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A MICROTOX TEST SURVEY OF LAKE ST. CLAIR WATER

by

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Management Perspective

Title: A Microtox test survey of Lake St. Clair water

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Date: November, 1987

Perspective:

This manuscript reports new research results on a Microtox test survey of Lake St. Clair water, undertaken in June, 1984. The results indicate the existence of zones of low toxicity in near-shore waters (up to approximately 5 km from shore) in all but the eastern part of the lake. Water in the central portion of Lake St. Clair does not show any toxic effects in this test. As this test is non-specific, i.e. determines the overall effect of substances or conditions present which impair the bacterium's (*Photobacterium phosphoreum*) metabolism, different areas in the lake may be receiving different contaminants. Some of the observed low toxicity levels coincide with higher population densities on the adjacent shores. Other areas, such as along the southern lake shore may indicate non-point source rural contaminants. Low to moderate toxic effects observed in the areas south of Walpole Island could be the result of point source discharges upstream in the St. Clair River.

Although the determined effects cannot be related to specific compounds or conditions, the Microtox toxicity data to be useful as indicators of the health or impairment of the aquatic ecosystem.

Perspective-gestion

Titre : Étude de l'eau du lac St. Clair à l'aide de l'épreuve Microtox

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Perspective :

Le présent manuscrit présente les nouveaux résultats de recherche obtenus dans le cadre de l'étude de l'eau du lac St. Clair à l'aide de l'épreuve Microtox, effectuée en juin 1984. Les résultats indiquent l'existence de zones de faible toxicité près de la rive (jusqu'à environ 5 km de la rive) dans toutes les parties du lac sauf dans la partie est. Cette épreuve n'a révélé aucun effet toxique dans l'eau de la partie centrale du lac St. Clair. Comme cette épreuve est non spécifique, c'est-à-dire qu'elle détermine l'effet global des substances ou des facteurs en présence qui inhibent le métabolisme de la bactérie (<u>Photobacterium phosphoreum</u>), différentes parties du lac pourraient recevoir différents contaminants. Dans certains endroits où la toxicité observée était faible, la population était plus dense sur les rives adjacentes. Dans d'autres endroits, comme le long de la rive sud du lac, il pourrait y avoir des contaminants d'origine rurale non ponctuelle. Des effets toxiques faibles à modérés observés à certains endroits au sud de l'île Walpole pourraient provenir de sources ponctuelles de pollution en amont de la rivière St. Clair.

Bien qu'on ne puisse relier les effets observés à des substances ou à des conditions particulières, les données de toxicité obtenues à l'aide de l'épreuve Microtox devraient contribuer à indiquer l'état de santé ou de détérioration de l'écosystème aquatique.

ÉTUDE DE L'EAU DU LAC ST. CLAIR À L'AIDE DE L'ÉPREUVE MICROTOX

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RÉSUMÉ

Des échantillons d'eau de surface prélevés à 67 endroits dans le lac St. Clair et dans une partie du delta de la rivière St. Clair ont été soumis à des épreuves de toxicité aiguë pour *Photobacterium phosphoreum* à l'aide de l'épreuve Microtox[MD]. Les résultats indiquent qu'il existe des zones de faible toxicité dans la plupart des endroits situés près de la rive (jusqu'à environ 5 km de la rive), sauf dans la partie est du lac et qu'il n'y a en général aucune trace de toxicité dans la partie centrale du lac et dans la rivière.

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ABSTRACT

Surface water samples of 67 stations throughout Lake St. Clair and parts of the St. Clair River delta were tested for acute toxicity to *Photobacterium phosphoreum* with the Microtox^{TM} test. The results indicate the existence of zones of low toxicity in most of the nearshore areas (up to approximately 5 km from shore), except for the eastern part of the lake, and generally no toxicity in the central offshore part of the lake and in the river.

INTRODUCTION

The Microtox^{TM,}[2] test, using the luminescent marine *Photobacterium phosphoreum* as indicator species has been developed to test industrial effluents for acute toxicity to aquatic organisms (Bulich and Isenberg, 1981). We have recently applied this test to survey the Detroit River (Ribo et al., 1985) and to test selected environmental contaminants and model chemicals (Ribo and Kaiser, 1987; Kaiser and Ribo, 1988). In this test, the parameter calculated is the gamma (Γ) value. The Γ value is the ratio of light emission lost to light emission remaining after a given exposure time, commonly 5, 15, or 30 min. The toxicity of any sample is usually expressed as the concentration that causes a 50% reduction in light emission (Γ = 1.0). Details of this bioassay, procedures and applications have been described in the literature (Bulich and Isenberg, 1981; Ribo and Kaiser, 1987).

This survey is part of a multidisciplinary study on the upper Great Lakes connecting channels and was undertaken concurrently with investigations on the distribution of volatile halocarbon contaminants (Kaiser and Comba, 1986) and on the distribution of yeasts, filamentous fungi and bacteria (Kwasniewska and Kaiser, 1988) in Lake St. Clair surface water. Furthermore, it is of interest to determine whether or not parallels exist between any of the contaminant data with any of the biological data of this study. This report gives the Microtox results and provides an attempt to interpret these data in view of the other results as well.

EXPERIMENTAL

Surface water samples (at 1 m depth), were collected in 500 mL glass bottles at 67 stations during 18 and 21 June, 1984. The station locations are shown in Figure 1, except for #100, which is at the mouth of the Little River at Windsor. The samples were kept in darkness and analyzed at a mobile laboratory unit onshore within 4 hr from collection. Except for a few turbid samples, which were decanted after settling, all samples were tested without further processing according to the procedure and data reduction scheme used previously (Ribo et al., 1985). Due to the generally low reduction of light emission observed with these samples, the results are given in gamma values rather than in the effective concentration values, normally used for solutions of higher toxicity.

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2) Microtox is a registered trademark of Microbics Corporation, Carlsbad, California, USA.

RESULTS AND DISCUSSION

The classification and enumeration of the test results is given in Table 1, and the test data for all stations are shown in Table 2. The toxicity measurements of the unprocessed water samples show generally good agreement between the 5 min and 15 min exposure time values. In some cases, 15 min values are higher, in other ones lower than those of the corresponding 5 min values. Furthermore, there is a significant number of samples where negative Γ values were observed. These type of results generally indicate no or low toxicity in combination with nutrients, which boost the bacterial metabolism, resulting in a stronger light emission of the exposed bacteria compared to the controls. This type of effect has also previously been observed for both natural water samples (Ribo et al., 1985) and for selected pure chemicals. Therefore, interpretation of these results should take into account that this test determines the bacterial response to the combination of stimulating and inhibiting factors present in each sample.

TABLE 1. Classification and enumeration of samples

Gamma range	Class	Number of samples
$\Gamma < 0.00$	0	25 (37%)
$0.00 < \Gamma < 0.05$	1	14 (21%)
$0.05 < \Gamma < 0.10$	2	19 (28%)
$0.10 < \Gamma < 0.50$	3	10 (15%)

TABLE 2. Gamma (Γ) values and classifications of Lake St. Clair and lower St. Clair River water samples as determined by the Microtox test with 5 min and 15 min exposure times.

Station No.	Γ 5 min	Γ 15 min	Class	Station No.	Γ 5 min	Γ 15 min	Class
100	0.12	0.11	3	237	<0	<0	0
201	0.07	0.08	2	238	<0	<0	0
202	0.08	0.11	2	239	0.13	0.12	3
203	<0	0.01	0	240	0.10	0.11	3
204	<0	<0	0	241	0.03	0.02	1
205	0.01	0.01	0	242	0.02	<0	0
206	<0	<0	0	243	0.09	0.13	3
207	0.02	<0	0	244	0.05	0.10	2
208	0.10	0.09	2	245	<0	<0	0
209	NT	NT	NT	246	NT	NT	NT
210	0.08	0.06	2	247	0.27	0.53	3
211	0.03	0.04	1	248	0.15	<0	2
212	0.02	0.03	1	249	<0	<0	0
213	0.03	0.02	1	250	<0	<0	0
214	0.05	0.03	1	251	0.07	0.15	2
215	0.01	<0	0	252	<0	<0	0
216	<0	<0	0	253	0.09	0.03	2
217	<0	<0	0	254	0.07	0.09	2
218	0.01	<0	0	255	<0	0.01	0
219	<0	0.07	1	256	<0	<0	0
220	0.09	0.06	2	257	0.15	0.10	3
221	0.02	<0	1	258	0.08	0.07	2
222	0.03	<0	1	259	NT	NT	NT
223	<0	<0	0	260	0.08	0.08	2
224	0.07	0.08	2	261	0.05	0.06	2
225	0.06	<0	1	262	0.12	0.08	2
226	0.01	<0	0	263	<0	<0	0
227	0.02	<0	0	264	0.17	0.09	3
228	0.08	0.10	2	265	0.02	0.03	1
230	0.23	0.22	3	266	0.16	0.09	3
231	0.07	0.03	1	267	0.15	0.19	3
232	0.04	<0	1	268	0.08	0.01	1
233	0.14	0.15	3	269	0.01	<0	0
234	0.02	0.07	2	270	<0	<0	0
235	0.08	0.09	2	271	<0	<0	0
236	0.03	0.01	1	272	0.05	0.04	1

NT: Not determined.

Table 1 also lists the number and percentage of samples in each class. It is interesting to note that the percentage of samples in classes 0 and 1 are almost identical with those found in the Detroit River survey (Ribo et al., 1985), while there is a higher percentage of samples in class 2 and a smaller percentage in class 3 in Lake St. Clair, compared to the Detroit River. Moreover, no samples with Γ values higher than 0.5 were found in Lake St. Clair, compared to 5% in the Detroit River. This indicates a generally much better water quality of Lake St. Clair.

Figure 1 shows the test results on a chart of Lake St. Clair and the lower St. Clair River on the basis of the classification scheme given in Table 1. For the purpose of this figure, the data have been averaged between the 5 min and 15 min exposure values and, to a limited extent between adjacent sites and also by grouping together the class 0 and 1 data and the class 2 and 3 data. This process leads to a representation of the data which indicates - in general terms - the presence or absence of conditions or substances affecting the metabolism of the test bacteria. Figure 1 shows clearly that zones of low to moderate toxicity ($\Gamma > 0.05$) exist in the nearshore waters (up to approximately 5 km from shore) in the northern, western and southern parts of the lake. In contrast, the central portion of Lake St. Clair and most samples in the St. Clair River delta show no toxicity or even stimulating effects on the bacteria ($\Gamma < 0.05$).

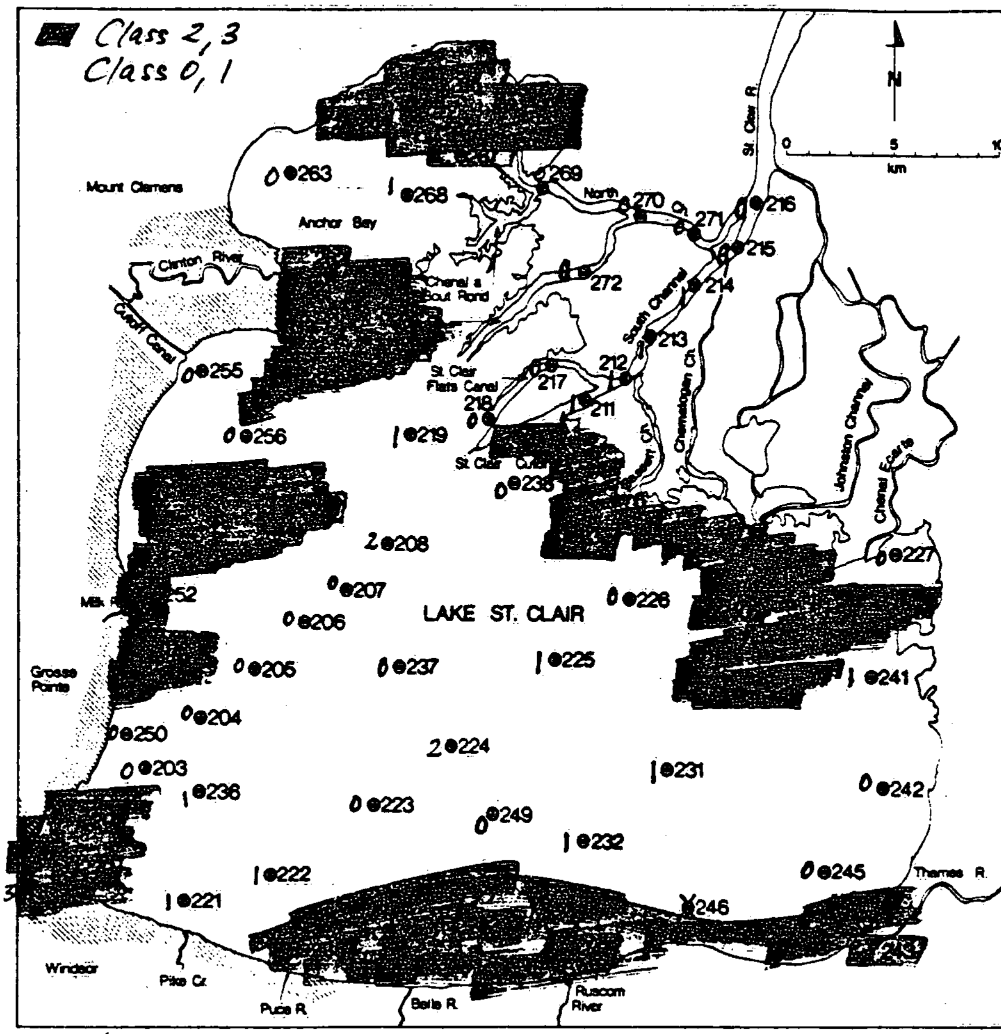

FIGURE 1. Presence and absence of agents in Lake St. Clair water causing low acute toxicity to *Photobacterium phosphoreum*; see text for definitons of categories.

Recently, Kaiser and Comba (1986) showed that a variety of volatile halocarbon contaminants enter Lake St. Clair from the St. Clair River. As that survey was undertaken concurrently with this investigation on Microtox toxicity, comparison of the contaminant distributions with the toxicity values is a logical step. Of the volatile halocarbons investigated, only chloroform, 1,1,1-trichloroethane, trichloroethylene, tetrachloroethylene and carbon tetrachloride showed significant concentrations in the St. Clair River and plumes of contaminated river water were found to extend as far as the center of the lake. Similar data were also obtained for the distribution of the more persistent, higher molecular weight organochlorine contaminants on suspended sediments (Charlton and Oliver, 1986). In contrast, the Microtox values reported here indicate class 0 and 1 type water in the major St. Clair River delta channels. As most of these samples were taken approximately midstream, any substances discharged nearshore would not likely be detected until much further downstream or in the lake, as transverse mixing in the river is very limited (Chan et al. 1986). Therefore, the class 2 toxicity levels observed in Anchor Bay could arise from sources along the north/west shore of the river or along the Bay itself. Similarly, the levels of low to moderate toxicity found along the northshore of the lake, east of the St. Clair Cutoff Canal, could be the result of nearshore point source discharges upstream in the St. Clair River. For example, discharges upstream of the delta could enter the lake mainly through the Bassett and Chematogan Channels without having much effect on water quality in the much larger Cutoff Canal. Several additional zones of low to moderate toxicity in the western, northern and southern nearshore parts of the lake indicate additional point sources in such areas, probably associated with a number of other tributaries to the lake, such as the Clinton, Milk, Ruscom, and Thames Rivers, and/or nonpoint sources in those areas.

Also of interest is a comparison of the observed toxicity values with the results of another concurrent biological investigation, namely the distribution of yeasts, fungi and bacteria in Lake St. Clair (Kwasnieswska and Kaiser, 1988). In that work, generally higher densities of naturally occurring red, white and black yeasts were found in the northern and western parts of the lake and along the eastern shore. This distribution, in general terms, coincides with population densities on the lake shores and may indicate nutrient sources from municipal wastes. There is a certain degree of overlap between these elevated levels of microorganisms in the water and the observed toxicity values. However, this cannot be said for each of the stations. Consequently, no direct or firm correlation can be made in this comparison either.

Overall, the presence of low to moderate toxic effects of some of these water samples in the Microtox test indicates several areas of different sources and likely different materials causing the effects. Some of these coincide with higher population densities on the adjacent shores, such as on the western shore of Lake St. Clair. The effect levels observed in the lake waters south of Walpole Island could come from discharges upstream in the river. The relatively uniform levels of low toxicity in the other nearshore waters may indicate more rural point and non-point source type causative agents. For example, the predominantly rural areas on the south shore may contribute non-point source type contaminants from agricultural activities. Although the determined effects cannot be related to specific compounds or conditions, the Microtox toxicity data appear to be useful indicators of the health or impairment of the aquatic ecosystem.

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