XVIII.—THE PURIFICATION OF REFUSE WATER.

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[Translated by Herman Jacobson.]

It is of great importance, not only for hygiene, but also for pisciculture and agriculture, that this whole matter should be more fully investigated, both theoretically and practically, in order to gain and diffuse knowledge.

I have on a former occasion published a treatise on this subject in this journal (vol. 209, p. 1), but, urged from many sides, I will not hesitate to reproduce, part of this treatise, embodying all the recent discoveries.

It is an undoubted fact that refuse of various kinds is in a reckless manner thrown into public waters, thus doing injury to public health and depriving agriculture of valuable fertilizing matter, and finally depopulating brooks and rivers of fish, which form so valuable an article of food.

The objection that this had been so from time immemorial does not hold good; no bad habit like this could ever be justified even by the usage of ages. Not even old-established manufactures can claim such a privilege, because the progress of industry, based on the progress of chemistry, has taught us to make use of a number of hurtful and unhealthy substances whose refuse flows into public waters. Any such privilege, very questionable in itself, cannot possibly include innovations of every kind which were formerly quite unknown.

Every man ought to be held responsible for any injury to public interests caused by his business.

Since the above principle is often carried out very rigorously with regard to street-cleaning, &c., why should this not be done with regard to public water in brooks, rivers, and ponds? If changes in any branch of industry, even if these changes only mean an enlargement of the business, involve hurtful influences, it can justly be demanded that such influences should be neutralized.

Chemistry is not only one of the strongest levers of modern industry, but it certainly falls within its province to remedy all injuries to public property caused by industry. Chemical knowledge should not only be utilized in a one-sided manner for the benefit of various industries, but

* *Reinigung des Abfallwassers.* Von E. Reichardt in Jena. Archiv der Pharmacie, vol. xii, Halle, 1879.

it should also strive to utilize all refuse matter in as complete and satisfactory a manner as possible.

It is a fact which can be observed everywhere that nature utilizes refuse matter of different kinds in such a manner as not to injure deeper-lying springs, that is, the upper layers of soil or rock absorb the refuse, either changing its character or forcing it to enter other combinations, so that in both cases the lower strata receive but very little of it. This purifying process, which is going on on an extensive scale, is both of a mechanical and chemical nature, and presents the best and simplest starting-point for discussing this whole question.

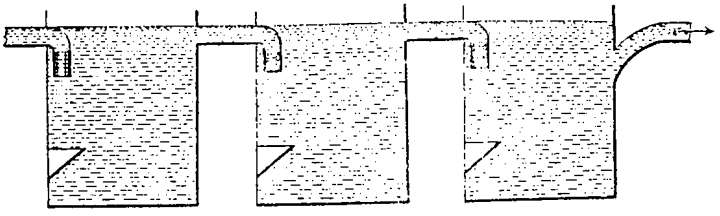
PURIFICATION OF WATER BY REPOSE.

The success of this purifying process is very clearly demonstrated by the glacier water flowing from lake to lake. In a turbid and milky condition the icy water leaves the mountains on its way to the plain, till it enters a lake often of very considerable depth and extent. Although the same quantity of water leaves the lake to continue its journey towards the plain, it comes out as clear as crystal, whilst long banks of clay or sand gradually mark the entrance of the turbid glacier water. The same observation may be made in rivers. A strong current carries all the floating particles of clay and sand far down the river, while a sluggish current allows them to gather in the bed of the river or on its banks, thus purifying the turbid waters. An attentive observer may watch the same process in every brook; wherever an indentation of the bank delays the rapid flow of the water, numerous particles of mud will gather, and many substances injurious to the life of fish are in this way removed from the water. This natural process of purifying flowing water by allowing it to enter a condition of repose can easily be imitated in an artificial way, and should be adopted wherever turbid water enters brooks and rivers.

This is particularly the case in the neighborhood of mines, quarries, factories, for instance, beet-sugar factories, &c. It will suffice in every case to construct so-called "mud-catchers"—ponds through which the turbid water is led. If the water, as is often the case in mines, flows out with the strength of small brooks, 2 to 3 ponds should be constructed, one by the side of the other, regulating their depth according to the quantity of impure matter in the water. It will also be well to cultivate in these ponds aquatic or floating plants or reeds, and to plant willows on their banks, as such vegetation aids the purifying process in more ways than one. I have often observed that by simply following these rules a single pond proved sufficient to purify completely the turbid water flowing from a mine. In such a pond hardy fish, and even carps, were raised.

From time to time the pond would yield a great quantity of mud, which, when taken out during the cleaning of the pond, proved a valuable fertilizer.

If the flow of turbid water is not very strong it will be sufficient to dig deep water-tight pits, 2 or 3, close together, as shown in the following diagram:



These pits, which should be lined with brick and be cemented or made water-tight by clay, receive the turbid water through drain pipes (of terra cotta) which bend towards the bottom of the pit. The flow of water, however, is broken by a stone projecting from the side of the pit, so that below this stone the water is in repose. The pipe through which the water leaves the last pit is bent upward, so that any particles floating on the water, such as oil, &c., may remain in the pit, from which they are removed from time to time, and are in this way prevented from entering the public water-courses. Such floating particles are specially injurious to fish, because they are in the habit of collecting anything floating in the water; tar, petroleum, &c., may thus prove poisonous.

By repeated personal observations I have become convinced that even lighter organic matter floating in the refuse water has settled at the bottom, and that from the third, or even from the second pit, the water flowed out perfectly pure and clear.

PURIFICATION OF WATER BY CHEMICAL PROCESS.

This method of purifying water will, of course, be influenced by general or local conditions.

In the first place it should be unlawful to introduce any hurtful matter into public waters; and it would be very desirable if the recently appointed inspectors of manufactures were to give some attention to this question of refuse. As soon as there is a doubtful case, it should be submitted to competent chemists or health-officers, making, if necessary, a last appeal to the imperial health officer. German manufactures are but too frequently carried on in a one-sided manner, excluding the chemist who is often the only person capable of giving information or rendering aid, especially as regards the greatest possible utilization of all manner of refuse.

Such utilization is often prevented by the ignorance of manufacturers, who, though well versed in everything pertaining to their special branch of industry, avoid anything which does not seem to come within their immediate province. It is therefore the duty of the government to take this matter in hand by diffusing information and making regulations.

Even large factories simply lead the refuse of soap from the washing

of wool, &c., into the nearest river. Such a thing could not happen in England, where experience has taught people to utilize such refuse for the manufacture of soap or gas, &c. It is therefore as great an advantage to industry as to the purification of the water not to let soapy water flow into public water-courses.

It may justly be demanded of every manufacturer who uses large quantities of water that he should purify the refuse water, and allow only such water to flow into the river or brook which cannot do any harm. The water used in working machinery should be kept apart from water which in cleaning dyed substances absorbs the superfluous coloring matter; this last-mentioned water should be purified, while the former may safely be allowed to flow into the river.

It will also be advisable to see to it that not unnecessarily large quantities of water are made impure; this will be comparatively easy, as a great deal of water may be saved by the modern improvements of our machinery.

In the above I have, of course, only given hints, which will have to be specially adapted to every individual case, and which will only be appreciated by competent persons. Here is another field of usefulness for our inspectors of manufactures.

No manufacturer should allow refuse water containing free acid or free alkali to flow into public water-courses; such strong chemical substances should at any rate first be changed to salts, which are far less injurious. Lye may mostly be used again, especially if the first strong lye is at once employed.

The simplest, cheapest, and very generally used purifier is lime, employed either as quicklime or chalk. Nature employs lime and magnesia as purifiers of the soil. Organic substances combine with them; water containing iron loses it; and thus water penetrating the surface soon becomes pure, containing only particles of the stratum through which it has passed. The purifying effect of lime is still further heightened by the circumstance that a large number of coloring substances enter into insoluble combinations, not only with lime, but also with carbonated lime. These combinations have long since been employed in the manufacture of coloring substances. The effect of the lime does by no means reach its end by its chemical combination with acids, but is continued when the lime has assumed the form of carbonated lime. Lime is, therefore, the most effective purifier of all those waters which contain coloring matter. Lime likewise enters into insoluble combinations with albuminous substances, and therefore removes those substances which chiefly cause putrefaction. Alum is frequently employed with the lime, but its addition should be entirely regulated by the local demand.

Lime is used in the same kind of pits as mentioned above. The burnt lime is placed in the first pit. As soon as the pit is filled with refuse water it is stirred a few times, and the water will become clear in a very short time, so that it frequently enters the second pit with but very

little coloring or impure matter. The water flowing from the third pit is generally so pure that it contains nothing but the superfluous lime and the soluble salts formed by it.

The quantity of superflous lime is generally very small, as lime only dissolves in 500 parts of water; but it might nevertheless, prove injurious to the fish. It is therefore necessary *to lead off the water in open ditches*, as lime very quickly becomes impregnated with carbonic acid from its immediate surroundings or from the air; the carbonated lime is then separated, as well as the last remnants of coloring matter. The water which has passed through these ditches will thus enter the river in a perfectly pure condition, and it is not even necessary to let it flow through such open ditches for any considerable distance. It has also been proposed to let the pipe through which the water finally flows into the river open from below, about the middle of the bottom, so that the refuse water might immediately mingle with a great quantity of river water, and thus be deprived of anything of an injurious character which might have remained in it.

In most cases, however, the application of lime is sufficient to purify the water. In my former treatise on this subject I have entered into details, and will here only mention a few instances of purifying water. Soapy or fatty matter will generally be separated from the water by lime. These, however, are special cases, which were mentioned in my former treatise in order to show the value of the method. These lime deposits form very valuable fertilizers, so that, according to observations made in England, the expenses of this purifying process are fully covered. The whole arrangement is not at all expensive, and if once introduced it only requires a little attention to make it pay. Two pits are frequently sufficient to purify the water.

In Saxony the government ordered an investigation* to ascertain the number of complaints of water having been made impure by refuse. In 1877 complaints were made in 140 places and traced to 273 sources. Half of all these cases were traced to the weaving industries, especially dyeing, bleaching, and wool-weaving; 9 per cent. to the manufacture of paper; 8 per cent. to the manufacture of leather; 8 per cent. to mining industries; 6 per cent. to the manufacture of articles of food; 2 per cent. to the manufacture of chemicals. Of the 626 breweries in Saxony only 6 were accused of rendering public water-courses impure.

I found that many brewers have introduced purifying pits in connection with their establishments, and have worked them very successfully, as the mud obtained from these pits forms a most valuable fertilizer. In one case I was enabled to get a better insight into this question and to render aid.

A large brewery was accused of making the water in a large neighboring pond so impure by refuse water that it began to putrefy, thus causing considerable damage to the pond and annoyance to the people living near it. A chemical analysis of some of the most turbid refuse

* GÜNTHER, "*Berliner Klinische Wochenschrift*," 1879, No. 8.

water from this brewery showed large quantities of albuminous matter, in fact substances containing nitrogen, and the search for organic substances showed 1,000 parts in 100,000 parts of water, that is, 1 per cent. The purifying arrangement, containing two pits, which has now been introduced into this brewery lets the water from the second pit run out as clear as spring water, containing only faint traces of nitrogen and only 5 parts organic substances in 100,000 parts of water; in fact, the composition of the refuse water differed but little from that of the original water employed in the brewery; all that could be noticed was a slight increase in the quantity of lime. The water after having been thus purified entered the pond at no great distance from the brewery.

If we compare the experience of this and other countries with the actual condition in manufacturing districts located on small streams and rivers, it cannot be denied that so far little or nothing has been done to prevent public waters from being rendered impure. The above-mentioned cases where water has been artificially purified are entirely isolated, although the above-described purifying apparatus is neither expensive nor difficult to keep in order.

It must be acknowledged that even in Germany more and more attention is paid to the depopulation of the fishing waters, so that in many places suitable regulations regarding the fishing-season have been introduced either permanently or temporarily. But one of the greatest evils has so far been almost entirely ignored, and this is the impure water of many streams and rivers, rendered so by many different kinds of refuse, whose utilization as fertilizers or for industrial purposes is urgently demanded in the interest of economy. It will, perhaps, be difficult to make rules which would apply in every case; but so far nothing has been done to remedy this evil, and it is to be hoped that soon we shall have suitable legislation on this question.

The basis for such legislation will be found in the following points:

No impure or hurtful matter of any kind shall be allowed to enter any public water.

In the different industries the impure water, properly so called, shall be separated from simple refuse water, and the former shall undergo a purifying process of either a mechanical or chemical character.

Both methods should be under the superintendence of the health-officers; investigations are to be caused and directed by the inspectors of factories.

The washing of colored substances in public waters shall be prohibited, as it can be done by suitable machinery in a much more efficient manner; the refuse water should, however, be subjected to a further purifying process.

In most cases it will suffice to use lime for this process, and the sediments should, if possible, be utilized in some manner.

The refuse materials from privies should never be thrown into public water, as they possess a considerable value as fertilizers, and can be much more suitably employed for such purposes.