霞ヶ浦流域を対象とした食生活の変化シナリオによる全窒素濃度の推計
Estimation of Dietary Change Scenario Effect on TN Concentration in the Kasumigaura Watershed

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INTRODUCTION

Management of nitrogen runoff from agriculture is crucial to mitigate effects of nitrogen pollution. Recently, eating shift towards sustainable dietary patterns have been recognized as a promising solution. Certain foods such as livestock products require more fertilizer input due to necessity for large amount of feed crops and also raise difficulties in handling animal waste which is rich in nitrogen. While national-scale studies are common, understanding the impact of dietary changes on a localized scale, like a watershed, is crucial since nitrogen pollution is often localized. This study emphasizes the need to consider dietary impacts in watershed conservation strategies. Therefore, the objective of this study is to assess whether changes in the population's diet in Japan could lead to nitrogen load reduction and water quality improvements in the Kasumigaura watershed, a selected focus area (Fig.1).

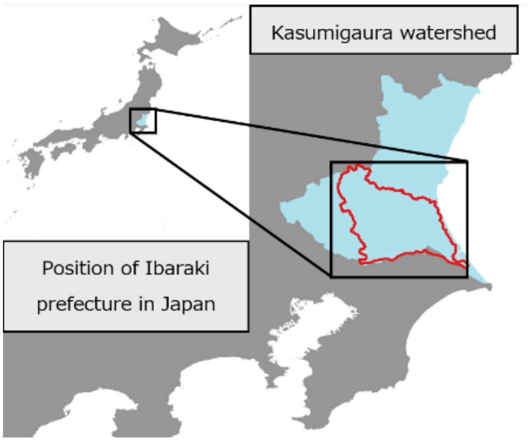

Fig.1 Study Area

METHODS

Kasumigaura watershed covers area of 2,157km^2 has 937,300 residents (2020). It is a significant food producer of Japan, with its large portion of land covered by agricultural fields (Fig.2). Therefore, non-point pollution from agricultural fertilizers is contributing to its degraded water quality. Despite water quality improvements from the past decades, nutrient levels still remain above environmental standards. The study had firstly estimated current nitrogen load, by examining various nitrogen flows, mainly focusing on food production. This consisted of estimating nitrogen load from farmland through balance of fertilizers, with its area determined by land-use analysis. Moreover, contribution from livestock was based on livestock numbers and manure leaching. Furthermore, food self-sufficiency of the watershed for human consumption and animal feed was assessed, calculated from food production data and average yearly protein intake of Japanese population (MAFF 2020). Lastly, two dietary scenarios were explored to assess their effect on the load and water quality. In scenario 1, livestock protein production was replaced by

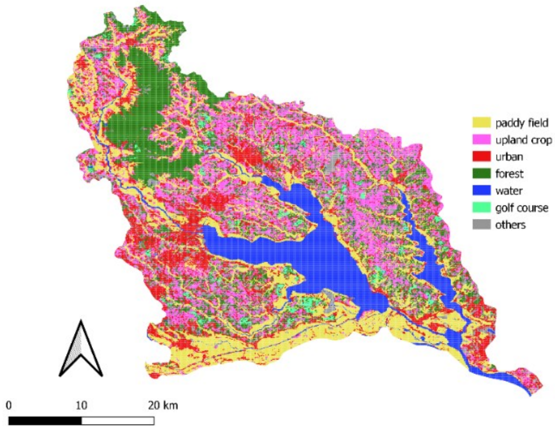

Fig.2 Land-use of the watershed (2016)

legumes. In scenario 2, watershed was assumed to be self-sufficient in animal feed. To understand loading impact on water quality, expected total nitrogen (TN) concentration in the watershed was estimated through division of estimated nitrogen load with runoff water (1.39×10^{12} liters). Calculation to obtain estimated annual runoff water (R) is accommplished by equation (1).

$$R = (P - ET) \times A \qquad (1)$$

R: Runoff water amount (m^3)
P: Average annual rainfall (mm/year)
ET: Average annual evapotranspiration (mm/year)
A: Watershed area (km^2)

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Subsequently, TN changes were calculated according to each dietary scenario´s nitrogen load change. This was accomplished by division of scenario-related nitrogen load with runoff water.

RESULTS

Estimation of nitrogen load (Fig.3) correlated with results of 4,343.5 ton/year reported by Ibaraki Government (2022). Food production contributed with total load of 1,668 ton/year. Table 1 shows protein supply and food self-sufficiency of various food groups in the watershed. Results revealed that self-sufficiency depends on the food group. Protein supply in this watershed is self-sufficient in cereals, vegetables, fruits, beef, and eggs. Their additional supply is possible to export to other parts of Japan or abroad. Analysis also showed that the watershed produces only 14.3% of the feed for the its livestock. Therefore, most of the livestock production related emissions are generated outside of the watershed.

Table 1 Protein supply and self-sufficiency of watershed among various food groups

Food group	Yearly protein supply of watershed (kg)	Yearly protein intake per citizen (kg)	Number of people supplied by the watershed (persons)
Cereals	16,324,000	6.57	2,484,627
Legumes	1,116,000	3.61	309,141
Vegetables	10,549,000	1.42	7,428,873
Fruits	707,000	0.33	2,142,424
Beef	1 079,000	1.10	980,910
Pork	741,000	2.34	316,667
Chicken	184,000	2.77	66,426
Eggs	6,789,000	2.08	3,263,942
Milk	1,574,000	2.99	526,421

Analysis of 2 dietary scenarios used food production load as a baseline, to understand the impact of dietary changes (Fig.4). Scenario 1 demonstrated that replacing all livestock protein produced in the watershed with legume protein would decrease nitrogen load by 419 ton. On the other hand, production of all animal feed for the watershed´s livestock would increase load by 492 ton. Using these estimates, the potential impact on water quality was calculated, revealing corresponding improvements in scenario 1 and deterioration in scenario 2.

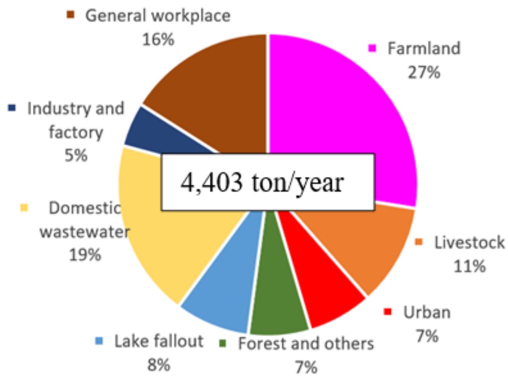

Fig.3 Estimated nitrogen load (2020)

Estimated TN Concentration

The calculation of expected TN concentration was 3.17mg/L. With Scenario 1, the average TN would decrease from the current situation to 2.88mg/L. In case of Scenario 2, the TN would increase to 3.53mg/L.

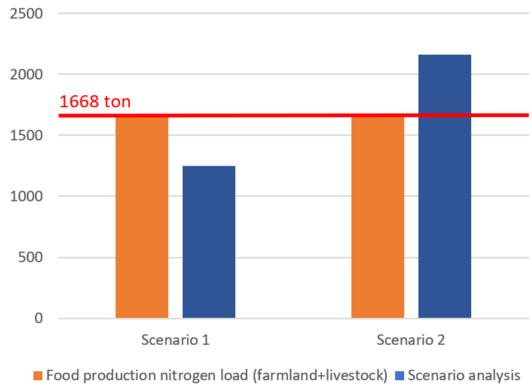

Fig.4 Scenario analyses (ton/N/year)

CONCLUSIONS

This study represents a pilot investigation of the impact of dietary changes on nitrogen loads in the watershed scale. Replacing livestock protein by legumes resulted in significant decrease in nitrogen load and calculations revealed that this might lead to improved water quality. To encourage shift towards sustainable eating habits, policymakers should focus on alternative protein education, incentives, accessibility improvements, and subsidies.

REFERENCES

Ibaraki Government. (2022): 8th period Kasumigaura lake water quality conservation plan.

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