Potable Water Quality in Rural Georgetown County

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The biological effects of heavy metals are well documented (LEE, 1972) and the metals being non-degradable pose more insidious problems than environmental pollution by pesticides, sulfur dioxide, nitrogen oxide, carbon monoxide and other gross contaminants. Most of the inorganic pollutants--lead, arsenic, mercury, iron, cadmium, nitrates, phosphate, etc.--that concern man, occur in nature and are almost ubiquitous. In some cases, their environmental levels are largely due to natural sources while in others, the levels are generally produced by man's activity.

Mercury fungicides have been used for seed treatment against fungi for more than half a century. Arsenic compounds, cacodylic acid (CA) and disodium methane arsinate (DSMA) are still popular pesticides. Arsenic concentrations up to 70 ppm were detected (ANGINO, 1970) in several presoaks and household detergents. Waste water of these detergent products along with numerous metallic ions once discharged into the environment have distinct possibilities of entering the water system and therefore contributing to water pollution.

The drinking water quality of selected interstate carrier supplies tested (PUBLIC HEALTH SERVICE, 1963) showed more than 90 percent of them contained variable amounts of copper, iron, lead, manganese, zinc, arsenic, etc.

Twenty percent of the ground and surface drinking waters studied (NOWELL, 1971) showed trace contaminations of silver, barium, copper, mercury, lead and zinc. Manganese concentrations up to 20 ppm were recorded (ANGELILLO, 1961) in some water supplying reservoirs. Analysis of tap water, from 148 municipalities showed (SCHROEDER and BALASSA, 1966) that 98 percent of the supplies contained variable amounts of arsenic.

The search for mercury in drinking water (HAMMERSTON et al, 1972) lead to the detection of trace quantities of the element in 70% of the samples but only one of 698 waters examined exceeded the health limits. The drinking water supply wells have been found to have high levels of nitrates (HARRIS and BRECHER, 1974) due to possible seepage from septic tanks. Infant cyanosis caused by excessive nitrates in drinking water has been reported from various parts of the country (ENVIRONMENTAL STAFF REPORT, 1970).

The Health Services closely monitor the public potable waters for biological contamination but some 90 percent of the systems checked by them were not tested for metals or any other chemical (HARRIS and BRECHER, 1974), though lead poisoning and environmental lead pollution has been found in softwater areas (GOLDBERG, 1974) where lead lined water tanks were considered the source of metallic contamination. The principal sources of lead in municipal drinking waters are lead pipes and goose necks in houses and plumbing services (KEHOE et al, 1940).

This study was conducted in the rural Georgetown County of South Carolina, the location of which is shown in figure 1. Georgetown County has a population of 33,600 of which 61% live in rural areas (MCLEAN,

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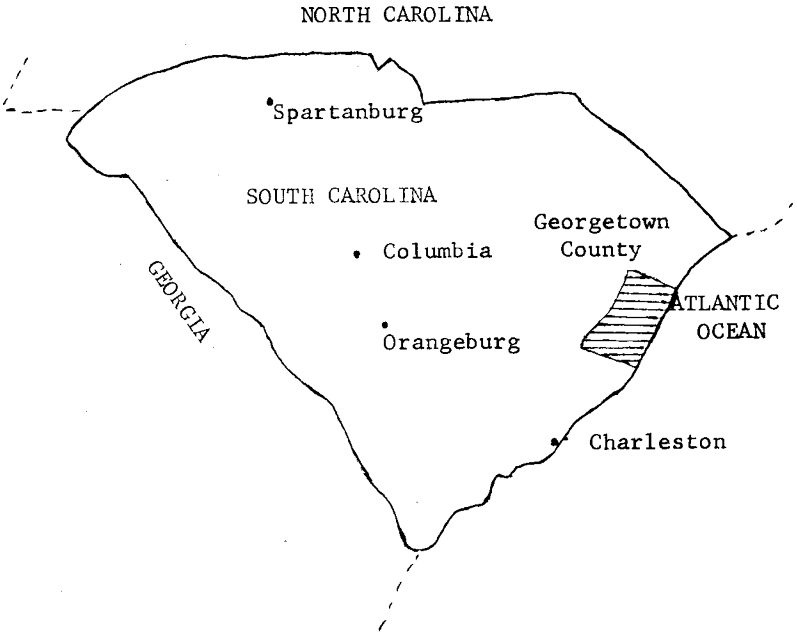

Figure - 1 Location of the study

1970). Consequently, most of the drinking water in this county comes from private water supplies, many of which are probably ill designed from a sanitation standpoint. This study was undertaken as a thorough investigation of the drinking water quality of the rural homes and communities. The findings on the extent of chlorinated hydrocarbon and bacterial contamination have been reported previously (ACHARI et al, 1975, SANDHU et al, 1974). This presentation desires to assess the levels of inorganic constituents in potable waters of rural Georgetown County, to determine if the inorganic components in drinking waters exceed the federally recommended limits (PUBLIC HEALTH SERVICE, 1962) and to determined whether pollution sources can be identified.

Method and Materials:

Drinking water supplies of 161 rural communities were randomly selected for sample collection. The sample size was determined by the density of population and varied from 5 to 10 percent in different areas of the county. The information concerning the water supply sources such as location, types of water source, water table, fertilizers used, location of industry in the vicinity and family income, were also obtained at sampling time. All samples came from sources where it was not possible to chlorinate or otherwise pretreat the water before its household use. At sampling, the water did not show any offensive physical characteristics.

The water samples collected were analyzed according to the methods published in Standard Methods for the examination of water and waste water (AMERICAN PUBLIC HEALTH ASSOCIATION, et al 1971). Temperature and pH were recorded at the point of collection. Chlorides were determined by the Argentometric method. Nitrites were converted to nitrates, and then, total nitrates determined by the phenol disulfonic acid method. Total residues were determined by the evaporation of a suitable aliquot in Pyrex dishes. Turbidities were determined by the Nephelometric method. Sodium and fluoride concentrations were determined using specific-ion electrodes from Orion Research (ORION RESEARCH, 1972). Aliquots of samples were preserved with nitric acid. The acidified samples were directly aspirated, under standard conditions, into a Perkin-Elmer, model 306, atomic absorption spectrophotometer for the evaluation of copper, iron, manganese and zinc. One-hundred ml of the acidicfied water samples were concentrated to 10 ml by evaporation on a water bath, for the determination of arsenic, lead and cadmium using a sampling boat system. Mercury in the water was determined by flameless atomic absorption spectrophotometry (PERKIN-ELMER CORP, 1971).

Results and Discussion

A summary of chemical and physical characteristics of the potable waters, sampled from rural communities of Georgetown County, along with the mandatory limits (PUBLIC HEALTH SERVICE, 1962) are presented in Table I. The majority of waters were slightly acidic. Arsenic was detected in 92 percent of the samples analyzed and 72 percent of them ranged between .01 ppm (recommended limit) and .05 ppm (mandatory limit). Only 2 percent of the water supplies had arsenic concentrations above the mandatory limit, Cadmium was found in only 22% of the water supplies, and the concentrations were very low. Lead and mercury occurred in 98% of the water supplies. Three percent of the water samples had lead concentrations above .05 ppm, and only one sample showed mercury above .01 ppm. The frequency of iron and manganese occurence were 99 and 82 percent respectively. Iron was above recommended limits in 82 percent of the waters, and manganese exceeded the established health limit in 37% of the waters. According to the United States Public Health Service's recommendations (PUBLIC HEALTH SERVICE, 1962), these waters are unfit for human consumption. Small quantities of copper were found in 98% of the water supplies. Two percent of the water supplies had zinc concentrations above 5.00 ppm.

Nitrate, phosphate, chloride and fluoride were found in small quantities in nearly all the water supply sources examined, but none of these components were found in sufficient amount to endanger human health. In general total dissolved solids were well below the prescribed limits (PUBLIC HEALTH SERVICE, 1962) and only 10.4% showed high quantities of dissolved solids. The majority of these samples containing high quantities of dissolved solids came from the area boarding the ocean. The majority of the drinking waters showed variable amounts of turbidity, and 45.3% of the samples had turbidities higher than the upper limit, of 5 unities (PUBLIC HEALTH SERVICE, 1962).

Statistical analyses of the data in Table I were done in an attempt to identify the possible sources polluting the drinking water supplies (Table II). There are many variables in the present study, and the problem of clearly defining the pollution sources is quite complex. The consumer, in general, was not aware of the quality of water he used and his income or educational status did not show any persistant relation

TABLE I

Chemical Composition of Drinking Waters

Component	Concentration, ppm				Percent Frequency of Occurence	Percent Exceeding Mandatory Limit
	Mean	Range	Standard Deviation	Mandatory Limit (Public Health Service, 1962)		
Arsenic	0.018	0.070 -- 0.0	0.012	0.05	92.	2.0
Cadmium	0.004	0.005 -- 0.0	0.001	0.01	22.	0.0
Chloride	21.430	135.5 -- 1.2	30.25	250.0	100	0.0
Copper	0.064	0.530 -- 0.0	0.120	1.00	89	0.0
Iron	3.918	32.00 -- 0.00	4.968	0 30	99	88.3
Fluoride	0.163	00.6 -- 0.00	0.155	0.8	98	0.0
Mercury	0.004	0.030 -- 0.000	0.005	0.01	98	1.8
Manganese	0.059	0.46 -- 0.0	0.075	0.05	82	37.0
Sodium	1 593	5.60 -- 0.46	1.025	----	100	---
Nitrate	2.641	9.80 -- 1.22	1.965	45.00	100	0.0
Phosphate	1.935	5.10 -- 0.93	1.431	-----	100	----
Lead	0.018	0.132 -- 0.00	0.018	0.05	98	3.0
Zinc	1.050	21.60 -- 0.101	2.352	5.00	100	2.0
Total Dissolved Solids	277.8	1184 -- 24	233.0	500		10.4
pH	6.86	8.4 -- 4.7	0.87	----	----	----
Turbidity (units)	14.48	100 -- 0	22.91	5	73.0	45.3
Temperature °C	23.06	17 -- 37	3.4			

TABLE II

Statistical Analysis of Data in Table I

Parameter	Correlation-Coefficient	Slope, m	Intercept, Xi
Income, X vs Iron, Y	-0.19**	-135.8	5519.0
Income, X vs Lead, Y	+0.17	------	4848.7
Septic Tank Well Distance, X vs Iron, Y	-0.14	- 3.3	100.4
Septic Tank Well Distance, X vs Arsenic, Y	-0.14	177.7	85.8
Septic Tank Well Distance, X vs Phosphate, Y	-0.17	- 8.5	102.4
Septic Tank Well Distance, X vs Nitrate, Y	-0.18	- 10.5	109.3
Depth of Well, X vs Iron, Y	-0.33 ***	- 1.1	69.0
Depth of Well, X vs Lead, Y	-0.04	- 58.5	66.0
Depth of Well, X vs Arsenic, Y	-0.20*	76.0	75.0
Iron, X vs Manganese, Y	-0.02	- 0.003	13
Hydrogen Ion, Y vs Iron, X	0.06	$2.2x10^{4}$	3.8
Hydrogen Ion, Y vs Lead, X	0.25 **	$6.4x10^{3}$	4.0
Turbidity, X vs Iron, Y	0.32 ***	3.6	0.02
Income, X vs Depth, Y	0.60***	24.5	3350

Statistically Signigicant at: *p = .10, **p = .05, ***p = .01

to many of the chemical measurements. Significant correlations were found between the income of the consumers, the iron content of their water supplies and the depth of the wells. It appears that higher income groups had deeper wells, thus drawing on waters generally low in iron (Table II).

Though not pronounced, it appears that phosphate, nitrate, iron and arsenic contents of waters decreased as the distance of the water supply source from the septic tank increased. The statistical analysis indicates that iron and arsenic concentrations decreased with increasing well depth. The lead concentration did not show any correlation with the water supply depth.

It has been observed (MINEAR, 1973) that ground-water tracer pollutant salts diffused 800 feet within 17 hours. It may be inferred from the data of Table II that the quality of drinking water is affected by at least two factors: (1) the depth of the well, and (2) the location of the septic tank. The nearness of shallow water supply sources to the septic tank is likely to affect the water characteristics adversely due to possible seepage from the septic tank and leaching of the soluble soil components into the ground water.

The hydrogen ion concentration did not have any pronounced effect on iron content in the waters, but lead content increased as the hydrogen ion concentration of the waters increased.

The type of material used in the plumbing service has a strong bearing on the amount of lead found in drinking waters. The data of Table III suggest that plastic plumbing pipe in the house has very low lead contamination as compared to iron or galvanized plumbing.

TABLE III

Lead Concentration as Affected by Types of Plumbing

Type of Plumbing	Mean	Range	Standard Deviation
Iron	17.5	9.7 - 30.0	6.1
Galvanized	8.6	2.0 - 13.0	5.0
Plastic	1.1	0.0 - 1.8	1.5

The amount of manganese found in waters is independent of iron concentration. The turbidity of water is a direct consequence of the amount of iron as indicated by the data in Table II. The water when drawn from the supply source seldom showed any turbidity, but when kept overnight, resulted in the development of turbidity due to possible oxidation and precipitation of iron (STUMM and MORGAN, 1970).

Summary

Drinking water supplies of 161 rural communities, in Georgetown County, South Carolina, were randomly selected for sample collection. The analysis showed that most of the waters were slightly acidic. Low, but acceptable concentrations of chloride, copper, fluoride, sodium,

cadmium, nitrate and phosphate were found. A few water samples showed higher then recommended levels of arsenic, mercury, zinc and lead. Although only 2% of the samples exceeded the mandatory limit of 0.05 ppm for arsenic, 72% exceeded the recommended level of 0.01 ppm.

The mandatory limit for manganese was exceeded in 37% of the waters while 88% exceeded the limit for iron. The high iron content was generally responsible for the high turbidity found in 45% of the samples. The well depth and the consumer income had some bearing on water quality. Statistical evidence suggested that septic tank seepage was partially responsible for nitrate, phsophate, iron and arsenic contamination of shallow water supplies. Lead concentrations appear to vary according to the plumbing used and the pH of the waters.

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