experiments of Burri and Stutzer,[1] in which they found that the mixed organisms from several samples of soil from widely separated sources assumed an almost constant nitrifying power after a series of cultivations in an artificial medium. Whether their results are to be interpreted as an evidence of constant nitrifying power in organisms from widely different soils when these organisms are cultivated in the same medium, or whether they are to be regarded only as another example of the extreme variability that bacterial species have so often been observed to exhibit, is only to be determined by extended experiments. Of high value for the confirmation of these, or of any other results obtained by means of artificial culture medium, is the re-inoculation of several soils with each of the organisms studied, noting the results during long periods of time. Both sterilized and unsterilized soils should be used for this purpose, as well as soils in which the chemical and biological conditions have been variously modified by artificial means.

We feel that the contribution that we have just made to the knowledge of this subject is almost lost in the vast unknown of the field that still remains to be explored, but this is offered as a note of the work that has been undertaken by us of attempting to make a comparative study of the microorganisms important to agriculture in typical soils from all parts of the United States. This note is not presented with any desire to preempt this field of study, for it is broad enough to monopolize the time and skill of many workers for many years to come.

STANDARD PRISMS IN WATER ANALYSIS AND THE VALUATION OF COLOR IN POTABLE WATERS.

BY ALBERT R. LEEDS.

Received April 16, 1896.

IN one of the first papers read before this Society and contained in its Proceedings, Vol. II, p. 1, for 1878, I have given an account of an instrument and a method for reading the quantities of ammonia obtained in nesslerizing, the instrument being termed a color comparator. It was designed primarily for this purpose only, and had its origin in the irregularities observable

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[1] *Centralblatt f. bakteriologie u. Parisitenkunde*, *1896*, 2, 105-116.

in the readings of the very minute amounts of ammonia obtained in the course of water analysis. It was subsequently found to be of great service in giving more precision to the measurement of color in potable waters, and it was used for this purpose and also for the estimation of the percentage of carbon in pig-irons, etc. The color struck by 0.01 milligram of ammonia was taken as the unit for natural waters.

The apparatus has been figured in the catalogues of the dealers for the past twenty years, and I need not describe it again here. It avoided the sources of error due to reading the tubes under different conditions and from the side, from the top and in different manners.

The light was reflected from a mirror, placed at an angle of 45°, down and through the middle of the tubes standing on the rack, and then by a second mirror placed below, but at right angles to the first, outward to the eye of the observer. The object was to compare the colors obtained in nesslerizing not with any one series of trial tubes prepared at the time and which might vary within wide limits, but with a coloring material contained in a wedge in connection with which the results of many readings could be plotted and so preserve a permanent standard of comparison. This wedge was placed below the aperture, next to the tube under comparison, but in order that the optical image might be similar in all respects, a tube filled with distilled water was placed above the wedge and the dark rings made by the light transmitted downward through the walls of this tube, made a part of the image also.

All that the eye then had to do was to determine whether the depth of color in two rectangular spaces, as seen in the lower mirror, each space being twenty-five mm. by ten mm. and separated by an interval of ten mm., was or was not equal. When the rack is full, which is the case in two duplicate nesslerizings, the whole of the results are before the eye of the observer at one and the same time, and twelve blocks of color strung along one after another in a horizontal line, are seen brilliantly lit up on a perfectly black ground.

But the difficulty was to obtain a suitably colored fluid to fill the prism. Naturally enough recourse was had in the first place to the chromogenic metallic salts as being easiest to prepare of a definite strength, and as probably of the most permanent composition. To this end very many trials were made with mixtures of iron, chromium, nickel, cobalt, ferrocyanogen, gold and platinum, but all without success. When a solution gave a series of tints which were satisfactory for the lower end of the scale, it was unsatisfactory for the upper, and vice versa. Then mixtures of these salts with admixtures of coloring matters and with infusions of tea, coffee, etc., were tried and finally a solution of caramel corrected by anilin red showed as close a parallelism with the colors struck by the nesslerized ammonia as any combination experimented upon.

It was fully recognized at the time that none of these expedients fulfilled the conditions of complete parallelism of tint, permanence and ease of handling, that were desirable, and the attempt was made to substitute for the hollow wedge one of colored glass. Mr. Emil Greiner obtained many specimens of greenish-yellow, yellow and orange-yellow glass, and lent his skill in grinding them down into suitable long thin prisms. But they all failed at one or the other end of the scale, and when they were examined by the spectroscope and the difficulty was found to be due to a selective absorption of the color in the different parts of the prism, the attempt to make a satisfactory prism out of one kind of glass only was abandoned. Then thin sheets of differently colored glasses were taken, with the hope that by combination and superposition the changes of tint throughout the scale could be imitated. But at this time a very limited number of shades of color in glass could be obtained. At the present day, with the enormous development of the art of making and using glass for decorative purposes, the case is different. I am experimenting upon composite wedges, made up of wedges of different colors, and the results are promising. Certainly the obstacles to be overcome are not nearly so great as those which have been surmounted in getting rid by means of over-correction and under-correction of both spherical and chromatic aberrations in a lens. Similar composite glass wedges could be employed to estimate minute amounts of iron when a color reaction with a thiocyanate or ferrocyanide is utilized, or for small quantities of copper or other color-giving substance.

We are only too familiar with the sources of error in the Nessler process, and every chemist at the outset of his work in water analysis is compelled to devote much time to their study. A very slight variation in the mode of preparation makes a great difference in the sensitiveness of the Nessler reagent itself. Potassium, mercury, chlorine and iodine form a large number of salts, and that their molecules are complex and constantly changing is shown by the gradual change of color of the reagent from its first pale greenish-yellow color to a light straw tint with a corresponding gain in sensitiveness. But even with a reagent which is duly sensitive in the lowest part of the scale, and with due care in seeing that the liquids are brought to a proper temperature, and with every minute precaution as to measurements, thorough admixture, etc., there still remains many uncontrollable irregularities. It frequently is the case that the color struck by 0.001 milligram of ammonia is even greater than that given by 0.002 milligram; that given by 0.002 about the same as that given by 0.003, and so on. On standing, the precipitates which settle out, are not uniform in composition, red tetragonal crystals, resembling mercuric iodide, being oft-times accompanied by dark green crystals resembling the mercurous salt. By making up a sufficiently large number of trial sets at one time, it is possible to pick out from them a series in which the differences of tint corresponding to five-tenth cc. of ammonia are, so far as the eye can judge, equal.

The same result is obtained by plotting the results of many readings on a permanent scale. As ascertained by comparison with such a scale, the sum totals of the readings are more accurate than those obtained by comparison with any one trial set made up of fluctuating and perishable members. When we consider that there is an increase both in the delicacy of the reaction and in the ability to read the color tint up to a maximum, after which both fall away again, it is probable that the most accurate method of reading would be to have a permanent scale, divided into equal parts, and to use the scale only for so much ammonia as corresponds to the differences of color which the eye is capable of estimating with certainty.

VALUATION OF COLOR.

As has been remarked above, it was not till after the color comparator had been proposed as a means of estimating the percentage of nesslerized ammonia, that the same scale was extended to the measurement of color in waters. The article in the Journal was reprinted with illustrations in the *Zeitschrift für analytische Chemie*, 17, *276*, and in the *Chemical News*, in the issue of June 7, 1878. In the issue of the latter journal for April 14, 1881, in their report upon the London water supply, Crookes, Odling and Tidy gave the following account of a similar method:

"For some time past we have been experimenting on methods of determining the colors of water, and we have this month adopted a process which, whilst it does not pretend to absolute accuracy, is a great improvement over the arbitrary 'degrees of tint depth' by which the color of water has hitherto been estimated. The process briefly is as follows:

"Two hollow wedges are filled, one with a brown and the other with a blue solution,[1] and these are made to slide across each other in front of a circular aperture in a sheet of metal. In this way any desired combination of brown and blue can be produced. Each prism is graduated along its length from one to forty, the figures representing millimeters in thickness of the solution at that particular part of the prism.

"On a level just below the prisms is a two-foot tube containing the water under examination, and having in front of it a circular aperture of the same size as the one in front of the prisms.

"The stand supporting the prisms and tube is placed horizontally in front of a uniformly lighted window. The observer, standing a little distance off, sees two luminous disks, the lower one illuminated by light, which has passed through two feet of water, and the upper one illuminated by light which has passed through the respective thicknesses of the brown and blue solutions.

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[1] The solutions are made in the following way: *Brown Solution.* Dissolve ferric chloride and cobalt chloride in distilled water in such proportion that one liter of the solution contains 0.7 gram of metallic iron, and 0.3 gram of metallic cobalt. A very slight excess of hydrochloric acid must also be present. *Blue Solution.* Dissolve ten grams of pure crystallized copper sulphate in one liter of distilled water.

"By sliding the prisms sideways, one way or the other, it is easy to imitate with considerable accuracy the depth and tint of the color of the lower disk. A metal pointer affixed over the center of the upper disk shows on the prism scales the number of millimeters in thickness through which the light has passed to produce a color which corresponds to that of the water, and the results are recorded in the following way: Brown : Blue. Thus: "February 21, (New River), 20 : 21 means that on that date the color of New River water seen through a two-foot tube was represented by twenty millimeters of brown and twenty-one millimeters of blue solution."

Subsequently the board of London examiners abandoned the use of iron and substituted for it one of potassium dichromate.

Recently Allen Hazen, in the March number of this Journal, has advocated the use of a solution of platinic chloride, this constituent being of fixed strength, together with a solution of cobalt chloride to be added in accordance with the color sense of the observer. Possibly other chemists are employing still different solutions, and it is probably somewhat premature to expect at the present moment a concensus of opinions as to the best substances to be employed. In laying out the methods to be pursued in the examination of the waters submitted to the State Board of Health of Massachusetts (see their Report for 1890), T. M. Drown adopted the Nessler ammonia scale as the scale for color also. And in the January number of this Journal, E. H. Richards has given at length the reasons for adhering to this scale and her method of applying it through an intermediate set of colored natural waters, verified by fiduciary comparisons of certain points on the Nessler ammonia series.

In order that this renewed discussion may have the greater practical value, I shall venture to make the following suggestions:

1. That the unit of depth in the measurement of the color of water should be taken at 200 mm. This depth was used in the comparison tubes, which contain 100 cc. at the 200 mm. mark, for the reason that the same depth has already been adopted in the polariscope. Moreover, 200 mm. or eight inches, is a depth of water familiar in household use, while two feet is not, and

it is a unit that can be more conveniently applied to the unfiltered surface waters now in general use in this country, than the two-foot depth made necessary in gauging the filtered waters supplied to London and other European cities. With the general introduction of filtered waters in this country, three times 200, or 600, (which is very nearly two feet), could be used in measuring color in water that fell below 0.2° on the scale. The unit tube could be applied to waters showing between 0.2° and 2°. In order to preserve identity of conditions, which is of such fundamental importance in optical measurements, instead of diminishing the depth of the more highly colored waters, those between 2° and 4° could be diluted with an equal bulk of water and read in the unit depth of tube.

2. I would respectfully urge as a matter of priority and inasmuch as a very great number of measurements of color in this country are already so recorded, that the unit therein adopted which corresponds to the color struck by 0.01 milligram of nessnerized ammonia, should be retained. It may be said that for the reason already given this unit is one which cannot be precisely ascertained. But to compare lesser things with greater the same thing may be said of the meter; to rectify it in the manner originally intended, will prob bly never be attempted, and yet, at the same time, the meter is an universally accepted and well defined magnitude. Moreover, every time an ammonia determination is made, this unit must be ascertained and the readings for color are usually done at the same time as those of ammonia. Whether a scale is made with chromium or platinum or any other pure substance, there would be no difficulty in determining the weight of metal to be used to give the same color as that struck by 0.01 milligram of ammonia, within any such limit of precision as the eye is capable of measuring. Such a scale divided from 0 to 1 into ten equal parts and then the same divisions continued higher, could be used in the estimation of ammonia also.

3. Instead of using this scale directly, there would be great gain in using its equivalent in glass. If he desired, each chemist could test the glass scale by comparison with a fluid one made

by himself, but in daily use indestructable and properly compensated glass wedges have many advantages.

A METHOD FOR SEPARATING THE "INSOLUBLE" PHOSPHORIC ACID IN MIXED FERTILIZERS DERIVED FRON BONE AND OTHER ORGANIC MATTER FROM THAT DERIVED FROM ROCK PHOSPHATE.

BY A. P. BRYANT.

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DURING the year 1895 the wholesale price of rough bone was about $19.50 per ton in the New York markets. Ground bone brought $22.75 per ton, and ground Charleston rock averaged $8.12½ per ton. After allowing for the value of the ammonia, the phosphoric acid purchased in bone still costs considerable more than the same amount purchased in mineral phosphates.

Estimating 3.75 per cent. of nitrogen in the ground bone, wholesale cost 12.3 cents per pound, there would be $9.23 worth of nitrogen per ton. This value would make the phosphoric acid in a ton of ground bone cost at wholesale $13.52, when the same amount approximately of phosphoric acid in ground rock costs about $8.12½ per ton.

This cheapness of mineral phosphates has led to their very general use by fertilizer manufacturers instead of bone as a source of phosphoric acid.

While the so-called Available Phosphoric Acid[1] of the two may be of equal value, it seems wrong to classify the phosphoric acid of mixed fertilizers insoluble in the ammonium citrate solution at the same price in the two. The Connecticut State Station's Report "Trade Value," of the organic phosphoric acid is (average) five cents per pound, while in the raw ground rock it is but two cents per pound.

It has been urged that there is no means of telling whether the "insoluble" phosphoric acid in mixed fertilizers was derived from minerals, or from bone and tankage. It was for

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[1] That portion soluble in a neutral solution of ammonium citrate, sp. gr. 1.09, digested at 65° C. for thirty minutes.