Research Paper

Impact of chemical fertilizers on nutrient level of surface water bodies

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ABSTRACT

Farmers in the modern era are forced to follow the principle of intensive agriculture with the application of larger amounts of modern technological inputs, in particular chemical fertilizers. But its continuous use or overuse is fraught with danger because a considerable amount of applied fertilizer is lost to the environment, especially to the soil system and surface water bodies, including ponds, rivers, lakes, and estuaries. The objective of the study is to examine and measure the impact of chemical fertilizers on nutrient levels or the gross productivity of surface water bodies. For the study, water samples have been collected by primary field survey in five different study villages from different corners of the Mayurakshi-Basloi interfluve, Birbhum District, West Bengal, India. Thereafter these are examined in the laboratory to measure the level of increase of nutrients. The results show that, in every case, the amount of nutrient or gross primary productivity in the water bodies has been augmented after the application of chemical fertilizers to the crop fields.

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1. INTRODUCTION

The world population is increasing at a shocking rate. This increases the demand for food grains and other necessities. So, farmers are forced to increase the productivity of crops for which the dose and application of chemical fertilizers and other agrochemicals, like pesticides, weedicides, etc., are gradually increasing. It is found that the use of chemical fertilizers in crop fields has increased severalfold during the past 50 years in India as well as elsewhere in several developed and underdeveloped countries [1]. Modern mechanized farming systems with large amounts of fertilizers containing nitrogen, phosphate, and potassium salts and pesticides have no doubt increased the productivity of crops, but they have, at the same time, put uncontrollable waste into the environment [2] because a considerable amount of these chemicals, especially nitrates and phosphates, are lost from the crop fields to the soil-water systems [1], [3]. Nitrogen (N) fertilizer is highly soluble and readily percolates from field's soil into the subsurface and ultimately water bodies on the surface in the form of nitrates. It has been found that cereal crops could only recover 51% of the fertilizer nitrogen applied and that the average nitrogen recovery by crop plants may be much lower when applied at high rates [4]. So about 49% of applied N fertilizer is lost to the air-soil-water system.

After the fertilizer N is added to the soil as urea or ammonium, a part of it is used by the crop plants, a part is transformed to gaseous form (NOx) to mix into the atmosphere, and the rest is runoff and percolated down onto the soil system, probably to mix into surface and underground water bodies, as shown in Figure 1.

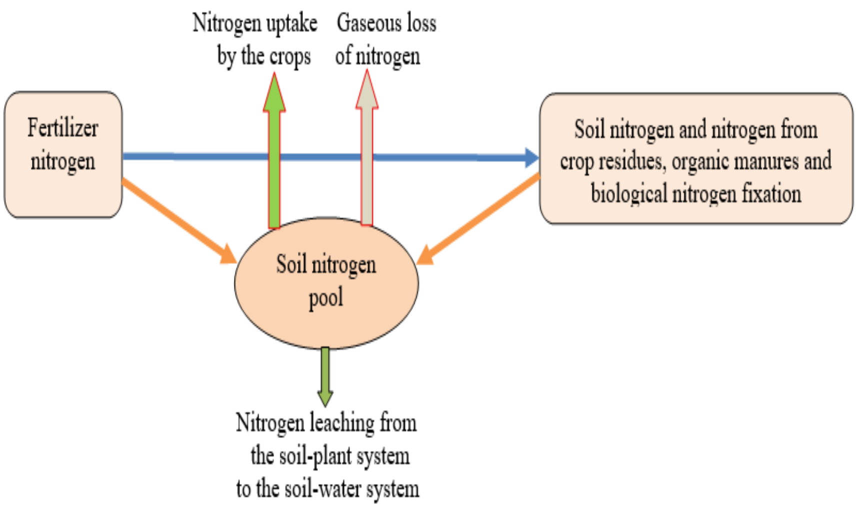


Figure 1. Schematic Diagram of the Fate of Nitrogen Fertilizer Applied in the Crop's Field's Oxides of Nitrogen

Firstly, the applied nitrogen undergoes a metabolic transformation to nitrate, which has the potential to seep into water bodies outside of the soil-plant system. However, the final destination of nitrogen in the subterranean environment is dependent on a number of biochemical and bio-physico-chemical processes. Since land use activities, fertilizer N management, rainfall, irrigation management, soil N dynamics, and soil characteristics are all intricately related, it has proven difficult to accurately quantify nitrate leaching to surface and groundwater bodies [5].

Phosphorus, although it is less mobile in soil, can be carried by runoff or linked to degraded soil particles. This also adds large amounts of nutrients to the surface water bodies. All these changes affect the chemistry and quality of water, especially of surface water [6], [7] and stimulate rapid growth of gross primary productivity (phytoplankton), which may later invite a larger number of algae and aquatic plants, causing eutrophication [2], [8]. This is a situation of an overabundance of aqueous algae and plants in the surface water bodies that frequently create dense "algal blooms." [9].

In this context, the main objective of the paper is to observe and measure the increase of plant's food nutrients, or gross primary productivity, of fertilized water bodies located around the crop fields in the Mayurakshi-Basloi interfluve of Birbhum District, West Bengal, India.

2. RELATED WORK

In today's agriculture different types of chemical fertilizers containing micro and macro-nutrients are being excessively used in the agricultural fields for boosting up crops' productivity [10]. Continuous use of these chemical fertilizers with high doses is fraught with danger for the environment because an ample amount of applied fertilizer is lost from the crop fields to the soil-water system, causing pollution and degradation [11], [12], [13]. G. X. Xing and L. Zhu (2000) concluded that the portion of nitrogenous fertilizers more than required moves from agricultural fields to the surface waterbodies, causing eutrophication [13].

Although it is very difficult to determine the exact contribution of agriculture to ground and surface water contamination, in contemporary agricultural systems, 10–30% of the nitrogen fertilizer is often lost to the environment [5]. It is estimated that only 50% of applied chemical fertilizers are used by the crops, while the rest is deposited in the soil-water system [14], [15]. Tilman and Howarth (2008) claim that in certain places, increases in N flows of up to 10 to 15 times are significantly worsening coastal eutrophication [15]. Accelerated eutrophication of surface waters is often caused by high phosphorus losses from agricultural fields [16], [17].

Reutter (1989) has added that agricultural fertilizers, detergents, and sewage are major sources of phosphorus in a form capable of stimulating the growth of algae in surface water bodies [18], causing eutrophication. On the basis of the study reported by various workers in India [19], [20], [21], it is said that nitrate pollution in surface and underground water in India is a very severe problem, and it is likely to grow to a high dimension with the continuous use of nitrogenous fertilizers. The U.S. Environmental Protection Agency identified nutrients as a significant national problem contributing to water pollution. Several water reservoirs and rivers in Asia, Europe, and North and South America are highly eutrophic owing to nutrient loads from agricultural fields and households [22], [23]. Major causes of eutrophication of most of the lakes of the western Netherlands are the influx of nitrogen- and phosphorous-rich river and canal water [24].

3. METHODOLOGY

3.1. The Study Site

The area selected for the study is the interfluve of the Mayurakshi and the Basloi rivers in the Birbhum district of West Bengal, India. It is characterized by a wet and dry monsoon-type climate with around 170 cm of annual rainfall and a temperature of 12–35°C. The area is basically a flat plain with clay-to-loam soils, with some lateritic patches in the west. Farmers in this area use a variety of chemical fertilizers (NPK and urea-based) to produce a variety of crops, including rice, potatoes, wheat, mustard, and so on. The rate of application of chemical fertilizers in producing such crops is around 510 kg/acre/year (NPK = 340 kg/acre and Urea = 170 kg/acre/year). A meager amount of organic manure, mostly conventionally prepared farmyard manure, is also used by some farmers. But due to insufficient supply, it is used only on some selected plots. With time it is further declining because of the scarcity of cattle. For data collection, five villages, namely Angargoria, Dakshingram, Kamakha, Paikar, and Tail Para, have been selected purposefully from different corners of the entire study area, as shown in Figure 2.

3.2. Sample Collection

To conduct the study for observing and measuring the increase of a plant's food nutrients or gross primary productivity value of surface water, two types of samples were collected from five different water bodies/ponds in each of five study villages (total 5x5=25 water bodies) in different corners of the interfluve having almost similar environmental characteristics and similar agronomic management in 2023.

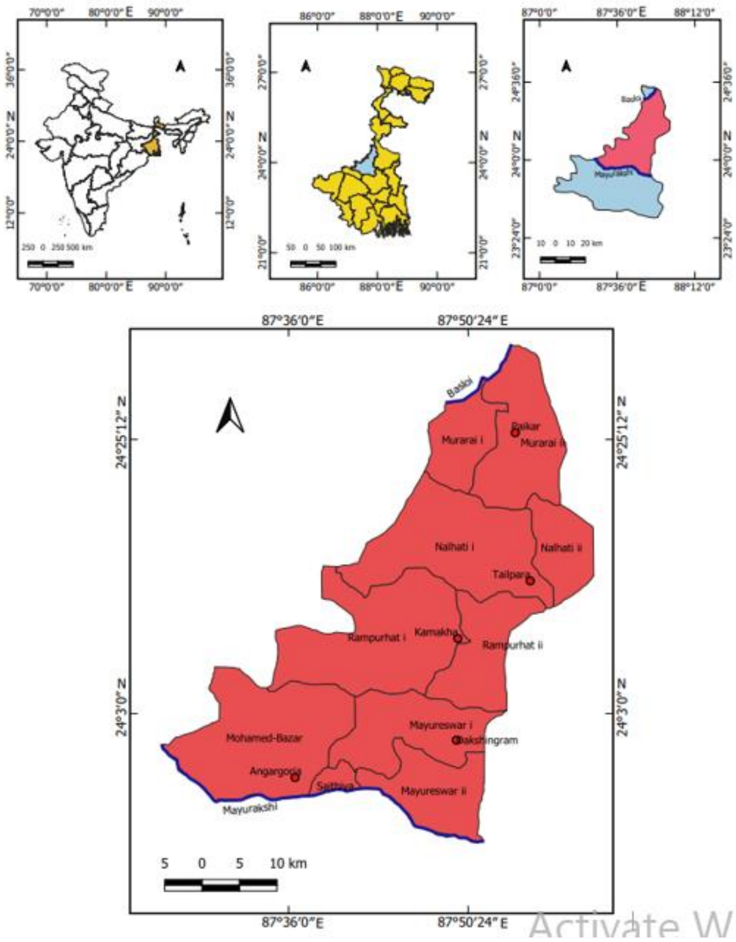


Figure 2. Location of the Sample Villages

These are selected in such a way that they are surrounded by the crop fields having intensive farming. There is no scope for mixing of sewage water from the drain or manure pit in such water bodies, but there is a huge influx of water from fertilized crop fields during aman or boro paddy cultivation. The ponds are rain-fed and 10-15 feet in depth. In every summer these are almost dried out and filled again with rainwater by draining in from the crop fields with the onset of the monsoon.

The water samples are collected from these ponds using clean and sterilized plastic containers twice a year for the estimation of water quality parameters (nutrients): before sowing the paddy in July (newly filled rainwater) and after harvesting the same in December. So, there are two types of samples. (a) Sample I, containing fresh or non-fertilized water, and (b) sample II, containing fertilized water. Thereafter, these are immediately brought to the laboratory for analysis.

3.3. Methods

The methodology used to conduct the study is a laboratory test of the water samples, which was followed by a statistical analysis and interpretation. The collected samples were analyzed by a CHNS analyzer in the laboratory to find out the amount of nutrients in the form of increase of the dry weight (carbon) of algae (Standard Methods for the Examination of Water and Wastewater, 20th Ed., APHA, AWWA, WEF. Washington DC, 1998). The statistical investigation of the analyzed data has been performed using standard methods. Correlation for significance has been tested by applying the student t-test.

3.4. Analysis

To find out the increase of the plant's food nutrients or the gross primary productivity value of fertilized water, a comparison has been made between each pair (sample-I and sample-II) of samples. Then the differences are calculated. This difference is the increase of the plant's food nutrients or the gross primary productivity value of fertilized water bodies. For determining the magnitude of impact statistically, a student's t-test has been done with (n-1) degrees of freedom.

4. RESULTS AND DISCUSSION

The results of the study given in Table 1 show that the water of sample-II (fertilized water) is to some extent rich in nutrients in the form of the dry weight of carbon from algae, and the nutrient value of the fertilized sample is always higher than that of the non-fertilized samples. This indicates that application of chemical fertilizers increases the nutrient level of the water. From the Table 1, it is sure that the increase of nutrient or gross primary productivity of fertilized water ranges in different samples from 0.1 to 19.2 mg carbon/cubic meter/hour.

Table 1. Changes of Gross Primary Productivity Value of Water Samples in Different Study Villages

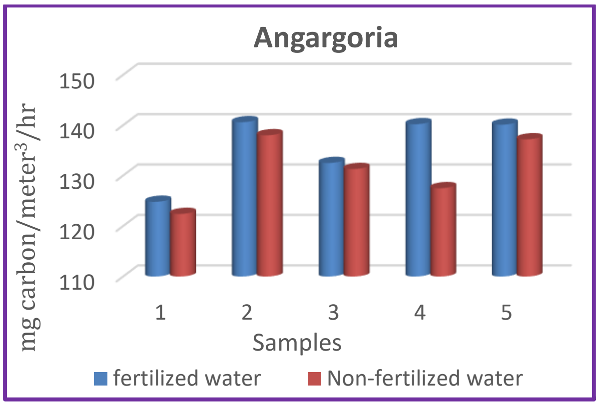
Sample Villages	**Increase of Gross Primary Productivity for Applying Chemical Fertilizers**	
	Samples	Extent of Increase(Mg Carbon/Cubic Meter/Hour)
Angargoria	100%	1.2-12.7
Dakshingram	100%	0.8-14.8
Kamakha	100%	1.2-17.9
Paikar	100%	0.1-13.0
Tail Para	100%	1.9-19.2

As far as the village-level study is concerned, it is found that all the sample water bodies at Angargoria village show an increase of nutrient value, which is between 1.2 mg/cubic meter/hr and 12.7 mg/cubic meter/hr from the pre-monsoon to post-monsoon seasons, as found in Table 1 and which is supported by Figure 3 (a). In the case of Dakshingram village, an increase of nutrient value is observed in all the samples, which ranges from 0.8 to 14.8 mg/cubic meter/hr. From Figure 3 (b), it is clear that 80% of samples show an increase of more than 1 unit in this village. At Kamakha village, the nutrient level has increased from 1.2 to 17.9 mg/cubic meter/hr after the application of chemical fertilizers. In this village, all the samples show an increase of more than 1 unit Figure 3 (c). The study shows that, in the case of Paikar, all the samples show an increase in soil pH value ranging from 0.1 to 13.0 units Figure 3 (d). At Tailpara village, an increase in nutrient level takes place by 1.9-19.2 mg/cubic meter/hr due to the application of chemical fertilizers in the crop fields, which is found in Figure 3 (e).

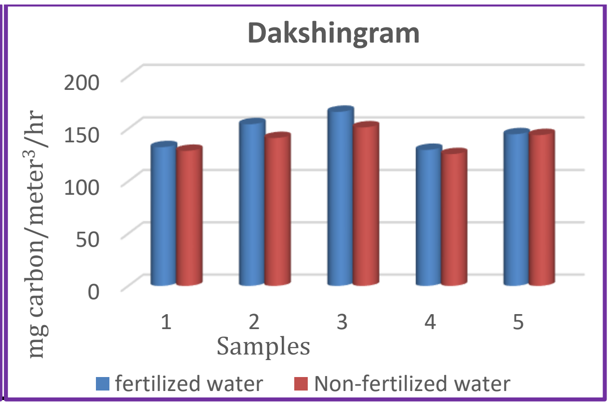
The statistical analysis (X=fertilized water, Y=non-fertilized water) made on the basis of the results for all the study villages clearly indicates that the level of nutrients, i.e., the increase of gross primary productivity (mg carbon/cubic meter/hour), is always greater in the post-monsoon period than in the pre-monsoon period.

Table 2. Distribution of T Test Results at Different Study Villages

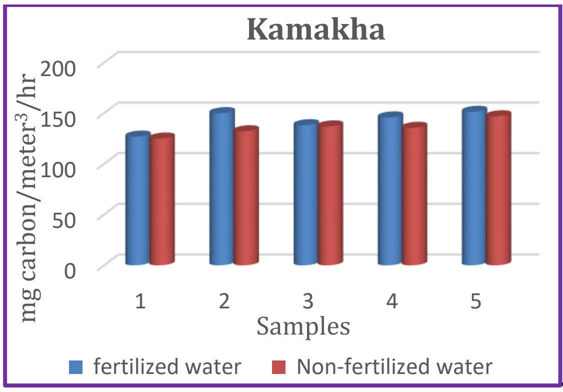
Sample Villages	**T Test Result**		
	Observed Value	Tabulated Value	Level of Significance
Angaroria	2.17	2.01	0.1%
Dakshingram	2.58	2.13	0.1%
Kamakha	3.13	2.77	0.05%
Paikar	2.33	2.13	0.1%
Tail Para	3.21	2.77	0.01%



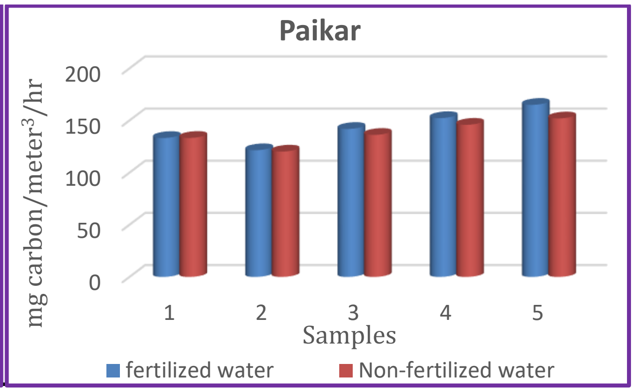
(a) Angargoria Village



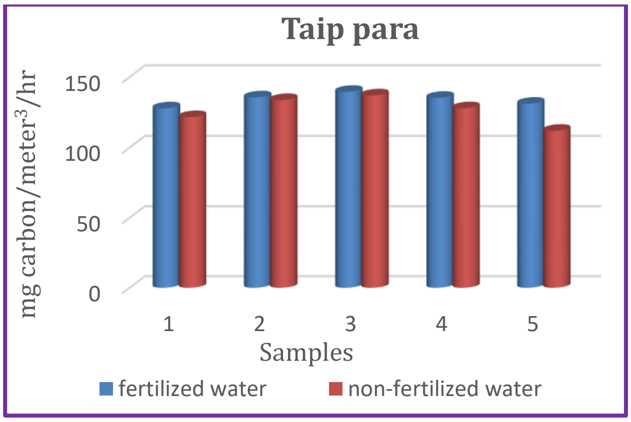
(b) Dakshingram Village



(c) Kamakha Village



(d) Paikar Village



(e) Tail Para Village

Figure 3. (a, b, c, d, e): Comparative Nutrient Levels in Different Samples in Different Study Villages

From Table 2, it is found that the observed value (2.17) of t at Angargoria village is greater than the tabulated value (2.01) at the 1% level of significance. So the null hypothesis (Ho: $\bar{X} = \bar{Y}$) is rejected and the alternative hypothesis (Hi: $\bar{Y} > \bar{X}$) is accepted. This indicates that the nutrient value of fertilized soil and non-fertilized soil is not equal, and the same is higher in the case of X samples. This clearly points out the fact that the nutrient value of fertilized water increases.

In the case of Dakshingram village, the experimental value of t (2.58) is also greater than tabulated value (2.13) at the 10% level of significance Table 2. So, in this case, the null hypothesis (Ho: $\bar{X} = \bar{Y}$) is rejected

and the alternative hypothesis (Hi: $\overline{X} > \overline{Y}$) is accepted. So here also the nutrient value of the fertilized water is greater than that of non-fertilized water.
As far as the Kamakha village is concerned, it is found that the experimental value of t (3.13) is greater than tabulated value (2.77) at the 5% level of significance Table 2. So, the null hypothesis (Ho: $\overline{X} = \overline{Y}$) is discarded here and the alternative hypothesis (Hi: $\overline{X} > \overline{Y}$) is accepted. This indicates that the nutrient value of fertilized water at Kamakha village is greater than the nutrient value of non-fertilized water ie the mixing of chemical fertilizer with water increasesits nutrient content.

It is evident from the table that, due to the influx of fertilized water, the nutrient level of water bodies in Paikar village increases because here also the experimental value of t (2.33) is greater than the tabulated value (2.13) at the 10% level of significance Table 2 which is the indication of the rejection of the null hypothesis (Ho: $\overline{X} = \overline{Y}$) and the acceptance of alternative hypothesis (Hi: $\overline{X} > \overline{Y}$).

The Table 2 indicates thatthe experimental value of t (3.21) is greater than tabulated value (2.77) at the 10% level of significance at Tailpara village. So, in this case also, the null hypothesis (Ho: $\overline{X} = \overline{Y}$) is discarded and the alternative hypothesis (Hi: $\overline{X} > \overline{Y}$) is accepted. This is the sign of an increase of the nutrient level of fertilized water bodies.

5. CONCLUSION

From the above discussions, it is clear that mixing of fertilized water from crop fields increases the nutrient level or the gross primary productivity valueof surface water bodies. Eutrophication and consequent contamination of water are their resultant effects. But the magnitude of eutrophication depends largely on the type of crop produced, the type and amount of fertilizers applied, the type of land and soil, the type of farming practiced, the nature of the application of fertilizer, and so on. In order to preserve aquatic ecosystems and guarantee environmentally friendly water supplies, it is essential to comprehend and reduce the effects of chemical fertilizers on nutrient levels and the ensuing eutrophication. To overcome the situation, the Integrated Nutrient Management System (INMS) may be followed. Organic farming can largely reduce the nutrient losses from crop fields. Also, the leaching and runoffloss of chemical fertilizers, especially the nitrogenous ones, should be reduced by adopting the latest irrigation technology and switching over the production process to traditional methods of organic farming for a better green revolution and agricultural development.

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Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Dr. Lakshman Chandra Pal	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review &**E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Conflict of Interest Statement

I, the author had full access to all in this study and take complete responsibility for the integrity of data and the accuracy of data analysis. I declare there is no conflict of Interest.

Informed Consent

I give my consent to publish the data, images and the paper.

Ethical Approval

I assure that this article do not have any plagiarism.

Data Availability

All the datasets generated and/or analyzed during the current study are available in File depository.

REFERENCES

[1] D. Tilman, 'Global environmental impacts of agricultural expansion: the need for sustainable and efficient practices', Proc. Natl. Acad. Sci. U. S. A, vol. 96, no. 11, pp. 5995-6000, 1999. doi.org/10.1073/pnas.96.11.5995

[2] R. Rocket, 'Down on the Farm? Yields, Nutrients and Soil Quality', Scienceagogo.Com. Retrieved On, 2007

[3] N. Blair, R. Faulkner, A. Till, and P. Poulton, 'Long-term management impacts on soil C, N and physical fertility: Part I: Broadbalk experiment', Soil and Tillage Research, vol. 91, pp. 30-38, 2006. doi.org/10.1016/j.still.2005.11.002

[4] S. H. Chien, L. I. Prochnow, and H. Cantarella, 'Chapter 8 recent developments of fertilizer production and use to improve nutrient efficiency and minimize environmental impacts', in Advances in Agronomy, Elsevier, 2009, pp. 267-322 doi.org/10.1016/S0065-2113(09)01008-6

[5] J. J. Meisinger and J. A. Delgado, 'Nitrogen leaching management', Encyclop Soils Environ, vol. 2, pp. 1122-1124, 2006.

[6] 'Ecosystems and Protection of Water Bodies from Mineral Nutrients', International Journal of Advanced Research, vol. 1, no. 3, pp. 483-488, 2013.

[7] P. Haygarth, 'Agriculture as a source of phosphorus transfer to water: sources and pathways', Sci. Committee Phosph. Eur. Newslett, vol. 21, pp. 1-15, 1997.

[8] M. Aizak, A. Otsuki, and T. Kawai, 'Relationship between loading and phytoplankton standing crop in outdoor experimental ponds with continuous flow systems', Water Res, vol. 20, pp. 859-864, 1986. doi.org/10.1016/0043-1354(86)90173-9

[9] V. H. Smith, G. D.Tilman, & J. C. Nekola, Eutrophication: impacts of excess nutrient inputs on freshwater, marine, and terrestrial ecosystems. Environmental Pollution, 100(1-3), 179-196, 1999 doi.org/10.1016/S0269-7491(99)00091-3

[10] S. Gupta and P. K. Gupta, 'Impact of chemical fertilizers on soil properties and crop productivity: A review', Journal of Pharmacognosy and Phytochemistry, vol. 6, no. 4, pp. 1605-1610, 2017.

[11] T. Afolabi, B. Omotayo, and T. Olusegun, 'Environmental Effects of Application of Fertilizers and Pesticides on Water and Soil in Ibadan, Nigeria', Nigeria. Nigeria" Journal of Emerging Trends in Engineering and Applied Sciences, vol. 4, no. 6, pp. 773-777, 2013.

[12] D. Malathi and U. Bangarusamy, 'Harmful effects of agricultural chemicals. Agro-India Handbook on Food processing', R. K. Business International, pp. 232-235, 2001.

[13] G. X. Xing and L. Zhu, 'An assessment of N loss from agricultural fields to the environment in China', Nutr. Cycl. Agro Eco Sys, vol. 1, pp. 67-73, 2000. doi.org/10.1023/A:1009717603427

[14] D. Tilman, 'Global environmental impacts of agricultural expansion: The good, the bad, and the ugly', Proceedings of the National Academy of Sciences, vol. 96, no. 11, pp. 5995-6000, 1999. doi.org/10.1073/pnas.96.11.5995

[15] R. W. Howarth, 'Coastal nitrogen pollution: A review of sources and trends globally and regionally', Harmful Algae, vol. 8, no. 1, pp. 14-20, 2008. doi.org/10.1016/j.hal.2008.08.015

[16] F. Djodjic and L. Bergstrom, 'Phosphorus losses from arable fields in Sweden: effects of field specific factors and long-term trends', Environ Monit Assess, vol. 102, pp. 103-117, 2005. doi.org/10.1007/s10661-005-2689-y

[17] M. R. Perez, 'Regulating farmer nutrient management: A three-state case study on the Delmarva peninsula', J. Environ. Qual, vol. 44, no. 2, pp. 402-414, 2015. doi.org/10.2134/jeq2014.07.0304

[18] J. M. Reutter, Lake Erie: Phosphorus and eutrophication. Fact Sheet 015. Ohio Sea Grant College Program. Columbus, 1989.

[19] A. N. Chowdhary and B. K. Handa, 'High Nitrate content of ground water in Lonar village', Buldhana District, Ind. Buldhana District, Ind.Geohydrol, vol. 9, pp. 87-93, 1973.

[20] B. K. Handa, 'Effect of return irrigational flows from irrigated lands on the chemical composition of ground water from shallow aquifers', Prog. Water Tech, vol. 11, pp. 337-345, 1979.

[21] R. K. Jain, Study of the effects of excessive use of fertilizers on the quality of groundwater in Barna command area. Bhopal, 1993.

[22] M. García-Llorente, B. Martín-López, I. Iniesta-Arandia, C. A. López-Santiago, P. A. Aguilera, and C. Montes, 'The role of multi-functionality in social preferences toward semi-arid rural landscapes: An ecosystem service approach', Environ. Sci. Policy, vol. 19, no. 20, pp. 136-146, 2012. doi.org/10.1016/j.envsci.2012.01.006

[23] S. Ventury, S. D. Francesco, F. Materazzi, and P. Manciola, 'Unmanned aerial vehicles and G eographical I nformation S ystem integrated analysis of vegetation in T rasimeno L ake, I taly', Lakes Reserv, vol. 21, no. 1, pp. 5-19, 2016. doi.org/10.1111/lre.12117

[24] R. D. E. Gulati, 'Lakes in the Netherlands, their origin, eutropication and restoration: State of the art review', Hydrobiologia, vol. 478, pp. 73-106, 2002. doi.org/10.1007/978-94-017-1335-1_5

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