Observations on urban ecology of Surat and bubonic plague transmission in the city

Vijay K. Saxena and T. Verghese*

National Institute of Communicable Diseases, 22, Shamnath Marg, Delhi 110 054, India
*Directorate General of Health Services, Nirman Bhavan, New Delhi, India

Observations were made on the urban ecology of Surat city to understand the ecological support system conducive for wild rodent epizootic and its spill-over to initiate human bubonic plague outbreak. The unprecedented flood situation prior to the Surat outbreak was also appraised from the standpoint of plague dynamics. No obvious evidence could be gathered relating to the ecological support system and ecological linkages between rodents from urban and feral habitats which could have led to the spill-over of sylvatic rodent plague to initiate bubonic plague in humans. Flood conditions in Surat also could not be identified as a factor contributing to an epizootic of plague and subsequent epidemic of human bubonic plague.

DURING September–October 1994, Surat city in Gujarat State witnessed an outbreak of suspected plague (1027 cases) of which 52 died[1]. Although Surat lies close to the northern tip of an erstwhile endemic centre along the eastern watersheds of the Western Ghats in Maharashtra State, the city does not figure in the endemic zone of western India[2]. In May 1995, efforts were made to study the ecology of Surat city and human association with rodent habitats. The primary objective of these field observations was to identify factors which may have led to a plague epizootic among rodents with subsequent spill-over to humans leading to an outbreak of bubonic plague.

Extensive observations were made all over the Surat city with regard to housing pattern, population distribution, developmental activities and industries. Rodent burrows were examined at several places both in the town as well as the periphery of the city. Several interviews were conducted with the local population and the municipal health officials on rodent control activities in Surat city.

The urban area of Surat city is spread out in about 140 sq. km, with a population of about 1.5 million. The city is divided into 6 zones – North, South, East, West, Central and South-West (Figure 1). The North zone and part of Central zone are low lying areas. River Tapti passes through the city and separates the West zone from the rest of Surat city. During the past 2 decades, the city has witnessed rapid expansion of the urban area on its periphery, and there has been gradual encroachment of ruderal sites as well as cultivated fields, for development of housing complexes. The general sanitary and hygienic conditions of these residential colonies were poor.

The Central zone of the city represents old Surat city and has the highest population density, with about 1/3 of the total city's population (0.5 million) residing here. The population in the 6 zones of Surat city (in descending order) is Central zone > South > East > North > West > South-west.

Surat is a highly industrialized city and the industries mainly comprise of diamond processing, metal works and polyester textiles. All industries are located within the city limits. The entire urban waste (solid, liquid as

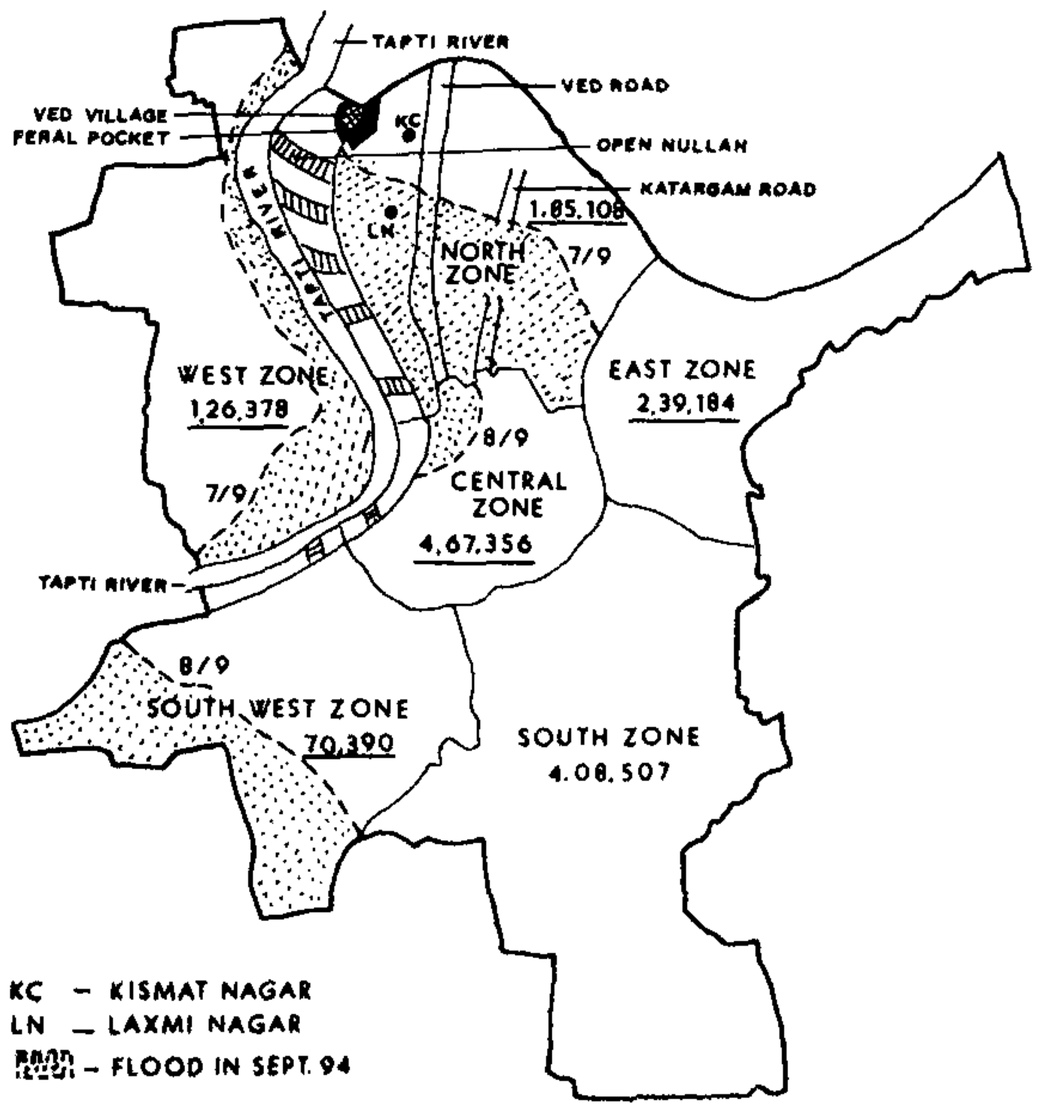

Figure 1. Map of Surat showing city zones and ecological features.

Table 1. Disposal of dead animals by Surat Municipal Corporation

Month/ Year	1992		1993		1994	
	Big animal	Small animal	Big animal	Small animal	Big animal	Small animal
January	91	155	79	180	98	172
February	84	169	63	175	76	162
March	66	183	86	201	106	180
April	69	187	55	193	61	213
May	58	190	58	207	88	201
June	95	205	85	215	102	266
July	91	195	102	198	201	226
August	154	217	83	203	204	861
September	142	214	76	220	355	1127
October	108	177	103	153	277	461
November	120	186	76	171	149	203
December	106	155	76	165	132	179
Total	1104	2233	942	2281	1849	4251

well as industrial) is disposed off through wide open nallahs and, at some places, through closed city drains, into the river Tapti.

The periphery of Surat city has rapidly expanded, particularly in the North, West and South-west zones, with emergence of several slums. The South-west zone has mainly occupied ruderal habitats for urban expansion, but the North and West zones have encroached upon both waste land as well as cultivated land.

The urban area of Surat in the Central zone and its surroundings in the North, East, South zones (Figure 1) do not support habitat diversity congenial for survival of sylvatic rodents. However, the area is conducive for the growth of domestic rodents like *Rattus* species (e.g. *R. rattus, R. norwegicus*) and house mouse (*Mus* spp). The land, on both sides of the Tapti river appeared to harbour the field rodent *Bandicota bengalensis*. However, near the bank of Tapti, about 2.5 km away from Laxminagar colony (believed to be the *index case locality* during the September, 1994 outbreak), across a wide agricultural field of Ved village (North zone), a small circumscribed pocket of feral habitat with very a scanty population of wild rodent *Tatera indica* was detected, in dry sandy soil (Figure 1).

During the monsoon period (i.e. June–September) every year, the river water in Surat rises above the danger mark and enters the peripheral areas of the West zone. As a result, the few slum areas situated in this zone along the bank of the river, are adversely affected and the population temporarily shifts elsewhere. In the first week of September 1994, the floods in the river were of unusual magnitude (perhaps the highest in 25 years) and the flood waters entered the east of Tapti, inundating several localities in North, South-west, Central and East zones of the city (Figure 1). Consequently the entire city waste from nallahs and drains, reverted back into the city due to pressure of water from the swelling river and remained *stagnant in the city for 5 days* (7–11 September 1994) and after the flood water receded, a large number of animals were found dead in the city. A comparison of monthly animal mortality (for 3 years) in Surat as recorded by the Surat Municipal Corporation is given in Table 1.

From an ecological standpoint, the circumscribed, small feral pocket away from human population is not supportive of initiating an epizootic of plague in *T. indica* which may spill-over, to cross the 2.5 km distance interspersed with cultivated land, and enter domestic biotope in Laxminagar colony. The absence of adequate ecological linkages between diverse habitats, essential for the dynamics of plague transmission, does not support the outbreak of bubonic plague in Surat city with its origin in feral habitats. Characteristic biotope associations are a pre-requisite to establish ecological linkages to support spill-over of wild rodent infection to humans[3,4]. However, if the urban rodent population was enzootic for plague infection, there should have been bubonic plague cases reported even in the preceding years. The floods in September 1994 were of such high magnitude that they must have left many domestic rodents in the city dead along with their flea ectoparasites. The flood waters were highly polluted (containing human, animal and industrial waste), even large animals (cattle, buffalo, etc.) died in large numbers (Table 1). The number of dead animals in September 1994 was 4 and 5 times higher than in September of 1992 and 1993. These animal deaths can be attributed, both to drowning and chemical/organic pollution of flood waters.

1. Report of the Technical Advisory Committee on Plague, 1995, p. 79.
2. Sharif, M., *Bull. WHO*, 1951, **4**, 75–109.
3. Saxena, V. K., D Sc. Thesis, University of Kanpur, 1992.
4. Saxena, V. K., *J. Commun. Dis.*, 1987, **19**, 310–316.

ACKNOWLEDGEMENTS. V. K. S. thanks Dr K. K. Datta, Director, NICD, Delhi for providing the opportunity to investigate the Surat episode. We are also thankful to Prof. V. Ramalingaswami for encouragement and useful suggestions during the course of this study.

Epilogue – What next?

V. Ramalingaswami

All India Institute of Medical Sciences, Ansari Nagar, New Delhi 110 029, India

The good news is, accepting the recommendation of TAC, the Government of India (vide their order no. T-21011/8/94-PH (Pt. 1) dated 24 April 1996) established a National Apical Advisory Committee (NAAC) for National Disease Surveillance and Response System. The Committee would have the responsibility of playing an advisory role in the establishment of a National Disease Surveillance and Response System.

The terms of reference of the Committee would be as follows:

1. The Committee would give advice and suggest mechanisms for setting up of a National Disease Surveillance and Response System.
2. The Committee would review the progress periodically regarding implementation of the National Disease Surveillance Programme.
3. The Committee would examine the epidemic preparedness of health care providers.
4. The Committee would assist and advise in the development of an early warning signal mechanism.
5. The Committee would review various programmes, guidelines and mechanisms available for prevention and control of communicable diseases with special reference to new, emerging and re-emerging pathogens and epidemic-prone diseases.

There is growing realization today that as new microbial threats are appearing, well-known illnesses thought to have been controlled are resurging[1–3]. The Acquired Immuno-deficiency Syndrome (AIDS) is a good example of the former while malaria, kala-azar and plague are notable examples of the latter. Emerging or re-emerging, bacterial resistance to drugs is an increasingly serious problem. Population growth and consequent population movements from the hinterland into urban areas and into forest regions, changes in human behaviour, poverty and overcrowding, changes in ecology and climate, floods and earthquakes, increased tourism, trading and travelling, the evolution and adaptation of microbes and the inadequacy and breakdown of health infrastructures are some of the factors behind the ever-changing scenario of infectious diseases[2,4]. As far as plague is concerned, the importance of earthquakes, floods and local changes in ecology affecting microbe-carrying rodents and acting as triggering factors is well brought out in the preceding pages. While the canvas of NAAC's operations has been kept very wide covering all diseases, which is to be welcomed, it is to be hoped that Surveillance and Response Mechanisms for Plague and other Infectious Disease would receive the most urgent attention of NAAC for, after all, plague was the agent provocateur.

The essential task before NAAC is to advise the Government on national capability building related to preparedness, early detection and control of emerging and re-emerging infectious diseases and to establish proper disease reporting systems. Establishing the aetiological diagnosis, understanding the sources and modes of transmission of the infectious agents, identifying high risk groups, investigating antibiotic sensitivity of isolated microorganisms and facilitating the development and production of readily available reagents for diagnostic purposes are some of the elements of capacity building. Clinical samples and microbial isolates need to be referred expeditiously to designated laboratories in the country for further study and, at times, they may be referred to centres abroad and the WHO could be a useful ally in such tasks. While national networks of laboratories and scientists would need to be developed on a disease basis, it is equally important to participate in the establishment of a global disease surveillance and response network. The need for this is amply borne out by the fruitful interaction that took place between Indian scientists and scientists located in the WHO Reference Centres on Plague at CDC, Fort Collins (USA), Paris and Stavropol (Russia) in the plague outbreaks of 1994.