

Accumulated nitrogen from organic fertilizer affects river nitrogen pollution

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Introduction

Lake Kasumigaura is located in the 70km northeast of Tokyo and is the second largest lake in Japan (**Figure 1.**). The lake has a surface area of 219.9 km², a basin area of 2,157 km², a shoreline of 252 km, a water volume of 0.85 billion m³, an average of depth 4 m, a maximum depth of 7 m, an annual rainfall of 1,350 mm and a hydraulic retention time of about 200 days. Water from the lake is used for urban consumption, industry, agriculture and recreation, and is an important water resource for the Tokyo area. However, Kasumigaura is eutrophic with algal-blooms since the 1970's. Recently, a lake water quality conservation plan was established for review every five years. Of the three basins that feed the lake, the water quality from the Kitaura basin has not improved, with high nitrogen loads continuing.

The total nitrogen (TN) concentration of Hokota River is the highest and increasing most rapidly (**Figure 2.**). Intensive agriculture is common in the Hokota River basin including pig farming along with horticultural crops such as melons, strawberries and tomatoes. However, the cause of increasing nitrogen concentrations has not been established, in particular the rapid TN conc. increase from 2004 to 2007 in the Hokota River.

The Japanese government has been advocating conservation measures such as a reduction in the use of chemical fertilizers and synthetic pesticides. As a result, organic forms of nutrients were believed to be good for the environment and less harmful than chemical fertilizers. However, incorrect application of nutrients in any form may contribute to nitrogen pollution. On November 1, 2004, the Japanese government declared the commencement of a management program, "Enforcement of the act on promotion of use of manure management and optimization" mandating that livestock farmers were no longer able to apply livestock waste. Prior to these declaration livestock farmers are likely to have applied large amounts of livestock waste (organic N fertilizer) to fields. Therefore, the objective of this study was to identify potential sources of high and increasing TN in the Hokota River at the Kitaura river inflow. Because, we founded similar phenomena and it shows in **Figure 3.**

Is the organic fertilizer good for the environment?

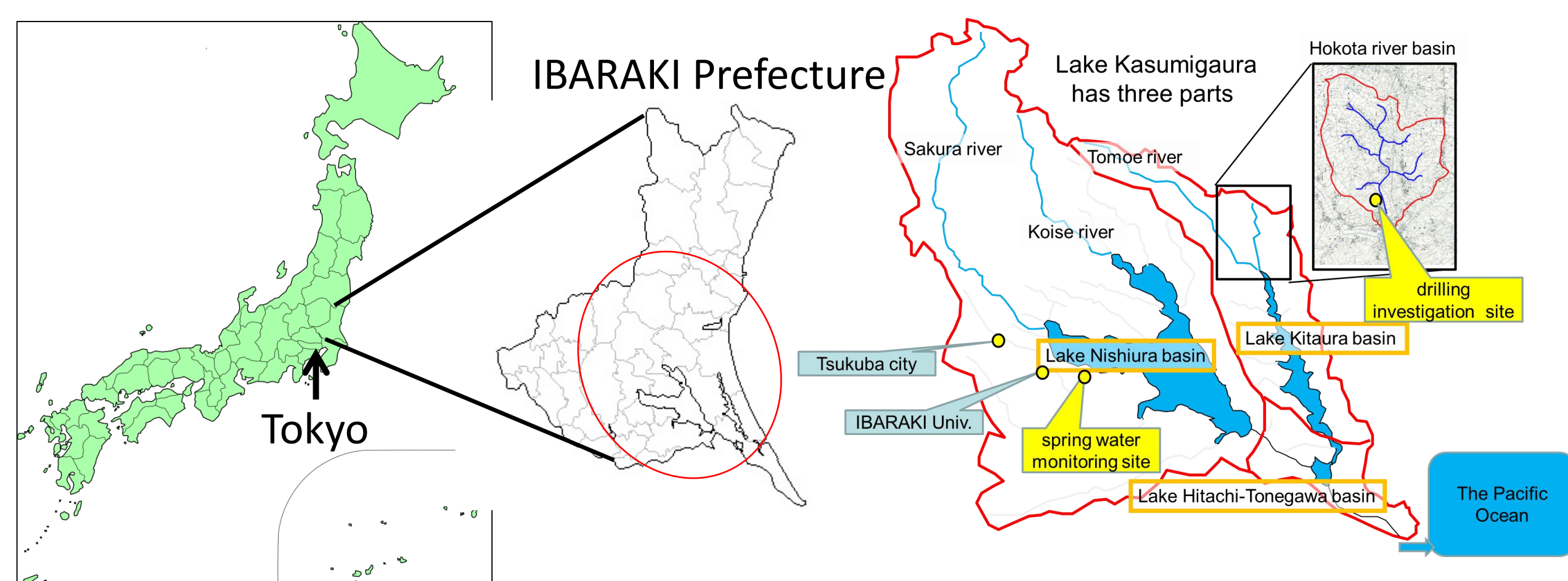


Figure 1. The location of study area is Hokota river basin in Lake Kasumigaura basin

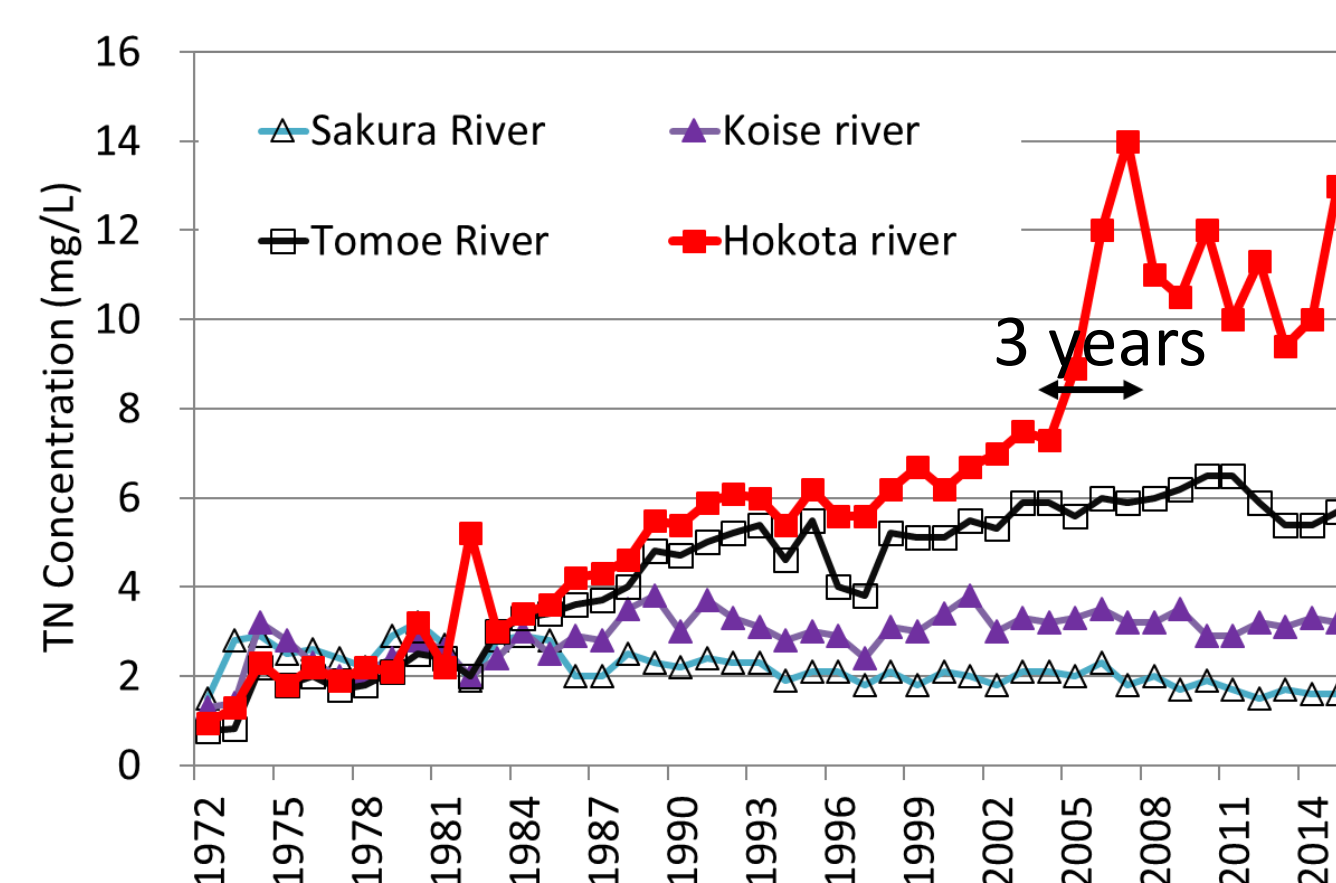


Figure 2 and figure 3 indicate a similar phenomenon.

Figure 2. Temporal change in TN concentration of four major rivers

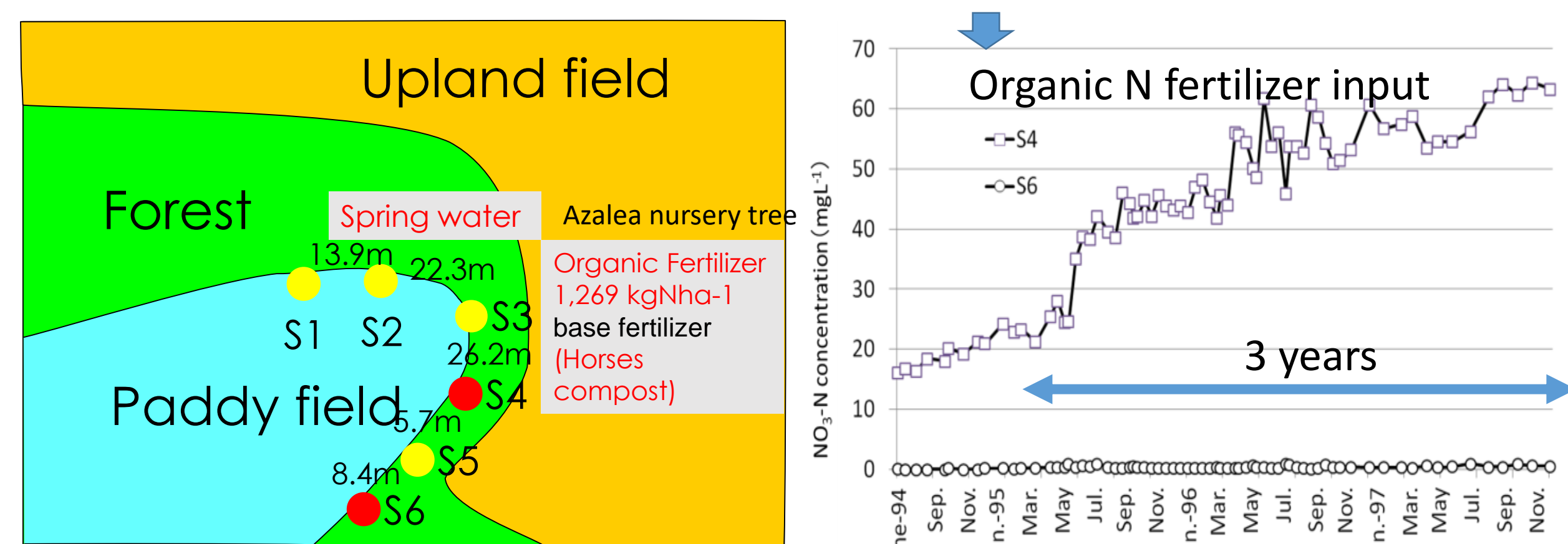


Figure 3. Outline of spring water monitoring site and change in NO₃-N Conc. from upland fields (S4) and forest (S6).

Investigation of soil cores from waste land

We carried out an investigation to reveal the dynamics of nitrogen infiltration into an upland field in the Hokota River basin. On top of this upland fields to about 30 years ago(**Figure 4.**), a swimming pool was built. This pool has been dismantled in 2011. Therefore, this period, rain, did not infiltrated downward. Three years later in 2014, undisturbed soil core samples were collected by a drilling rig to a depth of 10m, transported to the laboratory, and divided into eight depth increments: 0 - 115 cm, 115 - 290 cm, 290 - 325 cm, 325 - 536 cm, 536 - 640 cm, 640 - 737 cm, 737 - 830 cm, 830 - 1,000 cm (**Figure 5.**). The respective soil texture was heavy clay, heavy clay, sandy clay, loamy sand, sand, heavy clay, sand, loamy sand. The nitrogen concentration in soil water, and denitrifying activity was analyzed for each soil layer. Extraction of soil moisture was carried out in a centrifuge. If not be extracted in a centrifuge was carried out with water extraction.

at 1975 1980's-2011(photo at 1992) at present condition



Geospatial Information Authority of Japan.

Figure 4. Long-term land use change at the drilling investigation site



Figure 5. The drilling investigation in the waste land on February 20, 2014.

Investigation of soil cores from waste land

A high NO₃-N concentration was seen below 290cm, however above this NH₄-N, NO₂-N, NO₃-N and Org.-N concentration are all very low(**Figure 6.**). The annual infiltration rate in these soils is typically 1m. The depth to low nitrogen concentration at 290cm matches the period of **three years of infiltration at 1 m per year**. As a result, we concluded that residual soil nitrogen leached from upper soil layers into lower soil layers with rainfall. Further time and infiltration would be required to show the leaching of residual soil nitrogen deeper into the soil profile.

Denitrifying activity (acetylene block method (Hideshige et al, 1994)) was about 0.4 µgN/g-wet/day in the surface layer, about 0.1 µgN/g-wet/day from 115 - 640cm, and 0 µgN/g-wet/day in the lower layers. These value are 1 - 2 orders smaller than the value of the wetland soil (Kitamura et al, 2014). From this it was concluded that in the upland soil denitrification does not occur, and hence changes in residual soil nitrogen could be due only to the action of rainfall and infiltration.

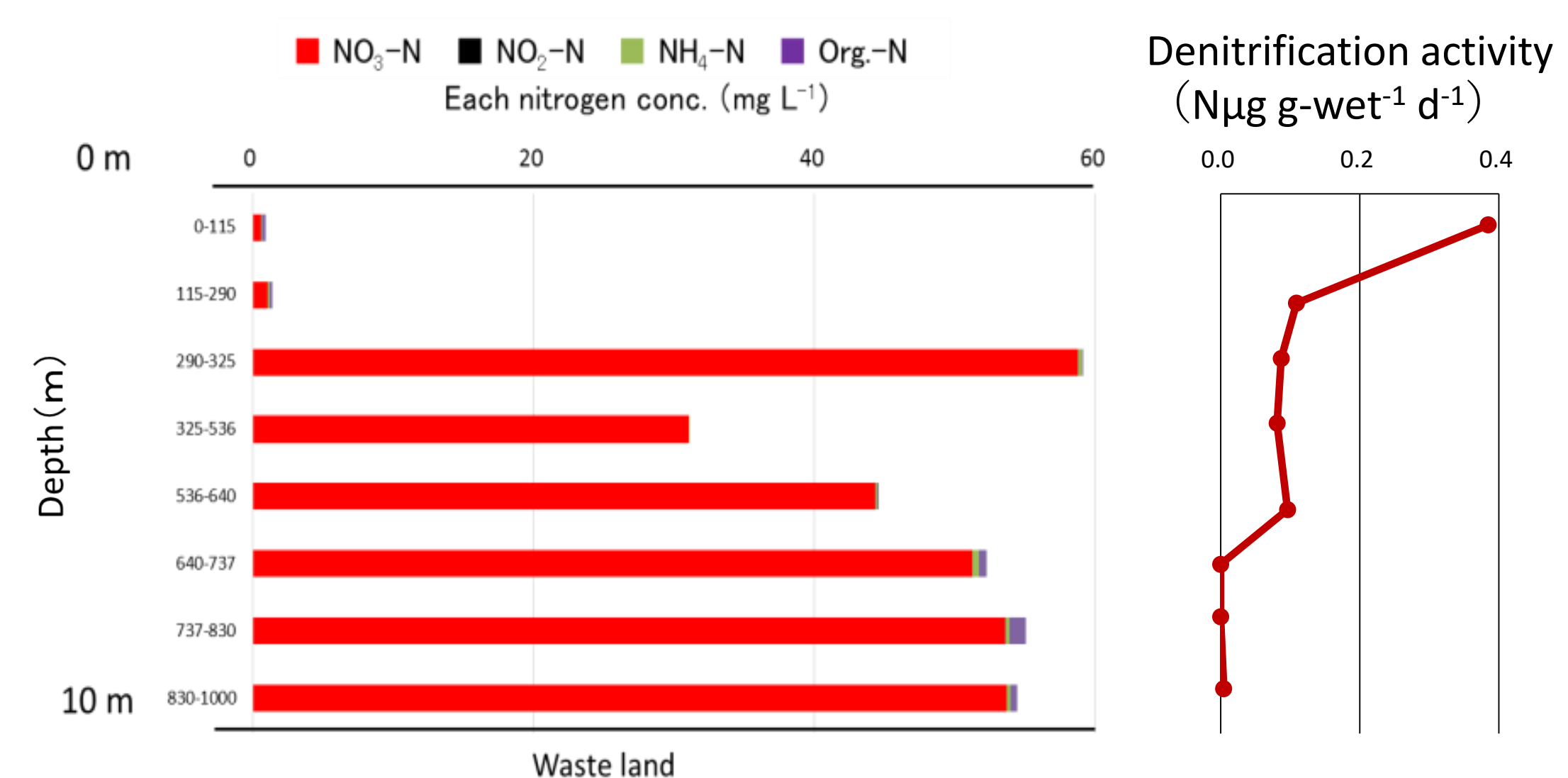


Figure 6. The Vertical distribution of each nitrogen conc. and the denitrification activity in soil pore water

Conclusion

We investigated nitrogen dynamics in an agricultural area where nitrogen concentration of river and spring waters is high. We concluded:

1. Livestock waste or organic fertilizer is a potential cause of nitrogen pollution.
2. Nitrogen infiltration following the application of organic forms of nitrogen (manure) has a time lag.
3. Nitrogen movement from upland field soils can be driven by rainfall.

Chemical fertilizer is often considered the major source of nitrogen pollution in Japan. However, an overuse of organic forms of nitrogen (manure) may also exacerbate nitrogen pollution. Farmers applying excessive amounts of nutrients in an organic form may contribute significantly over longer time periods because of the slow decomposition of manure. The Japanese government has been advocating conservation measures such as a reduction in the use of chemical fertilizers and chemical synthetic pesticides. As a result, organic forms of nutrients were believed to be good for the environment and less harmful than chemical fertilizers. However, incorrect application of nutrients in any form may contribute to nitrogen pollution. This study suggests that organic forms of nitrogen (manure) may be a significant contributor to nitrogen contamination. A detailed investigation of fertilizers and nitrogen pollution will follow this study. We also propose further work investigating methods to reducing nitrogen contamination from the residual soil nitrogen that now exists in upland fields and will continue to supply high nitrogen levels into waterbodies for many years.

A balance of organic fertilizer and chemical fertilizer is needed.

References

- Hideshige TODA et al. (1994), Nitrate Disappearance in an Irrigation Pond, Jpn.J. Soil Sci Plant Nutr., 65, 266-273. (in Japanese)
- Kuroda H (2013). The subject of the water quality conservation about agriculture, 705-708, Water, Land and environmental engineering Vol.81, No.9. (in Japanese)
- Tatsumi KITAMURA et al. (2014), Spatial Distribution of Denitrification Activity and Effects of Water Temperature and Nitrate Concentration on Denitrification in the Sediments of the Lake Kasumigaura, Journal of Japan Society on Water Environment Vol.37, No.6, pp.265-271. (in Japanese)

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