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A Review on Impacts of Agricultural Runoff on Freshwater Resources

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ABSTRACT: Changing environmental and climatic conditions, along with land use and land cover patterns, have been immensely affecting freshwater bodies. Significant sources of water pollution are point and non-point sources. While point sources are manageable, non-point sources prove to be challenging to control or even monitor. In the present scenario where scarcity of water resources is haunting nations, the availability of potable water has become nearly impossible due to pollution. On the other hand, intensive agricultural patterns towards providing food to the ever-increasing population have been inevitably using more quantities of fertilizers and pesticides in the process of cropping. One of the chief non-point sources leading to eutrophication of freshwater bodies is runoff from such agricultural activities. This review is an attempt to focus on this diffuse pollution source precisely from agricultural activities and its impact on water bodies, environment, and human beings. The effect of cropping practices on the nearby rivers and lakes is deliberated about understanding complex, interacting factors linked to land use and water quality. The significant challenges of the present study are to consolidate methods available to identify, monitor, and quantify these sources in order to overcome Agricultural pollution and to enhance the quality of water resources are discussed.

Keywords: Freshwater, diffuse pollution, agricultural activities, nitrogen, and phosphorus.

I. INTRODUCTION

Among the most significant drivers of changes in the environment around the world is agriculture, yet it is also the most vulnerable to changes in climate [1]. Despite adverse environmental effects, practices of agricultural production are primary channels towards achieving food security, providing food and fiber to about 7.7 billion population [2]. Nearly 37% of the land area around the world is used for agricultural purposes. Countries with less arable land are forced to intensify agricultural practices (use of fertilizers and pesticides) [3]. Augmented agrarian systems tend to use more significant quantities of fertilizers and pesticides, which, unfortunately, are not entirely utilized. The residues of these fertilizers and pesticides possess the potential to be transported as NPS (Non-Point Source) in either particulate or dissolved form during the events of storm and runoff. This type of pollution has received much attention during recent years owing to the expansion of hypoxic zones. For example, the hypoxic zone of 2019 was recorded as the eighth largest at 18,005 Km^2. Further, the largest hypoxic zone was reported by Van Meter *et al.* 2018 in the Gulf of Mexico during August 2017 with an extent of 22, 720 km^2. The resulting water pollution persists to be a chief global problem leading to problems related to human health, fresh and marine waters eutrophication thus enhancing treatment cost for water supply [4].

Nearly 70% of water resources worldwide are used for agriculture practices which is occupying an essential part of the pollution of water. Pollution from agricultural sources is usually understood to be diffused in nature or as non-point source (NPS) contaminating freshwater bodies all over the world. Prime pollutants from these sources comprise excessive nutrients due to the use of fertilizers and manures from commercial sources. Extreme nutrient inputs containing nitrogen and phosphorus lead to eutrophication of surface waters, increase toxicity, and also exert adverse influences on flora and fauna communities.

The most common chemical contaminants from agriculture NPS pollution is Nitrogen and phosphorus, which has been reported to be found in most of the world's aquifers [5]. Statistics around the globe suggest that 38% of water bodies in the European Union be under pressure from agricultural NPS, while in USA agricultural NPS stands as a significant source polluting rivers and streams, second in pollution wetlands and third in polluting lakes [6]. On the other hand, in China agricultural NPS pollution accounts for the lion's share in polluting surface water and groundwater precisely by nitrogen [7] and in developing countries agricultural NPS pollution is being aggravated by enhanced sediment runoff becoming a significant concern [8].

Substances like nitrate, phosphate, potassium, dieldrin, Aldrin, endrin, chlordane, arsenic, cadmium, chromium, and similar toxins derived from various agrochemicals eventually find their way to water bodies [9-10]. Several studies have stated that the loss of N and P (nitrogen and phosphorus) from croplands to nearby rivers and streams has dynamically enhanced in comparison to other sources like residential and industrial during the recent years in many regions of the world [11-12].

Since then, several researchers have been trying to analyze these substances in the receiving waters to appraise their concentrations, related effects of taking appropriate management steps. For example, algal blooms in Lake Taihu of China have been reported quite

earlier as 1987, but the condition of the lake has not improved but has been seen worsening since then [13]. This condition has led to the shutting down of drinking water from the lake, upsetting people who are dependent on it [14]. Concentrations of nitrate and phosphate higher than permissible limits given by WHO. Divya and Belagali, 2012 [15] reported standards in groundwaters near agricultural lands in Mysore.
Khanna and Gupta, 2018 reviewed the cycle of water pollution from agricultural NPS and the same water used for irrigation and its ill effects on the ecosystem [16]. Mohapatra *et al*., (1995) reported residues of persistent organochlorines in waters of many Indian rivers [17]. Further, they also stated that the concentrations of DDT, aldrin, and heptachlor were found to be present in excess over their guideline limits. In these lines, the current review alleviates the contemporary scenario of global agricultural pollution, major elements from agrarian practices contributing to water pollution, effects or implications of this pollution, and available alternatives or control methods, thus it helps in sustainable agricultural practices.

II. AGRICULTURAL NPS – CONTRIBUTING SUBSTANCES

Identifying and understanding the impact of cropping practices on the environment has become mandatory, owing to the adverse effects of nutrient run-offs [18]. One of the common causes of water pollution from agricultural NPS is due to oversupply of inorganic fertilizers precisely in countries where fertilizers are available with high subsidy [19]. The two substances that are significant contributors include nitrogen and phosphorus. Pollution due to nitrogen and phosphorus is through the application of excessive synthetic fertilizers leading to enhanced and unwanted loading of water bodies.

III. POLLUTION FROM NITROGEN

The development of an automated method for fixing nitrogen from its elements are boosted, as the nitrogen to plant availability is low due to continuous agricultural practices. It was thus led to a worldwide intensification of agriculture. Although regarded as a development decisive towards feeding the growing population, nitrogen used in excess contributed to a wide range of adverse impacts on environment comprising of nitrate leaching to water bodies, acidification of soils, eutrophication, emissions to air and also greenhouse gases, making agricultural sector to be the primary source of water pollution by nitrate [20]. It is reported that nearly 50% of nitrogen from fertilizers and manures which are spread on to agricultural lands is lost to the surrounding environment [21]. Furthermore, anthropogenic nitrogen input to the biosphere can substantially alter the earth's system leading to exceeding more than planetary boundaries [22]. It has been seen that water contaminated by nitrate can cause long-term environmental damage threatening both ecosystem and economic health [23].
Nitrogen, upon entering into the soil in reactive form as fertilizer or through microbial fixation, it serves as the substrate for numerous microbial processes becoming available for uptake by the plant. Successful uptake of nitrogen by plants is governed by factors like moisture, temperature, aeration, and availability of other substrates like carbon. As a result, these environmental conditions play a significant role in determining the fate of nitrogen other than the targeted plant growth [24].
Denitrification and denitrification are understood to be dominant processes in the conversion of nitrogen species in soils to harmful substances [25]. When applied in excess quantities, unused nitrogen results in enhanced volatilization of ammonia and nitrous oxide emissions into air and run-off to surface and groundwater as nitrate and ammonium. Precisely nitrous oxide from agriculture accounts for around 56 – 81% of gross anthropogenic emissions, which is projected to double by 2050.
Several studies have been addressing this problem towards altering the respective authorities for coming up with appropriate measures for control. For example, Rabalais *et al.,* (2002) [26] and Turner *et al*., (2006) [27] reported nitrogen load from the Mississippi River, which has significantly enhanced over the past 100 years, is one of the significant causes for summer hypoxia in the Gulf of Mexico. The dominant form of nitrogen, Nitrate, has been increasing in surface water since (1970)[28].

IV. POLLUTION FROM PHOSPHORUS

Phosphorus is added to croplands through inorganic fertilizers, imported manures, concentrates, and slurries, etc. Maintaining optimum phosphorus or balancing phosphorus in farming is essential in identifying potential prospects for arable spread lands [29]. Runoff from catchment zones ruled by agricultural land is understood to be an essential source for phosphorus into surface water bodies leading to eutrophication. Phosphorus being a limiting nutrient reducing its transport from agriculture is mandatory towards avoiding ill effects. Kleinman *et al*., (2015) [30], terms legacy soil phosphorus, which is defined as a residual store of accumulated phosphorus in the soil beyond the agronomic requirements [31-32]. Some soils possess the high adsorptive capacity to retain phosphorus, which in small amounts is released slowly to natural runoff [33], resulting in overwhelming impacts on receiving waters. Managing such phosphorus, hence persists to be a challenge both to catchment mitigation measures and water quality, which are expensive to implement and, therefore, possess economic burden [34].
Transfer of phosphorus to surface water can be briefed as a dynamic interlacing stage from the source through mobilization and discharge to receiving waters, polluting those [35]. The step of mobilization comprises of departing of phosphorus molecules from the source through processes like biological solubilization, geochemical desorption. The rate and magnitude of these processes tend to increase with some soil conditions like high organic matter, moisture, and management regimes [36]. The mobilized phosphorus is carried both through surface and subsurface pathways and discharged to surface waters where it becomes a pollutant [37].
Several researchers around the world focussed on studying phosphorus loads in receiving waters, the latest studies to be quoted are by Gurung *et al*., 2013 [38] have studies nitrogen and phosphorus loading in two watersheds of Mulberry and Catoma using pollutant loading model and presented that the values of total

nitrogen and total phosphorus were in the range of hypertrophic for lakes and eutrophic for rivers. Further, Darch *et al*., (2014) [39], from their study concluded higher mobility of bioavailable organic phosphorus over its recalcitrant forms, and organic phosphorus represents a significant risk for eutrophication. Bacelo *et al*., (2020) [40] reviewed methods for removal of phosphorus from water using adsorption and its subsequent recovery via desorption.

The precise consequence of agricultural NPS pollution: Pollution from nitrogen and phosphorus, as discussed previously, occurs from numerous sources of which agriculture contributes a significant proportion [41]. Leaching of nitrogen and phosphorus in excess results in pollution of air, water, and soil. Especially eutrophication of water bodies resulting in impacts on the diversity of aquatic life. After entering into the environment, nitrogen gets converted to numerous forms leading to the process called nitrogen cascade resulting in a wide range of environmental impacts. Mitigation impacts caused by these two substances are associated with high costs; for example, mitigation of eutrophication caused by phosphorus loads.

Feasible available solutions: Usually, all types of land use and agricultural practices are treated as agrarian NPS pollution, which depends on hydrological conditions causing difficulty in measurement and control directly. However, owing to the features of NPS pollution management, which are dependent on spatial-temporal simulation modeling, this is a primary method to estimate NPS pollution linked to spatial uncertainty. Techniques like watershed-scale modeling and small spatial-scale experiments can accurately calculation pollution loads from different land uses [42].

Studies by Saunders and Kalff (2001) [43]; Schulz and Kǒhler (2006) [44] proposed riverine retention processes for reducing transportation of nitrogen and phosphorus. Riverine retention occurs as a result of the burial of organic matter in sediments, sorption of sediment, denitrification, and uptake by plants and microorganisms. Methods like mass balance modeling [45], mechanism models [46], experimental measurements [47] and statistical regressions has been used for estimating total nitrogen and phosphorus retention in rivers [48].

Natural zeolite, aluminum modified clay, and lanthanum modified bentonite were used towards amending natural soil that has been collected from the lakeside of the Kelan reservoir in China for examining the removal of dissolved inorganic phosphorus and ammonia nitrogen using three amended grounds under simulated conditions. This study provided a significant basis for the construction of a lakeside buffer zone in the eutrophic watershed. Moore and Locke (2020) established 12 experimental mesocosms using silt loam atop a base of sand to examine the ability of 3 emergent aquatic plants for remediation of nutrients and pesticides from agricultural runoff. It indicated that this kind of vegetated ditches might help in reducing the transport of agrarian contaminants to aquatic ecosystems. Another most suitable method is integrated buffer zones, which is a novel form of edge-of-field technology for the retention of different species of nitrogen and phosphorus [49].

V. CONCLUSION

Water quality monitoring persists to be a priority in most of the ecological studies, restoration projects, and water quality control. The current review presents water quality deterioration due to agricultural NPS, identifying nitrogen and phosphorus as significant contributors. Further, it also focused on pathways of their entry into the water bodies and their impacts on the receiving environment. We also presented some of the current technologies available for reducing the transport of these substances to water bodies. Monitoring and measuring techniques help in continuous recording of concentrations of nitrogen and phosphorus levels, which can be managed through process control technologies like integrated buffer zones, which seem to offer excellent retention capabilities. Further, using integrated techniques is always considered to be effective.

Conflict of Interest. All the Authors declare no conflict of Interest.

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REFERENCES

[1]. Godfray, H. C. J., & Garnett, T. (2014). Food security and sustainable intensification. Philosophical transactions of the Royal Society B: *biological sciences*, *369*, 1-10.

[2]. Souza, L.R.R., Pomarolli, L.C., & da Veiga, M.A.M.S. (2020). From classic methodologies to application of nanomaterials for soil remediation: an integrated view of methods for decontamination of toxic metal(oid)s. *Environmental Science and Pollution Research*. 27, 10205–10227. (17th February, 2020)

[3]. RUNOFF, U. E. U. (1975). Sediment-yield prediction with universal equation using runoff energy factor. *ARS-S.*, *40*, 244.

[4]. Le Moal, M., Gascuel-Odoux, C., Ménesguen, A., Souchon, Y., Étrillard, C., Levain, A., & Pinay, G. (2019). Eutrophication: A new wine in an old bottle? *Science of the total environment*, *651*, 1-11.

[5]. Connor, R. (2015). *The United Nations world water development report 2015: water for a sustainable world* (Vol. *1*). UNESCO publishing.

[6]. Lemly, A. D. (2002). A procedure for setting environmentally safe total maximum daily loads (TMDLs) for selenium. *Ecotoxicology and Environmental Safety, 52,* 123-127.

[7]. Mateo-Sagasta, J., Ongley, E., Hao, W., & Mei, X. (2013). Guidelines to control water pollution from agriculture in China: Decoupling water pollution from agricultural production. *FAO Water Reports*, *40*.

[8]. Evans, A. E., Mateo-Sagasta, J., Qadir, M., Boelee, E., & Ippolito, A. (2019). Agricultural water pollution: key knowledge gaps and research needs. *Current opinion in environmental sustainability*, *36*, 20-27.

[9]. Rahman, K. A., & Debnath, S. C. (2015). Agrochemical use, environmental and health hazards in Bangladesh. *International Research Journal of Interdisciplinary & Multidisciplinary Studies*, *1*, 75-79.

[10]. Hasan, M. K., Shahriar, A., & Jim, K. U. (2019). Water pollution in Bangladesh and its impact on public health. *Heliyon*, *5*(8), e02145.
[11]. Yin, F., Fu, B., & Mao, R. (2007). Effects of nitrogen fertilizer application rates on nitrate nitrogen distribution in saline soil in the Hai River Basin, China. *Journal of Soils and Sediments*, *7*(3), 136-142.
[12]. Panagopoulos, I., Mimikou, M., & Kapetanaki, M. (2007). Estimation of nitrogen and phosphorus losses to surface water and groundwater through the implementation of the SWAT model for Norwegian soils. *Journal of Soils and Sediments*, *7*(4), 223-231.
[13]. Janssen, A. B., Teurlincx, S., An, S., Janse, J. H., Paerl, H. W., & Mooij, W. M. (2014). Alternative stable states in large shallow lakes? *Journal of Great Lakes Research*, *40*(4), 813-826.
[14]. Wang, M., Strokal, M., Burek, P., Kroeze, C., Ma, L., & Janssen, A. B. (2019). Excess nutrient loads to Lake Taihu: opportunities for nutrient reduction. *Science of the Total Environment*, *664*, 865-873.
[15]. Divya, J., & Belagali, S. L. (2012). Impact of chemical fertilizers on water quality in selected agricultural areas of Mysore district, Karnataka, India. *International journal of environmental sciences*, *2*(3), 1449-1458.
[16]. Khanna, R., & Gupta, S. (2018). Agrochemicals as a potential cause of ground water pollution: a review. *Int J Chem Stud*, *6*, 985-990.
[17]. Mohapatra, S. P., Gajbhiye, V. T., Agnihotri, N. P., & Raina, M. (1995). Insecticide pollution of Indian rivers. *Environmentalist*, *15*(1), 41-44.
[18]. Vallejo-Hernández, L. H., Rodríguez, G. B., Elghandour, M. M. M. Y., Greiner, R., Salem, A. Z. M., &Adegbeye, M. J. (2019). Influence of phytase enzyme on ruminal biogas production and fermentative digestion towards reducing environmental contamination. *Environmental Science and Pollution Research*, *26*(10), 9992-9999.
[19]. Bindraban, P. S., Dimkpa, C., Nagarajan, L., Roy, A., &Rabbinge, R. (2015). Revisiting fertilisers and fertilisation strategies for improved nutrient uptake by plants. *Biology and Fertility of Soils*, *51*(8), 897-911.
[20]. Torrecilla, N. J., Galve, J. P., Zaera, L. G., Retamar, J. F., & Alvarez, A. N. (2005). Nutrient sources and dynamics in a Mediterranean fluvial regime (Ebro river, NE Spain) and their implications for water management. *Journal of Hydrology*, *304*(1-4), 166-182.
[21]. Nolan, B. T., & Stoner, J. D. (2000). Nutrients in groundwaters of the conterminous United States, 1992–1995. *Environmental Science & Technology*, *34*(7), 1156-1165.
[22]. Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., & Folke, C. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, *347*(6223), 1259855.
[23]. Ward, M. H. (2009). Too Much of a Good Thing? Nitrate from Nitrogen Fertilizers and Cancer: President's Cancer Panel-October 21, 2008. *Reviews on environmental health*, *24*(4),
[24]. Butterbach-Bahl, K., Baggs, E. M., Dannenmann, M., Kiese, R., & Zechmeister-Boltenstern, S. (2013). Nitrous oxide emissions from soils: how well do we understand the processes and their controls?. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *368*(1621).
[25]. Benckiser, G., Schartel, T., & Weiske, A. (2015). Control of NO 3− and N 2 O emissions in agroecosystems: a review. *Agronomy for sustainable development*, *35*(3), 1059-1074.
[26]. Rabalais, N. N., Turner, R. E., & Scavia, D. (2002). Beyond Science into Policy: Gulf of Mexico Hypoxia and the Mississippi River: Nutrient policy development for the Mississippi River watershed reflects the accumulated scientific evidence that the increase in nitrogen loading is the primary factor in the worsening of hypoxia in the northern Gulf of Mexico. *BioScience*, *52*(2), 129-142.
[27]. Turner, R. E., Rabalais, N. N., & Justic, D. (2006). Predicting summer hypoxia in the northern Gulf of Mexico: Riverine N, P, and Si loading. *Marine pollution bulletin*, *52*(2), 139-148.
[28]. Pellerin, B. A., Downing, B. D., Kendall, C., Dahlgren, R. A., Kraus, T. E., Saraceno, J., & Bergamaschi, B. A. (2009). Assessing the sources and magnitude of diurnal nitrate variability in the San Joaquin River (California) with an in situ optical nitrate sensor and dual nitrate isotopes. *Freshwater Biology*, *54*(2), 376-387.
[29]. Schröder, J. J., Schulte, R. P. O., Creamer, R. E., Delgado, A., VanLeeuwen, J., Lehtinen, T., & Wall, D. P. (2016). The elusive role of soil quality in nutrient cycling: a review. *Soil Use and Management*, *32*(4), 476-486.
[30]. Kleinman, P. J., Sharpley, A. N., Withers, P. J., Bergström, L., Johnson, L. T., & Doody, D. G. (2015). Implementing agricultural phosphorus science and management to combat eutrophication. *Ambio*, *44*(2), 297-310.
[31]. Cassidy, R., Doody, D. G., & Watson, C. J. (2017). Impact of legacy soil phosphorus on losses in drainage and overland flow from grazed grassland soils. *Science of the Total Environment*, *575*, 474-484.
[32]. Withers, P. J., Neal, C., Jarvie, H. P., & Doody, D. G. (2014). Agriculture and eutrophication: where do we go from here?. *Sustainability*, *6*(9), 5853-5875.
[33]. Sharpley, A., Jarvie, H. P., Buda, A., May, L., Spears, B., & Kleinman, P. (2013). Phosphorus legacy: overcoming the effects of past management practices to mitigate future water quality impairment. *Journal of environmental quality*, *42*(5), 1308-1326.
[34]. Sharpley, A. (2016). Managing agricultural phosphorus to minimize water quality impacts. *Scientia Agricola*, *73*(1), 1-8.
[35]. Haygarth, P. M., Condron, L. M., Heathwaite, A. L., Turner, B. L., & Harris, G. P. (2005). The phosphorus transfer continuum: linking source to impact with an interdisciplinary and multi-scaled approach. *Science of the total environment*, *344*(1-3), 5-14.
[36]. Daly, K., Styles, D., Lalor, S., & Wall, D. P. (2015). Phosphorus sorption, supply potential and availability in soils with contrasting parent material and soil chemical properties. *European Journal of Soil Science*, *66*(4), 792-801.
[37]. Moloney, T., Fenton, O., & Daly, K. (2020). Ranking connectivity risk for phosphorus loss along agricultural drainage ditches. Science of the Total Environment, 703, 134556.
[38]. Gurung, D. P., Githinji, L. J., & Ankumah, R. O. (2013). Assessing the nitrogen and phosphorus loading in the Alabama (USA) River Basin using PLOAD model. *Air, Soil and Water Research*, *6*, ASWR-S10548.

[39]. Darch, T., Blackwell, M. S., Hawkins, J. M. B., Haygarth, P. M., & Chadwick, D. (2014). A meta-analysis of organic and inorganic phosphorus in organic fertilizers, soils, and water: Implications for water quality. *Critical Reviews in Environmental Science and Technology*, *44*(19), 2172-2202.
[40]. Bacelo, H., Pintor, A. M., Santos, S. C., Boaventura, R. A., & Botelho, C. M. (2020). Performance and prospects of different adsorbents for phosphorus uptake and recovery from water. Chemical Engineering Journal, 381, 122566.
[41]. Aneja, V. P., Schlesinger, W. H., Erisman, J. W., Behera, S. N., Sharma, M., & Battye, W. (2012). Reactive nitrogen emissions from crop and livestock farming in India. *Atmospheric environment*, *47*, 92-103.
[42]. Jabbar, F. K., & Grote, K. (2019). Statistical assessment of nonpoint source pollution in agricultural watersheds in the Lower Grand River watershed, MO, USA. *Environmental Science and Pollution Research*, *26*(2), 1487-1506.
[43]. Saunders, D. L., & Kalff, J. (2001). Nitrogen retention in wetlands, lakes and rivers. *Hydrobiologia*, *443*(1-3), 205-212.
[44]. Schulz, M., & Köhler, J. (2006). A simple model of phosphorus retention evoked by submerged macrophytes in lowland rivers. *Hydrobiologia*, *563*(1), 521-525.
[45]. May, L., House, W. A., Bowes, M., & McEvoy, J. (2001). Seasonal export of phosphorus from a lowland catchment: upper River Cherwell in Oxfordshire, England. *Science of the Total Environment*, *269*(1-3), 117-130.
[46]. Andersson, L., & Arheimer, B. (2001). Consequences of changed wetness on riverine nitrogen–human impact on retention vs. natural climatic variability. *Regional Environmental Change*, *2*(3), 93-105.
[47]. Takeda, K., & Akira, S. (2007). Toll-like receptors. *Current protocols in immunology*, *77*(1), 12-14.
[48]. Chen, D., Lu, J., Wang, H., Shen, Y., & Kimberley, M. O. (2010). Seasonal variations of nitrogen and phosphorus retention in an agricultural drainage river in East China. *Environmental Science and Pollution Research*, *17*(2), 312-320.
[49]. Zak, D., Kronvang, B., Carstensen, M. V., Hoffmann, C. C., Kjeldgaard, A., Larsen, S. E., & Gertz, F. (2018). Nitrogen and phosphorus removal from agricultural runoff in integrated buffer zones. *Environmental science & technology*, *52*(11), 6508-6517.

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