Watershed Characteristics and Water Quality in Suburban River in Tokyo: Asakawa River

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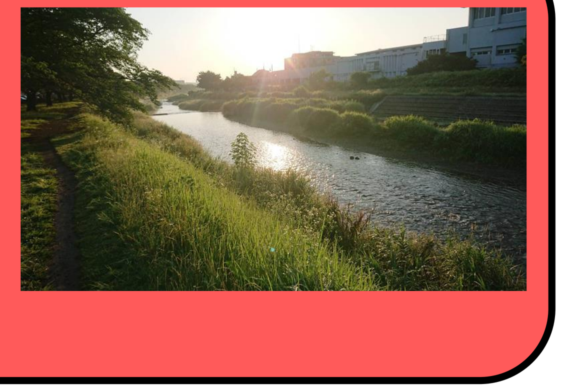
Keywords: Water quality, Electric conductivity, Cluster analysis, Septic tank, Nitrogen saturation



I Introduction

Many Japanese rivers were polluted due to economic growth in the past. Although many have since been improved, there are still some areas where local pollution remains. In the Asakawa River, a suburban river in Tokyo, there are issues with water quality, such as wastewater problems or substance runoff from the forest ecosystem. To understand the water quality and characteristics of the river basin, comprehensive studies combining various methods are required, not only field surveys. This study aims to clarify the characteristics of the Asakawa River watershed based on the results of field surveys, water quality analysis, and statistical analysis using the obtained results.

II Region Overview

Asakawa Riv. is one of the tributaries of the Tamagawa Riv., which is a major river that flows through Tokyo. It has its source in Hachioji City, the largest city in western Tokyo, and flows through the city before joining the Tamagawa Riv. in Hino City. Asakawa Riv. is considered the most urbanized tributary of the Tamagawa Riv. While the upper reaches are covered with forests, the lower reaches are characterized by urban areas. The geology of the upper reaches consists of accretionary wedge deposits, while the lower reaches are composed of loam, which is the volcanic ejecta layer. Since it is difficult to lay sewage pipes in the upper area, septic tanks have been installed.

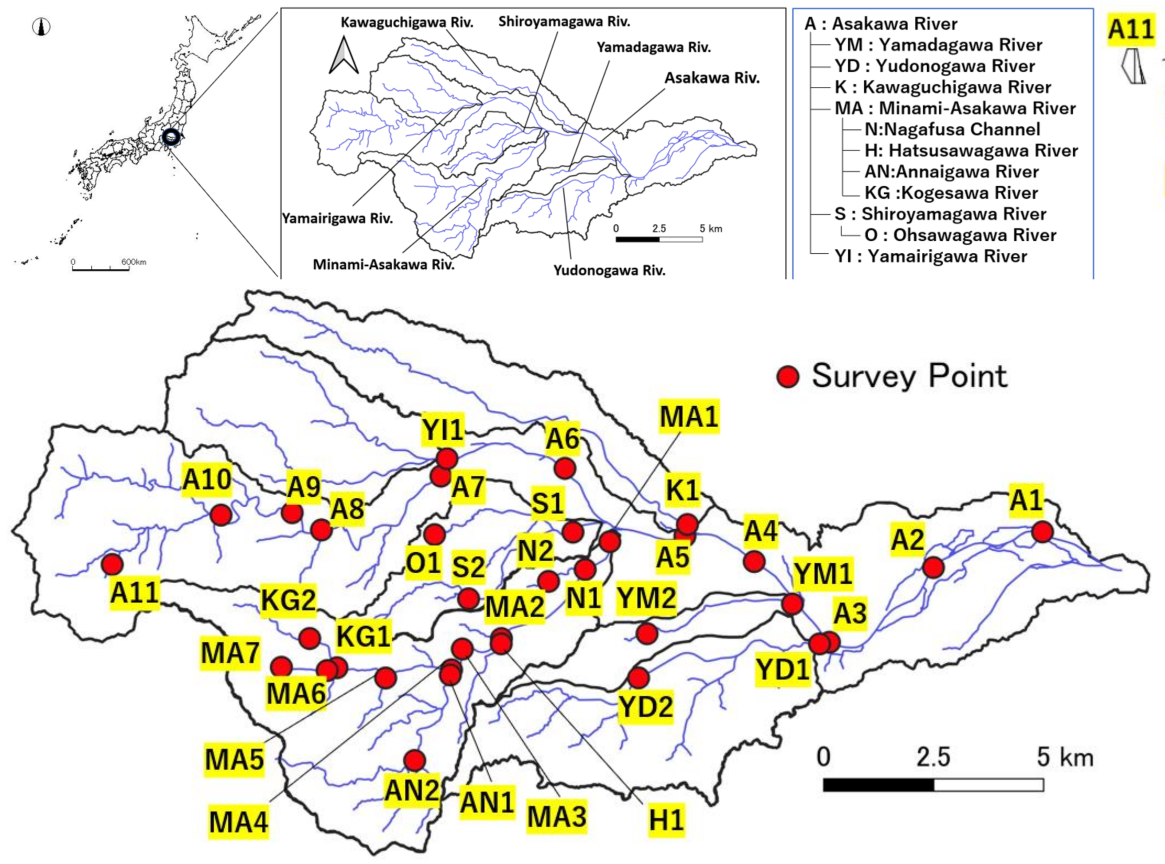
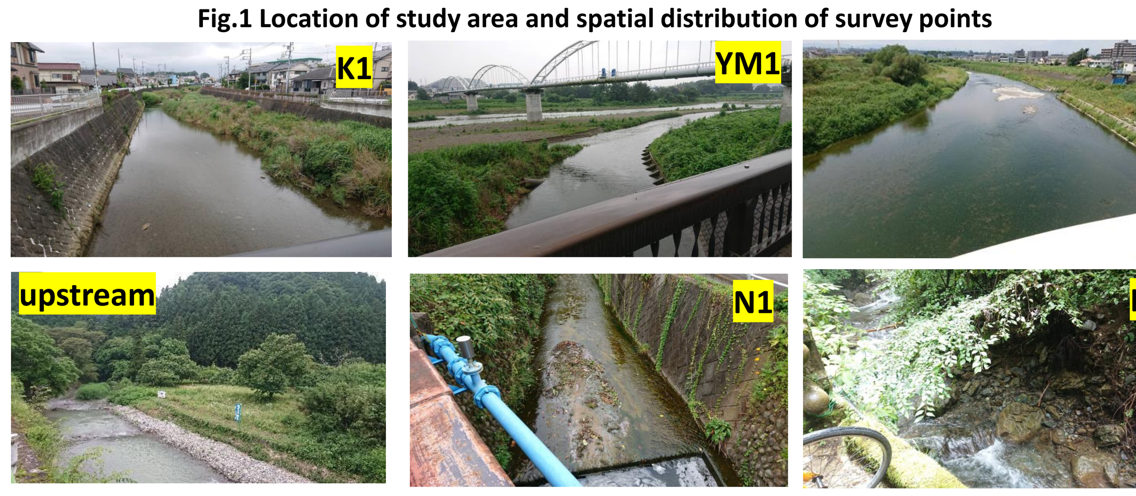


Fig.1 Location of study area and spatial distribution of survey points



Picture.1 Survey points and study area

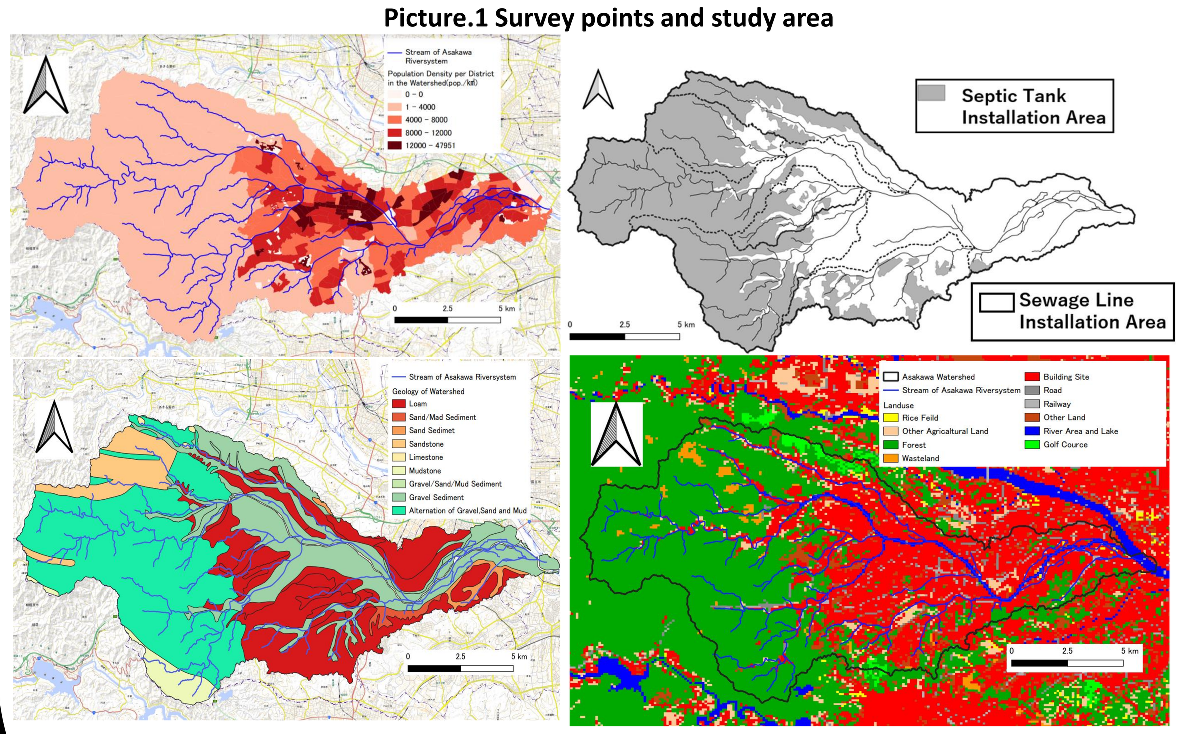


Fig.2 Spatial distribution of watershed indexes

III Research method

1. **Field survey**
Monthly survey at 34 points in the Asakawa River watershed (EC and pH)
2. **Water quality analysis**
The major dissolved components analysis(Na, K, Ca, Mg, Cl, HCO_3, SO_4, NO_3) using ion chromatography.(June and October 2020, January and September 2021) TOC, COD, NH_4, and NO_2. analysis (September. 2021)
3. **Watershed indexes calculation using GIS**
Extract watersheds for each of the 34 survey points using DEM and calculated 24 watershed indexes, including land use, geology, population, and sewage treatment status, within each watershed
4. **Cluster analysis**
Making groups using the Ward method for both the water quality indexes and watershed indexes.
5. **Comparison with previous studies**
EC value comparison in each tributaries

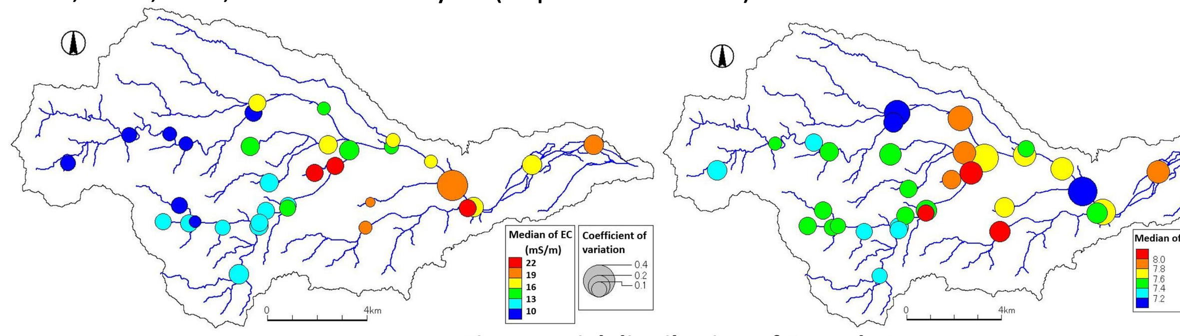


Fig.3 Spatial distribution of EC and pH

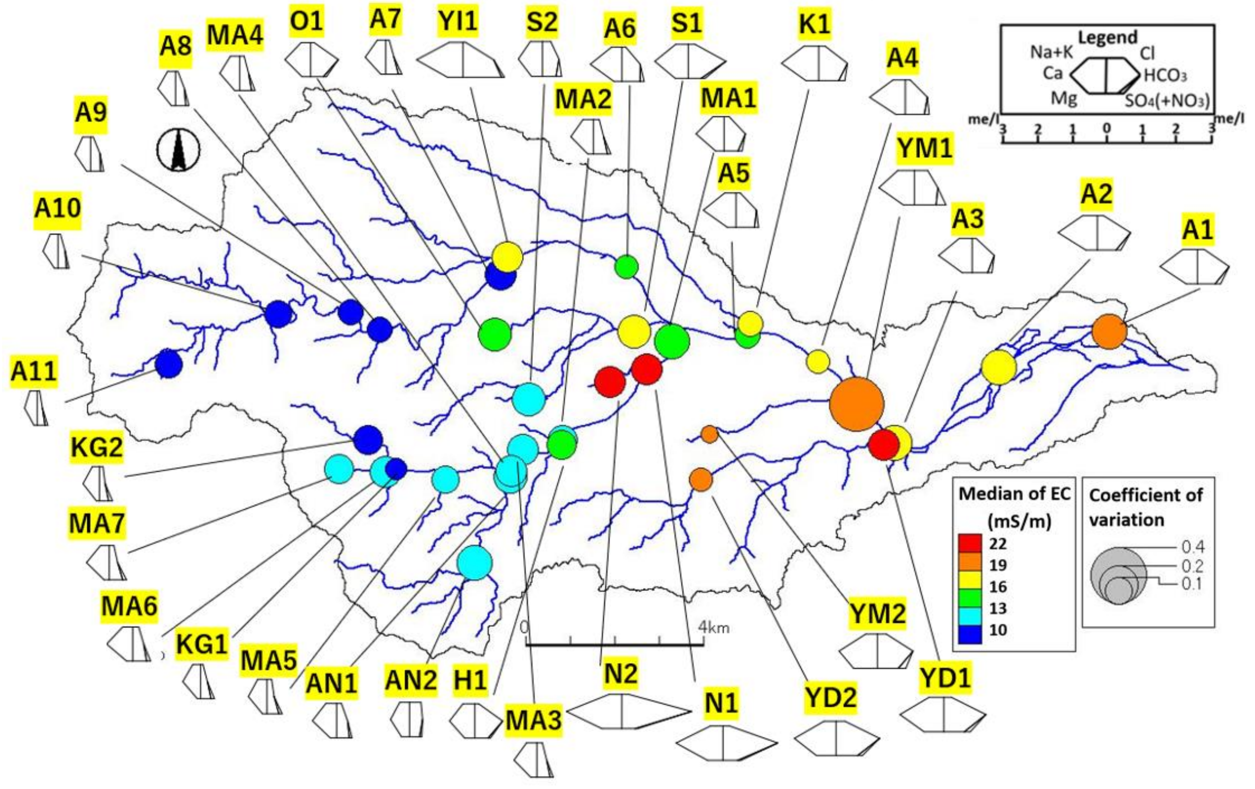


Fig.4 Median of EC and water quality components

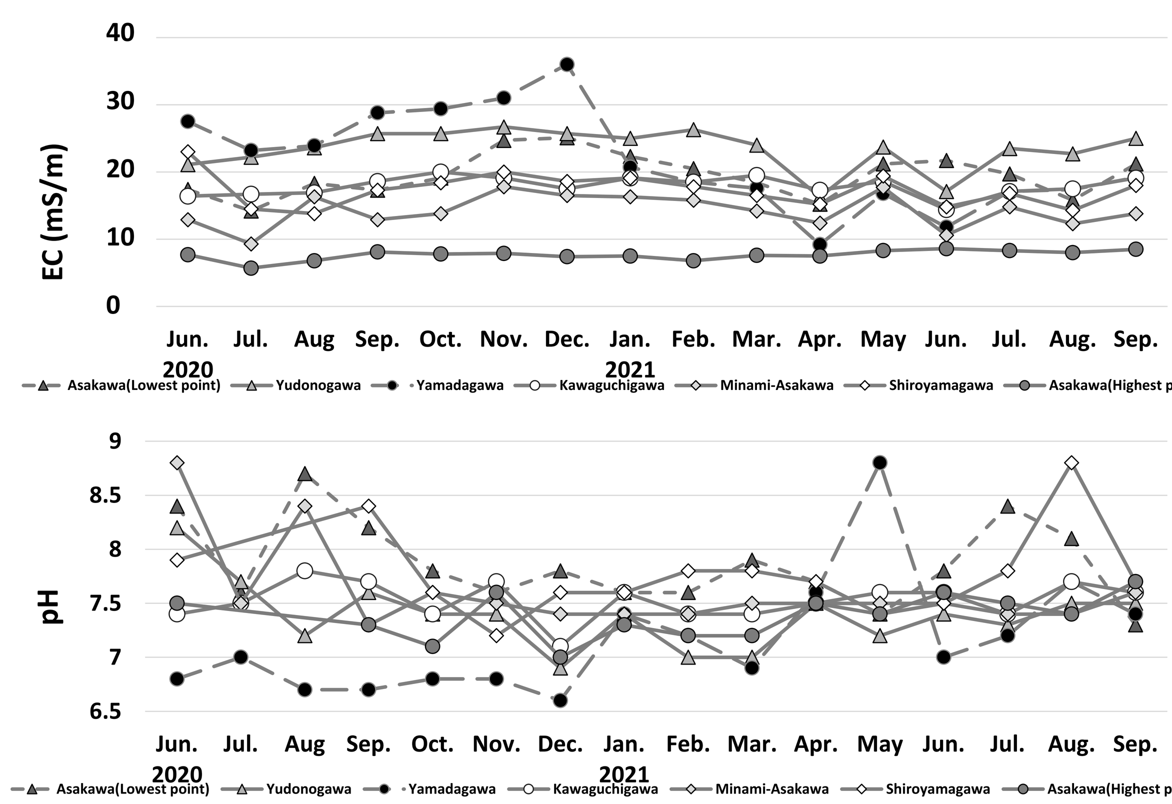


Fig.5 Seasonal trends in EC and pH

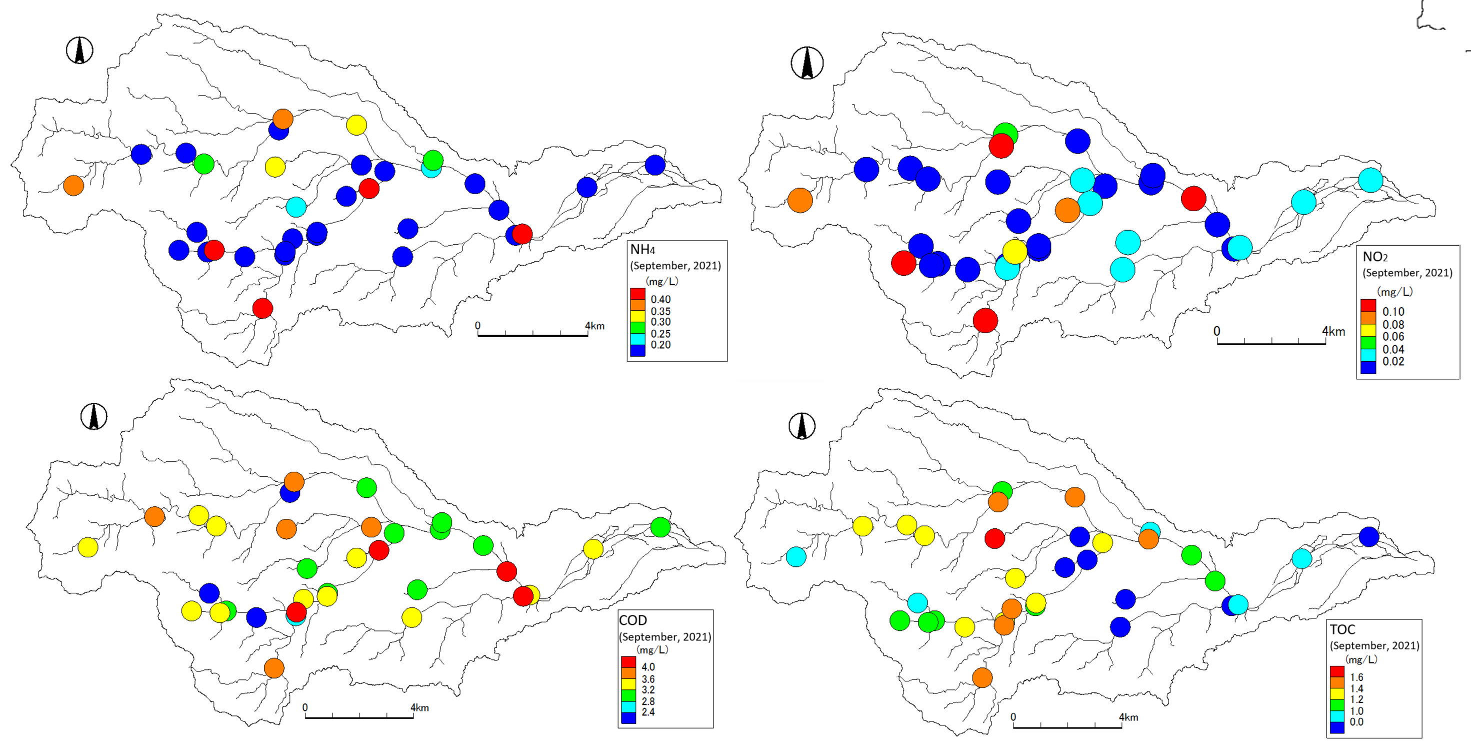


Fig.6 Spatial Distribution of NH4, NO2, COD and TOC (September, 2021)

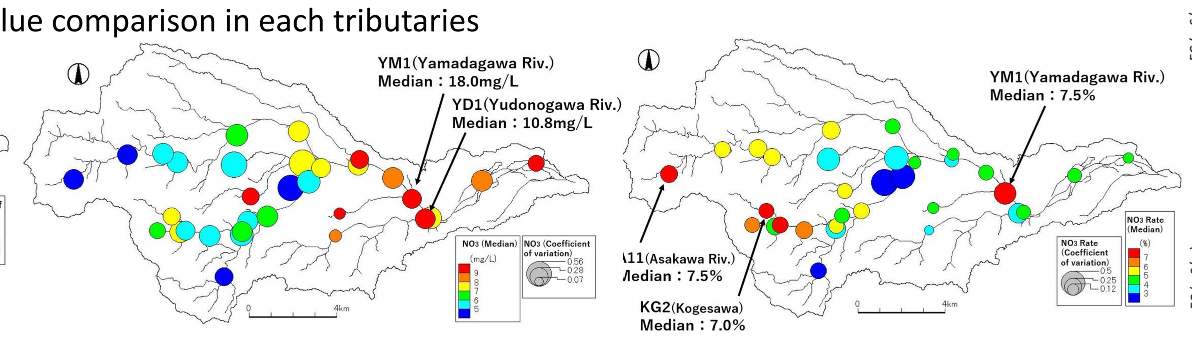


Fig.7 Spatial distribution of NO3 and NO3 rate

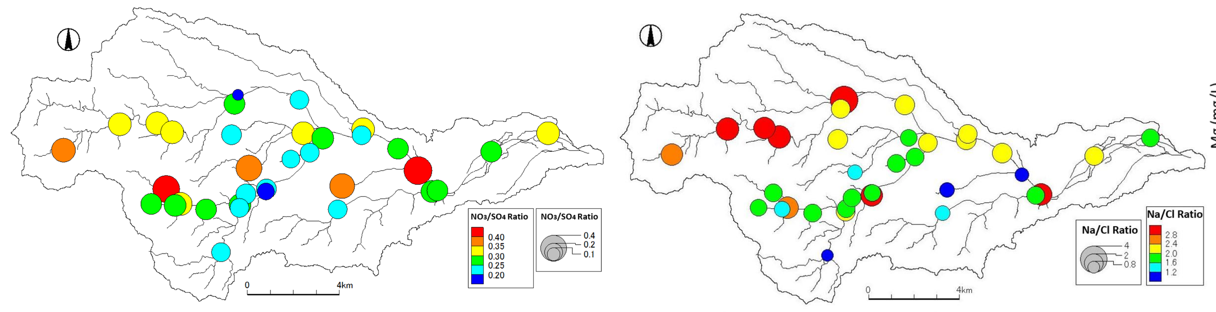


Fig.8 Spatial distribution of NO3/SO4 ratio and Na/Cl ratio

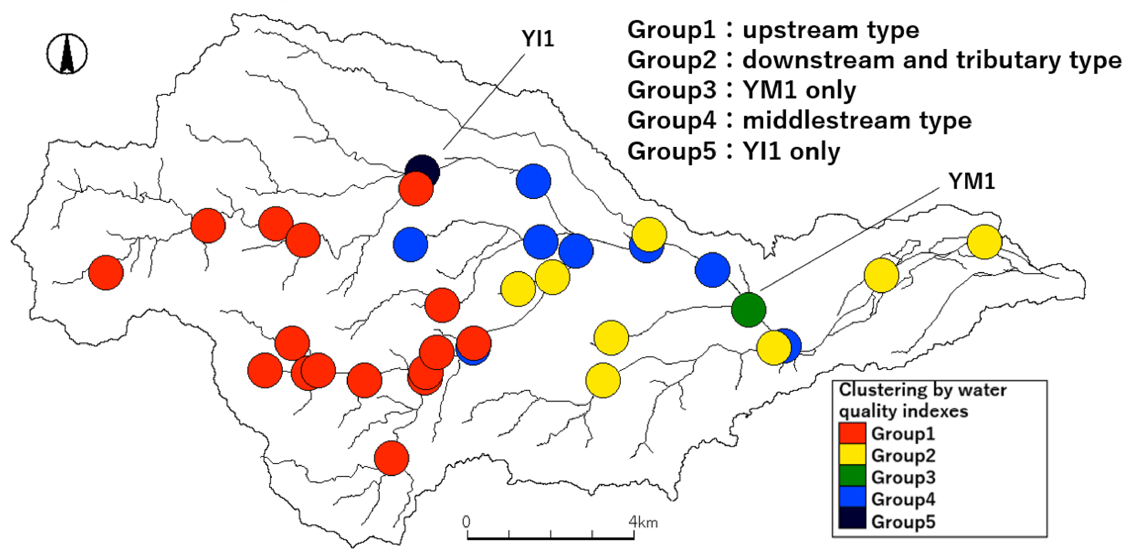


Fig. 9 Result of cluster analysis using ward method (water quality indexes)

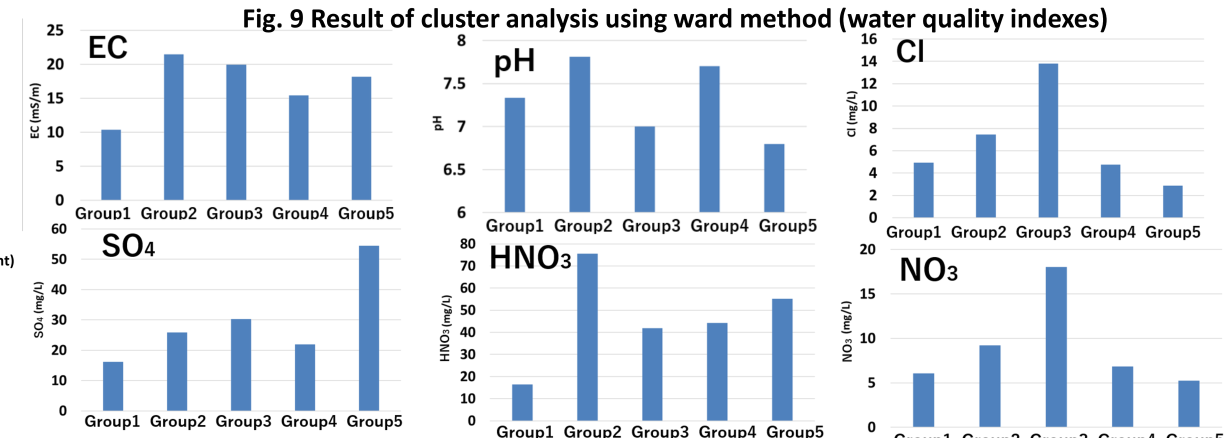


Fig.10 Average of water quality indexes in each cluster

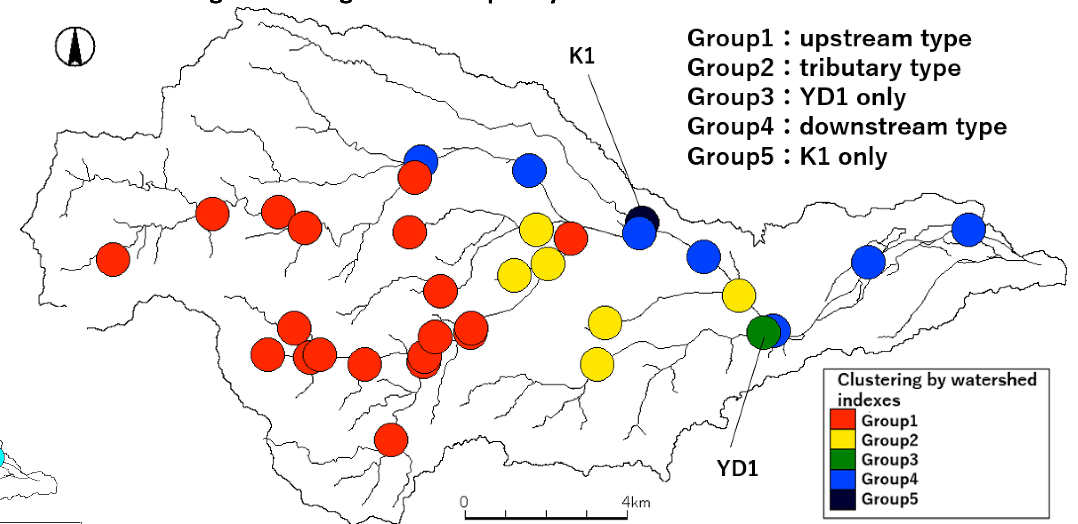


Fig.11 Result of cluster analysis using ward method (watershed indexes)

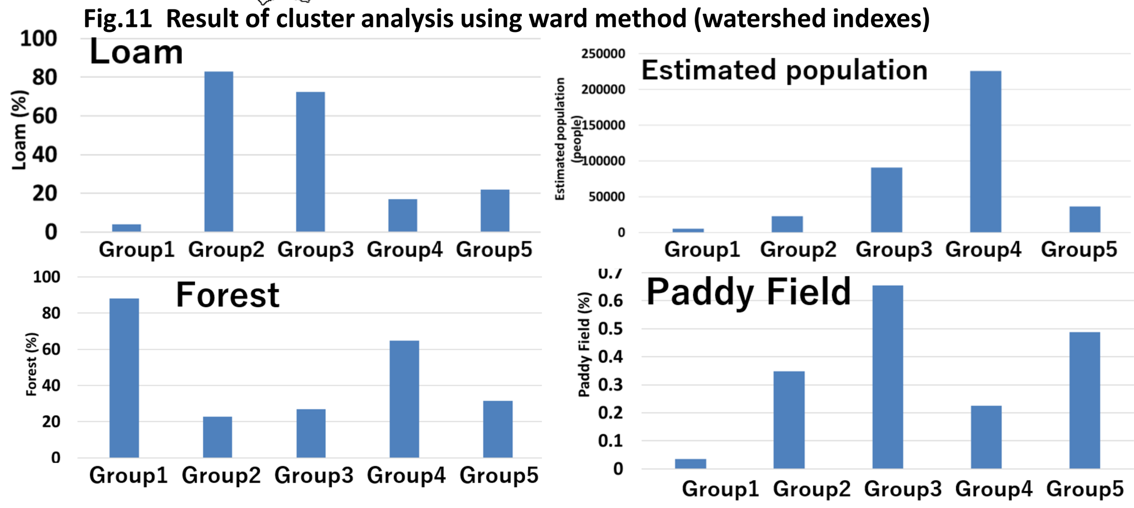


Fig.12 Average of watershed indexes in each cluster

Table 1 Correlation coefficient between water quality indexes and watershed indexes

	EC	pH	Na	K	Ca	Mg	Cl	HCO_3	SO_4	NO_3
Loam rate	0.86	0.51	0.61	0.47	0.77	0.86	0.58	0.85	0.32	0.53
Sand and mud deposits rate	0.40	0.02	0.40	0.30	0.31	0.35	0.16	0.28	0.20	0.26
Sandy sediment rate	0.23	0.10	0.42	0.39	0.24	0.14	0.11	0.15	0.21	0.31
Sandstone rate	-0.01	-0.32	0.05	0.26	0.17	0.01	-0.40	-0.03	0.60	-0.15
Limestone rate	0.17	0.05	0.34	0.31	0.19	0.12	0.07	0.11	0.19	0.27
Mudstone rate	-0.24	-0.18	-0.10	-0.20	-0.25	-0.19	0.27	-0.25	-0.22	-0.30
Gravel, sand, and mud deposits rate	0.37	-0.02	0.35	0.25	0.28	0.34	0.15	0.26	0.18	0.24
Gravel deposits rate	0.48	0.20	0.70	0.71	0.47	0.33	0.26	0.33	0.43	0.49
Conglomerate, sandstone, mudstone alternation rate	-0.90	-0.41	-0.80	-0.68	-0.84	-0.87	-0.65	-0.83	-0.52	-0.52
Paddy Field rate	0.40	0.34	0.37	0.26	0.35	0.40	0.21	0.38	0.22	0.23
Farming Land rate	0.56	0.22	0.62	0.59	0.54	0.47	0.30	0.43	0.48	0.40
Forest rate	-0.88	-0.44	-0.79	-0.69	-0.80	-0.85	-0.60	-0.82	-0.47	-0.68
Waste Land rate	0.15	-0.08	0.31	0.32	0.23	0.14	-0.04	0.10	0.40	0.16
Other Field rate	0.46	0.40	0.25	0.10	0.43	0.43	0.12	0.62	0.06	0.03
Building Site rate	0.84	0.41	0.73	0.67	0.74	0.81	0.65	0.74	0.42	0.71
Traffic Route rate	0.34	-0.06	0.50	0.48	0.20	0.36	0.59	0.11	0.28	0.72
River and Lake rate	0.37	0.23	0.50	0.60	0.40	0.17	0.00	0.20	0.40	0.28
Septic tank installation area rate	-0.88	-0.44	-0.78	-0.70	-0.79	-0.85	-0.64	-0.79	-0.46	-0.69
Sewage line installtion area rate	0.88	0.44	0.78	0.70	0.79	0.85	0.64	0.79	0.46	0.69
Estimated population	0.35	0.28	0.49	0.53	0.34	0.16	0.11	0.22	0.25	0.28
Estimated population density per watershed	0.82	0.40	0.69	0.63	0.72	0.79	0.64	0.75	0.37	0.69
Mean slope degree	-0.90	-0.46	-0.80	-0.68	-0.82	-0.88	-0.62	-0.85	-0.47	-0.63
Elevation of survey point	-0.74	-0.37	-0.82	-0.76	-0.71	-0.62	-0.41	-0.60	-0.55	-0.51

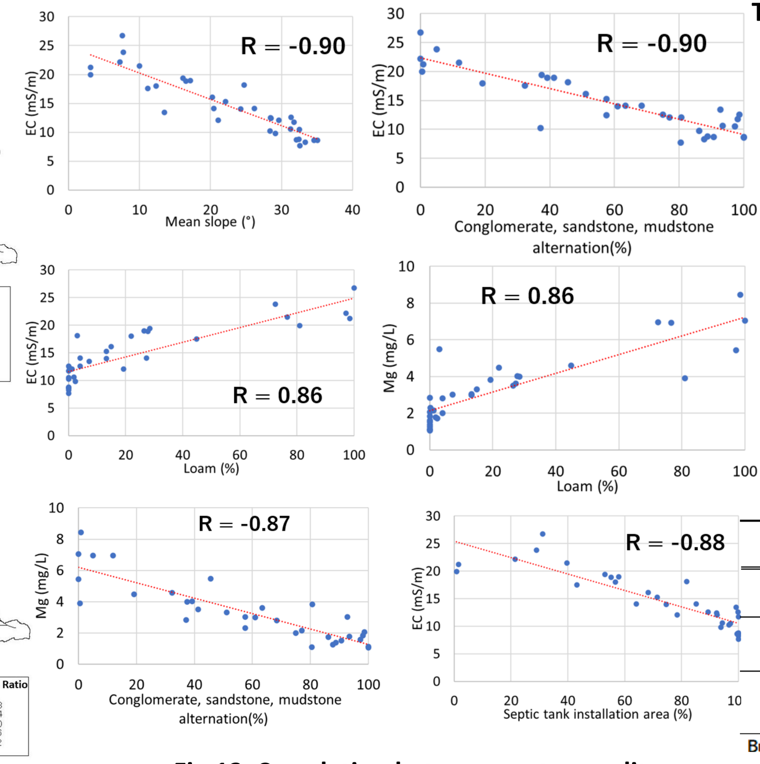


Fig.13 Correlation between water quality index and watershed index

Table 2 Electric conductivity comparison among previous studies and this study

Study	Value	Minami-Asakawa Riv.	Yudono-gawa Riv.	Kawaguchi-gawa Riv.	Yamairi-gawa Riv.	Shiroyama-gawa Riv.
Ogura(1980)	range (mS/m)	17 ~ 36	-	-	-	-
	mean (mS/m)	23.7	-	-	-	-
	(max+min)/2 (mS/m)	26.5	-	-	-	-
Ohta and Ohmori(2004)	range (mS/m)	21.6 ~ 30.5	27.5 ~ 28.0	26.5 ~ 27.0	18.4 ~ 20.8	22.2 ~ 23.0
	(max+min)/2 (mS/m)	26.2	27.7	26.7	19.6	22.6
This Study (2020-2021)	range (mS/m)	9.3 ~ 17.8	16.3 ~ 26.7	14.4 ~ 20.0	15.8 ~ 21.8	13.8 ~ 23.0
	mean (mS/m)	14.2	23.4	17.9	18.4	17.3
	(max+min)/2 (mS/m)	13.5	21.5	17.2	18.8	18.4

Table 3 Area and Rate in Septic Tank Installation Area and its Building Site per Tributary in 2016

	Asakawa Riv.	Minami-Asakawa	Yudono-gawa Riv.	Kawaguchi-gawa Riv.	Yamairi-gawa Riv.	Shiroyama-gawa Riv.	Yamada-gawa Riv.
Watershed Area(km²)	160.31	30.52	19.40	16.43	15.20	9.71	5.14
Septic Tank Installation Area(km²)	82.18	22.74	5.62	9.27	12.44	4.24	0.03
Ratio of Septic Tank Installation Area(%)	51.26	74.51	29.00	56.43	81.82	43.62	0.58
Building Site Area in Septic Tank Installation Area(km²)	9.27	1.53	2.58	0.93	0.43	0.82	0.00
Building Site Ratio in Septic Tank Installation Area(%)	11.28	6.72	45.89	9.99	3.45	19.39	0.00

IV Results and Discussion

1. **Field survey (Fig. 1)**
・EC and pH values were low at upper stream and high at downstream.
→influence of ground water, water-rock interaction or waster water
・High coefficient of variation at YM1.
(because of drainage inflow from sewage treatment plant)

2. **Water quality analysis (Fig. 4)**
・Cations were high at upstream and low at downstream.(water-lock interaction)
・SO_4 was high at YI1 due to inflow of ground water.
・NO_3 were high at Yudonogawa Riv.(YD), Yamadagawa Riv.(YM) or Kawaguchigawa Riv.(K).
・NO_3 rate were high at upstream.(due to nitrogen saturation)
・NH_4 and NO_2 were also high at upstream.(due to septic tank effluent)
・COD were high at tributaries

3. **Watershed indexes calculation using GIS**
・EC and mean slope of watershed showed highest correlation.
→EC value were low at upstream and high at downstream.
・Loam rate were high at tributaries and downstream watershed.

4. **Cluster analysis (Fig. 9 - 12)**
(1) Clustering by water quality indexes
・YM1 and YI1 classified as unique points.→low pH, high SO_4, NO_3 and Cl
・HCO3 were high at meddlestream points(due to inflow of groundwater)
・Water quality of downstream were similar with tributary's.
→Influence from tributary were high.
(2) Clustering by watershed indexes
・YD1 and K1 classified as unique points.→high paddy and farming field rate
・The overall trend is similar with water quality clustering.

5. **Comparison with previous studies**
・EC values decreased in all tributaries. (due to installation of sewage line)
・Not much changed in Yamairigawa Riv. and Yudonogawa Riv.
→Yamairigawa Riv. had little land use change.
→Building site rate in septic tank installation area is high at Yudonogawa Riv.

V Conclusion

From this study, four issues in the Asakawa Riv. watershed were identified: the pollution caused by septic tank effluent in upper stream, nitrate runoff due to nitrogen saturation in the forest ecosystem upstream, pollution caused by the inflow of sewage treatment plant effluent into the small tributary named Yamadagawa Riv. and pollution caused by domestic wastewater from the Yudonogawa Riv. watershed which locates in southern part of its basin. To solve these problems, improvement of the watershed environment is required.

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