Drinking water: A geochemical factor in human health

W. D. KELLER *Department of Geology, University of Missouri–Columbia, Columbia, Missouri 65201*

ABSTRACT

Water that is drunk primarily to slake thirst may also supply major, and especially minor or trace elements, nutritionally essential to good health and longevity. Of the 14 trace elements known to be essential for human beings (Schwarz, 1974), apparently some are significantly more readily assimilated from water than from food.

Modern, municipal water-treatment plants condition water more for the sake of the steam boiler, laundry, and industry (the large volume users) than for the stomach. This paper considers water for drinking purposes from the perspective of health benefits. Means are explored by which healthful drinking water may be formulated.

The use of glacial milk, essentially an aqueous extract (solution and suspension) of rocks, by the natives of Hunza, West Pakistan, has been cited as a major factor contributing to purported excellent health and unusual longevity of those peoples. A suspension of rock flour can supply not only immediately assimilable substances in solution, but also continuous, delayed-action, mineral-nutrient reserves after ingestion.

Cooperative effort between geologists knowledgeable about water and nutritionists knowing the needs for optimum human health should upgrade the role of drinking water in human health and longevity.

INTRODUCTION

The health of primitive man was conditioned to a great extent by the natural, uncontrolled environment in which he lived. For drinking water, he accepted that which Nature directly produced from springs, creeks, and pools which accumulated during rains.

Modern man artificially tempers the climate of his domicile and refines his food. The water he drinks, however, has not always been conditioned toward health and longevity. Most modern water treatment (excluding that related to disease-causing microorganisms) serves for the sake of the steam boiler, the laundry, and other industrial processes rather than for the health or optimum nutrition of the human drinker.

The purpose of this paper is to overview the role of drinking water in terms of benefitting the health and longevity of human beings. Although health and longevity are more real and meaningful than numbers, they are not numerically definable (even longevity without quality of life is not sought), and therefore this paper cannot be as scientifically rigorous as is desired. Variables, options, and even speculation cannot be avoided in effort to search for better health from drinking water.

FUNCTIONS OF DRINKING WATER

Americans are typified internationally by their practice of slaking thirsts by drinking plain water. If thirst quenching were the sole benefit from drinking water, presumably distilled water would be best. Experience has shown, however, that such water is not the optimum, because the health of some persons is adversely affected by continued drinking of distilled or exceedingly soft, nonmineralized water.

On the otherhand, drinking water can be a significant source of rapidly assimilable elements that can condition health beneficially or adversely — for example, alkalinizers, NaCl for salt-deficiency, or NO_2 as a toxic absorber of blood oxygen. Drinking water is further important in that elements in solution are assimilated more quickly and more effectively than equal (or larger) amounts of the same elements in nonliquid food. Whether it is a threshold concentration, ion-pairing, chelation, or other factors that apparently endow the dissolved state with greater potency, the effective cause has not been generally elucidated.

As essential nutritive substances, both major and minor (trace) elements are found to be dissolved in water. Some 25 chemical elements have been shown to be vitally essential to life. Frieden (1972) cited 24; since then, Ni has been added (Nielsen and Ollerich, 1974). Eleven of these, cited by Frieden (1972), comprise 99.99 atomic percent of the human body; in decreasing atomic abundance they are: H, O, C, N, Ca, P, Cl, K, S, Na, and Mg. Furthermore, all of these, except N and P, according to Frieden, comprise 99 atomic percent of the dissolved content of sea water.

Of the preceding list of elements, good evidence exists that at least 14 of them, as trace elements, are essential for human beings: F, Si, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Se, Mo, Sn, and I (Hopps, 1975). Not only are they essential, but they are needed in only trace amounts, typically in concentrations of parts per million in solution to as low as parts per billion for some. Significantly also, the amount and concentration can easily be exceeded to the point of toxicity. A geologic clue relative to the nutritional requirements for them was pointed by Schwarz, who wrote in 1974, "It appears that the nutritional requirement for fluoride corresponds to the amount in the oceans and not that found on land. A similar case can be made for other trace elements."

Although man has an evolutional relationship to sea water, we now live on land and drink "fresh" water. Assuredly, all of the 25 elements essential to life are present in various ground waters in various concentrations, as was shown representatively by White and others (1963). Data on the trace elements, however, in natural waters are disappointingly meager. White and others stated, "the literature contains almost no information on the minor-element content of the more dilute waters" (1963, p. F4).

Regardless of this lack of knowledge, we do know that trace elements unquestionably are essential to health and that they variously occur in solution in different ground waters. Thus one problem or task can be clearly stated: let us analyze geologic (that is, not artificially processed) waters and assemble sound data for the sake of better health. After such facts, that is, the required elements for health, and the compositions that have been determined in waters,

Geological Society of America Bulletin, v. 89, p. 334–336, March 1978, Doc. no. 80302.

we can modify water from natural sources in order to artificially formulate drinking water having optimum dissolved contents of major and minor trace elements. Such modifications and treatment clearly could be done either in addition, or supplemental to, the typical, established municipal water treatment.

RAW WATER AND ITS TREATMENT

Early rural settlers, and primitive man before them, drank untreated water much as it emerged in springs from the rocks or in streams. Clear water was categorized as "good" or "bad" for drinking, variously described as containing iron, sulfur, or alkali (slick). The quality of good water was further judged by its hardness.

As urban and industrialized centers and population increased, the ratio of the quantity of water used for steam generation, cleaning of all sorts, and other industrial uses increased with respect to the quantity used for drinking purposes. A major trend in the purpose of water treatment was to soften the water which otherwise formed scale in boilers and left "tattle-tale gray" in laundered clothes.

Softening meant, in some cases, to replace dissolved Ca with dissolved Na (not welcomed by those on low-Na intake). More recently some medical research has suggested (not unanimously confirmed) that the incidence of human hypertension may be lower in regions where hard water prevails than where it is soft. Possibly hard water — or is it the accompanying trace elements dissolved with the hardness? — is more healthful for drinking purposes than water that has undergone softening treatment.

Current, typical treatment of water prepared for nondrinking purposes thus may not be the best for drinking use. While the larger quantity of water is needed for nondrinking uses, and economics dictates the kind of treatment for them, the economics and values of health may impel treatment for two uses.

The organic components (living and nonliving) of drinking water also affect its potability. Increased population and industrialization have vastly increased pollution of water by introduction of human, animal, and industrial organic wastes. To clean such water, municipal plants filter out suspended matter, aerate the water, and add chlorine to control the bacteria and other micro-biota. Recent investigations have suggested, however, that the added chlorine, or part of it, may react with certain other substances in the water to produce compounds harmful to health when drunk. Hence both the inorganic and organic constituents of water need to be considered when it is treated for drinking purposes.

ROCK FLOUR IN DRINKING WATER?

Before recommending artificial formulation of a most healthful drinking water, an unorthodox variety of drinking water, purportedly a significant contributor to good health and longevity, will be described, namely, the glacial milk in Hunza, West Pakistan. If it is found to be as validly effective in health as earlier claimed (but not proven), it could serve as a prototype for an innovative type of beverage and an industry to supply it.

McCarrison (1936, 1961) after visiting Hunza, reported that the Hunzukuts enjoyed outstandingly excellent health and amazing longevity. More recent writers have sharply questioned the details and accuracy of the records of Hunza longevity, though it does appear that the individuals were indeed long lived. The good health and longevity was attributed in significant part to the use of glacial milk for irrigation of food crops, and for drinking. The possible chemical and nutritive ramifications of glacial milk as a beverage are interesting.

The dissolved contents of glacial milk tend to become equilibrated with the composition of the colloidally fine, relatively fresh rock particles. The dissolved composition of the water in glacial milk reflects, in major elements, the composition of the rock particles (Keller and Reesman, 1963; Keller and others, 1963). It is hardly to be doubted that the trace elements, as well as the major elements, in the rock that had been glaciated would likewise be transmitted to solution in the glacial milk. It is likely that many of those trace elements would be the same as the suite in the human body, as diagrammed by Frieden (1972). Hence, an extract of rock flour in otherwise pure, ice-derived water might be a significantly nutritious drink (though dilute, especially in trace elements) for healthful purposes.

Second, the finely pulverized rock flour has the potentiality of furnishing to the drinker a continuous, delayed-action, "8-hr-aspirin type" of mineral nutrient, as follows. When pulverized rock particles, from Earth (or Moon), are stirred into water, they first yield within minutes a dilute incongruent solution of their more soluble ions (Huang and Keller, 1972; Keller and Huang, 1971; Marshall and McDowell, 1965). A thin coating film of gelatinous Al silicate remains on the grains which, if undisturbed, slows further dissolution. Such a film would tend to be removed, however, as ingested rock flour moved along a human digestive track, whereupon the newly exposed rock components would be dissolved. By this action, trace elements as they occur in native rocks would be continuously released in low concentration for assimilation by the "weathering" host.

Thus, by a two-stage contribution — immediate solution, and then by decomposition over a longer period of time — it is conceivable that glacial milk might, in the form of a relatively fresh extract of rock, be a nutritiously healthful source of trace elements.

Needless to say, this line of inference followed is not necessarily proof that rock flour and/or its direct extract can be beneficial to health. It is an unorthodox approach to a beverage of dubious popular acceptability to man. Nonetheless, selected amendments of mineral foods are being regularly and very successfully used in improved nutrition of cattle and poultry. Moreover, although geophagy as a ritual is strongly suspect, other evidence indicates possible benefit to humans by ingestion of certain geologic substances, for example, uses of clay minerals in foods have been described and patented (Grim, 1962, p. 367). Though "rock nutrition" has questionable appeal, where health and longevity that could affect whole populations are involved, careful testing of appropriate glacial milk of known, analyzed, and synthesized compositions appears to be well justified.

Admittedly, a suggestion that natural, or artificially prepared, glacial milk could contribute to health runs so counter to popular thinking that it might be summarily branded as "even poor geopoetry." On the other hand, if (a large "if") it had even a modicum of merit, it does not require much imagination to visualize our grocery stores having a shelf stocked with bottles of (a) natural glacial milk, or (b) artificially pulverized suspensions of selected, compounded rock flour. Geologists could then serve as consultants — to more affluent, commercial producers and salesman of colloidally rock-charged drinking water (which geologists would also buy to drink).

WHERE DO WE GO FROM HERE?

Bypassing the speculation on glacial milk, but considering crystal-clear drinking water for improved health purposes, several pertinent health facts are certain. Trace elements and major elements, such as are dissolved in ground water, are indispensibly essential to the health of man.

Furthermore, a fairly complete assemblage (variety) of nutrient elements is necessary. Williams (1976) stated, "unlike drugs, single nutrients always act constructively like parts of a complicated machine, and are effective as nutrients *only when they participate as members of a team.*" The concentrations of elements and compounds (and their ratios and combinations) have become questions for investigators in the areas of health and nutrition to answer. They may be guided in part by the occurrences of chemical elements in the sea, and in native rocks, which served as the raw materials on which primitive man progressed.

One may ask if waters from health spas are the answer to the question as to what is the most healthful drinking water. Information was requested from six widely publicized health spas and/or water bottlers on the chemical analyses, including trace elements, of their waters. Although the literature returned from them dramatically extolled the potentially curative and health-benefitting properties of the spa waters, their analytical data were scanty. The best data, from only two of the spas, expressed analyses of their major elements in parts per million, but only one included a few minor elements. A third one reported not ions, but hypothetical compounds (for example, "ferrous Carb.") in parts per million. The other three reported only qualitatively, also in hypothetical compounds, such as "sulphate of lime," "sulphuretted hydrogen," "sodium chloride 2.993" (but with no designation as to what the numbers quantified), "magic bubbles," "carbonic acid gas in solution," and others. One of these analyses, presumably the most recent available from that spa, had been made long ago, evidently in the late 1800s!

It is extremely doubtful that mineral waters of typical spas are optimum for general health. Some of the "saline" waters they promote may be so high in Na as to be harmful to persons on low-Na diets, or may possibly contribute to hypertension. Other mineral waters are radioactive to a level above the maximum permissible for drinking by standards of the Public Health Service. A cursory opinion is that a most healthful drinking water is probably not available directly from spa-type highly mineralized springs. More likely it can best be formulated by appropriately modifying "ordinary" ground or surface water so as to supply the range in concentrations and amounts of elements and compounds (chelates and complexes) that are desired for health.

A word of caution should be inserted here. It would be foolhardy — and could even be disastrous to health — to indiscriminantly add soluble ions, as an ill-motivated entrepreneur might do, just to supply certain trace or major elements in drinking water. For example, Schwarz has pointed out that although Se is an essential element, selenite-selenium may be 300 times more toxic than synthesized "tailor-made selenium compounds" (1974, p. 1750). Hopps stressed that "We need to know much more about the geochemistry of these elements if we are to understand how much of each of them, in what chemical form, reaches the biological system under consideration" (1975, p. 7). The formulation of superior healthful drinking water, desirable as it is, is not to be done overnight, anymore than have advances in nutrition from foods been made instantaneously. Good health and longevity are two goals most strenuously sought, and the water that human beings drink can affect either favorably or adversely both of them. Water being a part of the geological and geochemical environment, the supplying of drinking water of superior quality for health is a major responsibility that should be actively and co-operatively shared by geologists with colleagues in the health sciences.

REFERENCES CITED

Frieden, E., 1972, The chemical elements of life: Sci. American, v. 227, p. 52–64.

Grim, R. E., 1962, Applied clay mineralogy: New York, McGraw-Hill Book Co., 422 p.

Hopps, H. C., 1975, Geochemical environment related to health and disease: Geol. Soc. America Spec. Paper 155, p. 1–8.

Huang, W. H., and Keller, W. D., 1972, Dissolution of rock-forming silicate minerals in organic acids: Am. Mineralogist, v. 55, p. 2076–2094.

Keller, W. D., and Huang, W. H., 1971, Response of Apollo 12 lunar dust to reagents simulative of those in the weathering environment of Earth: Lunar Sci. Conf., 2nd, Proc., 1, p. 973–981.

Keller, W. D., and Reesman, A. L., 1963, Glacial milks and their laboratory-simulated counterparts: Geol. Soc. America Bull., v. 74, p. 61–76.

Keller, W. D., Balgord, W. D., and Reesman, A. L., 1963, Dissolved products of artificially pulverized silicate minerals and rocks: Part I: Jour. Sed. Petrology, v. 33, p. 191–204; Part II, p. 420–437.

Marshall, C. E., and McDowell, L. L., 1965, The surface reactivity of micas: Soil Sci., v. 99, p. 115–131.

McCarrison, Robt., 1936, 1961, Nutrition and health: London, Faber and Faber, 270 p.

Nielsen, F. H., and Ollerich, D. A., 1974, Nickel: A new essential trace element: Federation (Am. Soc. Experiment. Biology) Proc., v. 33, p. 1767–1772.

Schwarz, K., 1974, Recent dietary trace element research, exemplified by tin, fluorine, and silicon: Federation (Am. Soc. Experiment. Biology) Proc., v. 33, p. 1748–1757.

White, D. E., Hem, J. D., and Waring, G. A., 1963, Chemical composition of sub-surface waters: U.S. Geol. Survey Prof. Paper 440-F, Data of Geochemistry, 67 p.

Williams, R. J., 1976, On cataracts — and the possibility of avoiding them by intelligent nutrition: Executive Health, v. 13, no. 3, p. 1–6. An excerpt from Heffly, J. D., and Williams, R. J., The nutritional teamwork approach: Prevention and regression of cataracts in rats: Natl. Acad. Sci. Proc., v. 71, p. 4164.

MANUSCRIPT RECEIVED BY THE SOCIETY JANUARY 28, 1977
REVISED MANUSCRIPT RECEIVED JUNE 6, 1977
MANUSCRIPT ACCEPTED JULY 7, 1977

Printed in U.S.A.