MINERAL CONSTITUENTS IN WATER AND THEIR SIGNIFICANCE

T. B. Dover, Chemist
U. S. Geological Survey [a]

Pure water does not exist in nature. Because water is a powerful solvent, every drop of rain water carries dissolved or suspended material - dust, pollen, and smoke, as well as the atmospheric gases, oxygen, nitrogen and carbon dioxide. When rain falls, the water running over the rocks and percolating through the soil gathers more and more mineral matter in solution. As the uses to which a water supply may be put depend primarily on its mineral content, information concerning the chemical characteristics of water is of importance to each of us.

The mineral constituents usually found in natural waters are calcium, magnesium, sodium, potassium, iron, silica, carbonate, bicarbonate, sulfate, chloride, fluoride, and nitrate. The color, hardness and pH of the water are also important characteristics of a water supply. There are several common ways to express these mineral constituents, with each serving a particular need. The one most commonly used is parts per million which is the unit weight of the constituent in a million unit weights of water. A sample of water containing 75 parts per million calcium would have 75 pounds of calcium per million pounds of water. Another term commonly used by water-plant workers is grains per gallon which can be obtained by multiplying parts per million by the factor 0.0584.

There are different standards for quantities of substances that can be tolerated in water without damaging effects for practically every use. Industrial users have rigid requirements for mineral content, depending on the product manufactured. Agricultural uses are geared to the mineral

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constituents found in the supply. Likewise, there are limitations for domestic uses because of the chemical characteristics of the water supply. To the average household user of water, the most important factors in regard to the chemical content pertain to its taste and hardness, though the iron content may be sufficiently high to give trouble.

There is a surprising lack of agreement ~~between~~ among individuals as to their views on the taste of a water containing greater or lesser amounts of mineral matter. The chloride content of water, which is usually [redacted] in the form of sodium chloride or common table salt, gives a noticeable salty taste when its concentration is in excess of about 500 parts per million. However, in one Texas city of several thousand inhabitants, the chloride content of the water exceeds 600 parts per million and the entire population uses it with no apparent ill effects. However, the taste is quite noticeable to an outsider drinking it for the first time.

~~The presence of~~ Mineral constituents, ~~if within reasonable limits,~~ in water, within reasonable limits, add to the potability of a supply ~~since~~ inasmuch as they are responsible for its pleasant taste. If there were no chemicals dissolved in water, it would have the flat taste of rain water. On the other hand, the concentration may be so high as to ~~be~~ make it unusable. The minerals dissolved in any ground water and their concentration depend primarily on the chemical compounds present in the underground geologic formation with which the water has been in contact. There is usually one predominant acid and basic constituent in solution as a result of the one predominant compound in the underground formation. Varying amounts of the other constituents are also dissolved. One example [redacted] ~~might be that~~ is found in the vicinity of Norman, where the predominant constituents usually found in well water are sodium and bicarbonate which together form the compound commonly called baking soda. This is present in such concentrations in some wells that it can be easily detected by taste.

Hardness of water is caused by the dissolved minerals of calcium and magnesium, usually in the form of bicarbonates or sulfates. Compounds of aluminum, iron, and manganese, and free acid may also cause hardness but these constituents are not usually found in appreciable quantities in most natural waters.

Hardness in water caused by the presence of calcium and magnesium carbonates, usually dissolved from limestone to form the bicarbonates is called carbonate hardness and can be removed by treatment with lime. This type of hardness is sometimes called "temporary hardness" ~~since~~ because it can be partially removed by boiling. When the water is heated, the bicarbonates separate into carbon dioxide, which is evolved as a gas, and carbonate of lime or calcium carbonate, which remains behind as a scale or insoluble residue. Hardness caused by the presence of calcium sulfate, known as gypsum, and magnesium sulfate, known as Epsom salts, is called non-carbonate hardness. This type is sometimes called "permanent hardness" ~~since~~ because it requires more extensive treatment for removal than the carbonate hardness. Waters with such hardness can be treated by passing ~~it~~ them through a zeolite softener or by other methods.

Total hardness, caused by all ~~of~~ the constituents, is arbitrarily expressed in terms of calcium carbonate. Water that has a total hardness of less than 50 parts per million is usually rated as soft and its treatment for removal of hardness is seldom justified. Hardness between 50 and 150 parts per million does not seriously interfere with the use of water for most household uses, but its removal by softening processes may be profitable for laundries and other industries. When the hardness exceeds 150 parts per million, treatment for its removal is usually desirable for most uses.

Moderate quantities of sodium and potassium salts in water have little effect on its usefulness. Waters that contain more than 50 parts per million of the two require careful operation when used in steam boilers to prevent foaming. The amount of sodium present in water is also watched very carefully by doctors in treatment of patients with heart disorders, as such patients are usually placed on a diet containing little sodium salts. It is sometimes necessary to change them over to the use of distilled water entirely. Sodium salts are injurious to crops when present in sufficient quantities, and waters used for irrigation must be carefully checked for sodium content. The amount of sodium that can be tolerated in an irrigation water depends on a number of factors, among which are the type of soil, the crops grown, drainage and the amount of rainfall.

The presence or absence of fluorides in drinking water is being recognized more and more as an important feature. Fluoride concentrations in drinking water up to about 1 part per million have proved to be beneficial in the prevention of dental caries in growing children. As the concentrations progressively increase above 1 part per million, it will cause teeth to become mottled, stained, and disfigured.

Nitrates in water are considered to be the final oxidation product of nitrogenous organic material. The quantities usually present have no effect on the value of water for ordinary uses. When the concentration exceeds 44 parts per million, it is not advisable to use such water for small children. It is sometimes the cause of a condition called methemoglobinemia. This condition has not been recognized until relatively recent years and can be serious unless it is recognized and the patient given water of low nitrate content. The nitrate content of any water used for drinking and in the preparation of a baby's formula should be known.

Silica is found in various quantities in all natural water. The presence of silica does not affect the usefulness of the water, except when it is used as boiler-feed water. It contributes to the formation of boiler scale, either as a silica scale or in combination with compounds of calcium, magnesium, and aluminum.

Aluminum and manganese are not regularly reported in the practical analysis of water since they are usually present in only very small amounts. If present, in larger quantities, they can be troublesome to certain users of water. Manganese is especially objectionable in laundry work and in textile processing that involves washing.

Excessive amounts of iron in water will cause stains on white porcelain, or enameled ware and on clothing or other fabrics washed in the water. On exposure to the air, water that contains more than 1 part per million of iron soon becomes turbid with the insoluble oxide produced by oxidation.

A water may be quite low in mineral content and yet be corrosive, due in many instances to dissolved oxygen and carbon dioxide. These gases, particularly when the water is heated, will aggressively attack metallic surfaces. Corrosion is recognized by the presence of rusty water, staining of plumbing fixtures, or the pitting in pipes and tanks. With a given concentration of carbon dioxide or oxygen, a water with a low alkalinity and dissolved solids is more likely to be corrosive than one with a much higher alkalinity and a greater amount of dissolved solids. There are too many variables to make a simple statement as to the relationship between corrosiveness, carbon dioxide, oxygen, alkalinity, and dissolved solids. There is a direct relationship between the content of free carbon dioxide and pH; the larger the amount of carbon dioxide, the lower is the pH. If the carbon dioxide is present in quantities over 10 parts per million, the water is likely to dissolve iron from pipes and containers.

Scaling is another difficulty encountered with water where there is deposition of solid material from the water in pipes, hot-water tanks, and boilers, sometimes in quantities sufficient to completely clog the pipes. The scale in hot water pipes and heaters is largely produced by the deposition of the insoluble carbonates of calcium and magnesium. ~~Since~~ as calcium carbonate is less soluble than magnesium carbonate, it is usually deposited in larger quantities than magnesium carbonate.

The function of the Quality of Water Branch of the U. S. Geological Survey in the water business is to conduct investigations largely on a cooperative basis with various State and Federal Agencies to determine the chemical character of both surface and ground waters. The purpose of these investigations is to ascertain whether the waters are suitable for the many agricultural, industrial, municipal, and household uses, so that the economy of the entire State may benefit by the proper development of the water resources. At present, the Survey in cooperation with the Oklahoma Planning and Resources Board, A and M College Engineering Experiment Station, and the Bureau of Reclamation has 21 daily chemical sampling stations on surface waters throughout the State. Chemical analyses for the ground water studies are done in cooperation with the Oklahoma State Geological Survey ~~of~~ at Norman. This program is being operated as a public service and any inquiries as to work already done or that ~~which~~ should be done are welcome.