4 Water-Borne Diseases in West Africa

4.1 Distribution and Transmission Mechanisms of Water-Borne Diseases

For long periods, inland valley bottoms have not been used for agriculture because of the occurrence of water-borne diseases. Nowadays, however, with the declining yields on the uplands, the increasing population pressure on the available agricultural land, and the agricultural potential of the inland valley wetlands, they are being used more and more within the different farming systems.

The main water-borne diseases that are a major public-health problem in West Africa are malaria, schistosomiasis (bilharzia), trypanosomiasis (sleeping sickness), onchocerciasis (river blindness), and dracontiasis (guinea worm). Malaria is common

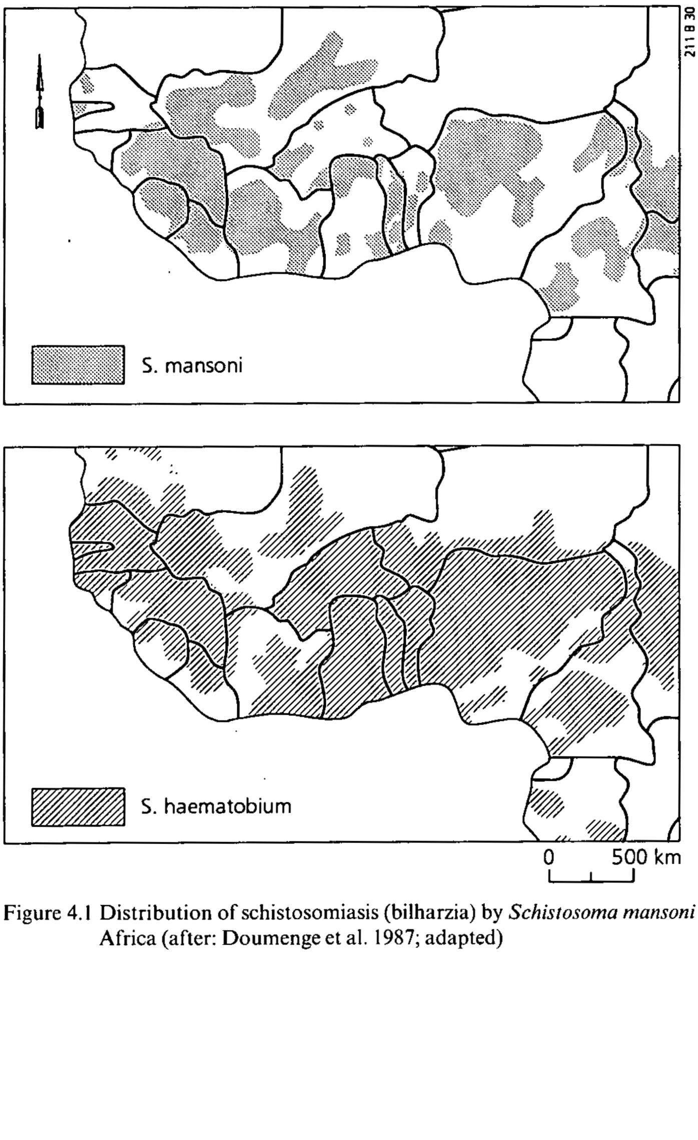

Figure 4.1 Distribution of schistosomiasis (bilharzia) by *Schistosoma mansoni* and *S. haemotobium* in West Africa (after: Doumenge et al. 1987; adapted)

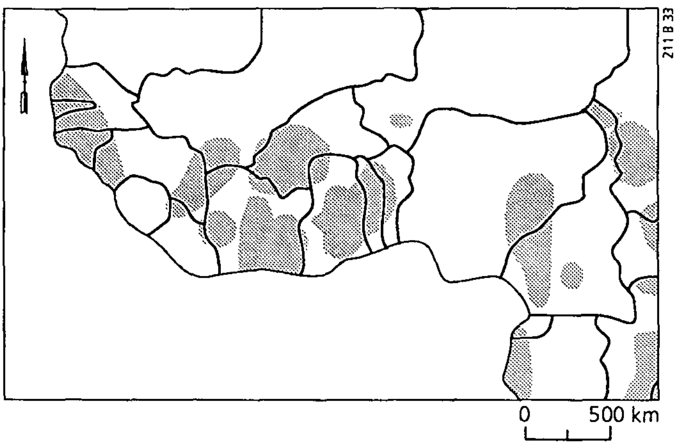

Figure 4.2 Distribution of trypanosomiasis (sleeping sickness) in West Africa (after: Mollyneux and Janssens 1980; adapted)

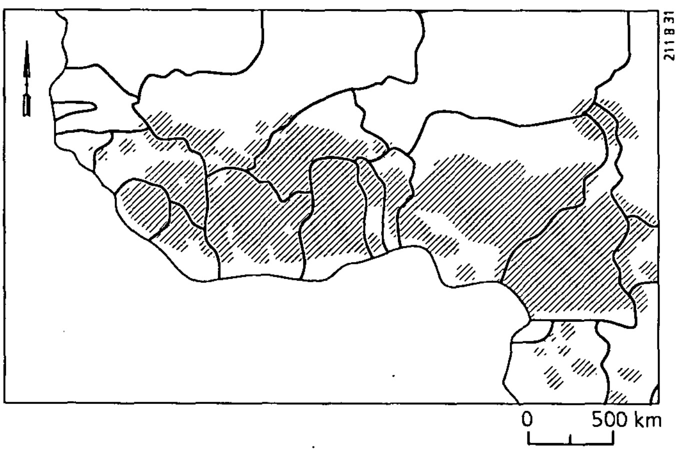

Figure 4.3 Distribution of onchocerciasis (river blindness) in West Africa (after: Muller 1980; adapted)

throughout the inventory area. The distribution of the other diseases is shown in Figures 4.1, 4.2, 4.3, and 4.4.

All these diseases are vector-borne. This means that, for their transmission, at least one intermediate host (vector) is required. The hosts may be insects or aquatic animals. If the host is an insect (mosquito or fly), it will acquire disease parasites by stinging an infected man or animal and may transmit these parasites to any man or animal it stings afterwards (mechanical transmission). If the host is an aquatic animal (snail), it acquires the parasites from infected water. After the parasites have completed a part of their life cycle within the host's body, they are released back into the water. There, they may penetrate the skin of any new host – man or animal – present in the water (biological transmission) (Oomen et al. 1990).

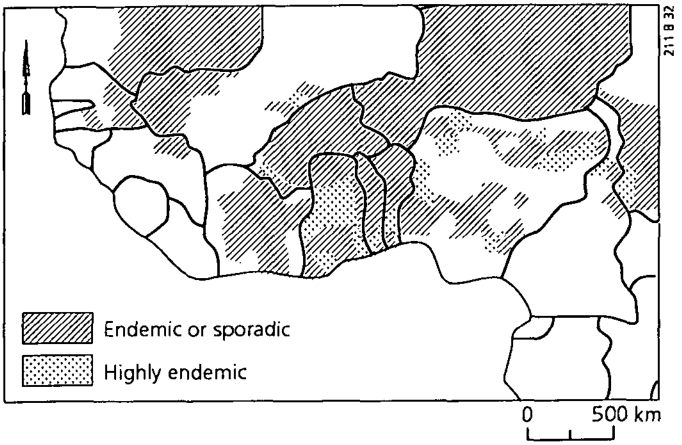

Figure 4.4 Distribution of dracontiasis (guinea worm) in West Africa (after: Watts 1987; adapted)

Ecological changes brought about by the development of wetlands, including valley bottoms, can lead to the explosive propagation of these vectors. The health infrastructure in many countries of West Africa is unable to cope with any increased burden of diseases. Therefore, from the very beginning of the development of water resources, one has to incorporate environmental safeguards to fight these diseases (Oomen et al. 1990; van der Laar 1985).

The distribution and incidence of water-borne diseases are influenced not only by water management for agricultural production but also by the quality of community water supplies, sanitation and housing facilities, and by the degree of settlement and migration of the population. Improvements in drinking-water supplies, in excreta disposal, and in nutrition and nutritional hygiene can reduce the transmission of many infections.

Table 4.1 lists various kinds of mechanisms of disease-transmission and the design components that can reduce such transmissions. These components of environmental health engineering should be kept in mind when rural development programs are being planned for wetland areas.

The burden of infectious diseases in a community can be reduced by the partial or complete disruption of their transmission mechanism. There are three ways in which this can be done (Oomen et al. 1990):
- By interfering with the transmission mechanism;
- By protecting the susceptible hosts;
- By reducing the reservoirs of infection.

Environmental management can disrupt transmission by eliminating the breeding places of the vectors. This might be supplemented by the use of chemicals, to kill either the disease agents by disinfection or the vectors with insecticides or molluscides. Bio-technological measures, such as genetic manipulation or the introduction of or-

Table 4.1 Transmission mechanisms of diseases and design components for environmental health engineering that contribute to integrated control (source: Oomen et al. 1990)

Design component	Transmission mechanism	Design feature	Related diseases
Occupation	Insect-vector breeding in water/biting near water	Dam construction Irrigation network	Malaria, onchocerciasis, trypanosomiasis, other vector infections
	Water-based	Agriculture	Schistosomiasis
Water supply	Water-borne Water-washed	Quality and/or quantity of water	Diarrhoeas & dysenteries Enteric fevers Enteric virus ingections
		Quantity only	Skin & eye infections Louse-born fevers
	Water-based	Protection of water source	Guinea worm infections
Excreta disposal	Person-person contact Domestic contamination Water contamination Field contamination Crop contamination	Latrine construction Excreta treatment Hygiene environment	Diarrhoeas & dysenteries Enteric fevers Soil transmitted helminths Beef and pork tapeworms Water-based helminths (Schistosomiasis) Filariasis
Housing	Siting near habitat	Siting/screening of houses	Malaria, filariasis, onchocerciasis, trypanosomiasis
	Overcrowding	Space and ventilation	Epidemic meningitis
	Air pollution		Acute & chronic respiratory infections Respiratory malignancies
	Vector breeding	Water storage	Arbo-viral infections (denque, yellow fever)
	Refuse	Refuse disposal	Chagas disease, leishmaniasis
	Construction	Construction materials	Soil transmitted helminths
	Fire	Burns	Fire hazards
Nutrition	Lack of calories	Staple crops	Under nutrition
	Lack of proteins	Home-gardens	Protein-caloric malnutrition
	Lack of vitamins		Vitamin deficiencies
	Food storage	Storage facilities	Food poisoning: diarrhoeas
	Food preparation		
Energy	Use of fire-wood	Kitchen stoves	Food poisoning: diarrhoeas
	Open fire	Chimneys	Burns
	Storage of kerosene		see: Air polution
Village infrastructure		Immunizations	Childhood infections, poliomyelitis, yellow fever
Health care		Mother-child care Education and communication	Perinatal/infant mortality Treatment endemic diseases: malaria, diarrhoea, repiratory infections, helminths, schistosomiasis etc. Birth regulation

ganisms that compete ecologically with the disease agents or vectors, can also be taken.

Hosts can be made less susceptible through the use of prophylactic drugs (e.g. in the case of malaria) or by reducing their contact with the vector by using mosquito-nets, by applying repellants, or by screening their houses.

Reservoirs of infection can be reduced by treating infected and ill people, and by treating or eliminating infected animals (e.g. in the case of trypanosomiasis).

The integrated control of infectious diseases is a control strategy that combines, if relevant, the above-mentioned approaches (WHO 1983).

4.2 The Main Water-Borne Diseases

4.2.1 Malaria

Malaria is the most widespread water-borne disease in West Africa and is clinically characterized by high fever, which may have a characteristic periodicity, and anaemia, which results from the destruction of red blood cells and enlargement of the spleen.

The disease is caused by a number of protozoan organisms of the genus *Plasmodium*, especially *P. falciparum, P. vivax*, and *P. malariae*. Malaria is transmitted by mosquitoes (*Anopheles spp.*), which breed in stagnant or slowly flowing water in streams and rivers, in small pools, and in standing water in, for instance, cans and barrels.

Malaria control aims at reducing the reservoirs of infection in the community and/or reducing the number of malaria vectors biting man. Depending on environmental and socio-economic conditions in the community, a control strategy could be (Oomen et al. 1990):

- To prevent mosquitoes from feeding on man;
- To prevent or reduce mosquito breeding;
- To destroy mosquito larvae;
- To destroy adult mosquitoes;
- To eliminate malaria parasites in the human host.

The inland valleys seem to be excellent breeding sites for different *Anopheles* species. If water management results in a prolonged wet season (double cropping of rice), the increased water availability provides extra breeding potential. With intensified swamp labour, the transmission of malaria can be promoted by the increased intensity of man-mosquito contact (van der Laar 1985).

In the cultivation of rice, intermittent water application and field drainage will reduce breeding facilities.

4.2.2 Schistosomiasis (Bilharzia)

Schistosomiasis is a complex parasitic infection that is caused by five species of parasitic worms of the genus *Schistosoma* which affect different organ systems. The different stages of this disease are (Oomen et al. 1990):

- Invasion: cercarial skin reaction and possibly some fever;
- Development: acute febrile illness, which is not always recognized;

- Established infection: early chronic disease with haematuria or intestinal symptoms;
- Late infection: chronic disease of the bladder/kidneys, intestinal tract, and liver.

Schistosomiasis is transmitted to man in a variety of freshwater habitats. Aquatic snails (*Bulinus spp.*, *Biomphalaria spp.*, and *Oncomelania spp.*) are the intermediate host in the life cycle of the parasites *S. haematobium*, *S. mansoni*, and *S. japonicum*, respectively. The reservoir of infection of *S. haematobium* appears to be in humans, whereas *S. mansoni* infections are found in monkeys, baboons, and rodents. There is no evidence, however, that these animals play a role in transmitting *S. mansoni* to humans. Domestic and wild animals contribute significantly to the transmission of *S. japonicum* to humans.

The snails also provide a transport function in spreading the disease.

Opportunities to control transmission are offered by the human host, the snail host, and the free-swimming stages of the parasite.

Human behaviour is important in the transmission of the disease. Good excreta treatment and hygiene (latrine construction) will reduce the release of schistosome eggs into the environment. Reducing the exposure of humans to infected water will lower the transmission too (Oomen et al. 1990).

Snail populations can be reduced through chemical control, but this is expensive and must be repetitive (McJunkin 1975).

The snails prefer standing water with a constant depth. Constructing and maintaining irrigation canals to increase the velocity of stream flow and to fluctuate the water level may reduce the snail populations and would seem to be the most beneficial measure. Vegetation in the drainage network lowers the stream velocity and should not be allowed to develop.

The ability of the snails to survive in the absence of free water varies with the species. If periods of drought are sufficiently prolonged or frequent, the snail population may be reduced or eliminated.

Since some snail species are drought-tolerant, they enable the parasites to survive a drying out of irrigation canals or the entire dry season, even in the savanna areas.

The cultivation of inland valleys increases the exposure of humans to infected water. On the other hand, clearing and cultivating the valley bottoms will probably lead to an increase in the stream velocity and the use of pesticides and anorganic fertilizers. This will change the environment required by the snails and will lower their numbers (van der Laar 1985).

4.2.3 Trypanosomiasis (Sleeping Sickness)

Trypanosomiasis is a fatal disease caused by protozoan parasites of the genus *Trypanosoma*. In West Africa, *Trypanosoma brucei gambiense* and *T.b.rhodesiense* are the causative agents of sleeping sickness in man, while *T.b.brucei* affects domestic animals. The different stages of this disease in man are (Oomen et al. 1990):
- The onset of the disease is characterized by recurrent bouts of fever;
- During the first stage, essential trypanosomal activity is in the lymph glands and the spleen;
- During the second stage, the central nervous system and the heart are affected, which

results initially in irritability and sleeplessness, followed by apathy and drowsiness;
- Death follows, usually because of an intercurrent infection like pneumonia.

Trypanosomiasis is transmitted by tsetse flies. In West Africa *T.b. gambiense* is transmitteed by *Glossina palpalis spp.* and *G. tachinoides*, and *T.b. rhodesiense* by *G. morsitans morsitans, G.m. centralis, G. pallidipes*, and *G. swynnertoni.* All these vector species need shady (forested) and relatively humid conditions. The distribution and ecology of the different species are closely linked with vegetation. Any modification in vegetational cover may affect the dynamic behaviour of the tsetse fly populations and the transmission of trypanosomiasis.

The reservoir of infection was believed to be man, but recently it has been isolated from domestic pigs, dogs, and forest antilopes, suggesting that a reservoir exists in the wild. The disease occurs in distinct isolated foci scattered over the 'tsetse belt'. Most foci are known and are geographically stable (Oomen et al. 1990).

The disease remains a problem despite its low incidence. Changes in climate, vegetation, and land use, population movements, or interruptions in medical surveillance may cause the outbreak of an epidemic.

Animal trypanosomiasis affects cattle, goats, sheep, and camels, and is one of the main obstacles to rural development in Africa.

Medical surveillance and treatment have proven to be effective in controlling trypanosomiasis. Removing the habitats of the tsetse flies and eliminating their hosts (e.g. by clearing the vegetation and destroying any infected wild animal) are other effective methods of vector control.

Land-use patterns can restrict the transmission of trypanosomiasis. If wetlands occur near villages, a buffer zone, cleared around the village and restricted to the cultivation of dryland crops, functions as an obstacle for the movement of tsetse flies between the village and the wet areas.

The development of inland valleys can result in a decrease in sleeping sickness if land clearing includes the removal of the habitat of the tsetse fly (gallery forests).

If the present habitat of the inland valleys is already unfavourable for the tsetse flies, sleeping sickness is not expected to increase through more intensive swamp farming and water management (van der Laar 1985).

4.2.4 Onchocerciasis (River Blindness)

Onchocerciasis is a vector-borne filarial infection caused by *Onchocerca volvulus*, a nematode worm. The most common symptoms are itching, changes in pigmentation, and the development of nodules containing adult worms. Microfilariae produced by these worms can invade the eyes and damage the eye structure, which results in blindness in the patients.

In endemic areas (e.g. the Volta River basin), the general pattern of infection shows an increasing prevalence and severity with age. Also, while the incidence of infection in males and females is similar, men have heavier infections than women because of the nature of their work (Oomen et al. 1990).

The infection is transmitted by species of *Simuliidae* (blackflies), in West Africa mainly *Simulium damnosum*. The *Simulium* vector breeds in rapidly flowing and wellaerated water. The World Health Organization (WHO 1980) indicates that the most commonly tolerated velocities range from 0.7 to 1.2 m/s. The adult fly is usually found near its breeding site, but it can fly considerable distances. This has important consequences for the spread of this disease.

Onchocerciasis can be controlled by campaigns against the parasite, the vector, or both. Since *S. damnosum* can disperse over long distances, control efforts must cover large areas to avoid re-invasion from adjacent foci.

Environmental management for vector control is focussed on turbulent water sites. These conditions may occur at spillways, rapids, bridges, or wherever streams face a temporary obstruction (e.g. from debris). The breeding sites are thus very specific and isolated. They may even occur at unanticipated locations. This remains a problem, especially because of the rapid development of *Simulium*, sometimes within five days.

There are also drugs available to control the parasite. Ivermectine has proven effective against microfilaria in the body, and needs to be taken only once a year (TRD 1988).

Inland valley development will not change the habitat of the present foci where the blackflies occur. Blackflies prefer to breed in high-velocity streams. If these are avoided in drainage and irrigation canals, river blindness is not expected to increase because of water-management measures (van der Laar 1985).

4.2.5 Dracontiasis (Guinea Worm)

Dracontiasis concerns infection with the helminth *Dracunculus medinensis* (guinea worm), which inhabits the subcutaneous tissues of the human host. Dracontiasis sores are painful and often give rise to abscesses, or they affect joints. Without other complications (e.g. tetanus), dracontiasis is not a killing disease but disables the infected for prolonged periods.

Infection occurs when water infested with *Cyclops*, a crustacean, is ingested. The time required to mature in the human host is one year. When an infected human steps into a well or pond from which others may draw drinking water, larvae are liberated from the sores to renew the cycle.

Infection is markedly seasonal because of the influence of the weather on the occurrence of water sources and on the development cycle of the parasite. The periods of the patients' incapacity therefore occur during the farming seasons.

The transmission of guinea worm infection can be totally stopped by the provision of safe drinking water. Effective control should therefore be based on improving drinking-water facilities (e.g. closed wells). Chemicals (e.g. Abate) can be used as well (Lyons 1973).