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HEAVY METAL IONS IN THE SURFACE AND SUBSURFACE WATERS AROUND SAVANNAH

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In an earlier study, Ghuman[1] reported some of the chemical characteristics of surface and subsurface waters around Savannah. Characteristics included were pH value, carbonate, bicarbonate, chloride, and total dissolved solids as well as qualitative observations regarding the presence of calcium, sulfate and phosphate in these waters. In the present investigation, heavy metal ions, including the total dissolved solids, have been studied. The optimum concentrations of metals such as calcium, magnesium, sodium, and potassium in the water are desirable. However, the excessive levels of these metals and very small amounts of toxic metals such as lead in the waters intended for domestic, industrial, and irrigation purposes and for marine life can cause serious hazards.

Ground water, one of the nation's most valuable natural resources, is defined as that part of the subsurface water in the zone of saturation. The geology of a certain area has a tremendous influence on the occurrence of water and its movement through the area. Obviously, then the geology determines to a considerable extent what happens to any contaminant that may be introduced into the habitat of ground water. Ground water is one phase of the hydrologic cycle. The hydrologic cycle consists basically of precipitation, runoff (both direct and ground water), and evaporation; and then the cycle starts again with precipitation.

Contamination of ground water can occur from a point or line source in a recharge area. The topography of the land surface also has a very important influence on ground water conditions. Water and any attendant contaminant in unconsolidated materials move through the interstices of the strata. In view of these conditions affecting the water quality, the present study was conducted to achieve the following objectives:

(1) To detect presence and/or buildup, in aquatic systems, of potentially hazardous substances.
(2) To evaluate the impact of salty ocean water on the quality of lake water and ground water supplied by the Ocala aquifer.

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Materials and Methods

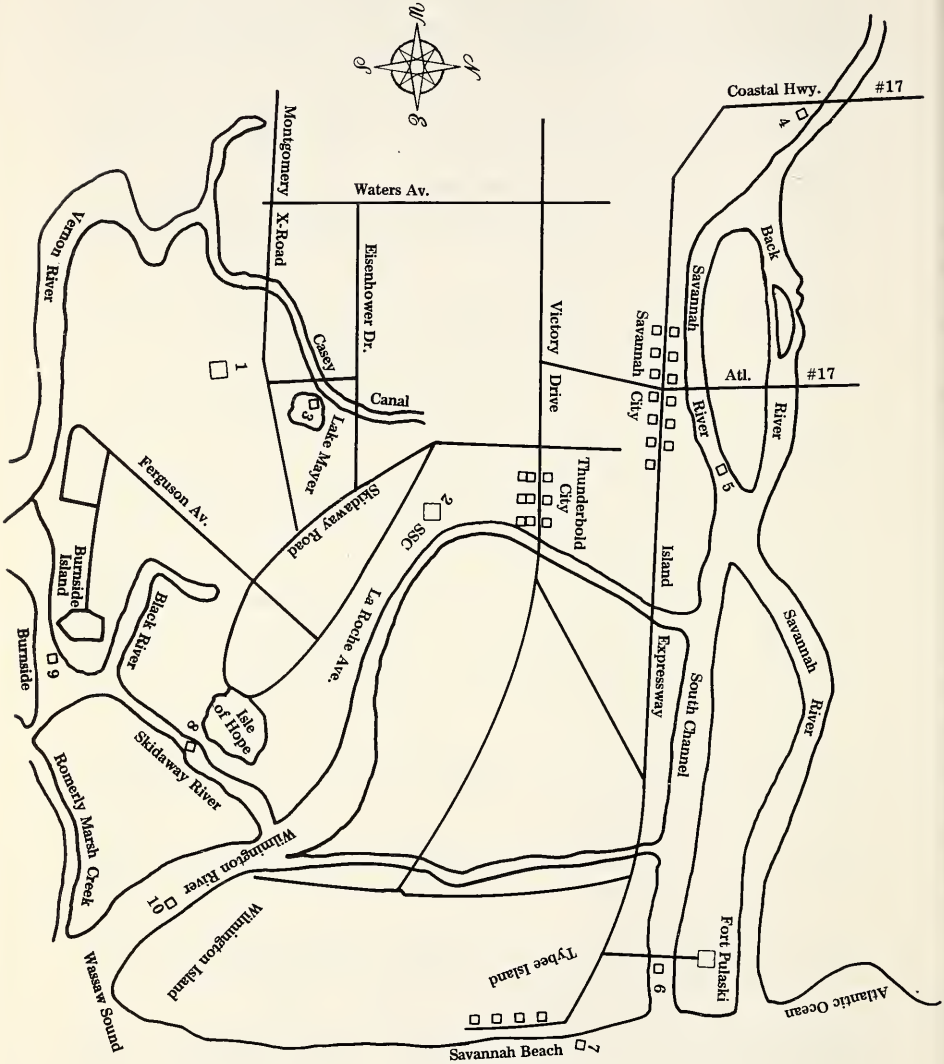
Water Samples

In the second week of June, 1974, ten water samples were collected in polyethylene bottles from Savannah and Thunderbolt cities, Lake Mayer, Savannah River and its branches terminating in the Atlantic Ocean. Sites of sample collections are shown in the attached map and the exact locations with their latitudes and longitudes are described as follows:

1. Savannah City water supply sample: Ground water taken from a house tap in Mayfair Subdivision. Location — 31° 58′ 30″N; 81° 06′W.
2. Thunderbolt City water supply sample: Ground water taken from a tap in the Earth Sciences Laboratory of Savannah State College. Location — 32° 01′ 24″N; 81° 03′ 20″W.
3. Lake Mayer water: Surface water collected from the artificial lake filled with rain water one year ago. Location — 31° 59′ 08″N; 81° 05′ 30″W.
4. Savannah River water: Surface water collected from the vicinity of the river bridge on Highway 17. Location — 32° 10′N; 81° 09″W.
5. Savannah River water: Surface water collected from a point just behind the Kilowatt Room of Savannah Electric Company. Location — 32° 04′ 48″N; 81° 05′ 37″W.
6. South Channel water: Surface water from a site under the channel bridge for the road leading to Fort Pulaski. Location — 32° 01′ 26″N; 80° 55′ 48″W.
7. Atlantic Ocean water: Surface water collected from the north end of Savannah Beach. Location — 31° 59′ 30″N; 80° 50′ 38″W.
8. Skidaway River water: Surface water taken at Modena Plantation Dock of Isle of Hope. Location — 31° 58′ 52″N; 81° 4′ 30″W.
9. Burnside River water: Surface water collected at the Burnside Island dock site. Location — 31° 55′ 42″N; 81° 05′ 56″W.
10. Wilmington River water: Surface water collected at the river boat dock on the Wilmington Island. Location — 31° 59′N; 80° 59′ 48″W.

In the ensuing discussion, these samples will be referred by their numbers or by short descriptive names.

IDEALIZED MAP SHOWING SITES OF WATER SAMPLES #1 TO 10



Analytical Methods

The water samples were carried to the School of Geophysical Sciences, Georgia Institute of Technology, Atlanta and were analyzed there by the author as part of the summer, 1974 study. The suspended particulates of samples were removed by filtration through a fine filter. The Orion Research Digital pH Meter, Model 801, was used to determine pH. Metal ions of calcium, magnesium, potassium, sodium, iron, manganese, and lead were determined with the use of Atomic Absorption Spectrophotometer, Model 303. In the estimation of major metals of Ca, Mg, K, and Na, the samples had to be diluted from 10 to 5,000-fold with deionized water to bring within the proper range of detection by the instrument. One hundred ppm (parts per million) Li as LiCl was mixed in standard and test samples to avoid interference with phosphate in the determination of Mg. Standard settings and flame conditions were used as recommended by the Perkin-Elmer instrument guide. Total dissolved solids were estimated in the Earth Science Laboratory of Savannah State College. The estimation was carried out by evaporating to dryness on a water bath 25 or 50 ml water samples in tared porcelain dishes. The drying of the samples was completed in the air oven at 100°C for one hour and the dried residues were cooled in a desiccator and then weighed accurately on a Mettler balance. The loss of weight due to the decomposition of bicarbonates during the process of drying was added to obtain the final estimate of total dissolved solids.

Results and Discussion

Analytical data regarding pH values, metal ions including calcium, magnesium, potassium, sodium, iron, manganese and lead, bicarbonate ion and total dissolved solids of water samples are given in Table 1.

The data indicate that with only one exception, the pH, bicarbonate content and total dissolved solids of all the surface and ground water samples are higher as compared to the values reported in 1969[1]. This confirms the general and gradual increase of salt content of waters with the passage of time. Ground water used for domestic purposes in Savannah and Thunderbolt cities is supplied by the Ocala aquifer. The aquifer flows through sedimentary limestone strata at a depth of 250 to 400 feet. Both the ground water samples contain an excess of sodium and magnesium over calcium and this may bear some relationships with the health of the people. From health point of view, greater concentration of Ca than Mg is considered desirable. Relatively high content of sodium (Na) makes this area's ground water "soft" as against the common belief of considering it as "hard" water. Such a composition may be attributed to the encroachment of ground water with sea water and also to the chemical nature of limestone layer which

TABLE 1

pH Value, Metal Ions, Bicarbonates, and Total Dissolved Solids of Water Samples

No.	Sample Description	Concentrations in ppm*									
		pH	Ca	Mg	K	Na	Fe	Mn	Pb	HCO_3	Total Solids
1.	Savannah City water	8.40	5.8	8.0	2.4	13	1.4	.06	Nil	146.4	254
2.	Thunderbolt City water	8.52	6.0	8.5	3.0	20	1.2	.07	Nil	175.7	285
3.	Lake Mayer water	7.91	44.0	12.5	7.0	16	1.2	.07	.15	175.7	409
4.	Savannah River water (Highway 17 site)	6.89	2.5	0.6	2.2	18	1.6	.05	Nil	58.6	134
5.	Savannah River water (Kilowatt room site)	6.93	33.0	107.5	50.0	1000	1.2	.07	.15	117.2	3995
6.	South Channel water	7.39	180.0	775.0	320.0	7000	2.3	.07	.38	146.4	26874
7.	Atlantic Ocean water	7.92	234.0	1075.0	480.0	10500	2.5	.10	.46	146.4	33126
8.	Skidaway River water	7.42	186.0	875.0	375.0	7600	2.5	.08	.31	146.4	26374
9.	Burnside River water	7.51	186.8	875.0	365.0	8000	1.8	.08	.38	146.4	26814
10.	Wilmington River water	7.51	202.5	950.0	380.0	8250	2.3	.10	.46	146.4	28894

*ppm = parts per million or milligrams per liter.

requires a study. Slightly higher levels of Ca, Mg, K, and Na in Thunderbolt water as compared to Savannah water is a manifestation of the effect of distance to the sea coast. However, low levels of total solids cause no immediate concern about the quality of ground water as the quality is considered excellent up to 700 ppm of dissolved material.

Lake Mayer is a man-made lake filled with rain water since one year ago. Presence of lead (Pb) and high total solids indicate its contamination either by runoff from the surrounding land or more probably by leaching from the adjacent Casey Canal which is filled during the high tide cycle of the ocean. Continuation of this process for a few years will turn the fresh lake water into salty water which may become a source of salt recharge to the ground water. Local government needs to take early steps to lay the canal bottom with impervious tiles to prevent the leaching of salty ocean water into the lake. Chemical contamination may move farther through an aquifer than bacterial contamination and is generally more difficult and expensive to remove from the water when it is reclaimed.[2]

Savannah River water at Highway 17 site has the lowest pH and tested constituents among the ten samples. The U.S. Geological Survey[6] reported the following chemical composition of Savannah River water at Clyo in May-June of 1971-72: Ca = 4.9 mg/l ; Mg = 1.3 mg/l; K = 1.4 mg/l; Na = 7.8 mg/l; Fe = 1.1 mg/l; Mn = less than 50 microgram/l; alkalinity as $CaCO_3$ = 22 mg/l; SO_4 = 4.0 mg/l; Cl = 5.0 mg/l; nitrite + nitrate = 0.42 mg nitrogen/l; dissolved ammonia nitrogen = 0.03 mg/l. In the determined elements of Savannah River water taken downstream from Clyo (sample #4), Ca and Mg are lower, K and Na are higher, while Fe and Mn are nearly the same as compared to those reported for Clyo site. Concentrations of metal ions and the pH of the river samples (#4 — #7 & #8 — #10) increase with the proximity to the Atlantic Ocean. Mn levels in all samples are 0.1 ppm or less as it rarely exceeds 1 mg/l. Natural waters seldom contain more than 20 ug/l of lead (Pb), although values as high as 400 ug/l have been reported. The concentrations of lead in the lake and river waters need to be further ascertained.[4] Lead is a serious cumulative body poison and must be avoided.

The major constituents calculated as percentages of all dissolved material in the water samples are listed in Table 2.

The data in Table 2 reveal that Na is the predominant metal ion in all water samples except the lake water in which calcium is the most abundant. Magnesium occupies second position except in the case of samples #3 and #4. The percentage of Ca is greater in the first four samples, but decreases in the brackish and salty waters (#5 to #10). Potassium varies within the narrow limits of 0.97 and 1.71. Metal ions in the fresh waters (#1 to #4) are primarily combined with bicarbonates the percentage of which ranges from 41.77 to 61.68. These values agree with those of Livingstone[3] who reported 48.6% of

TABLE 2

Distribution of Major Constituents as Percentages of all Dissolved Material in water samples.

No.	Sample description	Total Solids ppm	Percentage of Total Solids Na	Mg	Ca	K	HCO_3
1.	Savannah City water	254	5.12	3.14	2.28	0.97	57.68
2.	Thunderbolt City water	285	7.02	3.68	2.11	1.05	61.68
3.	Lake Mayer water	409	3.91	3.05	10.74	1.71	41.77
4.	Savannah River water (Highway 17 site)	134	13.43	0.45	1.86	1.64	43.72
5.	Savannah River water (Kilowatt room site)	3995	25.03	2.69	0.83	1.25	2.93
6.	South Channel water	26874	26.04	2.88	0.67	1.19	0.54
7.	Atlantic Ocean water	33126	31.69	3.25	0.71	1.45	0.44
8.	Skidaway River water	26374	28.81	3.32	0.70	1.38	0.55
9.	Burnside River water	26814	29.83	3.26	0.70	1.36	0.54
10.	Wilmington River water	28894	28.55	3.23	0.69	1.29	0.49

bicarbonate (HCO_3), and 6.5% of chloride in a river water sample with 120 ppm of total solids and 0.41% bicarbonate as well as 55.04% chloride in sea water. The percentage distribution data for the river and ocean water samples (#5 to #10) are very much similar to those reported by Sverdrup *et al.*[5]

Conclusions

a) All the surface and ground water samples showed an increase in pH value and total dissolved solids as compared to those reported in 1969.
b) Ocala aquifer ground water used for domestic purposes in the Savannah area contains more sodium and magnesium as compared to calcium, thus indicating its soft nature and slight contamination with sea water.
c) Lake Mayer water is getting contaminated by sea water through leaching from the Casey Canal and contains traces of lead.
d) Savannah River water at Highway 17 site and upstream has low level of total dissolved solids and can be used for domestic purposes when necessary.
e) Low levels of lead are present in the ocean water and the river waters mixed with ocean water. It requires further investigation.

A systematic monitoring of the chemical composition of ground and surface waters around Savannah and further inland is required to determine the rate and extent of encroachment of sea water and presence of any pollutants. A study of the health-related effects of magnesium, soft, and hard water will be highly appropriate.

Footnotes

[1] Ghuman, G. S. 1969. Chemical characteristics of surface and subsurface waters around Savannah. Fac. Res. Bull. 23, 15-21. Savannah State College.

[2] Ground water contamination. 1961. Proc. of Symposium, U.S. Dept. HEW, Robert A. Taft Sanitary Eng. Center, Cincinnati, Ohio.

[3] Livingstone, D. A. 1963. Chemical composition of rivers and lakes. U.S. Geol. Surv. Prof. Paper 440-G, p. 64.

[4] Standard methods for the examination of water and waste-water. 1971. Published by Amer. Public Health Assoc. 13th ed.

[5] Sverdrup, H. U., M. W. Johnson, and R. H. Fleming. 1942. The Oceans. Englewood Cliffs, N.J. Prentice Hall, Inc. p. 166.

[6] Water Resources. 1972. U.S. Dept. of Interior, Geol. Survey. p. 48.

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