ENVIRONMENTAL AREA STUDY IN AREA AROUND MAIZURU BAY

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Area around Maizuru Bay holds lots of predominance for the enclosed coastal sea located on the Sea of Japan side, as follows. 1) Maizuru Bay is a typical enclosed inland bay, where the mouth is only 1 km. 2) Mountains (Max. height: Mt. Aoba, 692 m) surround area around Maizuru Bay and result in the closed system spatially, too. 3) Maizuru has no big river (Max. flow: Isazu River 5 m^3/s) and the river transport is quite a little. 4) This area almost equals with only one local public bodies "Maizuru City" and about 94 thousand population is closed socially and there is no bigger city near Maizuru. 5) Maizuru Bay is located at center of Honshu Island (Japan Islands) on the Sea of Japan side. Most environmental data are observed in Tokyo and Nagoya: Tokaido Megalopolis on the Pacific Ocean side, or Osaka and Hiroshima beside the inland sea and Lake Biwa. There exist few data on the Sea of Japan side. 6) Maizuru is located 5 km close to Takahama Nuclear Power Plant. There exist so many Nuclear Power Plants that Wakasa bay area is called as "Genpatsu Ginza (Nuclear Power Plant Shopping Mall)". Besides, construction of a Coal Power Plant on the mouth of Maizuru Bay has been in progress. We will have more pollutant in area around Maizuru Bay. 7) The Sea of Japan side is damaged more than the Pacific Ocean side by acid precipitation for transboundary pollution from Manchuria and Korea, especially in winter. As our measurement, the pH value reached to 3.9 and conductivity 129 μS/cm. 8) Maizuru belongs to Western Japan, and is the most north-east end of Western Japan.

We faced latent or notable environmental issues in Maizuru, mainly have investigated in Maizuru Bay, river and atmosphere, in situ. Since 1989, we have measured water quality of sea and river in every month. With increased public awareness of the environment, an NGO, Kankyo Miru!-Kiku-Kangaeru Kai, which consists of about 30 volunteer citizens, has measured NO_x concentration in atmosphere in every months since June 15, 2000. Our continuous analytical data could show environmental changes of area around Maizuru Bay. The number of surviving carp stocked Tera River with, shows an exponential decrease. The East Bay has more pollutant than West one for geological difference: sewage works and layer of discontinuity. The pollution in atmosphere is in proportional to traffic amount. Maizuru Bay has faced a worsening habitat with declines in variety and pure number of species and a reduction in the catch of marine species. We have investigated by an interview of fishermen or specialists and tried. This report gives the outline about sociogeochemical research for area around Maizuru Bay in the present and future.

Key words: Sociological Aspect, Geochemistry, Area Study, Marine Ecology, Water Quality, Air Pollution

Introduction

Nowadays human activity has taken long strides to swell to reach a stage where we can not ignore even on global scale [1]. Though the present-day technology civilization brought us material abundance and convenience through spread of human activity, population and economic activity increased boundlessly and that connected with environmental destruction on global scale. Today, the global environmental issues come to the top of the most inevitable three issues; the others are international security and world economics. For instance, a Mecca of the world economic development, World Bank [2] mentions the environmentally sustainable development (ESD) as follows:

Environmental problem is very difficult and fundamentally different from other problems and burning problem to solve. In order to acquire the information and solve the global environmental problems, we should construct a new inter-discipline, which combined natural sciences and social sciences [3]. A polluted river or stream is not only an eye-sore, it poisons drinking and irrigation water, promotes waterborne diseases, kills off fish that are a valuable source of protein for local people, and adversely affects tourism. Loss of forests, likewise, has many repercussions -- biological diversity is lost forever, indigenous people lose their homes, and the atmosphere loses a valuable source of oxygen. But these are the most obvious environmental issues developing countries face [4] [5]. New environmental challenges, including those arising from urban growth, increasing motorization, and from a recent lack of

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attention to rural development, are emerging as priority concerns. In addition, the continuing need to extend basic services in water, sanitation, and transport to both urban and rural populations must be addressed in environmentally sustainable ways.

Acid rain has used in the literature written by R. A. Smith since 1872 [6]. Today, the precipitation less than pH=5.6 is defined to acid precipitation for the equilibrium of 350 ppm CO_2 in atmosphere. SO_x and NO_x are oxidized to H_2SO_4 and HNO_3 , which are the main chemical species causing acid precipitation and environment [7]. SO_x and NO_x set on various chemical reactions in atmosphere, water droplets or on solid surfaces. Lots of chemical species in atmosphere are involved in theses reactions. The relative importance of the three types of chemical reactions is altered depending upon the reaction conditions in atmosphere. Especially in winter, for the northwest monsoon from Manchuria and Korea, where economic development has reached to about 10 % GDP per year without regulation against pollution of the environment, the Sea of Japan side is damaged more than the Pacific Ocean side by acid precipitation for the transboundary pollution [8].

There are endless instances of similar situations nearer to us. Little regulation for environment or economics made lots of social problems gush out -- environmental pollution, traffic jam, an even distribution of the wealth, concentration to city. As part of this process of developing a better understanding of the relationship of development with the environment and human health, accurate environmental monitoring and analytical data is seen as key to the production of an improved lifestyle for the peoples of the region, and the promotion of an improved global environmental scenario. While environmental monitoring and analysis programs are being undertaken at the national and multinational levels, analytical methodologies throughout the developing countries have been and distinct, resulting in varying data and making comparison, as well as the availability of basic environmental data, extremely difficult. In order to more fully understand the relationship of development with the natural and human environments, there presently exists a great need for the intercalibration of analytical methodologies at the regional level. Intercalibration leads to the ability to compare the state of environments on a regional and global basis, generating data which can serve as the basis for effective policy- and decision-making by governments and agencies.

We desire no pollution for all time and are deeply conscious of the high ideals controlling human relationship. We desire to occupy an honored place in an international society striving for the preservation of the nature, and the banishment of pollution for all time from the earth. Now, however, global environment is rushing into an impasse and the expectations of environment will go from bad to worse. Now, even Katmandu, at the foot of the Himalayas, is swathed in auto exhaust.

In this point of view, I have investigated in tropical urban area and its outskirts and Maizuru in Japan [9) 10) 11)] with approach of the inter-discipline of natural sciences and social sciences.

Natural Setting

Geological and Physical Data of Maizuru

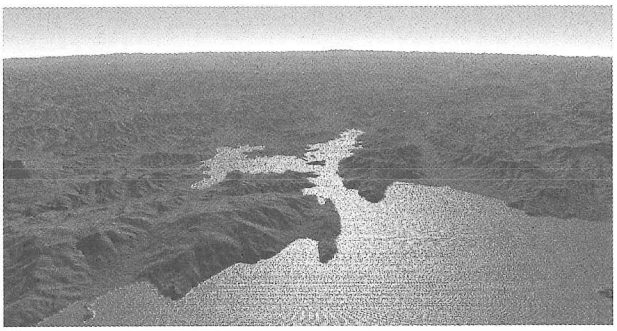

Fig. 1 Computer Graphic View of Maizuru Bay from North generated by Kashmir 3D. (http://www.kashmir3d.com/)

Fig. 2 Map showing Maizuru Bay in Japan.

Table 1 Physical Data of Inland Bay in Japan.

Inland Bay	Area / km^2	Average Depth / m	Volume / km^3
Sea of Japan [1]	1070×10^3	1535	1630
Wakasa Bay [2]	2570	98.8	250
Maizuru Bay	24.74	9.4	0.23
Miyazu Bay [2]	21	15.5	0.33
Tsuruga Bay [2]	46	20.3	0.93
Kurita Bay [2]	8	17.0	0.14
Uchiura Bay [2]	8	22.0	0.18
Takahama Bay [2]	58		
Tokyo Bay [3]	1200	17.9	21.5

Ise Bay [3]	1740	19.5	33.9
Mikawa Bay [3]	604	9.2	5.6
Inland Sea [3]	15570	32.0	498
Osaka Bay [3]	1530	27.5	42.1

[1] Calculated from Data [1)]. [2] Calculated from Data [12)].
[3] Calculated from Data [14)].

Maizuru Bay is located at 35° 30' N latitude, 135°22' E longitude and west part of Wakasa Bay (**Fig. 2 and Table 1**). Geological data of Inland Bay in Japan are listed in Table 1 [12)]. Maizuru Bay's data were obtained by weight method and the width of mouth is longest one 1 km and shortest one 0.6 km. International EMECS Center [13)] described that the enclosed index for Maizuru Bay is 1.77 but that should reach 4.78 by using mouth of 1 km.

Maizuru Bay is geometrically divided two parts: East Bay and West Bay. Though West Bay is relatively strait, East Bay is intricate and re-divided to Central Bay and East Bay by two islands (Jashima and Karasujima) (**Fig. 3**). Area around Maizuru Bay almost equals with only one local public bodies "Maizuru City".

Maizuru City has 342.11 km^2 area, south-north 24.9 km, west-east 29.7 km width, 98.0 km coast line and 94,060 population (October 1st, 2000), which has a little tendency to decrease but almost the same since 1947 [15)] and is closed socially and there is no bigger city near Maizuru. Area around Maizuru Bay holds lots of predominance for the enclosed coastal sea located at center of Honshu Island (Japan Islands) on the Sea of Japan side. Maizuru belongs to Western Japan, and is the most north-east end of Western Japan. Most environmental data are observed in Tokyo and Nagoya: Tokaido Megalopolis on the Pacific Ocean side, or Osaka and Hiroshima beside the inland sea and Lake Biwa. There exist few data on the Sea of Japan side.

Maizuru City is divided to three sub areas, that is, East, Central and West Maizuru, around the same as bay. Maizuru has not only typical enclosed inland bay but also mountains (Mt. Aoba 692 m, Mt. Akaiwa 669.5 m, Mt. Misen 664.0 m, Mt. Mikuni-dake 616.6 m) surround area around Maizuru Bay and result in the closed system spatially, too.

Maizuru is located 5 km close to Takahama Nuclear Power Plant. There exist so many Nuclear Power Plants that Wakasa Bay area is called as "Genpatsu Ginza (Nuclear Power Plant Shopping Mall)" (**Table 2**). Besides, construction of a Coal Power Plant on the mouth of Maizuru Bay has been in progress (**Fig. 2**). We will have more pollutant in area around Maizuru Bay.

Table 2 Nuclear Power Plants in Wakasa Bay (Genpatsu Ginza).

ID	Output / 10^4 kW	Type	
Tsuruga #1	35.7	BWR[1]	
Tsuruga #2	116.0	PWR[2]	
Tsuruga #3	153.8	PWR	Go into Operation in 2016 (scheduled).
Tsuruga #4	153.8	PWR	Go into Operation in 2017 (scheduled).
Tsuruga Fugen	16.5	ATR[3]	MOX (Thermal Use of Pu) Stopped in 2003.
Tsuruga Monju	28	FBR[4]	Stopped for Accident.
Mihama #1	34	PWR	
Mihama #2	50	PWR	
Mihama #3	82.6	PWR	
Ooi #1	117.5	PWR	
Ooi #2	117.5	PWR	
Ooi #3	118.0	PWR	
Ooi #4	118.0	PWR	
Takahama #1	82.6	PWR	
Takahama #2	82.6	PWR	
Takahama #3	87.0	PWR	MOX (Thermal Use of Pu) in 2010 (scheduled).
Takahama #4	87.0	PWR	MOX (Thermal Use of Pu) Stopped for Accident.
Maizuru #1	90	Coal	Went into Operation in 2004.
Maizuru #2	90	Coal	Went into Operation in 2010.
Miyazu #1	37.5	Oil	Stopped.
Miyazu #2	37.5	Oil	Stopped.

[1] Boiling Water Reactor. [2] Pressurized Water Reactor. [3] Advanced Thermal Reactor. [4] Fast Breeder Reactor

Geochemical Data of Maizuru

Maizuru Bay has mainly 10 river-systems flowed into: Kawabe River, Aseku River Shiraku River, Sobotani River, Yoro River, Tera River Isazu River, Yoshihara (tributary: Oote River), Takano River and Fukui River. Maizuru has no big river (Max. flow: Isazu River 5 m^3/s) and the river transport is quite a little.

Though the environmental data of Maizuru is observed mainly by Kyoto Prefectural Office [16], Maizuru City Office [17] and Maizuru Fisherman's Association & Fishery Research Station, Kyoto University [18] or Hydrographic Department, 8th Regional Coast Guard Headquarter [19], those are a little and the data was observed with a different purpose from us. For instance, Water Temperature, Salinity and Transparency in Maizuru Bay has been observed 6 times a year for 1982-1997 by Hydrographic

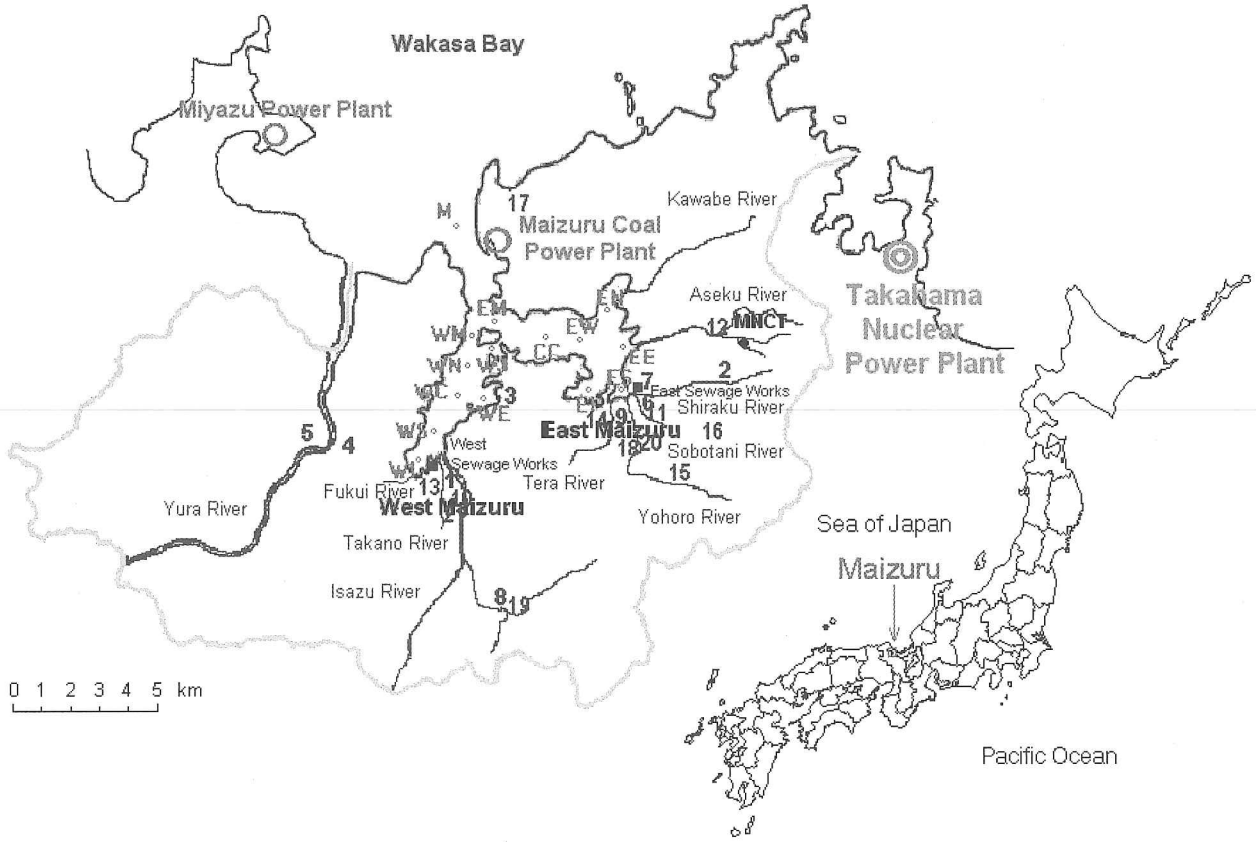

Fig. 3 Map showing an area around Maizuru Bay.

Department, 8th Regional Coast Guard Headquarter [19]. However, this observation had ceased for lack of budget.

For monitoring Takahama Nuclear Plant, Kyoto Prefectural Office observe Absorbed Dose Rate at 3 sites, α and β ray counts at only 1 site and γ ray Dose at 25 sites in Maizuru. Flow, pH, BOD (Biological Oxygen Demand), SS (Suspended Solid), DO(Dissolved Oxygen), Coliform Group, T-P (Total P) and T-N (Total P) are determined at 5 rivers every year by Kyoto Prefectural Office and at 11 rivers 2 seasons a year by Maizuru City Office. The pH, COD (Chemical Oxygen Demand), Coliform Group, T-P and T-N are determined at 4 sites in Maizuru Bay. SO_2, NO and NO_2 are observed at only 2 sites. Besides, a site in East Maizuru (Shin Maizuru elementary school) is located in low traffic zone and does not represent whole area. We collected data as much as possible but for these reason we should analyze by ourselves and examine both kind of. In this paper, ppm and ppb indicate mg dm^{-3} and ng dm^{-3}, respectively

Experimental

For simplification, we make it a rule to adopt simple and rapid analysis [20) 21)] or analysis, *in situ* [22]. The pH, Water Temperature (WT), Conductivity (Cond), Turbidity (Turb), Dissolved Oxygen (DO) and Salinity (Sal) was measured with Water Quality Checker U-10 (Horiba) at the same time in water (River or Sea), *in situ*. Transparency has been measured with secchi board by Takahashi, one of authors since July 20th, 1989.

The rain was sampled by AR-5 (Shimadzu) or Raingoround AR-8 (Horiba). AR-5 is capable for sampling of the first rain to 5 mm and Raingoround AR-8 is capable for divided sampling to each 1 mm to the first 8 mm rain. The snow was sampled into a plastic beaker and slowly thawed to the room temperature (20 ℃). Sampling site was located on the center of yard in Maizuru National College of Technology. In order to confirm correct latitude and longitude, GPS (Global Positioning System) instrument, GPS38J (Empex) was utilized. Colorimetric determinations with 6th generation type NO_2 passive sampler (Tsukuba Sogo Kagaku Kenkyusho) and Ecoanalyzer (ECOTEC) were carried out to NO_2 in atmosphere

23).

Results

Citizen group "Society to Clean Tera River up" stocked Tera River with 2000 carp fry at July 22, 1990. The same attempt had repeated but in vain to extinct. **Fig. 4** shows the extinction curve of carp. **Fig. 5** exhibits the Transparency at 13 sites in Maizuru

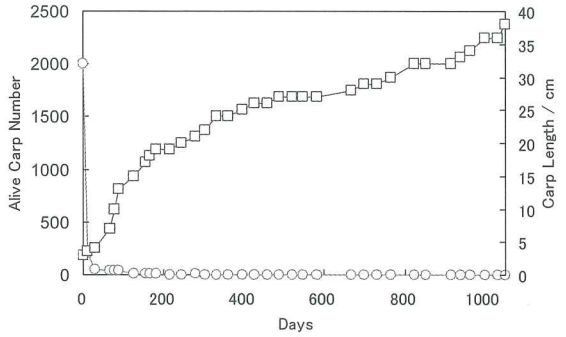

Fig. 4 Pursue Research of Carp *(Cyprinus carpio)* which was stocked Tera River with: Surviving Carp Number (○); Surviving Carp's Length (□).

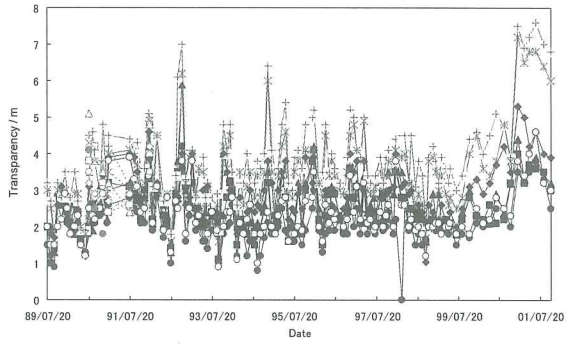

Fig. 5 Transparency in Maizuru Bay (July 20, 1989 - October 21, 2001).

The location code is indicated in **Fig. 3**.

East Bay: EN (▲), EE (■),ES (●), EI (×), EW (□) with solid lines.

Central Bay: CC (＊), EM (＋) with solid lines.

West Bay: WM (＋), WJ (＊), WN (□), WE (□),WS (○), WI (×), WC (□) with dotted lines.

Bay for July 20, 1989 October 24, 2001. This data consists in 7 sites in West Maizuru Bay 5 times for July 20, 1990 – July 20, 1991 and 7 sites in East Maizuru Bay every month for July 20, 1989 - June 29, 1999 and every 2 months for August 20 - October 24, 2001. Table 3 points out the decreased and increased marine biological species.

Fig. 6 shows precipitation in January 11, 1994 -February 12, 1995. Using GPS, I confirm sampling site at 35° 29.506' N latitude, 135° 26.541' E longitude (Tokyo method, ±33 m) and 30 m height. In early 1994's winter, precipitation is unusually little and less snow (only 3 snow samples and 17 rain samples), but in early 1995's winter, it is usually more. Usually there exists precipitation onto Maizuru in almost every season, especially in winter it snows or rains including mist almost every day. Moreover, sampling site (Maizuru National College of Technology) is located in area with usually more heavy snows than Maizuru Marine Observatory for geological difference. The members of Society of Natural Sciences, Maizuru National College of Technology and I have observed since January 1994 in order to estimate the influence of pollutant from Manchuria and Korea, especially in winter. There were obtained 13 snow samples and 9 rain samples in 1995's early winter. These data show that pH and conductivity of precipitation onto Maizuru in 1995's winter. NO_2 in atmosphere has observed for June 15, 2000 – January 16, 2001.

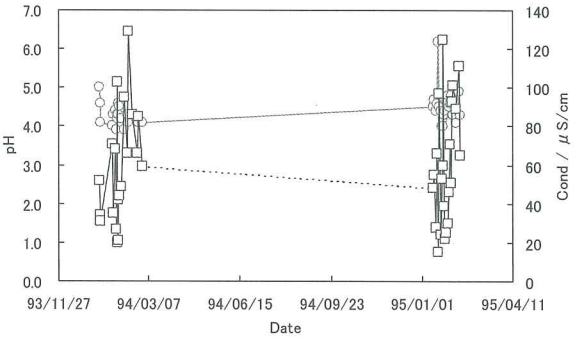

Fig. 6 Acid Precipitation onto Maizuru National College of Technology. pH (○); Conductivity (□).

Discussion

Terrestrial water

Fig. 4 suggests that the surviving carp fry number shows exponential decrease and the extinction function is described as follows:

$$N = N_0 e^{-\lambda t} \quad (1)$$

where N and N_0 is number of alive carp after t days and initially, respectively; half life $0.693/\lambda = 3.3$ days.

BOD value is a measure of organic matter to be decomposed by a microorganism [21] and in proportion to pollutant. DO value is provided from atmosphere and photosynthesis of plants, and consumed by respiration of lives and decomposition of organic matters [14]. Therefore, DO value is inversely proportional to pollution. The pH value increases for photosynthesis and decreases for decomposition of organic matter and is inversely proportional to pollution. Coliform group lives in intestines of man or domestic animals. T-N and T-P are a

good index of human activity because T-N is generated by decomposition of protein or urea and T-P is derived from synthetic detergent or chemical fertilizer [24]. Maizuru shows Tera River is the most polluted in Maizuru rivers by determinative consideration of the above 6 variables and SS[9].

Maizuru Bay

Transparency is so popular and primitive method but that is important relation to be in proportional to turbidity, SS and illuminance. Experimentally, transparency agrees with 15% of surface illuminance [20]. **Fig. 5** represents Transparency in Maizuru Bay. Variables of eutrophication (COD, SS, T-N, NH_4^+-N, NO_3^--N, T-P and PO_4^{3-}-P) increased rapidly to extremely high in the interior of Bay. EI and WI sampling sites are located off sewage works of East and West Bay, respectively. Transparency varies inversely to drainage population and area. Treated water from sewage works has still more matter of eutrophication.

Chlorophyll-a (Chl-a) is the substance which only plant plankton alive generally has and is rapidly decomposed after death. Eutrophication is commensurate with Chl-a and population of an opportunistic semelid bivalve *Theora fragilis*[25].

Salinity decrease indicates water flows in. Transparency has the minimum for biological activities and layer of discontinuity prevents from mixing over in summer. In October and March, there is the maximum for mixing and thawed water's flowing in or ocean current. This result suggests the existence of discontinuity layer in East Bay. That means surface water was not mixed in summer time. Therefore, for geological circumstance, East Bay is more polluted than West.

Table 3 Trend of Marine Biological Species in Maizuru Bay.

Year	Decreased species	Increased species
1977-1978	Torigai *(Fulvia mutica)*[1], Hotate *(Patinocepecten yessoensis)*, Sazae *(Batillus cornutus)*, Akanishi *(Rapana Venosa)*	
1980-1981	Anago *(Gorgasia maculata)*, Shimaisaki *(Rhyncopelates Oxythynchus)*, Ishidai *(Gorgasia maculata)*, Madai *(Pagtus major)*	
1984-1986	Iidako *(Octopus membbranaceus)*, Namako *(Holothuroidea)*, Kaminariika *(Sepia subaculeata)*, Madako *(Octopus vulgaris)*, Asari *(Tapes philippinarum)*, Kani *(Brachyura)*	
1989	Wakame *(Undaria pinnatifida)*	Hitode *(Asterias)*
1990	Makusa *(Gelidium elegans)*, Kaki *(Crassostrea gigas)*	Wakame *(Undaria pinnatifida)*
1991	Wakame *(Undaria pinnatifida)*, Kurodai *(Acanthopagrus achlegeli)*	Asari *(Tapes philippinarum)*, Namako *(Holothuroidea)*
1992	Kurodai *(Acanthopagrus achlegeli)* Igai *(Mytilus coruscus)*	Wakame *(Undaria pinnatifida)*,
1993	Kurodai *(Acanthopagrus achlegeli)*	Wakame *(Undaria pinnatifida)*
1994	Kurodai *(Acanthopagrus achlegeli)*, Igai *(Mytilus coruscus)* extincted	Wakame *(Undaria pinnatifida)*
1995	Kurodai *(Acanthopagrus achlegeli)*	Wakame *(Undaria pinnatifida)*
1996	Kurodai *(Acanthopagrus achlegeli)*, Kani *(Brachyura)*, Igai *(Mytilus coruscus)*	Wakame *(Undaria pinnatifida)*, Hitode *(Asterias)*
1997	Asari *(Tapes philippinarum)*, Igai *(Mytilus coruscus)* extincted, Kani *(Brachyura)* extincted	Wakame *(Undaria pinnatifida)*
1998	Asari *(Tapes philippinarum)*, Igai *(Mytilus coruscus)* extincted, Kani *(Brachyura)* extincted	Iidako *(Octopus membbranaceus)*, Suzuki *(Lateolabrax) japonicus)*
1999	Asari *(Tapes philippinarum)*,	Suzuki *(Lateolabrax)*
2000	Igai *(Mytilus coruscus)* extincted, Kaki *(Crassostrea gigas)*, Asari *(Tapes philippinarum)*	Igai *(Mytilus coruscus)*, Kurodai *(Acanthopagrus schlegeli)*, Aji *(Trachurus japonicus)*

[1] Japanese name (*scientific name)*

We have investigated trend of marine biological species in Maizuru Bay by an interview of fishermen or specialists and listed in **Table 3**. Water quality, especially Transparency recovers to the past in these days, as shown in **Fig. 5**. It seems to be explained turbid water from Coal Power Plant construction come to a halt and algae glowed and cleanse the seawater.

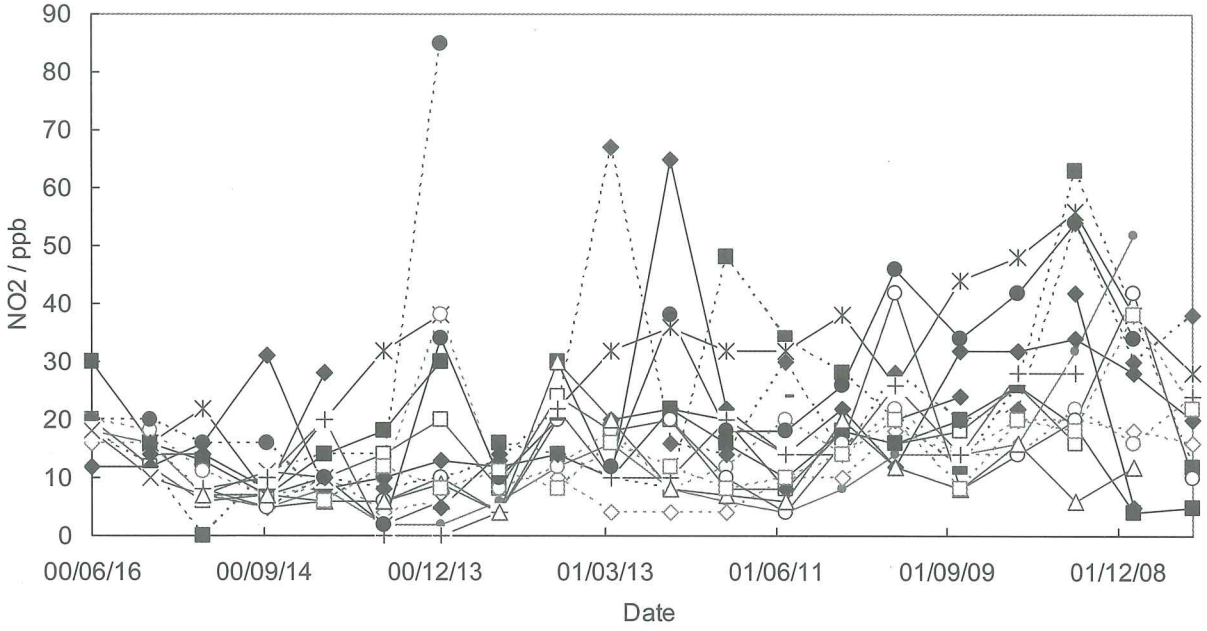

Fig. 7 NO_2 in Atmosphere in Area around Maizuru Bay.

The location code is indicated in **Fig. 3**. East Maizuru Rural Area: 17 (□), 12 (×), 2 (□), 16 (+), 15 (○) with solid lines. East Maizuru Urban Area: 7 (■), 6 (*), 11 (□), 20 (—), 18 (●), 9 (-), 14 (□) with solid lines. Central Maizuru Rural Area: 3 (•) with solid lines. West Maizuru Rural Area: 19 (□), 8 (○), 4 (□), 5 (×) with dotted lines. West Maizuru Urban Area: 10 (■), 1 (●), 21 (-), 13 (□) with dotted lines.

Atmosphere

It can be explained that the precipitation is purified through recrystallization at first in sky but it is melted to a droplet of rain and can dissolve lots of pollutants in falling onto ground level. **Fig. 6** shows the pH value is inversely proportional to conductivity of precipitation. This result indicates that acid pollutants are electrolytes, maybe NO_x and SO_x or their derivatives. In the most influence of monsoon from Manchuria and Korea, early in February, precipitation is most polluted. This result may be explained that there exists lots of acid pollutants in winter over Maizuru and they dissolved into rain or the reaction of acid substance took time. The Acid Rain Measurement Information Network HONEST in each prefecture show that values elsewhere are more moderate than our data, since our sampling site is located in the front line against monsoon from northwest. The values are in proportion of the economic growth of North East Asia, for few regulations in those countries.

With increased public awareness of the environment, an NGO, Kankyo Miru!-Kiku-Kangaeru Kai has measured NO_x concentration in atmosphere at 21 sites every month since June 15, 2000, as shown in **Fig. 7**. These data can be classified as 5 areas: East rural area (#17, #12, #2, #16, #15; average=13.34 ppb), East urban area (#7, #6, #11, #20, #18, #9, #14; average=22.52 ppb), Central rural area (#3; average=12.95 ppb), West rural area (#19, #8, #4, #5; average=13.88 ppb) and West urban area (#10, #1, #21, #13; average=22.20 ppb) These results shows that pollution in atmosphere is in proportional to traffic amount and human activities. Our continuous analytical data could show environmental changes of area around Maizuru Bay.

In combustion, coal generates not only more CO_2 but also much more pollutant including PAH (Ploy Aromatic Hydrocarbon) than petroleum does. In general a coal power plant pollutes atmosphere more than a petroleum power plant [26]. A new coal power plant is under construction and will be completed soon on the mouth of Maizuru Bay, in 2004. Besides to transboundary pollution, we will have danger to be damaged domestically by the new coal power plant and nuclear power plants in Maizuru. We must maintain to observe the development and the environment of Maizuru desperately.

Maizuru will ironically have lots of priority worth to observe more.

The economic development is apt to destroy their various and rich culture and life style. The changes of life style, and the environment there goes an impasse. Society centered on consumption of materials and energy needs to be reconsidered from the ground up. This report gives the outline about sociogeochemical research for area around Maizuru Bay in the present and future.

Acknowledgments

We are grateful to Dr. Mukai, H. for their help in our study.

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(Received in January 7, 2011)