A Simple Apparatus for Metering Volatile Liquids into Water

PETE E. BENVILLE JR. AND SID KORN

National Marine Fisheries Service
Tiburon Fisheries Laboratory, Tiburon, Calif. 94920, USA

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A metering device was developed to introduce benzene, toluene, xylene, and 1,2,4 trimethylbenzene vapors into water using air as a carrier gas. Setting the carrier gas flows for the respective aromatics at 10, 25, 120, and 500 cm³/min for 2 h resulted in concentrations of 8.2, 13.0, 12.0, and 7.2 µl/liter, respectively, in 4 liters of water. The aromatic concentrations were maintained in a static system by bubbling air through the water, and in a continuous flow system by replenishing the water. In static systems the respective aromatic concentrations were maintained for 4 days within the ranges of 13–14, 5.1–7.0, 0.40–0.50, and 0.018–0.028 µl/liter by bubbling the aromatics into the water at 5 cm³/min and independently aerating the water at 100 cm³/min. In a 14-day continuous flow system benzene concentrations ranged from 2.1–2.8 µl/liter when benzene was bubbling at 23 cm³/min and water was flowing at 1.8 liters/min.

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Nous avons mis au point un compteur pour mesurer les vapeurs de benzène, toluène, xylène et 1,2,4 triméthylbenzène introduites dans l'eau, utilisant l'air comme gaz porteur. Le réglage des débits du gaz porteur, pour les aromatiques respectifs, à 10, 25, 120 et 500 cm³/min pendant 2 h donne des concentrations de 8.2, 13.0, 12.0 et 7.2 µl/litre, respectivement, dans 4 litres d'eau. Les concentrations d'aromatiques sont maintenues en régime statique par barbotage d'air dans l'eau ou en régime à flot continu par renouvellement de l'eau. En régime statique, les concentrations d'aromatiques respectifs ont été maintenues pendant 4 jours dans les limites de 13–14, 5.1–7.0, 0.40–0.50 et 0.018–0.028 µl/litre en barbotant les aromatiques dans l'eau au taux de 5 cm³/min et en aérant l'eau indépendamment au taux de 100 cm³/min. En régime à flot continu pendant 14 jours, les concentrations de benzène ont varié de 2.1 à 2.8 µl/litre avec barbotage de benzène au taux de 23 cm³/min et débit d'eau de 1.8 litres/min.

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THIS note describes a device that vaporizes liquids, meters their vapors into water, and maintains their concentration in water for extended periods. The liquids that are currently being used in our acute and chronic studies on fish are benzene, toluene, xylene, and 1,2,4, trimethylbenzene. We determined that these aromatics are relatively insoluble in freshwater (1993, 401, 221, and 104 µl/liter, respectively) and volatilize rapidly from water. We found that 46–56% of these aromatics volatilized within 24 h from a 4-liter solution maintained at 20 C. Aerating the solution at 20 cm³/min increased the loss to 97–100%. Other metering apparatuses (American Public Health Association 1971; Mount and Warner 1965; Mount and Brungs 1967) were not suitable for metering these compounds because of the low solubilities, high volatilities, and high dosages necessary to produce toxic effects in fish. Our system avoids these difficulties by using air as a carrier to introduce the volatile compound into water. Another air source or water flow is used to maintain a stable concentration of the compound in water.

The metering systems — The static metering system is composed of two independent air sources (Fig. 1). One air source vaporizes the volatile liquid in the gas washing bottle and transports the vapor into the water. The vapor dissolves in the water and accumulates if there is no second air stream until saturation is reached. An accumulation experiment was conducted with four aromatics by aerating each aromatic into 4 liters of water at 20 C, one vapor flow rate being used for each aromatic. The concentrations of these aromatics were determined at three time intervals by extracting a 100-ml water sample twice with 10 ml of TF Freon (trifluorotrichloroethane). An aliquot of the 20-ml extract was injected into a gas chromatograph equipped with a 6-ft column. The column was

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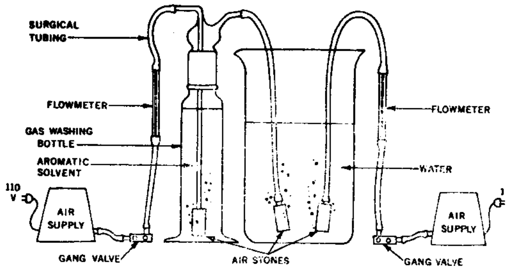

FIG. 1. Components of the static metering system.

packed with 5% Bentone-34 and 10% didecylphthalate on 80/100 mesh chromosorb PAW. The four aromatics accumulated rapidly in water (µl/liter):

Time (h)	0.5	1	2
Benzene (10)[a]	1.4	3.5	8.2
Toluene (25)	3.0	6.2	13
Xylene (120)	3.8	6.6	12
1,2,4 Trimethylbenzene (500)	3.7	5.8	7.2

[a] Vapor flow (cm^3/min).

Low concentrations of the aromatics in water are maintained by utilizing a second air source to limit accumulation of the dissolved vapors in water. At specific vapor and air flow settings an equilibrium is reached between the amounts of vapor dissolving and dissipating from the water. A 4-day equilibrium study was conducted with the four aromatics to determine the daily fluctuations in concentration. The air flows were set at 5 cm^3/min for vaporizing the aromatics and at 100 cm/^{3}min for aerating the water. For water samples taken daily after 24 h the concentrations (µl/liter) were:

Day	1	2	3	4
Benzene	14	13	14	13
Toluene	5.1	7.0	6.7	7.0
Xylene	0.50	0.41	0.43	0.40
1,2,4 Trimethylbenzene	0.028	0.024	0.024	0.018

In a continuous flow system the second air source is replaced by a flowing water source. With a continuous flow system that we had in operation for 2 wk, benzene concentrations were maintained at 2.1–2.8 µl/liter in 65 liters of water at 12 C. The vapor flow was 23 cm^3/min, the water flow 1.8 liters/min.

In both the static and flowing systems the air flow is observed on a flowmeter and controlled by a gas or gang valve. To maintain a constant air flow we tried three different air sources. In order of reliability, these are an air cylinder with a two stage regulator, an oilless air compressor with reservoir, and an aquarium air pump.

We found variations in the dissolved aromatic concentrations between some systems even though the flow rates were identical. Factors that caused the most variation in the concentrations were coarseness of the air stone or fritted disc, volume of the water, and shape of the aquaria. Also, temperature and salinity would be expected to affect the concentrations. Poon (1972) has discussed in depth the various factors influencing bubble aeration. Therefore, each system must be calibrated and furthermore should be monitored periodically as a quality control measure.

Advantages of the technique — Fish undergo many stresses during toxicity experiments that are not necessarily related to the compound being tested. Some of these stresses (such as decreasing oxygen concentrations and increasing carbon dioxide, ammonia, and other volatile wastes) may produce additive effects which bias the results. These stresses are reduced in our technique by aeration.

Some and perhaps most toxicants metered into aquaria are sufficiently insoluble in water to necessitate using a solubilizing agent with the toxicant. The solubilizing agent has a toxic effect on fish that can result in synergistic or antagonistic biases in the toxicity data. Our technique disperses the toxicant into the aquaria without a second compound.

The toxicants are replenished instantaneously in the solution, thereby maintaining a constant toxicant concentration. Any toxicant concentration in water below the saturation level can be achieved by changing one or both of the flow rate ratios, i.e. toxicant aeration to aquarium aeration and toxicant aeration to water flow. Thorough mixing of the toxicant is achieved by aeration. The toxicant is vaporized before it goes into solution, reducing the formation of colloidal particles and precipitates.

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