

**SILICIC ACID, ITS
INFLUENCE AND
REMOVAL IN WATER
PURIFICATION: THESIS**

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Silicic Acid, Its Influence and Removal in Water Purification: Thesis by Otto Mitchell Smith

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OTTO MITCHELL SMITH

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**SILICIC ACID, ITS INFLUENCE AND REMOVAL
IN WATER PURIFICATION**

BY

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SILICIC ACID, ITS INFLUENCE AND REMOVAL IN WATER PURIFICATION.

By Otto Mitchell Smith.

INTRODUCTION.

Little attention has been paid to the presence of silicic acid in natural waters except in cases where its content is quite high. It is universally present but usually in amounts less than 100 parts per million. It is more prevalent in the surface waters of the Mississippi Valley¹⁸ especially on the western watershed. It is found in as large amounts as 1,163 parts per million at Cesenate, Italy,⁴⁶ 1,230 parts per million at Deep Rock Springs, Oswego, N. Y.,³⁸ and 923 parts per million at the Yellowstone National Park.³⁷

Silica in solution usually occurs as colloidal silicic acid and³² in combination with the basic elements. Its presence in water used for steam purposes has always been considered detrimental and conducive to the formation of a hard flinty scale. Besides forming an undesirable scale, A. Goldberg²² believes silicic acid is responsible for many boiler disturbances. When the acid is distilled with water solutions of nitrates and chlorides, nitric and hydrochloric acid are liberated.

Turbidity in water is generally caused by the suspensions of very finely divided mineral matter, mainly clay. Clay may be defined as a mixture of minerals of which the most representative members are the silicates of aluminium, iron, the alkalies and alkaline earths. The hydrated aluminium silicate, kaolin. ($\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$) is the most abundant compound.

There are many cases in the literature emphasizing the difficulties of clarifying water containing finely dispersed clay particles. Fuller²⁰ in 1898 found at times a turbidity which was difficult to coagulate with an abnormal consumption of alum. Ellms,¹⁷ Black and Veatch,⁷ and Catlett¹² show the difficulties in the treatment of such water.

THEORETICAL AND HISTORICAL PART.

As silicic acid and clay suspension are considered as sol and suspension respectively a brief discussion of the general properties of colloids is pertinent. Burton²¹ defines a colloid solution "as a suspension, in a liquid medium, of fine particles which may be graded down from those of microscopic to those of molecular dimensions; these particles may be either homogeneous matter, solid or liquid, or solutions of a small percentage of the medium in an otherwise homogeneous complex. The one property common to all such solutions is that the suspended matter will remain almost indefinitely in suspension in the liquid, generally in spite of rather wide variations in temperature and pressure; the natural tendency to settle, due to the attraction of gravitation, is overbalanced by some other force tending to keep the small masses in suspension."

With the development of the ultra microscope and the investigations of Zeigmondy and Siedentopf²² it is possible to show that there is a continuous gradation in the size of particles of the disperse phase from 1.70×10^{-7} cm. in diameter to that of visible organisms and this leads to the belief that there is a gradation in size from the smallest of these particles to the molecules.

Tyndall²⁷ (1869) found that small particles could be revealed by the lateral diffusion of a beam of light traversing a solution. Applying this method Linder and Picton²⁸ were able to grade the sizes of particles of colloidal arsenous sulfide.

Wiedemann³¹ (1852) and Quincke³² (1861) confirmed the discovery of Reuss that a liquid would move across a diaphragm or through a capillary tube towards one of the electrodes when a current is passing. The migration of sols in the electric field was first observed by Linder and Picton. As suspended particles carry electrostatic charges, it seems logical to conclude that as result of these charges, suspended particles whose masses are small enough are equally distributed throughout the liquid, and prevented from ever settling because of the mutual repulsion of the charges. Such a solution is called a sol in contradistinction to the jelly-like form called a gel. When the dispersion of relatively insoluble particles is not so great as to become macroscopically invisible—such a system is termed a suspension. The change of an irreversible hydrosol to an amorphous precipitate wherein there is no Brownian movement is known as coagulation.

Schultz,⁴⁸ and Linder and Picton²⁸ showed that the coagulating power depends upon the valency of the metal ion and according to later workers, equivalent solutions containing monovalent, bivalent and trivalent metallic ions would possess, whatever the nature of the anion, coagulating powers in the ratio of 1:35:1023 which is nearly represented

by the formulae $1:x:x^2$. In 1899 Hardy²² found that the concentration of the acid necessary for coagulation of electronegative particles and of alkali for the coagulation of electropositive particles is determined by the laws of ordinary chemical equilibrium.

Burton,¹⁰ adding graduated amounts of aluminium sulfate $Al_2(SO_4)_3$ to a negative sol, found that there was a decrease and even a reversal of the charge. Thus if one is able to pass from a negative sol to a positive sol there must be a point of zero potential—"isoelectric point." Hardy²³ suggests that the coagulation of colloids by electrolytes takes place when the particles have their charges neutralized by the adsorption of oppositely charged ions of an electrolytic solution and at the isoelectric point. His previously published conclusions were²⁴ that the conditions which determine coagulation are: (1) concentration of colloid, (2) temperature, (3) the nature of the ion, and (4) that the action is additive if the ions are of the same valency and "subtractive" if of different valencies, as the one inhibits the other.

Crum,¹⁵ Lander and Picton,²⁰ and Whitney and Ober,⁵⁰ have established the fact that during the process of coagulation a portion of the electrolyte is always adsorbed by the coagulum and that amount is proportional to the electrochemical equivalents of the anion.

Lottermoser,²⁸ Blitz,⁸ and Billitzer⁵ demonstrated that colloids of opposite sign precipitate each other; that there is an optimum of precipitating action shown for certain proportions of colloid and that, if in any case these favorable proportions are exceeded on either side, no precipitation occurs; and that the direction of migration of the whole under the influence of the electric current is the same as that of the colloid in excess. This leads to the subject of protective colloids. Many organic colloids when added in comparatively minute quantities to suspensoids have the power of preventing the coagulation of the system.

PROPERTIES OF SILICIC ACID AND CLAY SUSPENSIONS.

Silicic Acid.

This colloid possesses the properties common to its class. In concentrated solutions it is unstable, but below 1 per cent it is stable for years. It has not been prepared free from electrolytes; its molecular weight is about 49,000. Billitzer⁴ and Fleming¹⁹ found it amphoteric, carrying a negative charge in alkaline and a positive charge in acid solutions. Fleming's data, converted into terms of hydrogen ion concentration, indicate that the isoelectric point lies between a P_H value of 13.6 and 13.9, which is not in accordance with facts. It exhibits the Tyndal effect and is precipitated by electrolytes and positive colloids. The