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A Brief Discussion of Some of the Determinations Made in a Chemical Water Analysis

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Introduction

The chemical analysis of water reveals its quality and the extent that it has been affected by gases and dissolved minerals.

Carbon dioxide (CO_2) taken from the air during rainfall is one of the most important gases found in water. Water containing carbon dioxide forms a weak solution of carbonic acid, which in turn strengthens the dissolving power of the water. As surface water percolates down through the earth, mineral salts are picked up and brought into solution. Thus, the quality of the solution is determined by the amount of carbon dioxide present and the types of formations encountered by the water.

A chemical analysis is important in answering any of the following questions concerning water:

1. Is the water satisfactory for domestic use?
2. Can the water be used for special purposes, such as irrigation or boiler-feed?
3. Is the water corrosive or incrusting, and to what extent?
4. How hard is the water?
5. Is the amount of iron and manganese present likely to cause staining or water discoloration?

The different constituents found in a water sample are reported in parts per million (p.p.m.). The total alkalies are given in per cent to aid in determining if a water is suitable for irrigation. Hardness is shown in parts per million but some sources may indicate it as grains per gallon. One grain per gallon is equal to 17.1 p.p.m., so it is easy to convert gr. per gal. to p.p.m. by multiplying by 17.1.

Following are brief explanations of some of the more important determinations made in the chemical analysis of water:

Turbidity

The amount of suspended matter in a water determines its turbidity. Silt and clay generally causes turbidity, but it may result from living or dead algae or other organisms. It should not exceed 10 parts per million.

Odor

Preferably, water should have no odor. Many of the offensive odors can be removed by aeration, chlorination, or use of iron removal filters (in the case of the "rotten egg" odor of hydrogen sulfide gas, up to 6 parts per million can be removed with the average iron removal filter). Aeration is common for getting rid of H_2S where it is practical. Algae and crenathrix cause many of the bad-smelling waters and are controlled by proper chlorination.

pH

A pH test determines the strength of the acid or alkali in a water.

The pH value is a measure of the hydrogen-ion concentration of water and it indicates the acidity or the alkalinity of the solution. It is expressed as a logarithmic value of the reciprocal of the hydrogen-ion concentration to the base ten. Distilled water has a pH value of 7 and is neutral; neither acid nor alkaline. Therefore, water with a pH value of 8 has 10 times as many (OH)-ions (and 10 times fewer H^+ ions) as water with a pH of 7. Likewise, a pH of 6 indicates water having 10 times as many H^+ ions (and 10 times fewer (OH)-ions) as water with a pH of 7.

Generally speaking, water having a pH value of less than 7 is acidic and corrosive in its reaction; whereas, water with a pH greater than 7 is alkaline and tends to be incrusting in its reaction.

Most groundwater in this area is alkaline (i.e. it has a pH of 7 or above) and will tend to incrust or deposit mineral salts on well casing, well screens, pumping equipment, and plumbing fixtures. Phenopthalein and methyl orange are the indicators used in making the pH determination. The higher the pH value of a water, the greater the hazards of incrustations.

Alkalinity

The carbonates, bicarbonates, and hydroxides of calcium, sodium, and magnesium are the common alkalinities found in groundwater. These plus carbon dioxide (CO_2) generally determine the pH value of water. Tests for alkalinity measure the amount or quantity of alkali (or acid) present in the water.

The total alkalinity is expressed in terms of the amount of calcium carbonate ($CaCO_3$) that would have to be dissolved in distilled water to develop a solution comparable to that of the water being tested. Methyl orange and phenolpthalein are the color indicators used to make this comparison. (Note: The relationship of alkalinity and hardness of water is discussed later under the heading of "Hardness").

The test for alkalinity is useful in checking water that will be used in boilers. Alkalies of sodium and potassium in excess of 50 to 100 parts per million may cause foaming when found in boiler waters.

Carbonates and Bicarbonates

The presence of carbon dioxide (CO_2) in groundwater forms carbonic acid (H_2CO_3) which in turn tends to dissolve limestones ($CaCO_3$) and dolomites $\angle$ Ca Mg $(CO_3)_2 \rangle$, thus forming carbonate and bicarbonate solutions. Calcium and magnesium carbonates and bicarbonates contribute most of the "temporary" or carbonate hardness of water.

Most people cannot tolerate over 300 parts per million of carbonate in water.

Silica and Oxides

Little information could be found in regard to these two determinations.

Silica is not readily soluble in water and will not normally be present in very large quantities.

Calcium

Calcium in water is not harmful other than it affects the alkalinity and hardness. It precipitates quite readily as calcium carbonate or calcium sulfate when the temperature is raised or the pressure is reduced. Thus, a well with a marked drawdown of the water during pumping will be more susceptible to incrusting the well screen and pump equipment.

Magnesium

Magnesium is also troublesome in forming incrustations. Like calcium, it precipitates as a carbonate or sulfate when the temperature is raised or the pressure is reduced. Magnesium should not exceed 125 parts per million. When sulfate (SO_4) is present it combines to form magnesium sulfate ($Mg\ SO_4$), or Epsom Salts.

Sodium

(Note: Potassium is determined and reported as sodium)

Sodium is highly soluble in water and generally occurs as sodium chloride (NaCl), or common table salt. If in excess of 250 to 300 parts per million the water will taste salty. When the amount of sodium exceeds the amount of chloride it will probably occur as sodium bicarbonate (baking soda). This contributes to the alkalinity of the water, but not to its hardness. Sodium should not exceed 50 to 100 parts per million if the water is to be used in boilers because foaming will result (CO_2 gas escapes).

Manganese

Manganese present in excess of 0.1 parts per million will cause black

"spots" or staining of laundry. However, manganese is seldom found in quantities sufficient to demand removal.

Iron

Over 0.3 parts per million of dissolved iron in water will tend to cause yellow or reddish-brown staining of laundry and plumbing fixtures. Occasionally, iron-precipitating bacteria, called "crenothrix", are present in iron-bearing water. The accumulation of semi-solid masses of reddish-brown growths by these bacteria may tend to clog pumps and plumbing fixtures. Too, water has a disagreeable odor when crenothrix are present. Chlorination will successfully dislodge these growths and kill the bacteria.

Many water softeners can remove 5 to 10 parts per million of iron, without the use of a separate iron-removal unit.

In analyzing the results of a water sample analysis, the amount of dissolved iron indicated may not be representative of the original collected sample. Dissolved iron oxidizes and precipitates rapidly, thus it is imparative that a water sample be sealed and analyzed soon after collection.

Sulfate

Sulfate (SO_4) should not exceed 250 parts per million in a water sample, and if over 500 parts per million are present (plus magnesium) a laxative effect may result. Most people cannot tolerate water that has over 2,000 parts per million of sulfate (SO_4).

Chloride

Chloride should not exceed 250 parts per million in water. Over 300 parts per million will be detected by persons with sensitive taste, and water

that contains as much as 1500 parts per million cannot be tolerated by most people. Sodium chloride (NaCl) or table salt is the common chloride found in natural waters.

Nitrate

Generally, nitrate is one constituent that is relatively low in most water samples. An excess of 45 parts per million of nitrate is highly dangerous, particularly if infants are drinking the water. The possibility of contamination from sewage should be investigated in the event that the nitrate content is over 10 parts per million.

Fluoride

Over 1.5 parts per million of fluoride may cause mottling of teeth, especially among children.

Total Suspended Matter

Total suspended matter is generally reported as turbidity. It includes silt, clay and algae or other organisms that may be in suspension in the water. Preferably, it should not exceed 10 parts per million.

Total Dissolved Solids

Total dissolved solids include all the mineral salts dissolved in a water. They should not exceed 500 parts per million but up to 1,000 parts per million are permissable. Livestock can tolerate up to 10,000 parts per million of total dissolved solids. Possibly they will have to be "conditioned" to drinking such water and all other sources of water removed.

Water that is being used for irrigation purposes should not contain over 2,000 parts per million of total dissolved solids, and for certain sensitive

crops 700 parts per million is the limiting figure. Also, irrigation water should not contain over 500 parts per million of chloride, with certain crops being confined to less than 150 parts per million.

Hardness

Hardness may be described as the quality in water which destroys the property of soap to form a lather. The mineral salts that cause hardness react with soap to form insoluble combinations and no lather is formed until all of these have combined with the soap.

Carbonate or "temporary" hardness results from the presence of carbonates and bicarbonates of magnesium and calcium.

Non-carbonate or "permanent" hardness results from the presence of sulfate and chloride salts.

After separate tests are made to determine alkalinity and total hardness, the carbonate and non-carbonate hardness are calculated from these results. If the total hardness is less than, or only equal to, the total alkalinity, then all of the hardness is carbonate. But if the total hardness is in excess of the total alkalinity, then the carbonate hardness is equal to the total alkalinity, and the remainder of the hardness is non-carbonate.

The limits of hardness of water are arbitrary. The use for which it is intended affects the maximum limits of hardness. For domestic use 250 p.p.m. to 300 p.p.m. of hardness is considered high. Boiler waters should not exceed 250 p.p.m. Up to 500 p.p.m. may be permitted for some types of irrigation.

Home water softening units generally operate on the base-exchange principle, with the water being softened by the "Zeolite" process. Zeolites are complex, insoluble mineral compounds. When water containing hardness - causing mineral salts pass over the Zeolite mineral filter, sodium from

the filter bed exchanges for calcium and magnesium in the water. The softened water has the same amount of total solids, but they are non-hardness - causing salts, such as sodium bicarbonate. Home softeners can remove large amounts of calcium and magnesium at a relatively low cost.

Per Cent of Alkalies

In a water analysis the calculation of per cent of alkalies present is useful if the water is to be used for irrigation. When the per cent of alkalies exceeds 75% the water is not suitable for most irrigated crops. If the alkaline content is in the 6% to 75% range, only limited types of crops may be irrigated. But water with less than 60% of alkalies is satisfactory for most all crops under ordinary conditions.