SPATIAL DISTRIBUTION OF NITRATE-NITROGEN IN KUMAMOTO'S RIVER BASIN

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1. INTRODUCTION

Nitrate-nitrogen (NO_3-N) contamination in water has become a critical issue in many countries around the world including Japan. During the last two decades, there has been an upward tendency in the level of NO_3-N in many areas in Japan due to intensive use of nitrogen-based fertilizers in agriculture (Kumazawa, 2002). It has become a critical issue especially for the regions that depend on its groundwater resources for water supply such as Kumamoto. Kumamoto is in the southwest part of Japan and is mainly an agricultural land. It is famous for its pristine groundwater which is used for majority of its water supply (Hashimoto, 1989). Increasing concentration of NO_3-N has been noticed in Kumamoto's water in recent years which can have harmful effects on health and environment. The concentration of NO_3-N varies according to location and ground water flow. It is assumed that toxic elements (e.g. fertilizers) might have infiltrated into the ground water and raised the level of NO_3-N in Kumamoto's water.

2. OBJECTIVES

According to the background research for development of WHO drinking water guidelines (2011), nitrate can reach both surface and ground water from many sources including agricultural activities (i.e. excess use of nitrogenous fertilizers and manures), wastewater treatment and oxidation of waste products etc. In Kumamoto, intensive use of nitrogenous fertilizers and manures in agricultural work is thought to be the main reason behind increasing level of NO_3-N in water (Hirohata et al, 1999; Kumazawa, 2002; Tomiie et el, 2011). The objectives of this research were to verify the level of NO_3-N in Kumamoto's water and to understand the present status of nitrate-nitrogen contamination in Kumamoto.

3. METHODOLOGY

3.1 Field observation

Field observations were carried out two times in Kumamoto: first time on August 10, 20 and 21; and the second time on December 19 and 20 of the year 2018. During the first field observation in August, the observation locations included Shimodate era bridge, Kurodo river, Kabutomushi park etc. in and around Aso city and Kumamoto city (shown in Fig. 1). Total 26 samples were collected from different locations to get an idea about the spatial distribution of NO_3-N in the water. The second field observation was also carried out in Aso city and Kumamoto city on December 19, 20 in 2018 with slightly different observation points. As rivers play a significant role in carrying nutrients to the sea, sampling points were set up along the length of the Shirakawa river up to the coastal area (shown in Fig. 1). Total 26 samples were collected this time as well.

3.3 Analyses for NO_3-N

After collecting the samples and freezing them, they were carried to Tokai University's Shonan Campus for analyses and were analyzed for NO_3-N. Dissolved inorganic nutrient (NO_3-N) was determined spectrophotometrically following HACH's principle using portable colorimeters (HACH DR/890): cadmium metal reduces nitrates present in the sample to nitrite. The nitrite ion reacts in an acidic medium with sulfanilic acid to form an intermediate diazonium salt which couples to chromotropic acid to form a pink-colored product (HACH Procedures Manual; pp 327).

4. RESULTS

The NO_3-N distribution data collected from the field observations in August 2018 and December 2018 are shown in Fig. 1. During the first field observation, the highest concentration of NO_3-N (1.95 mg/L) was detected in Kumamoto city area (32°53'31.3"N 130°59'47.9"E). Among the other sampling locations, 0.75, 0.75, 0.45 and 0.30 mg/L of NO_3-N were detected in some areas whereas most other locations showed a nitrate-nitrogen level below 0.30 mg/L. During the field observation in December 2018, the highest level of NO_3-N (0.9 mg/L) was seen in the village of Minamiaso in Aso city (32°49'15.8"N 131°04'19.5"E). Some of the other locations showed 0.85, 0.55, 0.45, 0.35 and 0.32 mg/L of NO_3-N.

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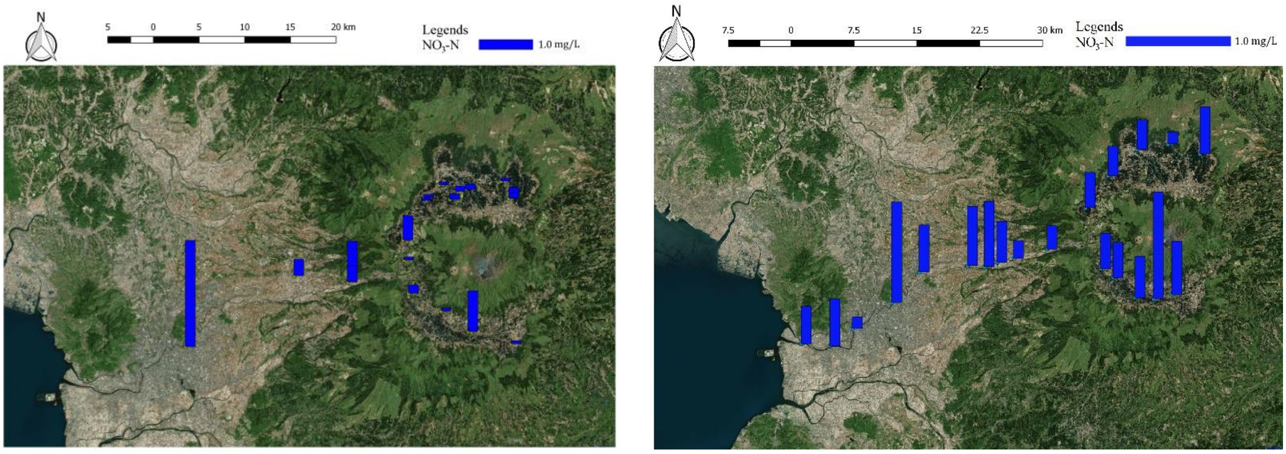

Fig. 1: Spatial distribution of NO_3-N in August 2018 (left) and December 2018 (right).

5. DISCUSSIONS

From the data gathered during the field observation carried out in August 2018, it was noticeable that the concentration of NO_3-N was especially high in the west side of Kumamoto (near the coast). Comparing the results of the field observations, it could be noted that the highest concentration of NO_3-N (0.9 mg/L) seen in December 2018, was observed near the location that showed 0.75 mg/L of NO_3-N in August 2018. There was significant rise in the level of NO_3-N in Aso city area during December. According to Tomiie et al (2009), the bed rock in Kumamoto city is mainly consisted of pre-Aso volcanic rock and the most prominent groundwater resource is the second aquifer flowing in the lava bed which is not covered by impermeable layer in all places, making it vulnerable to easy infiltration of foreign chemicals. Surplus nitrate resulted from excess fertilization, can readily move to the groundwater (USEPA, 1987; van Duijvenboden & Matthijsen, 1989). Under aerobic conditions, nitrate can percolate in relatively large quantities into the aquifer when all NO_3-N is not taken up by plant materials and when the net movement of soil water is downward to the aquifer (WHO, 2011). The west part of Kumamoto showed very negligible amount of NO_3-N with zero amount in southwestern areas in 2006 (Tomiie et al, 2009). However, during the field observations carried out for this research, high amount of NO_3-N was detected in west Kumamoto, proving the progressive increase of NO_3-N concentration in Kumamoto's water. NO_3-N contamination in groundwater has been a problem for some other parts of Japan including Gifu prefecture where it had reached 27.5 mg/L in 1974 (Kumazawa, 2002). However, steady decrease in the nitrate-nitrogen level in Gifu prefecture's water has been noticed after fertilizer use has been put under control. Varying amount of NO_3-N over time could be related to the farming season, which crops are being produced, how much fertilizer is being used, amount of rainfall, groundwater flow, river flow and groundwater level etc.

6. CONCLUSIONS

Nitrate-nitrogen concentration has gradually increased in many European countries over the last few decades; especially having doubled in some areas in the last 20 years (WHO, 2011). NO_3-N contamination in groundwater and surface water have become a pressing issue for Japan as well. According to WHO (2011), increasing use of artificial fertilizers, the disposal of wastes (particularly from animal farming) and changes in land use are the main factors responsible for the progressive increase of NO_3-N. Increasing levels of NO_3-N in water can cause a number of adverse health effects and ecological effects. Therefore, the upward tendency of NO_3-N in the water of Kumamoto should not be taken lightly.

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