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An Analysis of Filtered Water

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eral species of *Poa*, *Beckmannia erucæformis*, Host., *Schedonnardus Texanus*, Steud., *Eriocoma cuspidata*, Nutt., and several species of *Triticum*, complete the list of grasses collected.

Only two species of ferns were observed, a *Woodsia* and *Pellæa atropurpurea*, Link., the latter growing in the crevices of the rocky ledges on the summit of the buttes. A few mosses were seen, and two species of licheus.

The arboreal vegetation was, as might be supposed, very scanty. Aside from the timber on the Missouri river bottoms, only a few stunted willows, cotton-wood, box-elder and June berry were found scattered at intervals along the streams.

A curious feature of the country west of the Missouri, beyond the limit of the drift, was the great number of fossil tree stumps, protruding through the sod. Hundreds could be counted in many places, and in some localities, especially in Pyramid Park, the fossil trunks were found where they had fallen, almost whole and but little the worse for the ravages of time. There is no doubt that during the Cretaceous and Tertiary periods extensive forests flourished in this region; and to judge from the size of the stumps remaining, some of the trees must have been of immense size. Many stumps were seen ten feet or more in diameter, and I heard of others still larger.

This region will yet prove a mine of wealth to the botanist studying our fossil flora. Fossil leaves in great abundance occur everywhere in the Tertiary sandstones and soft Cretaceous clays. In some places the clay beds were originally underlain by seams of lignite, which have been burned, baking the clay above into a kind of brown, red, or yellow brick, which shows perfectly the forms and venation of these fossil leaves. The region is well worth the time and attention of working botanists, both in recent and fossil botany; and will doubtless ere long receive its due share of exploration and study, since it has become so easy of access.

[*Paper I.*]

AN ANALYSIS OF FILTERED WATER.—*James A. Dodge.*

The question of the ways and means of obtaining sufficiently pure water for drinking purposes and domestic use in this city, is one that has been several times discussed before the Academy and elsewhere. We must all admit that it is a question of importance.

We have been repeatedly informed by sanitary authorities what the consequences of drinking impure water may be—what they undoubtedly have been in some localities in this country and in Europe, and what they *may* be here. Whatever our source of supply, river water, lake water, well water, cistern water, we know that they are all liable to contamination with impurities of various kinds, and that certain of these impurities, especially human excreta, introduce into the water an element of *danger* and throw upon those who partake of it a positive risk of contracting disease. Now here in Minneapolis the greater number of us are personally concerned with the character of the water of the river as supplied by the city water works. We are for the most part willing to admit that there are worse waters used than the river water; but at the same time we are aware that the river water is not up to the standard of purity which an intelligent and cleanly community desires. Considering however, that it is the water with which we are likely to be supplied for some time to come, we are interested in any method by which this water can be made better, by the destruction or removal of its impurities. I have been giving some attention of late to the subject of the improvement of water by filtration, and more particularly by domestic filtration. At my residence we have been using for about a year a filtering apparatus which we have applied to the purification of water supplied by the city works, and, as I think, with satisfactory results.

(The construction of the apparatus was represented in a figure on the blackboard.)

The apparatus is of stone ware. A space holding about two gallons is the receptacle into which is poured the water to be filtered. The filtering medium is granulated animal charcoal or bone-black. A lower space holds the water after filtration delivering it from a faucet. At one point is a sponge stuffed into a cavity as represented. The upper space is emptied and cleaned from time to time, together with the sponge. It might surprise one not acquainted with the subject to see the amount of dirt which deposits itself in this space and in the sponge after a short time of use.

In order to obtain some definite knowledge of the efficiency of this filter, I drew a quantity of the filtered water into a well cleaned bottle and took it to the laboratory for analysis. We did not make a complete analysis, as I judged that unnecessary for my purpose. But I submitted the water to two particular tests which

were most important in the case, namely the test for *ammonia* free and "albuminoid" and the permanganate test. On the same day I took a quantity of the unfiltered city water from the pipe and submitted it to the same analysis. Both analyses were conducted with the utmost care and with every precaution to obtain correct results. The results of these analytical determinations are as follows for the ammonia test:

RIVER WATER NOT FILTERED.	RIVER WATER FILTERED.
Free ammonia .030 per million.	Free ammonia .005 per million.
Album. " .100 " "	Album. " .015 " "

On comparing these results, we see that the filtered water shows about one-sixth the amount of both free ammonia and albuminoid ammonia which is shown by the water not filtered. Let me say at this point that the results obtained for the water not filtered are by no means high results. As the members of the Academy have been reminded on previous occasion when results of chemical analysis of the river water have been presented, this water does not show itself decidedly bad through our chemical tests. Moreover, we must be reminded that these chemical tests are not perfectly conclusive as to the real purity or impurity of a water. They do not show all that is in a water; they need to be supplemented by other methods of examination, according to circumstances. But they are very good tests *for comparative purposes*, such as we are now concerned with. Now if we had submitted to us for chemical examination a sample of water in which we found the free and the albuminoid ammonia as low in amount as we have found them in our filtered water, with 5-1000 parts of free ammonia and 15-1000 parts albuminoid ammonia per million parts of water, we should say—unless other tests gave much higher results—that the water was of a high degree of purity.

The other test to which the two samples of water were submitted was, as stated, the permanganate or Forschammer test. This is also a test for the organic matter present in water, particularly for carbonaceous matter. It consists in determining the amount of permanganate of potash solution, which is decolorized by a given amount of water, and therefrom, by calculation, the amount of oxygen which is required to destroy the organic matter on that amount of water. The result of my determinations for the two samples of water are as follows:

RIVER WATER NOT FILTERED.	RIVER WATER FILTERED
Oxygen required,	Oxygen required.
1.95 parts per million.	.11 parts per million.

Here we see a still greater difference between the unfiltered and the filtered water than in the other test, the one requiring not much more than one-twentieth of the amount of oxygen required by the other.

In fact, the filtered water by this test appears to be almost as free from organic matter as the specially prepared distilled water which we use in connection with our water analysis.

This test, then, confirms the other test. From a chemical stand-point we should be perfectly satisfied with a drinking water giving such results.

Hence, considering the filtering apparatus in question, we may conclude that it does its work well and runs out a good water.

With regard to the appearance of the water after filtering, I will say that in this respect it is above criticism, being perfectly clean and colorless, whereas before filtering it is often decidedly turbid and yellow. In palatable character also, the filtered water is excellent. In both these respects it leaves nothing to be desired.

The particular kind of filtering apparatus used is of an English make, of George Cheavins' patent. There are various kinds of filters in the market. The filtering and purifying medium used in some of them is the same as in the one described, namely granulated bone charcoal. In others the material is "spongy iron." In others it is "silicated carbon." These filters are all well spoken of. I have not at this date personally experimented with any other than my own. "Spongy iron" is said to be very effective as a means of purifying water from organic substances. It is metallic iron in a spongy state, as reduced from lumps of hematite ore by special furnace processes. Its use has been introduced on a large scale at some places in Europe for purifying the entire water supply of cities. The water supply of Antwerp, taken from a river, is purified by this means. But, on the whole, good bone charcoal is equal to any material thus far used, and on the small scale is perhaps the best material. Professor Wm. R. Nichols, of the Massachusetts Institute of Technology, says that he considers nothing better than well burned bone charcoal.

Now, in view of what has been shown here in the way of analytical results, I can but add my recommendation to the recom-

mendations of physicians and others in this city, that we adopt the plan of filtering all the water which we are to drink. The cost of a domestic filtering apperatus is not great. One could be constructed quite cheaply from simple parts and materials.

(The plan of a cheap filter suggested by Dr. Smart, an eminent sanitarian, was given on the blackboard.)

Bone charcoal can be obtained from druggists. It is not expensive, varying according to quality from twelve cents to fifty cents per pound. It will retain its purifying power a good while before needing to be replaced. An efficient filter is something *more than a strainer*. The small globuler filters which are attached directly to the faucets of supply pipes, seem to be hardly more than strainers, as the amount of filtering medium in them cannot be great and as the water passes through rapidly and under strong pressure. A quiet and gradual passage of the water through a comparatively large amount of filtering medium seems essential to thorough effectiveness; still the small filters are much better than none. A good filter does not merely separate out the visible particles of suspended matter, such as clay and sand, from the water. Bone charcoal, by a peculiar absorptive power, separates also most of the organic matter which is in a state of partial or complete solution, and besides this, it destroys the organic matter in great measure by a process of oxidation. In this respect it is much superior to wood charcoal. In fact, wood charcoal is said by those who have investigated the subject to be of very moderate efficiency, and not much better than sand or a similar material for purifying water. In many cities the entire water supply is filtered, but on so large a scale nothing more than sand and gravel is generally employed, though as stated, spongy iron seems to be coming into use. A filtration through sand is of much advantage. It takes out all course impurities, but it does not effect a thorough sanitary purification, like bone charcoal. As we all know, no filtration of any kind is employed here in connection with the city water works. The new intake pipe terminates in a mass of loose stonework which serves the purpose of a coarse strainer and that is all. Filtration of the great amount of water pumped at the works would probably, under present circumstances, of location, etc., be impossible. Perhaps when the water is taken higher up the river, a system of filtering basins, etc., may be adopted. This is much to be desired.

For those who do not adopt domestic filtration, another resource consists in a *thorough boiling* of the water which is intended for drinking. This has some objections, chiefly on the ground of the unpalatable character of boiled water which has not been subsequently aerated. In some places apparatus for aerating boiling water or distilled water has been introduced; by aeration the water is again made palatable. It is generally believed by those who can speak with authority on the subject, as for example Professor Frankland, of London, that a thorough boiling of an impure water, say for half an hour, destroys the organic germs that may be present and removes the danger that would attend the use of the water. Opinion is a little divided on this question, some holding that filtration is more to be relied on than boiling for the removal of infectious germs and other objectionable matter.

I shall not hesitate to express the opinion that the river water, so long at least as it is taken from the same point as at present, *needs purification* before being used for drinking purposes. And I do not doubt that a good deal of the well water and cistern water used in the city needs purification too. A chemical analysis is not always necessary to support such an opinion. It is often, as in the case of the river water, enough to know the circumstances, to *see* the sources of contamination and to be aware of the contamination going on.

But, after all, far better than to depend upon filtering or any other treatment for the improvement of a water once made impure, far better would it be to have a water free from contamination in the first place, and to prevent the influx of all impurities, so far as the most strenuous efforts can accomplish that result. For, with the best of our methods and apparatus for the purification of water there always remains the possibility that some of the impurities are left in the water, and with that the further possibility that what so remains in the water may be potent for the making of a good deal of mischief.

April 8, 1884.