RIVER WATERS IN IOWA

A PRELIMINARY REPORT

BY

GEORGE A. GABRIEL

CONTENTS

RIVER WATERS IN IOWA

PRELIMINARY REPORT

Introduction.

Nearly every kind of industrial establishment requires water in some form or other. In case the water is to be used for domestic purposes, its value is its potability as determined by its freedom from dangerous or bad tasting or smelling organisms; but in its application to industrial purposes, the biologic features are secondary except in a very few industries like paper manufacture, breweries and the like. The real suitability of the water depends upon the mineral contents, dissolved or suspended in it. It is well known that water dissolves more or less of everything it comes in contact with, hence the purity of a water depends on its locality. Waters which have traversed limestone regions are hard; those from alkali regions are alkaline; those from swamps usually are highly colored and contain a large amount of organic matter; those from drainage ditches are almost always badly polluted and are necessarily unpotable. Therefore, in the industrial application of water it is essential to study its composition in reference to its adaptability to any particular industry.

The great importance of the mineral contents of water has led the Geological Survey of Iowa to study the composition of a few of the rivers in Iowa, with special reference to the high and low periods of the river. This investigation was undertaken during the late spring and summer of 1913, and the results of this work are incorporated in this report.

Methods of Examination.

It is generally recognized in sampling water that the mineralization of the water may change even 100 per cent while the samples are being gathered; therefore we did not feel justified in employing methods which were expensive and would make the

3

cost of the work prohibitive, since we could not at the least expect our samples from the same river to agree within 10 per cent. Therefore, we employed methods which were moderately accurate and at the same time easy of manipulation with considerable speed. None of the methods are new and all are recognized by competent authorities.

COLLECTION OF SAMPLES.

The waters from the rivers above any possible contamination of sewage, etc., were collected in gallon glass jugs and shipped direct to the Experiment Station at Ames, Iowa, and usually the water was in the hands of the analyst inside of three days. Particular attention was taken in gathering the samples that the sample of water was taken as near midstream as possible. Collection was usually done from boats.

TURBIDITY.

The determination of turbidity was made upon all samples of water gathered. All turbidity tests were conducted according to method described by the American Public Health Association in its bulletin of Vol. 30, pt. 2, 1905. The standard recommended by this association consists in suspending one gram of thoroughly dried precipitated Fuller's earth in one litre of distilled water. Such a standard has a turbidity of 1000 parts per million. Turbidities below this standard can be made by the usual method.

TOTAL SUSPENDED SOLIDS.

The total suspended matter was determined by use of the Gooch crucible as described in above mentioned bulletin. Usually 500 to 1000 cc. of water was used in this determination, yet in some samples the suspended solids were so high we were obliged to resort to smaller samples.

TOTAL DISSOLVED SOLIDS.

The total dissolved solids were determined in each case in 500 cc. of the sample, which was evaporated to dryness on the water bath in a tarred platinum dish, dried at 180°C for one hour, cooled and weighed. The residue was computed to parts per million.

In American Public Health Association Bulletin, Vol. 30, pt. 2, p. 43, 1905, it is recommended to dry solids at 103°C for one-half hour, but our results seem to warrant the higher temperature. One great advantage of the higher temperature is that the solids more nearly represent the conditions under which the solids are deposited in steam boilers.

Silica.—The residue from the determination of total dissolved solids was heated gently to destroy all organic matter, then treated with hydrochloric acid (1-1) and heated on the water-bath for about fifteen minutes. It was evaporated to dryness, and the residue was treated with 2 to 4 cc. of acid, diluted with water, heated on water-bath and filtered. The insoluble matter remaining upon the filter paper was thoroughly washed with hot water containing a small amount of hydrochloric acid, ignited in a tarred platinum crucible and weighed. It was then treated with a few drops of concentrated sulphuric acid, and hydrofluoric acid which upon being gently heated volatilizes the silica. After this had been accomplished, the crucible was again ignited, cooled and weighed to a constant weight. The part volatilized was computed to parts per million of SiO_2.

Iron.—The iron in the filtrate from the determination of silica was oxidized by addition of a few drops of concentrated nitric acid to the boiling solution. After a slight excess of ammonia had been added, the solution was boiled a few moments to allow the iron and aluminum hydroxide to precipitate. After filtration, the precipitate was washed with water containing a few drops of ammonium chloride. The precipitate was then dissolved in hydrochloric acid containing a small amount of nitric acid, boiled and the iron was determined calorimetrically.

Calcium.—The filtrate from the determination of iron was usually diluted to 100 cc. and divided into two portions, one for the determination of the calcium and magnesium and the other for the determination of alkalies and sulphates.

After the portion for calcium was boiled it was made alkaline with ammonia water; then there was added enough ammonium oxalate to convert all the calcium and magnesium to oxalates. The solution was then heated on the water-bath for three or four hours to insure complete precipitation of the calcium and

to dissolve the magnesium oxalate. The precipitate was then filtered and washed with water containing a small amount of ammonia. The flask which had contained the precipitate was placed beneath the funnel containing the precipitate and this was dissolved in dilute sulphuric acid (1-3), the solutions were diluted to 90-100 cc. and titrated against standard potassium permanganate solution, observing the usual precautions. The calcium found was calculated to parts per million of water.

Magnesium.—The filtrate from the calcium was made slightly acid with hydrochloric acid, and evaporated until the salts began to crystallize. An excess of 10 to 15 per cent solution of sodium ammonium phosphate was added and the liquid was allowed to cool. When it was cool, the solution was made distinctly alkaline with strong ammonium hydrate and was allowed to stand six to twelve hours for the complete separation of the magnesium. The solution was then filtered, the precipitate was washed with water containing ammonia until the wash water was free from phosphates. The precipitate was then dissolved in dilute acetic acid solution (5 per cent) and boiling water. Five or six cubic centimeters of 5 per cent ammonium acetate solution were added and the liquid was titrated against standard uranium solution, taking the usual precautions. The magnesium was calculated in parts per million of water.

Sulphates.—The usual gravimetrical method was employed for this radicle, and the SO_4 calculated to parts per million of water.

Sodium and Potassium.—The filtrate from the sulphate determination was used for these elements. The solutions were made alkaline with ammonia and treated with ammonium carbonate and filtered. The filtrate was evaporated to dryness on the water bath, was heated slowly over a flame to expel the ammonium salts, and then was digested with a little water. The magnesium was precipitated by barium hydrate solution, the solutions were again filtered and the precipitates were well washed with hot water. The filtrate was heated and the barium and calcium were precipitated with ammonium carbonate, and were removed by filtration, after which the filtrate was evaporated to dryness and gently heated over the flame to expel the

ammonium salts. The residue was treated with hot water and the above operations were repeated to remove any traces of barium and calcium. The solution was then filtered into a small platinum dish and evaporated to dryness and heated to near fusion and weighed. The alkaline chlorids in the dish were dissolved in water and filtered through an ashless filter paper, which was then washed, ignited in the platinum dish and weighed. The difference in weights was calculated to "sodium and potassium", the molecular weight fifty-eight being used for the material. This was calculated to parts per million of water.

Carbonate and Bicarbonate.—The determination of these radicles was made upon fifty cubic centimeters of the water, which usually was filtered. This water was titrated against M/50 potassium acid sulphate solution, using phenol phthalein as an indicator. The number of cubic centimeters of the potassium acid sulphate solution used multiplied by twenty-four equals the parts per million of the radicle CO_3. Methyl orange (two or three drops) were then added to the same solution and titration was continued. The total acid solution used, minus twice that required for the first end point equals that equivalent to the bicarbonates present. The latter figure multiplied by 24.4 equals parts per million of the radicle HCO_3.

Chlorine.—This radicle was determined by the usual volumetric method as recommended by Sutton in his handbook of volumetric analysis. One hundred cubic centimeters of water was usually concentrated to twenty-five to thirty cubic centimeters, when potassium chromate solution (two cc. of a five per cent solution) was added, and the solution was titrated against standard silver nitrate solution until a faint reddish tint was noted. The chlorine was computed to parts per million.

Nitrates.—The phenolsulphuric acid method was used in this determination. As most of the waters were more or less colored, the samples were first treated with alumina cream, shaken thoroughly, allowed to settle and fifty cubic centimeters of the clear liquor was used for this work. This was evaporated to dryness in a platinum dish on the water bath with a few drops of sodic carbonate solution. One cubic centimeter of phenolsulphuric acid was quickly and thoroughly incorporated into the residue

in the dish, ten cubic centimeters of distilled water was added and the solution was thoroughly mixed. The solution was made alkaline with potassium hydrate solution, and then transferred to a 100 cc. Nessler tube and made up to the mark with distilled water. The yellow tint of the nitrates was compared with standards in similar Nessler tubes. The results were calculated to parts per million of water.

SOLUTIONS USED.

All solutions used in this work were made up according to the recommendations of the American Public Health Association in its bulletin on Standard Methods for the Examination of Water and Sewage, 1913.

Uses of Water.

In judging the values of any waters from their analyses, it is very necessary to consider to what purpose the water is to be used. Water is used essentially for steam making, starch, paper, laundry, etc., and the industries and the amount of the different ingredients determine its value for the particular industry. If the water contains a large amount of iron, it might render the water unfit for some industries, while in other work, the iron would have no serious effect. So with the other ingredients. Therefore, it is essential to consider all available sources and qualities of waters before deciding upon its application.

WATER FOR BOILER PURPOSES.

The chief use of water industrially is in the manufacture of steam and its value depends upon the amount and the chemical nature of the mineral matter dissolved or suspended in it. The main difficulties experienced in the boiler room from mineral contents of the waters are corrosion, scale and foaming.

Scale.—The formation of scale within a boiler is the deposition of the mineral matter upon the shell and tubes of the boiler. This deposition is caused by the water being heated under pressure and hence concentrated, whereby the mineral contents are thrown out of solution and are deposited upon the boiler as indicated above. This deposition causes all kinds of trouble as well as increased fuel consumption and repairs. If allowed to accumulate, disastrous results are liable to follow.

The scale consists practically of all the suspended matter, silica, iron, aluminum as oxides, calcium as carbonate or sulphate, and the magnesium as oxide or carbonate. The scale, therefore, varies in amount as the ingredients of the water vary, and varies in hardness and composition with the different conditions of steam pressure, type of boiler, etc. Hence, the value of a water for boiler use depends upon the quantity of scale produced, and the physical properties of said scale.

Corrosion.—This is caused chiefly by the action of acids dissolved in the water upon the boiler or boiler tubes. Free acid is sometimes found in water, especially in the region of coal mines, where the drainage from the mines is in many cases acid. Acid is also found sometimes in the wastes of factories along the streams. Hydrogen sulphide and carbon dioxide are corrosive in action.

Acids freed from their basic radicles, like iron, aluminum and magnesium, precipitated as hydrates and later possibly converted to oxide, are particularly corrosive. The acid radicles that were in equilibrium with these bases may do one or all of the following: They may pass into equilibrium with other bases, or they may decompose carbonates that have been precipitated to form scale or they may act upon the iron of the boiler or boiler tubes. If the acid exceeds the amount necessary to decompose the carbonate and bicarbonate then the boiler tubes or shell are attacked, with resulting pits or possibly leaks.

Remedies for Boiler Troubles.—The best way to obviate boiler troubles is to treat the water, in other words, purify it before it enters the boiler. This can be done in a number of different ways, but will not be considered in this article. When it is not possible to give such treatment, there are various other ways which can be cited. Blowing off the boiler occasionally is a good practical way of preventing foaming and also carries away considerable soft scale or sludge. Boiler compounds have been employed with some success, but it is advisable to use caution in their use, for the result may be the exact opposite of what is expected. It is sufficient to say that most of the boiler compounds upon the market depend largely upon the action of soda ash, oil or some vegetable extract, which makes them costly.

Their only functions are to prevent hard scale, and blowing off the boiler is necessary to prevent too large an accumulation of the soft sludge. It is far better to treat the water judiciously with known chemicals, than to add unknown boiler compound indiscriminately.

WATER FOR OTHER PURPOSES.

It is well known that various manufactured articles are more or less affected by the water used in their manufacture. In some industries, like starch, milk, canneries, creameries, slaughter houses, breweries, sugar works, tanneries, glue factories, soap factories, etc., water is a part of the final product or is essential to its manufacture; therefore, a supply free from color, odor, suspended matter, iron and bacteria is generally necessary. Water fit for drinking is necessary in industries where the final product is for food consumption, such as beverages or dairy and meat products, hence, the manufacturer is confronted with the problem of purifying his water and of deciding whether the cost of doing this is warranted by the increased value of his product.

Effect of Free Acids.—Free mineral acids, like sulphuric acid from coal mines, is particularly injurious to many industries. In cotton mills, bleacheries and dyeworks the acid decomposes the chemicals and streaks the fabric, and in some cases even rots it. The acid also is very corrosive to all metal work, such as screens, pipes, etc.

Effect of Color.—Color is due primarily to the solution of organic matter and articles washed, bleached or dyed in colored water are likely to show the effects. Highly colored waters can be used in dark dyed articles or wrapping papers, and the like, but for the whiter grades, it is essential to have a colorless or low color water.

Effect of Suspended Matter.—Suspended matter may consist of various particles of sewage, bits of leaves, sawdust, sand or clay, etc., and is particularly objectionable to industries in which water is used for washing or for food purposes. Suspended matter of vegetable origin is liable to decomposition and therefore is objectionable. For these reasons, water should be freed from suspended matter where it is to be used in laundries,

bleacheries, dyeing, starch and sugar manufacture, breweries, etc.

Effect of Iron.—Iron is a particularly undesirable constituent of water, and even small quantities of it necessitate purification of the water for some industries. In all cleansing processes, precipitated iron is likely to cause rusty or dark spots. In goods containing tannin, iron will form greenish black substances that discolor the product. Therefore, the presence of even small amounts of iron necessitates purification before the water can be used in bleacheries, dyeworks, tanneries and the like, paper mills, where it is liable to cause a rusty spot in the fibre, and breweries, where it gives beer a bad color and sometimes a bad taste.

Effect of Calcium and Magnesium.—Calcium and magnesium have similar effects in the industries, particularly in any industry such as dyeing and paper making, where soap is used, for the calcium and magnesium are precipitated as insoluble compounds or soaps which instead of fixing themselves on the fibre, give a blotch or streak upon it. In the laundering industry they form insoluble soaps and therefore have no cleansing effect but are very likely to cause more or less trouble with the particular goods under treatment. In the soap industry, the calcium and magnesium form with the fatty acids curdy precipitates insoluble in water, and therefore of no value in the soap. It is also said that calcium and magnesium in water are a great source of trouble in distilleries because they tend to precipitate upon the grains, and therefore prevent the proper reaction from taking place during distillation.

Effect of Carbonates.—If hard waters high in carbonates and low in sulphates are boiled the bicarbonates are decomposed and the greater part of the calcium and magnesium are precipitated. For this very reason waters high in carbonates and low in sulphates are more desirable in industrial work than waters of low carbonates and high sulphates. It has been proven that waters high in carbonates are preferred in the manufacture of beer because they give a darker beer of more pronounced malt taste, while waters high in sulphates give a pale beer of a pronounced hop taste.

The Effect of Sulphates.—The effect of sulphates has been somewhat explained under "Effect of Carbonates". It is well known that sulphates interfere with the crystallization of sugar in sugar manufacture and tend to increase the amount of sugar retained in the mother liquor. Also sulphates are a source of trouble in the tanning industry, because they cause swelling of the hides.

Effect of Chlorides.—Waters very high in chlorides usually mean high alkaline waters. Such waters cannot be used in breweries or in canneries on account of the salty taste which the water would give the products. High chloride water is a detriment to the tanning industry, in that the hides are rendered soft and flabby. In the sugar industry the chlorides have a tendency to crystallize with the sugar, thereby affecting its quality. Chlorides also affect the germination of yeast, therefore, waters high in chlorides are a source of trouble to manufacturers of alcoholic beverages.

PURIFICATION OF WATERS.

Purification of water consists in the removal or reduction in the amount of those substances which render the water in the raw state unfit for the purpose desired. The main reasons why waters are purified are; (1) to render the water safe for domestic purposes; (2) to render the water fit for boiler purposes; and (3) to render the water free from those substances which are troublesome to the particular industry.

Waters for domestic purposes, or in other words, municipal supplies are required to be free from all disease bacteria, dirt, iron, odor, turbidity and taste; yet the elimination of the bacteria and suspended matter usually accomplishes the desired end. The usual method for this purification is slow sand filtration or rapid filtration after coagulation. The first method is quite slow, while the latter method is rapid and is accomplished by means of mechanical filters. The efficiency of either process is measured by the ratio of the amount of bacteria removed from the water to the amount of bacteria originally in the water. Under normal conditions this percentage is between 99. and 99.8 per cent.

For boiler purposes, it is essential to remove the scale-forming substances and to neutralize the corrosive constituents of the water. This is usually accomplished by one of the following methods—cold chemical precipitation, followed by sedimentation, and heat with or without the use of chemicals, followed by rapid filtration.

As already noted in this article, water for any particular industry requires special treatment, hence it is difficult to give any general method which is applicable to all; yet water properly prepared for municipal and boiler purposes, is generally fit for most industries, and it is usually more economical for small industries to purchase their water from the city than to maintain their own water and purification plant. It is not unusual for large industries to maintain their own water supply and purification plants. In some plants it is essential to have pure water, hence distilled water is manufactured and this is particularly essential in the manufacture of artificial ice and in breweries.

It is sometimes necessary to add copper sulphate, calcium hypochlorite, etc., to waters to kill organisms which may cause disease or give bad odors and tastes to the water. This method of purification requires great care, and must be done in such a way as to kill the bacteria and not render the water unfit for general purposes.

COMPOSITION OF RIVER WATER IN IOWA.

(Parts per million.)

WATERLOO—CEDAR RIVER.

Date	No. 3 June 18, 1913	No. 14 July 2, 1913	No. 22 July 15, 1913	No. 33 Aug. 12, 1913	No. 42 Aug. 31. 1913
Turbidity............	30.0	60.0	80 0	50.0	60
Coef. of Fineness.....	.66	.39	.30	6	21
Suspended Matter....	20.0	23.4	24.0	30.0	30 8
Dissolved Solids......	285.0	208.0	258.8	230.0	224 0
Dissolved SiO_2.......	9.6	15.4	7.4	6.8	7.6
Dissolved Fe.........	.16	.05	.1	1.1	.06
Dissolved Ca.........	56.	50.	59.0	48.6	37 6
Dissolved Mg........	16.8	15.5	19 8	15.3	14.9
Dissolved SO_4........	34.0	26.2	29.5	36.2	44 1
Dissolved Alkalies....	32.8	6.8	21.2	8.7	17.6
Dissolved CO_2........	9.8	5.9	12.7	11.7	11.6
Dissolved HCO_3......	218 0	170.0	221.0	192.0	162 0
Dissolved Cl.........	5.7	1.4	3.4	4.0	6 0
Dissolved NO_3........	.88	4.4	1 32	.35	2 64

COMPOSITION OF RIVER WATER IN IOWA.

(Parts per million.)

CHARLES CITY—CEDAR RIVER.

Date	No. 4 June 18, 1913	No. 13 July 2, 1913	No. 21 July 15, 1913	No. 32 Aug. 12, 1913	No. 41 Aug. 31, 1913
Turbidity............	40.0	70.0	15.0	80.	110.
Coef. of Fineness.....	.27	.6	.73	.21	.20
Suspended Matter....	11.0	42.4	11.	17.0	22.4
Dissolved Solids......	272.0	197.2	252.0	270.2	293.0
Dissolved SiO_2.......	22.8	16.0	14.8	10.0	16.4
Dissolved Fe.........	.06	.1	.08	.11	.12
Dissolved Ca.........	61.6	42.1	60.0	50.	64.4
Dissolved Mg.........	17.2	12.7	19 4	15.7	14.9
Dissolved SO_4.......	16.6	22.4	28.6	34.9	44.1
Dissolved Alkalies....	9.6	15.8	17.4	23.6	15.1
Dissolved CO_2........	13.6	....	9.8	19.5	5.8
Dissolved HCO_3.......	232.0	166.0	222.0	216.0	218.0
Dissolved Cl.........	11.3	3.5	7.0	11.0	8.0
Dissolved NO_3........	.7	3.52	.88	.88	3.16

COMPOSITION OF RIVER WATER IN IOWA.

(Parts per million.)

CEDAR RAPIDS—CEDAR RIVER.

Date	No. 5 June 19, 1913	No. 12 July 1 1913	No. 24 July 17, 1913	No. 34 Aug. 13, 1913	No. 44 Sept. 1, 1913
Turbidity............	70.0	160.0	60.0	80.0	70.0
Coef. of Fineness.....	.45	.5	.93	.53	.47
Suspended Matter....	30.8	66.0	56.0	42.6	33.0
Dissolved Solids......	269.6	251.2	257.8	173.4	177.0
Dissolved SiO_2.......	17.2	11.8	20.0	6.6	5.0
Dissolved Fe.........	.24	....	.07	.13	.1
Dissolved Ca.........	56.8	51.3	44.4	28.8	27.2
Dissolved Mg.........	19.1	14.1	19.7	15.3	11.2
Dissolved SO_4.......	49.6	40.7	50.0	28.8	38.0
Dissolved Alkalies....	21.2	13.2	20.4	9.3	14.7
Dissolved CO_2........	9.8	13.7	....	....	7.8
Dissolved HCO_3.......	186.0	182.5	182.0	146.0	120.0
Dissolved Cl.........	4.9	6.2	3.8	5.0	6.4
Dissolved NO_3........	.35	2.64	.18	.35	.88

COMPOSITION OF RIVER WATER IN IOWA.

(Parts per million.)

FORT DODGE—DES MOINES RIVER.

Date	No. 7 June 23, 1913	No. 16 July 3, 1913	No. 27 July 29, 1913	No. 38 Aug. 22, 1913
Turbidity............	60.	100.0	15.0	200.
Coef. of Fineness....	.32	.48	1.13	.39
Suspended Matter...	19.2	47.8	17.0	78.0
Dissolved Solids.....	484.8	368.0	417.6	416.8
Dissolved SiO_2......	16.1	18.8	18.6	16.2
Dissolved Fe........	.1	.3	.11	1.0
Dissolved Ca........	86.1	73.	68.4	77.2
Dissolved Mg.......	22.4	23.	29.9	28.2
Dissolved SO_4.......	134.4	102.8	118.5	153.5
Dissolved Alkalies..	41.2	19.0	23.6	17.0
Dissolved CO_2.......	34.1	12.7	....	5.8
Dissolved HCO_3......	280.0	219.0	252.0	238.0
Dissolved Cl........	4.4	3.0	12.4	11.6
Dissolved NO_3.......	1.06	2.64	.09	.35

COMPOSITION OF RIVER WATER IN IOWA.

(Parts per million.)

DES MOINES—DES MOINES RIVER.

Date	No. 8 June 24, 1913	No. 17 July 9, 1913	No. 28 July 29, 1913	No. 37 Aug. 14, 1913	No. 46 Sept. 2, 1913
Turbidity............	90.0	100.0	110.0	150.0	110.
Coef. of Fineness.....	.36	.44	.39	.21	.37
Suspended Matter....	32.4	43.6	42.4	32.0	41.0
Dissolved Solids.....	425.6	370.2	427.4	422.0	387.0
Dissolved SiO_2........	16.4	15.2	18.6	21.0	19.2
Dissolved Fe.........	.05	.5	.2	.16	.12
Dissolved Ca.........	73.7	65.8	82.0	72.8	60.8
Dissolved Mg.........	21.8	21.4	16.5	28.2	14.1
Dissolved SO_4........	114.4	108.2	120.0	141.5	113.1
Dissolved Alkalies....	42.5	26.4	26.0	21.9	19.3
Dissolved CO_2........	13.3	5.9	9.8	....	7.8
Dissolved HCO_3.......	243.0	232.0	238.0	256.0	188.0
Dissolved Cl.........	5.4	4.8	7.2	7.4	5.0
Dissolved NO_3........	.88	.35	.35	.35	2.2

COMPOSITION OF RIVER WATER IN IOWA.

(Parts per million.)

OTTUMWA—DES MOINES RIVER.

Date	No. 9 June 24, 1913	No. 18 July 10, 1913	No. 29 July 30, 1913	No. 36 Aug. 14, 1913	No. 45 Sept. 2, 1913
Turbidity............	2000.	80.0	120.0	160.0	320.
Coef. of Fineness.....	.408	.36	.35	.4	.40
Suspended Matter....	816.6	28.8	42.4	65.0	96.2
Dissolved Solids......	218.0	344.0	410.6	355.0	372.4
Dissolved SiO_2........	18.0	10.2	16.6	11.0	12.0
Dissolved Fe........	.28	.07	0.1	.06	.25
Dissolved Ca.........	55.8	63.7	72.4	64.0	67.2
Dissolved Mg.........	8.3	23.4	28.2	27.7	26.1
Dissolved SO_4........	46.3	88.4	102.7	112.2	118.7
Dissolved Alkalies....	15.5	17.8	26.3	18.7	17.6
Dissolved CO_2........	....	....	....	.13.7	....
Dissolved HCO_3.......	151.0	260.0	276.0	204.0	232.0
Dissolved Cl..........	4.4	5.8	10.2	8.0	6.8
Dissolved NO_3........	4.4	.18	.35	.88	.88

COMPOSITION OF RIVER WATER IN IOWA.

(Parts per million.)

MARSHALLTOWN—IOWA RIVER.

Date	No. 1 June 17. 1913	No. 10 July 1, 1913	No. 19 July 14, 1913	No. 25 July 28, 1913	No. 30 Aug. 11, 1913	No. 39 Aug. 30, 1913
Turbidity........	70.	180.0	50.0	20.0	60.0	70.0
Coef. of Fineness..	.95	.41	.55	.71	.51	.27
Suspended Matter.	66.6	74.8	16.6	14.1	30.8	19.0
Dissolved Solids...	392.0	338.8	302.4	332.2	286.8	307.8
Dissolved SiO_2.....	11.8	12.8	11.2	17.4	10.8	17.
Dissolved Fe......	.13	.14	.13	.15	.12	.25
Dissolved Ca......	57.3	68.5	67.8	62.8	53.20	60.
Dissolved Mg......	27.0	27.4	20.3	26.7	22.60	24.5
Dissolved SO_4.....	47.2	41.8	49.5	42.8	45.80	48.0
Dissolved Alkalies.	19.3	19.3	14.1	12.6	17.80	13.5
Dissolved CO_2.....	00.0	16.0	14.7	17.6	....	11.6
Dissolved HCO_3....	263 0	291.0	254.0	268.0	236.0	246.0
Dissolved Cl.......	3.0	3.0	3.4	9.2	3.4	4.0
Dissolved NO_3.....	1.24	2.5	.34	.17	.53	3.52

COMPOSITION OF RIVER WATER IN IOWA.

(Parts per million.)

IOWA FALLS—IOWA RIVER.

Date	No. 2 June 18, 1913	No. 15 July 3, 1913	No. 20 July 15, 1913	No. 26 July 29, 1913	No. 31 Aug. 12, 1913	No. 40 Aug. 31, 1913
Turbidity..........	200.0	180.0	180.0	200.0	170.0	240.0
Coef. of Fineness..	.41	.35	.24	.46	.17	.24
Suspended Matter..	82.0	62.6	44.2	21.0	29.4	58.0
Dissolved Solids...	419.0	379.4	338.0	357.4	372.4	341.6
Dissolved SiO_2.....	24.0	28.2	20.2	14.0	21.4	23.0
Dissolved Fe......	.3	.1	.15	.5	.2	.89
Dissolved Ca......	93.0	85.3	67.6	70.8	71.6	70.
Dissolved Mg......	14.0	27.4	25.8	30.8	23.0	23.3
Dissolved SO_4......	51.0	52.0	53.8	66.8	54.6	67.6
Dissolved Alkalies.	34.0	14.5	13.1	11.8	26.1	6.7
Dissolved CO_2......	20.0	13.7	....	6.8	....	9.8
Dissolved HCO_3....	301.0	309.0	314.0	296.0	324.0	254.0
Dissolved Cl.......	5.0	2.0	2.8	7.0	3.2	3.6
Dissolved NO_3.....	.12	1.3	.18	.35	.44	4.0

COMPOSITION OF RIVER WATER IN IOWA.

(Parts per million.)

IOWA CITY—IOWA RIVER.

Date	No. 6 June 19, 1913	No. 11 July 1, 1913	No. 23 July 17, 1913	No. 35 Aug. 13, 1913	No. 43 Sept. 1, 1913
Turbidity.............	190.0	380.0	200.0	170.0	190.0
Coef. of Fineness.....	.37	.29	.21	.18	.24
Suspended Matter....	71.2	109.0	42.2	47.0	46.
Dissolved Solids......	315.0	329.0	256.0	269.0	269.
Dissolved SiO_2........	11.6	15.2	15.6	7.2	23.
Dissolved Fe.........	.4	.1	.11	.2	.12
Dissolved Ca.........	77.4	74.3	43.2	57.6	59.2
Dissolved Mg.........	18.0	6.5	18.5	11.8	15.7
Dissolved SO_4........	55.2	68.2	33.4	55.6	51.5
Dissolved Alkalies....	26.4	23.4	12.0	20.4	5.2
Dissolved CO_2........	12.3	8.2	....	8.9	5.9
Dissolved HCO_3.......	245.0	214.0	250.0	204.0	198.0
Dissolved Cl..........	6.8	6.4	5.2	5.2	6.0
Dissolved NO_3........	.7	7.0	.18	.62	1.76

COMPOSITION OF RIVER WATERS IN 1912.

Place	Date	Sample Number	Direct from River or Filtered River Water	Turbidity	Suspended Matter	Dissolved Solids	Dissolved Si	Dissolved Fe	Dissolved Ca	Dissolved Mg	Dissolved SO$_4$	Dissolved Alkalies	Dissolved CO$_2$	Dissolved HCO$_x$	Dissolved Chlorine	Dissolved NO$_x$
Raccoon River—																
Des Moines........	6/25	H-3	Direct	220.	112.	428.	21.	4.	92.	22.	110.	21.	..	274.	4.2	41.0
Valley Junction...	6/25	H-5	Direct	385.	73.	460.	17.6	8.6	71.	22.	169.	1.0	..	236.	4.0	.04
West Ninth Street Bridge, Des Moines	7/22	H-19	Direct	3560.	602.	297.	10.0	1.4	54.	20.	94.	14.0	..	184.	11.0	0.5
Des Moines River—																
Des Moines........	7/22	H-13	Direct	430.	86.	249.	11.0	3.0	54.	17.	60.	17.0	..	103.	7.0	0.5
Harvey	7/23	H-20	Direct	490.	215.	320.	10.0	0.4	63.	19.	89.	12.0	..	198.	11.0	0.2
Keosauqua	7/23	H-21	Direct	720.	177.	353.	16.0	0.4	70.	24.	101.	8.0	..	218.	13.0	0.2
Ottumwa	7/23	H-22	Direct	625.	190.	335.	14.0	0.4	70.	21.	76.	3.0	..	212.	7.0	0.5
Emmetsburg	7/25	B-2	Direct	70.	29.	439.	4.0	.04	81.	32.	140.	17.0	..	248.	3.0	0.3
Fort Dodge	7/23	B-3	Direct	50.	20.	359.	7.0	.04	74.	23.	64.	11.0	..	126.	5.0	.4
Estherville	7/23	B-4	Direct	60.	22.	486.	5.0	.02	92.	32.	159.	16.0	12.	246.	9.0	.4
Boone	8/15	W-2	Direct	15.	49.	340.	10.0	.06	60.	25.	109.	21.0	..	220.	8.0	.06
Cedar River—																
Cedar Rapids	8/19	W-5	Direct	575.	191.	231.	6.	.8	35.	9.	55.	32.	..	162.	8.0	.3
Cedar Rapids	8/20	W-6	Filtered	5.	4.	276.	6.	.2	54.	21.	88.	8.	..	167.	6.0	2.0
Charles City......	9/14	W-11	Direct	80.	25.	258.	8.	.06	58.	19.	24.	12.	21.	208.	6.0	.4
Iowa River—																
Iowa Falls........	9/15	W-12	Direct	140.	95.	306.	14.	.5	58.	23.	36.	16.	21.	235.	2.0	.5
Iowa City.........	8/19	W-4	Direct	340.	159.	275.	7.	.5	56.	23.	76.	9.	9.	199.	7.0	.3
Iowa City.........	8/18	W-3	Filtered	5.	7.	324.	8.	1.0	65.	26.	61.	14.0	..	288.	7.0	.5