

Water and Soil Pollution from Agriculture: Mechanisms, Assessments and Mitigation Strategies

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1. Introduction to the Special Issue

Overuse of chemical fertilizers and pesticides, along with poor land management strategies, has turned farming practices into a significant source of soil and water contamination [1,2]. This Special Issue delves into “Water and Soil Pollution from Agriculture: Mechanisms, Assessments and Mitigation Strategies”. It investigates how agricultural contaminants, including nitrates, phosphates, metal pollutants, and agrochemicals, migrate and transform within agricultural environments, highlighting the importance of using sophisticated assessment techniques such as remote sensing, modeling, and biological monitoring to determine the extent of contamination and related environmental hazards. Furthermore, the articles suggest a variety of creative approaches to address these challenges, such as advanced farming techniques, ecological rehabilitation, protective areas, and regulatory measures, aimed at fostering sustainable agricultural practices [3,4].

Following the call for papers, five pioneering research studies were approved for publication through a rigorous peer-review process (contributions 1–5). These articles explore various subjects, such as novel nanobubble irrigation techniques to avert diffuse pollution, transforming farm waste to boost water and nutrient efficiency, and using SWAT models to simulate the temporal-spatial patterns of non-point source pollution. The evolution of agricultural non-point source pollution was examined using the pollutant discharge coefficient and equivalent pollution load method. This approach assessed farmers’ soil fertilization techniques and the associated risks of nitrogen-related water contamination. To gain insight into this Special Issue, we outline the key points of the published articles.

2. Overview of the Contributions to This Special Issue

Addressing the sustainability of nanobubble irrigation throughout its life cycle in circular agriculture, Arablousabet et al. (contribution 1) integrated controlled laboratory experiments, life-cycle evaluation (LCA), and multi-criteria decision-making guided by expert insights to evaluate the sustainability of nanobubble-enriched water (NBSW) for irrigation in agriculture. The findings indicated that energy usage during the creation of nanobubbles is the main factor affecting the environment, while the influence of nutrient leaching was minimal. Air and oxygen nanobubble therapies demonstrated comparable life-cycle characteristics. Traditional irrigation methods reduced electricity usage but increased nitrate leaching in sandy soil, heightening the threat of eutrophication. Their specialist assessment indicates that for NBSW to be embraced in the future, it is crucial to lower the energy consumption and enhance operational dependability. This research presents comprehensive life-cycle data supporting nanobubble technology as a sustainable innovation in cyclic farming practices.



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Qi et al. (contribution 2) investigated the combined use of chicken manure and urea in conjunction with precise irrigation techniques, examining the impact on the soil nutrient content, lettuce development, and quality across various irrigation levels. The ideal parameters were determined to be 75–78% field moisture capacity and a manure-to-urea nitrogen ratio ranging from 7:3 to 1:1. Under these conditions, crucial metrics—such as soil organic matter, ammonium nitrogen, nitrate nitrogen, fresh lettuce yield, soluble sugar, soluble protein, chlorophyll, and other pivotal indicators—exceeded 90% of their potential maximums, with nitrate levels staying within safe thresholds. The results endorse the use of manure resources and optimized water-nutrient strategies for the sustainable cultivation of leafy greens.

Chen and colleagues (contribution 3) utilized the SWAT model to assess composite non-point source pollution, simulating the spatial and temporal distribution of integrated agricultural and urban diffuse pollution in the Yapu Port Basin, China. The calibration and validation of the model yielded $R \geq 0.85$ and $NSE \geq 0.84$ for streamflow, alongside similar results for total nitrogen (TN) and total phosphorus (TP). Pollution levels were directly linked to rainfall, reaching their highest during periods of heavy flooding. The concentration of pollution rose progressively from the headwaters to the downstream regions, where sub-basins in the lower reaches accounted for 36% of TN and TP loads, marking them as key source zones. Through a comprehensive management initiative, the levels of TN and TP decreased by 57.9% and 50.4%, respectively, by minimizing fertilizer application, optimizing urban rainwater usage, establishing vegetative barriers, and incorporating grassed swales.

Tan and colleagues (contribution 4) investigated the development of agricultural diffuse pollution within the Yellow River Basin, utilizing the emission coefficient strategy and the equivalent pollution load technique to determine the progression trends of agricultural diffuse pollution across eight provinces within the Yellow River Basin spanning the years 2014 to 2023. The overall pollution rose from 4.94 to 7.45 million tons; however, the growth rate considerably declined over the last five years, and the contamination intensity per unit area dropped by 15–40%. Chemical oxygen demand emerged as the primary contaminant, accounting for more than 90%. Meanwhile, livestock and poultry farming surpassed crop cultivation as the leading source of pollution. The contamination focal point moved from lower to middle and upper streams, with regional differences becoming less pronounced. The authors suggest tailored strategies for different regions and sources to separate agricultural pollution from economic advancement.

Concerning agricultural nutrient usage and views on nitrogen-related water contamination within the Ouémé watershed in Benin, Gbedourorou et al. (contribution 5), using data from a survey conducted with 176 households and employing a blend of logistic regression and decision tree analysis, assessed the fertilization habits of lowland rice growers and their perceptions of the associated risks. The typical usage of nitrogen fertilizer, at 79.4 kg per hectare, surpassed the recommended level of 60 kg per hectare. Notably, 75% of farmers applied excessive urea. Sustainable practices were implemented by just 16% of agricultural producers. Respondents who received training on water pollution and were knowledgeable about fertilizer policies demonstrated a 36-times higher likelihood of implementing sustainable farming practices compared to those who lacked such training and policy familiarity. While 60.8% noticed eutrophication, only 34.1% attributed inappropriate fertilization to water contamination. The results underscore significant discrepancies between knowledge and behavior, emphasizing the necessity for specific extension initiatives.

3. Conclusions

The articles featured in this Special Issue will appeal to scholars, decision-makers, and professionals focused on water and soil contamination in agriculture. The compilation encompasses a wide variety of geographical settings, from intensive agriculture in China to small-scale lowland rice cultivation in Benin. It utilizes an array of approaches, such as life-cycle analysis, field trials, watershed simulations, regional statistical evaluations, and social research surveys. The central discoveries highlight the significance of efficient nanobubble technology, optimized manure–urea blends with precision irrigation, integrated management of composite non-point source pollution, region-specific management strategies for major river basins, and educational programs aimed at farmers to address knowledge–behavior discrepancies. We anticipate that the ideas and answers offered in this Special Issue will encourage additional studies and initiatives aimed at promoting sustainable farming and safeguarding water quality.

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