Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 14 [6] May 2025: 01-03

Online ISSN 2277-1808
Journal's URL: http://www.bepls.com
CODEN: BEPLAD

REVIEW ARTICLE **OPEN ACCESS**

Agriculture and Environmental Degradation Challenges

Shahram Kashkooli[1]*, Rasool Karimi[1], Mohsen Hamidi[2]
MSc in Environmental Education, Payame Noor University, Golestan Branch, Shiraz, Iran
Department of Agronomy, Varamin-Pishva Branch, Islamic Azad University, Varamin, Iran.***Corresponding Author Email:** shahram110120@gmail.com

ABSTRACT
Meeting society's food needs has always been one of humanity's fundamental challenges. Agricultural production activities play a key role in addressing this vital need. With the development of new technologies, agricultural producers have adopted modern methods and chemical inputs to increase production efficiency. However, these transformations have brought new environmental challenges that require special attention. In many regions of the world, including our country, the negative consequences of these activities on natural ecosystems have not received sufficient attention. Operations such as soil tillage, excessive use of chemical fertilizers and pesticides, and improper management of crop residues can lead to problems including water pollution, soil fertility reduction, and disruption of ecosystem balance. These issues not only affect environmental quality but may also threaten food security in the long term. This study scientifically examines the various environmental impacts of agricultural production activities. Research findings indicate that each stage of the production process, from land preparation to harvest, can have specific effects on ecosystems. In the final section, practical solutions are presented to mitigate these negative impacts and transition toward more sustainable methods. These recommendations can be valuable for policymakers, managers, and practitioners in this field.
Keywords: *Food security, Environmental challenges, Chemical fertilizers and pesticides, Agricultural sustainability, Crop residue management*

Received 22.03.2025 Revised 21.04.2025 Accepted 10.05.2025

INTRODUCTION

Agriculture plays a fundamental role in securing food resources, and its significance for human survival is evident. To meet rising demands, farmers increasingly adopt modern technologies, chemical fertilizers, and pesticides to boost yields and improve quality [1]. However, rapid population growth and industrialization have exacerbated environmental degradation, with agricultural activities contributing substantially to irreversible ecological harm [2]. Unlike industrial sectors, the environmental consequences of agriculture—such as soil tillage, pesticide use, crop harvesting, and residue burning—remain understudied, particularly in our national context. These practices generate severe air pollution, contaminate soil and water systems (both surface and groundwater), and alter soil properties [3, 4]. This paper explores the destructive environmental impacts of conventional agriculture and underscores the need for sustainable alternatives. The widespread practice of burning agricultural residues, particularly wheat straw, remains a significant concern in modern agriculture. In Iran's Fars Province, approximately 60-70% of wheat fields undergo post-harvest burning, primarily when immediate replanting is required [5].This practice leads to immediate atmospheric pollution, with studies showing PM2.5 concentrations exceeding 500 μg/m^3 during burning events - 20 times the WHO safety threshold [6]. From an agronomic perspective, residue burning triggers complex soil degradation processes. Short-term benefits of nutrient release are overshadowed by long-term damage, as demonstrated by a 30-year study in Russia's wheat belt showing a 0.5% annual decline in soil organic carbon [7]. The practice particularly devastates soil microbiota, reducing bacterial populations by 40-60% in the top 2.5 cm layer [9]. Furthermore, approximately 25-30% of nitrogen content is immediately lost through volatilization, while the remaining becomes more susceptible to leaching [8]. The hydrological impacts are equally concerning. Continuous burning reduces soil water holding capacity by 15-20% over three decades [10], exacerbating drought vulnerability in already arid regions. Perhaps most alarmingly, the practice disrupts essential ecosystem services - wild pollinator populations decline by 30-40% in areas with regular residue burning [11], while beneficial predator insects show even greater sensitivity [12]. Emerging research from Iran's agricultural universities suggests potential alternatives. Precision incorporation of residues combined with microbial inoculants has shown promise, increasing soil organic matter by 1.2% over five years while maintaining planting schedules [13]. These sustainable approaches may offer solutions to this persistent environmental challenge, though their widespread adoption requires significant policy support and farmer education.

CHEMICAL PESTICIDES: ENVIRONMENTAL AND HEALTH IMPACTS

Pesticides, including insecticides and herbicides, are widely used in agriculture to protect crops and increase yields, but their application has raised significant environmental and public health concerns. These chemical compounds, particularly organochlorines like DDT and organophosphates such as parathion, persist in ecosystems and bioaccumulate through food chains [14]. Organophosphates, originally developed as nerve agents, function by inhibiting acetylcholinesterase, causing neurological damage in both target pests and non-target species including humans [15]. Studies demonstrate their acute toxicity, with parathion showing an LD50 of just 2 mg/kg in ducks compared to 1,500 mg/kg for malathion [16]. The environmental persistence of these compounds is alarming - DDT residues accumulate in fatty tissues at concentrations up to 100 times higher than environmental levels, with just 3 ppm capable of causing liver necrosis in mammals [17]. Global monitoring studies reveal widespread contamination, with diazinon detected in 25% of Greek aquatic systems [18] and measurable residues found in food crops, though typically below 0.1 mg/kg in tomatoes [19]. The historical phase-out of organochlorines in developed nations since the 1970s stands in contrast to their continued use in developing countries, where they still comprise over 50% of pesticide applications in some regions [20]. These findings underscore the urgent need for adopting integrated pest management strategies and developing safer alternatives to mitigate the ecological and health risks associated with conventional pesticide use [25].

TILLAGE AND HARVESTING IMPACTS

Agricultural tillage and harvesting operations constitute significant sources of atmospheric pollution, particularly through particulate matter emissions. During tillage, mechanical soil disturbance generates substantial dust clouds (primarily PM10 and PM2.5) that can travel kilometers downwind, with this phenomenon being particularly evident in Fars Province's agricultural plains during planting seasons [21]. The harvesting process similarly contributes through three key mechanisms: 1) mechanical operations (cutting/threshing), 2) product loading, and 3) in-field transport, releasing complex particulate mixtures of soil, plant matter, and organic debris, with cereal crops producing 0.5-3.2 kg of particulates per ton harvested [22, 23]. Additional agricultural pollution sources requiring attention include land conversion, farm road dust, and machinery emissions, which collectively account for 15-30% of agricultural emissions in developing nations [24]. While these secondary sources demand separate analysis, modern mitigation strategies like conservation tillage demonstrate 40-60% emission reduction potential [26], highlighting the urgent need for sustainable practice adoption to address agriculture's substantial air quality impacts.

CONCLUSION

The burning of agricultural residues may enhance crop yield under certain cultivation conditions; however, frequent burning significantly degrades soil quality. Changes in soil quality occur very slowly across different parts of farmland and may only become evident after many years. Based on conducted experiments, there is a direct correlation between the amount of crop residues incorporated into the soil and changes in soil organic matter content. Moreover, any reduction in wheat plant residues leads to a decrease in soil organic matter. Thus, it has been established that burning crop residues is equivalent to a reduction in soil organic matter. The smoke generated from burning agricultural residues carries various chemical substances, including carbon dioxide (CO_2), water vapor (H_2O), carbon monoxide (CO), fine particulate matter (PM), hydrocarbons (HC), nitrogen oxides (NO_x), and hundreds of other compounds. These pollutants contribute to respiratory difficulties and other health issues, reduced visibility, traffic hazards on roads, and disturbances to neighboring communities. Pollutants such as PM_{10} (particulate matter with a diameter less than 10 microns), $PM_{2.5}$ (fine particles with a diameter less than 2.5 microns), NO_x (nitrogen oxides), SO_2 (sulfur dioxide), VOCs (volatile organic compounds), and CO (carbon monoxide) are released into the air from the burning of wheat, corn, and rice residues in fields, leading to air and soil pollution. This practice, while offering short-term benefits, poses long-term environmental and health risks, emphasizing the need for sustainable residue management alternatives.

REFERENCES

1. Ahamad, A., Ahamad, J., & Javed Naim, M. (2023). Current Perspective on Pesticides: Their Classification, Behaviour, Potential Use and Toxic Effects. Journal of Angiotherapy, 7(1).

2. Andersen, M. S., & Bonnis, G. (2021). Climate mitigation cobenefits from sustainable nutrient management in agriculture: Incentives and opportunities. OECD Environment Working Papers, (186), 0_1-45.
3. Apu, I. K. (2023). Exploring the Ecological and Public Health Implications of Brick Manufacturing in a Suburban Municipality of Bangladesh: A Comprehensive Case Study.
4. Carneiro, D. D., Mariotto, S., Sousa, D. A., & Bragotto, A. P. (2025). Presence of Pesticide Residues in Water Resources and Fish in Brazil: Narrative Bibliographic Review. ACS Food Science & Technology.
5. Dijoo, Z. K., & Khurshid, R. (2022). Environmental degradation as a multifaceted consequence of human development. In Environmental Biotechnology (pp. 39-56). Apple Academic Press.
6. Ekka, P., Patra, S., Upreti, M., Kumar, G., Kumar, A., & Saikia, P. (2023). Land Degradation and its impacts on Biodiversity and Ecosystem services. Land and Environmental Management through Forestry, 77-101.
7. Falkenberg, T., Ekesi, S., & Borgemeister, C. (2022). Integrated pest management (IPM) and one health—a call for action to integrate. Current Opinion in Insect Science, 53, 100960.
8. Guo, W., Su, J., & Han, W. (2024). The research progress on soil nitrogen addition: Methods, ecological impacts, and prospects. Advances in Resources Research, 4(4), 741-753.
9. Ike, V. (2021). The health effects of transboundary pollution and environmental cooperation (Doctoral dissertation, Northern Arizona University).
10. Kasongo, J., Alleman, L. Y., Kanda, J. M., Kaniki, A., & Riffault, V. (2024). Metal-bearing airborne particles from mining activities: A review on their characteristics, impacts and research perspectives. Science of the Total Environment, 175426.
11. Kimberly, J. (2024). Soil Degradation and Nutrient Loss: Burning of agricultural residues can lead to the loss of important soil nutrients and organic matter.
12. Kumar, A., Rajwar, N., & Tonk, T. (2024). Climate Change Effects on Plant-Pollinator Interactions, Reproductive Biology and Ecosystem Services. In Forests and Climate Change: Biological Perspectives on Impact, Adaptation, and Mitigation Strategies (pp. 97-117). Singapore: Springer Nature Singapore.
13. Lykogianni, M., Bempelou, E., Karamaouna, F., & Aliferis, K. A. (2021). Do pesticides promote or hinder sustainability in agriculture? The challenge of sustainable use of pesticides in modern agriculture. Science of the Total Environment, 795, 148625.
14. Majidian, P., Ghorbani, H. R., & Farajpour, M. (2024). Achieving agricultural sustainability through soybean production in Iran: Potential and challenges. Heliyon, 10(4).
15. Ouakhssase, A. (2022). Analytical methodologies and techniques for pesticide residue analysis in water and wastewater. In Pesticides Remediation Technologies from Water and Wastewater (pp. 55-73). Elsevier.
16. Rashid, A., Schutte, B. J., Ulery, A., Deyholos, M. K., Sanogo, S., Lehnhoff, E. A., & Beck, L. (2023). Heavy metal contamination in agricultural soil: environmental pollutants affecting crop health. Agronomy, 13(6), 1521.
17. Renu, M. N. (2022). Futuristic Scenario of Climate Resilient Agricultural and Approaches in Changing Climate and Global Warming. AGRICULTURE & FOOD E-NEWSLETTER.
18. Rezaei, E., Larijani, H., Kasraie, P., Moghadam, H. T., & Ghooshchi, F. (2022). The role of silica fertilizer on morphological traits of sorghum forage under drought stress. Pak. J. Agri. Sci, 59(1), 83-92.
19. Shukla, S., Shukla, K., Mishra, A., Jindal, T., Sharma, S., Upadhyay, D., & Singh, V. (2021). Ecological perspectives on soil microbial community involved in nitrogen cycling. In Soil Nitrogen Ecology (pp. 51-91). Cham: Springer International Publishing.
20. Singh, A., Kate, P., & Kumari, K. (2021). Environmental fate, toxicity, and risk assessment of persistent organic pollutants (POPs). In Persistent Organic Pollutants (pp. 59-90). CRC Press.
21. Sun, X., Armstrong, M., Moradi, A., Bhattacharya, R., Antão-Geraldes, A. M., Munthali, E., ... & Borre, L. (2025). Impacts of climate-induced drought on lake and reservoir biodiversity and ecosystem services: A review. Ambio, 1-17.
22. Taghizadeh-Alisaraei, A., Tatari, A., Khanali, M., & Keshavarzi, M. (2023). Potential of biofuels production from wheat straw biomass, current achievements and perspectives: a review. Biofuels, 14(1), 79-92.
23. Tudi, M., Daniel Ruan, H., Wang, L., Lyu, J., Sadler, R., Connell, D., ... & Phung, D. T. (2021). Agriculture development, pesticide application and its impact on the environment. International journal of environmental research and public health, 18(3), 1112.
24. Tulachom, P., Wongsrikaeo, J., Santiboon, T. T., & Alexander, G. S. (2024). Interactions with populaces 'perceptions of the policy for solving problems of the pm2. 5 dust toxic pollution on health and the impact contamination to affected respiratory system diseases. European journal of public health studies, 7(3).
25. Yadav, V. K., Kumar, A., Pandey, A., Akther, T., & Bhat, J. A. (2024). Introduction to Pesticide Toxicology and Risk Assessment. In Pesticide Toxicology and Risk Assessment (pp. 167-194). CRC Press.
26. Zimmermann, S., & Sures, B. (2023). Environmental toxicology. In Drug Discovery and Evaluation: Safety and Pharmacokinetic Assays (pp. 1-28). Cham: Springer International Publishing.

CITATION OF THIS ARTICLE

Shahram K, Rasool K, Mohsen H. Agriculture and Environmental Degradation Challenges. Bull. Env. Pharmacol. Life Sci., Vol 14 [6] May 2025: 01-03