaters and surface waters are also thought to contain a much greater diversity of compounds compared to groundwater, although this may be simply a function of the capability of analytical methods relative to the generally lower groundwater concentrations and the limited number of groundwater studies [28].

Effects of ECs on human and ecosystem health are largely unknown, and relatively little is known about the ways they travel through the environment or how they may be transformed or degraded in the course of their travels. Some studies have shown that even very low exposure to

certain ECs can have impacts on biological systems. Effects seen in aquatic species and some fish, but have not been observed in humans [27].

Pesticides have been determined at trace concentrations in groundwater worldwide for a considerable period and are well-known contaminants [31, 32]. By their nature degradates may be toxic and many of them are biologically active [28]. Pharmaceutical chemicals frequently have been observed in the environment except pesticides. The presence of pharmaceutical substances has long been recognised as a concern in the aquatic environment [28, 33]. The primary routes for pharmaceuticals into the environment are disposal of unused products, through human excretion and through agricultural usage [28, 34]. Pharmaceuticals have recently started to be found in the aquatic environment from ng/L to µg/L, mainly due to the inefficiencies of wastewater treatment plants. These micropollutants are biologically active molecules and they have sub-lethal or chronic toxic effects therefore most of these micropollutants raise considerable toxicological concerns [35].

There are a wide range of industrial substances which can be released to the ecosystem and many of these e.g. chlorinated solvents, petroleum hydrocarbons, adipates and phthalates, have led to well-established problems [36]. Nicotine, caffeine and the nicotine metabolite cotinine also have been widely determined in groundwater impacted by sewage effluent [37, 38].

Soil Pollutions

Soil is a vital part of the natural environment. It is just as important as plants, animals, loch, landforms, rocks and rivers. It provides a habitat for a wide range of organisms and influences the distribution of plant species. It controls the flow of water and chemicals between the earth and the atmosphere, and acts as both a source and store for gases in the atmosphere. Soils not only reflect natural processes but also record human activities both at present and in the past [39].

Soil pollution is the reduction in the productivity of soil because of the presence of soil pollutants. Soil pollutants have an adverse effect on the chemical, physical and biological properties of the soil. Chemicals, fertilizers, pesticides, organic manure, discarded food, radioactive wastes, clothes, plastics, bottles and leather goods-all contribute towards causing soil pollution [39]. Soil heavy metal pollution has become an important problem in many parts of the world [40, 41]. Following rapid economic and social development over the past decades, soil pollution by heavy metals has been both serious and widespread in China [42, 43]. Although heavy metals may occur naturally in soil, additional contributions come from anthropogenic activities such as industrialization, urbanization, agriculture and mining [40]. Indeed, many of studies have shown that pollution sources of heavy metals in the environment mainly derive from these anthropogenic activities [44, 45]. Chemicals like iron, lead, copper, mercury, cyanides, zinc, aluminium, cadmium, acids and alkalies etc. are present in industrial wastes and reach the soil either directly with water or indirectly through air. Unconscious and continuous use of pesticides to protect the crops from pests, alter the main composition of the soils and make the soil toxic for plant growth. Consequently, they have a very destructive effect on the plant growth and reducing the yield and size of fruit. Their degradation products may be absorbed by the plants from where they reach the animals and human

through the food chains [39]. Humans have intentionally added substances such as pesticides, fertilizers and other amendments to soils. Leaks of chemicals and accidental spills used for industrial or commercial purposes have also been sources of contamination. Some contaminants are moved through the air and deposited as dust or by precipitation [46]. Contaminated soil causes to health risks due to direct and indirect contact with these soil. The effects of pollution on soil are quite disturbing and can result in huge disturbances in the ecological balance and health of living beings on earth [39].

Some of Other Pollutants in Ecosystem

Heavy Metals

Heavy metal pollution is a serious problem in most countries of the world [11]. Contamination of trace metal is important due to its potential toxicity for humans and the environment [47]. The role of trace and heavy metals in the soil system is increasingly becoming an important matter of global concern [48]. Heavy metal pollution is persistent, covert and irreversible [43]. This kind of pollution not only degrades the quality of the atmosphere, food crops and water bodies, but also threatens the health and infiltrate animals and humans of the food chain [43, 45, 49]. Various anthropogenic activities, such as mining metallurgy, industries, burning of fossil fuel and transport redistribute toxic heavy metals into the environment, which persist for long period and translocate to different components of the environment, including biotic segment. These toxicants accumulate in the vital organs, including kidney and liver, and exert adverse effects on domestic and wild animals populations [11, 50, 51]. Accumulation of heavy metal in soil is concern in agricultural production due to adverse effects on crop growth and food quality [52, 53]. The heavy metals are health hazards either directly by inhaling dust or drinking contaminated water or indirectly; by consuming vegetables grown on contaminated soils [54]. Metals such as copper and cadmium are cumulative poisons. These metals cause environmental hazards and are reported to be extremely toxic [55]. Moreover, chronic exposure to cadmium can have adverse effects such as pulmonary adenocarcinomas, prostatic proliferative lesions, bone fractures, lung cancer, kidney dysfunction, and hypertension, while the chronic effects of Arsenic consist of dermal lesions, skin cancer, peripheral neuropathy and peripheral vascular disease [56]. Vegetables take up metals by absorbing them from contaminated soils, as well as from deposits on different parts of the vegetables exposed with air pollution [57]. Heavy metals may enter the human body through direct ingestion of soil, dust inhalation and consumption of food plants grown in metal contaminated soils [58]. Additionally, humans may come in contact with heavy metals via their jobs in industrial, agricultural or pharmaceutical. Children can also be poisoned as a result of playing in contaminated soil. Symptoms vary, depending on the nature and the quantity of exposed heavy metal. Patients may complain of vomiting, nausea, stomach pain, diarrhea, headache, sweating and a metallic taste in the mouth [48].

PAHs (Polycyclic Aromatic Hydrocarbons)

PAHs are especially emitted into the atmosphere by the incomplete combustion of fossil fuels [9]. They are extensively environmental pollutants that are characterized by their hazardous mutagenic and carcinogenic potential [59]. PAHs are found ubiquitously, not only air, soil and

water, but also in various foods we encounter in our everyday life [60-62]. Additionally, PAHs could be transported by the stormwater runoff [63, 64], imposing considerable risk on aquatic life [54]. The primary sources of PAHs are identified as anthropogenic in origin such as the exhaust of motor vehicles, heating in power plants, petroleum refineries, combustion of refuse, oil/gasoline spills, barbeque smoke, deposition from sewage, tobacco smoke and coke production [60]. PAHs can be engaged in metabolic activation in human mammalian cells which have adherence to DNA, and tissues leading to mutations [62]. Because of the diversity of their sources, PAHs have received increased attention in recent years. Dietary intake of PAHs is the major route of human exposure [63]. In recent years, increases levels of PAHs in different environmental media (air, soil, sediment and water) have been reported not only in developing but also in developed countries [62]. Therefore, PAHs are one of the most important environmental problems today.

Pesticides

Pesticides are chemicals used on agricultural land but also in along railways, private gardens and in other public areas [64]. The use of pesticides for crop protection is supposed to increase based on a growing world population and the need for more food sources. While pesticides increase agricultural production, bioaccumulation through the food chain can finally become a risk to living organisms because pesticides induce certain adverse effects [51, 65, 66]. Some parts of pesticides sprayed on crops will remain in agricultural areas, but some of them will enter the surrounding water, air and soil [67, 68]. Pesticides can remain in the environment for many years and may be transported over a long distance [69]. Pesticide residues in water, sediment and soil are significant environment threats and have been identified as carcinogen pollutants in many countries [70, 71]. Thus, the excessive application of these substances over the past half-century has posed serious risks to human health [72, 73]. There have been a lot of reports regarding pesticide residues detected in milk [74], vegetables [75], and grains [65]. Residue of pesticides such as dieldrine, aldrin, chlordane and heptachlor have been detected with increasing frequencies in farm animals and their products, including meat, milk and eggs in India [11]. Furthermore, many pesticides can persist for long periods in environment; organochlorine insecticides, for instance, are still detectable in surface waters thirty years after their use and had been banned [76]. Pesticides meet with non-target organisms in the food chain which including mankind. They accumulate in the body tissues of organisms and cause a various of health problems [77, 78]. Experimental research has shown that some of pesticides are endocrine disruptors that can disturb the functioning of different hormones throughout the body [79]. Studies reported that there are evidences of pesticide exposure and disorders in both hormonal regulation imbalance and immune system activities [80]. Several epidemiological studies showed in the last two decades suggest harmful effects of pesticides on human health, including a possible relationship between pesticide use and cancers, such as leukemia, non-Hodgkin's lymphoma and different types of solid tumor [81, 82].

For developing countries, the importance of agricultural pesticides is undeniable. However, the issue of environmental risks and human health has emerged as a key problem for these countries in a number of studies [83-86]. Many people are exposed to pesticides occupationally, and pesticide self-poisoning is an important public health

problem [87]. Annually, 3 million cases of acute poisoning have been reported from pesticide exposure, resulting in the deaths of 250 to 370,000 people every year [88]. For all this reason, unconscious use of pesticides is a serious problem for ecosystem pollution and human health.

CONCLUSION

In recent years, people have been exposed to several types of substances with broad spectrum due to the rapidly evolving technology. Technology has brought us clear conveniences, and thousands of chemicals produced in different areas are up on the market every year. The quality of life on earth is linked to the overall quality of the environment. All living organisms effect adversely by emerging pollutants in ecosystem due to anthropogenic activities. Anthropogenic pollutants include pesticides, pharmaceuticals, industrial additives and by-products, PAHs, water treatment by products, flame/fire retardants and surfactants, as well as caffeine and nicotine metabolites and hormones. Exposure of these pollutants have serious health problems in organisms which live in ecosystem. Regulation of these compounds in environment will be a challenging task and require much better understanding of key contaminant properties as well as their distribution and behaviour. Therefore, environmental concentrations of each pollutant must be determined. In addition, uptake, metabolism and excretion of pollutants must be investigated related species. For resolve the environmental pollution, the future should be plan to reduce the adverse effects of pollution and work together cooperation and coordination between the different disciplines.

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