ON THE EFFICIENCY OF POROUS PORCELAIN FILTERS.

LUCIUS PITKIN, PH. B.

The purification of water supplies by filtration is by no means a latter day invention. It is mentioned by Pliny as used in his time. Avicenna refers to it, and both of these authors speak of wool as the filtering agent. The variety of filtration apparatus, however, which we discuss to-night can claim a still higher antiquity in its essential features, for the ancient Egyptians used, not indeed porous porcelain, but the nearest approach possible to it, porous pottery, to improve the turbid waters of the Nile.

This was certainly before the germ theory of disease had been suggested, although a recent writer on the "Malarial Germ" notices that Lucretius—95 B.C.—had ascribed the fever of the Pontine Marshes to a micro-organism. Within the last fifty years about everything new in science has been hailed as a resurrection of the ideas of Lucretius, whether rightly or wrongly we will not here consider, but simply remark that the object in view in old systems of filtration was probably clarification alone. Since the proof, however, that some diseases are caused by micro-organisms and the possibility that these micro-organisms may obtain access to water supplies, and hence to the human system, the public have demanded more of a filter than simply a power of rendering turbid water bright. I have elsewhere said: "A filter is essentially a sieve, and the organisms that it must stop in their passage are in the neighborhood of $\frac{1}{25000}$ of an inch diameter. A filtering material sufficiently close grained, or tightly enough packed to prohibit their passage, must necessarily deliver water somewhat slowly in comparison to filtering surface. The fallacy of employing a little metal sphere a couple of inches in diameter, loosely packed with sponge or charcoal and screwed to a faucet, the water of which it will deliver almost as fast as it will flow is therefore apparent, and yet such filters have been and probably are now sold by the thousand.

If they claimed, as is their proper function, to catch simply the larger suspended matter and deliver the water freer from floating debris, we should have nothing to say against them; it would be at once seen that they were no better than the primitive plan of tying a small flannel bag to the faucet, which, indeed, is better since the bag is more readily cleaned than most of such filters when becoming clogged, and a prime essential of all filtration is that the filter should be kept clean since, if it is not, it may foul rather than purify the water."

The substances which have proven most efficacious in filtering, especially on a small scale, are all very close grained, as artificial porous stone, porous porcelain, compressed molded carbon, etc. To these I must add asbestos fibre, prepared as mentioned in this journal, Vol. 8, page 192.

I have not personally experimented with this micro-membrane, but the figures given by Mr. Stebbins place it high in the list. We are here especially speaking of what can be designated as permanent filtering strata, as opposed to temporary ones requiring frequent renewal.

The experiments of Dr. Frankland and others have shown that almost all granular bodies, as sand, powdered coke, etc., will, in strata of a few inches in depth, act as efficient filtering agents.

This power is, however, only temporary, as the shifting nature of the material allows the germs gradually to work through. Aside from the question of efficiency attention must be called to the advantage that a rigid permanent material possesses over one needing frequent renewal, in the matter of the attention required in refilling, etc. While some forms of filtration requiring renewal are well adapted to filtering on the enormous scale required for city supplies, I think I am justified in recommending the use of rigid porous materials as best for domestic filtration on a small scale, provided of course that the material is sufficiently close grained. Porous porcelain seems to possess exceptional advantages for filter construction since, from changes in its composition and in the mechanical condition of its constituents, it can be made of different densities and closeness of grain, while before baking it can be made into any shape that may be required. A form which has been recently introduced into this country consists of a tube of the unglazed porcelain of 1″ external diameter and 8″ length. When but a single tube is used this is surrounded by a cylinder of brass, glazed porcelain or any suitable substance with a bore sufficiently wide to allow an annular space of about $\frac{1}{8}$ inch between the two walls. It is easily seen that we have here a high proportion between the filtering surface and the size of the apparatus. The outer shell communicates directly with the faucet, which makes the filtration proceed from the outside of the tube to the interior, and thus allows of a more easy cleaning than where the direction of the current is in the reverse order. The walls of the tube being vertical also allows of much of the debris falling to the bottom, and thus aids in keeping the upper part of the tube in a condition for rapid filtration.

When it is desired to filter more water than the capacity of a single tube will permit of we have only to increase the diameter of the outer shell, and put within it from 3 to 100 tubes instead of one.

A screw clamp with a washer confines the porcelain tube within the shell, so arranged however that the nozzle-shaped lower end of the tube, through which the filtered water runs, may protrude. It was on such a form of filtration apparatus that my experiments were made. The tests were made upon two varieties of tubes (that is, tubes made with porcelain of two different densities). The denser marked "B," the lighter "F," the walls of the filtering tube being of $\frac{1}{8}$″ thickness. My attention was first called to this form of apparatus by the "editor" of one of our monthlies, who was desirous of knowing whether the claims made in its behalf could be substantiated. The tubes tested were therefore picked by myself at random from the stock, and it is probable represent fairly the character of the article now offered the public.

The tests were made in the usual way now employed in biological water analysis, *i. e.*, cultivation in sterilized nutrient gelatine on sterilized plates, with all precautions taken to secure freedom from accidental contamination during the sowing and subsequent incubation. The nutrient gelatine was prepared mainly according to the formula given by Frankland, but in place of the one gramme of salt which he recommends 5 grammes were used to the litre.

When used in this proportion the culture medium seems better suited to germ growth than where less salt is employed. The tests were varied and some purposely made very severe, to determine not only their efficiency under ordinary conditions, but also if possible the limits of their action.

In one set of experiments water purposely polluted, and containing 24000 germs to a c.c. was employed. In another set tank water with a variable number of bacteria—1400 to 3800 per c.c. —was used.

The first series of tests were made upon a "B" filter and an "F" filter; the water, as before stated, was foul with sewage and contained an enormous number of germs. The impure water was kept filtering under a head of two feet for 8 hours per day; after using one day the water escaping from the filters was tested biologically with the following results:

Filter "B"	0 germs per c.cm.
Filter "F"	0 " " "
Unfiltered water	24000 " " "

After 21 days use—8 hours in 24—another series of determinations were made:

Filter "B"	0 germs per c.cm.
Filter "F"	1560 " " "
Unfiltered water	24000 " " "
Efficiency—"B"	100 per cent.
Efficiency—"F"	93 "

Under exceptionally severe testing, then, we see one of the filters exhibiting perfect filtration after 3 weeks running on diluted sewage, while the other is allowing about one germ in 15 to pass. There is, however, no necessity for leaving the filter so long without cleaning, as it can so easily be removed, cleaned and replaced. The second series of tests were made with tank water containing about $\frac{1}{10}$ as many bacteria as the fluid before used, and representing more nearly what the filter would be required to cope with in actual practice. For this series I employed four other "B" filters and a different "F" filter. They were all set up with a common water supply on October 13th, 1886. The head of water was four feet, and to expedite the process the water was allowed to filter day and night without interruption. The object of this series was to determine how many hours running under such conditions each filter would stand without recleansing, and still deliver germ-free water. Sowings were made on October 18th, after 5 days (120 hours), and all the four "B" filters and the "F" filter were delivering water absolutely germ free. Tests at the end of 10 days showed *two* of the "B's" and the "F" filter delivering water free from germs. While at the end of 15 days, 360 hours, *one* of the "B" filters and the "F" filter were giving perfect results. It would seem wise, therefore, to clean the filters once in about 5 days, since when germs commence to pass through in appreciable quantity, they soon cause the effluent water to be as rich in germ life as the unfiltered fluid. In this connection I may perhaps be allowed to state a theory, possibly not new, but which I have not as yet seen advanced in reference to the filtering process in rigid porous substance.' We have said that a filter is essentially a sieve, and so it is but with an important difference. An ordinary sieve of say 50 mesh will not allow powder of larger diameter than its holes to pass, and would not after a year's shaking—granted the powder has not been broken—any more readily than at the first moment. How is it that a filter of porous material will deliver water absolutely free from germs when used and cleaned properly, and yet with neglect will let the water pass with a minimum of improvement. With a shifting material, as sand, powdered coke, etc., we can readily see how the bacteria can penetrate; but, with a solid wall, why is their transit barred at first and afterwards permitted. But one explanation is, I think, possible, namely that the holes of the material are in many cases larger than the diameter of the germs, and the germs are prevented from going through, not by being stopped on the outside, but by being caught against the rough walls or in the winding of the passage, just as a log of wood on a stream 50 times its diameter will, if the stream is at all winding, soon run against shore and stick. But this cannot go on indefinitely. Soon the angles are filled in with germ life, the slime of the zooglea formation renders the walls more or less smooth and slippery, and when a germ runs against the wall and is itself stopped it may as likely detach another, previously stranded, which continues the journey. The difference in filtering power of a clean and uncleaned filter is thus easily explained. While with proper care such results as detailed above are easily obtainable, I would rather trust to unfiltered water than to the best filter systematically neglected. Since all by neglect accumulate organic debris, which acts as a breeding ground for germs, which can afterwards pass through in the manner outlined above; which word of caution will not I trust deter any from using a suitable filter, but simply emphasize the fact that when one is used common sense requires that it should be kept in working order.

ON THE SOLUBILITY OF ALUMINA RESIDUES FROM BAKING POWDER IN GASTRIC JUICE.

By Lucius Pitkin, Ph. B.

During the month of December, 1886, I was called upon to make some experiments to determine the solubility of the alumina residues, left in bread or biscuit after the use of an alum baking powder, in the process of digestion. This paper is a resume of my experiments upon two of the factors in digestive action, namely, the saliva and the gastric juice. It does not pretend to give any figure as to complete digestive action; it is, however, I think, reasonably accurate in regard to stomachic digestion, which is an important factor (probably the most important) in the whole process.

The special class of alum powders to which my experiments directly refer are those in which acid phosphate of lime is used, in connection with burnt alum, to liberate the carbonic acid of the bicarbonate of soda. It is to this class that, as I am informed, the majority of the alum powders of to-day belong; but the experiments while made with such a powder may also throw some light on other alum powders leaving similar residues.

The proportions used by me in making the powder to be tested were as follows: