Characteristic of Heavy Rainfall Disaster in Central Area of Japan on September 11 to 12, 2000

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1. Introduction

Heavy rainfall occurred in during the Toukai district around Nagoya City (Central area of Japan) on 11 to 12 September 2000. Caused by Typhoon No.14 and a stationary front(Fig. 1), this heavy rainfall brought great damages to various areas in Tokai district. This paper report characteristic of this disaster from a viewpoint of comparison with past disaster events and disaster informatics.

2. Characteristic of damage

2.1 Outline of damage

The Fire Defense Agency, Ministry of Home Affairs (at present Ministry of Public Management, Home Affairs, Posts and Telecommunications), summarized this disaster inflicted on the entire country as of October 2, 2000, as shown in Table 1. Aichi Prefecture was damaged to the extent that it composed 92% of all the inundated houses in Japan. An embankment of about 100m was destroyed in the Shinkawa river in the Nishi Ward of Nagoya City. Besides this, embankments were destroyed at ten places in Aichi Pref., and much flood damage occurred surrounding Nagoya City and the northern part of the Chita Peninsula. Floods and debris flows occurred in the mountainous area of the upper reaches of the Yahagigawa river. Therefore, a lot of houses, roads, telephone lines, and power lines were damaged, and the villages became isolated one after the other.

The operation of the Toukaidou Shinkansen was suspended for about 24 hours from 11 September. 50,000 passengers had to stay in the train overnight. This suspension time was the longest since the Shinkansen began running in 1964. Since this created a large social problem, the Ministry of Transport (at present Ministry Land, Infrastructure and Transport) directed JR Central to improve the railway system so as to avoid such disasters in the future.

The National Disaster Act was put in force in 17 cities and towns in Aichi and Gifu Pref. (Fig. 2)

2.2 Comparison with the heavy rainfall disasters after 1971 in Japan

In Aichi Pref., about 65,000 houses were inundated in this disaster. There were especially a lot of over floors which were inundated. This is one of the heaviest inundator damage after 1971. There were nine heavy rainfall disaster events after 1971 in which the inundation of 50,000 houses or more was recorded in one prefecture. Most recent similar disaster occurred in Saitama Pref. 18 years ago (September 1982) when Typhoon No.18 and a stationary front caused the inundation of 60,100 houses (Japan Meteorological Agency, 1999). The inundation damage of a recent remarkable heavy rainfall disaster events were rather smaller than these two disasters. In the case of the Kouchi heavy rainfall disaster in September 1998, eight people died or missing, 141 houses were ruined or half-ruined, and 17,300 houses were inundated. In the case of the Hiroshima heavy rainfall disaster in June 1999, these factors were 32, 512, and 3827 respectively.

2.3 Past heavy rainfall disaster events in Aichi Pref.

Table 2 shows the major heavy rainfall disaster events after 1901 in Aichi Pref. Since large-scale sediment disasters such as those of July 1972 did not occur this time. This might account for the lesser damage to humans and housing in the present instance, though there was much precipitation.

The "Ise bay typhoon" in September 1959 is well-known as the cause of an especially large disaster around Aichi Pref. The number of dead or missing persons was 5,098 throughout the entire country(Aichi Pref. 3,251, Mie Pref. 1,273), about 830,000 houses were destroyed, and about 360,000 houses inundated. However, most of this damage was inflicted by the high tide. Two-day precipitation was 198 mm at Gifu(Gifu Pref.), 164 mm at Nagoya, and 265 mm at Ueno(Mie Pref.) etc. These values are much smaller than the 600mm experienced at Nagoya in the present case.

3. Characteristic of Precipitation

3.1 Precipitation before the heavy rainfall

In 2000, Japan's summer precipitation was so

slight that concern was expressed regarding a water shortage. The ratios in relation to the normal precipitation in the Toukai district of this year were from 70% to 100% in April and May, from 100% to 120% in June, and 40% or less in July and August(JMA, 2000a - 2000e). The five-day precipitation from April to September 2000 at Nagoya Local Meteorological Observatory is shown in Fig. 3. No five-day precipitation exceeded the normal during this period. Rainfall was not recorded from the middle of May to the middle of June. In Baiu seasen (June to July), seasonal precipitation was slightly less than normal; very few rainfalls had occurred since August. The total precipitation at Nagoya was only 23 mm (four small rainfall events) from the beginning of August to September 10.

3.2 Situation from September 11 to 12

Fig. 4 shows an isohyetal map of the two-day precipitation from September 11 to 12. This figure is based on data gathered by the Ministry of Construction, Japan Meteorological Agency (JMA) and Aichi Pref. As the figure indicates, heavy rainfall areas existed among the areas that received the total precipitation about 600 mm in the southern part of Mie Pref., the east part of Aichi Pref., and around Nagoya City. The southern part of Mie Pref. and the east part of Aichi Pref. are regions that experience heavy rainfall, while Nagoya receives lesser amounts. It is notable that such heavy rainfalls occurred around Nagoya City in the present instance. For example, 618 mm was recorded in two days at the Miyagawa observatory (Miyagawa Village) in the southern part of Mie Pref. This is 1.18 times the normal amount of precipitation in September (522 mm). On the other hand, the two-day precipitation of 567 mm at Nagoya is 2.43 times the normal amount of precipitation in September (233 mm).

Fig. 5 shows the hourly precipitation and cumulative precipitation at Nagoya and Yarigairi, which were selected as representative raingauges in the areas that received the heaviest amounts of rainfall. The heavy rainfall in the present instance occurred within about 24 hours. The first heavy rainfall occurred in Nagoya between 18:00 and 21:00 on September 11. The second was from 23:00 on Sep. 11 to 04:00 on Sep. 12th. Rain stopped around 08:00 on Sep. 12. Table 3 shows the precipitation data gathered at the main observatories. The precipitation record of this time can be summarized as follows: the maximum hourly precipitation is about 110 mm; 24-hour precipitation is about 500 mm; and the total precipitation is about 600 mm.

3.3 Comparison with past heavy rainfalls

Table 4 shows the historical maximum daily and hourly precipitation in the Toukai district. Daily precipitation records shown in Table 4 are rather small compared with records obtained in regard to the present event. However, investigating the records of other precipitation observatories in the district (213 locations), we found three events of more than 500 mm in single day(Table 4). Daily precipitation regarding the present case was especially heavy in relation to other in the past about 100 years.

Hourly precipitation (93 mm) slightly exceeded the historical maximum value (92 mm) in Nagoya Local Meteorological Observatory. However, as shown in Table 4, this can be regarded as comparable to the historical maximum over the past 100 years.

Fig. 6 shows the relationship to precipitation and duration (DD relationship) for recent 3 heavy rainfall events in Tokai district and Japan records. The all records of present event were smaller than highest records of Japan. However, the 1-hour to 5-hour precipitation is higher than the past two heavy rainfall events. Characteristic of present event is that a few hours precipitation was very high.

Frequency analysis by the GEV (general extreme-value) distribution using annual maximum daily precipitation data (1901-1999) at Nagoya showed that 100-year probable precipitation is 229 mm, while the 500-year is 334 mm. This analysis also indicated that the return period of the daily precipitation of 428 mm (Sep. 11) is 40137 years. According to the Aichi Pref. Flood Control Plan (Aichi Pref. 2000), the 100-year hourly precipitation in the Nagoya district is 98mm, and the 100-year daily precipitation is 330 mm. It is clear that the heavy rainfall in 2000 greatly exceeded the heavy storms predicted at Nagoya as based on past data.

4. Information dissemination by the Internet

The information dissemination and information exchange over the Internet regarding such disasters had been actively performed since the Fukushima and Tochigi heavy rainfall disasters in 1998 (Ushiyama, 1999). We may say that the use of the Internet had become generalized during the current disaster. In the past, ctizens and volunteer groups have been the primary Internet users. However, the information dissemination by the Local Government was enhanced in the present instance. Aichi Pref., Gifu Pref., the Ministry of Construction, etc. created homepages in regard to this disaster(Fig. 7). The URL of the main homepage as of April 2001 is shown below.

The River Bureau, The Ministry of Land, Infrastructure and Transport

http://www.mlit.go.jp/bosai/disaster/saigaitaiyou/toukaigouutaiyou.htm

Aichi Prefecture

http://www.pref.aichi.jp/kasen/TANTOU/GEKITOKU/SHINGEKI/index.html
Gifu Prefecture
http://www.pref.gifu.jp/s11652/saigai/saigai.htm
http://www.pref.gifu.jp/gib/3_news/0009/3082.htm
The present author (USHIYAMA Motoyuki, DPRI, Kyoto Univ.)
http://www.disaster-i.net/disaster/20000911/

After the disaster, all of these homepages were created within the course of a few days. However, there were differences existed regarding the contents of these homepages and how quickly they were created in terms of their originators. It is noteworthy that a newspaper article (Fig. 8) pointed out that several public offices did not use the homepages for disaster information dissemination. Probably this is the first time that such a report was carried on major newspaper in Japan. We may say that homepage usage is becoming more widespread as a way to provide disaster information.

5. Conclusion

(1) The principal damage over the entire area of Japan was as follows: The death toll was 10; the number of inundated houses was about 71,300; ruined or half-ruined houses about 310. The most damage occurred in Aichi Pref. The death toll and damaged houses were few, though the number of inundated houses was the highest in the last 18 years in Japan. Especially the percentage of over floor inundated houses were high (41%).
(2) In the heaviest rainfall area, two-day precipitation was about 600 mm, 24-hour precipitation was about 550 mm, and maximum hourly precipitation was about 110 mm. The previous record for daily precipitation was the highest in the past about 100 years in the Toukai district, while the entire hourly precipitation was comparative with the historical maximum records, which had been recorded several times in the past about 100 years. Especially a few hours precipitation was very high.
(3) A lot of disaster information were disseminated on Internet. Homepage usage is becoming more widespread as a way to provide disaster information, it came to be criticized that the local government didn't use Homepage.

Acknowledgements

This report was supported in part by a Grant-in-aid for Scientific Research (No.12800012; Representative: Tujimoto, T.) from the Japanese Minisroty of Education, Science, Sports, and Culture.

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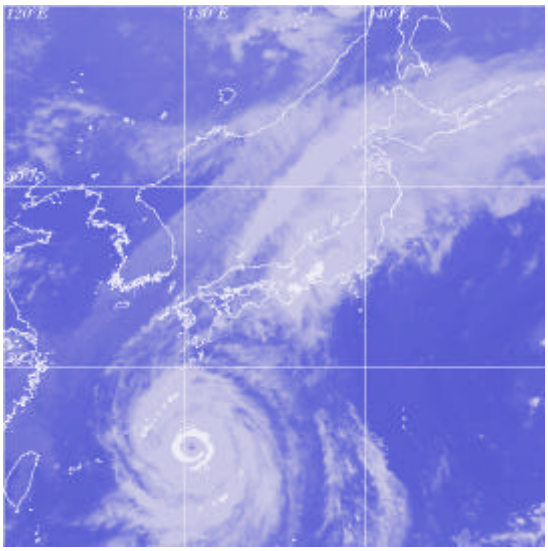

Fig. 1 Infrared image of meteorological satellite (GMS) at 19:00 Sep. 11, 2000.

http://www.tkl.iis.u-tokyo.ac.jp/SatIAN/

Table 1 The damage in each prefecture

	Damage of buildings (buildings)			
Prefecture	Death toll	Ruined and half-ruined	Inundated	
			Over floor	Under floor
Ibaraki	-	-	1	24
Tochigi	-	-	0	40
Gunma	-	-	3	35
Saitama	-	-	33	106
Kanagawa	-	-	8	39
Fukui	-	-	0	1
Yamanashi	-	9	101	549
Nagano	-	1	56	148
Gifu	1	28	108	375
Shizuoka	1	-	1	33
Aichi	7	239	26531	38879
Mie	1	2	283	2806
Wakayama	-	31	45	992
Osaka	-	-	0	12
Hyogo	-	-	0	16
Tokushima	-	1	3	28
Okinawa	-	1	7	28
All Japan	10	312	27180	44111

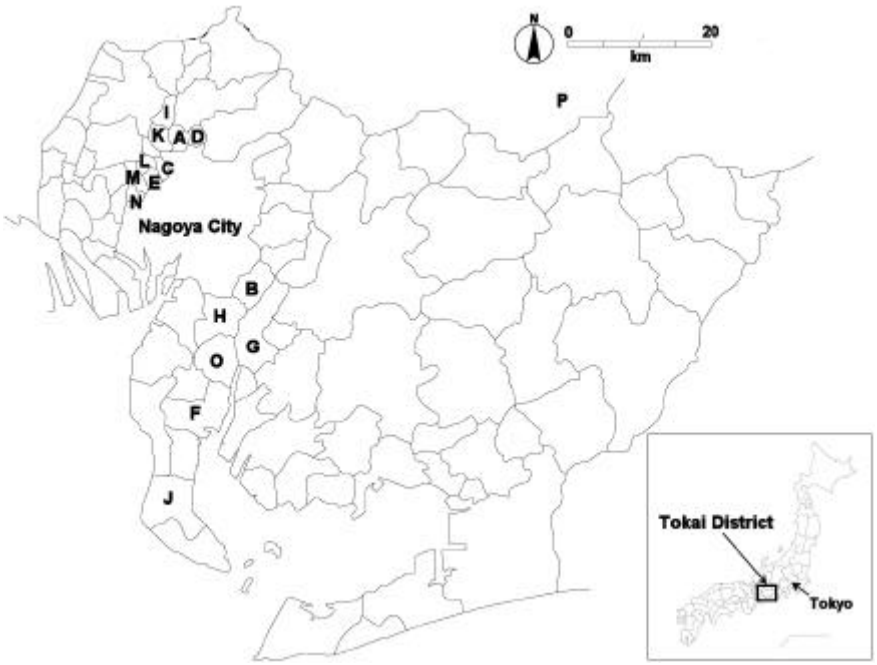

Fig. 2 The municipalities where the National Disaster Act was put in force

A:Shikatsu Town, B:Toyoake City, C:Nishibiwajima Town, D:Toyoyama Town, E:Shinkawa Town, F:Handa City, G:Kariya City, H:Oobu City, I:Iwakura City, J:Mihama Town, K:Nishiharu Town, L:Kiyosu Town, M:Jimokuji Town, N:Ooharu Town, O:Higashiura Town, P:Kamiyahagi Town.

Table 2 The heavy rainfall disaster Aichi Prefecture since 1971

Date	Death tool	Damage of buildings (buildings) Ruined and half-ruined	Inundated	Weather condition
1912/09/22-09/23	140	6,000	Unknown	
1921/09/25-09/26	27	Unknown	Unknown	
1925/09/11	12	* 52	20,000	
1926/09/04	23	* 166	1,400	
1930/07/19	13	* 13	2,000	
1932/07/01-07/02	26	* 30	2,700	
1952/07/10-07/11	0	* 5	52,000	
1953/09/25	75	* 6,769	90,000	Typhoon. Flood tide damage.
1957/08/07	33	177	17,508	
1959/08/14	0	23	80,840	Over floor inundated houses were 14.
1959/09/26	3,260	410,636	116,391	"Ise bay Typhoon". Flood tide damage. Over floor inundated houses were 53,560.
1961/06/23-06/29	6	103	74,623	Stationary front.
1965/09/17	1	74	51,350	Typhoon. *1
1966/10/12	10	29	20,758	
1971/8/30-8/31	4	67	0	Typhoon
1971/9/26-9/26		2	34500	Typhoon
1972/7/ 9-7/13	66	528	0	Stationary front *2
1972/9/14-9/17	2	315	0	Typhoon and occluded front
1974/7/ 7-7/ 7	2	69	8690	Typhoon and stationary front
1974/7/24-7/25		38	57620	Low passing along south coast
1975/8/21-8/23	3	2	997	Typhoon
1976/9/ 8-9/14	1	972	101100	Typhoon and stationary front *3
1979/9/24-9/24	2	0	24560	Typhoon and stationary front
1983/9/26-9/28	5	2	9886	Typhoon and stationary front
1989/9/19-9/20	2	2	12	Typhoon and stationary front
1991/9/18-9/19	2	9	13415	Typhoon and stationary front
2000/09/11-12	7	239	65,410	Typhoon and stationary front

*:Ruined only

*1 Maximum daily precipitation was 711mm(Tokuyama, Gifu Pref.). It is maximum record in Tokai district.

*2 Heavy debris flow occurred on the Obara Village(East part of Aichi Pref).

*3 Embankments were destroyed in the Nagaragawa river.

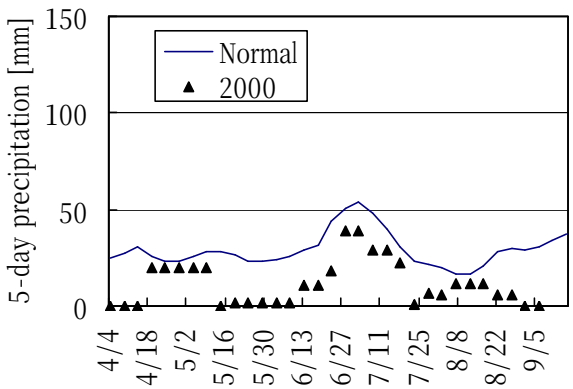

Fig. 3 5-day precipitation at Nagoya (Normal year: average from 1961 to 1990)

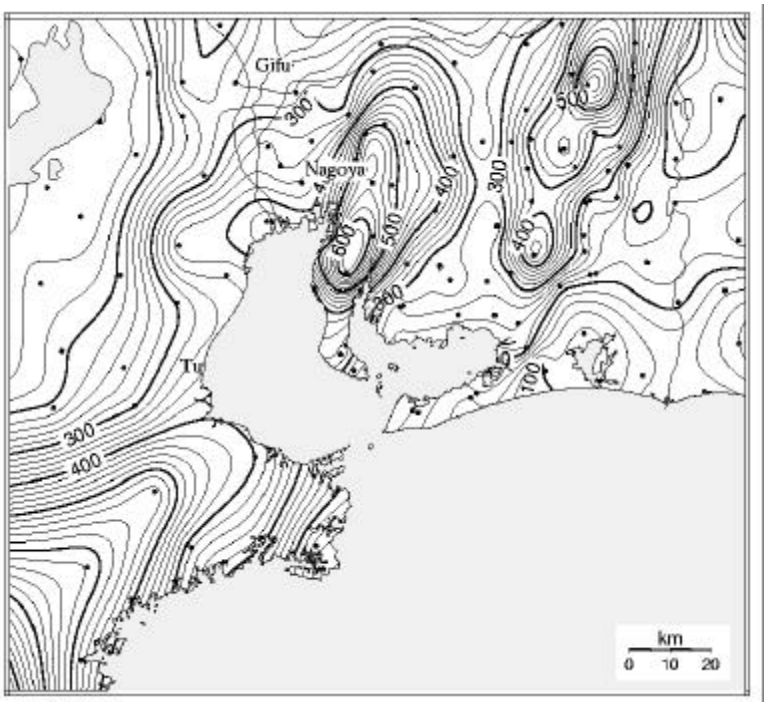

Fig. 4 Isohyetal map of the two-day precipitation from September 11 to 12 in Tokai District

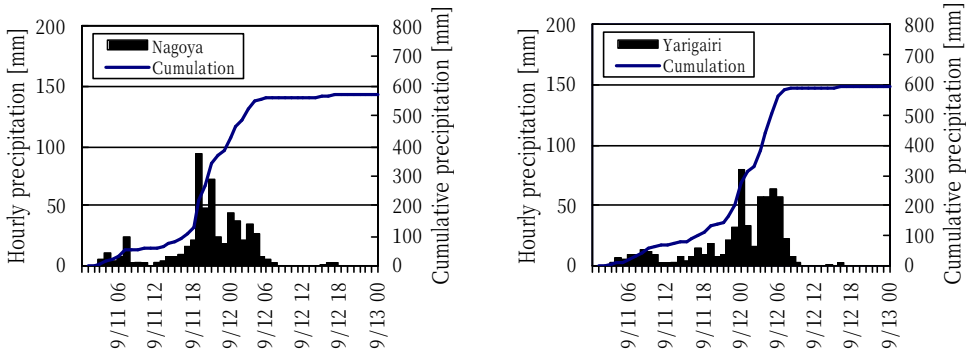

Fig. 5 Hourly and cumulative precipitations at Nagoya and Yarigairi from Sep. 11to 12, 2000.

Table 3 Precipitation data at the main observatories

Station name	Municipality, Prefecture	Precipitation (mm) Maximum Hourly	Sep.11	Sep.12	2-day	Maximum 24-hour
Japan Meteorological Agency						
Inabu	Inabu Town, Aichi	70	222	245	467	438
Nagoya	Nagoya City, Aichi	93	428	139	567	535
Toyota	Toyota City, Aichi 61	217	196	413	388	
Tokai	Tokai City, Aichi	114	492	97	589	557
Gifu	Gifu City, Gifu	34	204	38	242	224
Yokkaichi	Yokkaichi City, Mie	36	295	67	362	319
Tu	Tu City, Mie	25	284	70	354	284
Ministry of Construction						
Kamiyahagi	Kamiyahagi Town, Gifu	65	202	235	437	403
Yarigairi	Kamiyahagi Town, Gifu	80	278	317	595	552
Aichi Prefectural Office						
Uedagawa	Meitou Ward, Nagoya, Aichi	77	429	127	556	523
Agiu	Agiu Town, Aichi	80	498	124	622	588

Table 4 Historical maximum daily and hourly precipitations in the Toukai district

	Maximum daily precipitation Data(mm)	Date	Period	Maximum hourly precipitation Data(mm)	Date	Period
Observatory of JMA(Japan Meteorological Agency)						
Weather Office						
Gifu	260.2	1961/06/26	1883-1999	99.6	1914/07/02	1903-1999
Nagoya	240.1	1896/09/09	1891-1999	92.0	1919/07/18	1891-1999
Tu	288.2	1959/08/13	1889-1999	118.0	1999/09/04	1916-1999
Irako	337.1	1962/07/02	1947-1999	81.8	1962/07/02	1950-1999
Yokkaichi	271.0	1974/07/25	1966-1999	82.5	1971/07/07	1966-1999
AMeDAS (Automated Meteorological Data Acquisition System)						
Tarumi	351	1986/08/22	1979-1999	98	1986/08/22	1979-1999
Ibigawa	330	1986/06/17	1979-1999	65	1989/09/07	1979-1999
Kaburayama	319	1981/07/12	1979-1999	79	1981/07/12	1979-1999
Hachiman	250	1987/08/08	1979-1999	95	1987/08/08	1979-1999
Kanayama	194	1999/09/21	1979-1999	86	1999/09/21	1979-1999
Hirai	190	1986/06/17	1979-1999	84	1987/07/15	1979-1999
Other observatory						
Tokuyama	711	1965/9/15				
Ibigawa	502	1972/9/16				
Nishiyokoyama	439	1907				
Kuzuhara	430	1976/9/10				
Mino	420	1954/9/1				
Shimoda	542	1923				

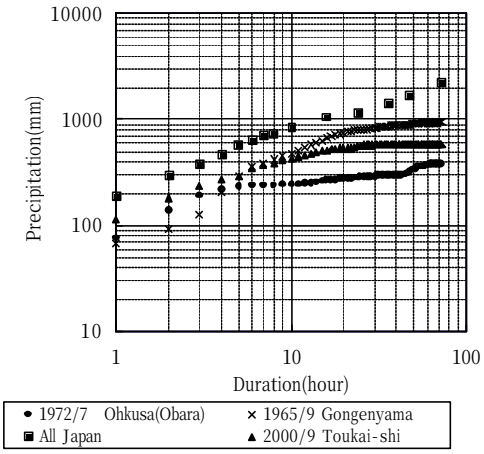

Fig. 6 Comparison of DD relationships for heavy rainfall events in Tokai district.

Fig. 7 The Web page about present heavy rainfall event by Gifu Prefecture.

Fig. 8 The report of Asahi Newspaper in September 14, 2000