1. AIR, WATER AND SOIL POLLUTION
2. MAJOR GROUND SUBSIDENCE AREAS

1. Air, Water and Soil Pollution

As pollution became one of the most serious problems in Japan, due to rapid industrial development following World War Two, the Environmental Pollution Prevention Act (1967) and 14 acts concerning pollution (1970) were enacted and countermeasures strengthened.

Environmental pollution encompasses many types but the major ones are air, water and soil pollution. Recently, global pollution has also become a major concern.

Air pollutants include floating dust, sulfur dioxide, carbon monoxide, hydrogen sulfide, nitric oxide and hydrocarbons, which are known as primary pollutants ; and photochemical oxidant, sulfuric acid mist and nitrates, which are called secondary pollutants and are formed by chemical reactions in the air. Pollution in the 1960s was due mainly to floating dust and sulfur dioxide, however, they began to decrease in the 1970s, with pollution by nitrogen oxide becoming a new problem. As well as being directly harmful to the human body, nitrogen oxide is activated in the air by absorbing sunlight and produces chemical reactions which result in oxidants and photochemical smog. It is also absorbed into rainwater as acid, together with sulfur dioxide, and causes damage to forests, lakes and marshes in the form of acid rain. When fuel burns at a high temperature, nitrogen and oxygen in the air combine to produce nitrogen oxide. The main sources of nitrogen oxide are factories using fuels and automobile exhaust fumes. The volume of nitrogen oxide remained static, perhaps showing a slight decrease, in the first half of the 1980s due to recent developments in combustion technology, but has shown a slight increase since 1986.

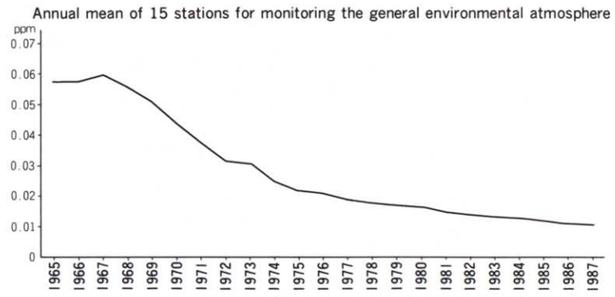
Water pollution influences the quality of municipal drinking water and those creatures living in the water, altering the very ecosystem. Damage caused by water pollution may be visible, such as abnormal development of plankton, mass death of fish, etc. Indices used to measure water pollution include pH, electric conductivity, the amount of nutritive salts, DO (Demand of Oxygen), COD (Chemical Oxygen Demand), BOD (Biochemical Oxygen Demand), the quantity of heavy metals such as cadmium and mercury, the amount of artificial organic matter such as PCB (Polychlorinated biphenyl), etc.

The following environmental standards for water pollution have been established : standards to protect the health of human beings against cadmium, etc., and standards to protect the environment, such as BOD, COD, etc. The rate of compliance with environmental standards to protect human health has been increasing since 1976, due to implementation and observation of laws, with only 0.02% of samples not meeting the required standard. Furthermore, 70.1% of all bodies of water met the safety standards for living environments, such as BOD and COD, in 1987. Serious water pollution is noted in closed water areas, such as lakes, inner bays, etc., and in medium-sized and small rivers in cities.

Soil pollutants include heavy metals and pesticides. Of the heavy metals, cadmium, copper and arsenic are regulated by the Soil Pollution Protection Act. By 1987, 128 areas with values exceeding the standard had been detected, a total area of 7,030 ha.

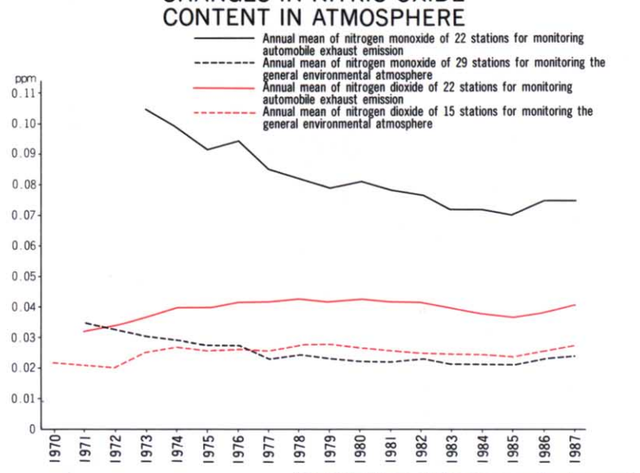
CHANGES IN SULFUR DIOXIDE CONTENT IN ATMOSPHERE

Annual mean of 15 stations for monitoring the general environmental atmosphere



(Compiled from *White Paper on Environment*)

CHANGES IN NITRIC OXIDE CONTENT IN ATMOSPHERE



(Compiled from *White Paper on Environment*)

Global environmental pollution includes the following phenomena : the ozone layer in the stratosphere is being damaged by freon gas with the result that the number of ultraviolet rays to reach the earth's surface is increasing ; the 'Greenhouse Effect' is expanding due to the increase of sulfur dioxide in the atmosphere and a corresponding rise in the earth's temperature is predicted.

[Salient Points of the Legend and Map Compilation]

pphm : 1/100 million
ppm : 1/1 million
BOD : the volume of oxygen required for aerotropic bacteria to oxidize and dissolve organic substances in the water . The higher the contamination rate, the more organic substances are found ; thus, a greater quantity of oxygen is required to oxidize and dissolve them. The limit of self-clearance is said to be 5ppm.
COD : the volume of oxygen required for oxidation of organic substances in water by the oxidizer. The higher the contamination rate, the greater the COD.

2. Major Ground Subsidence Areas

By 1987, ground subsidence had been recorded at 60 areas in 36 prefectures, amounting to a total area of 10,690 km². Of this total area, areas below sea level, commonly known as 'zero-meter areas', measured 1,143 km². As of 1987, an area of 500 km² existed which had subsided more than 2 cm per annum ; while this was less than that recorded prior to 1970, no marked change has been seen over the past 10 years.

It is believed that ground subsidences began to occur in Tōkyō, Ōsaka and other cities aronud 1900 but began to rapidly increase in size from 1930s, becoming a recognized social problem after these cities were damaged by high tides, etc. As the operation of factories was limited during World War Two as a result of air raids, the amount of groundwater pumped decreased, thus suspending subsidence for some time. The volume and area of ground subsidence began to increase again around 1955, encompassing local cities and villages in agricultural areas. Following this, ground subsidence in large cities almost ceased, except in some areas, due to countermeasures such as regulations imposed on pumping groundwater. However, ground subsidence of 4 cm per year and over is still being recorded in the north Kantō Heiya (Plain) and the Tikugo and Saga Heiya.

The main cause of ground subsidence is shrinkage by consolidation of the ground caused by excess pumping of groundwater . Thus, ground subsidence often occurs on alluvial plains with sand and gravel layers which contain large amounts of groundwater, and where thick soft layers easily develop. Recently, as groundwater is being pumped from very deep underground layers, ground subsidences of diluvial terraces have been recorded due to the contraction of layers beneath those formed in the Pleistocene Period.

Groundwater is pumped up mainly for industrial and municipal use, and for various uses (such as air conditioning, etc.) in city buildings. Other areas noted for pumping up large quantities of groundwater are: Niigata, and Kuzyūkuri Hama in Tiba Prefecture when natural gas was being extracted; Siraisi Tyō in Saga Prefecture for agricultural use; and areas with snowdrifts where groundwater is pumped up to melt snow. All these activities contribute substantially to ground subsidence.

In addition to direct damage resulting from ground subsidence, such as damage to buildings and poor performance of irrigation and waste water channels,there is also potential danger of submergence by high tides and floods. As well as the diverse regulations regarding the pumping up of groundwater, construction of tide embankments and the raising of ground by filling soil are also being carried out as countermeasures.

[Salient Points of the Legend and Map Compilation]

Isograms of ground subsidence were drawn using the results of levelling conducted by the Geographical Survey Institute and local public bodies.

STATUS OF GROUND SUBSIDENCE AREAS (1987)

Prefecture	Name of area	Area of ground subsidence (km²)	Area of 0-meter zones (km²)	Maximum ground subsidence at bench marks (cm)	Maximum ground subsidence at bench marks Observation period	Annual maximum ground subsidence according to the recent survey * (cm)	Annual maximum ground subsidence according to the recent survey * Observation year, Period
Hokkaidō	Isikari Heiya	250		45	1975～1983	1.2	1985～1987
	Kusiro Heiya			18	1952～1977	1.3	1969～1977
	Tokati Heiya			7	1977～1984	1.2	1981～1984
	Yūhutu Heiya			12	1955～1982	0.1	1968～1982
Aomori	Aomori Heiya	65	3	51	1958～1987	2.0	1987
	Tugaru Heiya			25	1968～1986	2.0	1983～1986
	Hatinohe	10		23	1975～1987	1.2	1987
Miyagi	Kesennuma	5	1	13	1975～1987	1.4	1987
	Hurukawa	10		18	1954～1987	1.3	1987
	Sendai・Siogama	290		70	1974～1987	4.2	1987
Akita	Kisakata・Kōnoura	10		57	1968～1985	1.8	1985
Yamagata	Yamagata Bonti	60		31	1974～1987	1.4	1987
	Yonezawa Bonti	5		12	1974～1987	0.9	1987
Hukusima	Hukusima Bonti			9	1954～1985	0.3	1978～1985
	Haramati	40		162	1955～1987	0.2	1987
	Iwaki			7	1953～1984	0.2	1978～1984
Ibaraki	Kantō Heiya	160		70	1974～1987	4.0	1987
Totigi	//	500		37	1967～1987	4.3	1987
Gunma	//	5		19	1975～1987	1.9	1987
Tiba	//	1,980	15	211	1962～1987	**4.5	1987
	Kuzyūkuri Heiya	800	14	70	1968～1987	**9.3	1987
Saitama	Kantō Heiya	1,650		161	1960～1987	4.8	1987
Tōkyō	//	955	124	454	1918～1987	1.5	1987
Kanagawa	//	230	6	139	1931～1987	3.2	1987
	Ken'ō・Syōnan	130		33	1967～1987	1.9	1987
Niigata	Niigata Heiya	805	142	272	1957～1987	1.7	1987
	Nagaoka	70		14	1975～1987	1.5	1987
	Takada Heiya	240		29	1968～1987	1.4	1987
	Minami-Uonuma	60		38	1975～1987	1.4	1987
Toyama	Toyama・Tonami Heiya			4	1973～1978	0.7	1975～1978
Isikawa	Nanao	15		16	1972～1987	0.3	1987
	Kanazawa Heiya			21	1974～1987	1.0	1987
Hukui	Hukui Heiya	15		7	1975～1985	0.6	1981～1985
Yamanasi	Kōhu Bonti	80		11	1974～1987	1.3	1987
Nagano	Suwa Bonti	20		29	1977～1987	4.0	1987
Sizuoka	Numazu・Misima			6	1967～1986	0.4	1984～1986
	Huzi (Gakunan)			2	1979～1987	0.4	1985～1987
	Sizuoka・Simizu			4	1950～1985	0.3	1983～1985
Aiti	Toyohasi Heiya		27	4	1976～1987	0.6	1987
	OKazaki Heiya	65	57	25	1975～1987	1.7	1987
	Nōbi Heiya	735	286	147	1962～1987	1.8	1987
Gihu	//	150	61	19	1973～1987	2.2	1987
Mie	//	120	55	159	1962～1987	1.7	1987
Kyōto	Kyōto Bonti			26	1973～1986	2.1	1984～1986
Ōsaka	Ōsaka Heiya	635	55	287	1935～1987	1.9	1987
Hyōgo	//	100	16	277	1932～1987	1.7	1987
	Toyooka Bonti			26	1971～1983	2.0	1978～1983
	Harima Heiya			7	1948～1970	0.7	1979～1982
	Awazisima Nanbu (Southern Awazisima)			5	1964～1970	0.9	1964～1970
Tottori	Tottori Heiya	10		32	1974～1987	1.3	1987
Okayama	Okayama Heiya			10	1969～1987	0.3	1987
Hirosima	Hirosima Heiya	35	9	20	1955～1973	0.4	1978～1981
Tokusima	Tokusima Heiya			11	1964～1971	0.6	1979～1982
Kagawa	Sanuki Heiya (around Takamatu)			10	1947～1979	0.2	1979～1982
	Sanuki Heiya (around Sakaide・Marugame)			6	1947～1979	0.2	1979～1982
Kōti	Kōti Heiya	25	10	15	1973～1983	0.7	1981～1983
Hukuoka	Tikugo・Saga Heiya		46	18	1957～1987	1.1	1987
Saga	//	320	207	106	1957～1987	3.7	1987
Kumamoto	Kumamoto Heiya	35	9	24	1974～1987	1.2	1987
Miyazaki	Miyazaki Heiya			11	1980～1987	3.5	1987

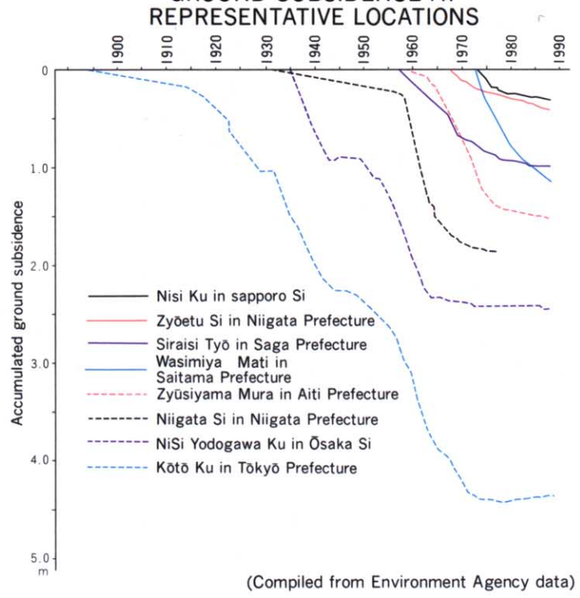
* In cases where the survey is not conducted every year, the degree of ground subsidence indicated is the annual mean of surveyed periods.
** Extraordinary ground motions, which are thought to have been caused by the Tiba Tōhō Oki Earthquake in December, 1987, were recorded.

(Compiled from Environment Agency data)

[Sources]

1. Environment Agency, *Result of Air Monitoring by the General Environmental Air Measuring Bureau*, 1987
2. Environment Agency, *Yearbook of Water Quality Monitoring in Public-Use Water area in Japan*, 1989
3. Ministry of Construction, *Yearbook of Water Quality of Japanese Rivers*, 1987
4. Environment Agency, *White Paper on Environment*, 1989
5. Geographical Survey Institute, *Change of ground subsidence in Major Areas in Japan*, 1988
6. Geographical Survey Institute, *Report on the Survey of Ground Subsidence in Kyōto and Hansin Area*, 1987
7. Geographical Survey Institute, 1 : 25,000 scale Land Condition Map
8. Environment Agency, *General Situation of Ground Subsidence Area in Japan*, 1987
9. Environment Agency data

GROUND SUBSIDENCE AT REPRESENTATIVE LOCATIONS



(Compiled from Environment Agency data)

17.1

AIR WATER AND SOIL POLLUTION

(1987)

AIR POLLUTION

Density of nitrogen oxide (NO) in the air (In pphm, 100 pphm = 1 ppm)

WATER POLLUTION

Biochemical Oxygen Demand (BOD) is indicated for rivers
Chemical Oxygen Demand (COD) is indicated for lakes and seas

- Less than 1 ppm
- 1 ppm and over but less than 2 ppm
- 2 ppm and over but less than 3 ppm
- 3 ppm and over but less than 5 ppm
- 5 ppm and over but less than 8 ppm
- 8 ppm and over
- Rivers and lakes for which no data is available

SOIL POLLUTION

- Areas where the copper content in soil exceeds 125 ppm
- Areas where the arsenic content in soil exceeds 15 ppm
- Areas where the cadmium content in harvested rice exceeds 1 ppm, and areas where it is feared the cadmium content exceeds 1 ppm

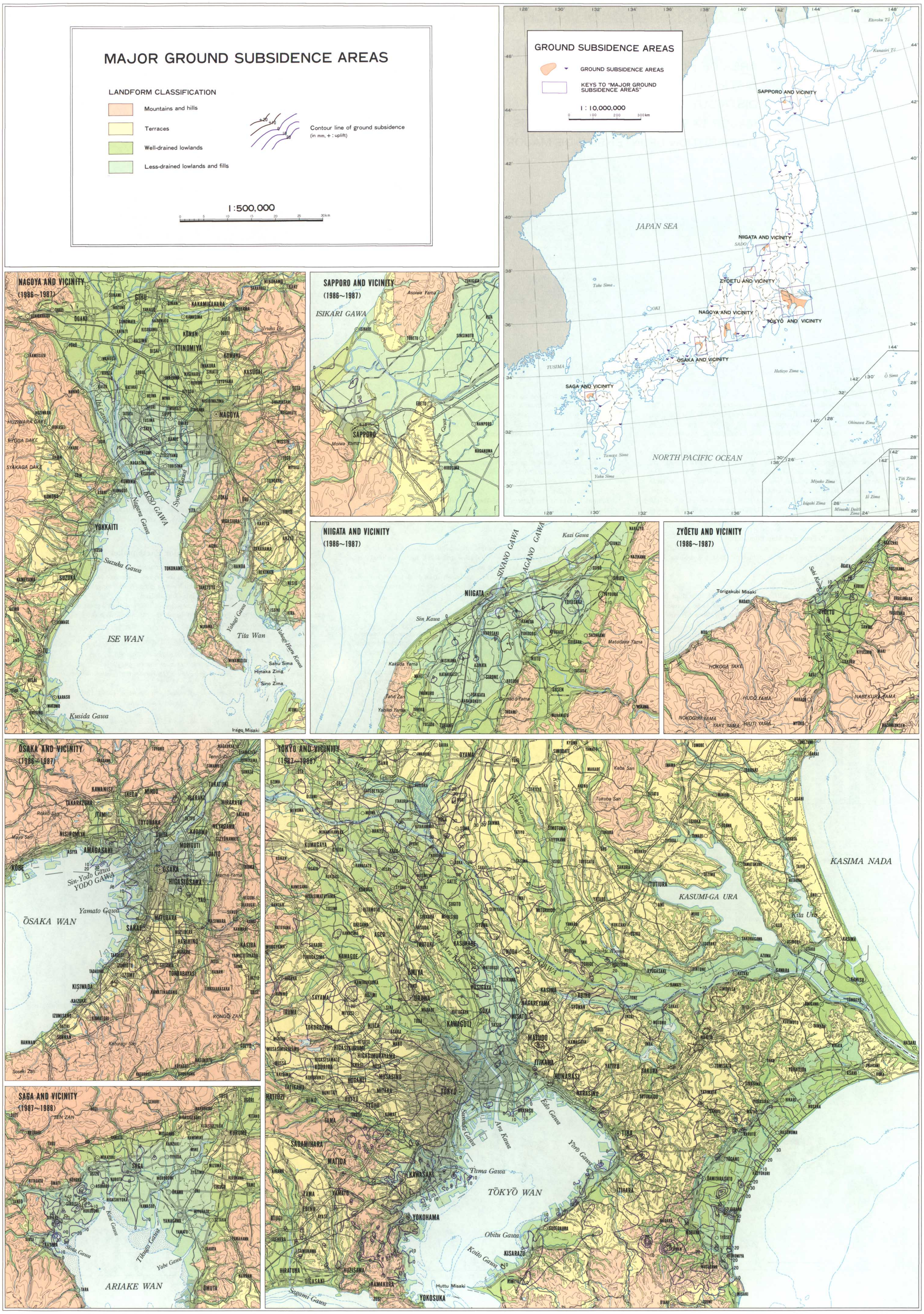
The annual average for 1987 was used for air and water pollution

The status as of March 1988 for soil pollution

1 : 4,000,000

0 50 100 150 200km

SEA OF OKHOTSK
JAPAN SEA
NORTH PACIFIC OCEAN
Etorohu Tō
Rebun Tō
Risiri Tō
Kunasiri Tō
Sikotan Tō
HABOMAI SYOTŌ
Okusiri Tō
SADO
Take Sima
OKI
TUSIMA
Awazi Sima
Ō Sima
Miyake Zima
IZU SYOTŌ
Hatizyō Zima
Aoga Sima
GOTŌ RETTŌ
KOSIKIZIMA RETTŌ
ŌSUMI SYOTŌ
Tanega Sima
Yaku Sima
TOKARA RETTŌ
AMAMI SYOTŌ
Tokuno Sima
Okinoerabu Zima
OKINAWA SYOTŌ
Okinawa Zima
Kume Zima
RYŪKYŪ SYOTŌ
SENKAKU SYOTŌ
SAKISIMA SYOTŌ
Miyako Zima
Iriomote Zima
Isigaki Zima
Yonaguni Zima
DAITŌ SYOTŌ
Kita-Daitō Zima
Minami-Daitō Zima
KAZAN RETTŌ
Iō Zima
OGASAWARA GUNTŌ
Titi Zima
Haha Zima


MAJOR GROUND SUBSIDENCE AREAS
LANDFORM CLASSIFICATION
Mountains and hills
Terraces
Well-drained lowlands
Less-drained lowlands and fills
Contour line of ground subsidence
(in mm, + : uplift)
1:500,000
0 5 10 15 20 25 30km
GROUND SUBSIDENCE AREAS
GROUND SUBSIDENCE AREAS
KEYS TO "MAJOR GROUND SUBSIDENCE AREAS"
1 : 10,000,000
0 100 200 300km
JAPAN SEA
NORTH PACIFIC OCEAN
SAPPORO AND VICINITY
NIIGATA AND VICINITY
ZYŌETU AND VICINITY
NAGOYA AND VICINITY
TŌKYŌ AND VICINITY
ŌSAKA AND VICINITY
SAGA AND VICINITY
NAGOYA AND VICINITY
(1986~1987)
ISE WAN
Tita Wan
KISO GAWA
SAPPORO AND VICINITY
(1986~1987)
ISIKARI GAWA
NIIGATA AND VICINITY
(1986~1987)
SINANO GAWA
AGANO GAWA
ZYŌETU AND VICINITY
(1986~1987)
ŌSAKA AND VICINITY
(1986~1987)
ŌSAKA WAN
YODO GAWA
TŌKYŌ AND VICINITY
(1987~1988)
TŌKYŌ WAN
KASUMI-GA URA
KASIMA NADA
SAGA AND VICINITY
(1987~1988)
ARIAKE WAN