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ENVIRONMENTAL MANAGEMENT FOR MOSQUITO CONTROL IN TROPICAL URBAN AREAS

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Abstract

The paper deals with effective manipulation of limited resources for maximum utilization in environmental management aimed at limiting mosquito breeding within acceptable levels in tropical urban centres. Almost invariably, rapid population increase and urbanization rate far outstrip municipal development in urban areas due mainly to economic and financial constraints. Optimum development of the environment involves provision of all infrastructural facilities and landscaping not attainable in most tropical countries. However, under an environmental management body including all organizations concerned directly or indirectly with land and water use, to coordinate environmental management and vector control activities, all infrastructural facilities for optimum development of any urban area will be incorporated in a master plan even if they will be installed piecemeal. The management body will also ensure proper construction of facilities like drains, roads, household sewerage systems, and garbage disposal systems which are the infrastructural facilities normally available in tropical countries. All useless water bodies and potential water-holding excavations and depressions will be eliminated by filling with excavated soil from construction sites etc. Road and drain construction must go *pari passu* to save costs and prevent water stagnation. Drain construction must be handled by competent firms (who will work hand in hand with the vector-control and landscape departments) instead of inefficient firms who usually construct drains. Much of water stagnation in drains is due to inefficient garbage disposal systems which are rudimentary in most ropical countries. This must be undertaken by commercial organizations on behalf of local councils. Research aimed at improving infrastructural facilities are to be conducted mainly on (1) design and construction of drains, man-holds and man-hold covers at road junctions; (2) the most appropriate waste disposal receptacles for domestic, industrial and public uses; (3) the development of the most efficient technology for turning garbage into manure and a basic component for drain and road construction.

Introduction

Appropriate municipal development of any locality is likely to limit mosquito breeding and abundance to levels which will make species inconsequential in disease transmission. However, in most developing countries, financial and economic constraints limit municipal development to such a level that it lags behind population growth and spread. The result is creation of a wide variety of mosquito-breeding habitats and elimination of others but, usually, it leads to a substantial increase in populations of some mosquito species and reduction in the populations or elimination of others. However, economic and financial constraints notwithstanding, with careful planning and environmental management involving judicious use of the limited resources available, mosquito breeding can be brought within manageable limits.

Town planning and development

Development planning of any locality, be it a village, town or city, must be bold, imaginative and far ahead of urbanization. Ideally, town planning includes construction of roads, drains, water supply infrastructure, telecommunication, electricity supply infrasctructure, garbage disposal facilities,

sanitation systems and landscaping. In most developing countries, provision must be made for farming activities. Environmental management in any tropical community will involve the infrastructural facilities and services listed above as well as management of natural vegetation, water bodies and control of farming activities.

Although all the infrastructural facilities listed above cannot be installed simultaneously because of financial constraints, they can be incorporated in a master plan even if they will be installed piecemeal. This will save cost and make allowance for installation of the others without much damage to or disturbance of already-installed infrastructure.

Environmental management

Environmental management, defined by the WHO's Expert Committee on Vector Biology and Control (WHO, 1980), involves activities like source reduction, naturalistic and physical measures of vector control and sanitation. These methods, which have been treated comprehensively by Rifatjah (1988), are summarized schematically in Table 1.

In this discourse, consideration will be given to only some aspects of environmental management in relation to institutions, individuals and groups of individuals whose activities lead to the creation of multiplicity of breeding habitats touching on specific habitats associated with prolific breeding in urban situations with the aim of reducing as much as possible the financial burden due to the municipal authorities *vis a vis* mosquito control. In developing countries, the main constraints are socio-economic and financial. Others include, political, legal, institutional and socio-cultural. The legal and institutional framework for environmental management is still poor in Ghana as in most sub-saharan countries (Sogreah & Comptran, 1994). However, under an all-embracing environmental management committee (which will integrate political, economic, legal and socio-cultural factors into the development planning and decision-making process) much can be achieved.

Environmental management committee

A committee comprising all agencies associated with land and water use eg. the environmental protection agency, the municipal health authority,

TABLE 1

Schematic representation of the main components of environmental management for malaria vector control

Methods for environmental management

Environmental modification	Environmental manipulation	Modification or manipulation of human habitation, behaviour
- Drainage	- Water level management	- Site selection
- Land filling and levelling	- Flushing of streams	- Dry-belting
	- Changing water salinity	- Mosquito proofing of dwellings.
	- Flooding and dewatering	- Individual protection
	- Pollution with organic matter	- Zooprophylaxis
	-Shading and exposure to the sun	- Basic sanitary measures
	-Dessication by trees	
	- Intermittent irrigation	

town planning and public works departments, representatives of contructional firms, landscape and vector control departments will be ideal. The work of the committee can be optimized through networking at the strategic policy level. This body will *inter alia* (1) co-ordinate the activities of all the organizations directly or indirectly involved in environmental management and vector control activities; (2) from time to time formulate new policies and give new directives on mosquito control; (3) supervise the incorporation of all infrastructural facilities onto a master plan and ensure their proper construction and installation. Through its co-ordination of the activities of the municipal health, the landscaping and vector control departments and all construction firms, all potential breeding waters (both natural and artificial) in extra-domestic locations can either be eliminated or prevented from breeding mosquitoes. For instance, during construction of roads, railways or major industrial plants, many excavations are made at the construction sites and apparently flat extensive lands can be converted into an area with numerous water pools during the rainy season through indiscriminate dumping of excavated soils. Under proper management, co-ordination and supervision, such excavated soils can be used in filling natural depressions and excavations as well as useless water bodies like some swamps and marshes while the edges of aesthetically or economically useful ones can be raised well above ground level with excavated soils.

One of the cheapest and simplest methods for preventing mosquito breeding in preserved water bodies is the use of stones bound together with cement and applied all along the water edge. This will prevent the growth of weeds with which acquatic stages of mosquitoes are usually associated. It is axiomatic that through such an action alone, most of the extra-domestic breeding which may represent about 70 per cent of all breeding in any urban area can be eliminated or prevented.

Facilities and activities which promote mosquito breeding

Infrastructures, the construction, use and inefficient maintenance or management of which are usually associated with mosquito breeding are roads, railways, drains, sanitation systems, water supply and garbage disposal facilities. Trees and farming activities also contribute to mosquito breeding. The ways and manner in which some of these items contribute to mosquito breeding and how this can be prevented are considered below.

Drains. Drainage can be executed by constructing open drains, laying underground drains, by pumping or by vertical drainage. In tropical urban areas where drains are mainly for disposal of waste water and excess water during the rains, the drainage is usually the surface open type and are usually concrete or earthdrains. The discourse on drains will, therefore, be limited to how inefficient construction and maintenance of open drains contribute to mosquito breeding. Extent and intensity of mosquito breeding in drains depends on several factors most importantly (1) the degree of modification of the land through land use and (2) the extent and quality of the drainage (Chinery, 1968).

Associated with uncompleted drains are stagnant pools of water consistently and constantly replenished with ever-flowing drain water (Chinery, 1969). Such water collections cannot be eliminated by dumping of excavated soil, and the prolific breeding there-in cannot be easily controlled with insecticides. This can only be prevented by imaginative town planning and development supported by efficient drain construction. It is imperative that drain construction must either proceed or accompany road construction to avoid dissipation of resources (both financial and material). It should be undertaken by highly-qualified (preferably specialist) and experienced firms. Although generally and implicitly stated in the National Development Planning Act, 1994 (Ghana

Government, 1994), many drains (e.g. in Accra) are inefficient because many drain construction projects are regarded as simple to execute and are, therefore, awarded to inexperienced firms or those rapidly and hurriedly established for the purpose of winning contracts. Government departments and municipal authorities must encourage specialization in drain construction by awarding such contracts to firms with considerable experience, proven ability and excellence in drain construction, contrary to the popular practice of awarding such contracts to small inexperienced firms to help them establish themselves with such awards because of the belief that drain construction is a simple undertaking.

In developing countries with minimal town planning and infrastructural development, drain construction will require considerable imagination and foresight. Contractors must work hand-in-hand with vector-control and landscaping departments right from the planning and surveying to the execution stages of the project to produce the most cost-effective drains. In this context, construction of large drains is most significant. If water stagnation in large drains (and for that matter all others) is to be prevented, then these large drains should be constructed in such a way as to ensure swift flow of water in both rainy and dry seasons (Chinery, 1969).

All drains must follow the direction of the general land gradient and not run counter to it. When this happens, an extensive permanent mosquito breeding habitat is created and elimination of breeding in such a habitat will be difficult as observed in Tema (Chinery, 1969) where, on the whole, control of mosquito breeding in poorly-constructed concrete drains was not successful (Chinery, 1969). In Accra, faulty drains not only supported breeding of a wide variety of mosquito species including the malaria vectors, but also created a potential for the breeding of snail vectors of schistosomiasis (Chinery, 1990a). The need for constructing efficient concrete drains is further underscored by the finding that in Accra, earth drains breed mosquitoes more frequently than concrete drains (Chinery, 1969). Control of the malaria vector in the latter was comparatively successful (Chinery, 1969).

Sewerage system. The ideal sewerage system is the centralized one, but because of financial constraints, the unit sewerage system will be used for some time. To prevent mosquito breeding in the latter, the most effective design *vis a vis* mosquito breeding must be adopted as standard model. The main problem with the designs in use at present is how to prevent mosquitoes from entering to oviposit in either the water-holding or the soak-away compartments of the system, each of which has its own mosquito species capable of vectoring different diseases. Some of these measures have been considered in some detail elsehwere (Chinery, 1969).

Garbage disposal facilities. Mosquito breeding occurs in drains mainly because of stagnation of water brought about by deposition of garbage in drains. This is due mainly to inadequate supply of garbage disposal facilities coupled with inefficient use and improper maintenance of these facilities. At present, garbage disposal is in its very rudimentary stages in most developing African countries, and considerable development in this area is needed. A most cost-effective way of disposing garbage is by a comprehensive garbage management programme, which can be operated on behalf of the city or local councils by private firms on commercial basis in co-operation with agencies directly associated with land-use, e.g. construction firms, landscape department large-scale and industrial farming companies for the benefit of both the councils and the country.

Landscaping. Landscaping of the vicinity of road and drain construction sites must be incorporated in the contracts awarded to firms (who will collaborate with the landscape departments) not only for aesthetic reasons but also to check desertification and soil erosion, very serious problems in most tropical African countries which experience torrential rainfall. It is envisaged that in

the near future tree planting in all localities *viz.* cities, towns and villages will be undertaken as part of environmental enrichment and desertification preventing programmes. In this context, it is envisaged that arrangement of trees in all localities (and it is expected that all streets, roads and alley-ways will be flanked on either side by most appropriate types of trees to provide *inter alia* shade and make walking less tedious) will be formally included in any master plan for any locality.

Advantage must be taken of tree planting to control mosquito breeding by either altering the nature or eliminating water collections especially swamps and marshes, or creating conditions unfavourable for mosquito breeding. For example, the use of trees in dessication of lagoons and water-logged areas through evaporation has resulted in successful control of mosquito breeding (Raftjah, 1988) while breeding of sun-loving species like *An. gambiae* s.l. and *An. funestus* have been successfully controlled experimentally through shading with trees like *Ficus benjamina* and *Cassia alata* (Rafatjah, 1988). Although aesthetically, climatically, recreationally and medically desirable and most essential, trees can breed and shelter mosquitoes some of which transmit serious diseases, particularly malaria and yelow fever. This can be eliminated through co-operation between the landscaping and vector-control departments (Chinery, 1969), or the horiticultural and botany departments of research institutes and universities to select trees with little or no cavities in their axils; avoiding planting of trees along irrigation canals.

Farming activities. With rapid increase in population in tropical urban areas and scarcity of employment opportunities, small-scale farming activities will continue to increase both in numbers and acreage in urban locations. However, with increase in the tempo of constructional activities, farmlands will be replaced by physical structures especially domestic and office buildings. However, displaced farmers will readily relocate in any available intra-urban locales especially land corridors between drains and buildings along roads or in the urban fringes. Although some crop plants like maize, banana and plantain provide larval habitats for mosquitoes, breeding in such habitats (which can only be controlled by application of insecticides) may or may not be considerable depending on the length of the rainy season. On the other hand, the activities and operations of perennial rain-independent (mainly vegetable) farms should be controlled in every possible way to prevent the creation of potential breeding waters in such farms.

Research and development

Research and development aimed at enhancing environmental management *viz-a-vis* mosquito control will be mainly in the area of drain construction and waste disposal. Research on garbage disposal should include (1) the most suitable designs of garbage disposal receptacles for the different categories of households identifiable in urban localities; (2) garbage disposal receptacles (which should be large and adequately supplied along streets and roads; (3) the most cost-effective way of separating the large quantity of fertile humus soil from garbage before recycling and the cheapest and most appropriate technique for incineration of garbage; (4) use of garbage for producing manure in conjuction with human, animal and vegetable waste; (5) use of land reclamation material as a basic component for drain and road construction and road maintenance. Research into the most cost-effective sewerage system especially covers for the septic tanks and soak-aways is also necessary.

Considerable research and development is urgently needed on the various aspects of drain construction especially the larger ones to evolve the most suitable drains for developing countries *viz.* cost, design, construction materials and methodology *viz-a-vis* drain strength and durability, flow rate of water and the optimum drain size in order to retrieve much of the area occupied by a previ-

ous earthdrain or stream. Research must concentrate on labour-intensive construction and maintenance techniques more appropriate in developing countries with abundant and cheap labour than the mechanized methods used in industrialized countries (Caincross, 1986). It should also concentrate on finding a suitable local alternative to cement in drain construction either to replace cement entirely or reduce this component to the barest minimum. This is most crucial if competition between drain and housing construction in the use of the limited supply of cement - a major and important component of concrete drains - is to be avoided. Research for the production of the most appropriate man-holds and man-hold covers at road junctions and cross-roads is also necessary. Improperly constructed man-holds and man-hold covers are among the major causes of stagnation of water in concrete drains. The research will involve collaboration between civil engineering research institutions, drain construction firms, and the departments of vector control and landscaping.

Discussion and conclusion

In controlling mosquitoes in any large town or city, integration of two or more unrelated methods such as combining methods of basic hygiene with chemical methods and environmental management programmes offers the best chance of success (Chinery, 1990a). In most developed countries, appropriate municipal development automatically makes basic hygiene and environmental management methods irrelevant. On the contrary, in developing countries, because of underdevelopment and financial constraints, basic hygiene methods involving the community and preventive and control measures such as environmental management are most desirable (Chinery, 1990a) and must predominate over chemical control because they are cost-effective, involve minimal foreign currenty component and enrich the environment instead of polluting it. There should be programmes for health education of the communities for their cooperation and participation in proper maintenance of peri-domestic drains through good garbage disposal practices and for intradomiciary and peridomestic prevention of mosquito breeding through application of basic hygiene methods. Other groups which deserve appropriate health education are petty urban and periurban farmers; more importantly are the constructional firms because they contribute to substantial modification of the land and so promote mosquito breeding, particularly at constructional sites where mosquitoes breed profusely in well-planned and developed districts because of execution of many constructional projects in these localities (Chinery *et al.*, 1965). Periodic training for selected staff from both the municpal health departments and the constructional firms on short courses to acquaint them with simple environmental management techniques, their planning, implementation and evaluation is desirable. Training may be extended to higher level professionals, e.g. engineers, entomologists and biologists for field training in planning, evaluation and operational research.

In most tropical urban localities, the mosquito-breeding problem can be grouped into two categories, namely (1) a variety of standing natural water bodies including rainpools and (2) stagnant waters in streams, rivers and drains caused by several factors particularly garbage dumping in extradomestic locations.

In peridomestic situations, the problem is mainly faulty construction and inefficient use and maintenance of infrastructural facilities associated with water supply and waste water disposal in the sprawling slum areas and other over-crowded localities because of rapid urbanization and inadequate municipal development. These include catchpits, hydrants and household drains.

Fortunately, in some large tropical urban areas e.g. Accra, where low rainfall is limited to a few months in the year, there is intensive pollution of most of the breeding waters. Indeed, in some large urban areas, e.g. Accra, variation in breeding frequency and intensity and adult mosquito populations in different localities (Chinery, 1979, 1990b) caused by ecological diversities in a single

but large urban are (*viz.* rainfall, natural ecosystem, housing pattern, infrastructural facilities and standard of life), results in differences in prevalence and seasonal variations of malaria infection in such area (Chinery, 1979, 1990b).

Physical methods of mosquito control, with its many advantages *viz.* employment of many hands, beautification and enrichment of the environment simultaneously with elimination of breeding waters in extradomestic and peridomestic locations should be preferred. In waste disposal alone, effective waste management will bring with it several benefits, including a more hygienic environment, reduction in the incidence of gastro-intestinal diseases, elimination of many breeding habitats, effective land reclamation and better landscaping, cheap road maintenance material, construction of cost-effective drains, and cheap and inexhaustible supply of manure.

With the rapid increase in urban populations with time, the quantity of garbage will continue to increase. All efforts should be directed into turning garbage disposal and management into a viable industry. To this end, collaboration between appropriate research institutions, user agencies and interested foreign investors is required to research intensively into all the possible uses of garbage. Waste management alone may offer new approaches to efficient environmental management in the control of mosquitoes. With the evident cost-effectiveness of environmental management and the estimation that about 70 per cent of mosquito breeding in urban locations can be eliminated through a collaborative effort in the recycling of excavated soils and possibly treated-garbage as land reclamation material, the effort of the municipal health authority in dealing with mosquito breeding in urban areas will be made a little lighter.

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