

## **Shimanto River Environmental Survey**

**4-5 July 2022**

### **Survey of Shimanto River Lower Reaches and Nishi Tosa Area**

#### **Key Findings of the Survey**

- Similar to the July 2021 results, locations with extremely low dissolved oxygen (DO) were identified. These locations were the Nakasuji River (67% and 79% this year; 58% and 74% in 2021) as well as 76.8% near Oshima this year. The lowest level of dissolved oxygen was recorded at the bottom of the Tsukurabuchi River (41.7%). There is a possibility that an anoxic water mass is expanding downstream of the Shimanto River. Unfortunately, the survey could not be conducted in the Takeshima River area due to Typhoon No. 4.
- Turbidity (FTU) increased and worsened more than 10 times compared to last July. This was due to sediment and soil flowing into the rivers as a result of the typhoon, and is thought to be caused by sediment and soil runoff from construction sites and land with fragile river banks and riverbeds. Turbidity of the Nakasuji and Tsukurabuchi Rivers also exceeded 10 FTU. These block the bottom sediments of the rivers and soil cavities in the banks, causing clogging and loss of living space for riverine organisms.
- Excavation at Egasaki in the midstream area revealed that there was no underground water flowing into the riverbed. This is presumably due to soil cavity closure caused by the increased turbidity mentioned above and loss of soil cavities due to the killing of soil bacteria from years of pesticide use.

#### **1. Purpose and Summary of the Survey**

The purpose of this survey, as in the past, is to provide objective scientific indicators of the state of deterioration and degradation of the Shimanto River environment, to provide scientific figures, and to clarify and estimate the causes of environmental degradation.

We arrived at Kochi Airport at around 9:30 a.m. on Sunday, July 3. Typhoon No. 4 (985 hectopascals at 15:00 on July 3, west of Okinawa), which originated in the southwest Japan on July 1, moved northeast at 30 km/h and made landfall near Nagasaki City at 8:00 on July 4. Shimanto City was directly affected by the typhoon as it made landfall near Uwajima City, Ehime Prefecture, just after midnight on July 4.

Due to the typhoon mentioned above, the survey sites in the downstream area were revised drastically. Originally, two locations were planned for the Akatetsu Bridge and the Togawaohashi Bridge on the left bank and the right bank, but these were changed to one location each. By this, the two locations upstream from the confluence of the Ushiro River were cut off. No changes were made to the south of the Nakasuji River confluence, which is the survey point south of that point.

However, by the time we finished the survey point at Hatsuzaki, at around 11:20 on the 9th, it was pouring and our waterproof jackets were ineffective. As we were soaked through, we returned to the starting point at Nabeshima. We gave up the survey once we returned to Nabeshima. We gave up the survey at the four sites in the Takeshima River basin, i.e., the green laver (sea lettuce) farm. The bad weather at the survey sites could have provided us with valuable scientific information that we could not normally obtain. The abandonment of the survey was extremely regrettable.

## **2. Survey Structure**

The leader for this survey was Dr Masayuki Komatsu and the surveyor was Mr Koichi Watanabe. The survey in the lower reaches of the Shimanto River was participated in by Mr Akihiro Yamazaki, head of the Shimanto River Downstream Fishery Cooperative Association, and Mr Kiyomi Yamazaki, director of the association. We also received assistance from Mr Tsuyoshi Fujimoto, Manager of the Nakamura Branch of Kochi Bank, regarding coordination of the schedule with Shimanto City and the Shimanto River Fishery Cooperative Association. We also thank Ms Shinobu Tamura, Senior Managing Director, and Mr Kiyohiko Takeuchi of Kochi Bank Head Office for their full support in setting up the overall schedule, especially in arranging meetings with the Kochi Prefectural Government and the Nishi-Tosa Fishery Cooperative Association.

## **3. Purpose of the Survey**

Understanding the river environment and estimating pollution and its causes: Since we entered the second year of the survey in July 2022, it is possible to compare the results with those of the 2021 survey. However, Typhoon No. 4 hit the Kochi Prefecture area almost directly, which affected the quantity and quality of the survey data. Although the survey in the Takeshima River area was abandoned in terms of quantity, it was beneficial to be able to survey the Shimanto

River environment under the typhoon's influence.

The results of the first year's survey and this year's survey indicate that (1) the construction of riverbank revetments and the straightening of the Nakasuji and Tsukurabuchi Rivers have reduced natural resilience, (2) the construction of dams and weirs have severed the ecosystem, (3) the inflow of agricultural effluents, including agricultural chemicals, over-fertilizers and soil runoff from Shimanto Town and the Iechi River basin, and (4) urban sewage discharge into the Ushiro River and industrial effluents from Kochi Southwest Central Industrial Complex into the Nakasuji River are assumed to be factors in the deterioration of water quality in the Shimanto River.

#### **4. Results of the Survey**

##### **(1) Chlorophyll content**

In the lower reaches of the Shimanto River, chlorophyll levels at the surface (10 cm at the surface in 2022 and 50 cm at the surface in 2021) were 1.1 to 1.6  $\mu\text{g}/\ell$  on July 4, 2022 and 0.96 to 1.7  $\mu\text{g}/\ell$  on August 2, 2022, respectively, and the range remained unchanged.

##### **(2) Turbidity (FTU)**

On the other hand, turbidity (FTU) increased significantly, and pollution and turbidity progressed. In the Ushiro River, the turbidity was 38 FTU at the Saoka Bridge, 44 FTU at the drainage outlet of the Uyama Drainage Treatment Plant, and 48 FTU at the confluence with the main stream of the Shimanto River, which are abnormally high levels, indicating the seriousness of the pollution. In the Nakasuji River, the turbidity was 10.4 FTU under the Shimanto Bridge and 8.9 FTU at the confluence with the main stream. In the Tsukurabuchi River, it was also 12 FTU. Thus, turbidity was unusually high in this survey. Turbidity values were not good at the Shimanto River Bridge (Akatetsu Bridge) and Watarigawa Bridge either. They were 1.6 FTU and 1.5 FTU, respectively. Muddy water was carried by the typhoon, which also brought turbidity from the Ushiro, Nakasuji, and Tsukurabuchi Rivers and their tributaries that join the Shimanto River in the lower reaches of the river. Of these, the Ushiro River is the worst.

\*Note: Turbidity in clean water is 0.3 FTU.



Muddy water at the confluence of the Nakasuji River and the main stream of the Shimanto River and rainfall on the river surface on July 4, 2022, 9:35 am



Akatetsu Bridge and rainfall viewed from the left bank to the right bank

### **(3) Dissolved Oxygen (DO)**

DO in August 2021 was bad, but that in November was in the 90% range and, in March, it improved further and generally exceeded 100% in all water zones. These improvements and changes were seen as seasonal variations associated with changes in the flora and a decrease in water temperature over the fall and winter months.

The results of the August 2, 2021 survey showed that the river bottom dissolved oxygen (DO) was shown to be deteriorating. In particular, in the Nakasuji River, DO was 58% below the Shimanto Bridge and 74% at the confluence. The values were 61.3 - 73% at the Takeshima River aquaculture farm. Such values were not observed in the previous year except on August 2,

but very low dissolved oxygen (DO) was observed in this survey. In the Nakasuji River, DO was 67% (below the Shimanto Bridge) and 79% (at the confluence with the Shimanto River).

In this survey, 41.7% of DO was recorded at a depth of 2 meters in the Tsukurabuchi River. This value is the lowest dissolved oxygen (DO) value observed in the Shimanto River system.

Although the river bottom of the same river was not measured on August 2 of last year, so a comparison could not be made, the water color of the Tsukurabuchi River also appears to be muddy at any time due to the construction of revetments and sluice gates everywhere. It is possible that these construction works are the cause of this value (41.7%).

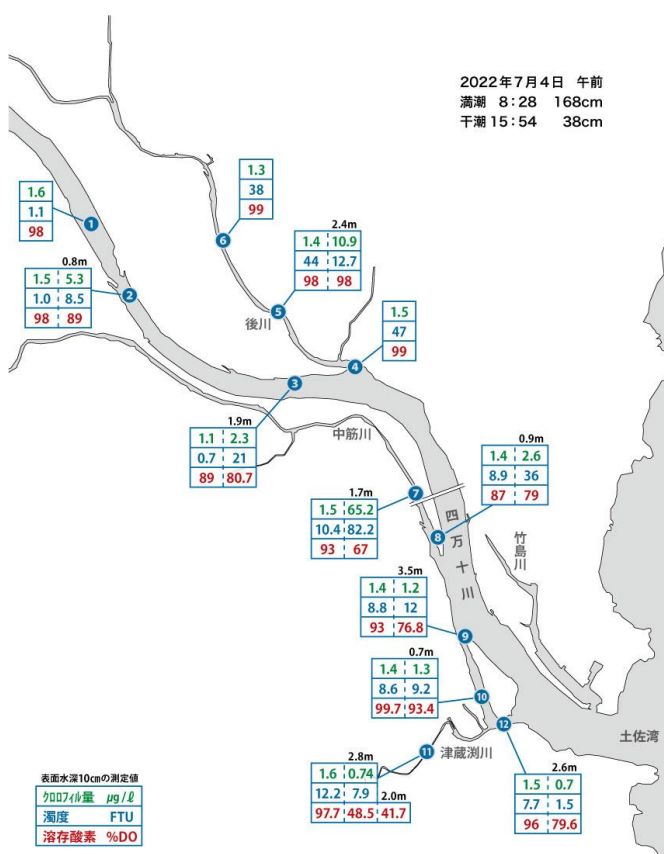


Chart 1: Chlorophyll content, turbidity and dissolved oxygen in the lower reaches of the Shimanto River at low tide on the morning of July 4, 2022

#### (4) Salinity

Salinity was measured up to the bottom of the Shimanto River Bridge (Akatetsu Bridge). The results showed that seawater did not reach the Shimanto River Bridge (Akatetsu Bridge) in

November 2021, March 2022, and July 2022 surveys.

Seawater is also not considered to have reached the confluence of the Watarigawa Bridge and the Ushiro River. The salinity at these points is only 0.04‰ (point ③). This level of salinity is also recorded in the middle reaches of the Shimanto River at the Oino Bridge, the Yoshimi River, and the Niida River. Therefore, it is appropriate to consider these salinities to be of terrestrial origin. What can be inferred from the results of this survey is that at a depth of 3.5 meters at Oshima, the salinity is 33.1‰, and since the salinity at this point and at the confluence of the Nakasuji River and the main stream is also about 7‰ at a depth of 3.5 meters, 100% of the seawater is considered to have reached the middle of these two points.

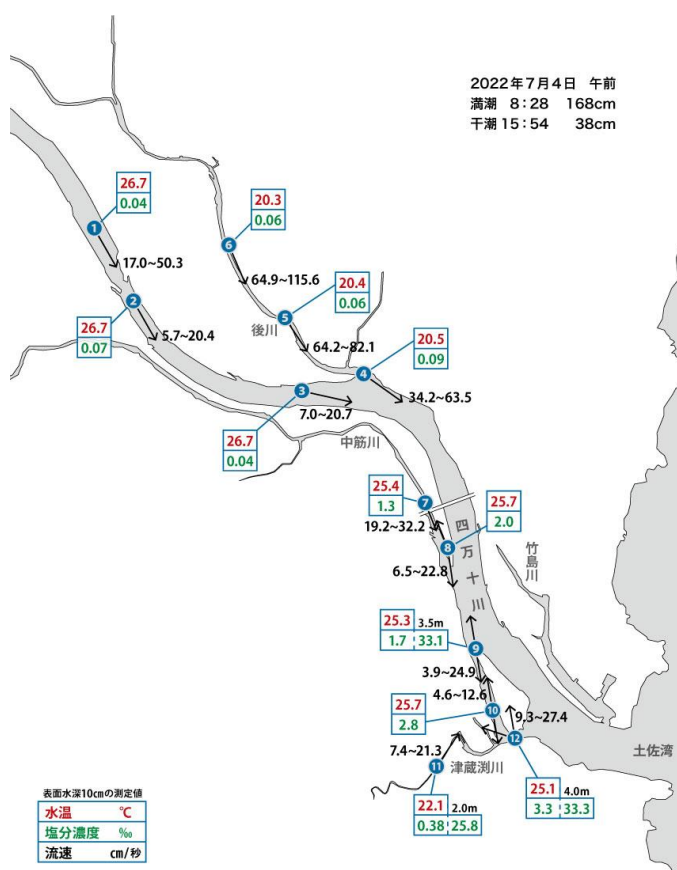


Chart 2: Current direction and velocity, salinity and water temperature in the lower reaches during the low tide on July 4, 2022

During the November 2021 survey and the March 2022 survey, fresh water was present up to the Watarigawa Bridge, and seawater reached the confluence of the Shimanto and Ushiro Rivers. The salinity at the confluence (50 cm depth at the surface) was about 25 to 27‰. This

time, however, the surface (less than 10 cm deep) at the confluence of the Ushiro River was mostly fresh water. This time, the salinity of the river bottom at this point was almost the same as that of the Akatetsu River.

The value was also 0.06‰ near the Saoka Bridge in the Ushiro River and it means that seawater did not reach. At the bottom of the Tsukurabuchi River (2.6 meters deep), the value was 25.5‰. Despite Hatsuzaki's proximity to Tosa Bay, surface salinity was 3.3‰, with seawater at 33.3‰ at a depth of 4 meters.

### **(5) Water Temperature**

In the lower reaches of the Shimanto River, the surface (0 cm) water temperature ranged from 24.5°C to 24.7°C. Compared to the temperature of 26.7°C at a depth of 10 cm, the temperature was 2°C higher from the Akagetsu Bridge to the confluence of the Ushiro River, only 10 cm deeper, and 1°C higher from south of that to the river mouth area. Even in the Kubokawa area in the middle reaches of the Shimanto River, the water temperature of the main stream was in the 26°C range, which is not different from the area from the Akatetsu Bridge to the Nakasuji River. In the Ushiro River, a tributary of the Shimanto River, the water temperature is extremely low, with a surface water temperature of 20.3 to 20.5°C at a depth of 10 cm, a temperature difference of 6°C from the main stream. Where is the source of cold water in the Ushiro River system? Or, is the underground water of the Ushiro River still active, and is there a functioning system where water flow enters the river bottom, riverbed and floodplain to be cooled? It is also a question of whether the cooling action of the underground water can function even during heavy typhoon rains. The temperature of the Nakasuji River is 25.4 to 25.7°C, which affects the water temperature on the surface of the main stream of the Shimanto River and down to the river bottom. Water temperature is a subject for further study and investigation.

## **5. Inspection of Nakasuji River Dam and Dragonfly Nature Park**

### **(1) Nakasuji River Dam**

The Nakasuji River Dam was constructed from August 1989 to March 1996, and completed in August 1998. The dam was constructed near the headwaters of the Nakasuji River. The Nakasuji River basin has always been a typhoon-prone area, and the gentle slope of the river makes it susceptible to the backwaters of the Shimanto River, which has caused flood damage on many occasions. For this reason, flood control measures have been desired. In addition, a stable

supply of irrigation water for Sukumo City and Shimanto City and industrial water for the core industrial park in the southwestern part of Kochi Prefecture were also needed. The management of the dam began in April 1999 (Watari River General Management Office).

The embankment is 73.1 m high, the crest length is 217.5 m, the total volume is 274,000 m<sup>3</sup>, and the effective water storage capacity is 12 million tons. The flood storage capacity is 86 million tons.



## (2) Dragonfly Nature Park

Located on the right bank of the Shimanto River in the Gudo district of Shimanto City, northwest of the Akatetsu Bridge. It is the world's first dragonfly park with a total area of 50 ha. 77 species of dragonflies have been confirmed. Unfortunately, it was raining in the afternoon of July 4 due to a typhoon, so we had to observe from inside a car. However, rather than artificially developing the area, there may have been an option to leave it as a natural wetland.

**6. Meeting with Shimanto City Municipal Governmenten - Mr Masato Asahina, Director,** Agriculture, Forestry and Fisheries Division, Mr Keiichi Okada, Section Chief, and Mr Yasushi Watanabe, Director, Environment and Livelihood Division, and others:

(1) We explained the results of the March 2022 survey. We explained that the deterioration of the water quality of the Shimanto River is caused by agricultural pesticides and over-fertilizers, urban sewage, and public works projects. Regarding agriculture, the Ministry of Agriculture, Forestry, and Fisheries (MAFF) has released the "Green Food System Strategy" and has been promoting organic agriculture, so the agricultural industry in Shimanto City should respond by gradually reducing the use of agricultural chemicals and fertilizers.



We also explained that ginger farmers in Shimanto Town use pesticides, chloropicrin which is a deleterious chemical banned in the EU and other countries, to prevent rhizome disease, and that water quality can be improved by replacing concrete ditches where pesticides flow with wastewater with natural banks, allowing plants to absorb the chemicals.

(2) Mr Asahina, director, explained that the "Green Food System Strategy" is suitable for large-scale agriculture, but small-scale agriculture in Shimanto City is aging without manpower and is forced to use pesticides and fertilizers. He also said that the Ministry of Agriculture, Forestry, and Fisheries' project to renovate ditches should be a nature-responsive project.

In response, Dr Komatsu stated that he would raise this point with Mr Shin Yokoyama, Vice-Minister of Agriculture, Forestry, and Fisheries, whom he is scheduled to meet with on July 19, 2022. In fact, Dr Komatsu raised this point with Mr. Yokoyama during a meeting, but received no response.

(3) The cause of the poor harvest of green laver was also discussed. Some suggested that the method of seedling collection was the cause, but the fact that the harvest has decreased every year and this year's is zero indicates that the problem is not simply one of seedling collection techniques. The level of turbidity of agricultural wastewater from state-owned farms has worsened to the point where we believe it is caused by poor oxygenated water. Dr Komatsu also stated that it is important to continue to visit the seaweed field by municipal government officers every year to communicate with the fishermen and green laver farmers.

(4) Dr Komatsu was also asked about the reason for taking up chloropicrin, which he explained was because it is a deadly chemical whose use is banned in the world, and because of the amount of use by ginger farmers.

(5) The visit to the "Central Wastewater Treatment Plant" in Mt. Uyama was cancelled due to the typhoon.



Excavation of riverbed near the Egawasaki Iwama Chinka Bridge, no underground water. Photographs of materials provided by Mr. Mitsuhiro Kanaya, President, Shimanto River West Fishery Cooperative Association; surveyed on February 2, 2022.

**6. Meeting with Mr Kikuo Horioka, President, and Mr. Masayuki Ohki, Vice President, Shimanto River Fishery Cooperative Association**

The results of the March 2022 survey and the results of the July provisional survey were reported.

**7. Egawasaki in Nishitosa; Meeting with Mr. Mitsuhiro Kanaya, President of the Western Shimanto River Fishermen's Cooperative Association, and Mr. Daisuke Hayashi, Vice President of the Cooperative Association**

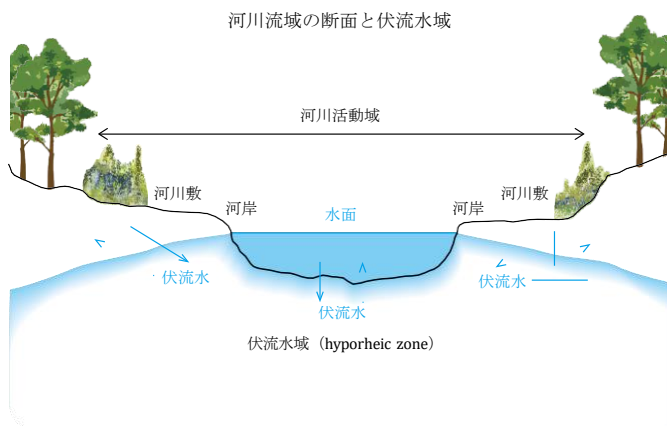
The meeting was held on the second floor of Nishitosa Roadside Station.

On 2 February 2022, Mr. Mitsuhiro Kanaya, the president of the association, conducted excavation work on the riverbed near Egawasaki in the middle basin of the Shimanto River. The excavation work was carried out in three locations near the riverbank near the Iwama Chinka Bridge (Mebu area) and two weeded areas on the mountain side of the riverbed. The depth of excavation was approximately 2 meters, and no subsoil water was observed (see note).

(Note: A similar excavation survey was conducted in the Tachibana area on 22 February and found subsoil water at excavation sites close to the river (at the edges of the water).

The subsoil water is not reaching the riverbed. Judging from this, it can be analogously concluded that although subsoil water also flows under the riverbed (see Figure 3), there is a large possibility that this too is blocked.

## Cross-section of river basin and subsoil waters



### 8. Scientific Assessment of Rivers and Subsoil Waters

River water flowing from the land to the sea through a river conveys water under the riverbed, along the banks of the river, or on the floodplain, and then flows back into the main stream of the river. This is called the hyporheic zone. The banks and floodplains contain microscopic holes and cavities into which river water flows and undergoes decomposition by microorganisms and bacteria to break down chemical substances and produce organic nutrients. Banks and floodplains also retain large amounts of rainwater that cannot be treated by rivers. In the U.S., the function of banks and floodplains is to retain large volumes of rainwater that cannot be treated by rivers. In the United States, the function of banks and floodplains is scientifically evaluated based on hydraulic conductivity (volume and velocity), soil accumulation (sediment), and soil texture.

In the case of the Shimanto River, there are two possible causes of degradation and shortage of the river's subsoil water:

- (1) Pesticides and over-fertilizers, as well as the killing of microorganisms, soil bacteria, and viruses in the soil. Pesticides, over-fertilizers (N: nitrogen and P: phosphoric acid), and basic drugs function to kill soil microorganisms, bacteria, and viruses that form cavities in the soil, and the loss of cavities is thought to have caused the loss of hydrophilicity and permeability of the soil.
- (2) It is estimated that the occurrence of typhoons and low-pressure systems will cause a large inflow of sediment from mountain forests and river basins, from rivers and road construction sites, and from areas with weak soil (due to the heavy rainfall of Typhoon No. 4 on July 4, 2022) into the main stream and tributaries of the Shimanto River, which will accumulate on the riverbed and floodplain and plug soil cavities.

## **9. Discussion with Kochi Prefecture Fisheries Division**

We explained the results of the Shimanto River survey and exchanged opinions on the current status and problems of Kochi Prefecture's inland water fisheries. In particular, the number of days of fishery activity for inland water fishery cooperative members is much less than the 90 days for marine fishery members, ranging from 30 to 90 days. The problem is that the number of days of fishing is much less than the 90 days at sea level, and membership is not strictly confirmed. There was also a question as to whether the current users of inland waters are recreational fishermen and whether inland water fishing rights are necessary as they are now.

Dr Komatsu suggested that, since inland water fisheries are in reality recreational or sport fishing, a license system (permit system) should be introduced, and a limit on the amount of fish caught should be imposed, either in terms of number of fish or quantity, similar to those in Europe and the U.S. As for the need for a fishery cooperative association for inland waters, he stated that, in reality, fishermen can no longer exist, and it is necessary to fundamentally examine whether this association is necessary as an organization under the Fisheries Act.

The meeting between the Agricultural Promotion Division and the Environmental Division in charge of the Shimanto River Ordinance could not be held due to their busy schedules. A meeting will be set up again during the next visit in November 2022.

## **10. Dr. Hiroyuki Ukeda, Executive Director and Vice President, Kochi University**

The visit was triggered by Dr Komatsu's lecture on the Shimanto River research at the Natural Resources Subcommittee of the Kochi Bonito Prefectural Citizens Conference held on 15 June. Dr Komatsu reported and explained the current status of the Shimanto River based on the manuscript of the "Report on the Shimanto River" published in August.

Dr. Ukeda asked if the report included a perspective on forests and forestry. Dr. Komatsu replied that in his experience, there is no particular unsustainable logging in the Hata District of Kochi Prefecture, but asked if Dr. Ukeda was aware of any specific problems. In response, he stated that he has not been able to identify any specific problem areas, but that a forest perspective is also necessary for watershed management.

Dr. Ukeda said that he and his colleagues will strive to make recommendations based on scientific evidence.

#### **11. Mr Hitoshi Fukuda, Kochi Shimbun (Newspaper) Reporter**

We reported and explained the current status of the Shimanto River based on the manuscript of our "Shimanto River Report" published in August 2022 and stated that we would like to feature it in the Kochi Shimbun at the timing of the report's publication.

#### **12. Postponement of survey activities**

Scientific observation of the green laver farm in the Shimoda Port area was not possible due to Typhoon No. 4, the person in charge of the Central Wastewater Treatment Plant was unable to visit the survey site due to wastewater treatment work, and the survey in cooperation with Shikoku Electric Power Company at Tsuga Dam was postponed due to required monitoring work of increased water levels in the dam as a result of Typhoon No. 4.