XIII.—THE POLLUTION OF PUBLIC WATERS BY REFUSE FROM FACTORIES.

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Our modern industry, which is steadily progressing from year to year, needs, above everything else, water, and its use is keeping step with the growth of industry. Rivers and brooks are the principal sources of supply, and they again receive the water, after it has been used, in an impure condition, either direct or indirect.

Water which has been used by factories is generally warm and contains numerous particles of refuse, *e. g.*, coloring matter, lime, alkaline salts in various combinations, remnants of plants, slime, &c. It will be evident that large quantities of such refuse will pollute rivers and brooks to such a degree as to render pisciculture impossible and to make the water unfit to be used for drinking by either man or beast.

Phenomena of this kind have been observed in all industrial districts; brooks and rivers have lost the fish which formerly were numerous, the water has become turbid, and during the warm season the air is filled with miasmatic effluvia which are both disagreeable and unhealthy.

An investigation of our smaller rivers and brooks would furnish incontrovertible proof of the growth and magnitude of the evil, and show the necessity of immediate relief.

The complaints concerning the refuse water from factories are growing louder and more numerous from year to year and cause many lawsuits.

In fighting this pollution of our waters the authorities have nothing to back them but the law regarding private waters of February 28, 1843, where it says: "The water used in dyeing, tanning, fulling, and similar establishments shall not be let into a river, if thereby the amount of pure water is diminished or the public is seriously inconvenienced."

Although this paragraph can be construed in various ways, it cannot, even if it is strictly carried out, remove the evil, for it is exceedingly difficult to furnish the necessary evidence, as is proved by the many wearisome and disagreeable lawsuits which have been engaged in on account of this very paragraph. Even if the lawsuit is decided in

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favor of the plaintiff, the only result is that a fine is imposed, the cause of the trouble remaining just the same as before. This law is frequently used for no other purpose but to extort money from the manufacturers, and I know several cases from the province of Saxony where millers and others entitled to the use of water-power have appealed to this law simply for the purpose of obtaining some money. It is self-evident that such a law is of no benefit to the general public, and that it cannot prevent the pollution of public and private waters.

My object in this article is to show that many industries may, without any detriment to themselves, diminish their consumption of water very considerably, and that it will even be to their *own advantage* to entirely avoid the pollution of public and private waters. Among these industries I include sugar refineries, starch factories, distilleries, breweries and malt-houses whose refuse-water is strongly impregnated with organic matter and causes most of the complaints.

The manufacture of beet-sugar, with which I have been familiar for many years, shall form the subject of a special investigation. This important industry, probably the most important of our agricultural industries, has, thanks to a sensible protective tariff and a rational system of taxation, developed from very small beginnings to its present vast extent.

This important industry certainly deserves to be protected in the interest of the national finances and agriculture; but it cannot be denied that this growing industry is the very one which contributes the largest share to the pollution of our brooks and rivers, particularly as it consumes an enormous amount of water.

It will be easily understood, therefore, why the complaints from the beet-sugar manufacturing districts are so numerous and well founded, and every impartial witness will have to concede that the brooks and rivers of those districts produce a very disagreeable impression not only on the eyes, but also on the olfactory organs. Such polluted brooks and rivers are, of course, entirely unfit for fish; but, what is worse, their water cannot be used for drinking and for agricultural purposes.

I will only mention the Bode, Selke, Haltemme, Aller, &c., and the brooks flowing into these rivers, as well as the Bruchgraben, near Oschersleben.

The consumption of water by a beet-sugar factory worked on the principle of diffusion shows the following per centage on the weight of the beets:

	Per cent.
Washing the beets	50
Production of juice	222
Condensation	1,02
Generating steam	150
Purifying through carbonized bones	50
Refining	25
	1,519

A sugar factory using every day 400,000 pounds of beets and working for 20 hours will, therefore, consume the following quantity of water per minute:

	Liters.		Cubic feet.
Washing the beets	83.33	=	2.7
Production of juice	370.00	=	12.0
Condensation	1,703.33	=	55.0
Generating steam	250.00	=	8.1
Purifying through carbonized bones	83.33	=	2.7
Refining	41.66	=	1.35
Total per minute	2,531.00	=	81.85

A factory using anually 7,000,000,000 pounds of beets will therefore consume the enormous quantity of 1,435,000 cubic feet of water. This mass of water is taken either directly or indirectly from public brooks and rivers, and after having been used is returned to them in slightly diminished quantity, but having a temperature of some 40° Réaumur, and containing organic matter and alkalies of every kind.

The high temperature favors the disintegration of organic matter, produces fermentation, causes the formation of algæ and fungi, becomes fatal to animal life, and fills the air with miasmatic effluvia.

It is possible, however, without any detriment to the beet-sugar industry, to diminish the consumption of water by one-half, as has been tried very successfully in factories where water was scarce.

This saving of water is accomplished by—

1. Working the diffusing apparatus by compressed air instead of water. By this means (always supposing a daily consumption of 400,000 pounds of beets) 191 liters, or 6.66 cubic feet of water are saved every minute.

2. By using for washing, generating of steam, and refining the condensed water from the two boilers, and thus saving 375 liters = 12.15 cubic feet.

3. By regaining two-thirds of the condensed water from the boilers, and by cooling the water to the temperature of the air by means of a suitable apparatus, 1,135.5 liters, or 36.6 cubic feet of water are saved.

The total saving per minute is, therefore, 1,205 liters; *i. e.*, one-half of the quantity consumed. Practically, the saving may be less, but certainly not less than one-fourth of the quantity consumed, *i. e.*, 600 liters per minute.

It is evident, therefore, that it would be a great gain if all beet-sugar factories could be compelled by law to introduce the saving system. There could certainly be no objection to this, if we consider that many factories have to follow this system, simply because they have not enough water.

"Polluted waters," properly so called, must be carefully separated

from the condensed water which is to be used again. These "polluted waters" may be classified as follows:

1. The water used in washing the beets, containing small particles of soil, leaves, and pieces of beet.

2. The water flowing off from the beets after they are cut, containing many slimy particles.

3. The water coming from the purifying process through carbonized bones, containing salts of every imaginable kind, lime containing phosphoric acid, combinations of ammonia, &c.

4. The condensed water from the first boiler, containing a good deal of ammonia. This water may, of course, be used for washing beets, only it must not pass through the purifying apparatus.

5. The so-called "purifying water," which is thoroughly saturated with lime, sugar, dirt, &c.

These polluted waters must be led into large basins, large enough to give the water time to become clear and pass through a process of fermentation, by which the insoluble organic particles sink to the bottom.

If the water-saving system has been introduced, a factory working 400,000 pounds of beets per day needs only six connected basins about 10 meters long, 2 meters broad, and 1½ meters deep. These basins may be simple earth-pits without any plastering.

All sugar factories already possess similar basins, but they are all too small and arranged in an impracticable manner, so as not to allow the water sufficient time for becoming clear and for fermenting. The first expense is considerable, but the interest and amortization is fully covered by the amount of manure thus gained. The water flowing out of these basins is somewhat turbid, and must not be allowed to enter the brooks and rivers, as is mostly done now, but should be led over fields and meadows, and, after having thus been filtered, flow into the public waters.

The sugar manufacturers fear that similar legal restrictions will prove detrimental to their industry, and that the burdens which they would have to bear in the interest of the general public would prove too heavy. But this idea is erroneous, for the irrigation with refuse water would prove a great advantage to the factories.

A factory using 400,000 pounds of beets per day has enough refuse water to irrigate an area of 20 hectares. Such an area would produce 20,000 to 30,000 pounds of the best hay, and would therefore represent a value of 750 mark=$178.50. The irrigation is by no means confined to the immediate neighborhood of the factory, for by means of a steam-pump and pipes the refuse water can easily be led to the most suitable place. Such an apparatus would not be as expensive as might appear at first sight, as the necessary steam-power would already be found in the factory itself. The cost of an irrigated area at a distance of 2 kilometers from the factory would, according to a very careful estimate, only

be about 30,000 mark = $7,140. This sum would be distributed as follows:

For pipes	$4,760 00
For steam-pump	952 00
For draining and grading 20 hectares	1,428 00
	7,140 00

Subtract from this 5 per cent. interest, 2 per cent. amortization = 7 per cent. per annum	$476 00
Rent of 20 hectares, at $42.84 per hectare	856 80
Cutting the grass	285 60
Repairs	285 60
Superintendence	238 00
Total per annum	2,142 00
Value of harvest, at $172.50 per hectare	3,450 00
Net gain	1,308 00

In making this calculation we have not taken into account the great advantage of having a large quantity of good hay, which is much needed in all sugar factories. The manufacturer, who is generally a farmer, can give his cattle larger quantities of better hay than hitherto; the cattle will enjoy better health, and he will have more animal manure, thus saving the expense for artificial fertilizers. Those factories which are worked by a joint-stock company could then give a meadow-area to each one of the stockholders in proportion to the amount of stock held by them.

The well-known civil engineer, A. Elsasser, formerly of Loburg, now of Magdeburg, has most successfully introduced a filtering apparatus for the refuse water in the sugar factory at Roitsch (province of Saxony), and any one interested in this question may there convince himself that the water becomes perfectly clear and odorless. The apparatus at Roitsch, however, is too small, and with the same amount of water twice the area could be irrigated.

Mr. Elsasser wants, for successful irrigation, a very level ground with tolerably loose soil, so the fluid parts of the manure may be evenly distributed. The area which is to be irrigated should be drained at the depth of about one meter; the drain-pipes should lie close together, and be so arranged that the water may flow off easily. The chemical substances contained in the refuse water should penetrate the soil only to a compartively small depth, in order to let the further disintegration take place under the cover of the soil, so that the nutritious matter which has assumed a gaseous form may be assimilated by the soil, and thus find its way into the roots of plants. In this manner the soil is always ready to receive

new refuse water. Mr. Elsasser, whilst living at Loburg, has very successfully made 250 hectares of artificial meadows which are irrigated with refuse water from several starch factories. In the potato-starch factories, mostly located on light soil, the advantage of irrigating with potato-refuse water is very evident, for formerly it flowed into brooks and rivers and made the water unfit for fish. Whenever a new starch factory is started intelligent farmers in the first place look to the possibility of irrigating their meadows with the refuse water, and of thus gaining a hitherto unknown wealth of good hay, and the gain from the factory itself only seems a secondary consideration. The best and most surprising specimen of what may be accomplished by constant irrigation with potato-refuse water may be seen at Knoblauchshof, near Loburg, the property of Counsellor Friedrich Knoblauch, of Magdeburg. Here may be seen the largest starch factory in Germany, and by the system of irrigation with potato-refuse water 50 hectares of entirely unproductive land have been transformed into magnificent meadows, yielding 25,000 pounds of the very best hay per hectare. The plans for this establishment have all been made by Mr. Elsasser.

Distilleries, malt-houses, and breweries may of course use their refuse water in the same profitable manner; the area to be irrigated need not be very large, but the expense of making the necessary arrangements will be amply repaid.

After carefully examining this whole question in all its bearings, I have arrived at the conviction that there will be no risk whatever if the government were to prohibit all factories from letting their refuse water flow into public waters in an unfiltered condition. A period of two to three years should be granted for making the necessary changes, and by appointing a commission of competent men the factories should in every possible way be assisted in the work.

Cities and villages should be absolutely prohibited from making rivers and brooks the receptacles of all the filth from their sewers. All exertions to revive our fisheries will be in vain if we cannot give the fish what they need above everything else, viz, pure, wholesome water. It must also be taken into consideration that as matters stand at present an enormous amount of valuable manure is absolutely lost in the refuse water from our factories. If the system of irrigation by refuse water from the factories and the sewers of cities could be generally introduced, our farmers would not only save a good deal of money which is now spent in buying artificial fertilizers, but they would also (more than by protective tariffs) be enabled to successfully compete with the agricultural products of foreign countries.

It is to be hoped that when our legislators—as will be the case at no distant date—take up the important subject of the pollution of public waters by refuse water, they will properly consider all the above-mentioned points.