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Engineers and urban malaria: part of the solution, or part of the problem?

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SUMMARY: *This paper describes the very serious health and other problems caused by different kinds of mosquito in urban areas of India, and how addressing diseases such as malaria, yellow fever and dengue fever requires controlling their breeding sites. It then describes how engineers rarely consider their role in mosquito control and how a series of workshops for engineers made clear this role - especially in the management of construction sites which often serve as major breeding areas.*

I. INTRODUCTION

IN INDIA'S CITIES, mosquitoes thrive in water storage tanks, blocked drains and on construction sites. Can engineers prove the maxim that - in the case of malaria - prevention is better than cure? Malaria is a major public health problem throughout the world; according to the World Health Organization, it kills around 2 million people every year and there are over 300 million new cases each year.⁽¹⁾ Malaria is caused by parasites in the human bloodstream and is transmitted from one human to another by the bite of female anopheline mosquitoes.

In the 1950s and 1960s, there was dramatic success in reducing the incidence of malaria although the original, widely accepted 1958 goal of "eradication" was not achieved. Now, the number of casualties is spiralling as a result of reduced government and agency funding for malaria control, mosquitoes' increasing resistance to insecticides, and growing drug resistance among malarial parasites. Not all types of mosquito transmit malaria but all mosquitoes are a nuisance and many can create other health hazards (see Box 1). As limitations to chemically based control emerge, more thought is being given to appropriate technology in mosquito control, and the role of environmental management.⁽²⁾

Although rural Africa presents the greatest problems, the incidence of malaria in India has also grown, with many more deaths now than 30 years ago. In 1994, official statistics recorded 2.4 million cases of malaria and 1,200 malarial deaths; the actual numbers are likely to be far higher. The risks are not

Box 1: The Problem with Mosquitoes

There are three broad groups of mosquitoes with differing environmental requirements: *Anopheles*, *Aedes* and *Culex*. Each creates its own kind of problem and all are important.

Anopheles mosquitoes are famous as the only mosquitoes which transmit malaria. *Anopheles* is easily identified when resting or feeding as its body leans at a sharp angle to the surface. They lay eggs in clean, still water free from organic pollution. An important urban species are night-biters which rest inside people's homes during the day. Some of the important *Anopheles* breeding sites in Surat are likely to be relevant elsewhere in urban India. Other sites to consider in cities include pools of fresh water from leaking water pipes or taps, and dips or depressions filled after rain.

Aedes mosquitoes are medically important because they can transmit yellow fever and dengue which, in turn, can lead to dengue haemorrhagic fever. Like *Anopheles*, they prefer clean still water for breeding but are particularly fond of artificial containers such as domestic water storage pots and vases, discarded cans, tyres, plastic bags or coconut shells. *Aedes* fly during the day and their biting peaks at dusk.

Culex mosquitoes are the most "successful" urban mosquitoes and the ones that residents find the most irritating. They can transmit filariasis, which can develop into elephantiasis, but are hated even where filariasis is not a problem simply because of the thousands of bites and sleepless nights they inflict. The urban poor can spend large portions of their income seeking temporary relief by buying mosquito coils. Malaria control programmes which ignore *Culex* run a very serious risk of losing popular support, as people have no faith in *Anopheles* mosquito control that still leaves so many biting *Culex* mosquitoes about. Unlike *Anopheles* and *Aedes*, *Culex* breed mainly in organically polluted water; these are the mosquitoes found breeding in septic tanks, flooded latrines, blocked drains and other heavily polluted water. They bite throughout the night, with a typical peak just after dusk.

1. WHO (1997), *The World Health Report*, World Health Organization, Geneva.

2. Curtis, C.F. (editor) (1989), *Appropriate Technology in Vector Control*, CRC Press, Boca Raton; also Chavasse, D.C. et al. (1995), "Mosquito control in Dar es Salaam", *Medical and Veterinary Entomology* Vol.9, pages 141-154.

evenly spread across the nation. Using official statistics as a rough guide, people in Surat district of Gujarat are 12 times more likely than other Indians to contract malaria and 18 times more likely to contract its more deadly (falciparum) form. What is even more surprising is that malaria appears to be worse in the city than in the rural areas; residents of Surat city appear to be three times more likely to contract malaria than other district residents. It is dangerous to interpret official statistics too literally but public health workers in Surat are in no doubt of the gravity of the problem and, in the 1990s, the Surat Malaria Research and Control Programme was developed by the state government of Gujarat with the assistance of the UK Overseas Development Administration (now the Department for International Development), the British Council and the London School of Hygiene and Tropical Medicine (LSHTM).

II. URBAN WOES

ADULT ANOPHELINE MOSQUITOES emerge seven to ten days after the female deposits her eggs in clean water (malaria-transmitting mosquitoes do not breed in heavily polluted water, unlike other troublesome mosquitoes). Breeding sites do not need to be large; footprints in mud can provide an ideal breeding ground for some species.

The transmission of malaria in India's towns and cities is a special case. Although malaria can only be transmitted by anopheline mosquitoes, this grouping includes many different species, each with varying environmental requirements and preferences. Mosquitoes which transmit urban malaria in India have adapted to artificial breeding sites although some rural mosquitoes are a problem on the city fringes. Ironically, engineers, builders, architects and residents have created most of the urban breeding sites; but careful design and construction can significantly reduce the problem.

The insecticide officers of the municipal corporation are the frontline workers against mosquitoes and malaria in Surat city - responsible for the elimination or control of mosquito-breeding. They do this through regularly applying chemicals to kill mosquito larvae at various breeding sites, by educating the public about controlling household breeding sites, and by enforcing municipal by-laws against individuals who create these sites. With their training and experience, they know the habits and preferences of anopheline and other mosquitoes. Box 2 shows the artificial sites they identify as some of the main breeding grounds for malaria mosquitoes in Surat city, and the officers are particularly concerned about the rapid spread of modern construction sites which seem to act as unpleasantly efficient breeding areas.

Box 2: Mosquito-breeding on Construction Sites - Problems and Possible Solutions

Site problem	Solution
• Flat concrete slabs	• Change curing water regularly; if practical, use jute sacks for curing
• Bottom of lift wells	• Fill after initial construction; dig out just before completion
• WC and bathroom sumps	• Fill after initial construction; dig out just before completion
• Upright uncovered bins	• Either cover or turn upside down when empty
• Basement excavations	• Drain weekly
• Borrow pits	• Dig deeper, with less surface area and border
• Blocked drainage of terraces, roofs	• Regular inspection; improve design

III. MOSQUITO CONTROL FOR ENGINEERS

INSECTICIDE OFFICERS KNOW where the breeding sites are but do not always know how to eliminate them; engineers and builders are often unaware that they are creating a problem. However, malaria experts have long recognized their contribution and for years India's National Malaria Eradication programme has run seminars for senior engineers on how poor engineering practice can spread malaria. But is this information getting through to field-level workers in Surat? To remedy this, Professor Desai, of the Government Medical College, made sure that, in 1997, the Surat Malaria Control and Research project added a training component for deputy engineers and assistant deputy engineers from the municipal corporation.

The training programme was launched with a three-day workshop, jointly organized by the Medical College, the SV Regional College of Engineering, the Surat municipal corporation, and the London School of Hygiene and Tropical Medicine. The workshop was developed on three related principles:

- engineers learn best by solving problems, not by hearing lectures;
- fieldwork is critical to understanding breeding sites and their control; and
- background information should be kept to the minimum required to understand the problem.

The workshop consisted of:

- a brief introduction to the problems of malaria and mosquitoes in Surat;
- fieldwork with insecticide officers to identify mosquito-breeding sites;
- group work to develop ideas to reduce these breeding sites;
- a discussion of institutional and enforcement issues with experts; and
- a presentation to senior engineering and planning staff of workshop findings.

The engineers spent a day and a half with the insecticide officers, visiting different parts of the city. Building sites, previously familiar in terms of contracts, materials and construction crews, now presented unusual biological challenges to engineers. The difficulty of exercising effective governmental control at the household level also became apparent; how hard can officials legitimately press people to change the way they store water in the home? While the educational efforts of the insecticide officers and others may help, the application of penalties and fines as a last resort is also needed. Visits to irrigation canals and the river presented different problems of responsibility and coordination: what can municipal engineers do about breeding sites outside their jurisdiction?

The workshop participants reached a broad consensus on the following:

- construction sites are a major source of anopheline mosquito-breeding in Surat city and are likely to be a significant factor in malaria transmission;
- construction sites that are “abandoned” for months or years at a time due to cash-flow problems during construction can be particularly troublesome;
- many of the sites can be eliminated at little cost (see Box 2);
- “good housekeeping” practices on-site can reduce these breeding sites so new strategies must be developed to ensure they are carried out;
- engineers have a significant role to play in reducing breeding sites but are not alone in creating them. Builders, architects and homeowners also create breeding sites and need to learn how to reduce them. Training should extend up and down the corporation hierarchy; and
- the responsibilities of municipal engineers and insecticide officers in enforcing by-laws need to be clearly defined. The role of the Irrigation Department should also be considered.

In summing up, engineers pointed out the need for much better understanding of the problem in general. Initially, few participants could see any link between their job and malaria; by the end of the workshop, they all did. “We need to explain this to everyone,” said one participant. “Not just to the junior engineers and builders but to those above us as well!”

Over 100 assistant engineers have taken part in similar workshops and there are efforts underway to help architects and builders learn about the reduction of mosquito-breeding sites. In years to come, progress can be measured: will construction and engineering practices have changed for the better and will there be coherent enforcement strategies in place? The particular strategy that is suitable for Surat may not work elsewhere; but the general principle of sharing biological and engineering knowledge to reduce artificial breeding sites should be universal.⁽³⁾ Through such collaboration, engineers can hope to become part of the solution to urban malaria; they have nothing to lose but their unwanted role as part of the problem!

3. An approach successful in the USA. Tennessee Valley Authority (1947), *Malaria Control on Impounded Water*, US Printing Office, Washington DC.

