WATER SOFTENING AND FILTRATION PROCESSES.

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For the purposes of the textile manufacturer, it is to be desired that a water should be perfectly soft. It is of course true that a special examination of the water used in a technical industry may reveal the fact that the water is perfectly fitted for the work to be done. At all events the water should receive especial attention and nothing should be done without consulting an experienced and capable man. The first cost of a water-purification process is in some cases high, but the saving in material as well as the increase in value of the final product, will soon offset this expense.

Many methods of water purification have been devised, and some of these have been experimentally tested and found of value. But only a very few of these methods have succeeded in actual practice. Many of the methods have been the outgrowth of mere mechanical work, but the more successful devices have been the result of a thorough study and the principles and conditions which govern the processes have always been kept in mind.

As before stated, a water may contain suspended matter as an impurity or the impurity may be in solution. Processes for the removal of dissolved impurities include softening processes which have already been considered. The method of purification by distillation might be mentioned here.

Practically all the impurities, both suspended and dissolved, are removed by distillation. The various methods of sterilization in which the bacteria are killed are not important enough to textile mills, to merit more than passing mention. There are two general methods for the removal of suspended impurities, sedimentation and filtration. These methods are really natural processes.

Sedimentation, is a more or less thorough process depending to a certain extent upon the character of the impurities. The water may be entirely freed of its suspended matter, depending upon what length of time is devoted to the process. The process is carried out artificially in large storage reservoirs, or in small settling-basins, which are especially designed for the purpose. Often the work is aided by the introduction of chemicals which produce a precipitate which coagulates and settles, carrying the finely divided matter with it to the bottom. The particular process to be used depends upon the character and quantity of suspended matter to be dealt with.

The sediment in most streams is principally of an inorganic nature, consisting of particles of sand and clay. These particles vary greatly in size. In some waters the finer particles of clay are less than 0.00001 inch in diameter. A small amount of organic matter may also be present in the water. Bacteria, which, so far as is now known are not particularly harmful to the textile industries, may also be present. The amount and character of the sediment varies greatly from time to time; it depends largely upon the stage of water in the tributaries of a stream and also upon the geological character of the various parts of the drainage area. The great variation in amount and kind of suspended matter is a most troublesome factor in connection with the purification of a water supply. If the water contains little that is objectionable besides the inorganic matter, sedimentation processes will often render the water fit for use.

Two methods of sedimentation are in common use:—Plain sedimentation, so-called, and sedimentation with the aid of a coagulant.

The particles of sand and clay are quite heavy and are kept in suspension by virtue of the currents maintained in the water. If these currents become retarded, part of the suspended matter is deposited. Fine particles resist sedimentation more than the coarser particles. While much of the coarser material may be deposited by a slight retardation of the current the finer particles will be held in suspension by the weakest currents. To secure thorough sedimentation in the case of finely divided impurities, it is therefore essential that the water be brought to a state of perfect rest. It is an open question whether or not the finer particles would ever settle, were it not for the fact that they are borne to the bottom by the coarser particles. The time required for complete sedimentation varies; some waters require weeks and even months to remove all turbidity, while others require but a day or two to accomplish good results. A period of twenty-four hours is about the minimum allowed, this seldom accomplishes perfect sedimentation. The average removal of suspended matter shown in the following table is taken from a Report on Water Purification for the City of Cincinnati:

Time of Subsidence	Amount of Suspended Matter Removed.
24 hours	62 per cent.
48 "	68 " "
72 "	72 " "
96 "	76 " "

There is a marked degree of purification noticeable after this sedimentation process is carried out. But in the case of a sewage polluted water, frequent tests of the water should be made, as organic compounds may be present and remain even after a long period of subsidence.

Various chemicals when added to water will combine with certain substances ordinarily present, forming precipitates which are more or less gelatinous in character. These precipitates readily coagulate and collect the finely divided suspended matter into large masses which are readily removed by sedimentation. The color of a water may be changed by this process and a clear sparkling water may be the result. In some cases, however, the water may have a peculiar coloring, the presence of which has never been satisfactorily accounted for.

This process is not an expensive one, the space required to put it into practice is not large and its efficacy from a textile standpoint is undoubted.

Several substances can be used as coagulants, alum, (K_2SO_4. $Al_2(SO_4)_3$) and sulphate of alumina ($Al_2(SO_4)_3$) are commonly used. When this substance is introduced into water containing (as water most often does) carbonates and bi-carbonates of lime and magnesia [$CaCO_3$, $Ca(HCO_3)_2$, $MgCO_3$, $Mg(HCO_3)_2$], it is decomposed.

This action may be represented as follows:—

$$3CaCO_3+Al_2(SO_4)_3+3H_2O=3CaSO_4+2Al(OH)_3+3CO_2$$

$$3Ca(HCO_3)_2+Al_2(SO_4)_3=3CaSO_4+2Al(OH)_3+6CO_2$$

$$3MgCO_3+Al_2(SO_4)_3+3H_2O=3MgSO_4+2Al(OH)_3+3CO_2$$

$$3Mg(HCO_3)_2+Al_2(SO_4)_3=3MgSO_4+2Al(OH)_3+6CO_2$$

The salts are transposed. The aluminum hydroxide is a bulky gelatinous hydrate and constitutes the coagulating agent. The exact amount of alum required to combine with the carbonates present must be calculated. Any excess of the sulphate remains dissolved and upon coming in contact with an iron pipe, the sulphate, which is an acid salt, is apt to rust the pipes and to make matters quite complex. If the water is not alkaline enough to unite with sufficient sulphate to furnish the necessary amount of coagulant, lime may be added to the water. Much more coagulant will be required if the sediment is fine than if it is coarse. Theoretically, one grain of sulphate will decompose eight parts of calcium carbonate, but it has been found that the suspended matter absorbs a certain amount of the coagulating agent before precipitation takes place. Water in which this coagulation has taken place is apt to be slightly hard, owing to the increase of sulphates of lime and magnesia. But with the quantities of coagulant ordinarily used, one to two grains per gallon, this increase in hardness would amount to from nine to eighteen parts only, per million. This is not a very important matter, but the objectionable increase in hardness may be avoided by the use of sodium carbonate instead of lime in case the water is not sufficiently alkaline. In most textile processes, the slightest degree of hardness is objectionable. The carbonic acid set free remains absorbed in the water, and its corrosive action is increased. This is a minor detail, however.

The amount of chemical to be used depends upon the amount and character of the sediment, upon the degree of purification desired and upon the time allowed for subsidence. The proper amount can only be determined by experiment. In general, the more chemical used, the greater the effect, and by using a sufficient quantity and by allowing enough time for sedimentation, a clear water can be secured. The rate of sedimentation depends greatly upon the amount of coagulant employed. Sedimentation takes place much more quickly than where no coagulant is used, so that a large part of the action will occur in a few hours. One day will be the time most generally allowed. Much less time can be allowed in many cases. Where a water contains large amounts of sediment, it will often be more economical to allow the coarser particles to settle out before introducing the chemical, this will effect a considerable saving in the cost of chemicals and will give a very satisfactory result.

Settling-basins for the purpose of allowing sedimentation are constructed as is any reservoir. Often a distributing or storage reservoir is used to allow the suspended matter to settle. If but a limited time can be allowed for sedimentation, special basins are constructed. These basins may be arranged so that the clear water is constantly flowing off, while the impure water flows in, or the basins may be arranged to allow the water to be drawn off at intervals. These basins are designed so that the water can be drawn off to any desired level, usually to a depth at which complete sedimentation has taken place.

Settling-basins are often used in connection with filtration systems which will now be considered. Sand filtration will be explained in a broad way.

When a solution containing suspended matter in it, is passed through a fine, porous medium, the suspended matter is caught and retained by this medium and only a clear solution passes through. This process of eliminating suspended matter from water is known as filtration. The filtering material may be paper, cloth, sand or charcoal. Natural filtration is occurring continually. Spring water is the result of this natural filtration. Rain water, falling from the clouds through the air, collects in its downward flight the dust and dirt which is in the air. The rain when it strikes the earth is absorbed by it, and trickles through the different strata and in this way it is freed from its suspended impurities. The water collects under ground in natural reservoirs, from which we get our spring water.

All filtration processes are based upon the same principle, the passing of the impure water through a compact, yet porous medium. Sand is the material generally used for filtering water.

To best explain the principle upon which all filters are based, let us consider a filter of the most simple type: A tank is fitted with a false bottom through which a number of holes are drilled, over this false bottom is stretched a piece of strong canvas cloth. On top of the canvas is placed a layer of fine sand, four to eight inches thick, and above this, a layer of coarser sand, six to ten inches thick. Above the coarse sand is placed a layer of fine gravel, three to four inches thick. The water is allowed to flow in from the top; as it trickles through the coarse sand, the larger particles of suspended matter in water are caught and held, the finer particles being carried along, till the water reaches the fine sand, when they in turn are caught and held. The clear water then passes through the cloth and the perforated bottom, to the compartment below, from which it is drawn off to wherever required. This of course is a very simple filter; the objection to it is that after it is in use for a long time it becomes clogged up with impurities and filters very slowly or not at all, and when this occurs the filter requires cleaning. The length of time such a filter can be used without washing, depends upon the character of the water filtered. If the latter contains a large amount of suspended matter, it must be washed more frequently, than when the water only contains a smaller amount of impurities.

When having to clean such a home made filter, the gravel must be taken off first and washed by placing it into a tank and allowing a stream of water to flow constantly through the tank, meanwhile stirring the gravel with a paddle or pole. It is better that the water should flow in from the bottom and overflow at the top, but this is not absolutely necessary. The rubbing of the particles against each other scours them and rubs off the impurities which are carried away by the running water.

The coarse and fine sand are then separated from each other, as good as possible, and washed in a similar manner as was the gravel. In the washing of the sand and gravel there is always some loss, because the running water will carry away some of the sand; the greatest loss occurs in washing the fine sand as this is more easily carried away. This loss must be made up with fresh material. Finally the cloth is taken out and thoroughly washed.

After washing, the cloth, sand and gravel they are put back into the tank in the same order that they originally were, when the filter is again ready for use.

The disadvantage of such a home-made filter is the trouble in having to wash the sand, cloth and gravel, and the replacing of them in the filter.

There are patent filters on the market, which reduce this trouble to a minimum; they are known as self washing filters. The sand or filtering material is then washed in the filter itself, and all the work that is required by the operator, is the opening and shutting off of certain valves. These patent filters are simple in construction and operation, and produce good results. They are built in various sizes in order to suit the various demands of a mill, again any number of these filters may in turn be connected to one main supply of filtered water in the mill. The filtering material in these patent filters is sand, the same as in the specimen filter previously described.

These filters consist of large tanks of cast iron, or steel shells, supplied in their interior at the bottom with specially constructed brass strainers, which retain the sand and permit the filtered water to flow freely from the sand during filtration. Moreover these strainers are so constructed that when the filter is to be washed the strainers distribute the wash water equally through all parts of the bed.

Another important feature of these patent filters is that every operation of the filter can be controlled by valves. These controlling valves are so simple that the most ignorant workman can operate them, in fact some filters have only one controlling valve operated by a lever outside of the filter, the said lever pointing against a dial carrying five different readings viz: (1) cleaning filter; (2) filtering purpose; (3) by passes-cut out filter for passage of water, when for example no filtering is needed for a short time; (4) setting valve so that the first filtered water which naturally is dirty will run in the sewer, in place of the supply pipes for the mill; (5) closed—everything closed up, filter completely placed out of use, *i. e.*, temporarily not needed.

These patent filters have an ingenious device by means of which a solution of potash alum is fed drop by drop into the unfiltered water before it enters the filter.

The alum, as has been explained, coagulates the impurities in the water and collects the exceedingly fine particles into gelatinous masses which the sand retains; these fine particles would pass through the filter if alum was not used. The supply of alum solution can be regulated so that an excess of alum is avoided.

There is also a great saving of time, for ten to fifteen minutes is usually sufficient for cleaning the filter, moreover no time is wasted in refitting the filter, as it is ready for use immediately after washing. The first cost of such a filter is much larger than the cost of a specimen filter previously referred to, but saving of time, labor, and material (since there is no loss of material in cleaning the patent filters) makes the final cost of the patent filter less in the end.