Water quality survey using aquatic organisms as environmental education and regional environmental management

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環境教育としての水生生物を用いた水質調査と地域環境マネジメント

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要約

本研究では、ベック津田β法、汚濁指数法を用いて、長野県飯田市阿智村に流れる阿智川・周辺の水辺を拠点とし、計測方法・考察を例に、地域マネジメントに寄与するべく水質調査の学習例案を提案したものである。実験は、阿智川その他 3 地点を拠点にし、同時期・時間・採集方法における水生生物を指数に用い、それぞれの計測指数に当てはめることで数値を測定した。調査では、調査地において 6 月に生育している水生生物を主な判断材料とし、ピンセットで捕獲できる大きさの個体のみを使用した。その結果、砂防ダム前を拠点とした川で 2 種の判定方法共に、水質は貧腐水性の数値が計測できた。ダム前という事で酸素の供給が絶えず行われており、林冠も見られ有機物の供給も豊富であると判断できた。また、底質環境からも多様性を高めている大きな要因と判断でき、水質階級 I のカワゲラであるキカワゲラほか多数採集することができた。さらには、今回のこの調査結果をもとに、阿智川周辺の生物を基調とした水質判断シートを作成し、昼神温泉郷の旅客に配布することで人々が生物に興味を持つ機会を提供した。環境学習としての川・水質の保全への関心を高めるというその学習目的を地域環境マネジメントにも活用することが出来た。

Key words
Beck-Tsuda-βMethod, Pantle-Buck Method, Achi River, Surveying aquatic organisms, environmental management

1. Introduction

Surveying aquatic organisms to measure water quality is carried out by elementary school students through the Ministry of Environment as part of their education during the summer vacation period. There are many experiences such as this for elementary students. When measuring water quality, we use a pack test/water quality measuring instrument (AZ-RWAZ-RW/ Kyoristu chemical-check lab), but the methods used to judge water quality for the aquatic organisms are not widely used. The aquatic organism survey is used to identify the pollution level of a river by examining the number and type and of aquatic organisms inhabiting the river. According to the Ministry of Environment, “this survey is mainly conducted by elementary school students and organizations throughout Japan. The Ministry of the Environment and the Ministry of Land, Infrastructure and Transport have been conducting a nationwide biological survey since 1985” (National Institute for Environmental Studies, 2008). According to the Toyota City website, children who participated had an opportunity to understand the importance of protecting familiar natural environments by identifying the various organisms living in rivers near their homes (Toyota City, Environment Department, Environment Policy Division, 2018). Surveying aquatic organisms to check the local conditions as well as observing the local environmental changes after the survey can clarify the periodic changes in the environment across seasons and temperatures. From these follow-up results, it is also possible to improve future water quality, preserve aquatic life and improve diversity. In addition, the development of student curiosity and interest (especially elementary, middle school, and high school students) in their local environments will be a key factor in improving environmental technology in the future. The difference between past and present environments is remarkable; even in pristine mountain areas, we do not know if the mixture of chemical substances will remain. Therefore, if it is possible to conduct a simple aquatic organisms survey with tourist families within and outside the prefecture, it is possible to deepen the interest of people of all ages. Also, since information of the “water quality” of hot springs in town is a tourist resource, local business may also benefit from water quality survey.

2. Study method

We surveyed four sites (Figure 1): the back swamp of the AHIRU spa (R.1); the Achi river (R.2); the river in front of the erosion control dam (R.3); and the river next to the Achi Shrine (R.4). In terms of velocity, the Achi river was the fastest, fol-

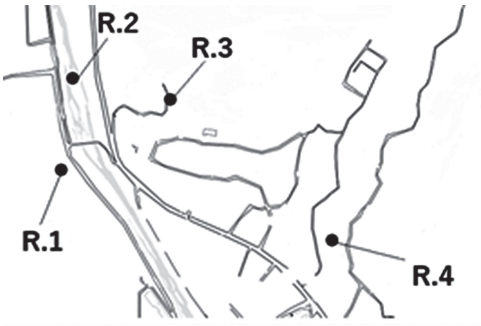

Figure 1: The four points surveyed

Notes: R.1: the back swamp of the AHIRU spa; R.2: the Achi river; R.3: the river in front of the erosion control dam; R.4: the river next to the Achi Shrine.
Source: Redrawn from Yahoo map. https ://map. yahoo. co.jp/maps.

lowed by the river in front of the erosion control dam, the river next to Achi Shrine, and the back swamp of the AHIRU spa. All four sites had coarse-grained organic matter (CPOM) and riparian forests, and the environment for living things was well-organized. In addition, there was evidence in the back swamp of the AHIRU spa suggesting that domestic wastewater had mixed with the water flow and the water quality had changed. We gathered data on the aquatic organisms present and identified all organisms to species level.

Next, we used a water quality kit to sample the water for four elements (NO_3^-, PO_4^{3-}, NO_2^-, NH_4^-).These are common elements in the water quality survey (Table 1).

We used two methods to judge aquatic organisms collected at the four sites. The first was the pollution index method, which can be an effective way to measure water quality if the number of occurrences of each captured species is between 1 and 3, the total occurrences multiplied by the water quality class can be calculated, and the family can identify the living aquatic organisms. In this study, two people gathered at a survey point for 1 hour and identified the species that were caught. Then, the number of occurrences and the pollution class were multiplied to indicate water quality. This was done twice at each of the four sites. In addition, the number of occurrences was calculated as that less than 10 is 1 value, 11 to 19 is 2 value, and over 20 is 3 value. The higher the pollution index, the “dirtier” the river as pollution has accumulated, while a lower number indicates a “clean” river. We then used the Beck Tsuda β method. In this method, organisms that cannot tolerate pollution are classified as “A”, and those that can tolerate pollution are classified as “B”. The formula 2A + B is used to judge the water quality. Discrimination between types of A and B organisms was made using an aquatic organism handbook (Karita, 2010, aquatic animal handbook) and monographs for this method, two people gathered at each survey point for 1 hour and identified the species that were caught. In this method, higher figures indicate “clean” rivers, while lower figures indicate “dirty” rivers. In addition, as pollution progresses

3. Results

The main organisms identified at the four sites are listed below. We captured about 800 individuals of 34 species: Shiro-heptageniidae mayflies *Ecdyonurus yoshidae Takahashi* (Ephemeroptera, Heptageniidae), which inhabits clean water with a relatively gentle flow rate, erumon-heptageniid mayflies *Epeorus latifolium Ueno* (Ephemeroptera, Heptageniidae), which inhabits water with a faster flow rate, and satsukihime-heptageniid mayflies *Rhithrogena tetrapunctigera Matsumura* (Ephemeroptera, Heptageniidae). In the slightly soiled water, there were clubtail dragonflies *Sieboldius albardae* (Odonata, Gomphidae), Golden-ringed dragonflies *Anotogaster sieboldii* (*Odonata, Cordulegastridae*), and Japanese freshwater snails *Semisulcospira libertina* (Cerithioides, Semisulcospiridae). In the dirty water, there were sludge worms *Tubifex tubifex* (Oligochaet, Naididae), waterlouse *Asellus aquaticus* (Isopoda, Asellidae), and leeches *Hirudinea* (Rhynchobdellida, Glossiphoniidae). There were many species of Ephemeroptera and Plecoptera, and larvae that could not be identified. The species that lived in the dirtiest site were leeches and waterlouse; however, since Dobson flies *Protohermes grandis* (Megaloptera, Corydalidae) were also found at this site, it was judged to be relatively clean. The results of the pack tests showed that there were no major differences between sites, and the low levels of ammonium nitrogen and nitrite nitrogen suggested it was a clean river, even upstream. The water quality in front of the erosion control dam was the highest, but the Achi river and the river next to Achi Shrine also had high water quality. The back swamp of AHIRU spa had the lowest water quality of the four sites, because it included domestic wastewater. However, this site was still relatively clean, with only a little pollution. Even with the β method, the river in front of the erosion control dam had the highest water quality. “However, even though this method has the same water quality condition, since the evaluation changes from the difference in the environmental conditions of

Table 1: Pack test results

	NO_3^-	PO_4^{3-}	NO_2^-	NH_4^-
The duck back of the AHIRU spa	0.3	0.030	0.005	0.1
The Achi river	0.2	0.005	0.005	0.1
The river in front of Sabo dam	0.2	0.020	0.005	0.2
The river next to the Achi Shrine	0.5	0.020	0.005	0.2

the bottom sediment, there is a point that the conditions have to be unified" (Hatta, 1980). The following is a summary of the number of occurrences of aquatic organisms at each of the four sites. At the back swamp of AHIRU spa, we did not find either Plecoptera or Ephemeroptera, but we found large numbers of fishworms, leeches, and Japanese freshwater snails. This also indicated that the water quality was low, and the flow rate was slow. From this, we concluded that donates can only live in high quality environmental conditions, with clean water quality that is rich in bait, plants that emerge from the water surface, and soil suitable for pupation nearby, some water quality deterioration. It can be thought that there is no relationship. About 70 % of Ephemeroptera and Trichoptera occurred at the Achi River, which had low velocity. As the environment varied depending on the site, there were many satsukihime-heptageniid mayflies and golden stoneflies *Acroneuria abnormis* (*Plecoptera, Acroneuria*) that inhabited the fast-flowing cleanest sites. Also, many tadpoles (Anura spp.) were observed, and Gomphidae spp. that prey on the tadpoles were also seen. In the river in front of the erosion control dam, there were a lot of both Epemeroptera and Trichoptera, which accounted for 80 % of the total number of organisms. Many relatively large stones and gravel were found where the flow was suppressed, which provided refuges for the organisms, so it is likely that many species of Epemeroptera and Trichoptera inhabit the river in front of erosion control dam. The constant discharging and circulating of the water may also have been a major factor. Also, although there was a bit of armorization of the topography, the discharge of the dam accumulated everywhere so it was good for the environment but gave an impression far from a moderate disturbance.

In the river next to Achi Shrine, there were a lot of Trichopteran, especially Glossosoma spp, which inhabited the entire area. The river had accumulated a lot of gravel at this site, and also "algae for Trichopteran to consume" (Katano et al., 2010). Rhithrogena spp. that inhabited sites of low velocity also feed on algae. As the number of inhabitants was small, and the increase in flow rate following the rain the next day was relatively late, we prepared a water quality judgment sheet of living organisms (Figure 2). The water quality survey and the large number of species that were caught showed that the river in front of the erosion control dam had the cleanest water quality and supply of organic matter that sustains larvae. We thought that conducting a study on oxygen supply was in order. In addition, the flow velocity and the types of organisms were related, and we could confirm it this time. According to Matuoka & Nakamura (2008), erumon-heptageniid mayflies inhabit a flow rate of 75 cm per second, and Shiro-heptageniidae mayflies can tolerate a maximum flow rate of 35 cm per second. In addition, "Erumon-heptageniid mayflies are emerging on the surface of the water, underwater, on land" (Isobe, 2005), and were abundant at every site, and can be considered as a species that increases the diversity of the environment, although the size and number of rocks


昼神温泉郷　水辺の生き物調査

20　年　月　日（名前）　（調査地）

水温：　℃	川幅：　m	天気：
水深：　m	流速：　m	川底の状態：

河川周辺の環境状況：

○生き物調査

見つけた生き物	見つけた数
A ヒラタカゲロウ	
マダラカゲロウ	
サツキヒラタカゲロウ	
キカワゲラ	
コナガカワゲラ	
トウゴウカワゲラ	
ヤマトビケラ	
ニンギョウトビケラ	
ナガレトビケラ	
プラナリア	
ブユ	
ヘビトンボ	
サワガニ	
B カワニナ	
ヒル	
イトミミズ	
ミズムシ	
オニヤンマ	
コオニヤンマ	
アメリカザリガニ	

計算方法

:2A+B

2×○+○

→　　点

a：～30
b：15～29
c：6～14
d：0～5

a:きれいな水
b:少し汚れた水
c:汚れた水
d:大変汚れた水

○その他の生き物

○気づいた事・感想

Figure 2: Water quality judgement sheet

are also related.

4. Discussion

During these surveys, we held a press conference with radio and newspaper media, after the final announcement. We also had a meeting with the village head (Achi Village village mayor: Kumagai Hideki), to promote the theme of "water quality" as a new resource for tourism. We believe that water quality can promote the region by increasing awareness and providing a previously unknown perspective of the area, because it derives from a survey of aquatic organisms conducted by residents. There are water quality problems affecting the ecology and growth of organisms at the construction of the Southern Alps Tunnel, which is also a concern at the Linear Central Shinkansen scheduled to open in 2027. When we think about these themes toward future, moreover, it is important for us to think about water quality address in the nearest environment. In Achi village, the natural assets of hot springs and flower peach blossoms are tourist attractions, so the water quality problems must be solved very carefully, because of the environmental and economic impacts. Also, from the local people, we heard various concerns before the excavation of the dam, such as the noise from heavy drilling equipment, soil mixed water, and obstruction of the night sky by exhaust gases. In fact, Achi village was promoted as Japan's first "starry sky" tourist attraction in 2006, and the economic loss will be immeasurable. When it rains, the water level of the Achi River spreads to the full width of the river bank, it becomes a muddy flow, and the water does not subside for several days.

The Tenryu river is a rapid river that flows down the central and Southern Alps through Nagano Prefecture. It is about 200 km long into which each tributary water flows. In the past, the Tenryu river has suffered damage Saburoku disaster that occurred in June 1961 and Typhoon No. 10 that occurred in September 1983. Precipitation is quite low in Nagano prefecture, but it is the third highest nationwide in forested areas, and the prefecture has the highest number of 3000 m peaks in Japan. In mountainous regions, it rains more, which mainly affects rivers more than average. Furthermore, according to the Ministry of Land, Infrastructure, Transport and Tourism, a "flooded river" is designated as one possibly causing considerable economic damage (Nagano Nippo Web, 2018). This risk may worsen after the tunnel construction. Daily moderate rainfall is a moderate disturbance does not affect the ecosystem to a great extent. However, a large amount of spring water can affect the diversity of fish food (aquatic life) and may cause deterioration of species, and changes in the aquatic environment. Also, if the groundwater contains harmful substances that exceed the standard values, the supply of organic matter to the river will decline with the death of surrounding trees. According to Yoshimura et al. (2006), many aquatic organisms depend on land-based granular organic matter in the upper and middle basin where there are many substances flowing from the terrestrial ecosystem. Furthermore, "the quality of the groundwater reflects the chemical composition of the surrounding rocks and soil. That is, components such as Ca, Mg, Na, K, and SiO2 are leached at a high rate from rocks and soils" (Kasama and Tsurumaki, 1971). Most of the Tenryu River is located on a plate of granite and if the substances exceeding the standard value, such as iron and manganese, are suppressed, it affects breeding and the ecological balance. Although it is a large amount of spring water, if the amount of water is at least that of the current river level and situation, flood damage is predicted to be maximal, so dam construction will be a substantial economic burden. At the time of opening, Iida City, one of the shopping areas, was nearest, so it is possible that the number of visitors from major cities such as Tokyo will increase. Also, as young people in recent years are more concerned about car usage, it can be a useful means of transportation. The rates for certain Traditional Japanese inn are relatively expensive, except during the Peak season and during seasonal events such as skiing. After opening, it can be expected to promote as a sightseeing spot and regional activity by appealing due to the increase of young generation and the richness of its communicativity. Then, we can show these results about tourism proposal, it will be effective enlightenment. Since environmental and economic aspects (regional promotion) are both affected, it is a dilemma, but the problem is a matter of to what extent species can tolerate change and what is compatible with tourism development.

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