

Chapter 8

Environmental Hygiene in the Islands of Kagoshima

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1. Introduction

The environment is generally perceived as the outside world that surrounds humans, with its range being subject to broad interpretation. It has long been accepted that the environment has various influences on human health. In recent years, there have been marked changes in the earth's environment in response to increased human activity. Environmental hygiene is used as a measure to determine the harm caused by an object, process, or phenomenon, which allows humans to continue leading lives that are considered healthy to the body and mind. Current environmental health problems are very extensive and diversified. Until about 50 years ago, measures for the prevention of communicable diseases were important. Such measures included the assessment of water supply and sewerage, human waste treatment, or measures against vectors for infectious disease. Measures have since become diversified, including measures of food hygiene, pollution, the hygiene supervision of a building, harmful household articles, or even endocrine disruptors.

The aquatic environment has a major influence on the continuation of human life on islands. The reservation of water resources and the maintenance of water quality are extremely high priorities on islands. The first part of this chapter introduces problems related to water resources. The second part discusses poisonous snakes and blood sucking insects specific to islands.

2. Water and life

2.1. Pollution of groundwater

Here, the importance of environmental problems is presented, ranging from global to local issues. Water pollution is the most common problem. Nitrogen compounds, including nitrates and nitrites, in water are undetectable without testing, because

they are colorless, odorless, and tasteless. Nitrates are nutrients that are applied to crops to enhance productivity. In addition, domestic animal wastes are also sources of nitrates. The acute health hazard associated with nitrates in drinking water with nitrate nitrogen occurs when bacteria in the digestive system transform nitrate to nitrite. Nitrite reacts with iron in the hemoglobin of red blood cells to form methemoglobin, which lacks the oxygen carrying ability of hemoglobin. This process creates the condition known as methemoglobinemia, in which blood lacks the ability to carry sufficient oxygen to individual body cells. Infants under 1 year of age have the highest risk of developing methemoglobinemia.

In recent years, groundwater contamination by nitrates has become noticeable in various places of Japan, and represents a major environmental pollution problem. The acceptable concentration of nitrate has been specified as below 10 mg/L by the environmental standard for water quality for the protection of health. NISHINAKASU *et al.* (2007) analyzed well water in an area where the stock raising industry is prosperous in the mainland of Kagoshima Prefecture. The well water of seven out of 51 sites exceeded the environmental standard (10 mg/L). Pollution sources were assumed to be dung and other fertilizers.

Groundwater contamination is expected to spread rapidly on a flat island with a high rate of arable land. Okinoerabujima Is., an island of uplifted coral reef, has a thriving floriculture, with a higher income per person being obtained by those engaged in agriculture. NISHIZAWA *et al.* (2000) investigated water, land use, and food. Okinoerabujima Is. covers an area of 93.6 km², of which 46.6 % is covered with arable land (1996). Water samples were collected from 30 wells and 21 springs. The concentration of

nitrate from eight samples exceeded 10 mg/L, while that of 20 samples was between 5 and 10 mg/L. It was recommended that activities to promote environmental conservation based agriculture should be carried out to reduce water pollution caused by fertilizers and pesticides.

2.2. Seawater desalination

A lack of fresh water reduces economic development and lowers living standards. Natural fresh water resources are particularly limited on small islands. Hence, desalinated sea water represents a potential alternative water source. Desalination refers to one of several processes that remove a certain amount of salt and other minerals from saline water. Most modern interest in desalination is focused on developing cost-effective ways of providing fresh water for human use. Several methods for desalination have been developed, and are actually in use. Thermal desalination methods include vapor distillation, multistage distillation, and multiple-effect distillation. Thermal methods of desalination involve boiling water and collecting purified water vapor. It requires a large input of energy to heat the water. Membrane methods of desalination include reverse osmosis and electro-dialysis. Membrane processes use selective permeability to separate salts from water. Other methods of desalination include freezing, solar dehumidification, and membrane distillation.

Small seawater desalination plants were constructed to produce fresh water suitable for human consumption on Suwanosejima Is. (small volcanic island) and Kodakarajima Is. (small coral island) of the Tokara Islands in 2000 and 2001, respectively. A larger water desalination plant was also constructed with governmental aid on Yoronjima Is. of the Amami Islands in 2001. Yoronjima Is. is the southernmost island of the Amami Islands, and has a population of about 5,300 people (2010) and an area of 20.19 km². Yoronjima Is. is a flat island formed from an uplifted coral reef. Water resources on Yoronjima Is. are all obtained from groundwater, and residents have been plagued by the hardness of water caused by the geology. The production of sugarcane and calves are important activities on Yoronjima Is. The concentration of nitrate has increased because of increasing amounts of livestock excreta and the use of



Fig. 1. Water desalination plant on Yoronjima Is.

fertilizers on sugarcane. Furthermore, groundwater became saline in years of low precipitation. To resolve these problems, a water desalination plant was constructed on Yoronjima Is. with a budget of JPY ¥1.1 billion (USD \$12 million) (Fig. 1).

The water purifying facility on Yoronjima Is. has the ability to produce 3,600 m³ water per day. Water was collected from nine wells, and was transferred to the water purification plant. Small particles were removed with rapid filtration equipment (pretreatment), and then the salt, nitrate, and other minerals were removed. The reasonable operation and maintenance of desalination facilities is indispensable for sustaining island life.

2.3. Underground dams

Water is also needed in agriculture as well as human life. A groundwater dam is a structure that obstructs the natural flow of groundwater, and stores water below the ground surface. There are basically two types of groundwater dams: sub-surface dams and sand-storage dams. A sub-surface dam is constructed below ground level and arrests the flow in a natural aquifer, whereas a sand-storage dam impounds water in sediments that are caused to accumulate by the dam itself (ONDER and YILMAZ 2005).

A sub-surface dam was constructed on Kikaijima Is. in 1999, with a budget of JPY ¥25.1 billion (USD \$ 270 million), through governmental aid. Kikaijima Is. is located 22 km east of Amami-Oshima Is., and has a population of about 9,300 people (2005), and covers an area of 56.9 km². The industry of the island is primarily focused on agriculture, with sug-

arcane being the primary crop type. Kikaijima Is. is an uplifted coral reef. Rain water exceeding the annual precipitation of 2,000 mm is stored in the underground dam, which covers an area of 5.8 km², and has a capacity to store 1,800,000 m³. The water of the underground dam is pumped up to six farm ponds to regulate the amount of water, and is transferred to 1,677 ha farmland by a 45 km pipeline. On the island, an impermeable layer of mudstone and sandstone forms the lower layer, which is covered by 20-40 m thick limestone. The limestone is porous and permeable, and serves as a good aquifer groundwater, being a good instrument for water storage. The same type of underground dam (total water capacity 1,085,000 m³) is under construction on Okinoerabujima Is.

An underground dam has several advantages compared to a surface dam. No overland area is flooded by dam construction. The water in the dam never evaporates, even in the dry season. Good quality and safe water can be obtained from the underground dam. The underground dam is in a state where it is stabilized dynamically. The underground dam generates many profits to agriculture. Since water is used throughout the year, an increase in yield and stabilization of production can be attained. Without being influenced by the weather, planned land use may be planned. The introduction of profitable crops and expansion of crop area is made possible by the supply of water.

3. Biting insects

3.1. Black flies

The family Simuliidae comprises approximately 60 species in Japan. This group of insects is usually small, black or gray, with short legs and antennae. The family Simuliidae contains species that feed on humans, as well as other species that prefer to feed on other mammals or birds. This group is a common nuisance to humans. Eggs are laid in running water, and the larvae attach to rocks. The larvae will pupate under water, and then emerge in a bubble of air as flying adults.

TAKAOKA (1976a, b; 1977a, b) presented a taxonomical summary of the species of Simuliidae on the Nansei Islands based on material collected over several years. In a series of four papers, the author

discussed a total of 18 species, including two new species, one new subspecies, and seven newly recorded species. All taxa of the black flies found on the Nansei Islands are classified into the genus *Simulium*, and belong to six subgenera: *Simulium* (*Eusimulium*) *uchidai*, *S. (E.) subcostatum koshikiense*, *S. (E.) aureohirtum*, *S. (E.) satsumense*, *S. (E.) mie*, *S. (E.) morisonoi*, *S. (G.) okinawense*, *S. (G.) tokareense*, *S. (G.) batoense*, *S. (Morops) yonakuniense*, *S. (Odagmia) aokii*, *S. (Gnus) bidentatum*, *S. (Simulium) arakawae*, *S. (S.) sakishimaense*, *S. (S.) japonicum*, *S. (S.) quinquestriatum*, *S. (S.) suzukii*, and *S. (S.) rufibasis*. Only female of *S. (S.) japonicum* have been reported to bite humans aggressively year-round on the Nansei Islands (TAKAOKA 1977a). Besides attacking humans, this species was also reported to feed on other animals, including horses, cattle, pigs, goats, cats, and chickens (TAKAOKA 1977a).

The distribution of black flies on the Nansei Islands is shown by TAKAOKA and TAKAHASHI (1977). *Simulium* (*S.*) *japonicum* is distributed on Kuroshima Is., Tanegashima Is., and Yakushima Is. of the Osumi Islands; Kuchinoshima Is. and Nakanoshima Is. of the Tokara Islands; and Amami-Oshima Is., Yoroshima Is. and Tokunoshima Is. of the Amami Islands. *Simulium* (*S.*) *japonicum* collected at Nakanoshima Is. are shown in Fig. 2. The black fly has a shallow bite. The black fly cuts the skin and ruptures its fine capillaries. Feeding is facilitated by a powerful anticoagulant in the saliva of the flies. Itching and localized swelling and inflammation sometimes occurs at the site of a bite (Fig. 3). Swelling may be quite pronounced, depending on the individual's immune response, and irritation may persist for weeks.

The larvae of black flies live in running water and are highly sensitive to water pollution. A small island where there is no water pollution supplies suitable habitats for black flies. To maintain a low population of black flies, insecticides must be applied to rivers on Kuroshima Is., Kuchinoerabujima Is., and Nakanoshima Is. The "Higashi Yosuke legend" concerning the black fly has been passed down through generations on Nakanoshima Is. There is a "Rock Yosuke" along the road on the way from the coast to the Hinode area. In the middle of the 16th



Fig. 2. *Simulium (Simulium) japonicum* collected on Nakanoshima Is.



Fig. 3. Swelling and inflammation caused by a *Simulium (Simulium) japonicum* bite.

century, a group of pirates led by Yosuke plagued the islanders. The inhabitants of Nakanoshima Is. deceived Yosuke, caught him, and burned him to death. The body was buried under a large rock, called Rock Yosuke, so that it may never revive. However, the ghost became countless black flies, flew about Nakanoshima Is., and even disguised itself as the vampire who attacks people violently and inhales blood (INAGAKI 1973).

3.2. Biting midges

The Family Ceratopogonidae comprises about 80 genera, with more than 4,000 species being known worldwide, of which more than 200 species are found in Japan. Most biting midges feed on other invertebrate, but some species of *Culicoides*, *Leptoconops* and *Forcipomyia* have evolved the habitat of feeding on warm-blooded animals. The biting midge has been neglected in comparison with mosquitoes because fewer human diseases are transmitted by biting midges.

Females of the genus *Leptoconopus* are particularly vicious biting midges that attack humans in many parts of the world. *Leptoconopus nipponensis* has been reported in several areas of Honshu and Hokkaido. TAKAOKA and HAYASHI (1977) collected biting midges on the sandy coast of the southern part of Amami-Oshima Is., and described them as a new subspecies of *L. nipponensis*. This species, *L. nipponensis oshimaensis*, is a serious annoyance on Katoku, Amami-Oshima Is. An ecological study of *L. nipponensis oshimaensis* was carried out by MATAYOSHI *et al.* (1985). The adults were captured

by light-traps from late March to late August, and a peak was observed between mid-April and mid-May. Two peaks of biting activity were observed in the early morning and late afternoon. The majority of larvae and pupae were found in the sandy zone, with *Imperata cylindrica* var. *major* being found along the beach and wind break forest zone of *Casuarina equisetifolia*.

The biting midge *L. nipponensis oshimaensis* seems to be widely distributed on the Amami Islands and Ryukyu Islands. HIGA *et al.* (1979), SHIMOJANA *et al.* (1979), and AZAMA *et al.* (2011) reported the results of a questionnaire and ecological survey on Keramajima Is. and Kumejima Is. of the Ryukyu Islands. Females of *L. nipponensis oshimaensis* are particularly vicious biting midges that attack humans, with both residents and tourists being bitten.

Recently, residents from the south of Amami-Oshima Is. and Kakeromajima Is. have enquired about biting midges. We carried out a distribution survey of the biting midge, *L. nipponensis oshimaensis*, on Kakeromajima Is. of the Amami Islands. There are 30 large and small villages on Kakeromajima Is. It was confirmed in an interview that biting midges were distributed in almost all areas of the island, with the midge causing severe damage. Biting midges, *L. nipponensis oshimaensis*, collected by the sweeping and dermatitis by biting midges are shown in Figs 4 and 5. However, there are two villages where residents did not complain of midge bites. These two villages had a seawall on a relatively narrow beach, and road adjacent to the seawall. Therefore, there was no grassland or wind break forest between the



Fig. 4. Biting midge *Leptoconopus nipponensis* oshimaensis collected by the sweeping.



Fig. 5. Dermatitis caused by biting midges, *Leptoconopus nipponensis* oshimaensis.

sea and houses. After the sea shore was turned into a seawall to extend the playground in Gerumajima Is., the occurrence of biting midges was no longer observed (SHIMOJANA *et al.* 1979). This information demonstrates the importance of grasslands and wind break forests to the midge life-cycle.

4. Venomous snakes

Five and one species of poisonous snakes inhabit the Amami Islands and Tokara Islands, respectively. Species include the Hyan coral snake (*Calliophis japonicus*), Hai coral snake (*C. japonicus boettgeri*), Himehabu (*Trimeresurus okinavensis*), Habu (*T. flavoviridis*), Tokarahabu (*T. tokaraensis*), and Ryukyu heelback (*Amphiesma pryorii*). The Habu (Fig. 6) is distributed on Amami-Oshima Is., Kakeromajima Is., Ukeshima Is., Yoroshima Is. and Tokunoshima Is. of the Amami Islands, and is a major poisonous snake in terms toxicity, ferocity, damage sustained, and population density. The Habu is also distributed on Okinawajima Is. and 20 islands of Okinawa Prefecture.

The Habu inhabits a wide range of habitats, including forests in the mountains, plains, and around houses. The Habu sometimes invades houses to chase mice for food. Because of the danger of the Habu bite, work in the field and forest is very restricted, limiting the development of these areas. Approximately 30 % of Habu bites occur in the vicinity of households, whereas 50 % occur on farmland. There were approximately 300 cases of Habu bites in the 1960s, but this number decreased to less than 70 after 2005 (Web site of Kagoshima Prefecture).



Fig. 6. The Habu, *Trimeresurus flavoviridis*.

In the past, approximately 10 % of Habu bite cases were fatal. Recent improvements to the anti-venom, its availability in villages and anti-collapse treatment has resulted in a major reduction in the mortality rate to a few accidental cases a year. The frequency of Habu bites is closely related to meteorological changes, particularly temperature. The bite cases show a high incidence in summer, and nearly none in winter. There are two peaks in the incidence of Habu bites in June and September on the Amami Islands. Habu are most active at a maximum soil temperature of 27 °C, with activity decreasing at higher temperatures. However, the reduction of bite incidence during midsummer seems to be influenced not only by the climate but also by the activity of the human population in connection with farm work in the fields (TANAKA and WADA 1977).

The average length of the Habu is 1.5 m, with the maximum length often exceeding 2 m. As the body size of the Habu is relatively larger than other venomous snakes, a greater quantity of venom is in-

jected by a Habu bite. After being bitten by a Habu, victims immediately experience excessive pain, and feel a dull ache as if having been struck with a stick. A dark purple swelling spreads from the bite site as time passes, and is usually present for up to a few days, with the entire body being affected in cases of severe swelling. When the swelling is severe, muscle necrosis occurs. Other major symptoms are nausea, abdominal pain, diarrhea, cessation of urination, fever, coldness of limbs, sweat, increased heart rate, decreased blood pressure, disturbance of consciousness, lethargy, and in rare cases death. In some cases, sequelae, such as pain and difficulty in bending the joints of the fingers or limbs remain.

The total population size of the Habu is expected to decline. On the Amami Is., the health center purchases Habu brought in by inhabitants, to reduce the number of living Habu and to collect snake poison for research and manufacturing antivenin for treatment. A Habu is purchased for JPY ¥4,000 (USD \$45), with 30,733 Habu being purchased in 2010 (Web site of Kagoshima Prefecture).

The Himehabu is approximately 60 cm in body length and is distributed on Amami-Oshima Is. and Tokunoshima Is., Okinawajima Is., and its adjacent islands. Since only a small amount of toxin is injected to humans per bite is small and the venom is less toxic than that from the Habu, the symptoms of bite victims are comparatively mild. Tokarahabu is distributed on Takarajima Is. and Kodakarajima Is., and has a body length of approximately 70 to 100 cm. The toxicity of the venom is considerably lower (TANAKA and WADA 1977).

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