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SPATIAL ANALYSIS OF ENVIRONMENTAL FACTORS FOR LEPTOSPIROSIS OUTBREAK FOLLOWING THE FEBRUARY 2007 FLOODS IN JAKARTA, INDONESIA

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About MICRODIS

MICRODIS is an Integrated Project funded under the EU Sixth Framework Programme – Thematic Priority 6.3 Global Change and Ecosystems (Contract number GOCE-CT-2007-036877).

Why create MICRODIS?

Disaster losses are increasing with great consequence to the survival, dignity and livelihoods of individuals and communities, particularly of the poor in developed and less developed countries. Disaster risk arises when hazards interact with physical, social, economic and environmental vulnerabilities. In the past two decades, more than 200 million people have been affected, on average, every year by these extreme events.

Environmentally unsound practices, global environmental changes, population growth, urbanisation, social injustice, poverty, conflicts, and short-term economic visions are producing these vulnerable societies. This takes on particular urgency in the face of long-term risks brought about by climate change, and goes beyond environmental degradation or the mismanagement of natural resources.

There is now international acknowledgment that efforts to reduce disaster risks must be systematically integrated into policies, plans and programmes for sustainable development and poverty reduction. The MICRODIS project locates itself within this above framework.

What are the Objectives and Goals of MICRODIS?

MICRODIS is a project with the overall goal to strengthen preparedness, mitigation and prevention strategies in order to reduce the health, social and economic impacts of extreme events on communities.

Broad Objectives

- ⇒ To strengthen the scientific and empirical foundation on the relationship between extreme events and their health, social and economic impacts.
- ⇒ To develop and integrate concepts, method, tools and databases towards a common global approach.
- ⇒ To improve human resources and coping capacity in Asia and Europe through training and knowledge sharing.

For example, the MICRODIS project will, among others, specifically aim at:

- developing an integrated impact methodology,
- establishing an evidence-base of primary field research through surveys,
- increasing the coverage accuracy and resolution of global disaster data.

Where will MICRODIS operate?

The two regions which form the focus of the MICRODIS project are:

1. European Union, associated countries and new accession states: Belgium, France, Finland, Germany, the Netherlands, Norway, the United Kingdom.
2. South and Southeast Asia regions: India, Indonesia, the Philippines and Vietnam.

These regions have been selected based on their high frequency of extreme events and the impact on affected communities.

What Extreme Events will MICRODIS focus on?

There are twelve broad and twenty-three sub-groups of distinct extreme events, ranging from chronic slow onset phenomena to acute rapid onset ones. The health and socio-economic impact implications differ vastly between these twenty three types and addressing all of these would compromise the quality and applicability of the project results, risking over-generalisation.

In both Asia and the European Union, three types of extreme events, namely **foods**, **earthquakes**, and **windstorms**, account for nearly seventy-five percent of the occurrence of all extreme events. The MICRODIS project will concentrate on these three phenomena.

Partners

European Union and Associated Countries

Belgium	Université catholique de Louvain
Finland	Finnish Institute of Occupational Health
France	University of Paris – Sorbonne (FERURBAT)
Germany	EVAPLAN – University of Heidelberg
Netherlands	HealthNet International
Norway	SWECO GRONER
U.K.	University of Greenwich
U.K.	University of Northumbria
U.S.A.	United Nations Office for the Coordination of Humanitarian Affairs

South and Southeast Asian Partners

India	Jadavpur University
India	Voluntary Health Association of India
India	University of Delhi
Indonesia	University of Indonesia
Philippines	Citizens' Disaster Response Center
Philippines	Xavier University
Vietnam Hanoi	School of Public Health

ABSTRACT

INTRODUCTION: Within the period of February 1 - 26, 2007, a major flood had occurred in Jakarta Province, inundating 60% of this capital city. In such condition, leptospirosis, as a disaster related disease, may cause outbreak.

METHOD: A combination of case series and ecological study was carried out to analyze 195 leptospirosis case reported from five major general hospitals in Jakarta. Spatial analysis using Arcview@ version 3.3 was done to observe the leptospirosis distribution and clustering pattern.

RESULTS: Our study showed that the high level of leptospirosis cases emerged within the period of massive and prolonged Jakarta flood in February 2009 was clearly a common source outbreak. Most cases were more concentrated in flooded areas, especially in northern part, where based on geographical, infrastructure and hydrological conditions was considered to be more flood prone. Interestingly, the case distribution showed clustering pattern around some parts of main city drains, canals and rivers. Our map also showed that almost all cases came from regions having slum pocket areas. In addition to that, the cases were mostly distributed in areas where there were waste accumulation sites.

CONCLUSION: Environmental factors, like water levels of flood, rivers, drains/canals, slum environment, waste disposal sites, especially in surrounding main city rivers and drains/canals, are suspected to induce the spread of the leptospirosis in Jakarta. Our findings underline the need to increase people awareness concerning the possibility of leptospirosis outbreaks after flood, to improve modifiable environment which may induce the occurrence of the outbreak and to establish biological causal relationship between determinants related to flood and the risk to get infection through further analytical study.

1. Introduction

The February 2007 floods were one of the most important floods in Jakarta, the capital city of Indonesia. This greatest flood (since the last 3 centuries) inundated 60% of the city, with water levels ranging from 10 centimeters up to 7 meters. About 70 000 houses in Jakarta were flooded (WHO, Bulletin # 6, 2007). Although floods seem to be a periodic disaster following a five-year cycle in Jakarta, disaster management, preparedness and response are still weak and water-borne diseases such as leptospirosis have significantly increased and become a public health problem in the last years.

Leptospirosis, a zoonotic bacterial disease caused by spirochetes, *Leptospira interrogans*, has a worldwide distribution (Terpstra, W.J., 2006), but is more common in tropical and rural setting (Ko. AI. 1999). Recently, however, leptospirosis has become an emerging problem in urban settings as well (Ko. AI. 1999). Leptospirosis is endemic in many parts of the world, but can become epidemic in certain conditions such as heavy rainfall or flooding. Leptospirosis has recently received growing attention in hydrological disasters.(Terpstra, W.J., 2006)

Leptospirosis can be transmitted by direct contact with urine, blood or tissues of infected animals, mainly feral and peri-domestic rodents, shrews, cattle, pigs and dogs (Jena, AB., 2004, Mohan Rao, AMK, 2006, WHO, 2006). Indirect contamination occurs when people get in contact with water, damp soil, mud or vegetation that are contaminated with infected animal urine (Ko, AI, et al., 1999; Sarkar,U. et al., 2002; Watson, JT, et al., 2007, WHO, 2006). The usual port of entry is through skin abrasion or through the conjunctiva, but hyper motility in leptospira can also allow them to penetrate into intact skin during prolonged immersion in infected waters (Levett P.N., Leptospirosis. Clin Microbiol Rev, 2001, Bharti et al, Lancet Infect Dis, 2003).

Flooding facilitates the proliferation of rodents and brings rodents into closer contact to humans shared high ground (Watson, JT, et al., 2007). Flooding also promotes the spread of contaminated waters (La Rocque, RC, et al., 2005; Sanders, E.J., et al.,1999).

Leptospirosis includes a wide variety of symptoms, from a flu-like illness to a severe illness with multiple organ failure (CDC, 2006; Haymann, DL, 2004), hence, without laboratory confirmation it could be easily mistaken for other diseases. Severe

forms of the disease are associated with case-fatality rates of 5-40% (Ko. AI. 1999). A report from one Indonesian general hospital stated that the fatality rate was between 15-40% (Pohan HT, 2000)

This study aims at observing possible relationship of environmental risk factors with the leptospirosis outbreak occurred immediately after February flood 2007, using mainly spatial analysis.

2. Methodology

The DKI Jakarta province is divided administratively into five municipalities and one Regency, namely South (*Selatan*) Jakarta, East (*Timur*) Jakarta, Central (*Pusat*) Jakarta, West (*Barat*) Jakarta, the North (*Utara*) Jakarta and the Thousand Islands (*Pulau Seribu*) Regency. This capital city is also divided into several lower administrative levels, i.e. 44 sub-districts (*Kecamatan*), 267 sub-sub-districts (*Kelurahan*) and thousands of neighbourhood blocks (RW), with a total population of approximately 9 million people (Jakarta in Figures 2007, Statistic DKI Jakarta Provincial Office). In our study, however, there was not any case reported from the Thousand Islands Regency, which consist of several scattered small islands located far separated from the “mainland” of Jakarta province, i.e. in the north bay of Jakarta.

Since leptospirosis is a notifiable disease in Indonesia, we first collected data from the Provincial District Health Office between November 1st 2006 and May 31st 2007, including the one-month period of heavy floods. Based on that figure, we decided to collect more specific demographic (age and sex) and geographic (address) information on the patients in five major hospitals in Jakarta, which together reported 87% of all reported leptospirosis cases over that period. The five hospitals involved in this study were RSU Persahabatan, RSU Sumber Waras, RSUD Tarakan, RSUD Budi Asih, RSUD Cengkareng,

We obtained information for 208 confirmed cases (based on positive finding of IgM for leptospirosis using Ig-M rapid immunochromatography dipstick assay) but ended up with 196 cases for the analysis, since 12 cases lived outside the Jakarta area. In addition, we obtained geographical and environmental data (locations of flooded areas, slum areas, waste concentrated area, and Jakarta’s rivers, the land altitude and the depth of the flood) from government agencies, such as Coordination Body for National Survey and Mapping, Coordination Body for National Disaster

Management, Provincial Government Office, etc. We used the software Arcview@, version 3.3 for our spatial analysis.

3. Result

3.1. Leptospirosis Outbreak and Its Relation to Flood.

The leptospirosis cases reported from the 5 general hospitals came from all 5 municipalities in Jakarta Province (Table.1). About 56% of the cases came from West Jakarta. As seen in Table.2., most of reported cases (68%) were young adults aged from 18 years to 49 years, and male cases were predominant (77%)

In this study, as seen in Table1., we compared cases of leptospirosis over the 7 months period. The floods started to occur in Jakarta in February 1 and was declared as over on February 26, 2007 (UN-OCHA, 2007). Using the range of incubation period, which is between 2 to 30 days (Haymann, DL., 2004; CDC, 2006; WHO, 2003), we can estimate the period during which patients were likely to develop the disease presumably through flood exposure by adding the shortest incubation period to the first day of floods, and adding the longest incubation period to the last day of floods. Thus, the period is from February 3 to March 28, 2007. All leptospirosis cases reported before the 3rd of February were labeled as cases infected “before the floods”, while those reported after the 28th of March, were labeled as cases infected “after the floods”. This very sharp increase of the leptospirosis cases since February 3, as reflected in the epidemic curve (Fig.1a.), has strongly indicated a leptospirosis outbreak during the flood.

Table.1. Distribution of leptospirosis cases among Jakarta resident (n=196) before, during and after flood by municipality, November 2006 – May 2007.

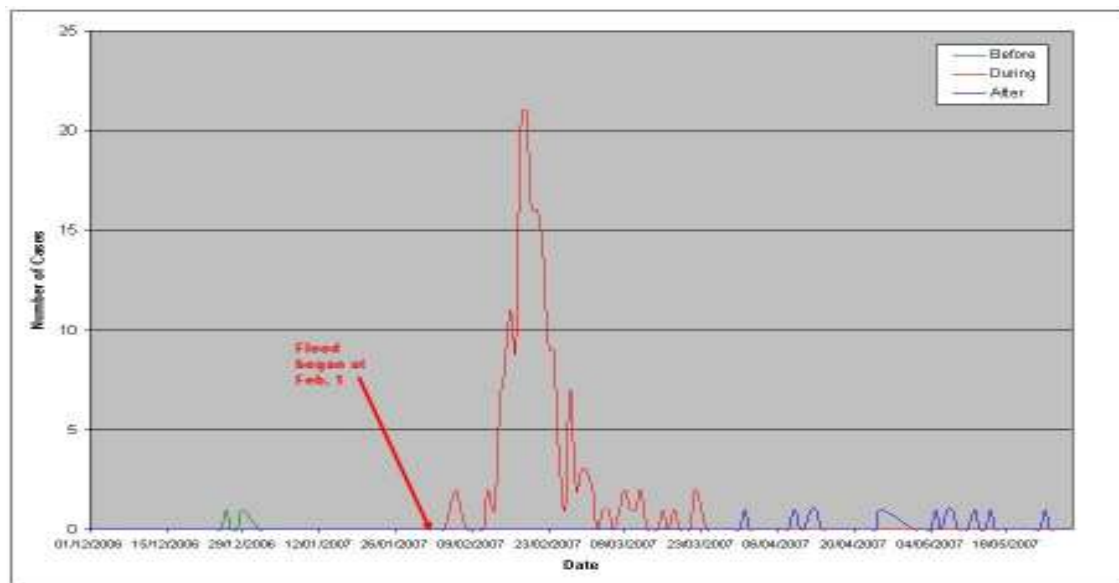
No	Municipality of Origin	Number of cases infected “before flood” (%)	Number of cases infected “during flood” (%)	Number of cases infected “after flood” (%)	Total number of cases from Jakarta (%)
1	West Jakarta	1 (0.9)	103 (93.6)	6 (5.5)	110 (100.0)
2	Central Jakarta	1 (3.2)	27 (87.1)	3 (9.7)	31 (100.0)
3	South Jakarta	0 (0.0)	9 (100.0)	0 (0.0)	9 (100.0)
4	East Jakarta	0 (0.0)	37 (97.4)	1 (2.6)	38 (100.0)
5	North Jakarta	0 (0.0)	7 (87.5)	1 (12.5)	8 (100.0)
	Total	2 (1.0)	183 (93.4)	11 (5.6)	196 (100.0)

Note: “before flood”: < Feb. 3, 2007; “during flood”: Feb. 3 – March. 28, 2007; “after flood”: > March. 28, 2007

Table.2.Distribution of leptospirosis cases among Jakarta resident (n=196) by age and gender

		Gender				Total	
		Male		Female			
		n	%	n	%	n	%
Age group	<18 years	10	6.6%	2	4.4%	12	6.1%
	18-29 years	34	22.5%	11	24.4%	45	23.0%
	30-39 years	32	21.2%	7	15.6%	39	19.9%
	40-49 years	36	23.8%	13	28.9%	49	25.0%
	50-59 years	28	18.5%	5	11.1%	33	16.8%
	>=60 years	11	7.3%	7	15.6%	18	9.2%
Total		151	100.0%	45	100.0%	196	100.0%

Fig.1.a. Epidemic curve of the leptospirosis cases due to the flood in February 2007



3.2. Leptospirosis Distribution Based on Altitude, Flooded Areas and River Flows

Although in general, the leptospirosis cases reported from the five general hospitals in five municipalities in Jakarta Province, we can see that the cases were more concentrated in flooded areas.

Most of the leptospirosis cases were originated from the northern areas of Jakarta (Fig.2) and most of them were clustered in northwest part of the province. In Fig.3, we can see that most of flooded areas also located in northern part of the Jakarta province, which have lower altitude level (≤ 10 m) as compared to Southern areas of Jakarta (> 40 m).

Fig 2. Leptospirosis cases distribution based on land altitude level

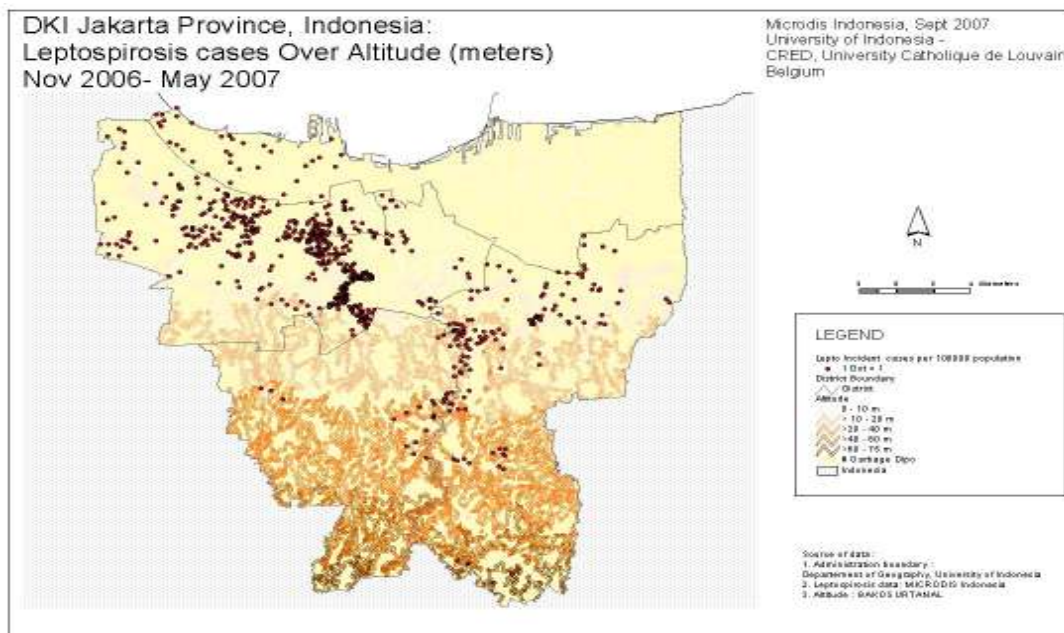
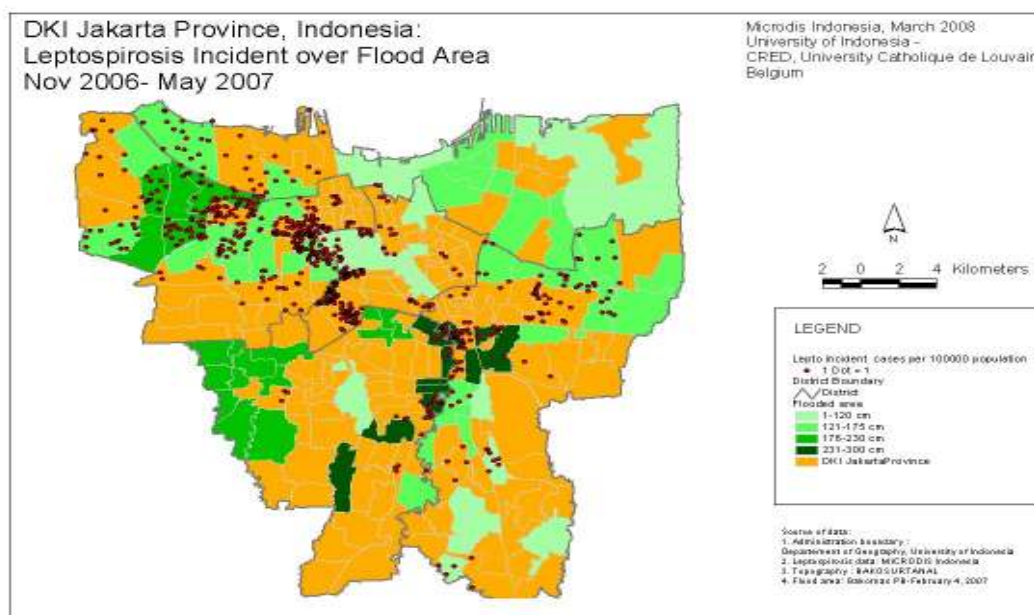


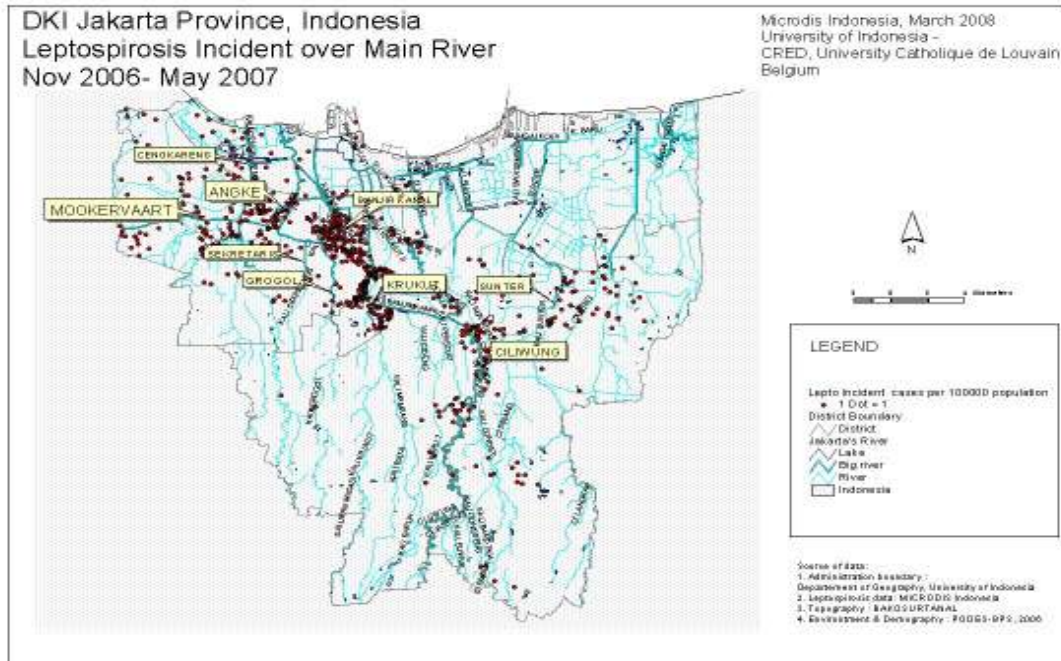
Fig.3. Leptospirosis cases distribution based on flooded areas



From the river map (Fig.4.), it was seen that the clusters of leptospirosis could also be observed in certain areas alongside some parts of the main city drains, canals and rivers. In north-western part of Jakarta, the leptospirosis cases spread close to some segments/ parts of the *Saluran Mookewart* drain, the *Cengkareng* drain, the *Angke* river, the *Sekretaris* river, the *Krukut* river, the *Grogol* river, and the *Banjir Kanal* canal. In the eastern part, the cases spread close to some parts of the *Sunter* river. From southern part to northern part, through the centre of Jakarta, the cases

spread next to of some parts of the biggest river of the city, i.e. *Ciliwung* river. In general, most of leptospirosis cases clustered around some parts of *Grogol* river, *Banjir Kanal* canal and *Ciliwung* river.

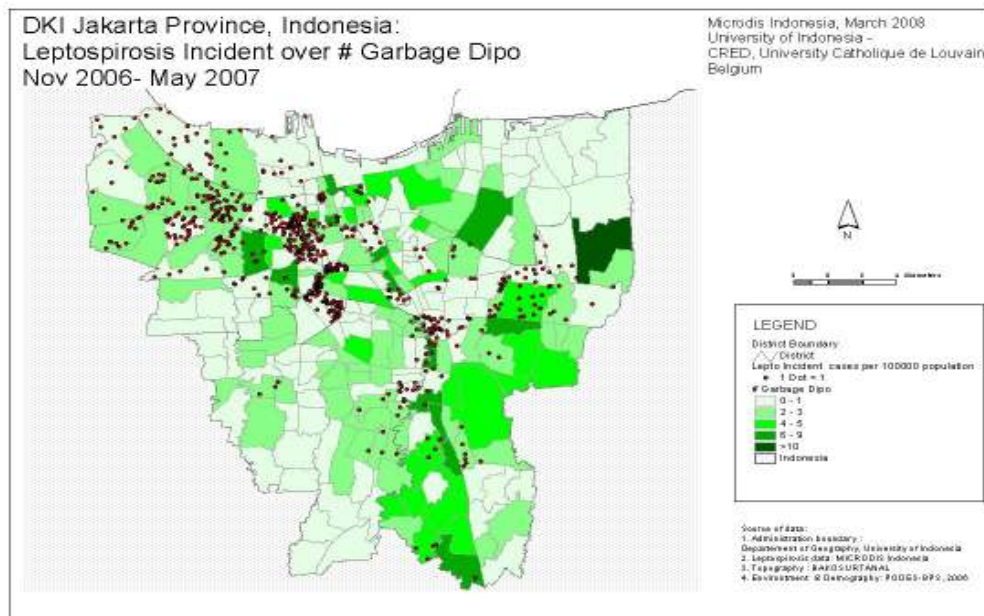
Fig.4. Leptospirosis cases distribution based on drain, canal & river location



3.3. Leptospirosis Distribution Based on Waste Disposal Sites and Slum Areas

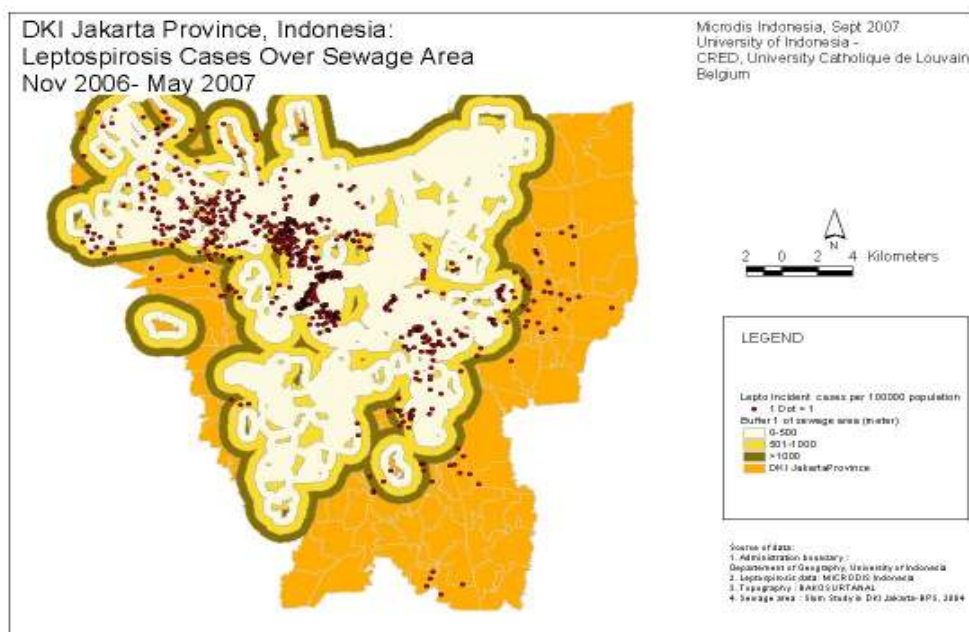
We observe from our study that the leptospirosis case distribution pattern was not fully overlapped with the pattern of areas having different amount of waste disposal sites (Fig.5.). What we meant with disposal site was any container or limited space specifically provided for temporary waste collection from the households, available in each sub-district level. The case distribution did not show clear tendency to cluster in areas with higher number of disposal sites

Fig.5. Leptospirosis cases distribution based on waste disposal sites



When we drew buffer layer areas in radius distance of “within 500 m”, “500-1000 m” or “> 1000 m” from the waste disposal sites, seems that most of the cases were distributed in areas within 500 m from the point of disposal (Fig.6.)

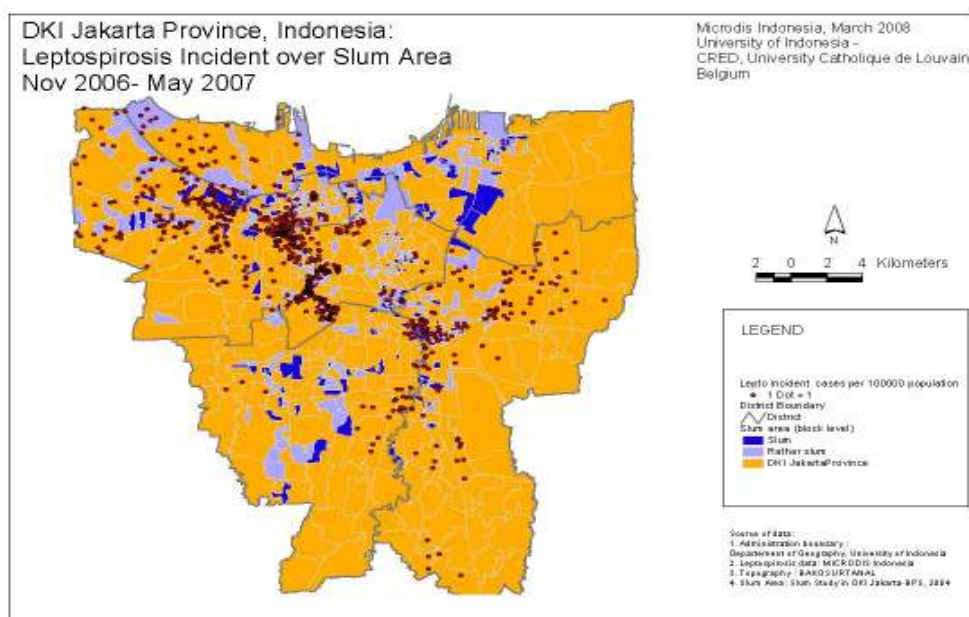
Fig.6. Leptospirosis cases distribution based on radius distance from disposal sites.



When we tried to see the case distribution based on slum areas, the cluster of leptospirosis cases did not seem to be superimposed with slum areas. The case distribution did not show tendency to be more concentrated in slum areas (Fig.7.). In this study we used definition of slum areas as defined by the Central Statistics

Agency, Province of Jakarta. This agency defined slum areas as neighborhood block where the score for slum indicators of physical and environmental conditions was below acceptable standard, i.e. < 36 (out of 40). The slum indicators comprised 10 conditions, i.e. population density, construction design, housing construction condition, housing ventilation, construction density, road/street condition, water drainage, clean water utility, human excrete disposal and waste management (BPS, 2004).

Fig.7. Leptospirosis cases distribution based on slum areas



4. Discussion

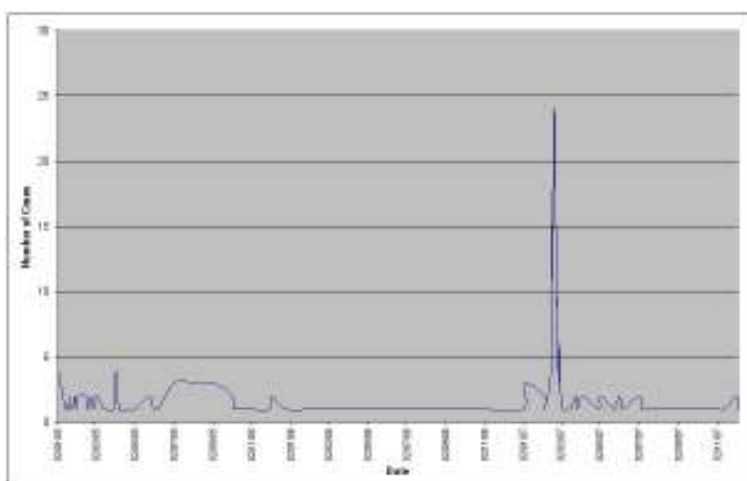
4.1. Impact of Flood to the Occurrence of Leptospirosis Outbreak

On the 23rd of January 2007, very heavy rains (150 mm per day) down poured continuously the southern part of Jakarta and the adjacent cities; Bogor and Depok (WHO, bulletin #2, # 5, #6, 2007). One week later, on the 1st of February 2007, major floods hit Jakarta severely, due the overflow of two main rivers; Ciliwung river and Pesanggrahan river (WHO, bulletin #2, #5, #6, 2007). Just after 1st of February, the reported leptospirosis cases increased sharply. The epidemic curve reaches its highest peak abruptly (23 cases) on 19th of February and falls again in a log-linear fashion,

suggesting a point source outbreak (Dwyer & Groves, 2005), meaning that the population was probably exposed from one common source, i.e, the massive floods, at one point in time. This kind of epidemic curve was also observed by Vanasco et al (2000) in the city of Santa Fe (Argentina) in 1998 after severe floods.

Comparing our epidemic curve of leptospirosis cases reported from 5 general hospitals around the February flood period with the trend of the whole leptospirosis cases in Jakarta reported by Jakarta Provincial Health Office (PHO) in previous period years, it is really clear that the February outbreak has reached very high level of cases that had never been experienced during the previous 2 years. Since Jan 2, 2005 until February 2, 2007, the infection had never reached the rate of 5 cases per month (Figure.1.b.).

Fig.8. Epidemic curve of the leptospirosis cases, January 2006 – February 2, 2007



4.2. Possible Influences of Altitude, Flooded Areas and River Flows on Leptospirosis Distribution

As mentioned previously, the cases were found more in the northern areas of Jakarta, while most of flooded areas located in northern part of the province. Assuming that flooding is a strong determinant of leptospirosis outbreak, we may speculate that major widespread of flooded areas in northern part of Jakarta may indirectly be related to the case predomination in the northern areas of Jakarta

Floods are more likely to occur in the northern part of Jakarta, partly due to the fact that:

1. The land altitude in northern part is the lowest ($\leq 10\text{m}$) and in southern part is the highest ($>40\text{m}$). About 40% of the areas in Jakarta are under the sea level (WHO, 2007), especially in northern part, making the areas become more prone to flooding. When, for several reasons (such as torrential rain) the 13 rivers overflow through the province, the flash flood will run from the uphill southern part to the downhill northern part of the province.
2. From 1979 to 1991, North Jakarta subsided at a rate of about 25-34 centimeters per year, while other municipals subsided at 2 - 8, centimeters per year (PDKI, in M.Douglass, 2005), caused by uncontrolled and unlimited deep groundwater extraction (Caljouw, Nas, Pratiwo, 2004).

The most interesting finding in this study was that the leptospirosis cases were mostly distributed in areas alongside some parts of the main city drains, canals and rivers, especially in northern areas of Jakarta. Many places alongside riverbanks in Jakarta have also frequently become unofficial, waste disposal places because many people in Jakarta frequently dump their waste or garbage into rivers and drains. World Bank in 1994 reported that about 30% of trash and *solid waste* is believed to get blown or washed away or is dumped into rivers and drains (Caljouw, et al. M, 2005). This waste disposal may become favorable nests and proliferation places of rodents, like rats. When the level of river water was rising and overflowing to the waste disposal sites, the river water was most likely be contaminated with *leptospirae* from the rodent's urine. Waste accumulation, the presence of rodents and floods have all three been recognized as common factors contributing to urban leptospirosis outbreaks (Barcellos C and Sabroza PC., 2001; Sarkar, U, et.al.,2002; Ko, AI, et.al., 1999; LaRocque, RC, et.al., 2005, Sanders, EJ., et.al., 1999; Terpstra, WJ, 2006;Watson, JT, 2007, WHO, 2006; Gaynor K, 2007). Thus, we can speculate that flood overflowing the garbage accumulation sites, especially in the river/drain banks, could amplify the probability of being infected through increasing people's exposure with flooding river/drain water, contaminated with rodent urine. Flooding is particularly favourable for the occurrence of leptospirosis, since floods prevent rat's urine from being absorbed into the soil or evaporating, so the leptospirae could pass directly into surface water or persist in mud (Sanders, EJ., et.al., 1999).

Since the water flow along the stream banks is slower, the concentration of micro-organisms may become greater and consequently increase the vulnerability of the people exposed with the contaminated water. It is a common custom in many

regions in Indonesia that people living nearby the rivers use the river for washing, bathing and defecating as reported by Fresh, J.W., et.al.(1971) and Ristiyanto, et.al. (2006). Therefore, the risk to get infected by *leptospirae*, through skin exposure, increases, especially when the river water level rises during the rainy seasons and flood. Johnson, MAS, et al. (2004) in his study in tropical urban slum areas in Iquitos, Peru, found that river bathing and living close to the river are among potential risk factors of leptospiral seropositivity. Sarkar, U, et.al. (2002) estimated that people being exposed with flood water or mud will have significant risk about 3 times higher to get infected. Even, within the period of two or three days after rains, when the flooding water remains stagnant, the leptospirae can still multiply in the flooded areas (Swapna RN, et.al., 2006). Under favourable conditions, i.e. neutral PH or slightly alkaline water and temperature of $\geq 22^{\circ}$ C, the leptospirae can survive in the environment an extended period of time (Terpstra, WJ, 2006, Katz, AR., 1991, Syam, AF, et al., 1997).

4.3. Possible Influences of Waste Disposal and Slum Areas on Leptospirosis Distribution

Given the occurrence of leptospirosis spread alongside the drains and rivers, as previously discussed, and the fact that most people living near city rivers and drains disposed their sewages in the edge of city rivers or drains (or even throwing in to them) we may speculate that the flood coming from the rivers or drains and passed through the waste disposal might had delivered water contaminated by rodent urine to not only people living in the river banks but also in surrounding farther residential places, leading to the increase probability of leptospirosis outbreaks. This possibility, which in our study was somewhat indicated by the distribution pattern of most cases within radius of 500 m around the waste disposal point, had also supported by Barcellos C and Sabroza PC (2001) stating that leptospirosis cases is not only found in the core of waste disposal point, but may also spread quite farther from the waste collection sites. Interestingly, he reported that the highest incidence rate of leptospirosis was actually found in areas located at a distance of 250 m to 500 m from the waste accumulation sites. This might be explained by the possibility that people living really close to the waste accumulation sites (<250meters) develop a certain

level of immunity against leptospirosis, while those who live a bit further (>250m) are more vulnerable in a situation of floods.

Our finding that the case distribution did not show tendency to be more concentrated in slum areas, was not consistent with notions in some literatures. Findings from other studies (Barcellos C and Sabroza PC, 2001; Ristiyanto, et.al., 2006; Ko, AI, et.al., 1999; and Sarkar, U, et.al., 2002), stated generally that slum areas with poor sanitation may produce high number of cases and may potentially become endemic areas of leptospirosis, especially during periods of flooding and heavy rainfall. This inconsistency needs further elaboration.

4.4. Limitation

We used in our study reported cases from hospitals. If the proportion of misdiagnosis or under-reported cases in the general population is high, the spatial distribution of our hospital-based cases may not perfectly represent the real distribution of cases in the general population. However, we assume that this kind of bias is expected to be constant through out the period.

The limitation of the analysis correlating the environmental factors with the leptospirosis distribution is mainly due to the absence of statistical procedures to test the hypothesis. In this study, analysis was done in more descriptive manners based on visual inspection of the distribution and pattern from the map.

Another potential problem was that we do not have information concerning the possible estimates of under-reported leptospirosis cases. However, many studies had reported the similarity of clinical profiles of leptospirosis cases with other infectious diseases, leading to misdiagnosis of leptospirosis. Withiekanun, et al. (2007) stated that several common infectious diseases, including leptospirosis in Thailand, are hard to differentiate. Among 208 leptospirosis cases reported by the five general hospitals in our study that coming from areas both Jakarta and outside Jakarta, leptospirosis was only suspected in 31.4% of the cases at admission (Le Polain, et al, 2008). A Indonesian national referral general hospital, i.e. Cipto Mangunkusumo general hospitals reported once that about 41% of hospital leptospirosis cases was initially diagnosed as other diseases such as hepatitis and typhoid fever (Syam, et al., 1997)

5. Conclusion and Recommendation

5.1. Conclusion

From the findings of our study, we may conclude that:

1. the greatest Jakarta flood occurred from 1-26 February and submerging 60% of this capital city was most likely to have induced the point source leptospirosis outbreak in Jakarta province.
2. certain environmental predisposition factors, like flows of rivers, drains/canals and possibly waste disposal sites, could be suspected to induce the spread of the leptospirosis, especially in surrounding main city rivers and drains/canals, in Jakarta

5.2. Recommendation

Based on the findings, we underline the need:

1. To increase people awareness concerning the possibility of leptospirosis outbreaks after flood
2. To improve modifiable environmental factors which may induce the occurrence of the outbreak
3. Further analytical epidemiologic researches are also needed to establish the biological and causal relationship between important determinants closely related to flood exposures and the individual risk of individual to get leptospirosis infection

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