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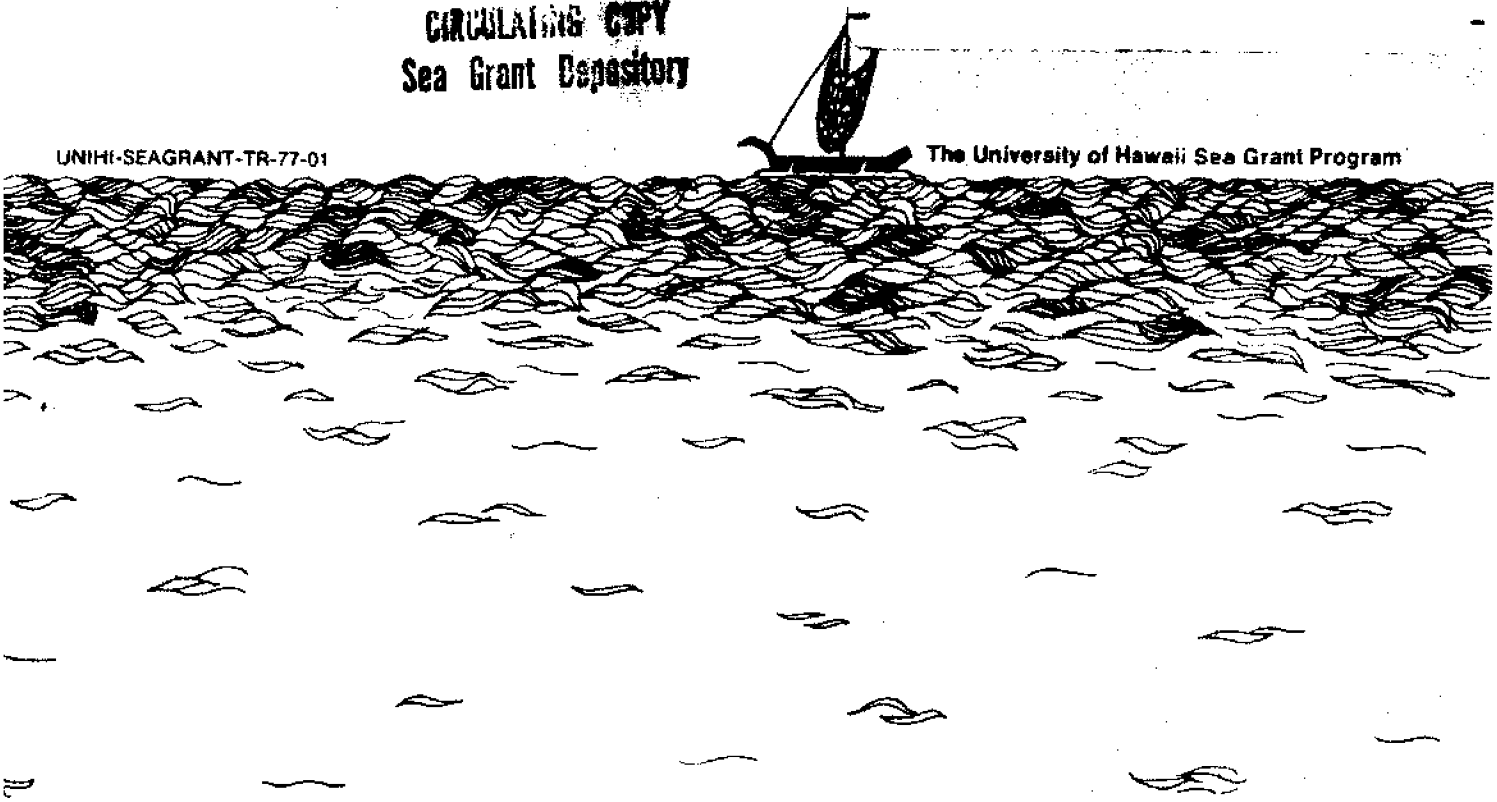

The Toxicity of Selected Chemicals Used in Power Generating Stations to Hawaiian Fishes

John C. McCain and James M. Peck, Jr.

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THE TOXICITY OF SELECTED CHEMICALS USED IN POWER GENERATING STATIONS TO HAWAIIAN FISHES

by

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ABSTRACT

The acute toxicity of two waterborne chemicals to fishes was investigated. The two compounds, filming amine and morpholine, are used as corrosive inhibitors in the steam and condensate lines of some power generating stations on Oahu. The acute-static 96-hour LC_{50} *or* TL_m *for these compounds was determined for four common Hawaiian marine fishes--the mosquito fish,* Gambusia affinis; *the white mullet,* Chelon engeli; *the damselfish,* Dascyllus albisella; *and a species of* Tilapia. *The 96-hour* TL_m *for morpholine was found to be between 100 and 180 ppm for* Chelon engeli *and between 320 and 560 ppm for* Gambusia affinis. *The 96-hour* LC_{50} *value for filming amine was found to be 0.41 ppm for adult* Gambusia affinis *and the 96-hour* TL_m *to be 0.25 ppm for juveniles. The range finding results for* Chelon engeli, Dascyllus albisella, *and* Tilapia sp. *indicated similar toxicity values for the filming amine. The discharges of these compounds do not exceed the maximum permissible values as determined by the* LC_{50} *or* TL_m *values after applying a 0.01 factor. The discharge of these compounds at less than 0.0025 ppm for filming amine and 1.00 ppm for morpholine does not constitute a waste as currently defined by state and federal laws and regulations.*

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INTRODUCTION

Since 1973, an inventory of chemicals which might reach the marine environment via waterborne discharges has been conducted by the Hawaiian Electric Company at various power generating stations on Oahu. A description of the nature and quantities of these discharges is presented in the appendix. The fate of these discharges is set forth in Table 1.

Discharges which may contribute to an adverse environmental impact such as fireside boiler wash water, air heater wash water, and any discharge from the treated water systems are currently disposed of via percolation and evaporation ponds. However, several other discharges to these ponds are of such a volume that disposition in this manner will ultimately be precluded since the capacity of the ponds is rapidly being reached.

Evaporator and boiler blowdowns and startup condensate are discharged into the circulating water system of some units and into retention ponds of others (Table 1). Those units which use corrosive inhibitors in the steam and condensate lines are routed to the retention pond. The corrosive inhibitors used are filming amine, the exact composition of which is not known since it is a proprietary compound, and morpholine (Tetrahydro-1, 4, 2H-oxazine), a neutralizing amine.

The federal ocean dumping regulation specifically mentions amines as a compound requiring special care since there is some evidence that amines may be toxic. If toxic, such a discharge would constitute a waste discharge.

In 1973, the Atomic Energy Commission conducted an extensive review of the various literature on the toxicity of power plant chemicals to aquatic life. The review contained no information on the proprietary filming amine compound; however, considerable information was provided on the toxicity of morpholine to freshwater organisms. Unfortunately, most morpholine tests were not conducted with the Tetrahydro-1, 4, 2H-oxazine formulation used by Hawaiian Electric Company. The review showed that some organisms showed extreme sensitivity to the N-trityl form of morpholine. A *Bulinus* snail had a 24-hour TL_m[1] of 0.01 to 0.05 ppm (Boyce et al., 1966). Most other forms of morpholine at concentrations of 5 to 10 ppm caused little or no effect within 24 hours. Hiatt et al. (1953) reported no observable response for the aholehole (*Kuhlia sandvicensis*) after a two-minute exposure at a concentration of 20 ppm. This is the only record available on the toxicity of morpholine to marine organisms as well as the only record of its toxicity to Hawaiian organisms.

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[1]The terms TL_m, TL_{50}, and LC_{50} are used in this report. In general, all refer to a situation where half of the test organisms die within a specified period of time. In reviewing the toxicity literature, the designation of the original author was followed. In this paper, LC_{50} (lethal concentration) is used where a value is calculated. When it was not possible to calculate an LC_{50}, an estimate of this value is used and it is expressed as TL_m (median tolerance limit). The term TL_{50} (tolerance limit) as used by others is a calculated value similar to the LC_{50} but refers to those organisms living rather than those which are dead.

TABLE 1. FATE OF WATERBORNE DISCHARGES FROM POWER GENERATING STATIONS ON OAHU

September 9, 1974

Discharge	Station					
	Kahe	Waiau 1&2	Waiau 3&4	Waiau 5&6	Waiau 7&8	Honolulu
Evaporator blowdowns	RO	--[1]	--[1]	--[1]	--[1]	O
Startup condensate	O	R	R	R	O	O
Demineralizer/softener regenerants	RO	--	RO	RO	RO	O
Roof drain	O	O	O	O	O	O
Boiler blowdown	RO	R	R	R	RO	S
Treated water	R	--	R	R	R	R
Air heater wash water	R	R	R	R	R	R
Boiler fireside wash water	R	R	R	R	R	R
Boiler chemical cleaning drains	R	--	R	R	R	R
Chemical lab drains	C	--	--	R	R	S
Chemical bench drains	RC[2]	S	R	S	S	S
Sewage	C	S	S	S	S	S
Floor drains	R	D	R	R	R	S
Chemical pump drains	R	D	R	R	R	S
Equipment oil drains	R	D	R	R	R	S

Disposition code:

O = Ocean
S = City sewer
D = Contained (excess mopped)

R = Evaporation and percolation pond
C = Cesspool or french drains

[1]Obsolete, equipment not in use
[2]Kahe Units 1 & 2 to retention pond, 3 & 4 to cesspool

To date, little work has been done on the toxicity of industrial chemicals and pesticides to indigenous Hawaiian organisms with the exception of Hiatt's aholehole study and the work of Nunogawa et al. (1970) on the relative sensitivity of five species of fish to four compounds--phenol, DDT, dieldrin, and lindane. Therefore, it was decided to conduct toxicity studies of the filming amine and morpholine on local fishes to determine whether the discharge of these compounds constitutes a waste discharge.

THE LEGAL BASIS FOR WATERBORNE DISCHARGES

The laws concerning the discharge of waterborne chemicals are not as clear as one would think necessary to insure the attainment of the objective of the Federal Water Pollution Control Act which is "...to restore and maintain the chemical, physical and biological integrity of the Nation's waters."[2] Under the act, the Environmental Protection Agency (EPA) administrator is given the responsibility of publishing a list of known toxic pollutants or combinations of pollutants which will degrade the nation's waters [section 307(a)] and any hazardous materials [section 311 (b) (2) (A)].

From the foregoing, it seems that the waters, the biota, and man are protected. However, in looking at the specific laws, the degree of protection afforded us becomes somewhat cloudy. In December 1973, the EPA administrator issued proposed toxic pollutant effluent standards. The toxic pollutants listed include the "hard" chlorinated hydrocarbon pesticides DDT, DDE, DDD, aldrin, dieldrin, endrin, toxaphane, benzidine and its salts, cadmium, cyanide, mercury, and polychlorinated biphenyls. These represent only the most toxic compounds discharged. The list of other compounds which are not quite as toxic as these would continue almost infinitely. Obviously then, somewhere the law must provide protection in a more general rather than in such a specific sense.

Such general protection is provided in section 227.2 of the EPA's final regulations and criteria for ocean dumping (October 1973) and, in the case of power generating stations, in section 423.12 of the effluent guidelines and standards for steam electric power generating point source category (September 1974). The former regulation lists categories of materials which are prohibited, including oils and those toxic pollutants listed by the EPA administrator. A list is also given of materials requiring special care in disposal, including many heavy metals and petrochemicals. The latter standards for the power industry do not state specific compounds for which discharge is prohibited but rather gives a list of the maximum concentration of those which may be discharged.

In order to discharge into the nation's waters, a power station operator must obtain a National Pollutant Discharge Elimination System (NPDES) permit from EPA. The purpose of this permit is to incorporate

[2]Public Law 92-500, Federal Water Pollution Control Act Amendments of 1972, October 18, 1972.

all the provisions and exclusions promulgated under the regulations mentioned on the preceding page. The NPDES permit for the operation of the Kahe Generating Station on Oahu states that materials other than heat ordinarily produced or used in the operation of this facility may be discharged, provided they do not violate section 311 of the act or are "...known to be hazardous or toxic by the permittee; except that such materials may be discharged in certain limited amounts with the written approval of, and under special conditions established by, the Administrator or his designated representative, if the substances will not pose any imminent hazard to public health or safety...."[3] Thus, there is a general prohibition against the discharge of materials which a company knows to be toxic and which pose imminent hazard to public health, implying of course a hazard to the ecosystem.

The State of Hawaii, Department of Health, Public Health Regulations Chapter 37 states that:

> No person, including any public body, shall use any state waters for the disposal of waste or the discharge of a pollutant, engage in activity which causes state waters to become polluted, or violate any NPDES permit or term or condition thereof without first securing approval in writing from the Director.[4]

The state only requires that a discharge not contain wastes or pollutants. Thus, the definition of wastes or pollutants is critical. Chapter 37 implies that wastes are something which degrades state waters below a particular quality. Chapter 37A sets forth standards for determining the waste loads which are acceptable in certain use classes of water. These standards state that all waters shall be free of substances attributable to industrial sources as:

> high temperature, biocides, pathogenic organisms, toxic, corrosive, or other deleterious substances at levels or combinations sufficient to be toxic or harmful to human, animal, plant or aquatic life or in amounts sufficient to interfere with any beneficial use of the water. As a minimum, evaluation by use of a 96-hour bioassay as described in the most recent edition of Standard Methods for the Examination of Water and Wastewater shall be conducted. Survival of test organisms shall not be less than that in controls which utilize appropriate experimental water.[5]

As with the federal regulations, the key word is "toxic." However, the state has gone a bit further than the federal government in that it requires that a minimum evaluation based on a 96-hour bioassay be

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[3]Environmental Protection Agency, National Pollutant Discharge Elimination System Discharge Permit, HI0000019, Kahe Power Plant, June 19, 1975.

[4]Public Health Regulations, Department of Health, State of Hawaii, Chapter 37-A, Water Quality Standards, May 25, 1974.

[5]Public Health Regulations, Department of Health, State of Hawaii, Chapter 37-A, Water Quality Standards, May 25, 1974.

conducted. The question may then be raised, Does this mean that a chemical in a concentration just slightly less than the 96-hour LC_{50} concentration can be discharged as a non-waste? It would appear so from Chapter 37A.

A clue as to the intent of the law regarding the discharge of toxic substances can be found in the ocean dumping regulation. Section 227.51 states that materials which do not exceed the limiting permissible concentrations may be considered nontoxic. The limiting permissible concentration is then defined in section 227.71 as:

> that concentration of a waste material or chemical constituent in the receiving water which, after reasonable allowance for initial mixing in the mixing zone, will not exceed 0.01 of a concentration shown to be toxic [for what duration?] to appropriate sensitive marine organisms in a bioassay carried out in accordance with approved EPA procedures....[6]

Three regulations, then, control the discharge of chemicals. The federal regulations (ocean dumping and toxic pollutants) allude to an application factor of 0.01 of the level toxic to sensitive marine organisms, but the EPA procedures for determining this toxicity level are far from clear with regard to the duration (acute, subacute, partial chronic, or chronic) of such tests. The state regulation gives a duration (96-hour) but omits an application factor; however, the state law does say that industry must conform to the NPDES permit and the Federal Water Pollution Control Act.

The NPDES permit is meant to encompass the effluent standards for industry and the other regulations governing the discharge, such as ocean dumping. Thus, the Kahe Generating Station's NPDES permit states that Hawaiian Electric Company can discharge chemicals not known to them to be toxic. Toxicity, according to state law, is determined by a 96-hour test and the ocean dumping regulation gives an application factor of 0.01 of the toxic concentration which is relatively undefined. Hence, a reasonable approach to meet the intent of the laws would be to use the 96-hour LC_{50} with the 0.01 application factor to determine if the discharge of a certain concentration of a chemical is toxic and, therefore, considered to be a waste discharge for which a permit is necessary.

MATERIALS AND METHODS

Toxicological testing was carried out using the acute-static method described in *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association et al., 1965) with minor modification. Fishes were obtained from several local sources who had collected them from streams on Oahu and from field collections by the authors. After

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[6]Environmental Protection Agency, Ocean Dumping, Final Regulations and Criteria, Title 40, Chapter I, Subchapter H, October 15, 1973, Federal Register, vol. 38, no. 198, part 2, pp. 28610-28621.

collection the fish were held for seven days prior to use in the bioassays. Two days before beginning the study, feeding was discontinued in order to empty the gut and prevent fecal contamination in the bioassay vessels.

The test water used was seawater drawn from the flowing seawater system of the Oceanic Institute (Makapuu, Oahu); its characteristics are shown in Table 2. Aeration was applied throughout the tests by bubbling clean, oil-less air through airstones in order to maintain a dissolved oxygen concentration near 6.8 ppm.

TABLE 2. ANALYSIS OF SEAWATER FROM OCEANIC INSTITUTE

Parameter	Sample A	Sample B
pH (units)	7.72	7.74
Salinity, °/oo	32.39	32.39
Na Cl, ppt	31.0	31.0
Turbidity, JTU	0.16	0.16
Settleable solids	ND (0.1)	ND (0.1)
Suspended solids	21	16
Total Kjeldahl nitrogen, as N	0.03	ND (0.01)
Nitrate, as N	1.75	1.53
Nitrite, as N	0.01	0.02
Ortho phosphate, as P	ND (0.1)	ND (0.1)
Total phosphate, as P	ND (0.1)	ND (0.1)
Sulfate, as S	775	775
Sulfite, as S	ND (0.1)	ND (0.1)
Phenol	ND (0.01)	ND (0.01)
Aluminum	ND (0.1)	ND (0.1)
Antimony	ND (1)	ND (1)
Arsenic	ND (0.1)	ND (0.1)
Barium	ND (0.1)	ND (0.1)
Boron	4.2	4.5
Cadmium	ND (0.01)	ND (0.01)
Calcium	412	412
Cobalt	ND (0.5)	ND (0.5)
Copper	ND (0.01)	ND (0.01)
Chromium	0.01	0.01
Iron	ND (0.1)	ND (0.1)
Lead	ND (1)	ND (1)
Magnesium	1300	1300
Manganese	0.02	0.02
Mercury	ND (0.01)	ND (0.01)
Molybdenum	ND (0.1)	ND (0.1)
Nickel	ND (0.1)	ND (0.1)
Potassium	400	390
Silicon	16	16
Silver	ND (0.01)	ND (0.01)
Strontium	7.5	7.5
Tin	ND (1)	ND (1)
Vanadium	0.2	0.2
Zinc	ND (0.01)	ND (0.01)

ND = not detected at the indicated concentration in parenthesis. Concentrations in mg/l (ppm) unless otherwise indicated.

Five-gallon, all glass aquaria were used as bioassay vessels. These aquaria were filled with 15 liters of seawater and then placed into larger aquaria with flowing seawater which acted as a water bath for temperature control. Water temperature within the test chambers was monitored using several maximum-minimum thermometers placed in several of the water bath aquaria. The temperature within the water baths remained relatively constant--ranging from 25.5° to 27.8°C--throughout the testing period from September 24 to November 24, 1974.

The four species used for testing were the mosquito fish, *Gambusia affinis*; the white mullet, *Chelon engeli*; the damselfish, *Dascyllus albisella*; and a species of *Tilapia*. Table 3 presents the lengths and weights of these fishes. These fishes seemed appropriate for testing since they are found in Pearl and Honolulu Harbors, the receiving waters of two Oahu generating stations.

TABLE 3. LENGTHS AND WEIGHTS OF FISHES USED FOR TOXICOLOGICAL TESTING

Fish species	Length (mm)		Weight (gm)	
	mean	range	mean	range
Chelon engeli	110.9	91 - 128	14.9	7.5 - 22.0
Dascyllus albisella	25	12 - 45	0.6	0.06 - 3.4
Gambusia affinis				
adults	50.0	38 - 64	1.8	0.8 - 3.5
juveniles	<10	<10	<0.05	<0.05
Tilapia sp.	47.6	30 - 65	2.0	0.3 - 4.5

RESULTS AND DISCUSSION

Initial 96-hour range finding tests were conducted using three fish per bioassay vessel. The results of these tests are shown in Table 4. After obtaining an estimate of the toxicity of the compound, 10 fish were placed in a more closely spaced series of concentrations. The results of these tests are given in Table 5. Lethal concentrations were estimated for all tests with the exception of those for *Gambia affinis* in the filming amine since the method used by Litchfield and Wilcoxon (1949) requires partial deaths between total and no mortality concentrations. Figure 1 presents the log concentration-probit line (mortality curve for *Gambusia affinis* in the filming amine). The 96-hour LC_{50} for adult *Gambusia affinis* is 0.41 ppm (range: 0.46 to 0.36 ppm at $P < 0.05$) and the 96-hour TL_m for juveniles is 0.25 ppm. A TL_m value is used for juveniles since calculations of an LC_{50} value require mortalities at concentrations between 84 and 16 percent. The range finding results for *Chelon engeli*, *Dascyllus albisella*, and *Tilapia* sp. indicated similar toxicity values in the filming amine.

TABLE 4. PERCENTAGE OF MORTALITY OF TEST FISHES AT INDICATED CONCENTRATIONS AFTER 96-HOUR RANGE FINDING EXPOSURE

Concentration (ppm)	Species: *Gambusia affinis* Adults	*Gambusia affinis* Juveniles	*Tilapia* sp.	*Chelon engeli*	*Dascyllus albisella*
Morpholine					
1000	100	---	0	100	
100	0	---	0	0	
10	0	---	0	0	
1.0	0	---	0	0	
Control	0	---	0	0	
Filming Amine					
1000	100	---	---	100	---
100	100	100	100	100	---
10	100	100	100	100	100
1.0	100	100	100	100	100
0.1	0	66	0	0	33
0.01	0	0	---	---	---
Control	0	0	0	0	0

TABLE 5. PERCENTAGE OF MORTALITY OF TEST SPECIES AT INDICATED CONCENTRATIONS AFTER 96-HOUR EXPOSURE

Concentration (ppm)	Species: *Gambusia affinis* Adults	*Gambusia affinis* Juveniles	*Tilapia* sp.	*Chelon engeli*
Morpholine				
1000	100			100
560	100			100
320	0			100
180	0			60
100	0			0
Control	0			0
Filming Amine				
100				
10				
1.00	100		100	100
0.56	100	100	100	100
0.50	100		100	
0.45	50		100	
0.40	70		10	
0.32	10	90	10	0
0.18	0	10		0
0.10	0	10		0
0.056	---	10		
Control	0	10	0	0

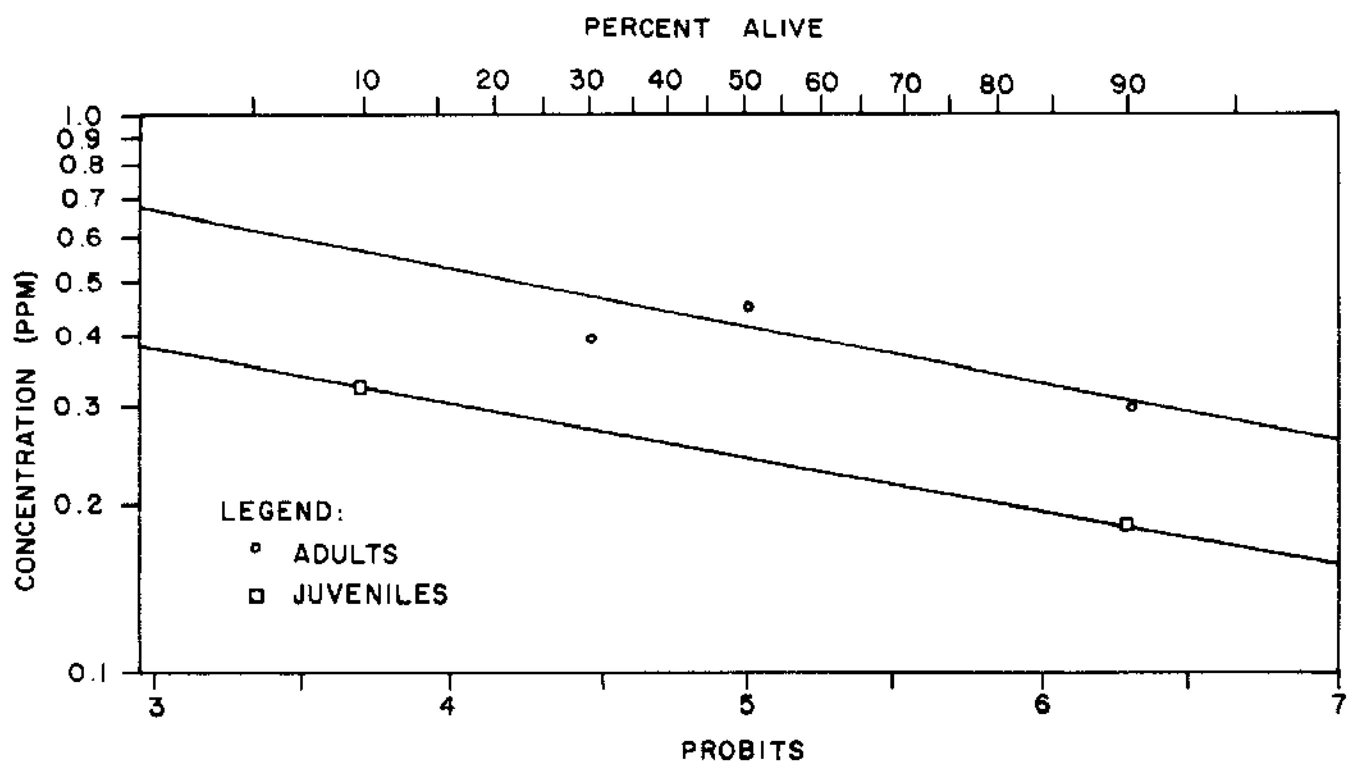

Figure 1. Mortality curve of *Gambusia affinis* in the filming amine

The 96-hour TL_m of morpholine to *Gambusia affinis* is between 320 and 560 ppm; for *Chelon engeli* between 100 and 180 ppm; and for *Tilapia* sp. greater than 1000 ppm.

The maximum concentration of these compounds in the circulating water systems of the Hawaiian Electric Company's power stations has been calculated and presented in Table 6. The discharges do not exceed the maximum permissible values of 0.0025 ppm for filming amine and 1.00 ppm for morpholine.

SUMMARY AND CONCLUSIONS

The waterborne, environmentally offensive chemicals used in the electric generating stations on Oahu are currently being disposed of via percolation and evaporation ponds. These ponds are currently approaching maximum capacity and an alternative means of disposal must be utilized, at least for a portion of the waterborne waste. Boiler and evaporator blowdowns seem appropriate for discharge into the ocean since the morpholine and filming amine contained in these discharges are considered nontoxic under the various laws governing the discharge of toxic wastes.

A toxicological study of the effects of these amines on selected marine fishes found in Hawaiian waters showed that the 96-hour TL_m for morpholine was between 100 and 180 ppm for *Chelon engeli* and between 320 and 560 ppm for *Gambusia affinis*. The 96-hour LC_{50} value for filming amine was found to be 0.41 ppm for adult *Gambusia affinis* and the 96-hour TL_m to be 0.25 ppm for juveniles. The range finding results for *Chelon engeli*, *Dascyllus albisella*, and *Tilapia* sp. indicated similar toxicity values for the filming amine.

Since the discharges do not exceed the maximum permissible values of 0.0025 ppm for filming amine and 1.00 ppm for morpholine, it can be concluded that the discharge of these materials do not constitute a waste discharge.

ACKNOWLEDGMENTS

We would like to thank Dr. Joseph Sylvester of the Oceanic Institute for his assistance and for supplying the white mullet used during this study. Several other members of the Oceanic Institute staff were quite helpful including Dr. Colin Nash, Mr. Paul Bienfang, and Miss Wendy Brand. Mr. Terry Astro kindly supplied the mosquito fish. Staff of the State of Hawaii, Division of Fish and Game supplied the *Tilapia* for testing.

TABLE 6. CONCENTRATION OF FILMING AMINE AND MORPHOLINE IN THE CIRCULATING WATER SYSTEM DISCHARGE FOR HECO'S OAHU POWER GENERATING STATIONS

Station	Maximum Concentration of Filming Amine in Boiler Blowdown (ppm)	Maximum Concentration of Morpholine in Boiler Blowdown (ppm)	Circulating Water Flow (gpm)	Maximum Blowdown Rate (gmp)	Maximum Concentration of Filming Amine in Discharge (ppm)	Maximum Concentration of Morpholine in Discharge (ppm)
Honolulu						
5	1	5	32,000	32	0.001	0.005
7	1	5	45,000	12	0.0003	0.001
8	---	5	64,000	38	0	0.003
9	---	5	64,000	38	0	0.003
Waiau						
1	---	5	12,000	20	0	0.008
2	---	5	18,000	20	0	0.006
3	1	5	45,300	32	0.0007	0.004
4	1	5	45,300	32	0.0007	0.004
5	---	5	55,340	38	0	0.003
6	---	5	55,340	38	0	0.003
7	---	---	74,000	50	0	0
8	---	---	74,000	50	0	0
Kahe						
1	---	---	72,000	50	0	0
2	---	---	72,000	50	0	0
3	---	---	74,000	50	0	0
4	---	---	74,000	50	0	0

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APPENDIX: CHARACTERISTICS AND COMPOSITION OF WATERBORNE DISCHARGES

Characteristics and Composition of Waterborne Discharges

Boiler and evaporator blowdowns

Continuous blowdown is utilized in the operation of low pressure boilers and all evaporators for the purpose of maintaining total dissolved solids concentrations below levels where carryover could occur, or where conditions conducive to deposition on heat exchange surfaces could exist.

High pressure boilers operate with essentially zero blowdown and discharge waste only during startups or system upsets, e.g., condenser leakage.

Startup condensate

Startup condensate is the condensed steam discarded during the initial phases of startup of a high-pressure steam generating unit. The condensate is discarded at this stage because it does not meet the stringent purity requirements of makeup water for high-pressure boilers. In other words, startup condensate is distilled water containing suspended and dissolved solids, dissolved gases (oxygen, carbon dioxide), and volatile preboiler water treatment chemicals (morpholine or ammonia, and filming amine in the case of peaking units) in the parts per million range.

Startup condensate is discharged each time the units are started up. This occurs at overhaul--normally every other year--and after the unit is brought down and cooled for repairs. Startup condensate is discharged at a rate of approximately 400 gpm for 4 to 5 hours.

Demineralizer/softener regenerants

Liquid waste from demineralizers and softeners are generated during regeneration of the ion-exchange resins or zeolites. Regenerant wastes (residual sulfuric acid and caustic soda) are discharged for approximately 2 to 4 hours per day per demineralizer of softener (residual sodium chloride).

Treated water

The treated (auxiliary cooling) water systems are closed systems and, therefore, pose a water pollution problem when draining of the chillers (heat exchangers) is necessary to make repairs, or when overboarding of the storage tanks or sumps is necessary due to system contamination.

In order to minimize the pollution hazard, all treated water systems have been converted from chromate treatment to the environmentally safer boron-nitrogen treatment. Further, when draining of the treated water system is necessary, the waste is routed to retention pits or ponds.

Air heater wash drains

Air heater washing is performed to restore necessary efficiency to fouled equipment. This operation involves removal of corrosive products (principally iron sulfate) from and neutralization of condensed sulfuric acid on air heater surfaces by flushing with an alkaline (soda ash) solution followed by a raw water rinse. The interval between air heater washings varies from several weeks to several months depending on the fuel oil used and the type and design of the particular air heater.

Boiler fireside wash drains

Boiler fireside washing dissolves soluble slag formations from fireside surfaces and attempts to neutralize acidic deposits. The chemical constituents of the deposits and wash drains generally reflect the chemical composition of the fuel oil used to fire the boiler.

Boiler fireside washings are generally performed during normal overhaul outages. Currently, the interval between fireside washings is 1 to 2 years for each boiler.

Boiler chemical cleaning drains

A boiler is chemically cleaned periodically in order to remove water-formed deposits from internal surfaces. Waterside cleanliness is important in order to ensure maximum heat transfer rates necessary for satisfactory boiler efficiency and in order to assure boiler reliability by preventing premature tube failures due to local overheating of heavily scaled surfaces.

Boiler chemical cleaning results in the discharge of 12,000 to 18,000 gallons of a 10 to 25 percent solution of a chelating agent (tetra-ammonium EDTA) containing dissolved boiler waterside solids, primarily iron oxide.

For all base-loaded units, boiler chemical cleaning is performed once every 2 to 4 years.

Chemical laboratory and bench wastes

Chemical laboratory and bench wastes are mainly laboratory glassware wash water drains, discarded boiler water samples, and small amounts of chemical reagents used for chemical analyses.

Sewage

Sewage includes normal discharges from toilets, showers, and sinks in the power plants. Drainage from the laundry facilities at the Waiau plant enters the city sewer system.

Floor drains, chemical pump drains, equipment oil drains

Plant floor drains, chemical pump drains, and equipment oil drains are occasional sources of liquid waste resulting from pipeline and/or pump leaks. These discharges are kept under control through good housekeeping and preventive maintenance practices.