Bull. Org. mond. Santé
Bull. Wld Hlth Org. 1956, **14**, 639-646

AN AUTOMATIC MOLLUSCICIDE DISPENSER FOR USE IN FLOWING WATER *

J. W. KLOCK, B.E.
Senior Assistant Sanitary Engineer,
Puerto Rico Field Station, San Juan, Puerto Rico

Manuscript received in November 1955

SYNOPSIS

The author describes the design and operation of an automatic molluscicide dispenser for use in flowing water. The equipment, which consists basically of a measuring weir coupled to a float-activated siphon, was designed for simplicity, low cost, construction with commonly available materials, and operation by untrained personnel. Observations in the field have shown that the dispenser increases the accuracy and consistency of dosage, reduces manpower requirements, and improves molluscicidal effectiveness.

The significance of bilharziasis as a major public-health problem with serious socio-economic implications in many areas of the world has emphasized the need for the development of effective and practical control measures. The infestation by snails—the intermediate host of the causative organism—of thousands of streams, ponds, and other bodies of water used continuously by millions of people in their daily activities, coupled with the fact that the snails remain infected for a relatively long period, make destruction of this host extremely important.

The host snail can be destroyed by the application of a molluscicide to its habitat. However, in many regions where vast stretches of water offer ideal surroundings for the development of large snail populations, financial resources are limited and the heavy investment in manpower and materials required for effective control by present methods cannot be supported. Therefore, some means of reducing the cost of molluscicidal treatment is urgently needed.

In this paper, an improved technique for applying molluscicides to flowing water, designed to reduce manpower requirements, to increase the accuracy and consistency of dosage, and to improve molluscicidal effectiveness, is presented. It was developed in Puerto Rico, where a recommended molluscicide—sodium pentachlorophenate—was being used in the aquatic

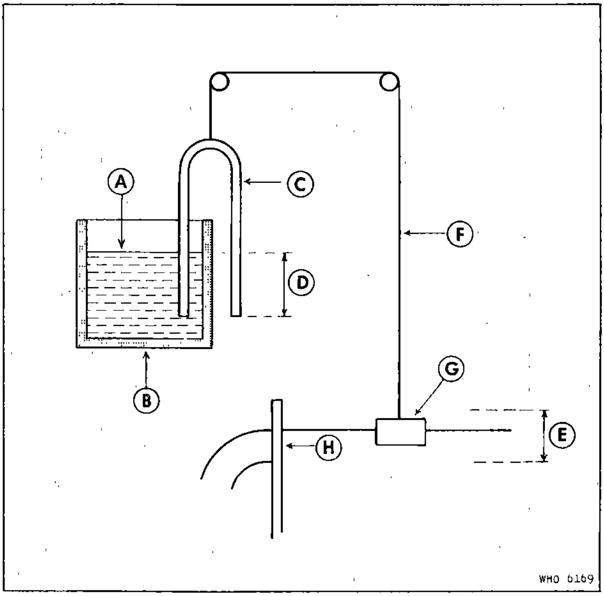
---

* From the Communicable Disease Center, Public Health Service, United States Department of Health, Education, and Welfare, Atlanta, Ga., and the Department of Health, Commonwealth of Puerto Rico, San Juan, Puerto Rico.

habitat of *Australorbis glabratus*. The chemical dispenser described here may be used wherever molluscicides are dispersed in liquid form in flowing water.

A molluscicide may be distributed in flowing water by applying it at a point above the snail colonies and utilizing the current to carry it to them. The rate of application is based on the quantity of flow, which is generally measured by a weir placed in the stream or by one of several other velocity-area methods. After the rate of flow has been determined, the molluscicide is applied continuously for the necessary length of time.

FIG. 1. BASIC COMPONENTS OF MOLLUSCICIDE DISPENSER INCLUDING PROPORTIONAL FLOW WEIR



A = concentrated molluscicide solution
B = reservoir
C = siphon
D = hydrostatic head
E = water height
F = cord
G = float
H = weir

Basically, the equipment consists of a measuring weir coupled to a self-operating dispenser. Simplicity of design and construction, using materials available in most endemic areas, were primary considerations. The dispenser consists essentially of the parts shown in Fig. 1. Concentrated molluscicide solution (A) is dispensed continuously at a desired rate from the reservoir (B) by means of a siphon (C). The quantity of concentrate issuing from the siphon is directly related to the hydrostatic head (D). Changes in the quantity of water flowing in the stream result in fluctuations of the water height (E) and necessitate a change in the rate of molluscicide application in order to maintain a constant dosage. This is accomplished by attaching the siphon, by means of a cord (F), to a float (G) riding on the surface of the stream. Thus the dispenser is basically a float-activated siphon.

The curves for the two variables, water height and siphon discharge, while exponential and directly related to the hydrostatic head, normally display slopes of a dissimilar nature which must be resolved into similar functions before working compatibility can be achieved. For mechanical simplicity, combination of the variables was undertaken by hydraulic means, and their resolution into linear or approximately linear functions allowed simple coupling of the float and the siphon.

The stream discharge-head relationship was brought into a linear form by the use of a Sutro proportional flow weir.[2] This can be expressed in the following manner:[3]

$$Q = ca^{1/2}b\sqrt{2g\ (h - a/3)}$$

where Q is the rate of discharge in cubic feet per second (c.f.s.), c the flow-coefficient ranging from 0.60 to 0.63, a and b ruling dimensions in feet, g the acceleration of gravity, and h the head above the weir crest in feet. The horizontal and vertical dimensions of the weir are expressed by the equation:

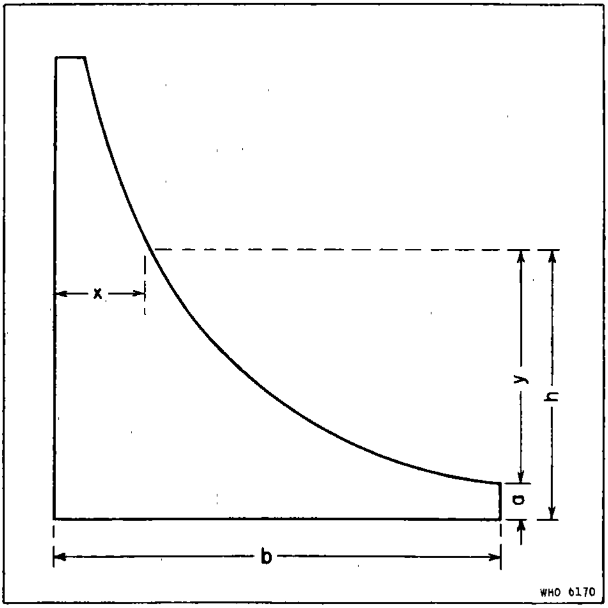
$$\frac{x}{b} = 1 - \frac{2}{\pi} \arctan \sqrt{\frac{y}{a}}$$

The dimensional relationship is shown in Fig. 2.

A weir with a discharge range of 0.05-2 c.f.s. (1.5-55 l/s) was adequate for most streams and canals harbouring the host snail in Puerto Rico. The basic design outlined above can probably be adapted successfully to weirs with a greater discharge-rate, possibly to the limit of accurate weir design —30-50 c.f.s. (0.8-1.4 m^3/s). A maximum head on the weir crest of 1.5 feet (45 cm) for all weirs provided sufficient mechanical activation for minimum head fluctuation, yet kept weir backwater and overturning within reasonable limits. A small cut-off gate, placed in the lower section of the weir, significantly reduced the time required for installation. While the weir was being placed in the stream, this gate was left open to allow the water to pass through, thus preventing the accumulation of backwater with the resulting pressure which might cause washing out of the partially erected weir. When the weir was in position, the gate was closed and sealed with mud.

An approximately linear siphon discharge-head relationship was obtained with heads up to a maximum of 0.75 foot (23 cm) by making siphons with a total-length/inside-diameter ratio equal to or greater than 360. The deviation of the discharge from a linear relationship was limited to 2%, and the maximum discharge was found to be 30-40 times greater than the minimum flow. The use of a maximum siphon head one-half that of the

FIG. 2. DIMENSIONAL RELATIONSHIP OF A SUTRO PROPORTIONAL FLOW WEIR

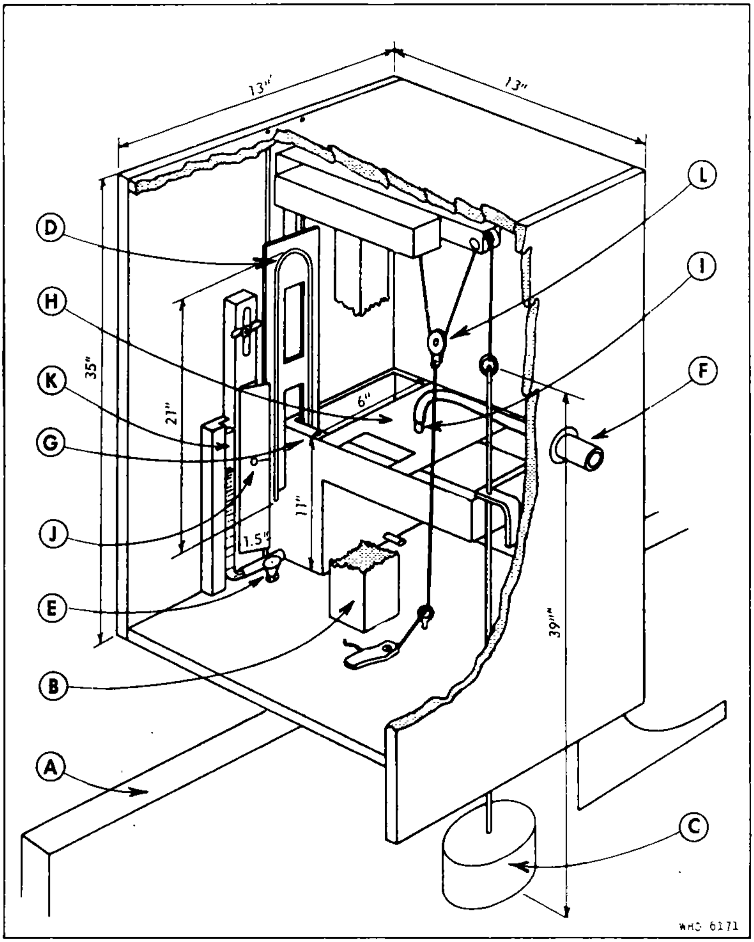


maximum head on the weir crest of 1.5 feet allowed for a mechanical advantage of two, thereby improving the accuracy and compactness of the instrument.

A diagram of the dispenser, as developed for use in the field, is shown in Fig. 3. The weir (A) is placed in the stream and the dispenser is fixed to the top of it by means of a holding-post (B) in such a way that the float (C) rides in the weir backwater and the siphon (D) discharges (E) into the downstream side. The concentrate, which is stored in a barrel, is introduced into the instrument via the hose-coupling (F) through which it passes into the siphon tank (G). A constant level is maintained by means of a float valve (H) mounted on top of the tank. A common automobile carburettor needle-valve (I) attached to a suitable float was found to give adequate regulation, the maximum drawdown being less than 0.005 foot. When the siphon tank has been filled, the vertically adjustable scale (J) is aligned until the zero reading is level with the surface of the concentrate as observed through the tank sight-glass (K). The scale corresponds to the range of heads on the weir crest, 0.0-1.5 feet, but is reduced to half size to allow for the siphon mechanical advantage of two. The siphon, which straddles the tank wall, is activated by filling the tube and is adjusted by raising or lowering the idler pulley (L) until the lower edge of the siphon is level with the figure corresponding to the head on the weir crest, read to the nearest 0.01 foot. The instrument is then adjusted and ready for operation.

Satisfactory siphon tubes have been made from glass tubing with an outside diameter of 5 mm. Slight differences in the inside diameters of tubes, and variations in dimensions after construction, produce siphons with different rates of discharge, which means that concentrates of different strengths have to be used to maintain uniformity of instrument design. For this reason, determination of the specific concentration for each completed instrument is necessary. This is done by setting the siphon at a

FIG. 3. DIAGRAM OF AUTOMATIC MOLLUSCICIDE DISPENSER AS DEVELOPED FOR FIELD USE



A = weir
B = holding-post
C = float
D = siphon
E = discharge
F = hose-coupling
G = tank
H = float valve
I = needle valve
J = scale
K = sight-glass
L = idler pulley

reading of 0.5 on the scale and measuring the discharge, using an arbitrarily chosen concentration of molluscicide. The quantity obtained is then applied to equation (1) below and the concentration of molluscicide for that instrument is determined in milligrams per litre (mg/l). A second evaluation of the instrument using a concentrate more closely approximating the final solution is not necessary, as the discharge variation due to differences in the concentrate is negligible. For operations using sodium pentachlorophenate, concentrations varying from 0.9×10^5 mg/l to 1.5×10^5 mg/l have been used in different instruments. An arbitrary selection of a 10^5 mg/l concentrate has given satisfactory calibration curves. The correct quantities of molluscicide (in pounds) and of concentrate (in gallons) are obtained from equations (2) and (3), respectively.

$$\text{Instrument concentrate (mg/l)} = \frac{28.315\ Qw_{0.5}\ (D)}{Qs} \tag{1}$$

$$\text{Pounds of molluscicide} = \frac{22.45\ (T)\ (Qw)\ (D)}{M} \tag{2}$$

$$\text{Gallons of concentrate} = \frac{1.2\ (10^5)\ \text{lb. of molluscicide}}{\text{instrument concentrate (mg/l)}} \tag{3}$$

where $Qw_{0.5}$ = weir discharge in c.f.s. at a head of 0.5 foot
Qw = weir discharge in c.f.s.
Qs = siphon discharge in litres per second
D = desired dosage in mg/l
M = percentage of active molluscicide (as stated by manufacturer)
T = treatment time in hours

For field work, a chart including the above information is generally prepared for the complete range of weir discharges. For purposes of determining the quantity of concentrate, determinations of the head on the weir crest to the nearest 0.1 foot are adequate. Whether, and by how much, the quantity of molluscicide concentrate should be increased beyond that determined from the weir discharge, as read at the time of installation of the instrument, must be ascertained from field observations. Conditions in Puerto Rico do not necessitate the use of additional concentrate.

The preparation of a very highly concentrated solution of sodium pentachlorophenate, which could be carried to the site of operations, was found to reduce the installation-time and to eliminate the disagreeable and dangerous dust that arises from weighing the dry molluscicide in the field. A standard concentrate of 2.0×10^5 mg/l was made which was then diluted to the proper concentration for the individual instrument.

Discussion

The following discussion on the performance in the field of the float-activated molluscicide dispenser is based on the results obtained from six instruments, two of which have been in operation for four months.

The primary concern in the development of the technique described above was to reduce the costs inherent in the existing treatment system, in which water discharge is measured by means of a weir and the continuous application of molluscicide is accomplished by a manually controlled drip-dispenser requiring the constant attendance of several operators throughout the treatment period. Approximately 50 man-hours are necessary for a 24-hour treatment, of which about 14 man-hours are devoted to installing the equipment. Using the technique and equipment described above, the same course of treatment can be accomplished in approximately 6 man-hours, of which 1½ are spent in installing the equipment. This decrease in installation-time has increased the number of treatments per unit time fourfold to fivefold. From the results so far obtained, it is estimated that the treatment of an endemic area can now be carried out in one month instead of in the three months previously required. Over-all expenditures for treatment are approximately one-fourth of the previous costs. The economic conditions prevailing in Puerto Rico are such that the savings realized in one or two treatments are sufficient to cover the moderate cost of constructing the equipment.

Molluscicidal effectiveness has been improved, thus further reducing treatment costs. Since dosage is correlated directly to fluctuations in stream and canal flows, treatment failure caused by over- or under-dosage has been virtually eliminated. Owing to the rapidity with which the equipment can be installed, simultaneous daily dosage of groups of four convergent streams and canals has been possible. This has doubled the distance downstream that treatment is effective. The manual system, in which the chemical could be released only once daily under equivalent manpower and economic limitations, often could not make effective use of the maximum treatment distances, as tributary water entering downstream from the application site diluted the concentration of molluscicide to below the effective level.

The mechanical reliability of the dispensers has been demonstrated by the continuous operation of two instruments for more than seventy 24-hour treatments over a 4-month period, with no failures or mechanical complications. In several experimental treatment areas in Puerto Rico, continuous fluctuation of the water level in streams and canals, due to intermittent tropical storms and to the operation of several large irrigation systems, has not resulted in any detectable decrease in the efficiency of the apparatus. Flows from 0.08 c.f.s. to 2.0 c.f.s. (2-55 l/s)—the maximum discharge of the present weirs—have been encountered with discharge fluctuations up to tenfold within these limits for a 24-hour period. No mechanical deviation has occurred, nor have variations from the desired rate of application been noted in quantitative evaluations in the field.[1,a] Maintenance has consisted of an occasional cleaning of the float valve and a bi-weekly flushing of the apparatus with fresh water. Sticks, weeds, and other gross contaminants have been removed from the diluent water by passing it through a 14-mesh sieve as it is poured into the reservoir barrel. After extended use of the instruments, slight deposits appeared on the inside of the siphons, but these apparently had no effect on the operational efficiency. However, since heavy deposits might cause less effective operation, the siphon should be flushed periodically with several washings of chloroform to remove deposits as they develop. Untrained field personnel have, in a minimum of time, been taught how to operate the dispenser, and no treatment failures due to incorrect use have been noted.

RÉSUMÉ

La destruction par les substances chimiques des gîtes de mollusques, hôtes intermédiaires des agents de la bilharziose, exige des dépenses considérables et un personnel nombreux que tous les pays ne sont pas en mesure de fournir. Aussi tous les efforts doivent-ils être faits pour en diminuer le coût.

C'est dans cette intention que les auteurs ont mis au point un dispositif nouveau de traitement des cours d'eau par les molluscocides, qui assure une plus grande efficacité de la substance active, à moindres frais, et qui demande, pour être mis en action, un personnel peu nombreux et non spécialisé. L'appareil en question consiste en un déversoir couplé à un siphon actionné par un flotteur qui permet de répandre automatiquement le molluscocide en quantités proportionnées au débit du cours d'eau. Grâce à cet appareil, le traitement d'une rivière ou d'un canal pendant 24 heures peut être appliqué en 6 heures-homme, dont 1½ heure pour l'installation. Auparavant, le même traitement demandait 50 heures-homme, dont 14 pour l'installation. Les deux appareils installés à Porto Rico pour la lutte contre *Australorbis glabratus* au moyen du pentachlorophénate de sodium ont effectué en 4 mois 70 traitements de 24 heures sans aucune avarie mécanique, même lorsque de violents orages faisaient varier brusquement le débit des cours d'eau. Le traitement d'une zone endémique peut être effectué en un mois au lieu de trois mois. Les économies réalisées dans le traitement de deux ou trois zones suffisent à couvrir les frais de construction de l'appareil. Pour en assurer le bon fonctionnement, il suffit de nettoyer quelquefois le flotteur et de passer l'appareil au jet d'eau fraîche, puis périodiquement au chloroforme, pour éliminer les dépôts qui se forment.

REFERENCES

1. Haskins, W. T. (1951) *Analyt. Chem.* **23**, 1672
2. Pratt, E. A. (1914) *Engng News*, **72**, 462
3. Soucek, E., Howe, H. E. & Mavis, F. T. (1936) *Engng News Rec.* **117**, 679

---

[a] Klock, J. W., unpublished material, 1955