XIX.—THE INJURIOUS INFLUENCE ON PISCICULTURE OF THE RETTING* WATER OF FLAX AND HEMP.†

By E. REICHARDT.

The question of the injurious character of the refuse water from the retting of flax is still an open one, inasmuch as opinions differ widely. Flax and hemp retting aims at a partial decomposition of the vegetable substances, during which process especially the outer parts of the plant (the bark or rind) soon become brittle, whilst the inner (glutinous or easily solvable) vegetable substances begin to ferment, whereby decomposition is furthered, but which, however, must not extend to the firm tissue of the plant. This tissue offers stronger resistance to the process of decomposition; but the action of the so-called retting process must be interrupted, as soon as repeated tests show that the outer (brittle) parts can be removed by simple rubbing, and that there is danger of the inner (firm) tissue being torn asunder. To continue the retting process any longer would injure the fibers of the tissue by likewise rendering these brittle and tender, and would therefore frustrate the object in view.

Retting is carried on differently in different parts of the country, either by the *dry* or by the *moist method*. If the *dry method* is employed, the plants, after having been pulled, are in the beginning of autumn spread over the empty fields and exposed to the alternating atmospheric influences of moisture and heat, to the dew of the night and the glaring rays of the sun by day, these natural influences being artificially assisted by occasionally sprinkling the plants with water. Whatever substances are dissolved and withdrawn from the plants assimilate with the soil on which they lie, and the whole process may be termed *decay*.

In the *moist method* of retting, the plants are soaked in water which is stagnant, or which is agitated as little as possible. Stones are placed on the bundles of flax or hemp, in order to keep them under water, and the process of *putrefaction* very soon commences, and is indicated by the solution of various vegetable substances, which imparts a dark color to

* [The literal meaning of the German verb "*rösten*," "*to ret*," is retained in the translation. The word is exclusively applied to the process of heating and fermentation produced in flax and hemp by laying these plants, after being cut, either on the fields, exposed to the dew and the sun, or in water.—EDITOR.]

† *Mittheilungen zur Gesundheitspflege. Von E. Reichardt in Jena. Schädliche Wirkung des Röstwassers von Flachs und Hanf für die Fischzucht. Archiv der Pharmacie*, vol. 219, part 1, Halle, 1881.—Translated by HERMAN JACOBSON.

the water; and by the development of gases, whose presence may be perceived by the smell. As soon as the necessary degree of brittleness has been reached, the plants are taken out of the water and dried in the air, during which process these decaying vegetable substances fill the entire neighborhood with miasmatic exhalations to such a degree as to cause animals to refuse to pass by. The impure water is frequently poured into the nearest running water, and the sanitary authorities have in most cases vigorously opposed this method.

The Thüringian Fishery Association therefore passed a resolution at its last annual meeting to cause an investigation of the disputed question of the injurious character of this retting water, and commissioned me to conduct this investigation. This fact had hardly been mentioned by several of our papers when I received from Chief Forester Mr. Wilke, of Waltershausen, a report on the subject, which he voluntarily placed at my disposal, portions of which I shall, with his consent, embody in this article, as communications of this kind are exceedingly acceptable in giving a practical insight into the matter.

Mr. Wilke was for a considerable time stationed near the River *Nesse*, along the banks of which flax is cultivated on a large scale, and where the moist method of retting is universally employed. Mr. Wilke says:

"Although it is prohibited by law to ret flax in rivers, I have every year seen large masses of flax, both in the bed of the *Nesse* and more especially in its small tributaries, where the water has been dammed for the purpose of retting flax. In these tributaries pestiferous pools are created. When such pools have been used for retting for any length of time, they are opened, and the whole mass of foul and putrid water is emptied into the river, and every living being coming within its reach is doomed.

"As soon as the retting of the flax commences, the water begins to assume a brownish color and to emit an offensive odor. This color and odor increase in intensity from day to day, till the water has the color of coffee, and the odor becomes so repulsive that I have often gone one-half league out of my way so as not to be obliged to pass near such water, especially in the morning and evening. The drier and warmer the temperature the more intense will be the odor and the infection of the water.

"Whenever the water has attained a certain degree of putridity all the fish will strive to reach the bank, gasping for air, and in such a state of torpor that they can easily be caught with the hand. If they do not speedily get fresh, pure water, they die, and remain lying on the bank, where they serve as food for birds, or are caught in the grates of mills, from which they are gathered, only to be thrown away.

"At one station I have known years when fish of all kinds were picked off the mill-grates by the hundred weight, some dead and some alive. The dead fish were immediately thrown away, and the live ones

were eaten. I myself once partook of such fish, which had been allowed to lie in fresh water for several hours before they were killed. But even after they were cooked they still smelled and tasted of the retting water, and all who ate of this dish felt the bad consequences.

"The inhaling of this pestiferous air for weeks and weeks certainly requires the attention of the health authorities.

"Mortification of the spleen, which is so frequent in the valley of the *Nesse* among sheep, cattle, and hogs, and which is exceedingly contagious, is quite probably produced by the drinking of retting water."

The above valuable communication by Mr. Wilke directs attention to the injurious influence of retting water on public health, and very justly, for we know now that putrefying substances are most effective in spreading contagious diseases. I have personally convinced myself of the very disagreeable impurities with which the air is tainted by the retting of flax, and which became especially noticeable during the slow drying process of the decaying flax.

In order to subject this matter to chemical tests, I obtained a considerable quantity of retting water, which, however, was tolerably clear and odorless, so that it could hardly possess many injurious qualities. These are not developed till the last stage of decomposition. Experiments made on a large scale to obtain vegetable poisons from this water led to no result. This determined me to obtain fresh flax-plants and, on a small scale, to go through the whole retting process.

For this purpose I laid a bunch of flax in water; after a few days gases began to develop, the water began to assume a brownish color, and finally complete decay set in, accompanied by the development of offensive gases, &c. As soon as the flax had reached this stage of decomposition, and the fiber could easily be separated from the outer (brittle) portions of the plant, I made the following experiments:

1.—WITH LIVE FISH.

In these experiments I used both kinds of whiting, such as are found in the river Saale, and which on the whole are an exceedingly tender fish, and bastard carp, weighing about 3-500 grams. The last-mentioned kind of fish is better able to stand a change of water. These fish had been living in running water of a temperature of 7° to 9° C., which is the usual temperature of water in spring time. In these experiments I therefore endeavored to keep the water at exactly the same temperature as that from which the fish had been taken. Some of the fish were put aside in the water in which they had been living, and some were placed in water mixed with retting water. In the fresh water the fish kept for several days without undergoing any change, so that they could again be transferred to the running water. The retting water was obtained by soaking flax for five days.

One part retting water and three parts running water mixed.—The fish placed in this water immediately showed signs of uneasiness, gasped un-

interruptedly for air, and were found dead the next morning. The experiment had commenced towards evening of the preceding day.

The second experiment, made the following day in exactly the same manner, led to exactly the same result. The fish died within three hours.

One of the large bastard carp lived in this mixture of fresh water and retting water for two days, but soon began to lose its color, gradually grew weaker, and, although again placed in running water, died after eight days.

One part retting water and nine parts running water mixed.—The fish immediately began to be sick, showing this by their motions and their gasping for air; lived for twenty-four hours in the mixture, and began to recover when again placed in fresh running water, but finally died after a few days.

One part retting water and two parts running water.—Small fish died very soon. A large bastard carp kept alive for one and three-fourths days, but was on the point of death when at that period again transferred to pure running water, from which time it began to recover, but only to die within two weeks.

Retting water fourteen days old.—In a mixture of one part of this retting water and four parts fresh water the fish died after one and one-half days.

The same retting water three weeks old.—Fish placed in it (one part retting water and four parts fresh water) grew sick immediately, gasped for air and changed their color, but managed to keep alive for several days, so that they could again be transferred to fresh running water.

As all these experiments led to the same expected result, they were brought to a close. The conclusion was as follows:

Retting water, when in a putrid condition, kills fish within a few hours, even when mixed with three to four parts of running water which is otherwise well adapted to pisciculture. When mixed with a larger proportion of fresh water the fish can stand it better, but are nevertheless considerably injured.

Retting water which is allowed to stand for some time, and which thereby loses its strongly putrid character, does not therefore hurt the fish so much.

These experiments fully corroborate the facts observed in rivers on a larger scale. Wherever actually putrid retting water mingles with pure water, a poisonous juice, which is positively injurious to fish, exists in the water, and shows its destructive character in proportion to the degree of putrefaction and its quantity.

I was not able to obtain water in which hemp had been retted; in such water one might have looked for positive vegetable poisons, as such substances have been shown to exist in hemp. Repeated experiments with water in which I had laid hemp and allowed it to putrefy did not show any substances of an alkaloid or acid nature in the water. The

usual offensive decaying process took place, developing substances whose composition is well known. My attention was, therefore, directed to the gaseous matter developed during the process of decomposition, and as these gases withdraw the oxygen from the water they are highly injurious to the life of fish.

II.—TO DETERMINE THE GASES.

Frequent experiments as to the gases contained in spring and running water (see this Journal, vol. 202, p. 238) showed the proportion found by Regnault, Bunsen, and others, viz, oxygen and nitrogen as 1 : 2, whilst the proportion of oxygen to nitrogen in the air is 1 : 4; *i. e.*, the solution of these two gases in water corresponds to these fully established proportions.

In 1,000 cubic centimeters of water taken from the river Saale during spring (see this Journal, vol. 206, p. 206) I found 30 to 31 cubic centimeters gas; these contained, at a temperature of 3° C., 6.2 per cent. carbonic acid; this percentage rose, when the temperature of the room grew warmer, to 16.5, without any noticeable change in the total quantity of the gas. One experiment showed that the water of the river Saale, at a temperature of 3° C., contained one part oxygen to 4.78 parts nitrogen, whilst a second experiment showed the proportion of these two gases to be 1 : 1.91. After the water had become somewhat warmer in the room the proportion was 1 part oxygen to 2.2 parts nitrogen; therefore the same as the one given above.

Water in which hemp had been retted, and which had attained a considerable degree of putridity, was found to contain in 554.3 cubic centimeters of water, 35.5 cubic centimeters gases, which might be expelled by boiling; this would make about 64 cubic centimeters gases in 1,000 cubic centimeters water. Calculating the percentage I obtained the following result:

Oxygen	4. 2 = 1
Nitrogen	29. 9 = 7. 0
Carbonic acid	65. 9
	100. 0

While river water mixed correspondingly shows a proportion of 1 : 2, this mixture shows a proportion of 1 : 7.

Carbureted-hydrogen gas, hydrogen or carbonic-acid gas could not be discovered, which may possibly be owing to the degree of putridity and to the difficulty of solving these gases in water. But these proportions must also be considered in connection with carbonic acid, which is just as hurtful to fish as nitrogen.

The percentage of gases in two different specimens of water from the river Saale (the temperature of the room being 20° C.), was that given

under No. I and No. II, whilst retting water, at the same temperature, showed a different percentage:

	Saale water.				*Retting water.*	
	I.		II.			
Oxygen	29.5	=1	25.9	=1	4.2	=1
Nitrogen	65.1	=2.4	57.6	=2.86	29.9	=22.8
Carbonic acid	5.4		16.5		65.9	

The proportion of oxygen to the other gases which can be expelled by boiling and which produce suffocation, has therefore been decreased *ten* fold. Taking finally into consideration the fact that 1,000 cubic centimeters retting water contained 64 cubic centimeters gases, whilst repeated experiments with river water showed that the same contained only 30.32 cubic centimeters, the fatal character of the mixture will become still more apparent in its relation to the breathing and life of fish.

It cannot be doubted, therefore, that retting water will kill fish by its lack of oxygen, if from no other cause. In this all observations made on a large and small scale will agree. The fish immediately gasp for air until they become tired, and finally suffocate. Even leaving this hurtful mixture of gases out of our calculation, it must be granted that putrefying substances must exercise a hurtful influence, both directly by producing changes which are injurious to life, and indirectly by rapidly absorbing oxygen and thereby depriving the surrounding objects of this gas which is so essential to all life.

If only small quantities of retting water are mixed with large quantities of running water there may be no immediate evil consequences, whilst if this proportion is reversed the injurious consequences will make themselves felt very soon; in either case, however, poisonous substances are introduced in the water which had better be kept out of it.

The introduction of retting water into fishing waters should therefore be strictly prohibited, and has actually been prohibited in many places. The retting water may be employed much more suitably in irrigating meadows, where, owing to the loose soil, it loses its putrid character very soon, and aids in forming good food for plants. It would be still better if the moist method of retting could be altogether abandoned, and the dry method adopted in all cases, or if other and less injurious methods could be discovered and come into general use.