INDIAN JOURNAL OF LEGAL REVIEW [IJLR – IF SCORE – 7.58]

VOLUME 6 AND ISSUE 1 OF 2026

APIS – 3920 - 0001 *(and)* ISSN - 2583-2344

Published by

Institute of Legal Education

https://iledu.in

AN ANALYSIS ON REGULATORY CONTROL OF TRANSBOUNDARY ACID RAIN POLLUTION

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BEST CITATION - NIKITHA ANN VARGHESE, AN ANALYSIS ON REGULATORY CONTROL OF TRANSBOUNDARY ACID RAIN POLLUTION, *INDIAN JOURNAL OF LEGAL REVIEW (IJLR),* 6 (1) OF 2026, PG. 191-201, APIS – 3920 – 0001 & ISSN - 2583-2344. DOI – https://doi.org/10.65393/QQWS6758

1. INTRODUCTION TO TRANSBOUNDARY ACID RAIN

Transboundary acid rain pollution is a significant environmental issue where sulfur dioxide (SO_2) and nitrogen oxides (NO_x) emissions from industrial activities, power plants, and vehicles travel across national borders through atmospheric circulation. These pollutants react with water vapor, oxygen, and other chemicals in the atmosphere to form acid rain, which falls to the ground as rain, snow, or fog. Acid rain has severe environmental consequences, including soil degradation, water contamination, forest destruction, and damage to historical monuments. It also poses risks to human health and biodiversity.

Many countries have experienced cross-border acid rain disputes, such as the USA-Canada acid rain conflict, which led to the 1991 U.S.-Canada Air Quality Agreement to reduce emissions.

Similarly, concerns have been raised about pollution from China affecting India, particularly in the Himalayan region, were black carbon and acid deposition impact glaciers and ecosystems. The issue of transboundary acid rain pollution highlights the need for international cooperation, legal frameworks, and stringent emission controls to address environmental damage and promote sustainable development.

11. TRANSBOUNDARY ACID RAIN

Transboundary acid rain refers to acid deposition that originates in one country or region and is transported by wind and atmospheric currents to another, often crossing national or international borders. It occurs when pollutants responsible for acid rain are transported by wind and atmospheric currents across national and international borders before being deposited as acidic precipitation. This environmental issue arises when sulfur dioxide (SO_2) and nitrogen oxides (NO_x) released from industrial emissions, vehicle exhaust, and power plants react with water, oxygen, and other chemicals in the atmosphere to form sulfuric and nitric acid. These acids then fall to the ground as acid rain, snow, fog, or dry particles.

While significant progress has been made through treaties and technological advancements, continuous efforts are needed to ensure a sustainable reduction in acid rain pollution.

111. CAUSES OF TRANSBOUNDARY ACID RAIN

The primary causes of transboundary acid rain are human activities such as industrial

processes, transportation, and agriculture, along with natural sources like volcanoes and wildfires.

Industrial Emissions: Power plants, factories, and oil refineries release large amounts of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) into the atmosphere. Coal-fired power plants are one of the largest contributors to acid rain, as burning coal releases significant amounts of

sulfur compounds.

Vehicle Exhaustion and Transportation: Cars, trucks, ships, and airplanes produce high levels of nitrogen oxides (NO_x), which contribute to acid rain formation. In urban and industrialized areas, transportation-related emissions are a major source of NO_x pollution.

Agricultural Activities: The use of nitrogen-based fertilizers releases ammonia (NH_3), which can react with other compounds to form acidic pollutants. Livestock waste decomposition also emits nitrogen compounds that contribute to acid rain.

Atmospheric Transport of Pollutants: Winds can carry SO_2 and NO_x emissions over hundreds or even thousands of kilometers, meaning that pollution from one country or region can cause acid rain in another. This makes acid rain a transboundary issue, requiring international cooperation for effective control.

Natural Sources:

Volcanic Eruptions – Release large quantities of sulfur dioxide (SO_2) into the atmosphere, which can lead to acid rain on a regional or global scale.

Lightning – Generates nitrogen oxides (NO_x) naturally, contributing to acid rain formation.

Forest Fires – Emit both sulfur and nitrogen compounds that can lead to acid rain when transported by wind.

Since these pollutants travel long distances before being deposited as acid rain, addressing this issue requires global and regional efforts to reduce emissions through cleaner energy sources, stricter regulations, and pollution control technologies.

IV. EFFECTS OF TRANSBOUNDARY ACID RAIN POLLUTION

Transboundary acid rain has widespread and severe consequences for the environment, human health, and infrastructure. Since pollutants like sulfur dioxide (SO_2) and nitrogen oxides (NO_x) can travel long distances before being deposited as acid rain, its effects are felt far from the

original pollution sources.

❖ Environmental Damage

a) Water Bodies (Lakes, Rivers, and Streams): Acid rain lowers the pH of water bodies, making

them too acidic for fish and other aquatic life. It leaches toxic metals like aluminum from the soil into the water, harming fish gills and aquatic ecosystems. Many lakes in Canada, Scandinavia, and the northeastern U.S. have suffered severe biodiversity loss due to acid rain.

b) Soil Degradation: Acid rain removes essential nutrients (e.g., calcium, magnesium, and

potassium) from the soil, reducing its fertility. It increases the presence of toxic metals (such as aluminum), which negatively affects plant growth.

c) Forests and Vegetation: Acid rain weakens trees and plants by damaging leaves, reducing their ability to photosynthesize. It makes trees more susceptible to diseases, extreme weather, and

pests. Forests in Eastern Europe, North America, and China have been particularly affected.

❖ Damage to Infrastructure & Cultural Heritage

a) Corrosion of Buildings and Monuments: Acid rain erodes limestone, marble, and concrete like the Taj Mahal (India), Parthenon (Greece), and Statue of Liberty (USA) have suffered damage from acid rain exposure.

b) Damage to Metal Structures: Acid rain corrodes bridges, railways, and vehicles, leading to increased maintenance costs and safety concerns.

❖ Human Health Impacts

While acid rain does not harm humans directly, its pollutants contribute to respiratory diseases

such as Asthma, Bronchitis and Lung inflammation. Fine particulate matter ($PM_{2.5}$)

formed from SO_2 and NO_x can penetrate deep into the lungs, leading to cardiovascular and respiratory

problems.

❖ Economic Consequences

a) Agricultural Losses: Acid rain reduces crop yields due to soil degradation and plant damage.

b) Fisheries Impact: Declining fish populations in acidified lakes hurt fishing industries.

c) High Maintenance Costs: Governments spend billions on repairing infrastructure damaged by acid rain.

d) Tourism Decline: Damage to cultural heritage sites and forests affects tourism revenue.

V. INTERNATIONAL REGULATORY FRAMEWORKS

Since transboundary acid rain affects multiple countries, it requires international cooperation and regulatory frameworks to reduce emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x).

Over the years, various treaties, agreements, and protocols have been established to combat this environmental issue.

- **The 1979 Convention on Long- Range Transboundary Air Pollution (CLRTAP)**

The CLRTAP Convention was adopted by the United Nations Economic Commission for Europe (UNECE). It is the first multilateral agreement addressing acid rain by requiring signatory countries to implement policies aimed at reducing emissions of Sulphur dioxide. The regions covered under this convention are Europe, North America and former Soviet states. The main objective is to reduce and prevent air pollution, including acid rain across national borders. The key precursor to acid rain through measures like emission caps and technology upgrades. While initially focused on acid rain the convention has expanded to include other air pollutants like Nitrogen dioxide, volatile organic compounds and heavy metals through additional protocols. It is considered as one of the most successful environmental treaties, with significant reduction in Sulphur emissions and improvements in air quality across its number states. The United Kingdom also have robust monitoring systems to track air quality and emissions, ensuring compliance with regulatory limits. Through CLTRAP, UK implemented domestically the National Emissions Ceilings Regulation (NECR). The NECR sets limits on Sulphur dioxide and Nitrogen Dioxide emissions aiming to significantly reduce emissions compared to baseline levels. Further also enforced specific regulations targeting different emission sources like power plants and vehicles. The key protocols under CLTRAP includes:

The 1985 Helsinki Protocol on the Reduction of Sulfur Emissions- Required countries to cut SO_2 emissions by at least 30% from 1980 levels by 1993.Focused on one of the primary causes of acid rain—sulfur dioxide emissions from industrial sources.

The 1988 Sofia Protocol on NO_x Emissions- Aimed at stabilizing NO_x emissions at 1987 levels. It required parties to adopt measures to control and reduce NO_x emissions, a major contributor to acid rain.

The 1994 Oslo Protocol on Further Reduction of Sulfur Emissions- It sets stricter SO_2 reduction targets based on each country's pollution levels and environmental vulnerability. Required parties to cut SO_2 emissions further beyond the 1985 Helsinki Protocol.

The 1999 Gothenburg Protocol (Multi-Pollutant, Multi-Effect)- Focused on reducing SO_2, NO_x, ammonia (NH_3), and volatile organic compounds (VOCs) to control acid rain,

eutrophication, and ground-level ozone. Also, encouraged the use of clean energy, improved fuel quality, and emission controls. It introduced national emission ceilings to limit acid rain and its effects on ecosystems and updated in 2012

to further tighten emission reduction commitments.

- **The 1991 US- Canada Air Quality Agreement**

In 1978 the US and Canada formed the Bilateral Research Consultation Group. Then in 1980 the Memorandum of Intent (MOI) was signed between US and Canada and later in 1986 the Special Envoys recommended emission reduction programs. It was in 1991 the US-Canada Air Quality Agreement was been entered into. The objective of the agreement is to reduce transboundary air pollution between the US and Canada focusing on acid rain and smog. The key elements are:

Sulfur Dioxide (SO_2) Reduction: Both countries committed to major reductions in SO_2 emissions from power plants and industrial sources.

Nitrogen Oxides (NO_x) Reduction: Measures to limit NO_x emissions from vehicles, industries, and power plants.

Monitoring & Reporting: Joint monitoring stations to track progress and ensure compliance.

1997ne Annex: Added to address smog-forming pollutants.

The emission reduction commitments for United States are to reduce annual SO_2 emissions by about 10 million tons from 1980 levels by 2000 and to reduce NO_x emissions from power plants by 2 million tons from projected 2000 levels. For Canada the cap SO_2 emissions at 3.2 million tons per year starting in 2000. And to reduce NO_x emissions from stationary sources by 100,000 tons from 1980 levels. The implementation and compliance of the both countries are to monitor emissions and air quality to track progress. They exchange data on transboundary air pollution to assess acid rain's effects. Both the nations conduct joint scientific research on acid rain's impact on ecosystems, forests, and water bodies. They use a harmonized monitoring system to evaluate environmental recover. The agreement includes mechanisms for reviewing progress and updating commitments as needed. The impact of the agreement includes that the agreement contributed to major reductions in acid rain-causing emissions in both countries. Sulfur dioxide and nitrogen oxides emissions declined significantly, leading to improvements in air and water quality. The

cooperation set a precedent for bilateral environmental agreements worldwide.

- **European Union (EU) Directives**

The main objective of these directives is to regulate air pollution and acid rain within the EU. The key policies include:

National Emission Ceilings (NEC) Directive (2016/2284) – Sets limits for SO_2, NO_x, NH_3, and $PM_{2.5}$ emissions for EU countries to mitigate acidification. Requires EU Member States to create National Air Pollution Control Programs (NAPCPs). It replaced the 2001 NEC Directive

(2001/81/EC) with stricter reduction targets by 2030.

Industrial Emissions Directive (IED) – Regulates emissions from large industrial facilities, a major source of SO2 and NO2 emissions. It requires the use of Best Available Techniques

(BATs) to minimize pollution and sets specific emission limits for SO_2 and NO_x for power stations, refineries, and other industrial facilities.

Large Combustion Plants Directive (LCPD), which is now integrated into IED – Imposes strict emission limits on power plants by burning fossil fuels. It phased out as the IED

(2010/75/EU) introduced stricter rules.

Ambient Air Quality Directive (2008/50/EC) & Fourth Daughter Directive (2004/107/EC)-

It establishes air quality standards for SO_2, NO_2, and particulate matter (PM) and mandates monitoring of acid rain precursors and their impact on human health and the environment.

Directive on the Reduction of Sulphur Content in Fuels (1999/32/EC, amended by 2016/802/EU)- Limits sulfur content in heavy fuel oil, marine fuels, and gas oil to reduce SO_2 emissions and requires low-sulfur fuels in sensitive areas like the North Sea and Baltic Sea (Sulfur Emission Control Areas - SECAs).

The impact of these Directives are significant reductions in SO_2 and NO_x emissions across the EU, decrease in acid rain damage to forests, lakes, and buildings and stricter industrial regulations leading to cleaner energy and sustainable air quality policies.

- **The Kyoto Protocol (1997) and Paris Agreement (2015)**

Neither the Kyoto Protocol (1997) nor the Paris Agreement (2015) explicitly focus on acid rain. However, both indirectly contribute to its reduction by addressing emissions of greenhouse gases (GHGs) and pollutants that are often associated with acid rain.

The Kyoto Protocol primarily targets the reduction of GHGs like carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). While, acid rain is mainly caused by sulfur dioxide (SO_2) and

nitrogen oxides (NO_x), which are not primary targets of Kyoto, efforts to reduce fossil fuel use and improve energy efficiency also help limit these emissions. Some countries included SO_2 and NO_x reductions in their national plans under Kyoto's clean development mechanisms (CDM).

The Paris Agreement focuses on limiting global temperature rise by reducing CO_2 and other GHGs but does not specifically mention acid rain. However, its promotion of renewable energy, energy efficiency, and reductions in fossil fuel use indirectly contributes to reducing SO_2 and NO_x emissions, thereby mitigating acid rain.

The key difference in addressing Acid Rainis that the Kyoto Protocol had some indirect impacts on acid rain through national emission reduction commitments and the Paris Agreement, being

more flexible and voluntary, does not impose binding emission cuts but encourages long-term transition to cleaner energy, which helps reduce acid rain precursors.

V1. INTERNATIONAL INSTITUTIONAL ARRANGEMENTS

- **United Nations Economic Commission for Europe (UNECE)**

It oversees the 1979 Convention on Long Range Transboundary Air Pollution (CLRTAP). It provides a platform for scientific cooperation, policy development and negotiations on reducing air pollution across borders. The key bodies under CLRTAP are:

1. **Executive Body for CLRTAP**
   1. Coordinates and oversees treaty implementation.
   2. Reviews scientific data and proposes policy recommendations.
2. **European Monitoring and Evaluation Programme (EMEP)**
   1. Collects and analyzes air pollution data.
   2. Assesses transboundary pollution impacts and helps nations track their emissions.
3. **Working Group on Strategies and Review (WGSR)**
   1. Develops new protocols and evaluates national implementation efforts.
4. **Task Force on Integrated Assessment Modelling (TFIAM)**
   1. Uses scientific models to assess emission reduction strategies.

- **United Nations Environment Programme (UNEP)**

The UNEP promotes global cooperation on air pollution and acid rain. It supports research, policy making and capacity building in

developing countries. It also monitors air quality and acid rain

impacts through programs like GEO (Global Environment Outlook). The EANET by Secretariat for acid deposition monitoring network in East Asia focuses on the monitoring and control of data, capacity building and awareness raising. Here, acid deposition means any form of precipitation with acidic components with a pH level of less than 5.6. such as sulfuric or nitric acid. The functions include:

1. Monitoring, evaluation and quality control
2. Providing technical support, research and capacity building
3. Awareness raising
4. Cooperation and information technology

- **European Union (EU) Institutions**

European Commission (EC)

- Implements and enforces air pollution laws, including the **National Emission Ceilings (NEC) Directive** and the **Industrial Emissions Directive (IED)**.

European Environment Agency (EEA)

- Monitors acid rain-related air pollution in Europe.
- Provides data and reports on emissions, deposition, and environmental impacts.

European Court of Justice (ECJ)

- Ensures compliance with EU environmental laws by imposing penalties on non-compliant nations.

- **US – Canada Air Quality Cooperation**

International Joint Commission (IJC)- Established under the 1909 Boundary Waters Treaty.

- Oversees the **1991 U.S.-Canada Air Quality Agreement**.
- Conducts joint research and monitoring of air pollution across the border.

Air Quality Committee (AQC)

- Reviews progress on emission reductions.
- Facilitates information sharing and policy coordination.

- **World Meteorological Organization (WMO)**

It is a specialized agency of UN responsible for international cooperation in meteorology, climatology, hydrology and related environmental issues. The functions of the body include weather forecasting and monitoring, climate change and environment monitoring, disaster risk reduction, water resource management and aviation and maritime meteorology. The WMO monitors atmospheric pollutants like sulfur dioxide (SO_2) and nitrogen oxides (NO_x), which cause acid rain. Through, the Global Atmosphere Watch (GAW) program, it tracks changes in air quality and deposition of acidic compounds. Also, collaborates with environmental organizations like the UNEP to assess and mitigate the effects of acid rain.

- **Global Environmental Facility (GEF)**

GEF is an international partnership that funds environmental projects in developing countries. It provides grants and financial assistance to address global environmental challenges. It supports clean energy transitions and industrial emission reduction programs. While the GEF does not directly target acid rain, it indirectly contributes to its reduction through:

- Air pollution control projects that reduce sulfur dioxide (SO_2) and nitrogen oxides (NO_x) emissions.
- Renewable energy and clean technology funding to decrease fossil fuel use, which is a major source of acid rain precursors.
- Support for sustainable urban development to improve air quality and reduce industrial pollution.

They work with UNDP, UNEP, and the World Bank to implement project and provides funds

initiatives under international agreements like the UN Framework Convention on Climate Change (UNFCCC), the Stockholm Convention on Persistent Organic Pollutants, and the Convention on Biological Diversity (CBD).

- **The Intergovernmental Panel on Climate Change (IPCC)**

IPCC is an international body for assessing climate change science. It provides scientific reports that inform global climate policies and negotiations. While the IPCC focuses on climate change, it also assesses air pollution, including sulfur dioxide (SO_2) and nitrogen oxides (NO_x) the main causes of acid rain. IPCC reports show that reducing fossil fuel emissions lowers both greenhouse gases (GHGs) and acid rain pollutants, benefiting both climate and air quality. The IPCC collaborates with organization like the WMO and UNEP, which tracks air pollution and acid rain impacts.

V11. REGIONAL FRAMEWORKS

United States

In US the regional frameworks in this area are The Clean Air Act , LRTAP and US-Canada Air Quality Agreement. The ***US*** combats acid rain through the Acid Rain Program (ARP), established under ***Title IV of the 1990 Clean Air Act Amendments***, which sets a cap on sulfur dioxide (SO2) emissions from power plants and uses a market-based allowance trading system to reduce pollution. It aims to reduce **sulfur dioxide (SO_2) and nitrogen oxides (NO_x)** emissions from the power sector, as these pollutants contribute to acid rain.

United Kingdom

The ***Clean Air Strategy 2019*** outlines ***the UK government's*** approach to tackling air pollution, improving public health, and protecting the environment. The strategy aims to reduce harmful emissions across multiple sectors, promote innovation, and ensure compliance with international air quality targets. The strategy sets legally binding targets to reduce emissions of pollutants like nitrogen oxides (NOx), sulphur dioxide (SO2), particulate matter (PM2.5), ammonia (NH3), and volatile organic compounds (VOCs).

Canda

The various frameworks include The Canadian Environmental Protection Act 1999 which have provisions regulating air pollutants and toxic substances, US-Canada Air Quality Agreement and The National Air Pollution Surveillance Program (NAPS). The NAPS program tracks pollutants that contribute to acid rain, providing data for regulatory decisions and public awareness. The Acid Rain Strategy for Post 2000 sets additional targets for reducing emissions, particularly SO2 and NO2 and includes specific measures to address acid rain in vulnerable regions like Eastern Canada.

V111. INDIAN DOMESTIC LAW TO CONTROL TRANSBOUNDARY ACID RAIN POLLUTION

India is a member of the United Nations Environment Programme (UNEP) and participates in global air pollution reduction efforts. India collaborates with neighboring countries (e.g., SAARC nations) on transboundary pollution control. Also, supports initiatives under the United Nations Framework Convention on Climate Change (UNFCCC), which indirectly helps mitigate acid rain. There are no direct laws in India to address the issues of transboundary acid rain pollution.

The Air (Prevention and Control of Pollution) Act 1981

The Air Act, 1981 does not explicitly mention acid rain, but it regulates air pollutants like sulfur dioxide (SO_2) and nitrogen oxides (NO_x), which are primary contributors to acid rain. Under Section 2(a), air pollution is defined as the presence of harmful substances in the atmosphere, making SO_2 and NO_x subject to regulation. The Act establishes the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) (Sections 3 & 4) to monitor air pollution and set emission standards for industries and power plants. The CPCB has the power to set national ambient air quality standards (NAAQS) (Sections 16 & 17),

while SPCBs ensure that emissions from industrial and vehicular sources remain within safe limits. The government can also declare "Air Pollution Control Areas" (Section 19) where industries must obtain

clearance before operating, helping to control SO_2 and NO_x emissions. Additionally, Sections 22 & 31A empower SPCBs to fine, shut down, or prosecute industries that exceed emission limits, ensuring strict enforcement. The Act also coordinates with other environmental laws, such as the Environment Protection Act, 1986 (Section 24), to further regulate air pollution and acid rain-related emissions.

The Environment (Protection) Act 1986

The Environment Protection Act (EPA), 1986 does not mention about acid rain, but it regulates pollutants like sulfur dioxide (SO_2) and nitrogen oxides (NO_x), which are primary contributors to acid rain. Under Section 3, the Central Government has broad powers to implement environmental protection measures, including setting emission standards for industries and vehicles, controlling SO_2 and NO_x emissions, and initiating pollution control programs. Sections 7 & 11 mandate industries to comply with air pollution limits, preventing excessive SO_2 and NO_x emissions, while government agencies conduct inspections to ensure compliance. The Act also empowers the government, under Sections 5 & 6, to restrict or ban industrial activities that cause severe pollution, including those emitting high levels of acid rain-causing pollutants. Section 15 prescribes strict penalties for violations, including imprisonment (up to five years), fines (up to

₹1 lakh), and extended penalties for continued violations. Additionally, the Environmental Impact Assessment (EIA) under EPA Rules, 1986, requires new industries to assess their environmental impact before starting operations, ensuring acid rain mitigation measures are in place. Sections 10 & 25 provide for coordination with the Central and State Pollution Control Boards (CPCB & SPCBs), which implement National Ambient Air Quality Standards (NAAQS) to regulate SO_2 and NO_x emissions. Lastly, the Act promotes cleaner technologies and renewable energy to minimize fossil fuel combustion, reducing pollutants that contribute to acid rain.

National Ambient Air Quality Standards (NAAQS)

The National Ambient Air Quality Standards (NAAQS) (Revised in 2009) was set by the CPCB under the Environment Protection Act, 1986. It prescribes acceptable limits for pollutants, including SO_2 and NO_x, to prevent acid rain. NAAQS set limits for Sulfur Dioxide (SO_2) and Nitrogen Dioxide (NO_2), the primary pollutants responsible for acid rain.

Central Pollution Control Board (CPCB)

The Central Pollution Control Board (CPCB) was established under the Air (Prevention and Control of Pollution) Act, 1981, to regulate and monitor air quality across India. It is responsible for setting emission standards and ensuring compliance by industries, power plants, and vehicles to control pollutants like sulfur dioxide (SO_2) and nitrogen oxides (NO_x), which contribute to air pollution and acid rain. Additionally, the CPCB issues guidelines and policies to promote cleaner technologies and sustainable practices, helping to mitigate environmental degradation and protect public health.

State Pollution Control Board (SPCB)

The State Pollution Control Boards (SPCBs) operate at the state level to implement regulations set by the Central Pollution Control Board (CPCB). They are responsible for ensuring industries comply with air pollution norms, particularly regarding emissions of pollutants like sulfur

dioxide (SO_2) and nitrogen oxides (NO_x). SPCBs also have the authority to grant or revoke environmental clearances for industries based on their adherence to prescribed air quality standards, playing a crucial role in controlling pollution and safeguarding environmental

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https://iledu.in

health.

Indian Meteorological Department (IMD)[544]

The IMD does not have a specific standalone provision or policy solely dedicated to acid rain. But it monitors air quality and pollution levels The IMD in collaboration with the other agencies such as CPCB and MOEFCC contributes to monitoring of pollutants and environmental conditions that lead to acid rain. They collect data and analyses on the pollution levels including acidification of water bodies, soil degradation and damage to ecosystems. It includes network of monitoring stations that measure the levels of SO2 and NO2 which are linked to acid rain formation.

1X. JUDICIAL DECISIONS AND CASE STUDIES

Trail Smelter Arbitration Case [545]

The Trail Smelter Arbitration case was a significant dispute between the United States and Canada over transboundary pollution, specifically emissions from a smelter in Canada that caused environmental damage in Washington, U.S.A. The case, heard by the Trail Smelter Arbitral Tribunal, was based on the Convention of Ottawa, signed on April 15, 1935, with arbitrators Charles Warren (U.S.A.), Robert A. E. Greenshields (Canada), and Jan Frans Hostie (Belgium). The tribunal issued its awards on April 16, 1938, and March 11, 1941, establishing key principles for preventing transboundary pollution, which significantly influenced international environmental law. A related environmental dispute occurred decades later when Canada accused the U.S. of contributing to acid rain through sulfur dioxide emissions from industrial areas in the eastern U.S. These pollutants were carried by winds into Canada, causing severe environmental damage to lakes and forests. This issue led to prolonged diplomatic tensions until the two countries signed the Canada-United States Air Quality Agreement in 1991, committing to jointly reducing emissions responsible for acid rain.

Great Smog of 1952[546]

On December 5, 1952, people in London, England, began to suffer respiratory illnesses after breathing thick smog. This deadly weather event, the Great Smog, would last almost a week and cost between 4,000-10,000 lives. Smog is a type of air pollution, created

by industrial output and natural weather patterns. London's reliance on coal-fired power plants for electricity and heat, and diesel-powered buses for public transportation, contributed

to the Great Smog. London's weather also contributed to the Great Smog. The city is contained in a large river valley, limiting air circulation. In addition, a mass of cold air blanketed the region the night before, trapping the valley's warmer air below. This warmer air was very high in pollution from homes, cars, and factories. The Great Smog of 1952 caused the United Kingdom to enact stricter laws about air pollution. Many cities around the world have tried to limit how much pollution is in the air. However, smog is still a problem in cities such as Mexico City, Mexico; Beijing, China; and Los Angeles, United States.

The United States v. Canada[547]

The United States alleged that sulfur dioxide (SO_2) emissions from Canadian industries and power plants were causing acid rain, leading to environmental damage in lakes and forests across northeastern U.S. states. Canada countered that U.S. emissions were also contributing to the problem, highlighting the shared responsibility for transboundary pollution. Instead of pursuing a formal legal ruling, both countries engaged in bilateral negotiations, ultimately resulting in the 1991 U.S.-Canada Air Quality Agreement. This agreement committed both nations to reducing SO_2 and nitrogen oxides (NO_x)

[544] IMD ,https://mausam.imd.gov.in
[545] United States v. Canada 3 UNRIAA ,1952
[546] Polivka BJ. The Great London, Smog of 1952.Am J Nurs.2018 Apr;118(4):57-61.
[547] (Acid Rain Dispute, 1980s-1991)

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APIS – 3920 - 0001 *(and)* ISSN - 2583-2344
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emissions to mitigate acid rain. The dispute underscored the importance of diplomatic solutions in addressing transboundary pollution and reinforced the principle of state responsibility for emissions that impact neighboring countries.

M.C Mehta v. Union Of India (Taj Trapezium Case)[548]

The M.C. Mehta v. Union of India case began in 1984 when environmental activist M.C. Mehta noticed that the Taj Mahal's marble was turning yellow due to pollution. He filed a petition in the Supreme Court, identifying industrial emissions as the cause. The Taj Mahal is located within the Taj Trapezium Zone (TTZ), a 10,400 sq km protected area established to safeguard the monument from environmental damage. In response, the Supreme Court ordered industries to relocate or switch to natural gas to reduce pollution. Additionally, it created the Taj Trapezium Zone Authority (TTZA) to oversee pollution control efforts. This case was significant as it set a precedent for public interest litigation (PIL) in environmental protection, reinforced the judiciary's role in safeguarding India's natural and cultural heritage, and emphasized the need to balance industrial development with the preservation of historic sites.

Indian Council for Enviro- Legal Action v. Union of India[549]

The Indian Council for Enviro-Legal Action (ICELA), a non-governmental organization, filed a Public Interest Litigation (PIL) in the Supreme Court of India against chemical industries in Bichhri village, Rajasthan, for illegally producing hazardous chemicals like H-acid. The resulting toxic waste contaminated soil and groundwater, causing irreversible environmental damage and severe health hazards for the villagers. In its judgment, the Supreme Court upheld strict environmental liability, applying the "polluter pays" principle, which mandates that polluters bear the cost of remediation. The court ordered the industries to compensate for the damage and directed the government to enforce stringent pollution control measures to prevent future violations. This ruling reinforced the principles of sustainable development and precautionary measures in environmental law. The case is particularly relevant to acid rain, as it underscores the legal accountability of industries for pollution that leads to long-term environmental harm.

Acid rain, caused by sulfur dioxide (SO_2) and nitrogen oxides (NO_x) emissions from industries and power plants, results in soil degradation, water contamination, and forest destruction, effects similar to those seen in the Bichhri case, emphasizing the need for strict pollution control measures.

Transboundary Air Pollution And Indo- China Border Pollution Concerns[550]

Although no specific legal case has been filed in Indian courts regarding transboundary acid rain, concerns have been raised about pollution from China affecting India. Research indicates that industrial emissions from China contribute to black carbon and acid deposition over the Himalayas, impacting glaciers and ecosystems. This raises significant legal implications, as India could potentially address the issue under international environmental law, drawing parallels to the Trail Smelter Arbitration (USA v. Canada), which established the principle of state responsibility for transboundary pollution. Such legal action could help establish accountability and cooperative solutions for mitigating cross-border environmental damage.

X. CHALLENGES

Some countries struggle to meet the targets due the economic or political constraints leading to challenges in enforcement and compliance. Many developing countries still rely on coal, increasing acid rain risks. Acid rain

[548] (1997) 2 SCC 353
[549] (1996) 3 SCC 212

[550] Cross Border Air Pollution in Asia, Asia Pacific Foundation of Canada, https://www.asiapacific.ca

policies should align with broader climate goals to ensure a sustainable approach. Political disagreements between nations, economic concerns over emission reduction costs and scientific uncertainties all add up to the challenges of the acid rain pollution control.

X1. CONCLUSION

Transboundary acid rain pollution is a critical environmental challenge that requires coordinated international action to mitigate its harmful effects on ecosystems, water bodies, agriculture, historical monuments, and human health. Since acid rain results from industrial emissions traveling across national borders, it underscores the shared responsibility of countries to control sulfur dioxide (SO_2) and nitrogen oxides (NO_x) emissions through stringent regulations, clean energy adoption, and diplomatic agreements. Historical cases, such as the U.S.-Canada acid rain dispute, demonstrate the importance of international cooperation in addressing cross-border pollution. Nations must work together under global environmental frameworks, such as the United Nations Framework Convention on Climate Change (UNFCCC) and regional air quality agreements, to develop effective policies for emission reduction. Moving forward, scientific research, legal accountability, and sustainable industrial practices must be strengthened to prevent and control transboundary acid rain pollution, ensuring a healthier environment for future generations.

X11. REFERNCES

1. William V Power, Acid Rain: Calling for a Transboundary Solution, William and Mary, Environmental Law and Policy Review, Vol 12(1987)

2. Armin Rosencranz, The International Law and Politics of Acid Rain, DENVER JOURNAL OF INTERNATIONAL LAW AND POLICY, Vol 10, January 1981

3. John Warren Kindt, International Environmental Law and Policy: An Overview of Transboundary Pollution, 23 SAN DIEGO L.REV.583 (1986)

4. Beverly A Ohline, Clean Air Act-Transboundary Acid Rain Pollution Abatement-Administrative Discretion Citizen Suit, NATURAL RESOURCE JOURNAL Vol 27 (1987)

5. Elizabeth Knapp, Our Neighbor's Keeper? The United States and Canada: Coping with Transboundary Air Pollution, FORDHAM INTERNATIONAL LAW JOURNAL Vol 9(1985)

6. ND Bankes and JO Saunders, Acid Rain: Multilateral and Bilateral Approaches to Transboundary Pollution Under International Law, UNIVERSITY OF NEW BRUNWICK, https://journals.lib.unb.ca

7. The 1979 Convention on Long- Range Transboundary Air Pollution (CLRTAP)

8. The 1991 US- Canada Air Quality Agreement

9. The Kyoto Protocol

10. The Paris Agreement

11. Clean Air Strategy 2019

12. Clean Air Act 1963

13. Acid Air Program, https://www.epa.gov/acidrain/acid-rain-program

14. United Nations Economic Commission for Europe (UNECE), https://unece.org

15. United Nations Environment Programme (UNEP), https://www.unep.org

16. US- Canada Air Quality Agreement, https://www.epa.gov

17. World Meteorological Organization, https://wmo.int

18. Global Environmental Facility (GEF), https://www.thegef.org

19. The Intergovernmental Panel on Climate Change (IPCC), https://www.ipcc.ch

20. The Air (Prevention and Control of Pollution) Act 1981

21. The Environment (Protection) Act 1986