Does Acid Well Water Erode Plumbing, Vessels, and Sanity?

Carl C. Pfeiffer, Ph.D., M.D.1

Critical attention is now focused on certain elements in man's drinking water that may, in toxic quantities, cause severe physiological and mental illnesses or death. The trace elements known to be essential to animal and human life are copper, tin, iron, manganese, zinc, chromium, molybdenum, cobalt, vanadium, iodine, sulfur, and selenium. Others, such as sodium, potassium, magnesium, and calcium are needed daily in large amounts to sustain life. Heavier elements such as lead, mercury, and cadmium are poisons which slowly accumulate with age as a body burden much like barnacles accumulate on a ship at sea.

These poisonous heavy metals can displace the normal zinc, manganese, and copper from their enzymes in brain and other body tissues. Malfunction such as hyperactivity or continuous stimulation can result. Even among the useful trace elements, an overabundance of copper or iron can substitute for zinc, manganese, and magnesium to produce a continuous level of overstimulation which can be manifested clinically as insomnia, elevated blood pressure, and restless nonproductive activity. Many depressed patients are also high in serum copper. Neurophysiologists have known for years that if the isolated nerve muscle preparation fires continuously, then some copper ions must have gotten into the nutrient saline solution. Class distillation of the water provides the base for nutrient solutions which do not stimulate the nerve endings.

Acid soft water as from a well bored into shale or peat can erode the plumbing to produce high levels of toxic heavy metals. Since zinc is not pure, galvanized piping can lead to excess cadmium in the drinking water, while copper piping with soldered joints can lead to an excess of copper and lead. In some areas of New Jersey soft well water will produce pin holes in copper piping in 10 years' time. The copper and lead goes into drinking water!

A question currently being asked by the World Health Organization is: do abnormal amounts of certain trace elements lead to arteriosclerotic heart disease, or does the disease itself cause such changes in trace elements? Considerable statistical evidence has caused some to strongly suggest that excess or deficiencies of trace metals might be critical factors in causing death from heart attacks. The controversy

[1] Brain Bio Cenlsr, 1225 State Road, Princeton, New Jersey

seems to center on trace and toxic elements and their content in hard and soft water with the underlying hypothesis that the concentration and interrelationships of calcium, magnesium, and carbonate are fundamentally related to the association of cardiovascular disease with drinking water. Other harmful trace elements, particularly the metal contaminants from pipes, may also be the cause of the cardiovascular death rate. In this theory, the liming of the pipe which occurs with hard waters would protect the individual from cadmium, copper, and lead.

Dr. Henry Schroeder (see review 1973) pioneered this field of research by initially studying cadmium as a determinant of chronic illness in rats and then studying cadmium levels in man. His studies revealed that a high cadmium content in the drinking water of his rats shortened their life span by 10 to 15 percent. Concurrent with this, hardening of the arteries, enlarged hearts, and high blood pressure was found. Similar studies on people dying of hypertension revealed a higher level of cadmium in their kidneys than in those of individuals dying of accidents or other diseases. Studies in St. Louis and also Philadelphia have confirmed that hypertension is highly correlated with high tissue cadmium levels. With the evidence presently available, it seems likely that cadmium is a factor in human hypertension and stroke. This is supported by the fact that soft well water tends to be acidic and the acid corrodes pipes; thus, the cadmium contained in pipes as a contaminant in galvanized pipes is more easily eroded in soft water areas and is consequently ingested by its users.

Other findings by Schroeder (1965) have indicated that the intestinal absorption of elements such as lead, cadmium, zinc, and chromium is inversely related to the concentration of calcium in the food, so that high lead absorption is more likely to be a problem in soft water areas where the calcium content is low. This is also supported by Crawford (1972) who found an inverse relationship between indices of water hardness and cardiovascular death. In one study done by Crawford et al. (1968), of large boroughs in England and Wales, the correlation coefficients between cardiovascular death rates and water hardness were inversely related and highly significant, with the greatest significance occurring with calcium and the carbonate fractions (the natural ingredients for pipe liming). The only other factor found to be significantly associated with the cardiovascular death rate was rainfall; this is to be expected because areas known to have a high average annual rainfall tend to be soft water areas high in cardiovascular disease. Also, areas where hardness had decreased over a period of 30 years show an increase in cardiovascular disease. Similar studies done in Oregon and Canada (Peterson et al., 1970; Neri et al., 1972) did not provide consistent evidence and suggest that further research is needed before all important factors are found.

The water calcium content seems to be one decisive factor, and it may be that because calcium may act by inhibiting the absorption of toxic elements from pipes and soil, it may be protective against several poisonous elements. Crawford and Clayton (1973) discovered that people living in soft water areas have higher concentrations of lead in their bones than those living in hard water areas, concluding that lead, is less likely to be absorbed by those living in hard water areas. A recent experimental study done by Six and Goyer (1970) showed clearly that there was a greater absorption of lead when dietary calcium is low and subsequently discovered that hard water acts as a protective agent against both the pickup of lead from soldered pipes and its absorption by the body. At low levels of calcium intake magnesium metabolism is altered, and this may be important. Two studies have shown differences in tissue concentrations of calcium and magnesium ions of patients in hard and soft water areas (Crawford and Crawford, 1967; Bieren-baum et al., 1969).

Other studies have implicated soft water as a determinant in the high rate of cardiovascular and infantile mortality (Schroeder, 1965; Crawford et al., 1972). Crawford and Stitt (1972) found that blood pressure, plasma cholesterol, and heart rate were higher in soft water towns and indicate that hypertension, "sudden death," and peptic ulcers are more prevalent in these towns. The possible explanations for these occurrences are that hard water could contain a factor that helps prevent heart attack and disease that could be missing in soft water, or that soft and acidic water could leach cadmium, copper, and lead from pipes and become harmful. Because these studies have been conducted in various geographic areas, the hypothesis that the harder the water, the lesser the degree of cardiovascular disease and mortality, seems to be generally upheld. The World Health Organization is conducting a study on toenails for trace element content. Toenails come in less contact with environmental elements than do fingernails and hair which are contaminated by lacquers, dyes, sprays, and shampoos. They are also comparing the amounts of trace elements in hearts, livers, and arteries from patients with degrees of arteriosclerosis varying from severe to minimal. Their contention is that because more people in urban areas drink limited amounts of water and more of other fluids such as milk, a geochemical environment might be a factor; thus, they are analyzing soils and studying soluble rock composition. The totality of this research seems to suggest a strong relationship between environmental factors, especially trace element content of drinking water, and the degree of cardiovascular disease and mortality.

A trace element that is presently being studied for its effect on physiological and psychological functioning is copper. Excessive amounts of this trace element in the blood can be toxic and harmful. Klein et al. (1972) postulated that hemodialysis with the use of water with high copper concentration could cause copper intoxication with hemolysis. They studied three patients undergoing repetitive hemodialysis and discovered a significant hypercupremia following dialysis and attributed the possible mechanisms of copper entry into the dialysis to contamination of tap water from copper pipes. The directions for house dialysis now include a flushing of the water system for five minutes before dialysis is started. Large medical buildings represent a bigger problem because of the extensive copper piping. Pigs and sheep fed excess copper develop hemolytic anemia. This same hemolytic anemia afflicted the hemodialysis patients.

When patients on dialysis accidentally accumulate excess copper ion in their blood stream, they have psychiatric symptoms of unreality, dysperceptions, and even psychosis (Halper, 1971, Table 1).

Recently, we at the Brain Bio Center have been studying the effect of certain trace elements, particularly copper and iron, as factors in various types of schizophrenia. Research thus far has implicated excessive levels of copper and iron plus low zinc and manganese as etiological factors (Pfeiffer and lliev, 1972).

Copper is a necessary element for supporting life, but in excess can be toxic. When the copper-containing protein, Ceruloplasmin, is adequate in the blood it inhibits the intestinal absorption of copper. But, as in the case of Wilson's disease, where the serum contains an insufficient amount of Ceruloplasmin, copper is absorbed in excess and diffuses into the tissues and may accumulate in high levels in the brain and liver producing severe mental illness and death. Because Ceruloplasmin is low the serum copper is low, but tissues are high. Fortunately Wilson's disease is rare; in over 900 psychiatric patients studied for copper levels we have not found a single case of Wilson's disease. In our present environment we are satiated with excess copper so that only premature infants might be deficient in copper. A comparison of

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TABLE 1

Dementia Dialytica: Clinical Mystery
or Diagnostic Dichotomy

Psychiatric Diagnosis Since 1974 (Peterson and Swanson) Termed "Dementia Dialytica"	Medical Diagnosis Since 1969 (Matter et al.) Tap Water Dialysis Increases Serum Copper
Neurological	**Medical**
Speech disorder, slow articulation	Hemolytic anemia, Hematuria (Ivanovich et al., 1969)
Stuttering, aphasia, headaches	
EEG: Slow waves with delta waves and spikes. Aiftey et al. (1972)	Lowered hematocrit with right (liver) or left (spleen) upper quadrant pain (Manzler and Schreiner, 1970)
Myoclonus, convulsions	Green plasma!
Hypertension, restlessness	Nausea, vomiting
Increased heart rate and irregularities	Yellow watery diarrhea
Cardiac standstill	Weakness, syncope
Psychiatric	**Psychiatric**
Inability to concentrate	Unreality
Impaired memory	Depression
Personality changes	Psychosis
Psychotic behavior	**Pathological**
"Disequilibrium syndrome" (unknown changes in vasoactive amines)	Increased tin in brain at autopsy
J.A.M.A. 224:1578 (1973)	
Ibid 226:190 (1973)	
PSYCHIATRIC THEORIES (Halper, 1971)	MEDICAL THEORIES
(1) Dependency increases aggressive feelings (dependency on public finances)	(1) Heavy metal intoxication
(2) Defences all brittle	(2) Copper intoxication (Mahler et al., 1971)
(3) Stress = Anxiety, Depression, Paranoia, and Suicidal	
(4) Denial of aspects of reality	
(5) Decreased sex activity	

The psychiatric, neurological, and medical findings of hemodialysis patients when tap water is used. Copper in the tap water may turn the blood plasma green since copper accumulates preferentially in plasma. Symptoms have been described since 1964, but only in 1969 was the syndrome correlated with excess copper or other heavy metals such as tin. In some instances, copper tubing and copperized plastic were involved (Barbour et al., 1971). Excess copper would be the most likely cause since some schizophrenics improve when their excess copper is removed. Cross references between the two columns are so rare as to suggest a dichotomy of diagnosis and thinking.

schizophrenic and normal subjects reveals that schizophrenics excrete less copper than do normals. This seems to correlate with the knowledge that excess copper can produce mental illness. Also this would validate the use of penicillamine in the treatment of schizophrenia. Penicillamine is a chelating agent of both zinc and copper. Therefore., some source of zinc plus Pyridoxine should be given to all patients on penicillamine therapy.

In a case report from Australia by Walker-Smith and Bloomfield (1973), the death of a 14-month-old child has as its possible cause chronic copper poisoning. The child was brought to the hospital with ascites and jaundice and died of severe micronodular cirrhosis with some biochemical evidence of Wilson's dis-

TABLE 2

Copper Content of some Drinking Waters in Eastern United States (a)

CITY	WATER SOURCE	DWELLING	COPPER CONTENTPPM (b)
New York City	River	Apartment	0.07
Long Island	Well	Cottage	0.03
Cleveland	Lake	Motel	0.06
Boston	Well	House	0.12c
Greenwich	Well	House	0.35c
Greenwich	Well	House	0.37c
Wilton, Conn.	Well	House	1.60c
Wilton	Well	House	1.34c
Wilton	Well	House	0.68c
Wilton	Well	House	0.36c
Wilton	Well	House	0.40c
Wilton	Well	House	0.18c
New Caanan	Well	House	0.85c
Redding, Conn.	Well	House	4.20c
Belle Mead, N.J.	Well	Clinic	0.12
Bernardsville, N.J.	Well	House	0.54c
Princeton, N.J.	Well	House	0.05
Princeton, N.J.	Well	House	0.11
Princeton, N.J.	Well	House	0.04
Princeton, N.J.	Well	House	0.06c
Milwood, N.J.	Well	House	0.09
Trenton, N.J.	Well	House	5.60c
Stamford, Conn.	Well	House	5.20c
Boston	Well	House	0.64c
Atlantic City	River	House	0.01c
Dayton, Ohio	Well	House	0.56c
Washington, D.C.	River	Hotel	0.01

(a) All waters were collected in plastic containers and were acidified with copper-free HCL prior for testing. The sample was the first collection of water in the morning.
(b) The United States Public Health Service rules that water containing more than 1.0 ppm of copper is unfit to drink. In earlier generations with lead plumbing, Grandfather, who drank the first cup out of the faucet in the morning, got lead poisoning. The possibility now exists in some suburban homes for Grandfather or others to get copper poisoning.
(c) Indicates a family in which at least one member has psychiatric problems.

ease, highly unlikely at such a young age. The possibility of copper poisoning was investigated, and it was found that the farm on which he lived was supplied with new copper piping and that the drinking water contained 6.75 ppm of copper, well over the USPH standard of 1.0 ppm —this water was clearly undrinkable. The family was tested, and all showed normal urine copper except the mother who, when given penicillamine, excreted large amounts of copper. This suggests that copper transference could have started in the neonatal period. The baby was bottle fed rather than breast fed, but the formula was made with the high copper water.

This tragic death was ascribed to the abnormally early occurrence of Wilson's disease, or to chronic copper poisoning, or liver infection in vitro with subsequent exposure to high copper levels. The very high level of copper in the drinking water would suggest chronic copper poisoning.

The serum zinc deficiency and serum

copper excess have become evident only since the change from galvanized water pipes to copper plumbing. Before copper plumbing was installed, man obtained his needed supply of zinc by drinking water which had coursed through zinc-lined (galvanized) pipes. With the increasing installation of copper plumbing in conjunction with the slight acidity of most drinkable water, we are getting an excess of copper which may be antagonizing the zinc we obtain from food. This is most likely when water is pumped from shale or loam. River water (Potomac) in Washington, D.C., as it comes from the faucet has picked up less copper (0.04 ppm) as compared to Princeton, N.J., well water, 1.25 ppm (Siegerman and O'Dom, 1972). Summary Table 2 indicates that certain well waters contain toxic or near-toxic levels of copper as ruled by the United States Public Health Service (greater than 1.0 ppm).

Our studies indicate that a possible factor in some of the schizophrenias is a combined deficiency of zinc and manganese with a relative increase in iron and copper, or both, the copper possibly originating from copper plumbing.

The evidence presented thus far gives strong indication that contamination of man's drinking water by many of the trace elements known to be essential to man's existence may, if accumulated in excessive amounts, cause serious physiological and psychological defects. Further research is needed to determine the exact roles of these elements in vascular and brain chemistry. If, in fact, zinc deficiency and copper excess is a crucial factor in causation of one of the schizophrenias, then more evidence is needed on the exact sources so that treatment can be facilitated and prophylaxis provided.

Summary

The general knowledge that the metals lead and mercury can cause insanity is extended to copper. Excess copper in drinking water can be a factor in certain schizophrenias when zinc is deficient in the diet. Dialysis of the blood against tap water containing copper can be the cause of "dementia dialytica" and other adverse mental symptoms in the uremic patient.

Conclusions

(1) A biological balance occurs between zinc and copper so that a deficiency of zinc may lead to an excess of copper. This excess can be corrected by zinc and manganese, both of which are sedative to the brain, whereas copper is stimulant.
(2) Acid well water erodes copper plumbing and provides an excess of copper.
(3) Dialysis of the blood of kidney patients against tap water leads to temporary reversible dementia because of green plasma (copper excess).
(4) The world populace is so deficient in zinc that the addition of more iron to bread may be harmful because of the antagonism between iron and zinc.
(5) The substitution of soybean protein for meat protein will provide more copper and less zinc.
(6) The use of copper to hasten the growth of chickens and pigs may make their livers inedible. A limit on copper content should be set for organs that are used as food.

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