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An Assessment of Environmental Pollution and Policy Initiatives in Punjab, India: A Review

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Abstract Environmental pollution is a global health concern. Air, water, and soil pollution cause 16% of premature deaths worldwide. Rapid urbanization and industrialization result in the environmental pollution in developing countries, including India. Environmental degradation is a grave issue in developing countries due to a lack of awareness, inadequate legislation and faulty enforcement. This research is mainly concerned with the issue of environmental pollution and various policy initiatives undertaken by the Punjab state of India. Punjab is a predominantly agrarian state. Anthropogenic activities such as burning fossil fuels, stubble burning, excessive chemical fertilizer and industrial waste are significant contributors to environmental pollution in Punjab. This study explores the causes and effects of environmental pollution in Punjab. It is exploratory, and secondary data used in this research were collected from newspapers, e-journal articles, reliable internet sources, government reports, "Punjab Pollution Control Board", and "Central Pollution Control Board" websites. Despite environmental legislation, findings revealed an alarming upsurge in Punjab's pollution levels, leading to air, water, and soil quality degradation. It causes serious health issues. Malwa region is identified as the "Cancer capital of Punjab" due to the shocking surge in cancer cases. It concludes with measures to control environmental pollution. It recommends a crucial need for a comprehensive awareness program and the proper implementation of policies to curb the harmful effects of pollution in Punjab, India.

Keywords Environment Pollution, Stubble Burning, Measures, Air Quality Index, Punjab

1. Introduction

Environmental pollution is the most crucial global issue. Environmental pollution can be described as "the contamination of physical, chemical and biological quality of the environment that cause harmful impacts on human and other living organisms". Urbanization, rapid industrialization, and associated human activities are prime reasons for environmental pollution in India. It is the leading cause of premature deaths and diseases across the globe. The majority of premature deaths occur in developing industrialized countries. According to HEI's report, "more than 1.1 million premature deaths in India were caused by air pollution in the year 2017" (HEI 2019) [1]. As per World Air Quality Report 2019, India ranks fifth in the world's most polluted countries, and out of the 30 most polluted cities globally, 21 are from India [2]. According to Poovanna, S. [3], the report entitled "Greenpeace: Cost to Economy Due to Air Pollution Analysis 2021" indicates that air pollution resulted in 160,000 deaths globally in 2020. Greenpeace Southeast Asia Analysis of IQAir data has indicated that air pollution led to over 120,000 deaths in India in 2020.

Punjab was the centre of the green revolution, and the emergence of new irrigation techniques, use of chemical fertilizers, pesticides and high-yielding varieties made Punjab self-sufficient. It is known as the "breadbasket of

India" due to its significant contribution with 20 percent of wheat and 9 percent of rice to national production. Punjab produces 2 percent of the global cotton and wheat production and one percent of world rice production (Behal, A.) [4].

The utilization of fertilizers is the highest in this region. The total utilization of fertilizers in 2018-2019 was 228 kg per ha, and the total use of pesticides was 5650 metric tonnes during 2018-2019 (Punjab Economic survey 2019-2020) [5]. According to a study conducted by Behal, A. [4], excessive use of fertilizers and pesticides has caused severe health concerns in this region. It also contributed to the contaminated air, water and soil. The burning of agricultural residue is also responsible for the degradation of air quality in north India, especially in Punjab.

Economic growth led to urbanization and Rapid industrialization in Punjab. Industrial waste and human activities such as burning fossil fuels and the vehicular sector are predominant causes of environmental pollution in Punjab.

Numerous environmental pollutions exist, but this study deals mainly with Punjab air, water and soil pollution. It explores the causes of pollution, its impacts and policy Initiatives of the government to control environmental pollution in Punjab.

2. Literature Review

Khan, M. A. & Ghouri, A. M. [6], in their research paper "Environmental Pollution: Its Effects on Life and Its Remedies", tried to analyze the effect of air, water, and soil pollution on human beings and other living organisms. It suggested that government and local organizations should take initiatives to control environmental pollution and encourage the public to adopt eco-friendly measures.

Mittal, S., Kaur, G., & Vishwakarma, G. S. [7], in their study "Effects of Environmental Pesticides on the Health of Rural Communities in the Malwa Region of Punjab, India: A Review", revealed that the Malwa region of Punjab is facing an environmental emergency associated with excessive use of pesticides and fertilizers. Around 75 percent of Punjab's pesticides are consumed in the Malwa region. Overuse of pesticides resulted in serious health issues such as depressed mood, insomnia, and thyroid, cancer. This region is identified as the "Cancer Capital of India" due to a three times increase in cancer cases.

Gulia, S., et al. [8], in their research "Assessment of Urban Air Quality around a Heritage Site Using AERMOD: A Case Study of Amritsar City, India", examined industries, transport, re-suspension of road dust, burning of crops stubble, burning of wood and coal in restaurants are primary sources of air pollution in Amritsar. It described various measures such as introducing battery-driven vehicles and installing pollution control equipment in the free kitchen.

Pratiksha & Sharma, P. [9], in their study "Status of Environmental Pollution in Rural Punjab and its Management," highlighted that burning of agricultural residue, industrial waste, vehicles and overuse of fertilizers are major causes of pollution in Punjab. It revealed the harmful effect of pollution on humans. It explored that air pollution is higher than water and soil pollution in rural Punjab. It examined various measures taken by the government to control pollution.

Ukaogo, P. O., Ewuzie, U., & Onwuka, C. V. [10], in their book chapter "Environmental Pollution: Causes, effects, and the remedies", revealed the issue of environmental pollution is very critical in developing countries as a result of poverty, low level of awareness and weak laws. It highlighted that urbanization, agriculture, motor vehicle, and overuse of fertilizers are responsible for pollution. Air pollution led to premature deaths in these countries.

Dandona, L. et al. [11], in their research entitled "Health and economic impact of air pollution in the states of India: The Global Burden of Disease Study 2019", revealed that in the year 2019, air pollution caused around 1.67 million premature deaths, which was 17.8% of total death in India and it resulted in the economic loss of US$28 8 billion during this year. Air pollution causes serious health concerns such as lung cancer, respiratory infections, skin diseases, ischemic heart disease, stroke, diabetes, and cataracts.

Thongzunhor, H., & Pochai, N. [12], in their research "Numerical Simulations of a Two-dimensional Vertically Averaged Air Pollution Measurement in a Street Canyon", examined the air pollution in a street Canyon with the help of two- dimensional vertically averaged air pollution, measurement model. Burning and fuel evaporation from vehicles contribute to air pollution.

Obiefuna, J. N., et al. [13], in their study, examined urban land uses concerning the geospatial assessment of ambient air quality footprints in Calabar Metropolis, Nigeria, based on data collected in wet and dry sessions in 2020. It revealed that the concentration of CO, NO_2, SO_2, H2S, and SPM2.5 was higher in the dry season than in the wet season. Commercial, transportation, and industrial activity are the chief contributors to the high concentration of air pollutants in urban areas.

Many studies have been conducted on the issue of environmental pollution. However, there is a lack of systematic and comprehensive studies on environmental pollution and various policy initiatives by the government to handle this issue in Punjab. This study is significant because it provides the causes and harmful effects of pollution in Punjab, and it can be helpful for planning and implementing a proper policy for the allotment of long-term funding to prevent the harmful effects of pollution at the state level.

3. Research Objectives

The prime objectives of this study are as under:

1. To explore the causes of environmental pollution in Punjab, India.
2. To examine the impacts of air, water and soil pollution in Punjab.
3. To analyze policy initiatives taken by the government.
4. To provide suggestions to control pollution in Punjab.

4. Methods

4.1. Study Area

Punjab is an economically prosperous state in India. It is located between 29 "30'N to 32 "32'N latitude and 73 "55'E to 76 "50'E longitude in the northwest part of India with a total area of 50,362 sq. km. The HDI 2018 ranking has the 9th ranking among Indian states and union territories. Punjab is an agrarian state. The economy of Punjab is dependent on agriculture and small-scale industry. It is one of the most productive regions of India due to the availability of plenty of water sources and alluvial soil. Around 75 percent population of the state depends upon agriculture.

4.2. Research Methodology

It is exploratory, and secondary data for this research were collected from newspapers, e-journal articles, reliable internet sources, government reports, "Punjab Pollution Control Board", and Central Pollution Control Board websites.

5. Environmental Pollution in Punjab

Agriculture and industrial activities have resulted in environmental pollution, a serious health and economic concern for Punjab. There are many types of environmental pollution, but pollution classification is not easy due to the interconnection of means by which the pollutants are transported. This study mainly deals with air, water and soil pollution in Punjab.

5.1. Air Pollution

Air pollution is "the presence of pollutants in the atmosphere in solid, liquid, or gas form that can harm humans and ecosystems". Air pollutants include natural sources like volcanic explosions, dust storms, forest fires, anthropogenic sources like burning fossil fuels, mining, transportation, construction of buildings, and gaseous pollutants such as sulphur oxides, nitrogen oxides, carbon monoxide, methane, chlorofluorocarbons, and carbon dioxide.

Punjab faces the challenge of air pollution due to rapid industrialization, urbanization and agricultural activities. Levels of pollution spike to dangerously high levels during the winter in Punjab due to stubble burning and dust particles. Crop residue burning releases aerosol particles - coarse particles (PM10) and fine (PM2.5) - and greenhouse gases (GHG), having harmful effects on human health. The release of aerosols and gaseous pollutants from stubble burning significantly affects air quality (Kaskaoutis et al.) [14]. The air quality index of eight cities of Punjab, "Khanna, Ludhiana, Dera Bassi, Gobindgarh, Jalandhar, Naya Nangal, Pathankot and Patiala", have been considered the worst. The leading causes of pollution in Punjab are residential and commercial burning, fossil fuel burning, industrial emission and construction activities and transport vehicles (Sood, A.) [15].

5.2. Water Pollution

Water pollution can be defined as "contamination of water bodies due to human activities or natural sources such as sewage containing domestic, industrial waste, pesticides from agricultural lands and release of oil from refineries". Water pollution is a major environmental issue in Punjab because releasing untreated wastewater into natural water resources can cause the degradation of the aquatic ecosystem. Kukreti, I. [16] highlighted that 80% of groundwater in the Malwa region is not safe for drinking due to the extreme utilization of chemical fertilizers and pesticides. It contains a high quantity of magnesium, fluorine, and phosphates that cause a blood disorder named "methemoglobinemia" in children, leading to inadequate oxygen supply to cells. The water quality index indicated that the Bathinda district of Punjab has highly contaminated groundwater.

5.3. Soil Pollution

Soil pollution can be defined as poisonous chemicals in the soil that harms human health and the ecosystem. Natural disasters such as earthquakes and erosion tend to damage the soil. Industrial, domestic waste and excessive use of fertilizers are major sources of soil contamination in Punjab. This overuse of pesticides and fertilizers such as ammonium nitrate, phosphorus and NPK fertilizer have destructive effects on human health and soil quality. Paddy burning leads to the deterioration of soil fertility. The heat generated from stubble burning leads to moisture loss and valuable microorganisms.

6. Causes of Environmental Pollution

Many sources such as agricultural activities, industrial and vehicular emissions, and excessive use of chemicals are responsible for environmental pollution. Some of these causes are described as under:

6.1. Burning of Agriculture Residue & Other Biomass

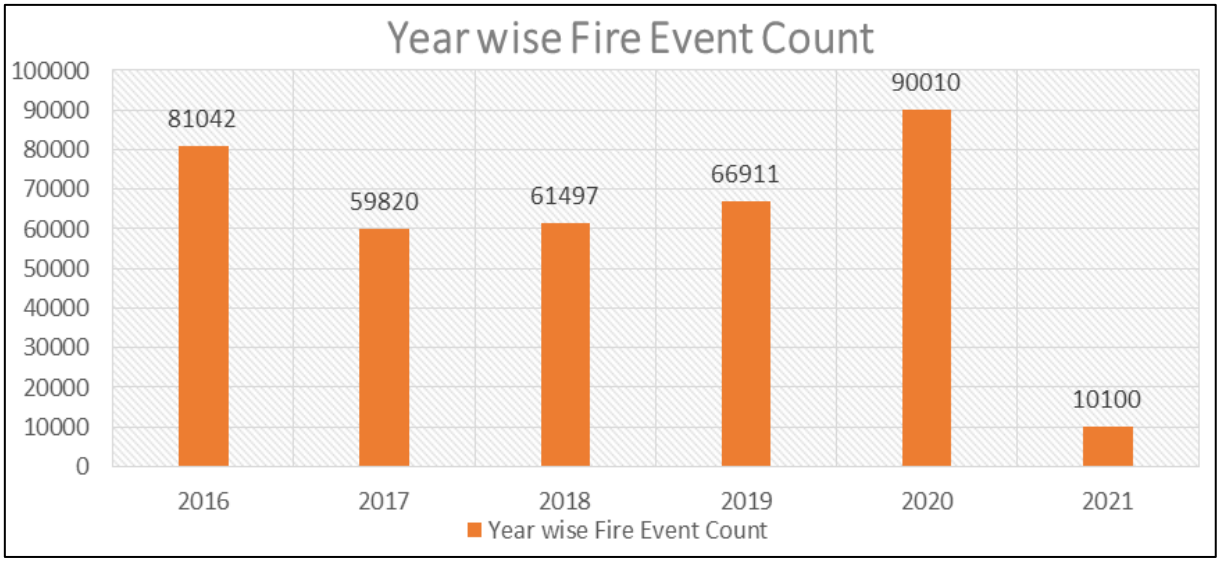
Agriculture residue burning is mainly responsible for environmental pollution in Punjab. Stubble burning can be

described as "the deliberate burning of crop residue by farmers after crop harvest". It releases particulate matter and gaseous pollutants like Methane, Carbon Monoxide, Nitrogen Oxide and carcinogenic polycyclic aromatic hydrocarbons that adversely affect humans and the environment. Mechanized farming produces a large amount of stubble in Punjab, and above 90% of farmers of the Punjab burnt crop residue (Ravindra et al. [17]). The burning of wood and cow dung cakes wildfire also contributes to pollution. This region of India produces "20 million tons of paddy" and "17 million tons of wheat stubble" annually. More than 81% of rice and 48% of wheat stubble is burned in the field during March-April and October-November, leading to a decline in air quality and loss in soil fertility [18]. "In the year 2015, PM 10 and PM 2.5 concentrations increased by 86.7% and 53.2% during paddy and wheat stubble burning periods, respectively, in Mandi-Gobindgarh city of Punjab" **(**Abdurrahman, M. I., Chaki, S., & Saini, G.,2020; Singh, R., Chanduka, L., & Dhir, A.,2015) [19, 20]. In 2019, the total production of paddy straw in Punjab was around two crore tons, and farmers burned 98 lakh tons of rice straw this year. Punjab Remote Sensing Centre reported "73,883 incidents" of crop residue burning in Punjab between September 21 and November 14, 2020, which is the highest number since 2016. A study conducted by IARI scientists on stubble-burning incidents revealed that the incidents of stubble burning raised from 180 to 515 in Amritsar and 92 to 341 in Tarn Taran during 2019-2020 (The Hindu, 2020) [21].

Figure 1 indicated year-wise events of stubble burning during the Rabi session. It revealed a massive increase in incidents of crop residue burning during 2020.

6.2. Industrial Emission

Industrialization is one of the significant contributors to environmental pollution in Punjab. The emission of dust particles, smoke, vapours, and toxic gas from industries such as thermal power plants, coal mines, cement, petroleum and chemicals lead to air pollution. The discharge of untreated industrial wastes, heavy metals, and solvents into land and water bodies contributes to permanent damage to the ecosystem. According to the "Water (Protection and Conservation) Act, 1974", "Air (Prevention and Control of Pollution) Act, 1981", "consent to establish" is mandatory from the "Punjab Pollution Control Board" before the establishment or expansion of the industrial unit. Punjab state pollution control board categorizes all industries in Punjab into red, orange, and green. The red category industries are highly polluted. Therefore, there is a requirement for a no-objection certificate from the State Authority of the Department of Environment. According to Punjab Pollution Control Board's data, "there are 13070 industries under the red category in the state. Many red category industries utilize coal as fuel which contributes to suspended particulates matter, nitrogen and sulphur oxides and organic compounds in the air" [23].



Source: Data compiled from Punjab Remote Sensing Centre during Rabi session (https://gisprsc.punjab.gov.in/residue/Index.aspx) [22]

Figure 1. Events of stubble burning during the Rabi session (2016-2021)

6.3. Use of Chemical Fertilizers and Pesticides

Overuse of Chemical Fertilizers and pesticides to increase the yield of crops is a major contributor to air, water and soil contamination in Punjab. It leads to the presence of residues of chemical pesticides in water, vegetables and other food products, which have harmful effects on humans and the ecosystem.

'Agricultural Statistics at a Glance 2019' report indicated a rise in the consumption of NPK fertilizer. The fertilizer consumption in Punjab during 2018-2019 was 224.49 kg, higher than the average consumption of 133.12 kg/hectare in India, leading to declining soil quality [24].

Figure 2 indicates the use of fertilizer in Punjab since 2011. The consumption of fertilizers was maximum in 2016-2017 due to the attack of whitefly pests.

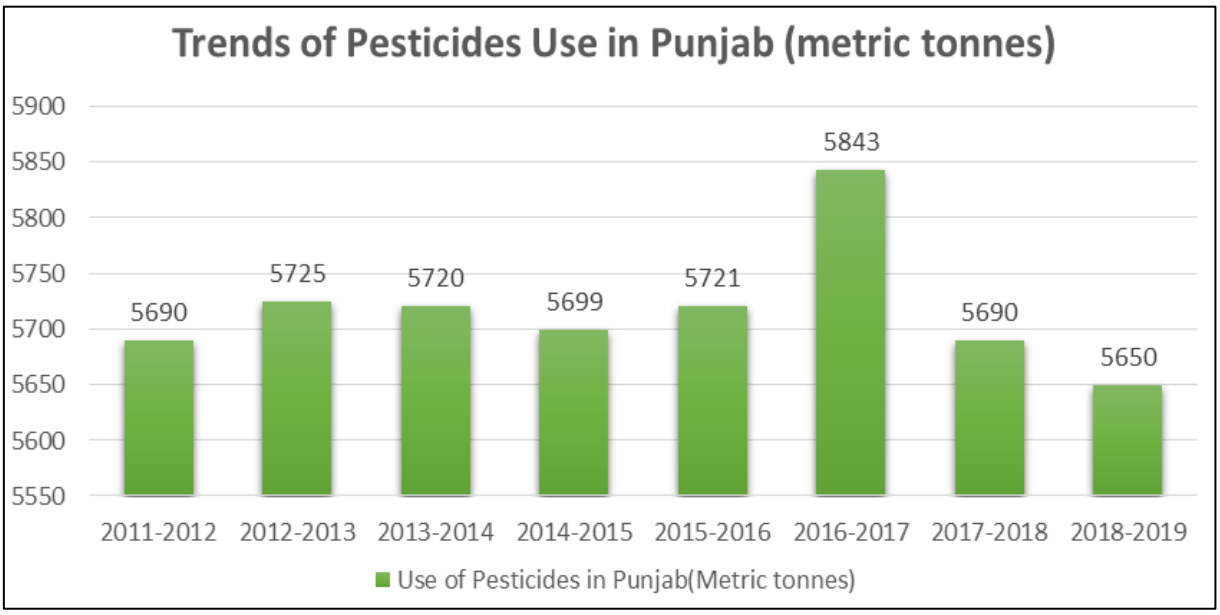
6.4. Vehicular Emission

Vehicular emission is also one of the main reasons for pollution in Punjab due to the increasing number of vehicles yearly. As per the Transport Department, Punjab and "Ministry of Road Transport and Highways, Government of India", vehicles are massive from 3,60,154 (1980) to 1,13,36,533 by December 2018. Poor maintenance of vehicles leads to high release of poisonous chemicals such as 'carbon monoxide, nitrogen oxides, and air toxins, namely benzene, aldehydes, 1-3 butadiene, lead, particulate matter, hydrocarbon, and Sulphur oxide' that adversely impact the atmosphere and human health. Exploration, refining, and distribution of petroleum through road transport often led to soil pollution.

Table 1. Estimated Consumption of Fertilizers (N, P&K) per Hectare in Punjab

Year	Chemical Fertilizers				
	Nitrogenous (N) in Punjab	Phosphatic (P2O5) in Punjab	Potassic (K2O) in Punjab	Total (NPK) in Punjab	Total (NPK) in India
2016-17	178.30	47.20	6.66	232.17	124.41
2017-18	168.70	38.08	6.54	213.31	127.88
2018-19	177.11	42.04	5.34	224.49	133.12

Source: Data compiled from Agricultural Statistics at a Glance 2019.
(https://eands.dacnet.nic.in/PDF/At%20a%20Glance%202019%20Eng.pdf)



Source: Directorate of Agriculture and Farmers Welfare, Punjab cited in Statistical Abstract 2018.

Figure 2. Use of Pesticides in Punjab (2011-2019)

6.5. Burning of Fossil Fuels

Burning of fossil fuels such as oil, coal and gas in petroleum refineries, power-generating plants, and homes to meet our energy requirements emits many pollutants, including SO_2, CO_2, CO, hydrocarbons, nitrogen oxides (NOx), airborne particles, nitrous oxide, methane (CH4), and fluorinated gases can cause contamination to soil and water. Around 30.7% of deaths in India were caused in 2018 due to air pollution from fossil fuel burning. (Sreedhar, N.) [25]

6.6. Road Dust and Construction Activities

Road dust emission caused by traffic movements and wind also contributes to air pollution. Roads of industrial areas like Gobindgarh & Ludhiana are not carpeted. Movements of vehicles on these uncarpeted roads caused dust particles into the environment, leading to a decline in air quality. Major construction projects such as housing and industrial also lead to environmental pollution.

7. Effects of Environmental Pollution

Environmental pollution has caused severe health conditions in Punjab. Vermylen J. et al. [26], in their study, revealed that Exposure to SO2 NOx causes respiratory diseases such as asthma and lung inflammation. CO reduces oxygen supply to the brain and heart, leading to heart diseases. Exposure to arsenic, mercury and lead can cause sleep disorder, fatigue and blurred vision (Ewan, K. B., & Pamphlett, R.) [27]. The presence of lead in soil can affect the mental development of young children. A high concentration of mercury can damage Kidneys. These heavy metals can have deadly health effects such as cancer, hormonal imbalance, and reproductive disorders. Organic pollutants can cause headaches, stomach aches, vomiting, diarrhoea, skin rash, depression and typhoid.

Levels of air pollution have resulted in premature death and economic loss. Annual report of "Down to Earth and Centre for Science and Environment", entitled "State of India's Environment 2021," revealed that air pollution caused around 41,090 deaths in 2019 in Punjab, 18.8% of total deaths. The economic loss caused in Punjab by air pollution during 2019 was 1,148 million US dollars, around 1.52% of the state GDP (Jassowal, G.,) [28]. Singh, S., & Singh, H. [29] in their study "Impact and extent of groundwater pollution: a case study of rural area in Punjab State (India)" revealed that polluted groundwater had caused various health problems such as "yellowish teeth, diarrhoea, constipation, premature greying of hair, hair fall, typhoid and joint pain" in rural areas of Punjab**.** According to Sharma A. [30], the overuse of chemical fertilizer in the Malwa region of Punjab leads to the spread of cancer. The number of cancer cases is increasing at an alarming rate in Punjab. As per the official record, there were 10109 in 2017 and 10,648 in 2018 in Bathinda's cancer institute.

Pollutants also have adverse impacts on animals and the ecosystem. Pollution leads to the degradation of soil, water and air chemical properties. The presence of harmful substances in soil and water results in damage to wild animals, damage to plants, and reduce the productivity of the land. Plastic pollution is also a significant challenge for animals which causes internal damage and other harmful diseases.

8. Government Policy Initiatives to Handle the Issue of Environmental Pollution

Implementing pollution control laws is the fundamental responsibility of the "Ministry of Environment and Forest", the "Central Pollution Control Board", and the State-level Pollution Control Board in India. Since independence, India has taken several steps to conserve the environment. The Central Government and the Government of Punjab have established various policies to control environmental pollution. There are eleven major pollution control laws in India. Under section 42 of the Indian constitution, state governments have been directed to make laws.

8.1. Role of Punjab Pollution Control Board

This leading governing agency was established in 1975 to plan a comprehensive policy and implement environmental laws in Punjab. It has taken various initiatives to control pollution. This Board observes the following pollution prevention laws in Punjab:

- The Water (Prevention and Control of Pollution) Act, 1974, has been amended.
- The Water (Prevention and Control of Pollution) Cess Act, 1977.
- The Air (Prevention and Control of Pollution) Act, 1981 has been amended.

The core functions of the Punjab Pollution Control Board are listed below:

- To frame a policy to prevent air, water and soil pollution.
- To collect data related to environmental pollution and its prevention.
- To provide advice to the state government about matters concerning pollution prevention.
- To encourage research related to environmental issues and find a suitable measure to handle these problems.
- To establish the laboratories for analyzing the sample of pollutants in the atmosphere.
- To create public awareness regarding a clean environment and rectify public grievances about pollution.

8.2. Measure Taken by Government to Control Environmental Pollution

Some of the measures taken by the government are given below:

8.2.1. Ambient Air Quality Monitoring

"National Air Quality Monitoring" Programme was launched by Central Government to monitor Ambient Air Quality. There are 793 operating stations with 344 cities or towns in 29 states and 6 Union Territories. The 'National Air Quality Monitoring program's main objectives are assessing the status and patterns of Ambient air quality, providing air pollution data to the public on time, assessing the effectiveness of action plans for pollution control, and researching the health consequences of air pollution.

In Punjab, under this program, ambient air quality is monitored for 24 hours thrice a week at 28 locations, including four rural area stations. Patiala, Amritsar, Jalandhar, Ludhiana, Khanna, Mandi Gobindgarh, Dera baba Nanak, Naya Nangal, and Derabassi are among the cities where this monitoring takes place. To monitor the influence of stubble burning on air quality, four stations have been established in rural areas of village Rasulpur of Amritsar, Village Gangsar of Sangrur, Village Himmatpura Faridkot and Village Mukandpur of S.B.S Nagar district. Under National Clean Air Programme, there are six online Ambient Air Quality Stations in districts: Amritsar, Jalandhar, Ludhiana, Khanna, Mandi Gobindgarh, and Patiala [31].

8.2.2. Water Quality Monitoring Programme

"National Water Quality Monitoring Network" was established by the "Central Pollution Control Board" in association with the "State Pollution Control Board" to examine the water quality and prevent contamination in water bodies. Under the National Water Quality Monitoring programme, there are 4111 stations established on surface and groundwater to monitor water quality monthly, quarterly, and yearly in 28 States and 8 Union Territories [32]. Punjab Pollution Control Board is monitoring the surface water quality of the Sutlej, Beas, Ghaggar and Ravi rivers. The water samples are collected from these rivers at 37 locations quarterly, and these samples are analyzed at Patiala, Ludhiana and Jalandhar in laboratories of the Punjab Pollution Control Board. This Board monitors the quality of the groundwater monitors at six locations in Ludhiana and sixteen in other industrial areas bi-annually under National Water Monitoring Programme [33].

8.2.3. Solid Waste Management

Solid Waste Management Rules 2016, 'Directorate Environment & Climate Change, Punjab' framed 'Action Plan for Waste Management 2019' to manage solid waste.

8.2.3.1. Municipal Solid Waste

"Punjab State Solid Waste Management Policy 2018" predicts that solid waste management will adopt scientific methods based on the principle of 6Rs (refuse, reduce, reuse, recycle, redesign and research). Door-to-door waste collection has been implemented in 162 Urban Local Bodies covering 2804 wards. Further, wet waste processing through honeycomb aerobic composting has started in 143 ULBs, including Municipal Corporations [34].

8.2.3.2. Plastic Waste Management

Punjab produces around 54,000 tons of plastic waste annually. Department of Local Government, Punjab notification dated 18/02/2016 has banned manufacturing, stock, distribution, recycling, selling, or using plastic carry bags in urban areas. Department of Local Government and Department of Rural Development and Panchayat has imposed a complete ban on plastic carry bags in their respective jurisdictions, w.e.f. April 1, 2016 [35].

8.2.3.3. Bio-Medical Waste Management

Biomedical waste generated during human or animal treatment or research can spread infectious diseases in humans or animals. According to the Action plan for monitoring waste management, many strategies are formulated by Punjab Pollution Control Board for properly managing biomedical waste. It is collected and disposed of by five licensed Biomedical Waste Treatment plants in "Ludhiana, SAS Nagar, Amritsar, Pathankot and Sri Muktsar Sahib districts of Punjab" [36].

8.3. Punjab State Council for Science and Technology

This institute was set up in 1983 to impart training to the public regarding pollution control policies and waste management strategies. The primary purposes of this institute are environmental protection, pollution control and providing technical advice to the industry for pollution control. It tries to resolve excessive use of fertilizers, a decline in groundwater levels, and ecosystem conservation.

8.4. Role of Punjab Agricultural University, Ludhiana in Management of Agriculture Waste

The government of Punjab is framing a policy to manage crop residue and prevent stubble burning. Punjab Agriculture University is working on developing technologies for recycling crop residue management. Some of the equipment developed by Punjab Agriculture University are:

1. In 2002, Punjab Agriculture University developed a "Happy Seeder Machine" for sowing wheat seeds in standing paddy stubble. The government of Punjab has adopted this technology. The agriculture department gives a 50% subsidy to individual farmers. (The Indian Express, 2019) [37]. According to Kamal N. [38], In 2017, the government of Punjab distributed direct seeders to many farmers to blend the rice straws into the soil.

2. Punjab Agriculture University also developed the "Tractor Operated Paddy Straw Chopper" to incorporate paddy residue into the soil. This machine harvests leftover stubble and spreads it into fields.

8.5. Punjab Energy Development Agency

The "Punjab Energy Development Agency" was set up to develop renewable energy programs in the state in 1991. This agency's main objectives are advancing power projects based on biomass, installing community biogas plants, implementing new technologies to save energy, developing and enforcing non-conservational energy technology projects, and enforcing energy conservation programs in the industrial, agricultural, and commercial sectors [39].

9. Recommendations

Some of the recommendations are given below:

1. There is a dire need for a comprehensive awareness program to educate farmers about the economic benefits of using alternative stubble management techniques.
2. Mass media can help the awareness among the public of the issue of environmental degradation.
3. There is a requirement for the effective enforcement of environmental laws.
4. There should be a provision of subsidies for farmers who use sustainable management practices.
5. Crop residue can be utilized as a fuel in power plants, and it can also be used as a raw material for paper manufacturing.
6. Crop residue can be utilized for the production of biogas.
7. Mixing crop residue into the soil increases the fertility of the land.
8. To reduce vehicular emissions, battery-operated vehicles should be promoted.
9. Public transportation should be encouraged.
10. There should be a proper arrangement for the proper disposal of solid waste.

10. Conclusions

The main aim of this research was to examine the issue of environmental pollution in Punjab. It highlighted various causes and impacts of environmental pollution in Punjab. It revealed that industrial and agricultural activities such as stubble burning and excessive use of fertilizers in Punjab are significant contributors to environmental pollution. It has indicated that air pollution caused around '41,090 premature deaths' and led to an economic loss of '1,148 million US dollars' in Punjab. Excessive use of fertilizers and pesticides has caused serious health concerns like asthma, heart diseases, hormonal imbalance, cancer and skin-related problems in this region. 80% of groundwater in the Malwa region is unsafe for drinking. Malwa region is identified as the "Cancer capital of Punjab" due to the alarming upsurge in cancer cases. It has highlighted various policy initiatives undertaken by the Punjab government to control environmental pollution through techniques such as "air quality monitoring", "water quality monitoring", and "solid waste management". It also highlighted the role of various agencies in managing the issue of environmental pollution. Despite environmental legislation, it has indicated a shocking upsurge in Punjab's pollution levels, leading to air, water, and soil quality degradation. A comprehensive awareness program is required to enlighten the public about environmental laws, and these laws should be implemented appropriately.

REFERENCES

[1] Health Effects Institute (HEI). 2019. State of Global Air Report 2019 India-Specific Findings Isaksson, C. 2010. Pollution and its impact on wild animals: a meta-analysis on oxidative stress, Eco Health, Vol.7, No.3, 342–50 https://doi.org/10.1016/ S2542-5196(20)30298-9

[2] 21 Indian Cities among World's 30 Most Polluted; Ghaziabad Tops the List: Report. (2020, February 25), The New Indian Express, online available from https://www.newindianexpress.com/nation/2020/feb/25/21-indian-cities-among-worlds-30-most-polluted-ghaziabad-tops-list-report-2108302.html#

[3] Poovanna, S. (2021, February 18). Over 120K died due to air pollution in India in 2020: Greenpeace. Hindustan Times. Online available from https://www.hindustantimes.com/india-news/over-120k-died-due-to-air-pollution-in-india-in-2020-greenpeace%20%20%20101613628725846.html

[4] Behal, A. (2020, July 16). The Green Revolution and a dark Punjab. Down-to-earth, online available from https://www.downtoearth.org.in/blog/agriculture/the-green-revolution-and-a-dark-punjab-72318

[5] Punjab Economic survey 2019-2020, Economic and Statistical Organisation, Department of Planning, Government of Punjab, online available from www.esopb.gov.in

[6] Khan, M. A. & Ghouri, A. M., Environmental Pollution: Its Effects on Life and Its Remedies, Researcher World: Journal of Arts, Science & Commerce, Vol.2, No. 2, 276-285, 2011. Online available from SSRN: https://ssrn.com/abstract=1981242

[7] Mittal, S., Kaur, G., & Vishwakarma, S. G., Effects of Environmental Pesticides on the Health of Rural Communities in the Malwa Region of Punjab, India: A Review, Human and Ecological Risk Assessment: An International Journal, Vol. 20, No.2, 366-387, 2014. DOI: 10.1080/10807039.2013.788972

[8] Gulia, S., et al., Assessment of Urban Air Quality around a Heritage Site Using AERMOD: A Case Study of Amritsar City, India, Environmental Modeling & Assessment, Vol.20, No. 6, 599-608, 2015.

[9] Pratiksha & Sharma, P., Status of Environmental Pollution in Rural Punjab and its Management, International Archive of Applied Sciences and Technology, Vol.11, No. 4, 98-104, 2020.

[10] Ukaogo, P. O., Ewuzie, U., & Onwuka, C. V. (2020). Environmental pollution: Causes, effects, and the remedies. In P. Chowdhary., D. Verma., A. Raj & Y. Akhter (Eds.), Microorganisms for sustainable environment and health, (Vol. 21, pp. 419-429). Elsevier, 2020. https://doi.org/10.1016/ C2018-0-05025-2

[11] Pandey, A., Brauer, M., Cropper, M. L., Balakrishnan, K., Mathur, P., Dey, S., ... & Dandona, L., Health and economic impact of air pollution in India: The Global Burden of Disease Study 2019, The Lancet Planetary Health, Vol.5, No.1, e25-e38, 2021.

[12] Thongzunhor, H., & Pochai, N. (2022). Numerical Simulations of a Two-dimensional Vertically Averaged Air Pollution Measurement in a Street Canyon. Environment and Ecology Research, Vol. 10, No. 1, 107 – 115. DOI: 10.13189/eer.2022.100110.

[13] Obiefuna, J. N., Inah, E. O., Atsa, J. W. U., & Emmanuel Asuquo Etim (2021). Geospatial Assessment of Ambient Air Quality Footprints in Relation to Urban Land uses in Nigeria. Environment and Ecology Research, Vol. 9, No. 6, 426 – 446. DOI: 10.13189/eer.2021.090609.

[14] Kaskaoutis, D. G., Kumar, S., Sharma, D., Singh, R. P., Kharol, S. K., Sharma, M., ... & Singh, D., Effects of crop residue burning on aerosol properties, plume characteristics, and long‐range transport over northern India, Journal of Geophysical Research: Atmospheres, Vol.119, No.9, 5424-5444, 2014. https://doi.org/10.1002/2013JD021357

[15] Sood, A. (2018, April 24). Punjab is among the top 4 states failing air quality standards. The Tribune, online available from https://www.tribuneindia.com/news/archive/punjab/punjab-among-top-4-states-failing-air-quality-standards-579301

[16] Kukreti, I. (2018, June 27). 80% of groundwater in Punjab's Malwa is unfit for drinking, Down To Earth, Online available from https://www.downtoearth.org.in/news/agriculture/80-groundwater-in-punjab-s-malwa-unfit-for-drinking-60951

[17] Ravindra, K., Singh, T., Mor, S., Emissions of air pollutants from primary crop residue burning in India and their mitigation strategies for cleaner emissions, J. Clean. Prod., Vol.208, 261–273, 2018. https://doi.org/10.1016/j.jclepro.2018.10.031.

[18] Burning of Agriculture residue & another Biomass, online available fromhttp://www.punenvis.nic.in/index2.aspx?slid=5971&mid=1&langid=1&sublinkid=1140

[19] Abdurrahman, M. I., Chaki, S., & Saini, G., Stubble burning: Effects on health & environment, regulations and management practices, Environmental Advances, Vol.2, 100011, 2020.

[20] Singh, R., Chanduka, L., & Dhir, A., Impacts of Stubble Burning on Ambient Air Quality of a Critically Polluted Area–Mandi-Gobindgarh, J. Pollut. Effects. Contr, Vol.3, No.2, 2015. https://doi.org/10.4172/2375-4397.1000135

[21] Stubble burning| Maximum cases in Punjab; anger over farm laws among primary reasons (2020, NOVEMBER 15). THE HINDU. online available from https://www.thehindu.com/news/national/other-states/stubble-burning-maximum-cases-in-punjab-anger-over-farm-laws-among-major-reasons/article33101909.ece

[22] Events of stubble burning during the Rabi session online available from https://gisprsc.punjab.gov.in/residue/Index.aspx

[23] Industrial Emission online available from http://www.punenvis.nic.in/index2.aspx?slid=5971&mid=1&langid=1&sublinkid=1140

[24] Agricultural Statistics at a Glance 2019. Government of India Ministry of Agriculture and Farmers Welfare Department of Agriculture Cooperation and Farmers Welfare Directorate of Economics and Statistics. online available from https://eands.dacnet.nic.in/PDF/At%20a%20Glance%202019%20Eng.pdf

[25] Sreedhar, N. (2021) One-third of deaths in India every year are due to air pollution, Mint. online available from https://lifestyle.livemint.com/smart-living/environment/onethird-of-indians-die-due-to-air-pollution-every-year-111612855290031.html

[26] Vermylen, J., Nemmar, A., Nemery, B., & Hoylaerts, M. F., Ambient Air Pollution and Acute Myocardial Infarction, Journal of Thrombosis and Haemostasis, Vol.3, No.9, 1955-1961, 2005. https://doi.org/10.1111/j.1538-7836.2005.01471.x

[27] Ewan, K. B., & Pamphlett, R., Increased Inorganic Mercury in Spinal Motor Neurons Following Chelating Agents, Neurotoxicology, Vol.17, No.2, 343-349, 1996.

[28] Jassowal, G. (2021, March 1), Rising air pollution led to 41,090 deaths in Punjab in 2019: Report, Hindustan Times, online available from https://www.hindustantimes.com/cities/others/rising-air-pollution-led-to-41-090-deaths-in-punjab-in-2019-report-101614594082244.html

[29] Singh, S., & Singh, H., Impact and extent of groundwater pollution: a case study of rural area in Punjab State (India), International Journal of Environment and Health, Vol.5, No.4, 277-292, 2011.

[30] Sharma, A. (2019). Cancer ravages rural Punjab due to chemicals in pesticides; govt assistance fails to improve the situation. First post, online available from https://www.firstpost.com/india/cancer-ravages-rural-punjab-due-to-chemicals-in-pesticides-govt-assistance-fails-to-improve-situation-6228451.html

[31] Ambient Air Quality Monitoring online available from http://www.punenvis.nic.in/index2.aspx?slid=56&mid=1&langid=1&sublinkid=930

[32] National water monitoring programme _monitoring _network_2020. online available from https://cpcb.nic.in/wqm/nwmp_monitoring_network_2020.pdf

[33] Water Quality Monitoring Stations. Environment Information System: centre Punjab, online available from http://punenvis.nic.in/index2.aspx?slid=7145&mid=1&lan

gid=1&sublinkid=1223

[34] Action plan for monitoring waste management in the state. Directorate of Environment & Climate Change, Punjab, online available from http://punenvis.nic.in/index2.aspx?slid=11714&mid=1&langid=1&sublinkid=2300

[35] Plastic waste, online available from http://www.punenvis.nic.in/index3.aspx?sslid=11715&subsublinkid=7244&langid=1&mid=1

[36] Bio-Medical Waste, online available from punenvis.nic.in/index2.aspx?slid=11714&mid=1&langid=1&sublinkid=2300

[37] Goyal, D. (2019, September 22). Explained: Using Happy Seeder and how it affects wheat yield. The Indian Express, online available from https://indianexpress.com/article/explained/explained-using-happy-seeder-and-how-it-affects-wheat-yield-6017640/

[38] Kamal, N. (2017). Provide Equipment to Tackle Stubble Residue. The Times of India, online available from https://timesofindia.indiatimes.com/city/chandigarh/provide-equipment-to-tackle-stubble-residue/articleshow/60835362.cms

[39] Punjab Energy Development Agency online available from https://www.peda.gov.in/