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The Mosquito Problem in Oxidation Ponds

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The use of oxidation ponds (or sewage lagoons) by small communities as a system of sewage purification has been provisionally accepted in Southern Africa for many reasons, the most important being the low cost when compared with the conventional sewage works. Various aspects of the system have been investigated, the work having been co-ordinated by the South African Council for Scientific and Industrial Research.

In tropical and sub-tropical areas, such as in Southern Africa, the problem of mosquito breeding is of considerable importance and requires immediate solution.

Mosquitoes are an interesting group of animals, the discovery of the part played by the adults as disease carriers having stimulated their study. More than 1,600 species have been described and they have almost a worldwide distribution, although the tropics are much richer in genera and species than the northern and southern latitudes (Imms, 1960). The eggs of mosquitoes hatch in water. The larvae are always aquatic and are the well-known "wrigglers". As a rule, mosquito larvae are only able to exist in small numbers in permanent waters because of the presence of predators, such as fish, various insect larvae and adult insects and, in particular, beetles. During the aquatic phase of the life-cycle the mosquito passes through four larval and one pupal stages. The duration of the larval stages varies, depending on environmental factors such as temperature, etc.

The mosquitoes that most commonly attack man are of two main types the culicines (derived from the principal genus *Culex*) and the anophelines (from the principal genus *Anopheles*). They can be distinguished from each other in all stages with relative ease. Very often, midges are mistaken for mosquitoes. In the larval stage the midge larva or bloodworm breathes by means of bloodgills, whereas the mosquito larva has to break the water surface with its respiratory siphon to breath air. The adults are superficially alike, but the mosquito has scales on its wings and has long piercing mouth-parts extended beyond the antennae or feelers, whereas the midge (or chironomid) is a harmless fly with no mouth-part capable of piercing the human skin. In fact, they do not feed at all in the adult stage. In the resting position, the adult mosquito has its *hind* legs raised whereas the midge or chironomid has its *fore* legs raised above the body.

It is of interest, particularly from the public health and nuisance points of view, that it is only the female mosquito that sucks blood. It is said she requires a feed of blood before she can mature her eggs. This may be true of many species, but is certainly not true of them all. Certain kinds have been bred through several generations in the laboratory without the females receiving any blood at all. The female does, however, produce more eggs when it has had a feed of blood. In the laboratory, more eggs were produced when the mosquitoes had been fed human blood than when fed hamster or chicken blood. A male mosquito cannot suck blood because its mouth-parts are only imperfectly developed and are incapable of piercing the human skin. Its food consists of the nectar of flowers and the juices of ripe fruits, food which the female will also take when it cannot obtain blood (Skaife, 1953).

Mosquitoes in Oxidation Ponds

An oxidation pond is a man-made structure of controlled size and shape, designed to receive crude or settled sewage (Beadle and Rowe, 1960), and is a natural place for mosquitoes to breed; in fact, not only mosquitoes but all aquatic animals, ranging from protozoa to fish, that can tolerate the environment.

The distance between the town producing the sewage and the oxidation pond is usually well within the flight range of mosquitoes. Any large outbreak of mosquitoes will thus be a nuisance, depending on the weather conditions prevailing at the time.

There has been no intensive investigation of the problem of mosquitoes breeding in oxidation ponds but valuable observations have been made during a study of the biological associations of oxidation ponds in various parts of Southern Africa and the Federation of Rhodesia and Nyasaland. In the oxidation ponds at Pretoria, where biological research has been in progress for more than a year, only culicine mosquitoes have been found. The most abundant species was *Culex fatigans*

Weidemann, with *Culex pipiens* Linnaeus present in very small numbers at times. The presence of these species may not be entirely due to chance, but because the water of the oxidation ponds presents them with a suitable environment. For *C. pipiens* the water can be dirty, unshaded and stagnant; they have no objection to water with a high organic content. The larvae of *C. fatigans* are tolerant of extremely foul water and breed abundantly in water rich in decaying organic matter (Hopkins, 1952).

TABLE 1. PLANKTON. APPROXIMATE WEEKLY AVERAGES, 1961

Numbers per litre

1961	Primary pond		Secondary pond		Tertiary pond	
	Culicines	Total animals	Culicines	Total animals	Culicines	Total animals
Jan. ..	20	2,000			1	30
Feb. ..	130	650	1	20		
March ..	20	550	1	700	1	60
April ..	2	670	4	40	2	200
May ..	–	–				
June ..	–	–				
July ..	–	–	1	200		
Aug. ..	–	–			1	260
Sept. ..	2	–				
Oct. ..		550	1	20	1	870
Nov. ..	1	30				
Dec. ..	–	–				

In 34 oxidation ponds, ranging from approximately 12° S to 34° S, which the author has inspected, only culicine mosquito larvae have been found. From a health point of view, particularly in connection with malaria control, this could be an important observation. It has yet to be established that the malaria vector, the anopheline mosquito, cannot breed in an oxidation pond system. It has been found that mosquito larvae occur most abundantly in primary ponds with weedy banks. The vegetation, aquatic or otherwise, provides the larvae with protection from excessive water movement and aids in feeding. They feed on algae, micro-organisms and other particles in the water. The culicine larva "hangs" in the water at an angle of about 45° and this enables it to feed by scraping food from any object in the water. Vegetation serves this purpose excellently.

At Pretoria, the banks of the oxidation ponds were purposely allowed to become overgrown with vegetation during summer and the population of mosquito larvae in the primary ponds reached a very high density within a few weeks. The macrofauna of the plankton and in the marginal vegetation of all three ponds was sampled weekly. In the primary pond plankton, the mosquito larvae population increased from 13/l to 245/l over a period of seven weeks (Table 1). Within three weeks the mosquitoes in the marginal vegetation had increased to 9,856 per sample, which represented 50% of the total animals present. At this point, all the vegetation in the pond was removed, when the mosquito population in the plankton fell to 18/l within a week.

In the secondary and tertiary ponds one larva per litre was found in the plankton. In the marginal vegetation of the secondary and tertiary ponds, the mosquito population was much higher than in the plankton. Within five weeks mosquitoes made up 14·8% (9,229) of the total population

TABLE 2. MARGINAL VEGETATION, 1961

Approximate weekly averages, collected in one 5 ft sweep with a hand-net of 26 cm dia. and a bag of silk grit gauze of 25 meshes to the cm.

1961	Primary pond		Secondary pond		Tertiary pond	
	Culicines	Total animals	Culicines	Total animals	Culicines	Total animals
Jan.	170	3,900	500	10,000	600	10,000
Feb.	22,000	56,000	100	7,500	750	10,900
March	Marginal vegetation removed		100	27,000		
April			1,300	120,000	90	57,000
May			800	133,000	700	220,000
June			2,000	67,000	90	60,000
July	-	-	1,700	42,000	450	46,000
Aug.			100	26,000	750	74,000
Sept.			200	120,000	150	78,000
Oct.			2,000	42,000		
Nov.			70	71,000	15	6,700
Dec.			1,600	556,000	100	147,000

in the secondary pond and 11·9% (24,198) after six weeks in the tertiary pond (Table 2). In these ponds numerous predators, such as *Odonata* nymphs and *Coleoptera*, established themselves in the water, due to a certain extent to the degree of purity obtained. These animals reduce the mosquito population. Breeding mosquitoes were, however, never completely eliminated in the vegetation and continued at a low level throughout the winter months.

CONTROL OF LARVAE

From the above it is clear that vegetation-free banks are very important in the control of mosquito breeding, so banks should be kept clear of vegetation. This should be removed and not allowed to float on the water and provide harbourage for mosquito larvae. In new ponds the banks are often consolidated by planting grass; this should be discouraged, especially during the summer months when maximum breeding occurs. Covering the banks of a pond at the water's edge with cement blocks or bricks to prevent the growth of vegetation proved an excellent measure in the control of mosquito breeding.

Fish are often introduced into ponds—mainly the so-called mosquito-larvae-eating fish, *Gambusia*. It was found that during the winter, when few mosquito larvae were present, the fish changed their diet to include other animals. When, however, the mosquito larvae again became abundant, the fish did not change their diet (Clarke, 1954). *Tilapia* have also been used with success in controlling the numbers of mosquito larvae.

The use of insecticides to control the larvae should be considered as the last line of defence, as not only will mosquito larvae be killed, but almost every type of animal present will suffer heavy mortalities which may affect the efficiency of the oxidation pond. Larvicides have been used in America, but only when there has been excessive mosquito production. The following materials have been used effectively: a thin layer of diesel oil, a 1% or 2% oil solution of DDT, BHC dust (3% gamma isomer), and a 2% malathion emulsion (Beadle and Rowe, 1960).

Oxidation ponds are gaining in popularity throughout South Africa and neighbouring territories and they should continue to be developed. It is hoped that people concerned with the construction and use of these ponds will bear in mind the need for minimizing the production of mosquitoes.

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References

[1]Beadle, L. D., and Rowe, J. A. Sewage lagoons and mosquito problems on waste stabilization lagoons. Proc. Symp. Kansas City, Missouri, 1960, Sec. 14.

[2]Clarke, G. L. *Elements of Ecology.* John Wiley and Son Inc., New York, 1954.

[3]Hopkins, G. H. E. *Mosquitoes of the Ethiopian Region. Part 1. Larvae Bionomics of Mosquitoes and Taxonomy of Culicine Larvae.* Brit. Mus. (N.H.), 1952.

[4]Imms, A. D. *A General Textbook of Entomology.* 9th Edn. Methuen & Co., London, 1960.

[5]Skaife, S. H. *African Insect Life.* Longmans, Green & Co., London, 1953.