TOXICITY OF ADDITIVES USED TO CONTROL ODORS IN RECREATIONAL VEHICLE WASTEWATER

WA-RD 322.1

Final Report
March 1994

Washington State
Department of Transportation

Washington State Transportation Commission
Transit, Research, and Intermodal Planning (TRIP) Division
in cooperation with the U.S. Department of Transportation
Federal Highway Administration

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. WA-RD 322.1	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE Toxicity of Additives Used to Control Odors in Recreational Vehicle Wastewater		5. REPORT DATE March 1994 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Ervin Hindin		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Washington State Transportation Center (TRAC) Civil and Environmental Engineering; Sloan Hall, Room 101 Washington State University Pullman, Washington 99164		10. WORK UNIT NO. 11. CONTRACT OR GRANT NO. GC8720, Task 13
12. SPONSORING AGENCY NAME AND ADDRESS Washington State Department of Transportation Transportation Building, MS 7370 Olympia, Washington 98504-7370		13. TYPE OF REPORT AND PERIOD COVERED Final Report Jan. 1, 1991 - Dec. 31, 1992 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

This report consists of three phases. Phase one was a review of existing information on all aspects of recreational vehicle (RV) wastewater additives. Surveys and interviews were held with retailers selling RV wastewater holding tank additives, RV owners and RV users. The surveys and interviews revealed that formaldehyde-methanol additives were the most widely used followed by paraformaldehyde formulations.

The second phase explored the toxicity of the commercially available additives when used in a dosage recommended by the manufacture. The Microtox^R toxicity bioassay and the change in oxygen uptake by sewage degrading microorganisms were used as indicators of toxicity. Formaldehyde-methanol formulation showed the greatest immediate toxicity. This was followed in decreasing toxicity by the alkyl phenoxy polyethoxy ethanol, paraformaldehyde, quaternary ammonium chloride, and enzyme-detergent formations. Enzymes which contained an inert filler were found to be non-toxic. The adverse impact of the additive on the oxygen uptake rate showed that the formaldehyde-methanol had a biocidal effect while enzyme formulations had no effect. The other additives caused a slow down in the rate of oxygen uptake by the microorganisms.

The final phase of the study characterized the RV wastewater being dumped at the rest area dump stations and the characteristics of various wastewater streams in the biological treatment systems. The three parameters monitored were the 5-day Biochemical Oxygen Demand (5-day BOD), pH and Microtox toxicity.

17. Key words: RV chemical additives, toxicity of RV additives, RV wastewaters	18. DISTRIBUTION STATEMENT No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
None	None	77	

Summary Report
for
Research Project GC8720, Task 13
"RV Wastewater Additive Toxicity"

TOXICITY OF ADDITIVES USED TO CONTROL ODORS IN RECREATIONAL VEHICLE WASTEWATER

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Washington State Transportation Commission
Department of Transportation
and in cooperation with
U.S. Department of Transportation
Federal Highway Administration

March 1994

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SUMMARY

Chemical and biochemical formulations are added to recreational vehicle (RV) black water holding tanks to control the odor and the biological activity which produce odors. Within the last 15 years new products have been introduced with different active ingredients. The older types have either been discontinued or are used to a lesser degree. The question continuously arises concerning the effect that these active ingredients have on biological sewage treatment systems treating these wastes. As a result a study was undertaken to determine the toxicity of the more popular additives used singly and in combination with black water.

The first phase of the investigation was to examine the existing literature pertaining to the various aspects of RV wastewater additives. The second part was to conduct a series of surveys to determine the retail sales and use of the commercially available RV wastewater additives. The use surveys revealed that the formaldehyde-methanol formulations continue to be the most often used additive, though their popularity has been decreasing. Their use was closely followed by paraformaldehyde formulations and then by enzyme preparations. Other types of formulations such as: alkylphenoxy polyethoxy ethanol, 1,5-pentanedial, and quaternary ammonium chloride are used to a lesser extent. A significant number of RV owners used home made preparations consisting singlely or in combination of pine oil, bleach, heavy duty detergents, and baking soda. The survey also revealed that many RV users did not use any additives, because black and gray waters are only stored for four or less days before disposal. In an accompanying survey on RV use it was found that the major use of the RV vehicles was during the extended summer season, late spring through

early fall. The peak use time was during the extended Independence Day and Labor Day holidays.

The next phase of the investigation dealt with the toxicity of the RV holding tank additives. Two studies were undertaken to determine the toxicity. One test used to establish toxicity was the Microbics Microtox^{R} toxicity bioassay method and the other, the rate of oxygen uptake by microorganisms found in raw sewage. The Microtox^{R} toxicity test results are expressed in terms of the effective concentration to cause a 50 percent reduction in the activity of the test microorganism. Aqueous solutions of the RV wastewater additives were prepared according to the manufacturer's recommendation. Preparations containing enzymes and an inert filler prove to be not toxic. A proprietary product of unknown formulation showed a slight toxicity. This was followed in increasing toxicity by formulations of enzymes with detergents, quaternary ammonium chloride, paraformaldehyde, alkyl phenoxy polyethoxy ethanol and formaldehyde with ethanol. The formaldehyde with methanol formulation was the most toxic and showed an extremely high instantaneous toxicity.

Another approach was to measure the effect of the additives on the oxygen uptake by the indigenous microorganisms found in the raw sewage while biodegrading the organic material. The formaldehyde-methanol formulation caused the immediate death of the microorganisms resulting in no oxygen uptake. Enzymes with inert fillers or with detergents showed little or no difference in the rate of oxygen uptake compared to that of raw sewage. The remainder of the additives caused an overall reduction in the rate of oxygen uptake. Some of the additives caused a lag time before oxygen uptake occurred, while others showed an initial normal rate followed by a sharp decrease in the rate. Microtox^{R} toxicity measurements were made at the beginning and conclusion of the oxygen uptake rate test. Where the microorganisms were viable, a reduction occurred in the toxicity of the raw sewage fortified with RV additive.

The chemical and toxicological characteristics of the black and gray water disposed at the rest area's dump stations had a bearing on the operation of the biological treatment system used. Black water is wastewater which contains body wastes, e.g. fecal material and urine. Gray water is composed of wash and rinse water and food fragments. The three parameters used to characterize the wastewaters being dumped and the operation of the treatment systems that were accessible were: the 5-day Biochemical Oxygen Demand (5-day BOD), hydrogen ion activity (pH), and the Microtox^{R} toxicity bioassay. A total of 182 wastewater samples were analyzed for the 5-day BOD of which 87 were black water, 56 gray water, 10 combined black and gray water and 26 from wastewater treatment systems. The black water had an average 5-day BOD value over ten times greater than that of the rest area's rest room wastewater or of an average strong domestic raw sewage. The average gray water was found to have a 5-day BOD of less than half of that of the black water.

Samples from the Selah Creek, Indian John Hill, Schrag and Sprague Lake sewage treatment lagoons systems showed that these treatment system were doing an excellent job in degrading or destroying the sewage organic matter as measured by the reduction and the toxicity and the 5-day BOD.

The pH is another important parameter used to monitor biological treatment systems. The average black water had a pH of 8.1. Aerobic biological treatment systems operate best at a pH of 6.0 to 8.5. The gray water was slightly acidic but well within the optimum operational range of biological treatment system. The average combined black and gray water dumped was slightly alkaline about in the middle of the optimum pH range for the activity of the sewage degrading microorganisms. In sewage lagoon treatment systems, the pH in the various lagoon cells ranged from 7.4 to 8.5. These values were within the range found in well operated sewage lagoon systems. Septic tank outflows were decidedly alkaline. These outflows had pH values similar to that of the average black water.

Microtox^R toxicity bioassay measurements were made of RV black and/or gray waters as they were being dumped. There were natural occurring toxic materials in black waters, e.g. ammonium ion, mono and diamines, and uric acid which accounts for their moderate toxicity towards the test microorganism. The chemical additives, except for enzymes, used by the RV users interviewed caused the black water to become more toxic.

Microtox^R toxicity bioassay measurements were determined on samples taken at various stages of wastewater treatment in the lagoon systems. The results showed that sewage lagoons can completely or near totally detoxify the toxic substances. The influents entering the primary cell of the lagoon were quite variable in toxicity. This was due to the varying proportions of black and gray water and/or rest area restroom wastewater in the flow. Septic tank outflow had a moderate to strong toxicity. Anaerobic conditions in the septic tank produced reduced nitrogen and sulfur compounds which are toxic to aerobic bacteria of which the Microtox^R test microorganism is a member. Since the septic tank is a primary treatment unit, the outflow receives further treatment which reduces its toxicity.

CONCLUSIONS

SURVEYS

The most important element of this phase was the surveys to determine the sales and use of RV gray water additives. Based on retail sales the leading types of RV wastewater additives sold in the state of Washington were the formaldehyde-methanol formulations containing coloring and odor masking agents. A close second in sales was the paraformaldehydes with odor masking and coloring agents. A mailed survey sent to selected RV owners and interviews with RV users who were disposing of the black and gray waters revealed that 21 percent of the respondents used the formaldehyde-methanol additive. Enzyme preparations with and without odor masking agents were gaining in popularity.

From the mailed survey, it can be concluded that the greatest use of RVs is during the late spring, summer, and early fall. The largest number of RVs on the highway was during the extended Independence Day and Labor Day holidays. The greatest use of the state's rest areas RV dump stations was on the last day of the above mentioned holidays. Black and gray waters being dumped were more often stored in the holding tanks for less than five days. Twenty-six percent of RV users did not use a chemical or biochemical wastewater additive to retard biological activity and odor production of the black water on one or more of their trips.

TOXICITY OF THE RV WASTEWATER HOLDING TANK ADDITIVES

Toxicity studies provided information which permitted the following conclusions.

Toxicity as measured by the Microtox^{R} toxicity bioassay method using a 15-minute-exposure time allowed the ranking of the non-proprietary type RV wastewater additives. The additives appear in descending order of toxicity.

1. Formaldehyde-methanol

2. Alkylphemoxy polyethoxy ethanol

3. Paraformaldehyde

4. Quaternary ammonium chloride

5. Enzyme

The presence of detergents, dye, and odor masking agents may enhance the toxicity. This was verified by comparing the Microtox[R] toxicity values for an enzyme preparation containing a dye and odor masking agent to that of an enzyme and an inert filler. Toxicity of the RV wastewater additives was measured by the effect that each additive had on the aerobic metabolic process. The most drastic effect on the rate of oxygen uptake occurred when no oxygen was taken up. While the least effect occurred where the additive did not change or enhanced the rate of oxygen uptake by the microorganisms. Between these two extremes are those additive which took longer for the sewage to reach the same level of oxygen uptake as raw sewage. The following is a ranking of additives in descending order of having an adverse effect on the oxygen uptake by aerobic sewage microorganism:

Formaldehyde-methanol
1,5 pentanedial
Alkylphenoxy polyethoxy ethanol
Quaternary ammonium chloride
Paraformaldehyde
Pine oil
Enzymes with detergents
Enzymes with inert filler

Except for the formaldehyde-methanol additive all other additives when added to raw sewage can be totally or partially aerobically biodegraded into products that show no toxicity in the Microtox^R toxicity bioassay test. Except for the enzyme additive all other additives caused a reduction in the rate of biodegradation.

CHARACTERIZATION OF RV WASTEWATERS AND TREATMENT SYSTEM EFFLUENTS

The organic strength of the average RV black water, as measured by the 5-day BOD, was slightly higher than ten times an average rest area restroom wastewater. The average black water 5-day BOD found in this study was within the same range found by other investigators. The gray water because of the nature of its biodegradable material, had a 5-day BOD value slightly less than half of the average black water. The 5-day BOD of the influent entering the primary lagoon cells varied depending on the proportion of RV wastewater and rest areas restroom wastewater comprising the flow. The influent values were slightly greater than that of an average strong domestic sewage. The lagoon treatment system did an excellent job in treating the sewage. The wastewater in final lagoon cells at Indian John Hill, Schrag and Sprague Lake was of such a quality as to meet the state of Washington discharge 5-day BOD limits. The 5-day BOD of the average septic tank overflow at Schrag which receives only RV black and gray water was slightly more than three times as great as the average value found at Gee Creek which receives a combine RV and rest area's restroom wastewater. Since the primary function of the septic tank is to settle out the suspended/settleable solids and to liquefy certain types of solids, drastic reduction in the 5-day BOD of the overflow was not anticipated. Biodegradation of the organic material in the overflow occurs in the drain field.

The pH in a biological active system is an important parameter as microorganisms responsible for the biodegradation are active within a limited pH range. The pH of black water and the outflow from the septic tank solely receiving RV wastewater were decidedly alkaline. The average was near the upper limits for active biodegradation. In contrast gray water was mildly acidic. The combined black and gray water showed to have a mildly alkaline pH. Of the sewage lagoons investigated on all but four occasions, the pH in the final or last cell or pond ranged from 7.6 to 8.5. This pH range was within that found in a well operating final cell of a sewage lagoon treating domestic sewage. Where a large algal bloom was noted the pH of the lagoon was in excess of 8.8.

The Microtox[R] toxicity bioassay test was used to measure the toxicity of the wastewater and water in the treatment systems. Black water contains a number of mono and diamines, heterocyclic organic nitrogen compounds, mercaptans, and organic sulfides which are toxic to the test microorganisms used in the Microtox[R] toxicity bioassay test. The toxicity increased with the addition of commercially available holding tank additives except for enzyme preparations. The greatest enhancement of toxicity was in the use of pine oil formulations. The dosage of pine oil formulations are not given by the manufacture for use as an additive in RV wastewater holding tanks. The tendency is to use an amount greater than what is needed. The commercial products containing paraformaldehyde additives used in an amount recommended by the manufacturer, gave RV black water the greatest toxicity. This was followed in descending toxicity by formaldehyde-methanol, and quaternary ammonium chloride preparations. Enzyme preparations, when added or present in black water, did not statistically change the toxicity of the black water. The survey revealed that additives were generally not added to gray water.

In most instances the raw sewage influent from rest areas entering the rest area's treatment system will show some degree of toxicity. However, during biological treatment of the wastewater most of the organic compounds toxic to the Microtox[R] toxicity test organisms are degraded into non-toxic substances.

This was observed at the Selah Creek, Indian John Hill, and Schrag sewage lagoon systems. In most cases the complete removal of toxic substances occur by the time the wastewater reaches the far end of the secondary or final lagoon cell. In some cases the detoxification occurs before leaving the primary lagoon cell. Septic tank overflow due to the nature of the anaerobic biological treatment system will produce products toxic to many aerobic microorganisms of which the Microtox^{R} test microorganism is a member. These anaerobic products can mask out the toxic effect by the RV additives if they are present.

RECOMMENDATION

The commercially available RV wastewater additives when added to the black water holding tank in a dosage recommended by the manufacturer and where the tank is at least half full with black water prior to dumping will not have an adverse effect on biological sewage treatment systems.

"Home made" mixtures of household cleaners containing disinfectants or cleaners to which disinfectants have been added should be discouraged. The amount of these mixtures used to control odor and the activity of microorganisms causing the objectionable odor are not known. Thus there is a tendency by the RV users to add an excessive amount of their "home-made" preparation to the waste water holding tanks. At time of disposal the residual quantity of the "home-made" preparation in the wastewater may be sufficiently high enough to cause a temporary shock to the sewage treatment unit(s) during low flows of raw sewage. During normal or high flows of sewage, these "home-made" preparations may be sufficiently diluted to cause no harm to the biological treatment units.

INTRODUCTION

INTRODUCTION OF THE PROJECT

The use of recreational vehicles (RV) as a means of transportation and temporary residences has shown a steady increase. This has been due to an increase in leisure time that many people have, particularly retirees and the unstructured independent life style that traveling in RVs offers. Currently the use of RV motorhomes are becoming more popular than campers and travel trailers. The trend in motorhome and to some extent in travel trailer construction in the last ten years has been to equip and furnish these vehicles with more of the comforts found in the fixed-stationary homes. Among such improvements has been to increase the volume of potable water that the vehicles can carry and a proportional increase in wastewater holding capacity. RVs, excluding campers, built within the last ten years have potable (drinking water) reservoir tanks with a capacity of 30 to 50 gallons. Another change in RV construction has been in segregating the wastewater into black water (human wastes) and gray water (spent wash waters). Each type of waste is stored in their respective holding tanks. Waste segregation facilitates easier disposal, cleaning, and maintenance. Public and private disposal sites or dump stations are normally used for disposal of the wastewaters. Though, a decrease in the number in private dumpsites have occurred in the last ten years. The state of Washington through legislative bill HB 1464 passed in 1980 has constructed and operates dump stations at several rest areas along the interstate highway system and on two U.S. highway routes (1). In addition to the dumping of the wastewater, complete or pretreatment of the wastewater is provided at the rest areas.

BACKGROUND

In 1980-82 a study on recreational vehicles waste disposal stations at highway rest areas was conducted for the Washington State Department of Transportation by the University of Washington, Department of Civil Engineering (2). The purpose of that study was as follows: to characterize RV combined black and gray waters, to identify effects on those wastewater treatment systems receiving RV wastewaters, to determine RV owners use of the dump station, and to determine the cost benefit of the disposal stations. In the 10-year-period (1982-1992) since the above mentioned study was concluded, the number of RVs licensed in the state of Washington had increased by 6 percent (3). However, the number of motorhomes had increased by 80 percent and the number of travel trailers had decreased by 20 percent according to the Washington State Department of Motor Vehicle Licensing (3). The new motorhomes have the largest water potable water reservoir capacity and larger wastewater holding tanks of all RVs. During the same 10 year time period the trend has been in the increased use of the environmentally safe or less toxic RV wastewater tank additives.

OBJECTIVES

This study was conducted to assist the Washington State Department of Transportation (WSDOT) in updating their management of RV wastewaters dumped at rest areas. The study is divided into three segments: use information, impact of RV wastewater additives on microbial activity, and the characterization of RV wastewater containing additives and that of the influent and effluent at wastewater treatment facilities. The objective of the use information segment was to compile information on the types of RV wastewater additives sold by retailers and used by RV owners. The owners use information was designed to determine motor home and travel trailer seasonal and holiday use. The second segment objective was to determine the toxic effect of the additives on sewage degrading microorganisms. The final segment objective was to characterize black and gray waters from RVs and influent and effluent at select WSDOT operated waste treatment facilities.

PRODUCT, USE/USER INFORMATION

INFORMATION REVIEW

A review of existing literature and internal/external reports showed most of the research in the use of RV wastewater additives and their impact on treatment systems was done prior to 1985 (2, 4, 5, 6, 7, 8, 9). Following 1985 most of the available information dealt with new product development (10, 11, 12).

Retail Sales Survey

To gain an insight of the types of RV wastewater additives marketed in the state of Washington, personal and phone interview surveys were conducted in 1991-1992. Thirty-two retailers in the following areas were interviewed: Spokane, Seattle, Tacoma, Vancouver, Yakima, Wenatchee, Tri Cities metropolitan areas, and in Clarkston and Pullman. The retailers were classified into two categories, those who sell a variety of brand and types of additives and those which sell one product. Retailers selling just one product sell one store brand product, e.g., Sears Roebuck exclusively sells the additive Pak-A-Potti. The RV accessories retailers stock and sell several types of additives. The retailer survey revealed that the formaldehyde-methanol mixture accounted for forty-five percent of the sales while paraformaldehyde accounted for forty-three percent. The other class of retailer are the discount and general merchandise stores. Paraformaldehyde based RV additives led in their sales. This was followed by enzyme based products and last by the formaldehyde-methanol additives. A variety of other types of RV wastewater additives are also marketed, but used to a more limited extent.

RV Users Survey

A survey was undertaken in 1991-92 to obtain information germane to motorhome and travel trailer use by owners whose RV's are licensed in the state of Washington. A questionnaire was sent to randomly selected RV owners from a list provided by the state of Washington, Department of Motor Licensing. With the assistance from the Washington State University Computer Service Center's statistician 256 RV owners were selected out of over 14,000 RV owners.

The purpose of this survey was to determine the following: seasonal and holiday use of their RV, extent of water using facilities in their vehicles, frequency of wastewater discharged per trip, use of rest area dump stations in Washington and four other western states, and the brand or type of RV wastewater additive used. A summary of the responses are found in Tables 1, 2 and 3.

Findings of RV User's Survey

Table 1 summarizes the responses from motorhome owners. The peak use of motorhomes was during the summer, showing a slight decrease in the spring and fall and a significantly lower use in winter. The most highly used holidays were Labor Day and Independence Day. Frequency of continuous weekend and monthly use varied with the season. Spring and autumn frequency of use differed from each other slightly. Though, it was noted that one or more extended trips were more frequently taken during the autumn than in any other season.

Water usage during the trips varied. All motor homes had sinks and toilets, while all but two percent had showers. The wastewaters from these water use facilities were dumped every one to four days. The frequency of wastewater dumping in the state of Washington was about equal to that used in the four other western states. California and Oregon dump stations were equally used.

Table 1. Summary of Motor Home Survey

I. Number of respondents = 52

II. Facilities (as percent)

A.	Showers	=	98
B.	Sink	=	100
C.	Toilet	=	100

III. Use 1990/1991 (as percent)

A. Season		Summer	Autumn	Winter	Spring
1.	Useage	100	90	62	83
2.	Continuously	15	13	16	16
3.	One or more extended trip	21	30	25	21
4.	Nearly every weekend	10	6	0	7
5.	About once a month	44	34	16	40
6.	Seldom	10	17	44	16

B. Holidays

1.	Christmas/New Years	19
2.	Memorial Day	44
3.	Independence Day	52
4.	Labor Day	58

IV. Discharge of wastewater (as percent)

A.	Dumped every 1-4 days	81
B.	Dumped every 5-10 days	19
C.	Greater than every 10 days	0

V. Use of rest area dump site (as percent)

A.	In the state of Washington	87
B.	In other states	83

VI. Dump sites used in other states (number of times)

Oregon	28
California	17
Arizona	12
Idaho	11

Table 2. Summary of Travel Trailer Survey

I. Number of respondents = 83

II. Facilities (as percent)

A.	Showers	=	87
B.	Sink	=	99
C.	Toilet	=	93

III. Use 1990/1991 (as percent)

A. Season	Summer	Autumn	Winter	Spring
1. Useage	98	83	53	68
2. Continuously	10	9	8	7
3. One or more extended trip	32	17	13	18
4. Nearly every weekend	16	10	2	10
5. About once a month	25	38	19	37
6. Seldom	19	26	58	28

B. Holidays

1. Christmas/New Years	16
2. Memorial Day	49
3. Independence Day	53
4. Labor Day	54

IV. Discharge of wastewater (as percent)

A. Dumped every 1-4 days	66
B. Dumped every 5-10 days	30
C. Greater than every 10 days	41

V. Use of rest area dump site (as percent)

A. In the state of Washington	67
B. In other states	48

VI. Dump sites used in other states (number of times)

Oregon	25
California	13
Arizona	8
Idaho	10

Table 2 summarizes the responses from travel trailer owners. The peak of continuous use of travel trailers was during the summer, closely followed by autumn, spring, then winter. This trend was not true for one or more extended trips. The greatest use occurred in summer, but the frequency during the other seasons were about the same. The frequency of use nearly every weekend was greatest during the summer, a slightly lower frequency during the spring and autumn and very low during the winter. The holiday usage of the travel trailers were highest and at about the same frequency on Memorial, Independence, and Labor Days.

Water usage in travel trailers is generally less than in motorhome vehicles, this may be explained by the fact that one percent of these travel trailers did not have sinks, seven did not have toilets and 13 did not have showers. The frequency of stored wastewater dumping was about twice as frequent every one to four days than that held every five to ten days. A preponderance of the travel trailers use the dump stations in the state of Washington more than in other states. Of the other states the dumpsites in Oregon were the most frequently used.

RV Wastewater Additive Use

To gain better knowledge of the types of wastewater additives used by RV owners, the mailed survey asked the respondents to indicate the brand and/or type of product used. Another information gathering approach was to interview the RV user when they were dumping their wastewaters. Table 3 summarizes the information obtained from the mailed survey, while Table 4 contains summarized information from the RV user's interviewed.

Table 3. Survey Summary of RV Wastewater AdditivesUsed in Travel Trailers and Motorhomes

Product or Brand Name	Type	Number of Users
Thetford Co. Aqua Kem	Formaldehyde + methyl alcohol	30
MonoChem T-5	Paraformaldehyde	17
Pine Sol	Pine oil	5
Camper Chem	Paraformaldehyde	4
Sealand enzyme	Enzyme	3
Trizyme	Enzyme	1
Dri Kem	Paraformaldehyde	4
Liquid Gold	Quaternary Ammonian Chloride	1
RV-Trine	Enzyme	2
Thetford Aqua Zyme	Enzyme	1
Always Fresh Powder	Unknown	1
Pack a Potti	1,5 pentanedial	2
TST Amco	Unknown	1
Borax	Sodium borale	3
Redex	Unknown	1
Chlorox	Sodium hypochlorite solution	1
Sur Fresh	Unknown	1

Table 4. RV Wastewater Additive User Information at Time of Dumping

Product or Brand Name	Type	Number of Users
Thetford Co. Aqua Kem	Formaldehyde + methyl alcohol	33
MonoChem T-5	Paraformaldehyde	14
Pine Sol	Pine oil	6
Camper Chem	Paraformaldehyde	6
Sealand Enzyme	Enzyme	7
Trizyme	Enzyme	1
Dri Kem	Paraformaldehyde	6
Liquid Gold	Quaternary Ammonian Chloride	3
RV-Trine	Enzyme	3
Thetford Aqua Zyme	Enzyme	7
Pack a Potti	1,5 pentanedial	3
Borax	Sodium borale	1
Redex	Unknown	0
Chlorox	Sodium hypochlorite solution	1
Sur Fresh	Unknown	1
Nothing		41
Tri Enzyme	Enzyme	1
Dishwater soal	Detergent	4
KMart H-D Pine	Pine oil	2
Baydo's-MFB	Unknown	3
Roebic RV	Unknown	1
Inca Gold	Paraformaldehyde	1
Travel John	Enzyme	3
Star Bright	Pine oil	1
Unknown		7
Chem-Clean	Enzyme	2
Natures Way	Detergent	1
Waste Be Gone	Formaldehyde	1
KN-48	Zinc sulfate	1
No Additive		41

FINDINGS OF RV WASTEWATER ADDITIVE USE

Of the 135 RV owners surveyed 78 responded to the question of the type or brand of additive used. Thirty indicated that they used a formaldehyde-methanol additive, 25 used paraformaldahyde, 7 an enzyme preparation, 5 pine oil, and 11 used miscellaneous products. The miscellaneous category are products which no more than three people used. No additive addition was not a category option offered.

One hundred and sixty-one RV users were interviewed to determine the brand and/or type of additive. The interview was conducted when the user was dumping their wastewaters. Forty-one RV users said they did not use any additive. Of those who did use an additive 34 used a formaldehyde-methanol mixture, 25 used a paraformaldehyde solution, 24 used an enzyme product, 9 used a pine oil solution, 4 used a heavy household detergent and 15 used miscellaneous products. It was of interest that one of the miscellaneous products used was a solution of zinc sulfate. Metal sulfate have been banned in most states.

TOXICITY OF THE RV WASTEWATER HOLDING TANK ADDITIVES

INTRODUCTION

Chemical or biochemical additives are added to RV wastewaters to mask the objectionable odors and to suppress odor formation. Wastes discharged into the black water holding tank being of fecal and urinous origin have an unpleasant odor. Those wastewaters sent to the gray water holding tank are generally not objectionable. In addition to the indigenous wastewater odors, microbial activity occuring in the black water holding tank will cause the formation of unpleasant odors. Chemical additives are added to suppress the odors. Many being biocidal or biostatic have an adverse effect on the microbial population. This has resulted in concern by operators/owners at those publically owned wastewater treatment plants (POWT) and RV park sewage treatment facilities receiving RV wastewaters. Other additives like enzymes enhanced or had minor effect on the biological activity. The difficulty in ascertaining if the effect is due solely to the active ingredient lies in the fact that the additives are mixtures of numerous ingredients. A typical liquid additive is an aqueous solution of the active ingredient, a masking odorant, coloring agent, detergent and miscellaneous trace ingredients. A dried enzyme preparation generally contains the active ingredient and filler. The granular nonenzyme type will contain the active dry ingredient in addition to a coloring agent, masking odorant and miscellaneous trace matters.

The study described herein investigated the toxicity of the RV wastewater additives. The initial study was to determine the toxic effect using the Microbics Corp. Microtox^{R} bioassay test (10). In addition, the study was to determine the biological activity, as measured by the oxygen uptake, of the indigenous aerobic bacteria in raw domestic sewage obtained from the Pullman, WA wastewater treatment plant. This raw sewage was used because RV black waters are highly perishable and whose quality varies from sample to sample. Black waters refrigerated or frozen show quality changes when brought to room temperature. This was the reason in using fresh raw sewage.

RESEARCH APPROACH

Toxicity of RV Additives

Aqueous solutions of nine RV wastewater additives were prepared using non-toxic glass distilled deionized water. The concentration of additive in each solution was equivalent to the amount recommended by the manufacturer. Table 5 is a compilation of the experimental data obtained using the Microtox^{R}

Table 5. Toxicity of Aqueous Solution of RV Wastewater Additives

Brand	Type	Concentration	Toxicity (EC50 as Percent)	
			5 min	15 min
Thetford Co. - Aqua-Zyme	Enzyme with detergent	0.78 m L/L	9.28 (7.04 to 12.23)	6.44 (3.52 to 11.81)
Thetford Co. - Aqua Chem	Formaldehyde-methanol	1.56 mL/L	2.19 (1.33 to 3.61)	1.65 (0.43 to 6.36)
Thetford Co. - Aqua-Green	Alkyphenoxy Polyethoxy Ethanol	1.56 mL/L	2.26 (0.57 to 8.99)	Not available
Thetford Co. - Aqua Kem-Tossins	Paraformaldehyde	0.375 g/L	3.23 (3.09 to 3.38)	2.67 (2.58 to 2.77)
Thetford Co. - Kem-Dry	Paraformaldehyde	0.375 g/L	2.56 (1.43 to 4.51)	2.26 (1.30 to 3.94)
Inca Corp. - Inca Gold	Paraformaldehyde	0.375 g/L	1.75 (0.77 to 3.95)	2.64 (1.39 to 5.00)
Conservation Chemistry Corp., Breakup	Proprietary product	8 mL/L	87.89 (75 to 100)	100
Merrick Racicot Corp - Sea Zyme	Enzyme	0.148 g/L	100	100
Sanitation Equipment Ltd. - Liquid Gold	Quaternary Ammonium Chloride	0.052 mL/L	11.45 (3.97 to 32.97)	4.89 (4.36 to 5.46)

bioassay toxicity method (13). A description of the method is found in Appendix A. The toxicity data are reported in terms of EC50 values. EC50 is the percent of sample required to cause a 50 percent reduction in the bioluminescence of test microorganism, Photobacterium phosphorium. Thus the smaller the EC50 value the more toxic is the aqueous solution of the wastewater additive.

Findings of RV Additive Toxicity

Aqueous solution of the RV additives prepared according to the manufactures instruction was ranked according to the Microtox[R] toxicity. Toxicity at the standard 15 minute contact time was selected. It has been observed that the reduction in bioluminescences by the test microorganism in contact with most organic biocides and heavy metals becomes constant after 15 minutes.

Enzyme products free of detergents were found to be non-toxic. This was followed by a slightly toxic proprietary product whose manufacturer claims contains no formaldehyde nor enzyme. Next least toxic was an enzyme-detergent preparation followed closely by a quartnerary ammonium compound. The next were the paraformaldehydes and the alkyl phenoxy polyethoxy ethanol formulations. The additive showing immediate toxicity was the formaldehyde-methanol mixture. The sequence of toxicity correlates with action that the additive have on the materials in wastewater and on the microorganism. Enzymes are non-toxic products usually obtained from microorganisms which liquefy the organic solids and break down complex organic compounds into simple more biodegradable compounds. Paraformaldehyde has a slowrelease toxic action while formaldehyde exhibits instantaneous toxicity as shown by the oxygen uptake tests.

RV Wastewater Additive Effect on Microorganism Oxygen Uptake

A study was undertaken to determine the effect each of ten RV wastewater additives had on the activity of microorganisms found in raw sewage obtained from the Pullman, WA wastewater treatment plant. The microbial activity was measured by the uptake of dissolved oxygen in biodegrading the organic material in fresh aerated raw sewage. The oxygen uptake in the raw sewage containing the RV additive was compared to a control of raw sewage free of the additive. All samples were run in duplicate. Accompanying the study Microtox^R toxicity bioassay measurements were made of the samples and control prior to the oxygen uptake test and at the conclusion of the uptake test.

The oxygen uptake study was conducted using six Rank-dissolved oxygen meters. The meters measure relative amounts of dissolved oxygen using the fixed voltametric electrode method. The meters work as follows. After preparing the electrode and checking for its response, twenty-five milliliters of sample or control is added to the reaction cell. The cell is sealed to prevent an inflow of oxygen from the air. Relative oxygen levels are measured manually at timed intervals. The control contained fresh aerated raw sewage while the sample contained fresh aerated raw sewage from the same lot to which the RV additive had been added. The amount of additive added to the raw sewage was according to the manufactures instruction. The recommended life of the oxygen sensing electrode system is two days.

Findings of the Oxygen Uptake Study

Figures 1 through 6 are oxygen uptake curves showing the impact of the RV wastewater additives. The uptake experiments were done in replicate.

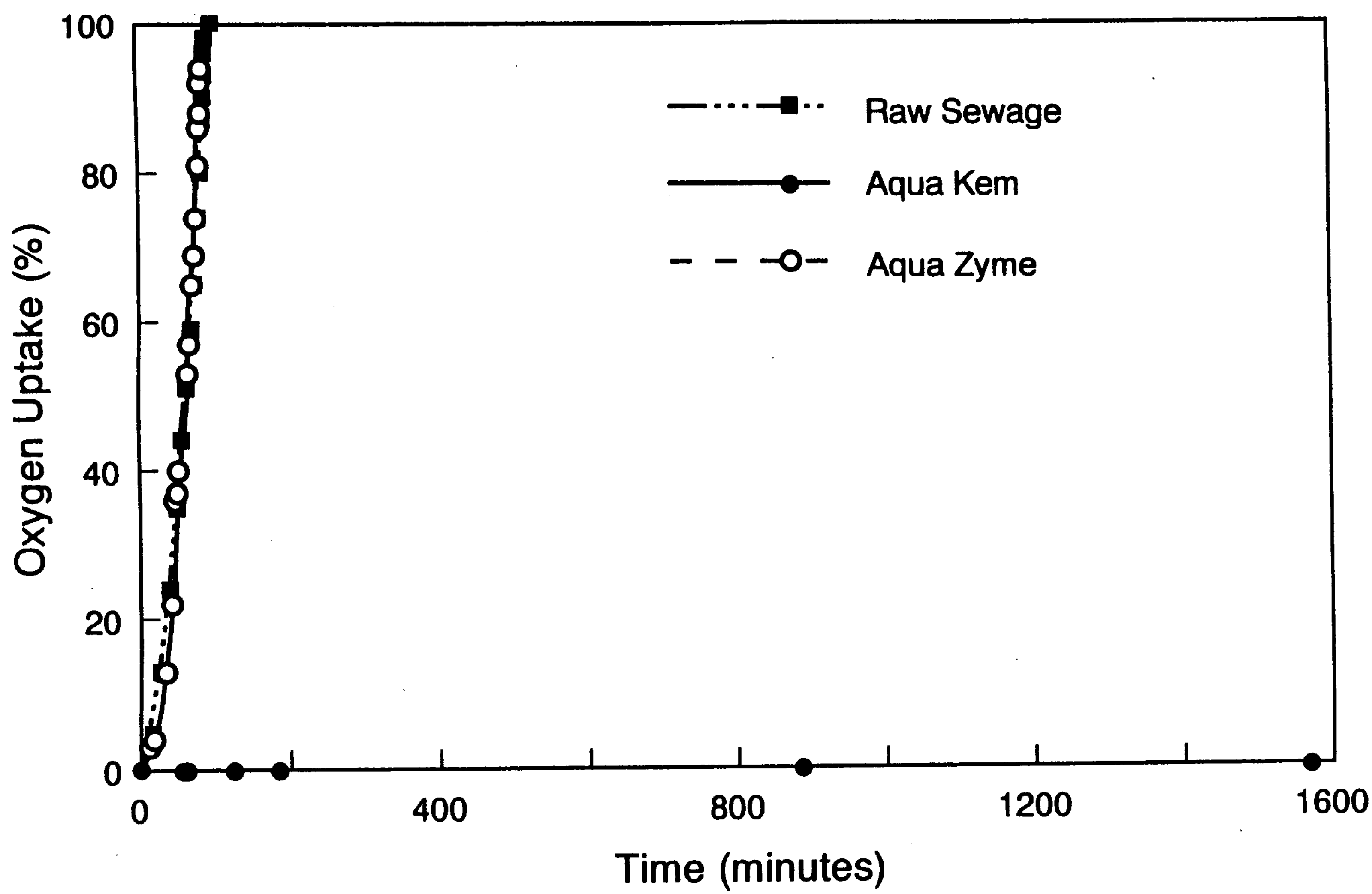

Figure 1. Effect of Aqua Kem Blue and of Aqua Zyme on the Oxygen Uptake of Raw Sewage

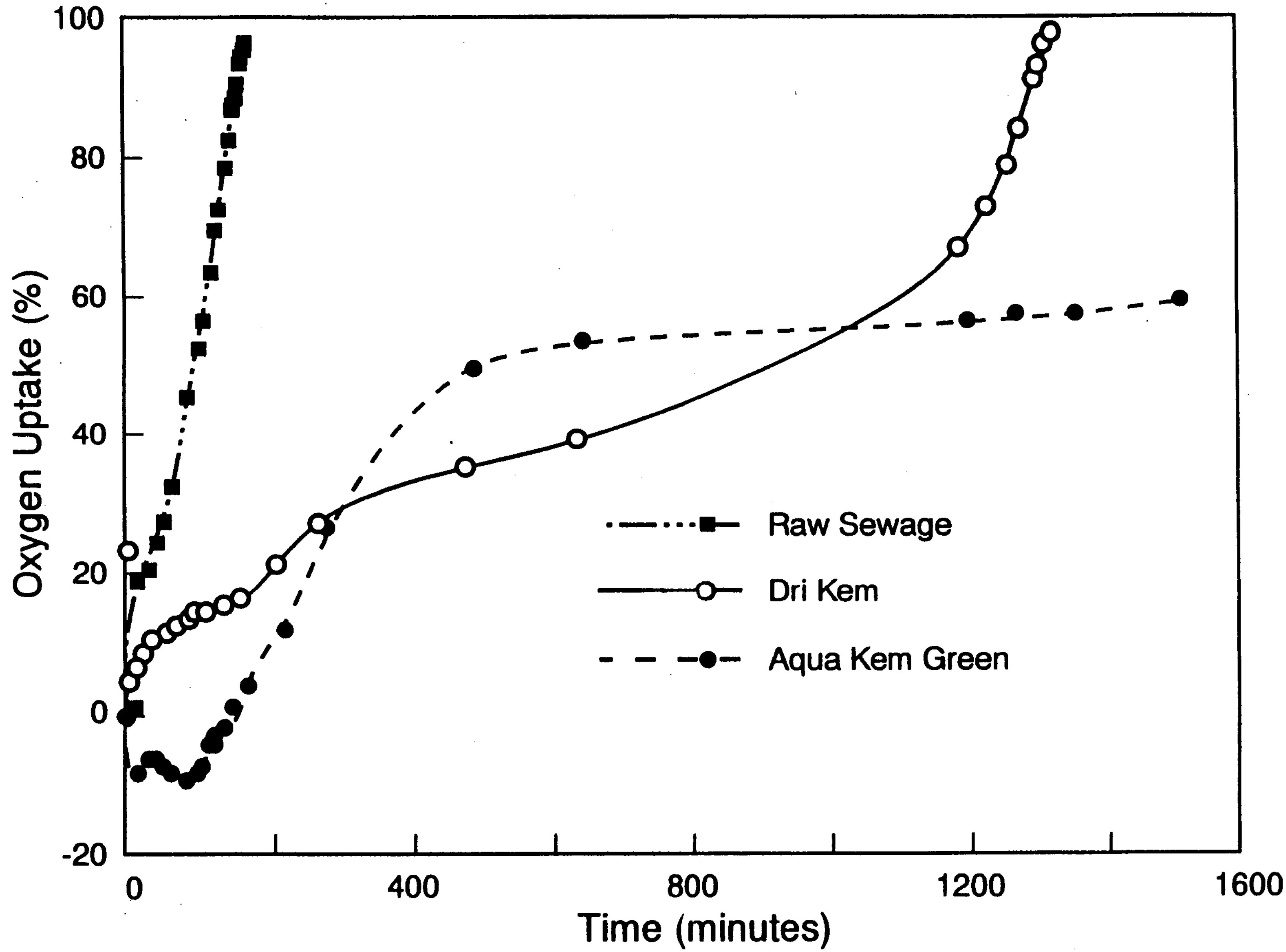

Figure 2. Effect of Dri Kem and Aqua Kem Green on the Oxygen Uptake of Raw Sewage

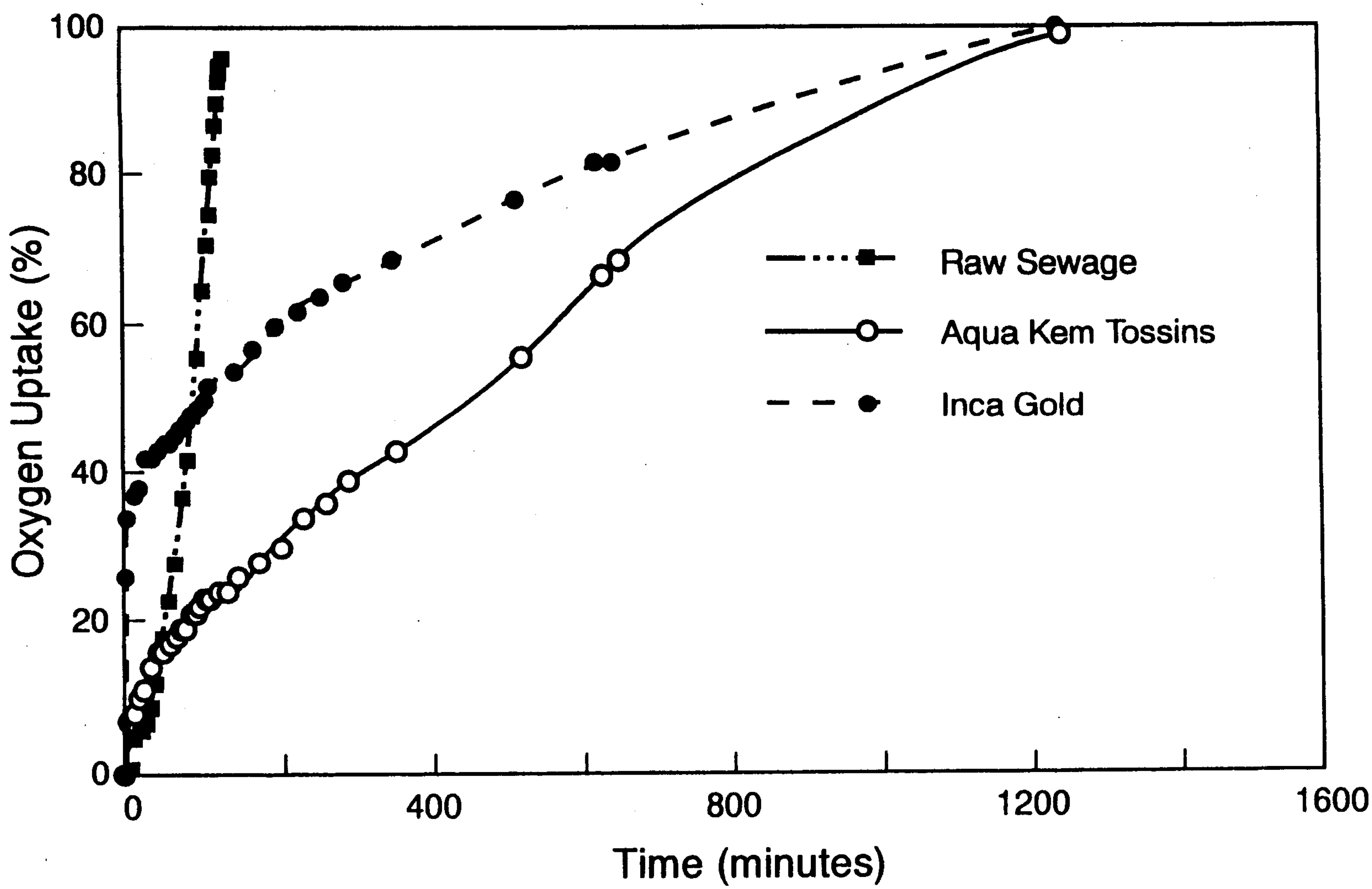

Figure 3. Effect of Aqua Kem Tossin and of Inca Gold on the Oxygen Uptake of Raw Sewage

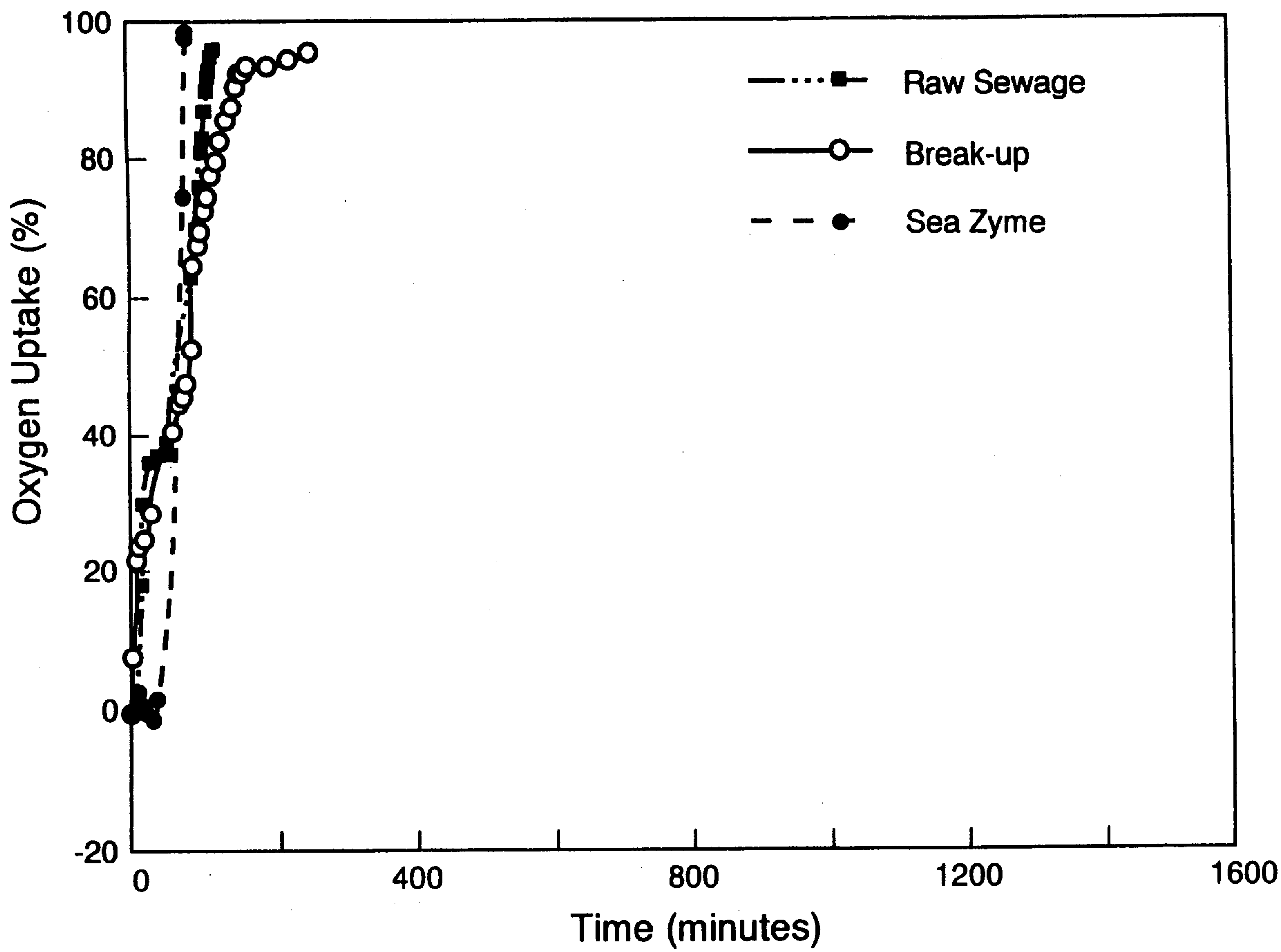

Figure 4. Effect of Break-Up and of Sea Zyme on the Oxygen Uptake of Raw Sewage

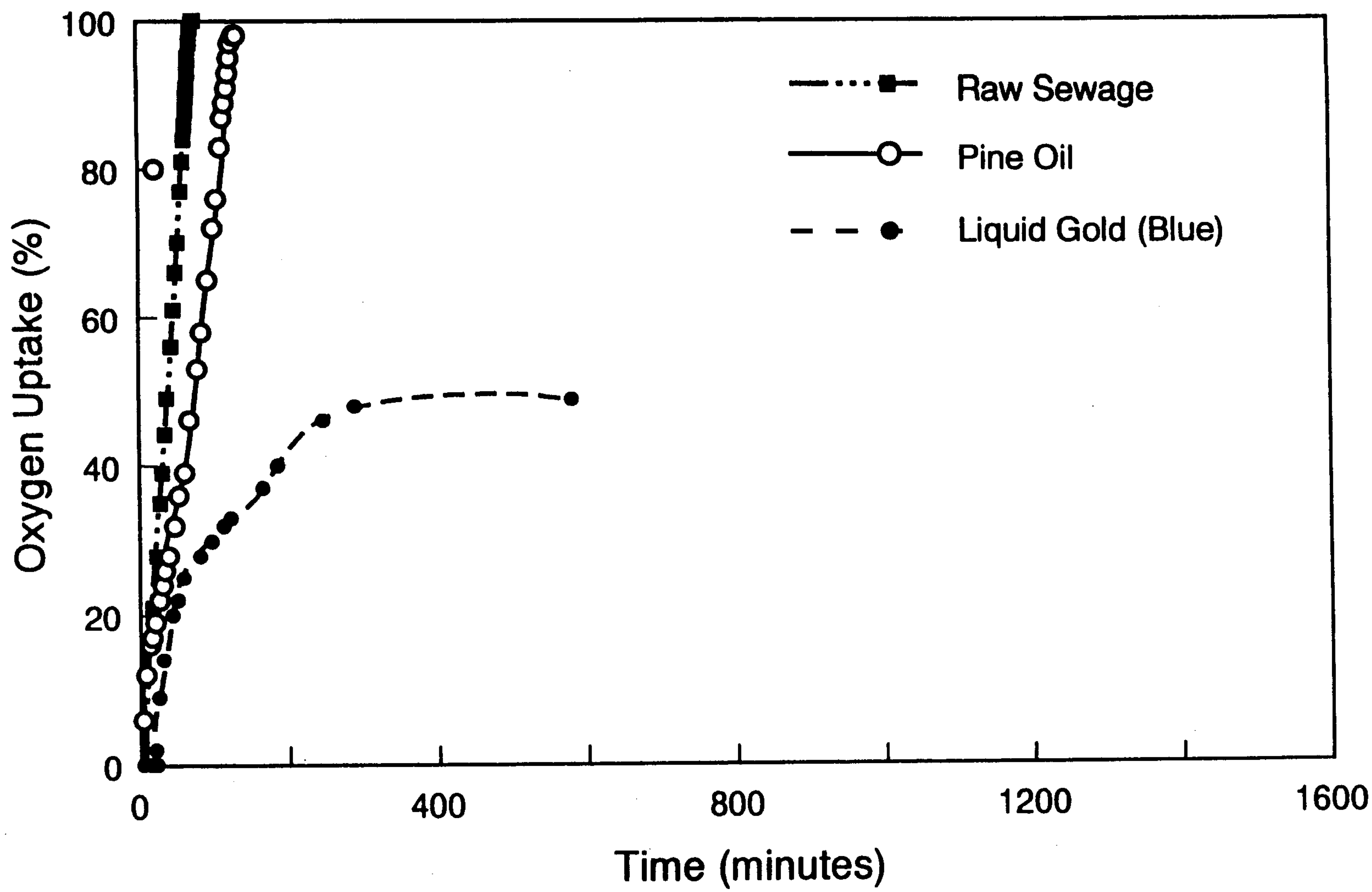

Figure 5. Effect of Liquid Gold and of Pine Oil on the Oxygen Uptake of Raw Sewage.

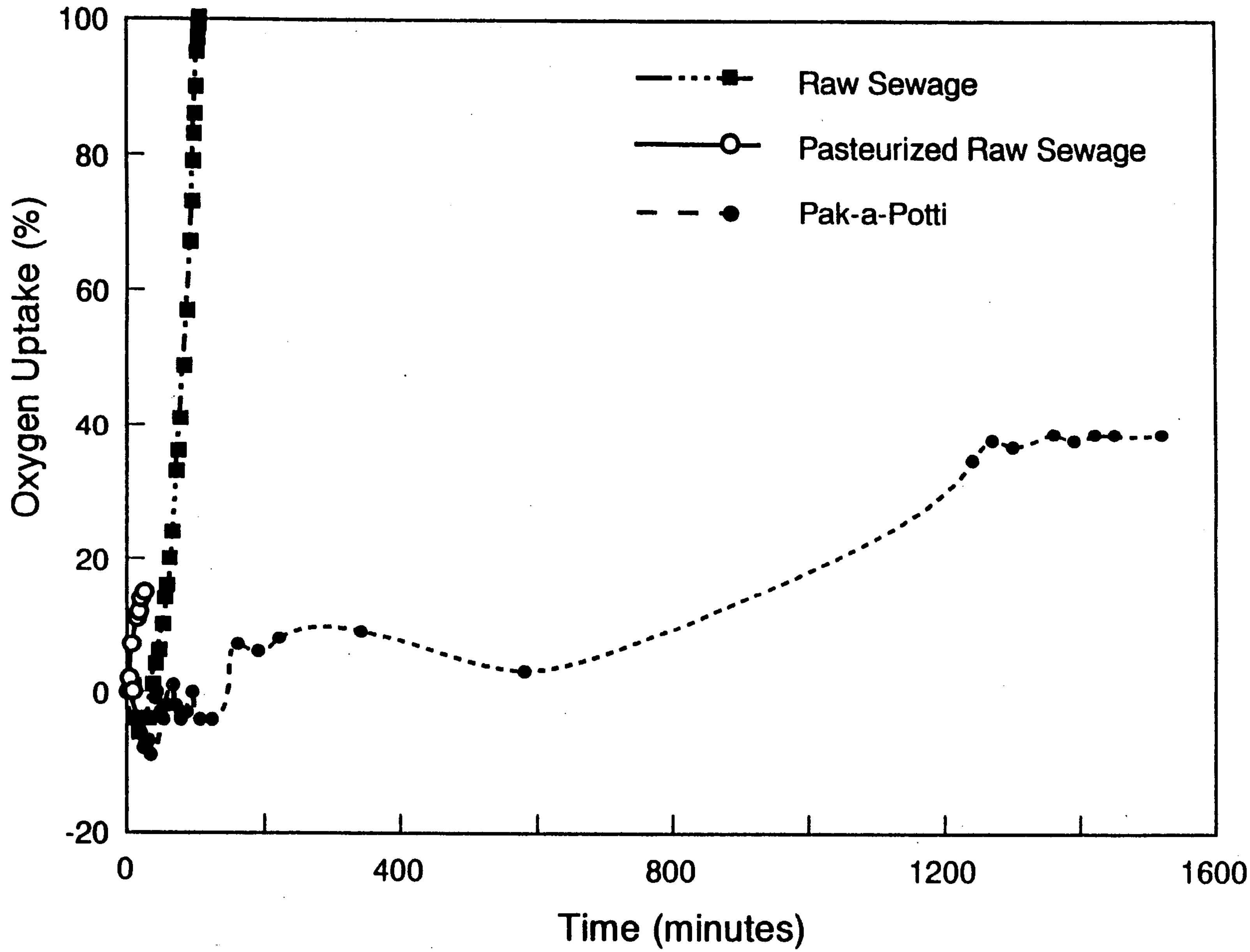

Figure 6. Effect of Pak-A-Potti and Pasteurization on the Oxygen Uptake of Raw Sewage.

Averaged values were used in preparation of the oxygen uptake rate curve. The time scale of all of the uptake curves were normalized to 1600 hours for comparative purposes. A raw sewage oxygen uptake rate curve is shown for each series of tests using the same lot of aerated raw sewage. Raw sewage being a heterogeneous mixture will vary in the concentration of the biodegradable organic material hourly and daily. The raw sewage oxygen rate uptake curve serves as a control to which the oxygen uptake rate curve for raw sewage of the same lot fortified with the recommended amount of RV wastewater additive can be compared.

Figure 1 shows that the oxygen uptake in the Pullman, WA wastewater treatment plant raw sewage was 99 percent in 89 minutes. The same curve shows no oxygen uptake at anytime when the same lot of sewage was fortified with Aqua Kem, which is a formaldehyde-methanol mixture. Samples of the same lot of raw sewage as that used in the above oxygen uptake test showed no toxicity at the beginning and end of the oxygen uptake test according to Table 6. Toxicity is not present when the Microtox^R toxicity bioassay test's EC50 is 100%. When the formaldehyde-methanol additive, Aqua Kem, was added to the aerated raw sewage the EC50 dropped to 1.85 percent and maintained that value throughout the test period. Aqua-Zyme which is an enzyme detergent preparation when added to raw sewage showed an oxygen uptake rate curve similar to that of raw sewage as seen in Figure 1. The oxygen uptake for the Aqua Zyme fortified sewage was 94 percent after 86 minutes while that for the raw sewage was 97 percent after 82 minutes. The toxicity test initially had an EC50 reading of 10.31. After the conclusion of the test, 96 minutes, it had become less toxic with an EC50 reading of 26.56.

The second lot of raw sewage taken on December 22, 1992 at the Pullman, WA wastewater treatment plant was significantly different from the

Table 6. Toxicity of Raw Sewage Fortified with RV Waste Water Additive

Sample Description	Additive Type	Lot Date	Toxicity: Initial EC50, 15 min (%)	Toxicity: Finished EC50, 15 min (%)
Raw Sewage	None	12/10/92	100	100
Raw Sewage + Aqua Kem Blue	Formaldehyde-methanol	12/10/92	1.85 (0.89-3.85)	1.65 (0.96-2.81)
Raw Sewage + Aqua-Zyme	Enzyme-detergent	12/10/92	10.31 (8.1-13.1)	26.56 (21.45-32.88)
Raw Sewage	None	12/22/92	15.2 (9.7-23.6)	31.0 (22.28-43.1)
Raw Sewage + Dri Kem	Paraformaldehyde	12/22/92	2.8 (2.36-3.40)	6.6 (5.66-7.65)
Raw Sewage + Aqua Kem Green	Alkylphenoxgpolyethoxy ethanol	12/22/92	10.2 (8.2-12.7)	2.5 (0.33-19.8)
Raw Sewage	None	12/28/92	56.8 (43.2-67.7)	100
Raw Sewage + Aqua Kem Tossin	Paraformaldehyde odorant	12/28/92	8.05 (4.95-13.08	3.21 (2.28-4.53)
Raw Sewage + Inca Gold	Paraformaldehyde	12/28/92	3.85 (1.97-7.53)	4.65 (4.59-4.72)
Raw Sewage	None	01/04/93	100	100
Raw Sewage + Break-up	Proprietary product	01/04/93	23.3 (12.61-48.72)	54 (39.16-82.71)
Raw Sewage + Sea Zyme	Enzyme	01/04/93	100	100
Raw Sewage	None	01/15/93	100	100
Raw Sewage + Liquid Gold	Alkyldimethyl benzyl ammonium	01/15/93	0.320 (0.308-0.332)	0.215 (0.152-0.306)
Raw Sewage + Pine oil	Pine oil	01/15/93	1.38 (0.192-9.96)	0.53 (0.113-1.73)
Raw Sewage	None	02/05/93	85 (67.3-100)	72.45 (55.3-94.89)
Raw Sewage + Pak-A-Potti	1,5-pentanedial	02/05/93	0.82 (0.791-1.05)	0.83 (0.531-1.86)
Pasteurized Raw Sewage	None	02/05/93	49.2 (24.98-97.02)	46.3 (20.76-95.37)

previous lot taken 11 days earlier. It took 161 minutes of the lot dated 12/22/92 to reach an oxygen uptake of 98 percent as shown in Figure 2. This lot of aerated raw sewage had a Microtox^R toxicity initially having an EC50 value of 15.2 while at the conclusion of the test, after 161 minutes, had an EC50 value of 31.0 according to Table 6. Dri Kem, a paraformaldehyde product when added to raw sewage lot date 12/22/92 had a high uptake rate for the first 25 minutes then it tapered off resuming an accelerated rate after approximately 1300 minutes. It took 1322 minutes to reach an oxygen uptake value similar to that of raw sewage. In Figure 2 raw sewage fortified with Dri Kem appears as an elongate "S" curve. The initial Microtox^R toxicity EC50 for this fortified raw sewage was 2.8 percent, increasing to 6.6 percent after 1322 minutes. Aqua-Kem Green, an alkyphenoxy polyethoxy ethanol, when added to the raw sewage showed an initial lag in the oxygen uptake for about 150 minutes after which there was a significant rate of oxygen uptake until 600 minutes after which it tapered off. A 61 percent oxygen uptake was observed at the conclusion of the test at 1600 minutes. The initial toxicity had an EC50 value of 10.2 percent, however, the E50 value at the conclusion of the test was inconclusive due to equipment failure.

The third lot of raw sewage was taken on 12/28/92. This lot of raw sewage reached 97 percent of the oxygen uptake in 125 minutes according to Figure 3. The initial toxicity EC50 value was 56.8 while at the conclusion of the test at 125 minutes, the EC50 value was 100 percent. When the raw sewage was fortified with Aqua Kem Tossin a paraformaldehyde/odorant it reached 97 percent of the oxygen uptake in about 1200 minutes. A moderate rate of uptake was noted, tapering off after about 75 percent of the oxygen was taken up according to Figure 3. The initial toxicity was moderate initially, but showed a lower (more toxic) EC50 value at the conclusion of the test. This fact may be an abnormality due to the presence of the odorant. Inca Gold is another paraformaldehyde product. When this product was added to the raw sewage a very rapid uptake of oxygen occurred in the first 15 minutes, thereafter there was a steady increase in the oxygen uptake. This fortified raw sewage reached 99 percent of the uptake in about 1200 minutes. The final Microtox^R toxicity EC50 value was slightly less initially than the value observed at the conclusion of the test, 1249 minutes.

Raw sewage lot #4 collected on 01/04/93 achieved a 97 percent oxygen uptake in 116 minutes. The sewage did not show Microtox^R toxicity initially and after completion of the test according to Table 6. When the aerated raw sewage was fortified with the additive Break-up, 96 percent of the oxygen uptake occurred after 164 minutes according to Figure 3. Though Break-up contains no formaldehyde or enzyme, it did have an initial Microtox^R EC50 of 23.3 percent and a final EC50 value of 54 percent according to Table 6. Sea Zyme which contains only an enzyme plus an inert filler when added to raw sewage resulted in a 98 percent oxygen uptake after 85 minutes according to Figure 4. The Microtox^R toxicity bioassay test revealed that the fortified raw sewage with Sea-Zyme was not toxic having an initial and final EC50 of 100 percent according to Table 6.

Lot number 5 of aerated raw sewage collected on 01/15/93 reached 99 percent of the oxygen uptake in 64 minutes according to Figure 5. The raw sewage did not show an initial or final Microtox^R toxicity. The same lot of raw sewage when fortified with Liquid Gold which is a quaternary ammonium chloride disinfectant reached 49 percent of the oxygen uptake after 578 minutes according to Figure 5. This fortified raw sewage was extremely toxic having an initial Microtox^R toxicity EC50 of 0.308 percent and a final value of 0.215 percent. Pine oil was another additive added to this lot of aerated raw sewage gave a 99 percent of the oxygen uptake at 140 minutes. Though the oxygen uptake rate was high, the Microtox[R] toxicity EC50 initial value was 1.38 percent and a final EC50 value of 0.53 percent. These EC50 values show a high degree of toxicity to the test microorganisms.

The raw sewage lot 6 collected on 02/15/93 reached a 99 percent oxygen uptake at 95 minutes according to Figure 6. The aerated raw sewage showed a slight degree of toxicity having an initial EC50 value 85 percent and a final value of 72.45 percent. When the same lot of raw sewage was fortified with PAK-A-POTTI a long oxygen uptake lag period occurred, about 190 minutes thereafter a slow steady oxygen uptake rate occurred reaching 39 percent after 1420 minutes according to Figure 6. This aerated fortified raw sewage had a high degree of toxicity having an initial Microtox[R] toxicity EC50 value of 0.82 percent and a finished value of 0.836 percent. A portion of the raw sewage from this lot was pasteurized to determine if the raw sewage contained substance which can cause a chemical uptake of oxygen. The oxygen uptake study on this lot of raw sewage, after being pasteurized, had an oxygen uptake of 15 percent of the dissolved oxygen after 24 minutes according to Figure 6. This can be due to the breakdown of heat liable complex organic sulfur compounds into mercaptans and the liberation of reduced metal from the metallorganic raw sewage complexes. A Microtox[R] toxicity bioassay test of the pasteurized sewage showed that the toxicity did not change statistically between the start and end of the oxygen uptake test. The initial toxicity is due to the mercaptan and metals mentioned in the above statement.

CHARACTERIZATION OF RV WASTEWATER AND OF TREATMENT SYSTEMS

INTRODUCTION

The characteristics of the black and gray waters discharged from RV wastewater holding tanks will have a bearing on the treatability of the wastewater. Those state of Washington operated rest areas that provide RV wastewater dump stations have facilities which completely treat or pretreat the wastewater. Most pretreated wastewaters are subsequently sent to a public owned treatment system. A few septic tank treated wastewater effluents located in Eastern Washington are discharged into a drain field. The lagoon treated effluents are allowed to evaporate from the open system. In most instances the wastewaters being treated are not exclusively RV black and gray waters, but contain the wastewater from the rest area's rest rooms. Because the amount of carrier water used in RV has been minimized the biodegradable organic material concentration may be ten times greater than that from the rest area rest rooms. The rest area rest room's wastewater will dilute the incoming RV wastewaters. Therefore, the quantity of each of the wastewater being discharged at any one time will result in variable strength influent flowing into the treatment units.

RESEARCH APPROACH

Sampling sites

Trailers and motorhomes black and gray water samples were collected from wastewater holding tanks being discharged at the rest area dump stations listed in Table 7 and shown in Figure 7.

Table 7. Rest Areas-Dump Station Location

Name of Rest Area	Code	Location
Elma	E	US Highway 12, eastbound
Gee Creek	NGC	Interstate I-5, north bound
Indian John Hill	WIJH	Interstate I-90, west bound
Nason Creek	NC	US Highway 2, west bound
Schrag	SCH	Interstate I-90, west bound
SeaTac	ST	Interstate I-5, north bound
Selah Creek	NSC	Interstate I-82, north bound
Selah Creek	SSC	Interstate I-82, south bound
Sprague Lake	SPL	Interstate I-90, east bound

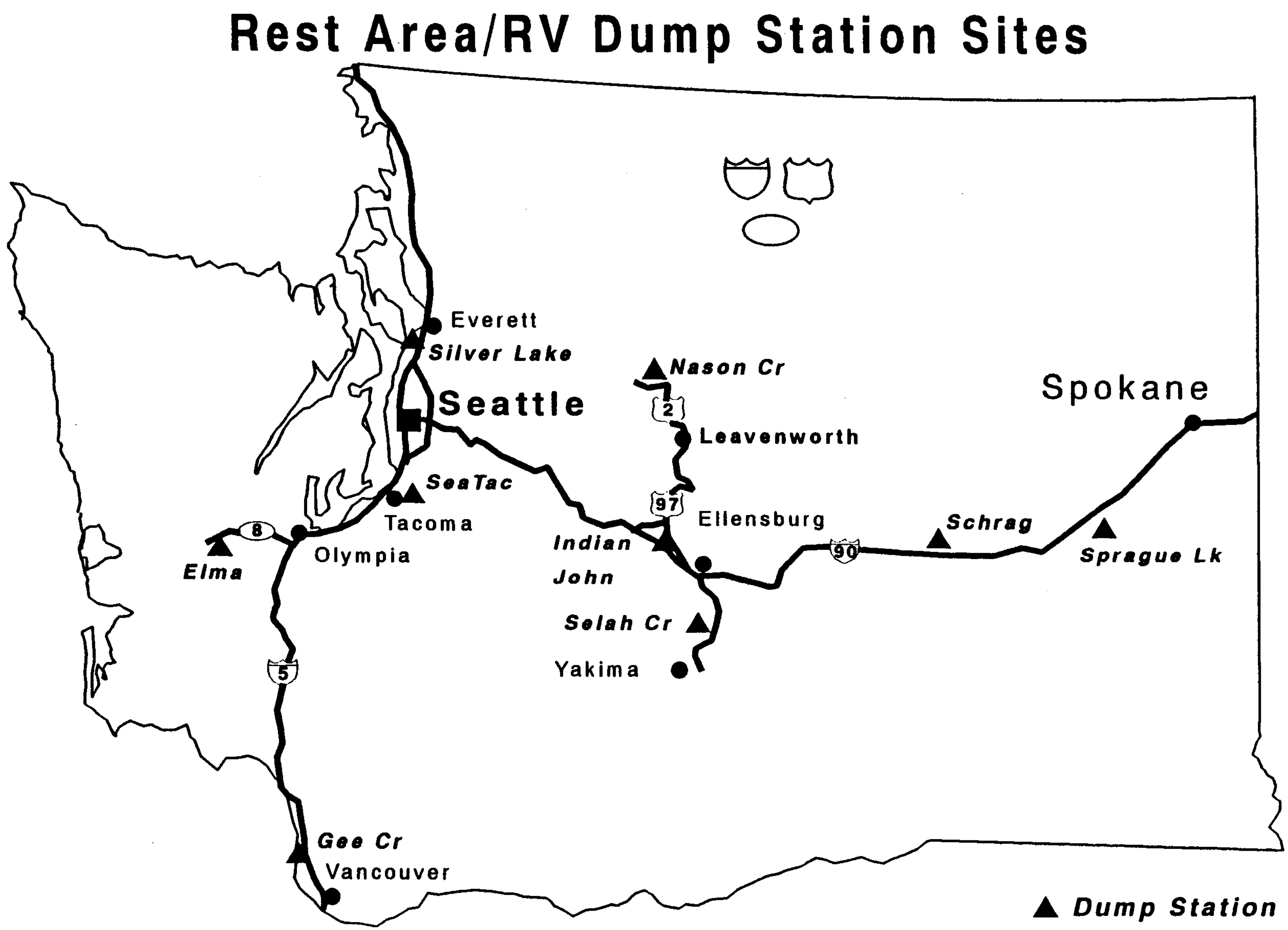

Figure 7. Rest Area/RV Dump Station Sites in Washington State.

Most rest area dump stations were sampled twice. The first series of RV sample collection was taken at all rest area sites during a 3 to 6 day sampling period. The second round of samples was taken over a 2 to 3 day sampling period at all stations except at Selah Creek and Sprague Lake. Those two dump stations were deleted due to security considerations at Selah Creek north and south bound rest areas and at Sprague Lake due to operational-electric power requirements. The deletion had little effect on the study.

Wastewater samples were taken from treatment lagoons at Selah Creek, Indian John Hill, Schrag and Sprague Lake rest areas. The Schrag lagoon influent consisted solely of wastewater from the rest area's rest rooms. Septic tank outflows were collected from the treatment units at Gee Creek and Schrag. The septic tank at Schrag received RV wastewater for treatment. Treatment systems at Nason Creek, Elma, and SeaTac were not sampled due to their inaccessibility of sample collection sites.

Sample Collection

Permission was requested from the RV occupant(s) to collected wastewater samples prior to the vehicles entrance into the dump station. At that time the occupants were interviewed to obtain the following information: type of wastewater additive used, number of days the wastewater was held in the holding tank, and estimated volume of the holding tank. In addition, the type of RV, license number, and sample coding and description were recorded. No attempt was made to measure the volume of wastewater discharged.

The procedure used by most RV users was to dump the black water first then switch the discharge valve to the gray water outlet. This scheme permitted the sampling of black and gray waters separately. Prior to wastewater collection a small volume of the wastewater was bled through the RVs discharge pipe. The wastewater being dumped was then discharged into a 4 gal plastic bucket. An 100 ml aliquot of the collected wastewater was placed in a clean bottle. All sampling equipment was thoroughly rinsed prior to collection of the next sample. Since the characteristics of the sampled wastewater can change rapidly. The samples were immediately analyzed. Where samples had to be held longer than one hour, they were iced as a means of preservation.

The procedure used to sample multi-cell sewage treatment lagoons was to obtain grab samples of the influent and overflow from the primary cell and the contents of the final cell. The sample from the final cell was collected from the bank opposite the location of the primary overflow channel. Septic tank overflow samples were obtained from just below the pipe leading to the drain field. Lagoon and septic samples were handled and preserved in the same manner as the black and gray water samples obtained from RVs.

The total number of samples that were collected per day was controlled by the number that could be analyzed that particular day and the analytical equipment available.

Methods of Analysis

As a means of characterizing the wastewater for of its strength, acidity/basicity, and toxicity the following parameters were determined: 5 day biochemical oxygen demand, pH, and the standard or basic "Microtox^{R}" toxicity bioassay test. The above mentioned tests were done at the respective rest areas using portable self contained and line operated equipment.

Biochemical oxygen demand, 5 day (BOD). The biochemical oxygen demand is a measure of the strength of the wastewater in terms of the dissolved oxygen consumed by the microorganisms in degrading the organic material. Since the magnitude of the oxygen uptake is time dependent, the standard 5 day incubation period was used. The samples were incubated at 20°C in a temperature controlled insulated chest. The method used to determine the 5 day BOD was method 5210B 5-day BOD test 5-4 found in Standard Methods for the Examination of Water and Wastes, 17 ed. (15). A total of 182 samples were analyzed for the 5-day BOD consisting of 87 blackwater, 56 gray water, 10 combined black and gray water, 26 wastewater treatment and 3 miscellaneous samples. The analytical results appear in Appendix B. Table 8 is a summary of these results.

The data in Table 8 reveals that the black wastewater had a higher amount of biodegradable organic material than the gray water. The values for the combined black and gray wastewater 5 day BOD values when compared to that obtained by Kiernan et al. in their 1983 report showed a close similarity (2). The values differed by 0.6 of a percent of each other. The average blackwater was about twice as strong as the average gray water. If equal volumes of black and gray waters were mixed having the average value as reported in Table 8, then the resulting combined black and gray water would have a 5 day BOD of 2,450 mgO_2/L. Though this value is 700 mgO_2/L less than the combined black and gray wastewater appearing in Table 8, the value only differs by 4 percent to that found by Robins and Green (14).

The data in Table 8 shows that the lagoons at the Selah Creek, Indian John Hills, Schrag and Sprague Lake rest areas were highly efficient in stabilizing the biodegradable organic material. Indian John Hill and Schrag had the greatest efficiency. More sampling would have had to be done at Selah Creek and Sprague Lake to make the above statement. In comparing the values for the Schrag septic tank overflow to that of the North Gee Creek septic tank overflow, one must consider that the wastewater entering the Schrag septic tank is solely

Table 8. Average 5-day BOD and pH Levels in Wastewater

Type of Sample	5 day BOD Average mgO_2/L	5 day BOD Range mgO_2/L	pH Average	pH Range
Black wastewater	3418 ± 1927	822-9240	8.1 ± 1.0	4.8 ± 9.5
Gray wastewater	1481 ± 1368	233-7749	6.1 ± 0.9	4.4 ± 8.5
Combined black and gray wastewater	3108 ± 2368	931-8487	7.4 ± 1.3	5.3 ± 9.0
South Selah Creek lagoon	42 ± 6	36-47	8.7 ± 0.2	8.5 ± 9.0
Indian John Hill lagoon, raw influent	245 ± 170	89-482	8.1 ± 0.4	7.7 ± 8.5
Indian John Hill primary lagoon overflow	260 ± 65	196-325	8.0 ± 0.2	7.7 ± 8.2
Indian John Hill final lagoon	25 ± 10	15-41	8.4 ± 0.6	7.7 ± 8.5
Schrag lagoon, raw influent	320		8.5	
Schrag primary lagoon overflow	18 ± 4	14-22	7.5 ± 0.1	7.4 ± 7.6
Schrag final lagoon	12 ± 8	3-20	8.2 ± 2	8.1 ± 8.4
Schrag septic tank outflow	1795 ± 245	1550-2041	9.4 ± 0.1	9.4 ± 9.5
Sprague Lake primary lagoon overflow	60		7.5 ± 0.2	7.3 ± 7.6
Sprague Lake secondary lagoon	11		7.6	
North Gee Creek septic tank outflow	492		7.4	

RV dumped wastes and that at North Gee Creek is a combined rest area rest room and RV dumped wastewater.

Hydrogen ion activity (pH). The reciprocal of the logarithm to the base ten of the hydrogen ion activity is known as the pH. This measurement is an important parameter in controlling microbial growth. The pH for optimum growth of sewage degrading microorganisms is between 6.0 and 8.5. In this study an Orion model 407 pH meter was used to measure the pH according to the method described by Clescin Et al. (16). A three point standard procedure was used to calibrate the meter.

The pH of most of the samples collected appear in Appendix B. This information is summarized in Table 8 for various wastewater types. The average pH values appearing in Table 8 are influenced by the nature of the organic substances in the wastewater, the length of time it has been held prior to dumping and the type of RV wastewater additive that had been used. Unless the wastewater in the holding tank is biologically inactive due to the RV wastewater additive, the wastewater in the holding tank becomes an active biological system where changes in pH occur rapidly. Therefore the average range of the black water is decidedly alkaline due to the biological brake down of nitrogen containing organic compounds to ammonium ion., the gray water which contains a minimal amount of organic nitrogen will become slightly acid due to the formation of organic acids during the breakdown of the organic material present. The pH of the combined black and gray wastewater lie somewhere between the pH of the black and gray waters. The average pH of the combined black and gray wastewater is that of a typical potable or carrier water.

The use of the pH parameter in evaluating treatment systems must be evaluated differently than in characterizing a RV wastewater being dumped. The difference is due to the more complex and diversified biotic present in a lagoon.

One class of microorganism that was present in some primary and all final lagoon cells was algae. The photosynthetic activity of algae will cause the wastewater undergoing treatment to become more alkaline which results in the elevation of the pH. This was observed in lagoons at the Selah Creek, Indian John Hill and Schrag rest areas. At these lagoons the wastewater in the final cell was greater than that in the primary lagoon cell. The influent pH enter the primary lagoon cell is influenced by the proportions of the black and gray waters and the rest area's rest room wastewater. The presence of black water in the influent may result in an influent having a pH greater than 8. Primary lagoon cells where active biodegradation occurs will have a lower pH than the influent or water in the final lagoon cell.

Biological activity in septic tanks are different than these in lagoons. These units are anaerobic systems where hydrogen sulfide and organic acids are major products, both of which are slightly acidic and ammonia which is alkaline. In addition, the nature of the influent into the septic tank will influence the pH of the septic tank outflow. The North Gee Creek septic tank which receives a combined black and gray water and rest room wastewaters had a slightly alkaline pH of 7.4. While the Schrag septic tank treating solely black water had a much higher outflow pH of 9.4.

Microtox^R standard/basic toxicity assay. The toxicity of black and gray waters and treatment system wastewaters is dependent on the nature of the chemical species present. The species found in black water are derived from human excreta. The constituents in gray water had a much more variable and different composition. Gray water contains wash water from showers and bathroom and kitchen sinks. Black and gray waters frequently contain toxic substances sensitive to microorganisms. Wastewater constituents which are toxic may become degraded during biological treatment to chemical substances which show little or no toxicity. The addition of certain RV additives can enhance the toxicity of the wastewaters preventing or slowing the degradation process.

A search was conducted to find a method to determine the toxicity of black and gray waters. Several methods were examined which could be carried out in the field and were rapid and simple. The "Microtoxic" Standard/Basic bioassay toxicity test met these requirements (13). The Microtox[R] method is based on the change in the intensity of bioluminescence produced by the marine microorganism *Photobacterium phosphorum* as a measure of toxicity. The test procedure utilizes the direct contact between the dissolved and suspended material and the bioluminescent microorganism for a specific period of time, usually 5 and 15 minutes. Using a serial dilution technique the percent or quantity of sample to cause a 50 percent decrease in bioluminescence, EC50, can be determined. Work done by Logue et al. (17) utilized this technique to determine the toxicity of wastewaters.

A Microbics Corp. Microtox[R] Model 500 analyzer with a portable data collection and reduction system was used to measure the bioluminescence and collect the resulting data. The protocols described in detail in Appendix A were followed in performing the standard/basic procedure. The data was statistically analyzed and reported using Microtox[R] version 5 software. The results of the toxicity bioassay and type or brand of additive present in each sample appears in Appendices B and C. The toxicity data appearing in Appendix B is reported as the reciprocal of the percent of the effective concentration necessary to cause a 50% reduction in the biolumenescence, EC50. This term though acceptable by the U.S. EPA is not preferred by many toxicologists. Therefore the data which appears in Appendix C is in terms as the EC50 the more preferred form. Appendix C is a compilation of the Microtox[R] toxicity data in terms of the EC50 value for each sample collected. In addition other information as vehicle license number, date and time of collection and information concerning the nature of the additive, if any, in the sample of black, gray, or combined black and gray water. Toxicity of the wastewater in the treatment lagoon and in the septic tank outflow are also found in Appendix C.

A summary of the average Microtox^R toxicity bioassay test data and the range of values for the black waters using a specific RV additive appears in Table 9. The average values are limited to where 5 or more samples for the specific additive were measured. This limitation was done to reduce the bias in the average value. Only one average and range of values are given for gray water as additives are not normally added.

Because of the limited number of samples taken at some of the treatment systems, the sample limitation concept was not used. The average toxicity value for blackwater where no additive had been added gave an EC50 value after 5 minute exposure of 4.86 percent while after 15 minute exposure it was 4.17 percent. Examination of the 95% confidence limit indicates that these two values are statistically the same. This means that slightly greater than four percent of the sample will cause a 50% reduction in the bioluminescence. The black water does contain naturally produced toxic substances which inhibit the activity of the test microorganisms. The wide range of these blackwater values shows a large variability in toxicity of the samples. A variety of factors previously mentioned will cause the variability. Black water without an additive was used as the reference value for comparing the effect of specific additives on the toxicity of the black water. Black water containing the paraformaldehyde additive increased in toxicity compared to the reference. The percent of the average black water containing paraformaldehyde required to cause a 50 percent reduction in bioluminescence was about half as much as the black water used as the reference. Paraformaldehyde being a time release form of formaldehyde will maintain a

Table 9. Summary of Toxicity Data

Type of Sample	Type of Additive	Number of Observations	Toxicity EC-50 Average (5 min)	Range	Average (15 min)	Range
Black water	None	45	4.86 ± 9.58	<0.01-29.32	4.17 ± 98.32	<0.01-38.60
Black water	Paraformaldehyde	36	2.03 ± 2.11	<0.01-10.16	1.78 ± 91.83	<0.01-7.81
Black water	Formaldehyde and methanol	31	3.31 ± 3.18	<0.01-10.60	3.26 ± 94.15	<0.01-10.90
Black water	Enzyme	15	4.58 ± 6.61	0.14-21.02	4.13 ± 96.19	0.18-24.75
Black water	Detergent	5	3.50 ± 4.19	0.35-10.72	3.00 ± 94.72	0.15-11.4
Black water	Pine-oil	7	0.21 ± 0.37	<0.01-102	0.19 ± 90.38	<0.01-0.94
Gray water	None	75	10.78 ± 27.30	<0.01-100	8.01 ± 920.28	<0.01-100
Selah Creek, lagoon		3	100		100	
Indian John Hill, influent		6	34.78 ± 44.16	11.75-100	36.5 ± 942.93	8.76-100
Indian John Hill, primary lagoon		3	100		100	
Indian John Hill, final lagoon		5	100		100	
Schrag, primary		2	29.2	12.85-45.62	56.08	12.15-100
Schrag, final lagoon		2	93.27	86.53-100	100	
Sprague Lake, primary lagoon		2	32.91	24.99-35.02	62.50	40.79-100
Schrag septic tank outflow		4	2.20 ± 1.18	0.77-3.66	1.62 ± 91.17	<0.01-2.78
Gee Creek septic tank outflow		1	1.57		1.59	

moderate level of formaldehyde during the wastewater holding period. The black water containing formaldehyde and methanol showed approximately a 26 percent increase in toxicity over the reference. Formaldehyde and methanol are difficult to degrade at concentrations initially found in blackwater holding tanks. As more blackwater is added to the holding tank the formaldehyde becomes more dilute and the wastewater becomes reinoculates by microorganisms in the incoming blackwater. Degradition then resumes as was found by Kiernan et al. in their study (2). The data in Table 9 shows that the EC50 value of the average black water containing an enzyme additive was statistically the same as the average black water reference. Addition of a large quantity of household dishwasher detergent to the black water caused an increase in the Microtox^{R} toxicity when compared to the average black water reference according to Table 9. The increase in toxicity was similar to the average black water where the formaldehyde-methanol had been added. Detergents when sufficiently diluted and reinoculated with microorganism from black water can be degraded. Pine oil added to blackwater gave the greatest degree of toxicity. The pine oil increased the toxicity of the black water without an additive by about 22 times. The black waters containing the pine oil additive had a very strong pine odor. This indicates that an excess of pine oil had been added beyond the minimum amount necessary to control biological activity and odor production.

The toxicity of an average gray water is reported in Table 9. Gray water normally does not contain an additive and the possibility that the water contains natural occurring toxic material is small. The effect of the latter is the reason that the average gray water had only about half the toxicity as the average black water without an additive. The toxicity values for the grey water ranged from extremely highly toxic to being non-toxic. This confirms the fact that gray water is a highly hetergenous wastewater.

A review of the treatment systems average toxicity values shows that the lagoons were doing an excellent job in degrading the toxic components in the wastewater. Water samples taken from the Selah Creek lagoon from a point furthest from the raw sewage inlet gave an EC50 value of 100. This value indicates that the wastewater does not contain toxic substances. Another lagoon system investigated was a four compartmentalized system at Indian John Hill. The influent to the primary lagoon was quite variable as shown by the range of EC50 toxicity values appearing in Appendix C. As previously mentioned the reason for the raw sewage influent variability in toxicity is the proportion of rest area rest room wastewater to the black and gray water reaching the primary lagoon. The raw sewage influent reaching had an average EC50 of approximately 35 percent. After undergoing biological treatment in the primary lagoon the EC50 value was 100 percent. This means the effluent leaving the primary lagoon and what is in the secondary lagoon was free toxic material. The content of the primary lagoon at Schrag had an EC50 value of 29.2 percent after 5 minutes of exposure and 56.08 percent at 15 minutes. The wide difference in toxicity is due to the susceptibility of the toxic material to become detoxification through biodegradation. The final lagoon at the Schrag rest area did a good job in detoxifying the toxic material the EC50 was statistically greater than 90 percent of the sample. The Sprague Lake primary lagoon was the only cell that contained water. The EC50 value from this lagoon were similar to the primary lagoon at Schrag. Septic tank outflows had a moderately to highly toxic as shown by values appearing in Table 9. The anaerobic conditions in the septic tank produced partially degraded products which are toxic to aerobic microorganisms which the Microtox^{R} toxicity test microorganism is a member.

ACKNOWLEDGMENT

The research reported herein was conducted under GC8720, Task 13 by the Washington State University. Mr. Ervin Hindin, Professor, Civil and Environmental Engineering Department was principal investigator from this study.

Special acknowledgment is made to Mr. Flyndt Windom, who assisted Mr. Hindin in the field studies, to Miss April Miller and Mr. Chris Warberg, who assisted in the various surveys and in conducting oxygen uptake rate studies, and the on campus Microtox^{R} toxicity bioassay tests.

Special thanks is given to Mr. William Melton whose guidance during the initial stages of this investigation made this study possible. Acknowledgment is made to all the custodians at the rest areas where sampling of the RV wastewaters and treatment systems were done.

Grateful thanks is given to Mrs. L. Cox for typing the project report manuscript.

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APPENDIX A

DESCRIPTION OF THE MICROTOX METHOD

BASIC (STANDARD) ASSAY PROCEDURE

Analyzer Preparation

1. Place clean unused cell in the reagent well and in A-1 through A-5 and B-1 through B-5.

2. Using the 500 ul pipettor with a blue pipettor tip, pipet two shot, aliquot, 1.0 ml of reconstitution solution into the reagent well.

3. Using the same pipettor (500 ul) pipet one shot of microtox diluent solution in the cells of row B, B-1 through B-5.

4. With the same 500 ul pipettor transfer by pipeting two shots, 1.0 ml of microtox diluent into the cells in row A. A-1 through A-4, leaving A-5 empty.

Sample Preparation

1. Using the 250 ul pipettor with a blue pipet tip, transfer 250 ul of microtox osmotic adjustment solution into the cell in well A-5.

2. Using the same 500 ul pipettor transfer 5 shots, 2.5 mls, of the sample to be tested in cell A-5.

3. Mix the contents of the cell in A-5 aspirating and dispensing the sample back in the cell five times.

4. Still using the same 500 ul pipettor transfer two shots, 1.0 ml, with the pipettor from cell A-5 to A-4 and mix with the pipettor, aspirating and dispensing, transferring 1 ml, two shots from cell A-4 to A-3 and mix as described previous, transfer 1 ml, two shots from cell A-3 to A-2 and mix as described.

5. Dispose the pipet tip on the 500 ul pipettor used in step 4 and wait 5 minutes for temperature equilibration.

Reagent Preparation

1. Get a vial of microtox reagent from the freezer.

2. Remove the seal and open the cap and observe the condition of the freeze dried pellet. Make sure the pellet is seated flat on the bottom of the vial. If not tap the vial and make the pellet lie flat.

3. Take the reconstitution solution in the cell found in the reagent well and empty the contents all at once into the vial of the microtox reagent.

4. Swirl the vial to make sure uniform wetting of the dry reagent. Then pour the contents of the vial into the cell that was in the precooling reagent well and place the cell back in the reagent well.

5. Use 500 ul pipettor with a clean tip, mix the reagent in the cell 20 times by aspirating and dispensing.

6. Using the 10 ul pipettor with the appropriate tip, white, transfer 10 ul of reagent from the reagent well to each cell in row B, from cell B-1 through B-5. Some care is required for precise and accurate handling of this small volume of liquid. Do not allow the end of the

tip to touch the bottom of the cell, that could prevent proper filling of the pipet. Rest the 10 ul pipet tip against the cell's inside rim, slide the tip down until you could feel the ridge of the pipet tip touching the rim of the cell; stop there. The tip is in a good position under the surface of the liquid but not touching the bottom.

7. Mix the contents of each cell in row B by gently swirling the contents.

8. Wait 15 minutes for the reagent in the cell in row B to stabilize. Set the timer for 15 minutes. While you are waiting to read the cell prepare the computer.

COMPUTER PREPARATION, Version 6

1. Connect all instrument components with the appropriate cables, microtox analyzer, computer, and printer.

2. Place the plugs for the Microtoxic analyzer, computer pack, and printer converter into the outlets of the surge protector strip.

3. Place the plug of the surge protector strip into a 110V electrical outlet box.

4. Turn the surge protector strip switch to the ON position.

5. Turn the computer and printer ON.

6. The monitor or computer screen will display the day-month-year. Make the necessary correction if needed. Then key ENTER. Next the time will appear, make the necessary changes if needed. Then ENTER.

7. The screen will display the C:TEMP prompt. If not, after the C prompt appears type CD/TEMP. Type MTX6, then key ENTER.

8. The screen will welcome you to the Data Capture and Reporting Program. Touch the space bar to continue.

9. The Master Menu will appear on the top dialog. The bottom dialog will ask you to enter the protocol or options. To run the standard or basic test, type, B, then key ENTER.

10. The Master Menu for the basic (standard) test will appear on the screen to collect data from the Microtox analyzer. Enter 1 - Start Testing, then key ENTER.

11. Answer the questions appearing in the Define Test Parameter menus. They will appear in the following order.

    a. Number of tests: ? Three tests may be run simultaneously. If one test is to be run at a time, type 1, if two tests at one time, type 2, and three simultaneously type 3. After typing the appropriate number key ENTER.

    b. File name for test: You may enter up to 8 characters, e.g., RVWASTE, PULLSTP, TEST 1, etc. After which key ENTER. Note: Do **NOT** enter a file extension. It is automatically done.

    c. Description: Enter the sample ID. You can enter 3 lines or about 200 characters. The sample ID should contain information as source of sample, date and time of sample collection, plus any other information you wish.

    d. After the description has been entered, the system will display the following variables with default values:

1) Number of controls: usually you need one per test. If one is not displayed, Key 1, then ENTER. Note: Normally only one control is needed, but more may be run.

2) Number of dilution: The default number is 6. That is six tubes of samples. If your sample has a low or low-medium toxicity EC_{50} value of 13% or greater you need only 4 dilutions (tubes). Key 2 to response to the dialog "Enter line # for correction," then key the number of dilutions (Key 4) followed by keying ENTER.

3) In duplicate?: The default value is NO. If you wish to run the test in duplicate, Key 3 to the dialog "response In duplicate" for correction, type YES then ENTER.

4) Initial Concentration--Dilution Factor: The default values are zero. If you are running the test to determine the EC_{50} as percent of sample, key 4 to "Initial Concentration" dialog request, then ENTER. The zero will disappear requesting a number to be entered. Type 45%, then ENTER. If the initial concentration is different than 45%, then key in the appropriate percentage. If a sample of a specific concentration is used, for that value consult the Microtox Manual for determining the concentration number. "Dilution Factor" - since you are making 1:1 dilutions, key 2, then ENTER The four serial dilutions will be automatically calculated and displayed on the screen.

5) Concentration Table: Leave this entry blank unless you are using non-serial dilutions.

6) Units: Retain the default value as % unless you wish to express results in concentration of a specific chemical compound.

7) Osmotic Adjustment, MOAS, Return the default value.

8) Report: Retain the default value.

9) Time 1: Usual value is 5 minutes, retain the default value.

10) Time 2: Usual value is 15 minutes, key 10, then ENTER. Then key in 15 minutes and ENTER.

11) Time 3: A time 3 is usually not run, so key 11, then ENTER. After which key 0, then ENTER for Time 3 will read none

Assay Procedure

1. The screen will show the Curvette or cell Layout. The screen will prompt readings for lines B and A.

2. After 15 minutes, place the cell from row B-1 in the read well, then press the SET button, the cell will be lowered in the turret below the surface then it will automatically return to the surface.

3. Read the initial light level of each cell in row B. As the B-1 cell is already in the read well then press the READ button. The data will be recorded automatically on the computer screen. The screen will tell you which curvette or cell you are at.

4. Return the B-1 cell from the read well to the B-1 well.

5. Read the remaining cells in the read well, in the following order: B-2, B-3, B-4, and B-5.

6. The computer will then start timing.

7. Immediately make the following 500 ul transfers with a 500 ul pipet and mix by aspirating and dispensing, mixing 3 times after each transfer A-1 to B-1, A-2 to B-2, A-3 to B-3, A-4 to B-4, A-5 to B-5.

8. The computer clock will time, when 5 minutes are up an alarm will go off. Then read B-1, B-2, B-3, B-4, and B-5. Note: B-1 is the blank.

9. The clock will continue to run. When the 15 minutes are up an alarm will go off. Then read B-1, B-2, B-3, B-4, and B-5, then hit space bar.

<u>Data Reduction/Data Report</u>

1. When the readings are complete, the system displays the names of the files it has created, containing the raw data:

   File name. K 5 minutes
   File name. K 15 minutes

   The K designates that you used the basic or standard analysis option, and the length of the contact time.

2. Hit space bar to return you to the Master menu for Basic test. Select RUN STATISTICS ON A DATA FILE from the Master Menu by keying 3 then ENTER.

3. The screen will read File specification: *.K*. Key ENTER. A file selection program menu will appear. Move the cursor to the file you wish the calculations to be performed, then key ENTER.

4. Touch space bar to run the statistics. The initial data will appear, then touch the space bar to continue.

5. The final statistical results will appear, then touch space bar to continue.

6. The Calculation Menu will appear on the Screen. Select PRINT REPORT, number 2, then ENTER. The data report will be printed by the printer.

7. After the report has been printed the computer will return you to the Calculations Menu. Select #6 Run a New Data File. Key ENTER, then key ESC. This will put you back in the File Review Program.

8. Repeat Step 3 through 6 for the next time period: e.g., File name. K15.

9. When you are all through the Calculations Menu will appear. Type X, then ENTER to get out of the Microtox program.

APPENDIX B

CHARACTERIZATION OF WASTEWATER SAMPLES

APPENDIX B. CHARACTERIZATION OF WASTEWATER SAMPLES

Code	Type	Toxicity Units 5 min	Toxicity Units 15 min	BOD5 mgO_2/L	pH
RV9ST	Black	5	5	2203	
RV10ST	Black	23	22	2420	
RV11ST	Black	47	58	2109	
RV12ST	Black	83	84	2078	
RV13ST	Black	407	484	5956	
RV14ST	Black	2	3	2885	
RV15ST	Black	42	88	1257	
RV17ST	Black	29	37	822	
RV18ST	Black	55	66	3381	
RV19ST	Black	57	100	1210	
RV20ST	Black	13	13	3000	
RV21ST	Black	186	370	1923	
RV6bE	Black	>100 0	>1000	4219	
RV7bE	Gray	447	1113	858	
RV8bE	Black	40	41	3102	
RV9bE	Gray	125	150	800	
RV10bE	Black		58	2699	
RV11bE	Gray	21	24	251	
RV12bE	Black	>100 0	>1000	3350	
RV13bE	Gray	410	650	1319	
RV1NGC	Black	42	54	1427	
RV2NGC	Gray	24	16	281	
RV3NGC	Black	98	104	2730	
RV4NGC	Gray	150	156	1458	
RV5NGC	Black	8	7	2481	
RV6NGC	Gray	22	6	620	
RV7NGC	Black	105	125	2699	
RV8NGC	Black	49	93	4280	
RV9NGC	Gray	37	81	690	
RV10NGC	Black	771	>1000	1127	
RV15NGC	Black & Gray	508	>1000	2854	
RV16NGC	Black	>100 0	>1000	8686	
RV17NGC	Gray	322	800	538	
RV18NGC	Black	70	246	2120	
RV19NGC	Gray	4	10	248	
RV20NGC	Black	115	180	4126	
RV1SSC	Black	>100 0	>1000	7500	8.7
RV2SSC	Gray	74		570	6.0

Code	Type	Toxicity Units 5 min	Toxicity Units 15 min	BOD5 mgO_2/L	pH
RV3SSC	Lagoon	<1	<1	36	8.7
RV4SSC	Lagoon	<1	<1	44	8.8
RV5SSC	Black rinse	<1	<1	8	6.8
RV6SSC	Gray	365	>1000	3720	5.2
RV7NSC	Gray	41	69	1290	6.6
RV8NSC	Black	20	26	2640	8.7
RV9NSC	Black	3	3	1663	8.6
RV10SSC	Gray	53	69	575	6.6
RV11SSC	Gray	35	82	597	6.5
RV12SSC	Lagoon	<1	<1	44	8.5
RV13NSC	Black	>1000	>1000	2880	9.5
RV14NSC	Gray	34	>1000	2565	8.2
RV15NSC	Black & Gray	342	611	1290	9.0
RV16NSC	Black	699	388	3105	7.6
RV17SSC	Black	26	45	4800	9.5
RV1RIJH	Black	>100	441	4260	7.9
RV2RIJH	Gray	531	679	1463	5.7
RV3RIJH	Black	29	38	3285	8.9
RV4RIJH	Black	13	12	7800	5.4
RV5RIJH	Lagoon #4 final	<1	<1	18	8.4
RV6RIJH	Lagoon raw infl.		8	165	7.9
RV7RIJH	Black & Gray	<1	5		7.5
RV8RIJH	Black		5		9.0
RV9RIJH	Gray		52		5.8
RV10RIJH	Black		49		6.1
RV11RIJH	Lagoon #2 prim.	<1	<1		7.7
RV12RIJH	Lagoon #4 final		<1		8.3
RV13RIJH	Black		6	1845	8.4
RV14RIJH	Gray		184	1642	5.0
RV15RIJH	Black		166	8100	6.7
RV16RIJH	Gray	<1	<1	343	7.1
RV17RIJH	Black		110	5160	6.8
RV18RIJH	Gray		121	960	6.6
RV19RIJH	Lagoon #4 final	<1	<1	24	8.0
RV20RIJH	Black		18		8.6
RV21RIJH	Gray		99		4.6
RV22RIJH	Black		36		7.7
RV23RIJH	Gray		27		6.5
RV24RIJH	Lagoon #4 final	<1	<1		7.9
RV1AWIJH	Black	50	60	1215	8.1
RV2AWIJH	Gray	17	41	682	6.8
RV3AWIJH	Black	144	198	3675	6.6
RV4AWIJH	Gray	83	101	756	5.4
RV5AWIJH	Black	5	4	2550	8.8
RV6AWIJH	Lagoonraw infl.	11	12	244	8.5
RV7AWIJH	Lagoon #4 final	<1	<1	15	7.8

Code	Type	Toxicity Units 5 min	Toxicity Units 15 min	BOD5 mgO_2/L	pH
RV1NC	Black & Gray	86	111		6.8
RV2NC	Black	76	>1000		8.5
RV3NC	Gray	301	761		6.1
RV4NC	Black	35	52		8.5
RV5NC	Gray	110	267		6.8
RV6NC	Gray	>1000	>1000	1530	5.8
RV7NC	Black	905	1000	2775	8.6
RV8NC	Black	289	559	4148	8.4
RV9NC	Gray	>1000	>1000	1320	6.7
RV10NC	Black & Gray	288	647	3480	9.0
RV11NC	Black	38	35	3510	8.9
RV12NC	Black	15	15	4560	8.8
RV13NC	Black	19	21	2080	8.9
RV14NC	Gray	341	396	1403	6.0
RV15NC	Black	40	52	5640	8.6
RV16NC	Gray	793	>1000	3360	5.6
RV17NC	Black	108	159	6840	6.5
RV18NC	Gray	275	329	1478	5.4
RV19NC	Black	22	28	1640	8.7
RV1SCH	Lagoon #2 final	8	8	20	9.5
RV2SCH	Lagoon #1 prim.	<1	<1	14	8.1
RV3SCH	Lagoon raw infl.	<1	<1		7.4
RV4SCH	Black	68	59		6.5
RV5SCH	Gray	17	17	320	6.7
RV6SCH	Black	278	341	4200	8.3
RV7SCH	Black	177	136	3990	5.3
RV8SCH	Black	368	>1000	7260	6.2
RV9SCH	Gray	105	189	3075	6.0
RV10SCH	Septic tank effl.	27	36		7.3
RV11SCH	Black	>1000	>100		9.1
RV12SCH	Gray	>1000	.1000		5.8
RV13SCH	Black	32	43		7.9
RV14SCH	Gray	267	676		6.5
RV15SCH	Lagoon #1	2	<1	22	9.4
RV16SCH	Lagoon #2	1	<1	3	8.4
RV17SCH	Septic tank effl.	45	53	1550	7.6
RV18SCH	Black	>1000	>1000	1416	6.4
RV19SCH	Gray	378	>1000	1654	6.4
RV20SCH	Black	80	135	8464	8.9
RV21SCH	Gray	>1000	>1000	7749	4.4
RV1SPL	Lagoon #1	4	4	15	9.8

Code	Type	Toxicity Units 5 min	Toxicity Units 15 min	BOD5 mgO_2/L	pH
RV2SPL	Lagoon #2	<1	<1	38	7.8
RV3SPL	Black	33	65	1768	9.1
RV4SPL	Gray	595	>1000	1175	6.7
RV5SPL	Black	>1000	>1000	2423	8.6
RV6SPL	Gray	22	29	819	6.4
RV7SPL	Black	69	159	9240	9.0
RV8SPL	Black	38	47		4.8
RV9SPL	Black	64	90		9.0
RV10SPL	Gray	722	889		5.1
RV11SPL	Black & Gray	162	167		6.1
RV12SPL	Black	23	27		8.0
RV13SPL	Gray	126	<1160		6.6
RV14SPL	Black Rinse	<1	<1	452	7.1
RV15SPL	Gray	75	198	3186	4.9
RV16SPL	Black & Gray	358	728	3084	8.2
RV17SPL	Gray	>1000	>1000	2562	5.7
RV18SPL	Black	22	19	4961	8.9
RV19SPL	Pond #1	3	<1	11	9.8
RV20SPL	Pond #2	<1	<1	60	7.6
RV1aNGC	Black	123	144	2532	6.1
RV2aNGC	Gray	17	15	961	5.1
RV3aNGC	Black	93	108	4766	6.7
RV4aNGC	Gray	26	32	563	6.2
RV5aNGC	Black	25	42	1966	9.0
RV6aNGC	Gray	>1000	>1000	748	6.4
RV7aNGC	Black	886	>1000	2949	9.0
RV8aNGC	Black	76	102		8.0
RV9aNGC	Gray	>1000	>1000		5.6
RV10aNGC	Gray	634	1000		7.0
RV11aNGC	Black	194	266		8.7
RV12aNGC	Black & Gray	290	538		7.1
RV13aNGC	Black	>1000	>1000		9.0
RV14aNGC	Gray	1000	>1000		5.7
RV15aNGC	Black & Gray	227	250	931	6.8
RV16aNGC	Black	234	>1000	3978	8.5
RV17aNGC	Gray	>1000	>1000	778	6.4
RV18aNGC	Black	31	42	3874	8.3
RV19aNGC	Gray	101	104	4202	3.9
RV20aNGC	Black	>1000	>1000	4902	9.0
RV21aNGC	Septic tank effl.	64	63	492	7.4

Code	Type	Toxicity Units 5 min	Toxicity Units 15 min	BOD5 mgO_2/L	pH
RV1dST	Black & Gray	267	>1000	1495	5.9
RV2dST	Black	36	47	1535	8.9
RV3dST	Gray	14	24	2429	5.7
RV4dST	Black	175	318	5543	8.4
RV5dST	Gray	104	164	782	6.5
RV6dST	Black	>1000	>1000	2816	7.4
RV7dST	Gray	414	589	1624	6.2
RV8dST	Black	31	44	1783	7.9
RV9dST	Gray	37	42	233	6.5
RV10dST	Black & Gray	55	66	1664	8.6
RV11dST	Black	150	>1000	571	8.5
RV12dST	Gray	128	326	728	6.7
RV13dST	Black	196	>1000	2607	6.4
RV14dST	Gray	202	344	768	5.3
RV1aNC	Black	141	200	3647	8.4
RV2aNC	Gray	18	25	627	6.8
RV3aNC	Black	240	652	6770	9.0
RV4aNC	Black	8	9	1860	8.8
RV5aNC	Gray	7	9	923	8.5
RV6aNC	Black	67	70	4863	8.4
RV7aNC	Gray	117	197	2342	4.9
RV8aNC	Black	178	556		8.7
RV9aNC	Gray	38	35		4.5
RV10aNC	Black	10	13		7.0
RV11aNC	Gray	>1000	>1000		6.5
RV12aNC	Black	519	.100		7.3
RV13aNC	Gray	7	26		6.1
RV14aNC	Black	37	35		8.0
RV15aNC	Black & Gray	51	88	8487	8.8
RV16aNC	Black	12	19	1260	7.7
RV17aNC	Gray	84	126	947	5.3
RV18aNC	Laundry washwater	32	58	873	6.7
RV19aNC	Black	121	145	2954	8.5
RV20aNC	Gray	84	73	4333	4.9
RV21aNC	Black	100	147	3117	8.7
RV1bIJH	Black	29	31	4291	8.3
RV2bIJH	Gray	162	391	493	7.8
RV3bIJH	Black	24	38	1262	8.9
RV4bIJH	Gray	>1000	>1000	753	5.8
RV5bIJH	Lagoon raw infl.	<1	<1	89	7.7
RV6bIJH	Lagoon #2 prim.	<1	<1	325	8.0
RV7bIJH	Lagoon #4 final	<1	<1	31	9.0
RV8bIJH	Black	20	26		8.5
RV9bIJH	Gray	20	14		5.8

Code	Type	Toxicity Units		BOD5 mgO2/L	pH
		5 min	15 min		
RV10blJH	Black	27	38		8.6
RV11blJH	Black	50	74		6.1
RV12blJH	Gray	>100 0	>1000		5.7
RV13blJH	Black	88	>1000		5.8
RV14blJH	Gray	6	6		6.0
RV15blJH	Black	61	>1000	2247	8.8
RV16blJH	Gray	150	230	543	6.9
RV17blJH	Black	57	72	5876	7.5
RV18blJH	Black	18	23	2560	8.0
RV19blJH	Lagoon #4 final	<1	<1	41	9.3
RV20blJH	Lagoon #2 prim.	<1	<1	196	8.2
RV21blJH	Lagoon raw	4	4	482	8.1
RV1aSCH	Black	62	76	5721	8.1
RV2aSCH	Gray	26	41	1639	6.7
RV3aSCH	Black	25	33	1877	8.7
RV4aSCH	Gray	265	402	738	6.9
RV5aSCH	Black	12	13	1654	8.6
RV6aSCH	Gray	315	413	1483	6.4
RV7aSCH	Septic tank effl.	40	56	2041	7.5

APPENDIX C

TOXICITY OF RV WASTEWATERS

APPENDIX C. TOXICITY OF RV WASTEWATERS

Code	Date	Time	License No.	EC50 - with 95% CF		Label/Brand/Type of Additive
				5 min (%)	15 min (%)	
RV1E	04/19/91	1700	WA.7894-JQ	0.67 (0.33-1.37)	0.65.(0.28-1.50)	Mono Chem T-5
RV2E	04/19/91	1725	WA.7584-JD	2.72 (1.61-4.60)	2.62 (1.44-4.77)	None
RV3E	04/19/91	1830	WA Transit	29.32 (9.67-88.96)	28.16(14.75-53.75)	None
RV4E	04/20/91	0846	WA.040-CTI	5.05 (2.89-8.85)	5.70 (2.84-11.45)	Thetford Aqua Kem Blue
RV5E	04/20/91	0900	WA.1684-JD	2.23 (1.25-4.00)	1.72 (1.06-2.81)	GB RV Trine waste digester
RV6E	04/20/91	1000	WA.ZG-2600	2.99 (2.14-4.18	2.50 (1.74-3.61)	Tri Enzyme
RV7E	04/20/91	1400	WA.579-CXB	3.67 (2.07-6.31)	3.08 (1.82-5.23)	Dry Chem
RV8E	04/20/91	1415	CA.IRPL-737	<0.01	<0.01	Bleach
RV9E	04/20/91	1425	WA 739-LGD	1.26(0.66-2.39)	0.99 (0.54-1.80)	None
RV10E	04/20/91	1430	WA.739-LGD	0.86 (0.75-1.00)	0.62 (0.40-0.96)	None
RV11E	04/21/91	1025	WA Transit	0.60 (0.36-0.96)	0.47 (0.44-0.50)	Thetford Aqua-Kem Blue
RV12E	04/21/91	1030	WA.WD-1459	1.71 (1.33-2.19)	1.30 (0.99-1.72)	Baking soda
Rv13E	04/21/91	1035	WA.487-AVC	9.80 (2.90-33.14)	10.09 (2.83-35.96)	Thetford Aqua Kem Blue
RV14E	04/21/91	1040	WA.6628-R	10.72 (6.94-16.58)	11.42 (6.60-19.77)	Dishwasher detergent
RV15E	04/21/91	1100	WA.6628-R	1.15 (0.22-6.01)	0.92 (0.11-7.50)	None
RV1ST	05/25/91	1020	AK CWB-399	2.35 (1.30-4.26)	1.50 (0.75-3.00)	None
RV2ST	05/25/91	1035	WA ILF-658	24.55 (17.26-34.91)	20.70 (16.37-26.17)	None
RV3ST	05/25/91	1100	BC NGN-924	1.21 (0.76-1.94)	0.99 (0.60-1.62)	MonoChem T-5
RV4ST	05/25/91	1130	BC MHX-245	0.42 (0.39-0.45)	0.23 (0.03-2.11)	Roebic RV & MARINE
RV5ST	05/25/91	1300	WA 881BJN	4.27 (3.25-5.21)	3.42 (2.78-4.22)	None
RV6ST	05/25/91	1300	WA 7339-JB	1.70 (0.53-5.42)	0.94 (0.03-31.53)	Unknown
RV7ST	05/25/91	1330	WA V-87143	5.49 (4.55-6.63)	5.02 (4.13-6.11)	MonoChem T-5
RV8ST	05/25/91	1400	WA 995-BOK	3.13 (2.73-3.58)	2.90 (2.32-3.62)	MonoChem T-5

Code	Date	Time	License No.	EC50 - with 95% CF		Label/Brand/Type of Additive
				5 min (%)	15 min (%)	
RV9ST	05/26/91	0830	WA 017-CVX	20.94 (4.57-96.01)	21.62 (4.41-100.00)	None
RV10ST	05/26/91	0900	WA EWM-441	4.33 (3.50-5.34)	4.63 (3.82-5.62)	None
RV11ST	05/26/91	0945	CA GWO-RKO	2.13 (1.37-3.30)	1.73 (1.08-2.75)	GB RV-Trine Waste digester (enzyme)
RV12ST	05/26/91	1030	NV 925-EAL	1.21 (0.64-2.27)	1.19 (0.84-1.69)	None
RV13ST	05/26/91	1015	AK CED-551	0.25 (0.12-0.49)	0.21 (0.08-0.54)	MR.CLEAN
RV14ST	05/26/91	1030	WA WV-5126	47.37 (27.94-80.31)	38.68 (20.76-72.07)	None
RV15ST	05/26/91	1130	WA DLN-925	2.40 (1.53-3.76)	1.14 (0.83-1.57)	Sunlight Dish washing detergent
RV16ST	05/26/91	1230	WA 778-DNE	25.56 (11.23-58.18)	19.15 (8.67-42.30)	None
RV17ST	05/27/91	0830	WA WFA-328	3.49 (3.03-4.02)	2.67 (2.36-3.03)	Unknown
RV18ST	05/27/91	1000	WA 205-BJQ	1.82 (1.35-2.44)	1.50 (1.27-1.78)	Ammonia
RV19ST	05/27/91	1000	WA 763-AUV	1.75 (1.53-2.00)	1.01 (0.89-1.14)	None
RV20ST	05/27/91	1000	OR 995-353	7.72 (6.72-8.87)	7.58 (6.53-8.80	Thetford Aqua Kem Bue
RV21ST	05 27/91	1020	WA WES-578	0.54 (0.23-1.25)	0.27 (0.11-0.67)	Sears Pack a Potti
RV22ST	05/27/91	1045	WA WE-5719	6.30 (3.69-10.76)	3.02 (1.83-4.98)	Thetford Aqua Kem Blue
RV23ST	05/27/91	1100	WA HPD-630	0.29 (0.07-1.13)	0.21 (0.00-100.00)	CPM
RV24ST	05/27/91	1100	WA687-DGF	0.93 (0.64-1.37)	1.71 (1.18-2.48)	Chem-Cleam
RV1aST	05/28/91	0830	MT 6-109262	29.16 (16.75-50.76)	25.67 (9.45-69.75)	Unknown
RV2aST	05/28/91	0845	NM 9700-RVA	0.75 (0.62-0.91)	0.54 (0.36-0.83)	Natures way RV & marine digester
RV3aST	05/28/91	0900	WA 726-APA	1.50 (1.12-2.00)	1.14 (0.97-1.34)	Thetford Dry Kem
RV4aST	05/28/91	0945	WA 692-DIB	5.78 (4.91-6.81)	5.04 (4.16-6.11)	Sears Pack a Potti
RV5aST	05/28/91	1000	WA 315-AZN	<0.01	<0.01	Travel John (non-formaldehyde)
RV6aST	05/28/91	1030	WA ITT-802	1.17 (0.95-1.45)	1.00 (0.77-1.29)	Thetford Aqua Kem Blue
RV7aST	05/28/91	1045	CA 2VJX608	1.59 (1.10-2.30)	1.30 (0.70-2.41)	Thetford Aqua Kem Blue
RV8aST	05/28/91	1130	WA 63036	1.66 (1.34-2.06)	1.01 (0.68-1.51)	Thetford Aqua Dry Kem
RV9aST	05/29/91	0915	WA 730-BSC	3.26 (1.35-7.90)	3.39 (1.33-8.66)	None

Code	Date	Time	License No.	EC50 - with 95% CF		Label/Brand/Type of Additive
				5 min (%)	15 min (%)	
RV10aST	05/29/91	0945	WA 170-BJZ	0.34 (0.18-0.65)	0.24 (0.11-0.50)	None
RV11aST	05/29/91	1030	WA 160-PQD	1.90 (1.57-2.30)	1.35 (1.16-1.58)	None
RV12aST	05/29/91	1045	WA 118-BXI	2.80 (0.91-8.57)	2.47 (0.79-7.74)	Thetford Aqua Kem Blue
RV13aST	05/29/91	1100	WA LFF-328	2.07 (1.71-2.51)	1.86 (1.60-2.16)	None
RV14aST	05/29/91	1115	WA 984-CNB	6.72 (4.53-9.95)	5.01 (3.57-7.05)	Thetford Aqua Kem Blue
RV15aST	05/30/91	0835	WA 244-BOY	1.70 (1.26-2.31)	1.79 (1.34-2.38)	None
RV16aST	05/30/91	0845	AK CEP-874	0.62 (0.30-1.31)	0.30 (0.16-0.59)	Thetford Dry Kem
RV17aST	05/30/91	0905	BC NEK-149	2.67 (2.09-3.43)	1.96 (1.36-2.82)	Thetford Aqua Kem Blue
RV18aST	05/30/91	0920	WA 882-CTB	1.82 (1.42-2.33)	1.94 (1.68-2.24)	None
RV19aST	05/30/91	0945	CA IFHH918	1.58 (1.16-2.16)	Data not available	Shur Fresh (emzyme)
RV20aST	05/30/9	0945	CA IFHH918	79.33 (4.31-100.00)	32.43 (12.83-81.95)	None
RV1bE	06/01/91	0945	OR 964083	1.07 (0.14-8.11)	0.73 (0.04-14.38)	Roebic RV & Marine
RV2bE	06/01/91	0945	OR 964083	0.23 (0.08-0.64)	0.10 (0.00-100.00)	None
RV3bE	06/01/91	1030	WA WT-5359	9.28 (7.49-11.50)	9.40 (7.91-11.17)	Bleach
RV4bE	06/01/91	1030	WA WT-5359	4.56 (2.72-7.63)	2.92(1.91-4.47)	None
RV5bE	06/01/91	1130	WA EWM-622	1.02 (0.87-1.18)	0.94 (0.82-1.07)	Pine Sol cleaner
RV6bE	06/02/91	0910	AZ DVR-937	<0.01	<0.01	K-Mart H-D Pine cleaner
RV7bE	06/02/91	0915	AZ DVR-937	0.22 (0.07-0.76)	0.09 (0.03-0.26)	K-Mart H-D Pine cleaner
RV8bE	06/02/91	0945	WA 512-BTR	2.52 (2.01-3.16)	2.44 (1.97-3.03)	Mono Chem T-5
RV9bE	06/02/91	0945	WA 512-BTR	0.80 (0.50-1.28)	0.67 (0.48-0.92)	None
RV10bE	06/02/91	1030	WA 370-CEO	1.84 (1.23-2.75)	1.74 (1.05-2.89)	BayDo's NF3
RV11bE	06/02/91	1030	WA 370-CEO	4.82 (2.21-10.50)	4.17 (1.50-11.61)	None
RV12bE	06/02/91	1130	WA 0668-JY	<0.01	<0.01	Mono Chem T-5
RV13bE	06/02/91	1130	WA 0668-JY	0.24 (0.20-0.29)	0.15 (0.04-0.66)	None
RV14bE	06/03/91	1110	WA 4186-JD	1.49 (0.97-2.29)	0.66 (0.39-1.12)	Mono Chem T-5

Code	Date	Time	License No.	EC50 - with 95% CF 5 min (%)	EC50 - with 95% CF 15 min (%)	Label/Brand/Type of Additive
RV16bE	06/04/91	1100	WA 392OC	0.79 (0.46-1.36)	1.22 (0.11-13.26)	Thetford Campa Chem
RV17bE	06/04/91	1435	WA 535-DJC	1.48 (0.79-2.76)	1.16 (0.60-2.27)	None
RV1NGC	06/07/91	0830	CA 2PBD892	2.40 (2.09-2.76)	1.85 (1.54-2.22)	Thetford Aqua Kem Blue
RV2NGC	06/07/91	0830	CA 2PBD892	24.19 (13.25-44.19)	6.21 (4.10-9.40)	None
RV3NGC	06/07/91	0900	WA BZC-668	1.02 (0.65-1.61)	0.96 (0.61-1.50)	Thetford Aqua Kem Blue
RV4NGC	06/07/91	0900	WA BZC-668	0.67 (0.44-1.01)	0.63 (0.52-0.77)	None
RV5NGC	06/07/91	0910	OR 917996	13.19 (9.62-18.08)	13.52 (9.90-18.47)	Baking soda
RV6NGC	06/07/91	0915	OR 917996	4.62 (33.27-6.54)	1.70 (1.10-2.61)	Baking soda
RV7NGC	06/07/91	0915	TX 177-LGJ	0.95 (0.72-1.25)	0.80 (0.63-1.01)	Thetford Dry Kem
RV8NGC	06/08/91	0820	OR H995870	2.05 (1.37-3.08)	1.07 (0.58-1.99)	Campers World
RV9NG	06/08/91	0825	OR H995870	2.53 (2.12-3.02)	1.23 (1.01-1.50)	None
RV10NGC	06/08/91	0830	CA 2BCK538	0.13 (0.02-0.85)	<0.01	Thetford Campa Chem
RV11NGC	06/08/91	0830	CA 2BCK538	3.56 (2.90-4.38)	2.33 (1.75-3.09)	None
RV12NGC	06/08/91	1015	WA WS2255	23.17 (17.02-31.54)	25.60 (14.75-44.42)	None
RV13NGC	06/08/91	1015	WA WS2255	11.10 (7.11-17.31)	7.50 (5.40-10.40)	None
RV14NGC	06/09/91	0825	WA GHF-839	11.32 (8.60-14.90)	9.25 (6,97-12.27)	Unknown
RV15NGC	06/09/91	0900	AZ C-5150Z	0.20 (0.00-100.00)	<0.01	Pine Sol & Bleach
RV16NGC	06/09/91	0930	CA SNZNCRZ	<0.01	<0.01	Pine Kleen
RV17NGC	06/09/91	0930	CA SNZNCRZ	0.31 (0.16-0.59)	0.13 (0.04-0.40)	Pine Kleen
RV18NGC	06/09/91	1000	CA 691-VTH	1.43 (0.99-2.06)	0.41 (0.12-1.33)	Star Bright Instant Treatment
RV19NGC	06/09/91	1000	CA 691-VTH	25.82 (14.29-46.63)	9.60 (8.65-10.64)	None
RV20NGC	06/09/91	1005	TX 896-ZCC	0.87 (0.43-1.75)	0.56 (0.26-1.18)	Soap
RV1SSC	06/28/91	1040	WA HXD-301	<0.01	<0.01%	Pine-Sol

Code	Date	Time	License No.	EC50 - with 95% CF		Label/Brand/Type of Additive
				5 min (%)	15 min (%)	
RV2SSC	06-28-91	1045	WA HXD-301	1.34 (0.62-2.90)	0.89 (0.71-1.10)	None
RV3SSC	06-28-91	1500	Lagoon	100	100	Side opposite overflow weir
RV4SSC	06-28-91	1500	Lagoon	100	100	Near overflow weir
RV5SSC	06-29-91	0830	CA 2KPH915	100	100	Vanish (small amount)
RV6SSC	06-29-91	0950	ID 2M-49-R	0.28 (0.07-1.10)	0.03 (0.00-0.45)	None
RV7NSC	06-29-91	1100	WA 859-BGP	2.43 (2.22-2.67)	1,45 (1.24-1.69)	None
RV8NSC	06-29-91	1100	WA 859-BGP	5.10 (2.83-8.20)	3.80 (2.26-6.39)	None
RV9NSC	06-29-91	1215	LA 43401	33.31 (30.99-35.81)	35.07 (25.08-49.10)	None
RV10NSC	06-29-91	1215	LA 43401	1.88 (1.07-3.29)	1.48 (0.79-2.69)_	None
RV11SSC	06-29-91	1245	WA 761-BNW	2.90 (2.51-3.36)	1.62 (1.32-2.00)	None
RV12SSC	06-29-91	1200	Lagoon	100	100	Near overflow weir
RV13NSC	06-30-91	0830	WA 063-AVG	<0.01	<0.01	Sears Pack a Potti with Joy detergent
RW14NSC	06-30-91	0830	WA 063 AVG	2.99 (2.61-3.42)	<0.01	None
RV15NSC	06-30-91	1045	WA 97309	0.29 (0.17-0.50)	0.16 (0.09-0.29	Thetford Aqua Kem Blue
RV16NSC	06-30-91	1245	WA HMM-114	0.14 (0.00-13.42)	0.26 (0.00-100)	Thetford Aqua Zyme
RV17SSC	06-30-91	1045	WA JDT-630	3.88 (2.20-6.82)	2.20 (0.96-4.93)	None
RV1WIJH	07-03-91	0845	AZ E-12507	<1.0	0.23 (0.08-0.68)	None
RV2WIJH	07-03-91	0915	WA 519-ABL	0.19 (0.02-2.20)	0.15 (0.02-1.26)	None
RV3WIJH	07-03-91	0915	WA 519-ABL	3.48 (2.49-4.87)	2.65 (1.70-4.12)	Thetford Aqua Kem
RV4WIJH	07-03-91	1030	ID 54-657	7.92 (3.13-20.05)	8.54 (2.96-24.62)	None
RV5WIJH	07-03-91	1120	Lagoon #4 fin	100	100	None
RV6WIJH	07-03-91	1130	Lagoon infl.	12.74 (2.34-69.18)	11.93 (1.62-87.65)	None
RV7WIJH	07-04-91	0830	WA WF-5589	29.29 (14.53-59.05)	21.25 (11.67-38.69)	None
RV8WIJH	07-04-91	1100	AZ HAE-595	11.35 (8.50-15.15)	20.91 (14.07-31.08)	None
RV9WIJH	07-04-91	1102	AZ HAE-595	0.72 (0.44-1.18)	1.92 (0.98-3.79)	None

Code	Date	Time	License No.	EC50 - with 95% CF		Label/Brand/Type of Additive
				5 min (%)	15 min (%)	
RV10WIJH	07-04-91	1130	WA FET-451	2.64 (2.13-3.27)	2.03 (1.79-2.30)	Liquid Gold
RV11WIJH	07-04-91	1237	Lagoon #2	100	100	None
RV12WIJH	07-04-91	1230	Lagoon #4	100	100	None
RV13WIJH	07-05-91	0705	WA JY-8159	15.70 (10.57-23.32)	18.78 (12.64-27.89)	None
RV14WIJH	07-05-91	0705	WA JY-8159	0.73 (0.29-1.87)	0.54 (0.20-1.49)	None
RV15WIJH	07-05-91	0715	WA EYJ-376	0.78 (0.65-0.92)	0.60 (0.50-0.72)	Unknow
RV16WIJH	07-05-91	0720	WA EYJ-376	100	100	None
RV17WIJH	07-05-91	0745	AZ 4EL-708	0.91 (0.58-1.45)	0.91 (0.48-1.71)	None
RV18WIJH	07-05-91	0745	AZ 4EL-708	0.97 (0.69-1.37)	0.83 (0.30-2.31)	Thetford Campa Chem
RV19WIJH	07-05-91	1025	Lagoon #4	100	100	None
RV20WIJH	07-06-91	0820	CA 2NP-J264	7.72 (4.40-13.56)	5.66 (4.07-7.89)	Thetford Aqua Kem Blue
RV21WIJH	07-06-91	0825	CA 2NP-J264	1.30 (1.18-1.44)	1.01 (0.90-1.13)	None
RV22WIJH	07-06-91	0905	WA WEK-524	5.04 (3.19-7.96)	2.81 (2.27-3.48)	Thetford Aqua Kem Blue
RV23WIJH	07-06-91	0910	WA WEK-524	4.61 (4.01-5.31)	3.73 (3.40-4.09)	None
RV24WIJH	07-06-91	1100	Lagoon #4	100	100	None
RV1aWIJH	07-07-91	0800	WA 2C-1115	2.01 (1.09-3.74)	1.68 (0.85-3.31)	Clean Line emzyme
RV2aWIJH	07-07-91	0805	WA 2C-1115	5.94 (3.71-9.50)	2.42 (1.52-3.86)	None
RV3aWIJH	07-07-91	0915	WA 4174-KE	0.70 (0.39-1.23)	0.51 (0.42-0.61)	Sea Land Waste B gone
RV4aWIJH	07-07-91	0918	WA 4174-KE	1.21 (0.97-1.52)	0.99 (0.79-1.23)	None
RV5aWIJH	07-07-91	0920	CO 080591	21.02 (17.21-25.67)	24.75 (8.58-71.40)	Sea Land Waste-B-Gone
RV6aWIJH	07-07-91	1237	Lagoon infl	1.75 (7.26-18.96)	8.76 (5.08-15.10)	None
RV7aWIJH	07-07-91	1215	Lagoon #4	100	100	None
RV1NC	07-09-91	0830	WA 574-DF8	1.16 (0.58-2.33)	0.90 (0.43-1.90)	Nono Chem T-5
RV2NC	07-09-91	0840	SK RGH-886	1.32 (0.92-1.90)	<0.01	Inca Rail-Pak2
RV3NC	07-09-91	0840	SK RGH-886	0.33 (0.22-0.51)	0.13 (0.04-0.39)	None

Code	Date	Time	License No.	EC50 - with 95% CF		Label/Brand/Type of Additive
				5 min (%)	15 min (%)	
RV4NC	07-09-91	0850	WA LF7-201	2.89 (2.74-3.04)	1.93 (1.70-2.18)	Mono Chem T-5
RV5NC	07-09-91	0850	WA LF7-201	0.91 (0.66-1.24)	0.38 (0.21-0.66)	None
RV6NC	07-10-91	0830	WA 597-DGB	<0.01	<0.01	None
RV7NC	07-10-91	0830	WA 597-DGB	0.11 (0.04-0.33)	0.08 (0.00-717.57)	Thetford Aqua Kem-Blue
RV8NC	07-10-91	0840	CA 2GWJ739	0.35 (0.19-0.62)	0.18 (0.12-0.27)	Thetford Aqua-Kem Blue
RV9NC	07-10-91	0845	CA 2GWJ739	0.07 (0.02-0.28)	0.02 (0.00-0.21)	None
RV10NC	07-10-91	0900	WA 065-AKS	0.35 (0.11-1.07)	0.15 (0.05-0.49)	Dishwashig detergent
RV11NC	07-10-91	0925	WA NCM-008	2.62 (1.92-3.58)	2.87 (2.32-3.55)	None
RV12NC	07-10-91	1150	WA 3666-JL	6.52 (4.85-8.77)	6.71 (5.28-8.54)	Thetford Aqua Kem Blue
RV13NC	07-11-91	0725	WA MDP-539	5.41 (3.77-7.76)	4.73 (4.05-5.52)	N.F.B.
RV14NC	07-11-91	0730	WA MDP-539	0.29 (0.16-0.54)	0.25 (0.06-1.02)	None
RV15NC	07-11-91	0740	WA 235-CTF	2.51 (2.09-3.01)	1.94 (1.65-2.29)	None
RV16NC	07-11-91	0745	WA 235-CTF	0.13 (0.07-0.23)	0.04 (0.01-0.20)	None
RV17NC	07-11-91	0825	WA D8025029	0.93 (0.62-1.38)	0.63 (0.30-1.31)	Thetford Aqua-Kem Blue
RV18NC	07-11-91	0830	WA D8025029	0.36 (0.25-0.53)	0.30 (0.20-0.47)	None
RV19NC	07-11-91	0850	WA 299-CEY	4.66 (3.50-6.19)	3.58 (2.61-4.91)	G.B.RV TRINE waste digester (enzyme)
RV1SCH	07-13-91	0800	Lagoon final	12.85 (10.14-16.27)	12.96 (9.72-17.27)	None
RV2SCH	07-13-91	0810	Lagoon primary	100	100	None
RV3SCH	07-13-91	1030	Lagoon infl.	100	100	None
RV4SCH	07-13-91	0740	IA TTF-576	1.48 (0.79-2.78)	1.69 (0.90-3.16)	Thetford Campa-Chem
RV5SCH	07-13-91	0740	IA TTF-576	5.76 (4.67-7.09)	5.98 (5.19-6.90)	Unknown
RV6SCH	07-13-91	0810	WA 783-ABA	0.36 (0.13-0.96)	0.29 (0.12-0.72)	Thetford Dry Kem
RV7SCH	07-13-91	0840	WA 3888-F	0.56 (0.18-1.76)	0.74 (0.31-1.73)	Unknown
RV8SCH	07-14-91	0720	WA 318-AUZ	0.27 (0.09-0.83)	<0.01	Thetford Aqua-Kem Blue
RV9SCH	07-14-91	0725	WA 318-AUZ	0.95 (0.77-1.17)	0.53 (0.16-1.70)	None

Code	Date	Time	License No.	EC50 - with 95% CF		Label/Brand/Type of Additive
				5 min (%)	15 min (%)	
RV10SCH	07-14-91	0810	Septic tank .	3.66 (2.49-5.37)	2.78 (1.78-4.34)	None
RV11SCH	07-14-91	0845	WA KYZ738	<0.01	<0.01	Travel Jon
RV12SCH	07-14-91	0840	WA KYZ738	0.02 (0.00-3.43)	<0.01	Unknown
RV13SCH	07-14-91	0900	WA 7040BFO	3.17 (2.06-4.87)	2.32 (1.44-3.74)	Borax
RV14SCH	07-14-91	0910	WA 704-BFO	037 (0.32-0.44)	0.15 (0.06-0.34)	None
RV15SCH	07-15-91	0825	Lagoon prim	45.62 (23.85-87.28)	100	None
RV16SCH	07-15-91	O820	Lagoon final	86.53 (0.14-100)	100	None
RV17SCH	07-15-91	0830	Septic tank.	2.22 (1.39-3.53)	1.90 (0.98-3.67)	None
RV18SCH	07-15-91	0815	AL 8164-OA	<0.01	>0.01	Liquid Gold & Pine Sol
RV19SCH	07-15-91	0815	AL.8164-OA	0.26 (0.08-0.92)	0.02 (0.00-0.08	Sm. amt Liquid Gold & Pine Sol
RV20SCH	07-15-91	0820	WA.IXA-068	1.25 (0.82-1.89)	0.74 (0.56-0.99)	None
RV21SCH	07-15-91	0910	N.J.GUY-70D	<0.01	<0.01	None
RV1SPL	07-16-91	0930	Lagoon #1	25.02 (1.78-100)	24.99 (0.21-100)	None
RV2SPL	07-16-91	0935	Lagoon #2	100	100	None
RV3SPL	07-16-91	0930	MN RV71312	3.03 (2.20-4.18)	1.55 (0.93-2.59)	Potty Toddy
RV4SPL	07-16-91	0940	MN RV71312	0.17 (0.03-0.98)	<0.01	None
RV5SPL	07-16-91	0940	B.C.0571-PK	<0.01	<0.01	Liquid Gold
RV6SPL	07-16-91	0950	B.C.0571-PK	4.64 (3.33-6.45)	3.35 (1.96-5.74)	None
RV7SPL	07-16-91	1020	FL.EXT-564	1.44 (0.58-3.61)	0.63 (0.27 1.45)	None
RV8SPL	07-17-91	0820	WA V-685579	2.61 (1.88-3.63)	2.13 (1.65-2.74)	Thetford Campa Chem
RV9SPL	07-17-91	0948	IA.JTF-105	1.57 (0.82-2.99)	1.12 (0.58-2.13)	None
RV10SPL	07-17-91	0950	IA.JTF-105	0.14 (0.10-0.19)	0.11 (0.07-0.19)	None
RV11SPL	07-17-91	1020	IL.103077	0.62 (0.26-1.48)	0.60 (0.33-1.10)	Sea Land waste B gone
RV12SPL	07-17-91	1050	WA WKT-772	4.33 (2.76-6.81)	3.72 (2.44-5.68)	Sea Land waste B gone
RV13SPL	07-17-91	1050	WA WKT-772	0.62 (0.36-1.10)	0.79 (0.52-1.22)	None

Code	Date	Time	License No.	EC50 - with 95% CF		Label/Brand/Type of Additive
				5 min (%)	15 min (%)	
RV14SPL	07-18-91	0730	WA 4292-JK	100	100	None
RV15SPL	07-18-91	0735	WA 4292-JK	1.34 (0.44-4.11)	0.50 (0.06-4.15)	None
RV16SPL	07-18-91	0830	OR 940171	0.28 (0.22-0.35)	0.14 (0.09-0.22)	Mono Chem T-5
RV17SPL	07-18-91	0850	MT.2206364	<0.01	<0.01	None
RV18SPL	07-18-91	0850	MT 22-6364	4.47 (2.72-7.35)	5.42 (4.06-7.23)	None
RV19SPL	07-18-91	0920	Lagoon #1	40.79 (4.75-100)	100	None
RV20SPL	07-18-91	0925	Lagoon #2	100	100	None
RV1aNGC	08-05-91	0820	WA 564-DBF	0.82 (0.80-0.83)	0.69 (0.42-1.16)	Mono Chem T-5
RV2aNGC	08-05-91	0825	WA 564-DBF	5.92 (3.71-9.45)	6.51 (4.26-9.95)	None
RV3aNGC	08-05-91	0840	CA 2LJN715	1.08 (0.71-1.63)	0.93 (0.62-1.38)	Thetford Aqua Kem Blue
RV4aNGC	08-05-91	0840	CA 2LJN715	3.79 (2.44-5.89)	3.15 (2.02-4.94)	None
RV5aNGC	08-05-91	0850	WA WF-2943	3.96 (1.64-9.65)	2.37 (1.23-4.59)	None
RV6aNGC	08-05-91	0850	WA WF-2943	<0.01	<0.01	
RV7aNGC	08-05-91	0900	WA TBZ-397	1.17 (0.67-2.05)	<0.01	Travel Jon (enzyme)
RV8aNGC	08-06-91	0915	WA 086-CNU	1.32 (1.14-1.53)	0.98 (0.80-1.20)	Thetford Aqua Kem Blue
RV9aNGC	08-06-91	0917	WA 086-CNU	0.02 (0.00-0.06)	0.00 (0.00-0.03)	None
RV10aNGC	08-06-91	0935	ID HAW-602	0.16 (0.11-0.22)	0.07 (0.03-0.16)	None
RV11aNGC	08-06-91	0930	ID HAW-602	0.51 (0.37 0.72)	0.38 (0.29-0.49)	None
RV12aNGC	-8-06-91	0838	CA 2XOB547	0.34 (0.27-0.45)	0.19 (0.11-0.31)	None
RV13aNGC	08-06-91	0950	OR 533394	<0.01	<0.01	Mono Chem T-5
RV14aNGC	08-06-91	0950	OR 533394	0.09 (0.03-0.31)	0.02 (0.00-0.28)	None
RV15aNGC	08-07-91	0727	CA 715-JLA	0.44 (0.30-0.66)	3.04 (2.20-4.18)	Mono Chem T-5
RV16aNGC	08-07-91	0745	WA 1826-JQ	0.43 (0.11-1.60)	0.02 (0.00-0.09)	NFB-5
RV17aNGC	08-07-91	0750	WA 1826-JQ	0.04 (0.00-3.02)	<0.01	None
RV18aNGC	08-07-91	0812	WA 250-BFY	3.26 (1.68-5.86)	2.41 (1.48-3.92)	Thetford Aqua Chem Blue

Code	Date	Time	License No.	EC50 - with 95% CF		Label/Brand/Type of Additive
				5 min (%)	15 min (%)	
RV19aNGC	08-07-91	0815	WA 250-BFY	0.99 (0.12-8.35)	0.96 (0.12-7.58)	None
RV20aNGC	08-07-91	0840	CA TT-7750	<0.01	<0.01	Star Brite Instant Fresh
RV21aNGC	08-07-91	0840	Septic Tank	1.57 (1.19-2.06)	1.59 (1.22-2.07)	Unknown.
RV1dST	08-10-91	0900	WA 61490-F	0.37 (0.14-1.00)	<0.01	Thetford Aqua Kem Blue
RV2dST	08-10-91	0925	B.C.426-160	2.78 (1.95-3.97)	2.11 (1.53-2.92)	Mono Chem T-5
RV3dST	08-10-91	0925	B.C.426-160	6.93 (1.79-26.89)	4.20 (1.51-11.68)	None
RV4dST	08-10-91	0950	WA 151-DMP	0.57 (0.35-0.94)	0.31 (0.00-38.05)	Thetford Aqua-Kem Blue
RV5dST	08-10-91	0950	WA 151-DMP	0.96 (0.35-2.62)	0.61 (0.24-1.57)	None
RV6dST	08-10-91	1015	WA 6478-KC	<0.01	<0.01	Travel-Jon
RV7dST	08-10-91	1015	WA 6478-KC	0.24 (0.12-0.48)	0.17 (0.06-0.50)	None
RV8dST	08-11-91	0727	WA 324-DBW	3.28 (1.91-5.65)	2.30 (1.38-3.83)	Mono Chem T-5
RV9dST	08-11-91	0729	WA 324-DBW	2.68 (1.72-4.17)	2.37 (1.64-3.42)	None
RV10dST	08-11-91	0815	B.C.LXL-072	2.24 (1.18-4.28)	1.52 (0.50-4.64)	None
RV11dST	08-11-91	0850	CA.998-YVY	0.67 (0.29-1.53)	<0.01	Thetford Aqua Kem Green
RV12dST	08-11-91	0850	CA.998-YVY	0.78 (0.44-1.38)	0.31 (0.17-0.55)	None
RV13dST	08-11-91	0900	AZ.C-97819	0.51 (0.21-1.23)	<0.01	Thetford Campa Kem Blue
RV14dST	08-11-91	0900	AZ.C-97819	0.49 (0.40-0.81)	0.29 (0.21-0.40)	None
RV1aNC	08-13-91	0800	TX.473-UJD	0.71 (0.17-2.99)	0.50 (0.07-3.65)	Thetford Aqua-Kem Blue
RV2aNC	08-13-91	0805	TX.473-UJD	5.73 (3.17-10.34)	4.00 (2.31-6.93)	None
RV3aNC	08-13-91	1022	CA.ZERJ-295	0.42 (0.14-1.25)	0.15 (0.01-1.58)	KN-48
RV4aNC	08-13-91	1200	WA.647-CVF	12.19 (8.31-17.89)	10.60 (6.78-16.59)	Thetford Aqua Kem Blue
RV5aNC	08-13-91	1204	WA.647-CVF	14.80 (9.43-23.22)	11.79 (7.84-17.74)	None
RV6aNC	08-13-91	1220	AL.LWL-896	1.48 (0.61-3.61)	1.43 (0.57-3.58)	Mono Chem T-5
RV7aNC	08-13-91	1220	AL.LWL-896	0.86 (0.64-1.15)	0.51 (0.41-0.63)	None

Code	Date	Time	License No.	EC50 - with 95% CF		Label/Brand/Type of Additive
				5 min (%)	15 min (%)	
RV8aNC	08-14-91	0827	B.C.135-376	0.56 (0.30-1.06)	0.18 (0.08-0.40)	Thetford Aqua Kem Green
RV9aNC	08-14-91	0830	B.C.135-376	2.62 (1.34-5.13)	2.87 (2.00-4.11)	None
RV10aNC	08-14-91	0835	CA 256-JSQ	10.16 (6.22-16.58)	7.81 (4.56-13.36)	Thetford Campa Kem
RV11aNC	08-14-91	0835	CA 256-JSQ	0.07 (0.01-0.78)	<0.01	None
RV12aNC	08-14-91	0925	BC SNG-471	0.19 (0.01-3.02)	<0.01	Mastercraft
RV13aNC	08-14-91	0925	BC SNG-471	14.78 (11.05-19.76)	3.87 (3.19-4.17)	None
RV14aNC	08-14-91	1000	WA 9522-JG	2.74 (1.83-4.08)	2.88 (2.30-3.62)	Mono Chem T-5
RV15aNC	08-15-91	0705	BC SXC-034	1.95 (1.48-2.57)	1.14 (0.82-1.58)	Thetford Aqua Kem Blue
RV16aNC	08-15-91	0800	CA 2MIW994	8.36 (6.69-10.50)	5.39 (4.23-6.86)	Thetford Aqua Kem Blue
RV17aNC	08-15-91	0800	CA 2MIW994	1.20 (0.83-1.72)	0.79 (0.54-1.17)	None
RV18aNC	08-15-91	0800	CA 2MIW994	317 (2.27-4.43)	1.71 (1.26-2.33)	Wisk detergent
RV19aNC	08-15-91	0910	MT 13-662B	0.83 (0.60-1.13)	0.69 (0.18-2.65)	Thetford Aqua Kem Blue
RV20aNC	08-15-91	0910	MT 13-662B	1.19 (0.56-2.53)	1.36 (0.50-3.71)	None
RV21aNC	08-15-91	0945	CA PR-3504	1.00 (0.67-1.49)	0.68 (0.26-1.65)	Ordorcon.
RV1bWIJH	08-17-91	0755	WA 2150-JZ	3.50 (3.05-4.01)	3.22 (2.80-3.69)	Thetford Campa Kem
RV2bWIJH	08-17-91	0755	WA 2150-JZ	3.22 (2.80-3.69)	0.62 (0.57-0.67)	None
RV3bWIJH	08-17-91	1115	CO GXL-763	4.10 (2.65-6.33)	2.66 (1.61-4.40)	Thetford Aqua Kem Blue
RV4bWIJH	08-17-91	1115	CO GXL-763	<0.01	<0.01	None
RV5bWIJH	08-17-91	1025	Lagoon infl	100	100	N.A.
RV6bWIJH	08-17-91	1030	Lagoon #1&#2	100	100	N.A.
RV7bWIJH	08-17-91	1035	Lagoon #4	100	100	N.A.
RV8bWIJH	08-18-91	0840	WA DNY-691	5.00 (2.63-9.49)	3.80 (2.27-6.38)	Tri-Enzyme
RV9bWIJH	08-18-91	0840	WA DNY-691	5.07 (4.13-6.23)	6.93 (6.57-7.31)	None
RV10bIJH	08-18-91	0917	WA 9851-JQ	3.49 (2.78-4.38)	2.63 (1.96-3.54)	SeaLand waste B gone
RV11bIJH	08-18-91	0950	WA 372-APA	1.99 (1.61-2.47)	1.34 (0.63-2.86)	Mono Chem T-5

Code	Date	Time	License No.	EC50 - with 95% CF 5 min (%)	EC50 - with 95% CF 15 min (%)	Label/Brand/Type of Additive
RV12blJH	08-18-91	0950	WA 372-APA	<0.01	<0.01	None
RV13blJH	08-18-91	1000	WA 16924 G	1.14 (0.92-1.41)	<0.01	Unknown
RV14blJH	08-18-91	1004	WA 16924 G	16.80 (13.32-21.19)	16.75 (11.15-25.17)	None
RV15blJH	08-19-91	0830	WA 7594-JV	1.63 (1.57-1.69)	<0.01	Potty Toddy
RV16blJH	08-19-91	0835	WA 7594-JV	0.67 (0.54-0.82)	0.43 (0.37-0.50)	None
RV17blJH	08-19-91	0900	WA 65322-T	1.74 (1.01-2.99)	1.40 (0.72-2.73)	Thetford Aqua Kem Green
RV18blJH	08-19-91	0955	WA WC-5321	5.54 (4.14-7.41)	4.42 (2.98-6.55)	SeaLand waste B gone
RV19blJH	08-19-91	1025	Lagoon #4	100	100	N.A.
RV20blJH	08-19-91	1028	Lagoon #1&#2	100	100	N.A.
RV21blJH	08-19-91	1110	Lagoon infl	24.63 (16.76-36.18)	25.36 (14.92-43.12)	N.A.
RV1aSCH	08-21-91	0815	WA 9893-JM	1.61 (1.26-2.06)	1.32 (1.03-1.70)	Thetford Campa Kem
RV2aSCH	08-21-91	0815	WA 9893-JM	3.89 (2.85-5.31)	2.46 (1.78-3.41)	None
RV3aSCH	08-21-91	1002	CA 1BK-2205	4.04 (3.53-4.62)	3.03 (2.62-3.49)	Thetford Aqua Kem Blue
RV4aSCH	08-21-91	1005	CA 1BK-2205	0.38 (0.20-0.70)	0.25 (0.14-0.43)	None
RV5aSCH	08-21-91	1010	CA 1AV-5858	8.04 (5.95-10.87)	7.51 (5.72-9.85)	Thetford Aqua Kem Green
RV6aSCH	08-21-91	1015	CA 1AV-5858	0.32 (0.24-0.43)	0.24 (0.18-0.33)	None
RV7aSCH	08-21-91	1030	Septic tank	2.51 (2.26-2.79)	1.78 (1.40-2.26)	N.A.
RV8aSCH	08-23-91	0718	CA 2RPK-161	<0.01	<0.01	None
RV9aSCH	08-23-91	0732	CA 2RPK-161	0.19 (0.01-3.04)	0.08 (0.00-5.62)	None
RV10aSCH	08-23-91	0910	AZ 62Z-3	3.38 (2.45-4.65)	2.65 (2.31-3.04)	Thetford Aqua-Kem Blue
RV11aSCH	08-23-91	0912	AZ 62Z-3	6.47 (4.93-8.49)	3.41 (2.20-5.30)	None
RV12aSCH	08-23-91	1100	WA 156-AWL	12.46 (8.15-19.05)	8.00 (5.24-12.22)	None
RV13aSCH	08-23-91	1100	WA 156-AWL	0.37 (0.27-0.52)	0.29 (0.16-0.54)	None
RV14aSCH	08-23-91	0820	Septic tank	0.77 (0.50-1.18)	<0.01	N.A.