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A SURVEY ON MOSQUITOES BREEDING IN SEPTIC TANKS IN SEVERAL RESIDENTIAL AREAS AROUND IPOH MUNICIPALITY

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SUMMARY

A survey on mosquito breeding in septic tanks in several residential areas was carried out on 211 septic tanks in the Ipoh Municipality. The septic tanks inspected comprised two types; the contact filter-bed with pump sump and pump motor type (Type A) and the subsoil filter trench type (Type B).

Mosquito breeding occurred in both types of septic tanks, with Type A septic tanks showing heavier breeding. Seventy-two (55.4 percent) of the 130 Type A septic tanks inspected had ***Aedes albopictus*** *breeding. Besides being a nuisance, mosquito breeding is a potential threat to public health, as* ***Ae. albopictus*** *is a vector of dengue fever. Prolific breeding by* ***Ae. albopictus*** *was encountered in areas where Type A septic tanks were used. Other mosquitoes encountered in the survey were* ***Culex quinquefasciatus, Armigeres subabaltus*** *and* ***Uranotaenia*** *spp.*

Analysis of effluent samples from Type A and Type B septic tanks revealed that of the 4 parameters measured (pH, chloride, BOD5 and Free Ammonia), only pH was not significantly different at the 95 percent level of confidence. Chloride, BOD5 and Free Ammonia levels in the Type B septic tanks were significantly higher than that in Type A septic tanks. Turbidity of the effluent in Type B septic tanks probably deters ***Ae. albopictus*** *from breeding.*

Several methods to prevent breeding of mosquitoes in septic tanks were discussed. The easiest method is to mosquito-proof the septic tanks but this has been tried not too successfully. A method using expanded polystyrene balls is suggested. Other methods include the use of parasitic nematodes and the use of insecticides but these are not favourable.

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INTRODUCTION

In tropical Asia, *Aedes albopictus* (Skuse) appears to be the primary vector of endemic dengue fever. [1] *Aedes aegypti* (Linnaeus) has been associated with the epidemics of dengue haemorrhagic fever in many South East Asian cities since the recognition of the disease in 1956. [2] Both species are known to prefer ovipositing in natural or man-made containers of fresh, clean water, both indoors and outdoors with *Ae. albopictus* being more of an outdoor breeder. [3] *Ae. albopictus* has become adapted to artificial containers especially in shaded situations. [4,5,6] In urban areas of Malaysia, ant-traps and earthenware jars are its preferred outdoor habitats. [7] In the urban areas of Singapore, 95 percent of the breeding habitats belong to the domestic category, the six most common breeding habitats are earthenware jar, tin can, ant trap, rubber tyre, bowl and drum with ant trap being the most common indoor and tin can the most common outdoor breeding habitat.[8]

Since 1974, the dengue and dengue haemorrhagic fever control programme in the State of Perak, Malaysia has been directed at controlling the breeding of *Ae. aegypti* and *Ae. albopictus* mosquitoes indoors and outdoors. A mosquito larval survey carried out in October 1979 by the Vector Control Unit, Health Department, Ipoh Municipality in a residential area, Lim Garden, revealed that although only 3 out of a total of 630 houses had *Ae. albopictus* larvae breeding in containers (Premise Index = 0.5%), mosquito breeding in the septic tanks was very heavy, 256 (47.3 percent) of 541 septic tanks examined had mosquito breeding, 184 (71.8 percent) had *Ae. albopictus* and 93 (36.3 percent) were found with other culicine larvae.

The above finding may necessitate the control of *Ae. albopictus* breeding in septic tanks if septic tanks in other areas are similarly affected. Ipoh Municipality (projected 1980 population: 320,000) has approximately 8,400 septic tanks installed in houses individually or communally (shared by 2 - 4 houses) and this number according to the Sewerage Department of Ipoh Municipality is growing at an average of 5 percent yearly.

Chan, 1972 [9] noted that septic tanks often break down and allow entry of the mosquito for breeding. In a survey, 5.9 percent of 793 tanks were found defective and breeding *Cu. quinquefasciatus* in Singapore. Almost every compartment of the tank was found suitable for breeding, the sedimentation chamber being the most favourable. It was found that modification of the tank by using mosquito proof netting over filter beds and sealing up of all inspection slabs, reduced *Cu. quinquefasciatus* breeding in septic tanks.

The present survey is an attempt to determine the extent of the mosquito breeding problem in septic tanks in several other residential areas, to find out the causative factors and possible means of overcoming the problem.

MATERIALS AND METHODS

Five residential areas in the Ipoh Municipality where individual or communal septic tanks (shared by 2 - 4 houses) were installed in houses, were chosen for this survey. The areas chosen and the types of septic tank systems used are as follows:

TABLE I
AREAS SURVEYED AND TYPE OF SEPTIC TANK USED

	Area	Type of septic Tank*
1.	Lim Garden (N)	Contact filter bed with sump & pump motor
2.	Yik Sang Garden	Subsoil filter trench
3.	Jalan Dato Khong Kam Tak.	Contact filter bed with sump & pump motor
4.	SEDC Houses, Jalan Aerodrome	Subsoil filter trench
5.	Rapat Setia	Contact filter bed with sump & pump motor

* Refer to Figs. 1 & 2.

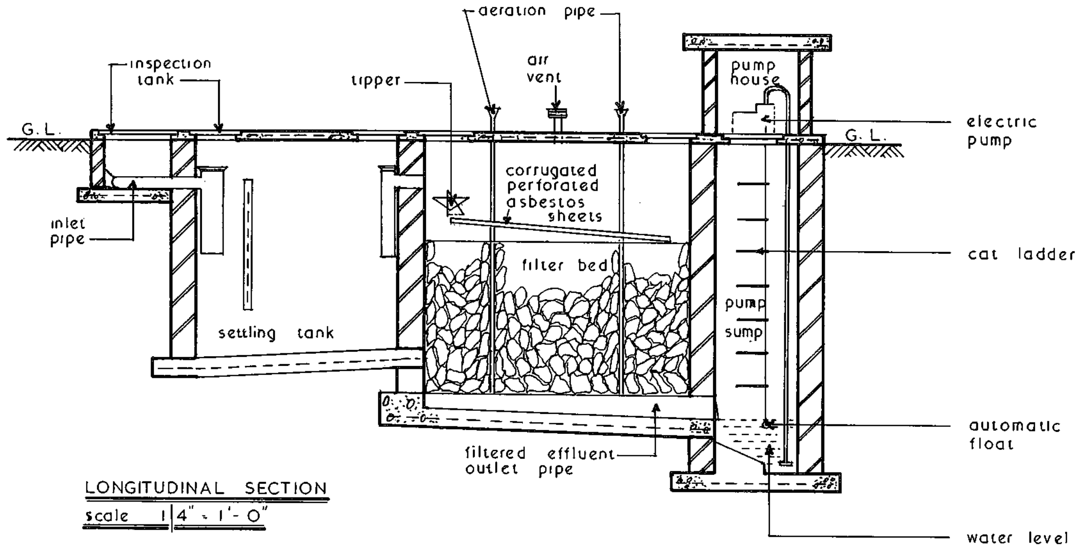
Figs. 1 & 2 show the two kinds of septic tanks commonly used in the areas surveyed and will henceforth be referred to as Type A (contact filter bed with sump and pump motor) and Type B (Subsoil filter trench) septic tanks.

The survey consisted of 2 parts and was conducted during October and November, 1980. The first part of the survey was to determine the extent of mosquito breeding and the types of mosquitoes found in septic tanks in the 5 areas. Due to constraints of time and manpower the survey did not cover all the houses. In areas 1, 2 and 5 roughly 1 out of every 5 houses (20 percent) was inspected. In area 3, 23 of the 29 houses (79 percent) were inspected and in area 4, approximately 1 out of 2 houses (52.5 percent) was inspected.

Areas 1 and 4 had semidetached and detached houses, whereas Areas 2, 3 and 5 had detached houses.

During the inspection of septic tanks in the 5 areas, mosquito larvae found were collected for taxonomic identification. Samples were collected by dipping a metal pail tied to a long nylon rope into the effluent and drawing it up when filled. Larvae found were collected into specimen bottles, and labelled, noting the sampling point and colour of the effluent.

Observations on the condition of the septic tank were noted (working, flooded, defective motor pump). Possible mosquito entry and exit points via inspection covers, fresh air inlets, holes in pumphouse floor for the suction pipe, automatic switch float line were also noted. Similarly, conditions suitable for mosquito harbourage, such



1. MOSQUITO BREEDING OCCURS IF FILTER BED IS FLOODED BY BACKFLOW FROM PUMP SUMP. MOSQUITO ENTRY IS VIA AIRVENT AND INSPECTION MANHOLE COVERS.

2. MOSQUITO BREEDING OCCURS ESPECIALLY IF PUMP SUMP IS NOT DEWATERED OFTEN, MOSQUITO ENTRY IS VIA HOLES IN THE PUMP HOUSE FLOOR FOR AUTOMATIC FLOAT LINE AND SUCTION PIPE OR INSPECTION MANHOLE COVER.

Fig. 1. Septic tank with contact filter bed with electric pump motor to sump. (Type A)

as shade, presence of overgrowth and trees, bushes were taken into account.

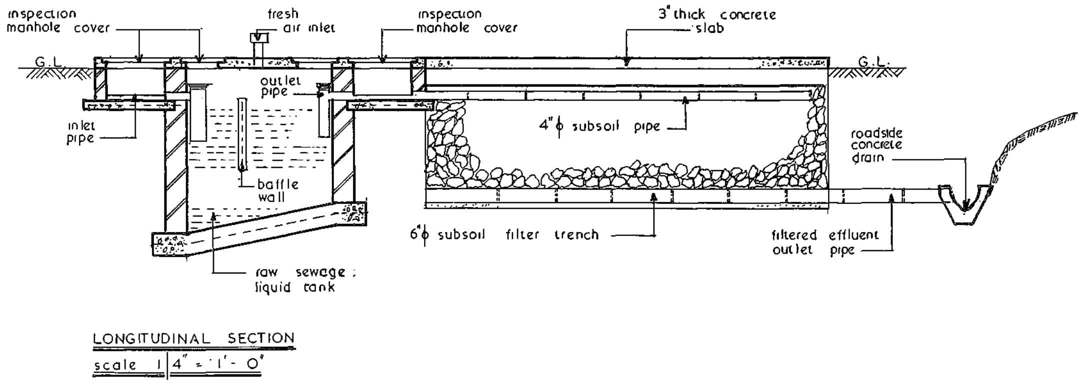
In the second part of the survey, septic tank effluent samples were taken from the pumps sump (Type A septic tank) and the raw sewage liquid tank (Type B septic tank) for analysis by the Chemistry Department, Ipoh for the following parameters:

a) pH (pH units)
b) Chloride (mg./lit)
c) B.O.D.$_5$ (mg./lit)
d) Free Ammonia (mg/lit.)

Other observations and measurements were also made at the same time:

e) effluent temperature (°C)
f) Shade (none, partial, heavy)
g) Colour of effluent (clear, coloured, turbid),

Effluent samples were taken from randomly



1. MOSQUITO BREEDING OCCURS IN RAW SEWAGE LIQUID TANK.
2. MOSQUITO ENTRY IS VIA IMPROPERLY SEATED INSPECTION MANHOLE COVERS AND DAMAGED FRESH AIR INLET

Fig. 2. Septic tank with subsoil filter trench (Type B)

selected Type A and Type B septic tanks, the day after the type of mosquito breeding was identified. Two effluent samples were collected from each of the 23 septic tanks selected for analysis. This was to compare the nature of the effluent in the two types of septic tanks and to correlate it with the mosquito breeding found.

RESULTS

Mosquito breeding was found mainly in the pump sump of Type A septic tanks (Fig. 1), occasionally breeding could be found in the filter bed as well if the septic tank was flooded. In Type B septic tanks (Fig. 2) breeding occurred only in the raw sewage liquid tank.

It must be noted that Type A and Type B septic tanks are of quite different construction and the sampling points for mosquito breeding were different for both. For Type A septic tanks, the pump sump holds the final treated effluent which is discharged into drains with the switching on of the pump motor manually or automatically. The effluent in the pump sump is normally quite clear and free from suspended matter. For Type B septic tanks, the raw sewage effluent tank holds raw sewage which is still undergoing anaerobic digestion and this is normally turbid and contains a lot of suspended matter and sediment.

The results of the first part of the survey, the mosquito larval survey are presented in Table 2. A total of 211 (25.9 percent) out of 814 septic tanks were inspected. Of these 117 (55.5 percent) were found to have mosquito breeding. Type A septic tanks represented 130 (61.6 percent) of the septic tanks inspected and Type B septic tank 81 (38.4 percent). Of the 130 Type A septic tanks examined, 72 (55.4 percent) were found to be breeding *Ae. albopictus* by itself and together with other species as shown in the breakdown of figures in Table II. It is interesting to note that 57 (43.8 percent) of the 130 Type A septic tanks, were breeding *Ae. albopictus* alone.

On the other hand, Type B septic tanks were free of *Ae. albopictus* breeding in the present survey. Of the 81 type B septic tanks examined, 29 (35.8 percent) had mosquito breeding. *Armigeres subabaltus* (Coquillet) and *Culex quinquefasciatus* (Say) larvae were found in the raw sewage liquid tank of Type B septic tanks. Other mosquitoes were not found at all. *Cu. quinquefasciatus* and *Ar. subabaltus* were found breeding by themselves, 17.2 percent and 41.3 percent respectively and also breeding together, (13.8 percent) in those Type B

TABLE II
RESULTS OF LARVAL SURVEY

Locality		1	2	3	4	5	TOTAL
Period of survey		21-22/10	23/10	24/10	25/10	28/10	
No. of houses at locality		300	80	29	120	285	814
No. of septic tanks inspected		60 (20%)	18 (22.5%)	23 (79.3%)	63 (52.5%)	47 (16.5%)	211 (25.9%)
No. of septic tanks with mosquito breeding		44 (73.3%)	7 (38.9%)	14 (60.9%)	22 (34.9%)	31 (66.0%)	118 (55.9%)
No. of Type A septic tanks		60	-	23	-	47	130 (61.6%)
No. of Type B septic tanks		-	18	-	63	-	81 (38.4%)
No. of septic tanks breeding:	Colour of effluent						
	clear	12	-	3	-	6	21 (17.9%)
Ae. albopictus	coloured	9	-	3	-	7	19 (16.1%)
	turbid	10	-	2	-	5	17 (14.4%)
Ae. albopictus +	clear	-	-	-	-	-	-
Ar. subabaltus	coloured	-	-	-	-	-	-
	turbid	1	-	-	-	-	1 (0.8%)
Ae. albopictus +	clear	2	-	1	-	-	3 (2.5%)
C. quinquefasciatus	coloured	1	-	1	-	3	5 (4.2%)
	turbid	-	-	-	-	1	1 (0.8%)
Ae. albopictus +	clear	-	-	-	-	-	-
C. quinquefasciatus	coloured	-	-	-	-	-	-
+ *Ar. subabaltus*	turbid	1	-	-	-	-	1 (0.8%)
	clear	-	-	-	-	-	-
Ar. subabaltus	coloured	1	-	-	-	-	1 (0.8%)
	turbid	2	-	2	12	-	16 (13.6%)
	clear	-	-	-	-	1	1 (0.8%)
C. quinquefasciatus	coloured	1	-	1	-	1	3 (2.5%)
	turbid	2	5	-	8	-	15 (12.7%)
Ar. subabaltus +	clear	-	-	-	-	-	-
C. quinquefasciatus	coloured	-	-	-	-	1	1 (0.8%)
	turbid	-	2	1	2	-	5 (4.2)
	clear	-	-	-	-	1	1 (0.8%)
Uranotaenia spp.	coloured	2	-	-	-	1	3 (2.5%)
	turbid	-	-	-	-	-	-
Uranotaenia spp.	clear	-	-	-	-	3	3 (2.5%)
+ *Ae. albopictus*	coloured	-	-	-	-	-	-
	turbid	-	-	-	-	-	-
Uranotaenia spp.	clear	-	-	-	-	-	-
+ *Ae. albopictus*	coloured	-	-	-	-	1	1 (0.8%)
+ *Ar. subabaltus*	turbid	-	-	-	-	-	-

***Locality** 1 = Lim Garden (N), 2 = Yik Sang Garden, 3 = Jln. Dato Khong Kam Tak, 4 = SEDC houses, Jln. Aerodrome, 5 = Rapat Setia.

septic tanks found with mosquito breeding.

Ar. subabaltus, Cu. quinquefasciatus and *Uranotaenia* spp. were found breeding in some of the Type A septic tanks. Where *Ar. subabaltus* was found breeding, the effluent was either coloured or even turbid. *Cu. quinquefasciatus* appears to be quite tolerant and could be found in effluent whose colour ranged from clear to turbid. Even *Ae. albopictus,* which is known to prefer clear and clean water could breed in turbid effluent in 12 of the Type A septic tanks either by itself or together with other species of mosquitoes. The finding is of interest as *Ae. albopictus* has normally been associated with clear and clean water in containers.

Type A septic tanks were also found to be breeding *Uranotaenia* spp. either by itself or together with *Ae. albopictus* and *Ar. subabaltus.* Specimens of *Uranotaenia* spp. were sent to the Division of Medical Entomology, Institute for Medical Research, Kuala Lumpur for taxonomic identification. This species is also normally found in natural plant containers with clean water. In this instance, the effluent in the Type A septic tanks where *Uranotaenia* spp. were found, were either clear or coloured at the most.

During the mosquito larval survey, many defective Type A septic tanks were observed. The defects ranged from flooded pump sumps, flooded filter beds, defective motor pumps, missing motor pumps, to damaged inspection covers, damaged and non-mosquito-proof fresh air inlet covers.

Mosquito-proofing of Type A septic tanks was a problem as there were numerous entry and exit points, eg. via the holes for the suction pipe and automatic switch float line in the pump house; broken fresh air inlet covers, improperly seated inspection covers or cement covers.

Flooded filter-beds also increased the surface area and volume of water available for mosquito breeding. In most cases where flooding of pump sump and filter-bed occurred despite having a serviceable motor pump, the house-owners had disconnected the automatic switch float line and operated the motor pump switch manually. These cost-conscious and negligent house-owners contributed mainly to the flooded pump sumps and filter-beds by not dewatering the sump often enough to prevent flooding and backflow of the treated effluent. Not only will this condition result in increased mosquito breeding but will also damage and impair the working of the septic tank.

Type B septic tanks are not so problematic and as it is only recommended in areas with high ground or a low-water table, these septic tanks seldom flood, unless the subsoil filter trench is choked. Compared to Type A septic tanks, there are less entry and exit points for mosquitoes. All except one of the Type B septic tanks examined were in working order. The smaller percentage of Type B septic tanks found with mosquito breeding (35.8 percent) can be attributed to the fewer entry and exit points. If the inspection covers are well-seated and sealed, the only entry and exit points is the fresh air inlet cover which can be mosquito-proofed with nylon mesh or wire gauze.

Tables IIIA and IIIB represent the results of the septic tank effluent analysis for Type A and Type B septic tanks respectively. Table IV shows the results of the statistical analysis of the parameters measured (pH, chloride, BOD5, and Free Ammonia), using the Student's t-test. Statistical analysia shows that at the 95 percent confidence level, only pH values of the effluent of the two types of septic tanks do not differ significantly, being almost of near neutral. The amount of free ammonia in Type B septic tanks is significantly higher than that in Type A septic tanks. Similarly the chloride and BOD5 levels too are higher in Type B septic tanks.

BOD5 and Free Ammonia levels normally are reduced when the septic tank effluent degradation reaches completion. Thus the higher BOD5 and Free Ammonia levels for the effluent sampled from Type B septic tanks is expected. Chloride levels are not affected by the waste treatment processes to any significant extent, therefore higher than usual chloride concentrations probably indicate heavier usage of the toilets.

Effluent temperature measured for both types of septic tanks are quite constant with the septic tanks exposed to the sun showing a slightly higher reading. However this did not appear to affect mosquito breeding.

From the results of the mosquito larval survey and the effluent analysis (Tables II, IIIA and IIIB), it appears that *Ae. albopictus* definitely prefers the breeding conditions in Type A septic tanks where the effluent is less turbid and even clear in many cases and where the BOD5 and Free Ammonia levels are generally lower than in Type B septic tanks.

Ar. subabaltus and *Cu. quinquefasciatus* survive

TABLE IIIA
SEPTIC TANK EFFLUENT ANALYSIS RESULTS FOR TYPE A SEPTIC TANKS

Sample No.	Type of breeding	pH	Chloride mg./lit.	BOD5 mg./lit.	Free Ammonia mg./lit.	Temp. deg.C	Shade	Colour of effluent	Condition of septic tank
1.	*Ae. albopictus*	7.8	56	12	84	28.5	shaded	coloured	flooded sump/ motor working
2.	*Ae. albopictus*	7.0	32	2	24	28.5	shaded	clear	flooded sump/ motor working
3.	*Ae. albopictus*	8.0	58	12	116	28.5	shaded	coloured	flooded sump + filter bed/motor defective
4.	*Ae. albopictus*	7.7	76	36	105	28.5	none	coloured	good condition/ motor working
5.	*Ae. albopictus*	7.6	74	3	47	27.5	shaded	coloured	flooded sump/ motor working
6.	*Ae. albopictus*	7.5	24	44	37	29.0	none	coloured	flooded sump/ motor working
* 7.	No breeding	7.7	91	28	220	28.5	shaded	coloured	flooded sump + filter bed/motor working
* 8.	No breeding	7.7	53	10	88	28.5	none	coloured	flooded sump/ motor working
* 9.	No breeding	7.7	43	1	46	28.5	partly shaded	clear	flooded sump + filter bed/motor defective
10.	No breeding	7.6	32	8	47	28.5	none	coloured	flooded sump + filter bed/ motor missing
11.	*Uranotaenia* spp	7.8	28	4	46	28.5	partly shaded	clear	flooded sump + filter bed/motor working
12.	*Uranotaenia* spp.	7.2	44	18	47	27.5	shaded	coloured	flooded sump + filter bed/motor working
13.	*Uranotaenia* spp.	7.8	24	70	28	30.5	none	coloured	flooded sump + filter bed/motor working
Mean ± S.E.		7.6 ± 0.073	48.8 ± 5.98	19 ± 5.66	71.9 ± 15.68	28.5 ± 0.19			

* Insecticide or oil-based compound used

and breed very well in turbid effluent, especially in Type B septic tanks. They can tolerate water with a lot of suspended organic matter, but can also be found in effluent which is just coloured.

In Table IIIA, it must be noted that in 3 of the 4 Type A septic tanks with no breeding, some form of insecticide or oil-based compound was used by the house-owner to control the mosquito breeding. In Table IIIB, the septic tank where no mosquito breeding was found, was mosquito-proofed. Thus it appears that probably, if not for the use of insecticides/oil or mosquito-proofing, most septic tanks could breed mosquitoes.

No attempt was made to study the intensity of breeding in the septic tanks, but in areas where Type A septic tanks were used, probably the mosquito breeding in the septic tanks is very heavy, as evidenced by the swarms of *Ae. albopictus* that come to bite and those that came flying out when the inspection covers were opened.

DISCUSSION

The results of the present survey indicate that individual and communal septic tanks (shared by 2-4 houses) have a serious problem of mosquito breeding, not only the nuisance mosquitoes like *Cu. quinquefasciatus* and *Ar. subabaltus,* but also *Ae. albopictus* a vector of dengue fever. This reservoir of dengue fever vectors breeding in septic tanks had been in the past neglected in the dengue fever control programme and most house/site inspections had been concentrated on the familiar and favoured breeding places of *Ae. aegypti* and *Ae. albopictus,* like bathtubs, jars, ant-traps, tins,

TABLE IIIB
SEPTIC TANK EFFLUENT ANALYSIS RESULTS FOR TYPE B SEPTIC TANKS

Sample No.	Type of breeding	pH	Chloride mg./lit	BOD5 mg./lit	Free Ammonia mg./lit.	Temp. deg. C	Shade	Colour of effluent	Condition of septic tank
1.	*Ar. subabaltus*	7.7	84	20	195	28.0	shaded	turbid	working
2.	*Ar. subabaltus*	7.9	126	36	420	27.5	shaded	turbid	working
3.	*Ar. subabaltus*	7.4	80	52	195	28.0	none	turbid	working
4.	*C. quinquefasciatus*	7.8	68	52	168	28.0	none	turbid	working
5.	*C. quinquefasciatus*	7.7	65	52	147	27.5	shaded	turbid	working
6.	*C. quinquefasciatus*	7.6	32	20	63	27.5	shaded	turbid	outlet choked
7.	No breeding	7.0	11	24	72	28.5	partly shaded	coloured	working/mosquito proofed
8.	*Ar. subabaltus* + *C. quinquefasciatus*	7.5	56	32	126	27.5	shaded	turbid	working
9.	*Ar. subabaltus* + *C. quinquefasciatus*	7.3	52	32	132	27.5	shaded	turbid	working
10.	*Ar. subabaltus* + *C. quinquefasciatus*	7.8	38	48	180	28.0	partly shaded	turbid	working
Mean ± S.E.		7.6 ± 0.086	61.2 ± 10.08	36.8 ± 4.21	169.8 ± 31.42	27.8 ± 0.11			

coconut shells, tyres and other receptacles inside or outside the house. There exists a potential threat all the time, of an outbreak of dengue fever in areas where Type A septic tanks (Fig. 1) are commonly used. Ipoh Municipality, with a population of about 320,000 has about 8,400 individual and communal septic tanks, of which a big proportion are the Type A septic tanks. If the results of the present survey can be taken to be representative of the overall picture, then there is a need for some rethinking on the source reduction and anti-larval control measures carried out so far in the dengue fever control programme, especially in the urbanised areas around the state.

In the present survey, 73.3 percent of the 60 septic tanks inspected in the Lim Garden area had mosquito breeding, compared to 47.3 percent of 541 septic tanks inspected in the earlier survey of October 1979. Of the 60 septic tanks inspected 60 percent had *Ae. albopictus* breeding, compared to 29 percent of 541 septic tanks inspected in October 1979. These results indicate that mosquito breeding in septic tanks in the Lim Garden area is a continuous problem and this problem appears to be serious.

This situation, where rampant mosquito breeding is occurring in septic tanks in residential areas is probably very much the same in other areas where similar Type A septic tanks are used in the Ipoh Municipality.

Regular surveillance to monitor *Ae. aegypti* and *Ae. albopictus* breeding by the Vector Control Unit, Health Department, Ipoh Municipality throughout 1980, has shown that breeding of these 2 vectors in containers inside and outside the household has been kept low, in many areas in the Ipoh Municipality it is below the level of five percent for Premise Index (a measurement of percentage of households found with mosquito breeding). Law enforcement by means of the Destruction of Disease-Bearing Insects Act, 1975 and health education campaigns through radio, press, talks to the public and school children and house-to-house visits by health staff have brought home fairly well the message about the danger of dengue fever and measures to control the breeding of *Aedes* mosquitoes.

In 1980, a total of 71 cases of dengue and dengue haemorrhagic fever with 1 death were reported in the Ipoh Municipality alone. These accounted for 32 percent of the 223 reported cases of dengue and dengue haemorrhagic fever in the State of Perak for 1980. Measures are already being taken by the Health Department, Ipoh Municipality to improve on the vector control activities to combat this problem and the mosquito breeding problem in

TABLE IV
RESULTS OF STATISTICAL ANALYSIS (STUDENT'S T-TEST) FOR THE PARAMETERS MEASURED (pH, CHLORIDE BOD5, FREE AMMONIA), COMPARING EFFLUENT OF TYPE A AND TYPE B SEPTIC TANKS.

Parameter	pH	Chloride	BOD5	Free Ammonia
t	0.442	2.64	2.38	2.99
P value	$p > 0.05$	$0.02 > p > 0.01$	$0.05 > p > 0.02$	$p < 0.01$
p = 0.05	Not significant	Significant	Significant	Significant

septic tanks ought to be given some attention although the currently surveyed areas have had very few cases of dengue fever reported so far.

Mosquitoes breed in septic tanks because the conditions for breeding are suitable and the septic tanks are not well mosquito-proofed. As shown in the effluent analysis for both types of septic tanks, pH of the effluent is near neutral, with little variation. *Ae. albopictus* larvae have been found to breed right through the entire pH range, but better between pH 6.8 and 7.6; [10] they prefer a slightly alkaline pH of about 7.5 and a total alkalinity value of from 55-150 ppm. [11] Effluent temperature is fairly constant even for septic tanks exposed to direct sunlight. The only parameters that fluctuated were that of BOD5, Free Ammonia and Chloride. The analysis showed that BOD5, Free Ammonia and Chloride levels in Type B septic tanks to be significantly different from that of Type A septic tanks. Probably BOD5, Free Ammonia or some other parameters yet unmeasured, may have some influence on the types of mosquitoes found breeding. Presently it is not possible to explain why *Ae. albopictus* were not found in Type B septic tanks other than the reason that the effluent in Type B septic tanks is normally very turbid, even more so than the effluent of Type A septic tanks described as turbid and this may be a deterring factor. It has been previously recorded that breeding of *Ae. albopictus* is confined to water of low turbidity [11] measuring 50-75 Jackson turbidity units with an average of 62.5. The larvae can tolerate a wide range of salinity. Chlorine concentrations of 10 mg./l and 59.5 mg./l in jars, 10.5 mg/l in a stone hole and 210 mg./l in a bamboo hole have been recorded. [12] *Ae. albopictus* larvae also show tolerance to a wide range of organic nitrogen content and have been found in containers with organic nitrogen content, measured by the consumption of $KMnO_4$, varying from 6.9 mg/l in a jar to 126 mg./l in a bamboo hole. [12]

Quite definitely, mosquito breeding is encouraged by the presence of uncut undergrowth, bushes and shade trees around the septic tanks which provide suitable harbourage for resting mosquitoes. The removal of some of this extensive cover of shade in some of the houses might help reduce the mosquito breeding by making the area more open and less attractive for mosquito harborage.

There are few methods available to prevent mosquito breeding in septic tanks. One method, presently practised, but not too successfully, is to cover openings like the fresh air inlets with nylon mesh to prevent entry or exit by mosquitoes and sealing the gaps around the inspection covers with cement or grease. This method works to some extent but neglect will allow the situation to revert to its former state in a short time. There is also the problem of sealing the holes in the pump house floor for the suction pipe and the automatic switch float line, which if not done properly will affect the working of the automatic switch which starts the pump motor for dewatering the pump sump. This applies only to Type A septic tanks.

Other methods are available too but have yet to be tried out locally. Among them, an interesting method appears to be that of Reiter [13] where the use of expanded polystyrene balls for mosquito control in still, clear or polluted water, protected from the wind (such as septic tanks and flooded pit latrines) is suggested. Expanded polystyrene is commonly used for packing and insulation material. The polystyrene balls can be made by heating the pre-expanded plastic beads to a temperature above 95 degrees Centigrade, for instance by boiling in water. A 3-5 cm. thick layer of these polystyrene balls forming a double or treble layer on the water surface killed all 3rd and 4th instar larvae of *Cu. quinquefasciatus* which were unable to penetrate through the plastic barrier to respire at the surface film. However, pupae, 1st and 2nd instar larvae could penetrate between the layers of polystyrene to respire and female mosquitoes laid egg rafts on water between the mouldings.

Levy and Miller [14] attempted the release of a mermithid nematode, *Romanomermis culicivorax* (Ross and Smith) to control mosquito breeding in sewage settling ponds. These parasitic nematodes can be used as biological control agents against mosquitoes breeding in some polluted water environments. However, Bheema Rao *et al* [15] found that *Romanomermis* sp. could not tolerate water where pH is greater than 7.5 and salinity more than 0.025 per cent, indicating that their utility in polluted water is limited.

Application of insecticides or oil-based compounds may control breeding of mosquitoes in septic tanks as evidenced by some septic tanks inspected in the present survey. However, this method is not advisable as insecticides or oil may have some deleterious effect on the working of the septic tank by damaging the waste treatment processes. In Singapore in 1968, Vapona (DDVP) in the form of resin strips was used in the control of *Cu. quinquefasciatus* in septic tanks but was discontinued due to its high cost and ineffectiveness. [9]

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