

though these exposures are in part reflected in the rurality and income variables, it would have been preferable to have included these variables explicitly. Moreover, the regression analysis cannot distinguish among organic chemicals and other possible carcinogens in Mississippi drinking water. A misspecification in the error structure arises from the fact that parishes vary in population. Heteroskedastic correction left the coefficients for drinking water roughly the same but raised the values of t by about 50 percent on average, leading to a large increase in the level of significance. While statistical studies cannot by themselves establish causality, this regression study supports the hypothesis that there is a link between carcinogens in drinking water and cancer mortality.

TALBOT PAGE

Resources for the Future, Inc.,
1755 Massachusetts Avenue, NW,
Washington, D.C. 20036

ROBERT H. HARRIS

Environmental Defense Fund,
1525 18th Street, NW,
Washington, D.C. 20036

SAMUEL S. EPSTEIN

Environmental Health Programs,
School of Medicine,
Case Western Reserve University,
Cleveland, Ohio 44106

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10. "New Orleans Area Water Supply Study," draft analytical report (Environmental Protection Agency, Dallas, Tex., 1974).
11. There are large differences in the organic chemical content between ground and surface waters generally ("Preliminary Assessment of Suspected Carcinogens in Drinking Water," interim report to Congress (Environmental Protection Agency, Washington, D.C., 1975); *Preliminary Assessment of Suspected Carcinogens in Drinking Water* (Environmental Protection Agency, Washington, D.C., 1975); J. Symons, *J. Am. Water Works Assoc.* **67**, 634 (1975)). The Mississippi system is a special case of surface waters, being far more heavily laden with organic chemicals than other sources of surface and ground water in Louisiana (J. L. Laseter, personal communication). Although it is difficult to estimate the industrial and agricultural emissions into the Mississippi several decades ago, chlorination has been practiced since the turn of the century and is of special importance in the Mississippi because of the relatively high concentration of organic matter naturally present. To construct W we used 1963 *Inventory of Municipal Water Facilities* (Public Health Service Publ. No. 775, Department of Health, Education, and Welfare, Washington, D.C., 1964).
12. Abbreviations: R is the percentage of the parish population that is rural [for whites, R was taken from Bureau of the Census, *Census of Population: 1960* (Government Printing Office, Washington, D.C., 1963), vol. 1; for nonwhites, *ibid.*, 1950 (1952), vol. 2]; I is the median family income [for whites, I was taken from Bureau of the Census, *County and City Data Book: 1972* (Government Printing Office, Washington, D.C., 1973); for nonwhites, I was taken from Bureau of the Census, *Census of Population: 1950* (Government Printing Office, Washington, D.C., 1952), vol. 2]; P , C , and M were taken from total employment and industry employments [Bureau of the Census, *County Business Pat-*

terns, First Quarter: 1962 (Government Printing Office, Washington, D.C., 1963)].

13. T. J. Mason and F. W. McKay, *U.S. Cancer Mortality by County: 1950-1969* (Government Printing Office, Washington, D.C., 1974).
14. There is some suspicion that cancers of the urinary tracts are associated with polluted drinking water (5, 9).
15. We estimated the following two equations:

$$MRF_i = a_0 + a_1W_i + a_2R_i + a_3I_i + e_i$$

$$MRM_i = a_0 + a_1W_i + a_2R_i + a_3I_i +$$

$$a_4P_i + a_5C_i + a_6M_i + e_i$$

where e_i is an error term; MRF_i is the age-adjusted mortality rate for some cancer site for females in parish i ; MRM_i is the term for males.

16. Considered separately, the regression coefficient for drinking water is significant ($P < .05$) for kidney cancer, white males; for bladder cancer, white males and nonwhite females; for cancer of the rectum, white males and nonwhite males; for cancer of the stomach, nonwhite males and nonwhite females; and for cancer of the large intestine, white females. The coefficient for W in the first regression can be interpreted as follows: On the assumption that the underlying specification is correct, if a parish that has been entirely dependent on Mississippi River water ($W = 1$) were to switch entirely to groundwater ($W = 0$), it could expect in the long run to reduce its total cancer mortality rate for white males by 32.5 per 100,000. Since the mean total mortality rate for white males is 190 per 100,000 for all parishes, this would result in about a 17 percent reduction. Similarly, for nonwhite males and nonwhite females the reductions would be 28 and 22 percent, respectively. (The coefficient for white females is not significant.)
17. The significance of the coefficient for drinking water in the total cancer regressions does not depend on the inclusion of urinary and gastrointestinal cancers in total cancer; regressions with the dependent variable "all cancers except urinary and gastrointestinal cancers" have the same pattern of significance for the drinking water coefficient as regressions with total cancer.
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Barium in Southern California Coastal Waters:

A Potential Indicator of Marine Drilling Contamination

Abstract. *The present barium content of Southern California coastal waters was determined to be 11 to 22 micrograms per kilogram of seawater. These values may be used as base-line concentrations to monitor marine contamination during future offshore oil and gas explorations.*

Earlier analyses of the barium content of seawater revealed only the upper limit of the concentration (1). Recent results demonstrate that the barium content of open oceans increases with the depth of

the water. The Pacific waters display barium concentrations of from 3 to 51 μg per kilogram of seawater (2, 3), whereas barium in the Atlantic waters ranges up to 105 $\mu\text{g}/\text{kg}$ (4).

Table 1. Isotopic composition of common and spike barium (in units of atom percentages).

Component	Isotopic mass						
	130	132	134	135	136	137	138
Common barium	0.10	0.10	2.42	6.59	7.81	11.32	71.66
Spike barium							
Scripps	<0.001	<0.005	0.454	93.47	1.629	0.885	3.560
Oak Ridge	<0.1	<0.1	0.36	93.6	1.61	0.87	3.56

I determined the barium content of seawater samples taken in the San Diego Trough off the Southern California coast by the isotope dilution method, using a 60° sector, single-focusing, solid-source mass spectrometer with a radius of curvature of 30 cm, equipped with an electron multiplier. An enriched ^{135}Ba spike, obtained from the Oak Ridge National Laboratory, was dissolved in 5 percent nitric acid to make up a standard solution containing 283 μg of barium per milliliter. The isotopic compositions of the common and spike barium were determined (Table 1).

About 60 g of unfiltered seawater was introduced into a 100-ml Teflon beaker, and 100 μl of the barium spike solution was added. The mixture was gently heated below boiling for 48 hours to ensure the equilibration of the spike and sample barium. About 10 μl of the solution (containing about 0.005 μg of barium) was placed on a tantalum filament that had been heated at 2.5 amperes to cleanse the surface. The details of the mass spectrometric operation have been described elsewhere (4). The filament current was slowly raised to about 1.8 amperes, corresponding to a temperature of 1000°C. At this temperature, the barium isotopic spectrum was observed. The changes in the $^{135}\text{Ba}/^{138}\text{Ba}$ ratio, precisely measured to ± 0.1 percent, were used to compute the barium concentrations of seawater samples (Table 2).

The barium content of seawater above the thermocline was 12 $\mu\text{g}/\text{kg}$, and that below the thermocline to a depth of 968 m increased slightly to between 15 and 22 $\mu\text{g}/\text{kg}$. The low barium content of the euphotic zone may be caused by the downward transport of barium by marine organisms. These barium concentrations are similar to those reported earlier for the pristine waters of the Pacific Ocean (2, 3).

The barium concentration in seawater is regulated by SO_4^{2-} . If we use as the negative logarithm of the solubility product constant of BaSO_4 (2) for the surface and 968-m waters values of 10.05 and 10.17, respectively, and take the SO_4^{2-} concentration in seawater as 28 mM, thermodynamic calculations show that the total soluble barium concentrations in the surface water could reach 46 $\mu\text{g}/\text{kg}$, and those of the 968-m water could reach 35 $\mu\text{g}/\text{kg}$. Thus, Southern California coastal waters are undersaturated with BaSO_4 .

Sections of the Southern California outer continental shelf have been leased for offshore oil and gas exploration. Many potentially toxic chemical com-

Table 2. Barium content of Southern California coastal waters (32°44.4'N, 117°43.0'W) on 4 December 1975; maximum water depth, 1077 m.

Depth (m)	Temperature (°C)	Salinity (per mil)	Density	Barium ($\mu\text{g}/\text{kg}$)
1	14.62	33.62	1.02503	11
2	14.21	33.62	1.02511	12
196	8.84	34.09	1.02648	21
291	8.13	34.20	1.02667	17
488	6.42	34.30	1.02699	15
582	5.76	34.34	1.02711	18
683	5.09	34.39	1.02723	17
776	4.74	34.43	1.02730	15
963	4.06	34.49	1.02742	22
968	4.05	34.49	1.02742	22

pounds will be unavoidably released into the ocean during the drilling operations. Any spillage of drilling mixture (in 1975, the United States used 1.4 million metric tons of barite in the drilling mixture), which will result in dissolution of the BaSO_4 , can be readily detected in terms

of a significant increase in Ba^{2+} in these waters. Therefore, the barium content of seawater may serve as an indicator to monitor drilling-related contamination.

TSAI-HWA J. CHOW

Scripps Institution of Oceanography,
University of California, San Diego,
La Jolla 92093

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Ethanol-Induced Depletion of Cerebellar Guanosine 3',5'-Cyclic Monophosphate

Abstract. Single doses of ethanol induce a severe depletion (95 percent) of cerebellar guanosine 3',5'-cyclic monophosphate (cyclic GMP) within 1 hour after administration. The degree of this depletion is dose-dependent and is a function of the amount of ethanol in the blood. Interactions between ethanol and cyclic GMP may account for some of the intoxicating properties of ethanol.

The role of guanosine 3',5'-cyclic monophosphate (cyclic GMP) in neuronal function is just beginning to be understood. Cyclic GMP may be a mediator of the actions of acetylcholine (ACh) in the superior cervical ganglion (1), cerebral cortex (2), and cerebellum (3) and may play an additional role as an antagonist of the actions of adenosine 3',5'-cyclic

monophosphate (cyclic AMP). The relation of cyclic nucleotides to neuroexcitability has prompted several investigations of the effects of ethanol on the cyclic AMP system (4), but so far there have been no reports of the effect of ethanol on cyclic GMP. Because ethanol induces ataxia which is probably cerebellar in origin (5) and cyclic GMP is involved in excitatory responses in the cerebellum (6), we undertook a study to determine whether ethanol has any effect on cyclic GMP concentration in the cerebellum.

Male Sprague-Dawley rats (200 to 300 g) that had been deprived of food overnight were given ethanol (2 to 6 g/kg) as a 20 percent (weight to volume) aqueous solution by intragastric intubation. At intervals after treatment the animals were killed by focused microwave irradiation (7), the brains were excised, and the cerebellums were removed for analysis. Cyclic GMP and cyclic AMP were isolated (8); cyclic AMP was quantitated by the competitive protein binding assay of Gilman (9), and cyclic GMP was measured

Table 1. Cerebellar cyclic GMP and cyclic AMP 2 hours after a single dose of ethanol. Each value (mean $\pm$ standard error) was obtained from five to ten animals.

Dose (g/kg)	Cyclic GMP (pmole/mg of protein)	Cyclic AMP (pmole/mg of protein)	Blood ethanol (mg/dl)
Control			
None	4.0 $\pm$ 0.14	3.4 $\pm$ 0.16	
Ethanol-treated			
1	4.3 $\pm$ 0.58		31 $\pm$ 10
2	2.6 $\pm$ 0.42*		100 $\pm$ 6
3	1.4 $\pm$ 0.11*		183 $\pm$ 11
4	1.0 $\pm$ 0.16*		285 $\pm$ 24
6	0.5 $\pm$ 0.04*	3.2 $\pm$ 0.08	373 $\pm$ 9

*Denotes statistical significance ($P < .05$) as determined by Student's *t*-test.