THE IMPACT OF ENVIRONMENTAL INSTABILITY ON THE PLANT WORLD

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Annotation: This article analyzes the effects of environmental instability on plant ecosystems. It examines how air pollution, soil degradation, climate change, and anthropogenic pressure influence the morphological, physiological, and population structures of plants. The study also discusses mechanisms of ecosystem recovery, the importance of phytomonitoring, and offers recommendations for maintaining ecological stability.

Keywords: ecological stability, plant world, anthropogenic factors, climate change, phytomonitoring, soil degradation.

Introduction. Ecological stability refers to the ability of natural ecosystems to resist external influences, self-regulate, and maintain long-term equilibrium. Over the past decades, rapid industrialization, urbanization, excessive resource extraction, and the intensive use of agrochemicals have disrupted this balance globally. In Uzbekistan, particularly in the Republic of Karakalpakstan, Khorezm, and Bukhara regions, the drying of the Aral Sea stands as a striking example of ecological imbalance. As a result, increased salinity, dust and salt storms, and soil degradation have significantly affected vegetation structure and plant physiology. The main objective of this paper is to identify the primary pathways through which environmental instability affects plant ecosystems, analyze the related issues, and propose scientifically grounded measures for restoring ecological stability.

Materials and Methods. The research was conducted in several natural-geographical zones of Uzbekistan — the desert zone of Karakalpakstan, the forest-cultural zone of Tashkent region, and the subtropical zone of Surkhandarya region.

Key Methods:

1. **Phytocenological observations** – The species composition, density, and biomass of natural vegetation were examined.
2. **Physiological measurements** – Leaf water-holding capacity, chlorophyll content (SPAD index), and photosynthetic intensity were measured to assess ecological stress levels.
3. **Soil analyses** – Soil pH, salinity, organic matter content, and heavy metal concentration were determined in laboratory conditions.
4. **Climatic data analysis** – Meteorological data from 2000–2024 were analyzed to determine changes in temperature, precipitation, and wind intensity.
5. **GIS-monitoring** – Satellite imagery was used to map vegetation degradation using NDVI (Normalized Difference Vegetation Index).

These methods allowed for a quantitative evaluation of ecological stability and systematic identification of changes in plant communities.

Results. Impact of Air Pollution on Plants. In industrial zones with high emission levels, leaf chlorophyll content decreased by 25–30%. High concentrations of nitrogen oxides and sulfur dioxide caused chloroplast degradation and cellular damage. Physiological analysis showed reduced photosynthetic activity and increased respiration rates, leading to slower growth and reduced biomass accumulation. Soil Degradation and Salinization. Increased soil salinity disrupts plant water exchange and ion balance. In saline soils, root systems weaken and nutrient uptake decreases. Experiments in Karakalpakstan revealed that the growth rate of wheat, alfalfa, and melon crops decreased by up to 40% when soil salinity exceeded 8 dS/m. Climate Change and Plant Phenology. Rising temperatures have shortened vegetation periods, causing flowering and fruiting phases to occur 5–10 days earlier than normal. In Surkhandarya region,

observations over the last 20 years showed that flowering in cotton and tomato plants began an average of 7 days earlier.

Table 1. Effects of environmental instability factors on plant physiological and morphological parameters

Environmental factor	Observed changes in plants	Measured indicators	Consequences for ecosystems
Air pollution (SO_2, NOx, particulate matter)	Chlorosis and necrosis on leaves; reduced chlorophyll content	Chlorophyll (SPAD) ↓ 25–30%; decreased photosynthetic rate	Reduced primary productivity and slower biomass accumulation
Soil salinization	Root growth inhibition; osmotic imbalance; leaf wilting	Electrical conductivity (EC) > 8 dS/m; Na^+/K^+ ratio imbalance	Decline in crop yield; reduced vegetation cover
Climate change (temperature rise, irregular rainfall)	Early flowering and fruiting; shortened growth period	Vegetation phase shift by 5–10 days; reduced soil moisture	Phenological mismatch between plants and pollinators; biodiversity loss
Heavy metal contamination (Pb, Cd, Zn)	Accumulation in roots and leaves; inhibited enzyme activity	Increase in heavy metal concentration in plant tissues	Toxicity and bioaccumulation in food chains
Land degradation and overgrazing	Decline of perennial species; dominance of weeds	Vegetation density ↓ 20–40%	Loss of habitat stability; soil erosion intensification

Such shifts disrupt ecosystem balance, affecting pollination and fertilization processes and leading to a reduction in biodiversity. Due to environmental instability, the number of plant species has significantly decreased. Observations across Uzbekistan indicate that the average number of natural plant species has declined by 18–22% compared to the early 2000s. The most significant losses occurred in desert ecosystems (e.g., saxaul, sand acacia, and wormwood species).

Discussion. The findings demonstrate that environmental instability affects not only the external morphology of plants but also their internal physiological processes. Disruptions in photosynthesis, transpiration, nutrient uptake, and water balance reduce plant resistance and ecological stability.

Increased pollution and accelerated climate change intensify ecological stress, driving some species toward extinction. For example, populations of Haloxylon aphyllum (white saxaul) and Calligonum setosum have declined by about 40% in the past 15 years.

Moreover, ecological stability depends not only on natural factors but also on human activity. Excessive use of agrochemicals, improper irrigation practices, and land overexploitation hinder the natural regenerative capacity of ecosystems.

Therefore, the implementation of phytomonitoring systems, the development of sustainable agricultural practices, and the expansion of national biodiversity conservation programs are essential to maintain and restore ecological balance.

Conclusion. The research confirmed that the disruption of ecological stability has multidimensional and profound effects on the plant world. The main conclusions are as follows. Air and soil pollution negatively affect plant physiological activities. Climate change alters phenological phases, disturbing interspecies relationships. The decline in biodiversity weakens ecosystem resilience. Restoration requires the integration of environmental monitoring, green technologies, and bioindicator plant systems.

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