



ECOTOXICOLOGY AND ITS EFFECTS ON THE QUALITY AND QUANTITY OF FORESTS AND FOREST PRODUCTS

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Abstract

Ecotoxicology is an important aspect in sustainable development providing knowledge that helps in improved preservation and productivity of environment. The abundance of forest ecosystems is of utmost concern because of the benefits derived from forest resources such as timber, firewood, wildlife habitat, soil and water protection, and refuge from environmental stress. Air pollution is one of the important pollution that causes havoc to forest trees. The injury caused by air pollution is so enormous to the extent that it damages the tree living tissue, affects photosynthetic activities and respiration ability. Air pollutants make the trees weak, predisposing them to more attacks by insects and disease. Plants that absorbed pollutants becomes harmful affecting the abundance of forest resources. The impact of some air pollutants can make the plants to become unhealthy affecting their normal physiological processes such as soil chemistry and nutrient cycling. This may account for impaired growth and reduced tree efficacy that can lead to tree mortality causing low abundance of tree resources. This paper compiles past literatures on air pollution and how much it affects the quantity and quality of forests and their products. Appropriate recommendations to protect forests were made.

Keywords: Air, Pollution, Forest, Ecotoxicology, Ecosystem.

Introduction

A world without forest is unimaginable, forests provide a lot of benefits at the local, national and global levels; forest resources is an integral part of natural resource based of any community, region or country and they increase socio-economic well-being of the people of those communities (Sheil, 2013). Most rural farmers especially in sub-Sahara Africa depend on natural resources gotten from the forest for their source of income (Amulya, 2015). Forest is known to provide food, medicine, timber and many other products, it also plays protective roles against soil erosion, drought, floods, and intense radiation. In addition of the performance of other functions like recreation and aesthetics centres as well as housing for different wildlife (Anjaneyulu, 2005).

The efficient use of forest ecosystem depends not only on the forest quantity, but also on the forest quality (Garcia et al., 2020). There is utmost need to sustain the forest management in order to improve forest quality which in essence will improve the forest quantity over time (Kumar et al; 2013). Ecotoxicology is the study of environmental pollution that poses toxic effects of chemical and physical agents on living organisms, especially on populations and communities within defined ecosystems like forest (Butler, 1978). The effects of pollutants on trees in one way or the other affects the value and abundance of forest resources (Christopher & Wayne, 2005).

Forests especially on high altitudes are often faced with serious effects of air pollutants. The harmful effects of air pollution on forests were identified for quite a number of years, there were several issues recognized and prevalent on forest damage (Lorenz et al., 2010).

Air pollutants that affect forest quality and quantity

Air pollution occurs as a result of emissions of its pollutants, the main air pollutants involved in forest damage are sulphur compounds, nitrogen compounds, ozone, and heavy metals; they react in the atmosphere with water, oxygen, and oxidants to form various acidic compounds (Gheorghe & Ion, 2011). The chemical compounds affect the chemistry of water and soils predisposing them to environmental stressor (Ashraf et al., 2014). The particles occur in dry which fall to the ground or can be in wet form dropped to the ground as rain, snow, and fog; they destroy their leaves by reducing the nutrients available to them, or gradual exposure of the soil to toxic substances (USDA, 2021).

Air pollution damage and their effects on forest trees

The damages caused by air pollution can affect the tree slowly or becomes visible with immediate effect and become permanent resulting to decrease in number of trees in the forest (Gheorghe & Ion, 2011). The symptoms of tree damage occurs first in the foliage; changing the leaf pigmentation, patches between the veins or the tips swindled (Christopher & Wayne, 2005). The risk poses by air pollution injury is hard to identify because they are quite similar to the signs of nutritional deficiencies and drought plants (Clattebuck, 1999).

Air pollutants may affect trees in two ways;

- 1) The wet deposition
- 2) The dry deposition

The wet deposition involve the rain, hail, and snow, and at high percentage determined by atmospheric activities while the dry deposition involve gases, aerosols, and dust, and mostly affected by physical and chemical composition of the receptor surface (Lorenz *et al.*, 2010). There is usually larger deposition in forests than open spaces based on the species of the tree and the composition of the canopy (Erisman & Draaijers, 2003). Factors such as leaf area index, shape of leaf, leaf surface roughness, and size of the stomata determines pollutants intercept by the foliage. A canopy with a high degree of roughness results to increase air turbulences which creates more relationship between the air and the foliage (Nowak *et al.*, 2000). The dry deposition absorbed by the foliage is later washed off by precipitation to encourage the deposition under the canopy (throughfall) (Balestrini *et al.*, 2007). The throughfall is largely determined by canopy leaching and canopy uptake of elements (De Schrijver *et al.*, 2007). Over the years, sulphur dioxide (SO₂) emission and deposition of acids has greatly decreased forest areas around the world (Bytnerowicz *et al.*, 2007). It is present in the air by fossil fuels burning directly damaging trees through their foliage; the foliar damage results in loss of chlorophyll and also disrupts photosynthesis (Sha *et al.*, 2010) (Figure 1). High concentration of sulphur dioxide reduces tree growth in that it reduces the stem diameter and height leading to physical damage of needles and leaves (Dincer *et al.*, 2003). Nitrogen oxides (NO_x) are also introduced into the air during various burning processes when nitrogen (N) in the air is modified mainly to nitrogen monoxide (NO), and reduce nitrogen dioxide (NO₂) (Klimont *et al.*, 2001). During the day, NO is converted easily to NO₂ by photochemical processes involving hydrocarbons present in the atmosphere, both gases, especially NO, are also formed biologically by soil bacteria during nitrogen cycle (FinlaysonPitts & Pitts 2000). They *endanger* trees as dry deposition directly via the foliage (Lorenz *et al.*, 2010).



Figure 1: Foliage injury caused by sulphur dioxide (Canadian Forest Services)

Another pollutant that poses the most toxic effect on forest ecosystems is ozone, it is found in photochemical smog produced by conversion of its precursors (nitric oxides, organic compounds and carbon monoxide); it affects various physiological processes, especially photosynthesis and water absorption in plants, (Baciak *et al.*, 2015). High ozone concentration decreases the rate at which forests absorb carbon dioxide (Karlsson *et al.*, 2006).

The effects of Ozone, SO₂, NO₂, and Ammonia are direct which include visible leaf damage, decrease in the number of needle age classes in conifers, and increased pollutant concentrations in plant tissues causing falling off of leaves (Legge & Krukpa, 2004). Indirect damage is caused by the toxicity of air pollutants through soil-mediated processes which results to soil acidification, leaching of base cations, thereby producing toxic species of aluminum (Al) (Gbondo-Tugbawa & Driscoll 2002). Atmospheric pollution results to imbalances in uptake of nutrients and water, increased predisposition to frost, droughts and diseases (De Vries, 2021). Snoeijers *et al.*, (2000) highlighted that the damages posed by increased deposition of nitrogen causing plant disease is still understudied whereas studies have shown foliage to increase bacterial and fungal diseases (Deveau *et al.*, 2018).

Emission of greenhouse gases for example carbon dioxide, methane (CH₄), and nitrous oxide (N₂O) produced naturally and through human activities, are dangerous to forest health. They affects forests directly or indirectly through the foliage or the soil respectively (Wu *et al.*, 2019). The sensitivity of forest trees to pollutants in the air is very high, especially sulphur dioxide (SO₂), nitric oxides and ozone (O₃) disrupt their growth and make them susceptible to insect attacks (Paoletti *et al.*, 2010).

Conclusion and recommendation

Air pollutants disrupts good tree conditions, tree physiology, and biogeochemical cycling; making trees susceptible to insects and diseases causing tree death hereby reducing the high yield value of forest resources. Air pollution destroys forest ecosystems over an area of 39000 km² indicating a low forest quantity. The abundance of forests decreases over significantly larger areas due to the effects of damages caused by air pollution in addition with other factors, such as fires, fungal diseases, and insect attacks. Air pollutants do not only cause visible damages but adversely affect growth, yield, and quality of forest products. More awareness should be created on the damages to forest caused by air pollutants which should enhance more research and monitoring for possible air pollution controls. Researches on different concentrations of air pollutants should be conducted in different forest layers.

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