

Theoretical Study on Pollution, causes, types, and some analytical techniques for estimating pollutants

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Abstract :

Pollution is one of the deadliest scourges of our time, not only because of its impact on climate change but also because of its impact on health as a result of increased rates of severe illness and mortality. Numerous pollutants are the leading cause of human illness. There are also micropollutants and particulates with a variable diameter and a tiny size. The inhalation of these pollutants can cause respiratory and cardiovascular diseases, dysfunction of the central nervous system, renal disease, and cancer. In addition, nitrogen oxide, sulfur dioxide, hydrogen sulfide gas, and volatile organic compounds are all considered air pollutants that negatively impact human health. When exposed to and inhaled at high concentrations, carbon monoxide can also cause direct toxicity. Heavy metals such as mercury, when assimilated by the human body, can cause acute or chronic toxicity, depending on the level of exposure. The diseases that can be caused by pollution from a variety of sources include primarily respiratory conditions like obstructive pulmonary disease, asthma, and bronchiolitis, as well as lung cancer, central nervous system dysfunction, and skin diseases. This study emphasizes regulatory efforts to reduce environmental pollution and population exposure to avoidable environmental hazards. This study will shed light on the analytical techniques with high reliability for detecting pollutants that affect human health.

Keywords: Heavy metals, Lung cancer, Nitrogen oxide, Pollution, Sulphur dioxide

دراسة نظرية عن التلوث، أسبابه، أنواعه، وبعض التقنيات التحليلية لتقدير الملوثات

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مستخلص:

التلوث هو واحد من أخطر الآفات في عصرنا، ليس فقط بسبب تأثيره على التغير المناخي ولكن أيضاً بسبب تأثيره على الصحة نتيجة زيادة معدلات الأمراض الشديدة والوفيات. العديد من الملوثات هي السبب الرئيسي للأمراض البشرية. بالإضافة إلى ذلك، هناك الملوثات الصغيرة جداً والجزيئات الصغيرة ذات القطر المتغير والحجم الصغير. تشبث استنشاق هذه الملوثات أمراض الجهاز التنفسي والقلبية والوعائية، ويؤدي إلى اضطراب في الجهاز العصبي المركزي، وأمراض الكلى، والسرطان. بالإضافة إلى ذلك، يُعتبر أكسيد النيتروجين وثاني أكسيد الكبريت وغاز كبريتيد الهيدروجين والمركبات العضوية القابلة للتطاير جميعها ملوثات هوائية تؤثر سلباً على صحة الإنسان. عند التعرض لها واستنشاقها بتركيز عالية، يمكن أيضاً أن يسبب أول أكسيد الكربون سمية مباشرة. المعادن الثقيلة مثل الزئبق، عند امتصاصها من قبل الجسم البشري، يمكن أن تسبب سمية حادة أو مزمنة، اعتماداً على مستوى التعرض. الأمراض التي يمكن أن يسببها التلوث مثل مرض الانسداد الرئوي، والربو، والتهاب الشعب الهوائية، بالإضافة إلى سرطان الرئة، واضطرابات الجهاز العصبي المركزي، وأمراض الجلد. تشدد هذه الدراسة على الجهود التنظيمية للحد من التلوث البيئي وتعرض السكان للمخاطر البيئية التي يمكن تجنبها. تشير الدراسات السابقة ان التقنيات تحليلية هامة ذات موثوقية عالية لكشف الملوثات التي تؤثر على صحة الإنسان.

الكلمات المفتاحية : التلوث، المعادن الثقيلة، أكسيد النيتروجين، ثاني أكسيد الكبريت، سرطان الرئة.

Introduction

Nowadays, one of the most important problems humanity has begun to face is environmental pollution. With the increasing incidence of pollution and its widening, the situation has become a direct and sometimes indirect factor in eliminating or threatening a particular environmental or social situation. Pollution is an urgent worldwide problem that endangers the survival of all life on Earth. It includes the introduction of dangerous compounds into the environment due to human activities, which can contaminate the air, water, soil, and other ecosystems. Therefore, human thought has tended to the inevitability of reducing pollution cases, and this requires laying foundations and determinants to control pollution cases [1]. This process requires setting global foundations and determinants to control pollution cases and finding sophisticated and accurate scientific devices that can be used to reduce various pollution cases. It is known to researchers in the environmental field that people with high environmental awareness are more aware of the damage caused by pollution.

For this reason, they considered pollution a severe threat to their survival and growth. The various pollutants led to a clear imbalance in the environmental system, and their effect is evident on the earth in its atmosphere, soil, and water [2,3]. One of the objectives of this study is to raise the level of environmental awareness in human society, to protect and improve the environment, and to establish belief in the importance and necessity of preserving it. Human society needs a balanced environment for its well-being and progress, as the human ability to adapt to environmental change is limited, resulting from the limited change in physiological processes, which are very slow [4]. This study also aims to review the results presented by specialists in the environmental field, which provided appropriate solutions to many environmental problems in different parts of the world. This study also shed light on the relationship between various diseases and exposure to environmental pollutants, including air, soil, and water pollution with heavy metals. Environmental pollution can be defined as the chemical, physical, and biological changes that oc-

cur in the environment and cause the emergence of a negative situation with a direct impact on the environment. We can also know that it is the addition of any substance or any form of energy, such as heat, sound, and radiation, to the natural environment at a rate that produces natural concentrations higher than the concentration of material or materials [5,6].

Kinds of pollution

1. Water pollution: The pollution of water supplies is currently a significant threat to human and environmental health. In addition to being tainted by disease-causing human waste, water can also become polluted by the input of industrial waste [7]. Water may be polluted in several ways, including heat, chemicals, organisms, and machines. Various water-soluble additives are available due to the wide range of settings in which they can be used. These compounds accumulate in aquatic ecosystems, including oceans, lakes, and rivers, as they make their way around the water cycle. As a result, there was a spike in pollution levels in the water supply, which has consequences for many creatures, including people [8].

The main pollutants of the water:

Inorganic pollutants (such as acids, salts, and toxic metals), anions, and cations (Ca^{+2} , Mg^{+2} , and F^{-} , as well as nitrates, phosphates, and sulfates) are among the most prevalent types of pollutants that may be found in water [9]. Other sorts of pollutants that may be found in water include organic pollutants. Organic pollutants such as oil and pesticides can represent a substantial threat to the ecology of the water. This will be discussed in depth in this investigation [10,11]. Heavy metals are found at high concentrations in water. The extensive use of pesticides in agriculture and the improper disposal of trash from industry and households are two examples of the various human activities that lead to the introduction of these minerals into surface water and groundwater. Even though many of these minerals are considered necessary for human health, when significant amounts are consumed, they pollute the water supply and lead to major health issues for all living species, including people [12].

Heavy metals: Pollution caused by heavy metals can have long-lasting detrimental impacts on the environment.

A significant number of locations all over the world contain unhealthy concentrations of various minerals and heavy metals. Heavy metal contamination is caused mainly by the inefficient handling of waste from mining and industrial processes and the extensive use of pesticides in agricultural production. When heavy metals reach incredibly high concentrations in the soil and water, they pose a significant risk to the natural environment [13]. Heavy metals, including cadmium (Cd), mercury (Hg), lead (Pb), and thallium (Tl), are among the many that can harm human health. Compounds of cadmium have been used extensively in the production of rechargeable nickel-cadmium batteries. Cadmium (Cd) emissions are at an all-time high right now as a direct result of the extensive use of cadmium that has taken place in recent years. Another significant way people are exposed to cadmium is through the use of tobacco products. Due to this fact, the negative consequences of cadmium exposure on one's health can most likely result in renal failure, in addition to a significant number of other disorders [14,15]. Fish are a significant source of exposure to different

mercury compounds; hence, eating fish can increase a person's risk of mercury poisoning. There is speculation that (Hg) from amalgam fillings may be the root cause of various ailments, and this hypothesis may be supported by the fact that dental fillings contain mercury [16]. Lead (Pb) may enter the body by inhaling contaminated air and consuming foods containing high lead levels. For the last century, lead emissions in the air have substantially contributed to air pollution. This is due mainly to lead emissions from petrol. Because of the high absorption rate of the gastrointestinal tract and the porous blood-brain barrier in children, children are the most susceptible to lead poisoning [17,18].

Heavy metal, known as thallium (Tl), is known to have a poisonous impact and has negative consequences for living creatures. Tl is a contaminant that may be found in the environment in high amounts, particularly in places that have been industrialized [19]. The toxicity induced by this poisonous metal can affect the malfunctioning of the mitochondria and the role that Tl plays in significant disorders such as cancer. Thallium may be either dissolved or

insoluble in a solid state when found in natural waterways. When dissolved, thallium can be either monovalent or trivalent, depending on its condition [20]. Researchers in the field of environmental science are concerned about the disposal of thallium or the reduction of its toxicity; as a result, their interest has been focused on finding ways to eliminate the effect of its toxicity. Some of the essential factors affecting the removal of thallium include, in a nutshell, pH, ions that are metal oxides, and organic substances. Most of the research successfully investigated the influence of pH by identifying the optimal pH at which the effect could be evaluated [21].

Regarding metal oxides, where they were utilized as adsorbents to remove thallium with a high adsorption capacity, studies on thallium removal are summed up by four metallic oxides [22]. These metallic oxides include titanium, iron, manganese, and aluminum [23]. Organic molecules are significant in transporting metal ions, and these materials constitute a complicated combination of naturally occurring chemicals. The organic material is adsorbed onto the surface of the adsor-

bent, which alters the interaction of Tl with the adsorption sites. As a result, the impact of thallium ions is reduced due to their connection with the active groups present in the organic compounds [24,25].

2. Air pollution

Air pollution is well recognized as a prominent risk factor for human health in contemporary society, including conditions such as chronic obstructive pulmonary disease, lung cancer, respiratory infections, impairment of the neurological system, and cardiovascular ailments [26,27]. Air pollutants that threaten human health include nitrogen oxide, sulfur dioxide, carbon monoxide, volatile organic compounds, dioxins, and polycyclic aromatic hydrocarbons. Inhalation of large doses of this substance has the potential to induce direct poisoning. Air pollution may also be defined as a mixture of gases and particles that have the potential to infiltrate the human body upon inhalation via the respiratory system, with the most minute particles capable of directly accessing the brain through the olfactory system [28]. A wide range of solid, liquid, and gaseous pollutants

are discharged into the atmosphere, originating from natural and anthropogenic sources. These emissions include pollutants produced by power production facilities, as well as gases exhaled during the combustion of solid waste. The composition and concentration of these pollutants vary significantly. Various factors contribute to entering detrimental substances into the atmosphere, exacerbating air pollution [29].

The classification of air pollutants

1. Gaseous pollutants

1.1 Carbon monoxide (CO)

Incomplete fuel combustion results in the release of this colorless, odorless gas. Pollutants like these are released when fuels like coal or wood are burned for heating. This gas is very harmful to humans and animals and is often regarded as one of the most hazardous forms of air pollution. When carbon dioxide binds to hemoglobin to create carboxy hemoglobin, oxygen is prevented from binding to hemoglobin, and the organism is starved of oxygen. The manifestation of specific symptoms in individuals exposed to this gas can be attributed to several factors,

such as respiratory distress, muscular weakness, relaxation, compromised visual acuity, and decreased blood pressure[30,31].

1.2 Carbon Dioxide (CO₂)

When organic materials, including paper, firewood, coal, and petroleum oil, are burned, carbon dioxide gas is produced as a byproduct. Carbon dioxide gas, which results from fuel combustion, is one of the most significant pollutants people contribute to the air. It is important to note that the excessive use of fuel, the cutting down of forests, and the reduction of green areas led to the rise in the percentage of carbon dioxide gas in the atmosphere [32]. Global warming can result from this increase in atmospheric carbon dioxide. This gas makes breathing difficult and creates congestion when concentrations rise. It also causes bronchitis and throat inflammation by irritating mucous membranes [33].

1.3 Nitrogen Dioxide (NO₂)

This gas and other nitrogen oxides come from organic molecule burning and vehicle, truck, and industrial exhaust [34]. This gas mixes with atmospheric water vapor to generate nitric acid, which causes acid rain and envi-

ronmental damage. The ozone layer, which protects the planet from radiation, is severely damaged when the rest of the nitrogen oxides reach it. NO₂ is a dangerous gas because it irritates the mucous membranes of the respiratory system, which in turn causes lung damage. Additionally, it irritates the eye's mucous membranes, making it difficult for a person to see clearly [35,36].

1.4 hydrogen sulfide gas (H₂S)

Hydrogen sulfide gas, commonly known as H₂S, has the odor of rotten eggs and is produced when organic matter decomposes [37]. It is also one of the gases that are released during the process of refining crude oil into a more usable form. (H₂S) is unlike carbon monoxide or hydrogen cyanide in that it mixes directly with hemoglobin in the blood, which results in a deficiency of oxygen reaching tissues and other organs throughout the body. Exposure to this gas directly harms the neurological system, manifesting as impaired cognitive function and tiredness [38]. Even though (H₂S) gas causes damage to people when they are exposed to toxic concentrations, it was discovered that many drugs contain sulfur radicals in their composition. These sulfur rad-

icals, when ingested, can release (H₂S) gas, which plays an effective role in treating some diseases or reducing the severity of others [39,40].

1.5 Sulfur dioxide (SO₂)

Sulfur dioxide gas is one of the corrosive gases because it is regarded as one of the most hazardous air pollutants in populated cities and hydrocarbon industrial facilities. It involves the combustion of hydrocarbons like coal and petroleum oil. (SO₂) is considered to be one of the gases emitted by volcanic activity. As one of the components of rain on Earth's surface, sulfur dioxide gas pollutes the soil, vegetation, rivers, seas, and waterways, causing an imbalance in the ecosystem [41].

2. Solid polluting substances

Added to petrol and vehicle fuel to increase fuel efficiency, lead is one of the most polluting substances. Air pollution is caused by lead released into the environment by vehicle emissions, including mercury and cadmium, which were emphasized in the study's section on water contamination.

3. Influence of pollution on health

It is evident that since the advent

of human society, individuals have increasingly displayed a lack of concern for the ecosystem and have adopted a predominantly negative approach towards their environment. Over time, the human population has grown, increasing demand for various resources to fulfill their basic needs [42]. This has led to various industries' emergence to cater to these needs. Furthermore, there has been significant progress in the utilization of chemicals and the deployment of diverse weaponry in warfare. The factors above have contributed to environmental pollution and degradation, rendering it susceptible to destruction. Consequently, it is imperative to elucidate the ramifications of these factors in order to prevent such occurrences and safeguard the environment and human well-being [43]. Consequently, we will provide a list of diseases that have impacted human health due to a lack of interest in the environmental system.

3.1 Lung cancer

As a result of smoking being one of the most significant contributors to the development of lung cancer, lung cancer is one of the most prevalent forms of the disease. It is common knowledge

that an increase in the number of people diagnosed with lung cancer may be traced to a combination of factors, including long-term exposure to polluted air and the expansion of smoking in environments with a high population density [44]. In developing countries, where there is a correlation between continuous exposure to cooking fumes in which wood is used as fuel and the rate of lung cancer among non-smokers, there is a belief that women are more likely to be infected because they are the ones who do the duties of cooking, as women spend much time every day cooking. This belief is based on the fact that women spend more time in the kitchen than men do on average [45].

3.2 Asthma

Asthma is well recognized as a prevalent chronic respiratory condition globally. Numerous research has yielded substantial data substantiating that air pollutants play a significant role in the onset and escalation of asthma [46]. The emissions generated from fuel combustion directly impact the escalation of hazardous gas concentrations, thereby exposing individuals to these gases and by-products. This ex-

posure might result in respiratory system irritation. One of the most critical risk factors for the primary outcomes of asthma in children and adults is exposure to pollutants that are present in abundant amounts in the air. This is especially true for industrial pollution and pollution connected to the traffic generated by motor vehicles and other types of vehicles [47].

3.3 Skin disease

The human skin, which serves as a barrier between the body's outside and interior, is the biggest organ in the human body. The skin on a human being is mainly made up of three different layers (fig .1) . In addition to playing a significant part in sensory perception and playing a critical function in the regulation of the body's temperature, the skin is also an essential part of the body's defense system against alterations, external influences, and biological variables [48]. It plays these roles in addition to playing an essential role in protecting the body from change. It is possible to injure or scrape the skin, which leads to this organ losing many of its functions; yet, the skin's rapid self-healing occurs when damage occurs. On the other hand, the skin is neg-

atively impacted by all forms of pollution, but notably by air pollution [49]. This is because pollutants interact with the skin, which may result in various skin illnesses and damage to the skin. It is well known that exposing an organ to pollutants results in inflammation, tissue damage, and a substantial fault in the skin's numerous tasks. This, in turn, adds to the ageing of the skin. Examining the inflammatory area of the skin as a target is one of the methods utilized and essential to protect the skin from pollutants. This is done to avoid the formation and worsening of skin disorders that are a direct result of pollution and to minimize damage and inflammation by preventing the activation of inflammation [50].

Three Main Layers of The Skin

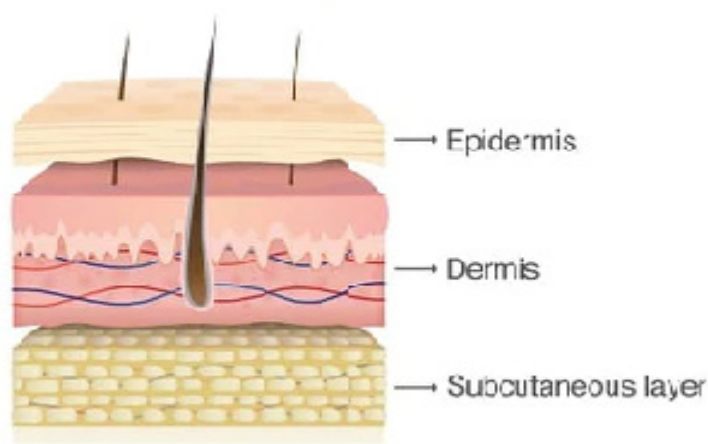


Fig 1: Describes the various skin layers.

3.4 Kidney Disease

Kidney disease is a condition that often affects a large number of individuals all over the world. One of the possible causes of kidney disease is environmental pollution. Heavy metals, fluoride, medications, bacterial toxins, and chemical fertilizers are only some of the many variables that might contribute to developing this persistent condition. Given its rising prevalence and associated risks to human well-being, it is a significant health concern. Heavy metals will be the primary topic of discussion in this section since they are one of the most significant environmental contaminants that disrupt the everyday activities of the body's many

organs and can even lead to death [51].

Furthermore, research conducted by experts in the area demonstrated a link between ingesting water polluted with heavy metals and the development of renal illness. Even though initial exposure to air pollution directly impacts the respiratory system, it is possible to argue that the kidney is the organ subjected to more significant amounts of pollutants due to its filtering role [52]. This is frequently seen in nations with poor and intermediate levels of wealth. In order to combat this worldwide issue affecting the public's health, it is critical to protect the quality of the air we breathe and to advocate for specific actions that may be taken to reduce the

risk of kidney disease. In addition, further research is required [53].

4. Analytical Techniques

The analysis of pollutants is widely regarded as one of the most essential steps in controlling the spread of pollution. One of the most significant threats to human safety is the accumulation of toxic heavy metals that, when ingested, threaten human health. Food safety requires developing a practical test for identifying contaminants in general and heavy metals in particular. The methodologies employed to analyze pollutants exhibit variability contingent upon the specific physical and

chemical characteristics of these pollutants. Nowadays, there is a vast array of analytical techniques that may be used to identify and quantify various kinds of contaminants. Chromatography, spectroscopy, and several other approaches, including electrochemical methods and colorimetric titration, are among the techniques that are highlighted most extensively in this article. (Table 1) lists some of the other methods that are covered. Some examples of spectroscopic methods are atomic absorption spectrometry (AAS) and inductively coupled plasma mass spectrometry (ICP-MS).

Table .1 demonstrates the analytical techniques for detecting pollutants in various environmental samples.

Analytical Technique	Analyte	Ref.
ICP-OES	As, U, Pb, Mn, Se	54
ICP-MS	Pb and Cd	55
ICP-MS	U, As, Hg, Pb, Cd	56
ICP-MS	U, As, Zn	57
ICP-MS	As, Cd, Cr, Cu, Ni, Mn, and Pb	58
ICP-MS and ICP-OES	V, Ca, As, Mn, Li, and U	59
Cold vapor atomic absorption spectrophotometry	Hg	60
Spectrophotometric techniques	NO_3^- , NO_2^- , NH_3 , PO_4^{3-}	61
Titration methods	As, Na, K, Ca, Mg, Li, B	62
AAS, semiquantitative modified	As	63
(AAS) and graphite furnace AAS	Hg, As, and Cr	64

Analytical Technique	Analyte	Ref.
GC-MS/MS, and ICP-MS	Pharmaceuticals, pesticide and Metals.	65
HPLC-ESI-MS	Pesticides	66
UPLC-MS/MS	Pharmaceutical, herbicides, and disinfectants	67
HPLC- MS	Pharmaceuticals	68
Q-TRAP LC/MS/MS	Pharmaceuticals	69
GC/MS	Pesticides	70
UPLC-MS/MS	Antibiotics	71
SPE-HPLC-AFS	Hg ²⁺ , MeHg	72
ICP-MS/AAS	Mn, Cr, As	73
ICP-AES	Hg, As, Cd	74
LC-MS	Mycotoxins	75
LC-MS/MS	Aflatoxins B1, B2, G1, and G2	76
GC-MS/MS	Pesticides	77
LC-MS/MS and GC-MS/MS	Pesticides	78
LC-Q-TOF-MS	Pesticides	79
HILIC-MS/MS and RPLC-MS/MS	Veterinary drugs	80
Electrochemical	Zn(II), Cd(II) and Pb(II)	81
Colorimetric	Uranyl	82
ICP-MS	Fe, Mn, Hg, As, Cd, Cr ⁶⁺ , and Pb	83
ICP-MS	Fe, Mn, Zn, Ba, Ni, Cu, Pb, Se, Cd, and Ag	84
ICP-MS	Fe, Cr, As, Zn, V, Ni, Se, Sr, Cu, Al, Pb, Cd, Sb, and Hg	85

5. Pollution prevention strategies implemented by the government and society

Governments in various regions of the world have implemented various anti-pollution initiatives, one of which

is using affordable renewable energy sources. Several national governments have made significant investments using the abundant solar and wind power accessible in their nations [86]. In addition to lowering the amount of fos-

sil fuels used, which is a significant contributor to environmental pollution. Moreover, government agencies' persistent monitoring of industrial enterprises urges these businesses to exercise greater responsibility in their production processes to ensure that automobile manufacturers produce models that use less fuel and produce fewer harmful emissions[87,88]. At the community level, it is essential to encourage families to utilize less polluting modes of transportation, such as trains or bicycles, so fewer vehicles on the highways, fewer fumes, and less pollution. In contrast, the optimal use of all forms of energy, including light, water, and furnaces, enables us to reduce fuel consumption. We will produce fewer pollutants due to increased energy consumption [89,90].

Conclusion

This study clarified that several significant inferences may be made regarding environmental contamination after serious consideration. First, whether pollution is bad for the planet and people is not debatable. Premature mortality and respiratory disorders are exacerbated by the air pollution gen-

erated by emissions from factories, cars, and the combustion of fossil fuels. When pollutants are released into water bodies, aquatic life suffers, and the availability of clean drinking water for people is threatened. Soil pollution lowers agricultural yields and ruins soil quality when farming practices and improper garbage disposal cause it. Second, it is imperative to recognize that environmental deterioration is a global problem that can only be addressed by coordinated action. Easily, pollution can transcend continents and oceans. Successful action requires global cooperation and coordination. Governments, corporations, and individuals must adopt sustainable behaviors, clean technology, and strong legislation to reduce pollution. The best way to combat environmental degradation is to prevent pollution. Solar and wind power investments reduce greenhouse gas emissions and climate change. Recycling and proper disposal can prevent dangerous waste from accumulating in landfills and marine bodies. Promoting electric cars and public transit can minimize city air pollution. Education and awareness are crucial to fighting environmental contamina-

tion. Knowledge of pollution's causes, effects, and solutions fosters environmental responsibility and agency. Educational institutions, governments, and nonprofits must prioritize environmental education for sustainability. Environmental contamination threatens world stability and health. All layers of society must act immediately. We can give future generations a cleaner, healthier, and more sustainable world by acknowledging pollution's consequences, enhancing international collaboration, focusing on prevention, and encouraging education.

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