Water Management for Malaria Control

Wim Vander Hock, Felix Amerasinghe and Eline Boelee*

Why water management?

Malaria control is facing major challenges worldwide due to several factors including increasing resistance of malaria parasites against anti-malarial drugs and resistance of vector mosquitoes against insecticides. With no vaccine available, there is a need to find alternative ways of dealing with the disease. In the first part of the 20th Century a lot of experience was gained with environmental management methods to control the mosquitoes that transmit malaria. However, this knowledge was done away with when DDT became available after World War II, leading to a global campaign to eradicate malaria by spraying houses with this insecticide. Currently environmental management plays an insignificant role in malaria control programs but it should become more important in future control activities.

Malaria: still a public health problem in Sri Lanka

Sri Lanka is considered the text book example of the success and subsequent failure of malaria eradication efforts by the international community. Spraying of houses with DDT started in 1946 and malaria morbidity and mortality declined steadily. In 1955, the World Health Organization (WHO) declared the goal of global eradication of malaria with a four-phase program: preparatory, attack, consolidation, and maintenance. In Sri Lanka the malaria eradication program started along these lines in 1958 and in 1963 the "attack" phase was successfully completed with only 17 malaria cases reported island wide during that year. In 1964 the "consolidation" phase was started and most of the DDT spray teams were disbanded. The discontinuation and weakening of the vector control program led to a resurgence of malaria with a massive epidemic in 1968 now considered the classical example of a post-eradication epidemic. Malaria had re-established itself as a major disease especially in the dry zone of the country. Reintroduction of DDT had limited effect due to vector resistance.

With the increasing resistance of mosquitoes to DDT, other insecticides were introduced for malaria control, first Malathion, followed by others, with each generation of insecticides being much more expensive than the previous one. A large proportion of Sri Lanka's health budget is therefore spent on malaria control. The most recent year for which a central figure is available is 1989, prior to the devolution of the health budgets to the provinces. At that time, 11.6% of the total budget was spent on anti-malaria activities. The cost to the government of anti-malarial activities relates mainly to vector control, e.g. spraying houses with insecticides and larviciding vector breeding habitats, supporting diagnostic and treatment facilities, and maintaining an information system. The bulk of malaria control expenditure is currently used on importing insecticides. However, since the implementation of a selective spraying program in 1994 the total amount of insecticides used has declined significantly.

Flushing of streams

Due to the breeding preference of certain vectors of malaria such as for streams and rivers, water management has long been considered an effective intervention. Between 1934 and 1936 experiments were performed with engineering and manual measures to reduce the creation of pools in rivers in Sri Lanka, then called Ceylon. Clearing the stream from falling trees, creating drainage canals along the side of the stream, filling up permanent rock pool formations and constructing special dikes made the stream less conducive for the breeding of the vector mosquitoes. Technical feasibility tests were carried out in a number of rivers and streams using hand operated flushing devices and automatic siphons to flush waterways. Much later flushing activities were carried out in the Mahaweli River below the reservoirs close to Kandy town aimed at reducing the mosquito breeding potential. However, due to the conflict with other water management objectives, e.g. hydropower generation, this practice was stopped.

Several other countries in Asia, including India, the Philippines, Indonesia, and Malaysia have made extensive use of automatic siphons. Siphons that were constructed in Penang, Malaysia before World War II are still in good operating condition.

The case of the tank cascade systems in Sri Lanka

One of the salient features in the landscape of the Sri Lanka dry zone are the many water reservoirs. There are an estimated 18,000 of these tanks in Sri Lanka and many are interlinked through canals or natural streams to form cascades. In 1994 a study was initiated in the Huruluwewa watershed assessing the options for control of malaria vectors through different water management practices in a natural stream that formed part of such a tank cascade system. The studies established conclusively that *Anopheles culicifacies* was the major vector of epidemiological importance and that a small river, the Yan Oya, was the primary vector-breeding habitat in the watershed, which posed a significant risk factor for malaria early during the transmission season. Villages further away from the stream had lower densities of the main vector, and concomitantly lower malaria than the villages closest to the stream. Detailed analyses of water dynamics of the entire watershed area have been used to model different water management practices that could reduce vector breeding in this key habitat and thereby have a system-wide impact on malaria in the watershed. The most viable management option was a redistribution of existing water flows in order to maintain a water depth sufficient to discourage the breeding of the vector. Costs analyses of the potential water management measures and other vector control interventions such as the spraying of houses with insecticides and the use of bednets have shown that flushing the streams through seasonal water releases from upstream reservoirs would be the cheapest vector control measure (see Table 1). These studies were implemented by a multidisciplinary research team with expertise in the diverse disciplines of vector ecology, parasitology, epidemiology, social science, economics and irrigation engineering (representing IWMI, the University of Peradeniya and the Anti-Malaria Campaign). In the second phase of this project the water management methods will be implemented on a routine basis in consultation with the health workers, irrigation managers and farmers and the impact on vector mosquitoes and malaria incidence monitored.

Apart from natural waterways and those that link components of tank cascade systems, the tanks themselves may pose a malaria risk by generating vector mosquitoes. In the Huruluwewa study, for instance, one tank generated large numbers of the main malaria vector in water-filled pools on the tank-bed during a particular year. Other tanks investigated in this area have been shown to generate substantial numbers of secondary malaria vectors, which are becoming increasingly important in malaria transmission as human populations increase and more and more forestland is opened for settlement. In the south of Sri Lanka, a malaria risk map was developed in the Udawalawe area using a geographic information system (GIS). This showed that high malaria was significantly linked to areas with a large number of abandoned old irrigation tanks. A recent rapid reconnaissance of a few of these tanks again revealed the presence of important secondary vectors of malaria breeding in them. Managing small and large irrigation tanks in such a way that they maintain a minimum malariogenic potential could well be a new challenge in the years ahead.

Conclusion

Water management and other environmental management methods deserve a place in malaria control activities. Key issues in determining the success of environmental methods are (1) knowledge of the local vector ecology and malaria epidemiology; and (2) close interactions and real collaboration between health specialists and engineers.

References

Konradsen F, Amerasinghe FP, van der Hoek W, Amerasinghe PH (2000). *Malaria in Sri Lanka: Current Knowledge on Transmission and Control*, International Water Management Institute.
Konradsen FP, Steele P, Perera D, van der Hoek W, Amerasinghe PH, Amerasinghe FP (1999) Cost of malaria control in Sri Lanka. *Bulletin of the World Health Organization* 77:301-309.
Matsuno Y, Konradsen F, Tasumi M, van der Hoek W, Amerasinghe FP, Amerasinghe PH (1999) Control of malaria mosquito breeding through irrigation water management. *International Journal of Water Resources Development* 15:93-105.

Table 1: Total operating & Capital costs to the government of various preventative interventions

Intervention	Operating Cost per day in Rupees	No. of Households protected per day	Operating cost per household per Intervention day (in Rs.)	No. of Interventions per year needed for Protection	Annual operating cost per household (in Rs.)	Annual capital cost per household (in Rs.)	Total annual cost per individual protected (in Rs.)
Spraying (Fenitrothion)	6412	25	256	3	768	24	158
Spraying (malathion)	4613	25	185	3	555	24	116
Bednet impregnation (permethrin)	5244	50	105	2	210	32	48
Larviciding (temephos)	1652	56	30	4	120	16	27
Water management	6600	600	11	6	66	0	13

* Water, Health & Environment Theme, IWMI