#### ON ANIMAL LIFE IN WATER CONTAINING FREE ACIDS. 185

40 ounces, and were filled about half full. It was found in most cases (I might almost, indeed, say in all) that the nitrate-of-silver solution was not required, the water and hydrochloric acid absorbing all the arsenic which was in the air drawn through.

The idea of arsenic being present in the atmosphere surrounding chemical works is by no means new. The fact of its existence in large amounts in the ore from which the greater amount of our vitriol is made leads one to suppose that it must find its way into the atmosphere at one place or another; but I believe this is the first time the comparative amounts have been brought forward. It would be very interesting to have similar analyses made on this subject in the various works where large quantities of sulphur ore are burnt, so that we could have an idea of the amount of this impurity which is being daily thrown into the atmosphere in the neighbourhood of Manchester.

I also made some attempts to determine the amount of arsenic in grass grown close to the works at which these experiments were carried on; but the result was very unsatisfactory. The grass should be got from some distance from the alkali-works, in the direction of the prevailing winds.

XXII. On Animal Life in Water containing Free Acids. By H. A. Smith, F.C.S.

Read April 30th, 1872.

So much has been written lately concerning animal life, its origin, and the conditions under which it can originate and exist, that I thought it might be interesting to find out to what extent it could be present in water containing free acids, and also to notice how far free acids prevented its origination.

The animals upon which the experiments were tried were the Rotifers (*Rotifer vulgaris*). These were obtained by washing a certain amount of air in distilled water and exposing the washings to the air in a small wooden vessel, which was kept lightly covered. Five days elapsed before they came to perfection.

The method of procedure was very simple:—One litre of air in the neighbourhood of an alkali-work was washed in a glass vessel with 100 cubic centimetres of pure distilled water; this was then transferred to a small wooden vessel and allowed to stand in the laboratory, at a temperature which remained nearly constant at  $60^{\circ}$  F. Previously, however, the total amount of acidity had been obtained, which equalled 0.065 grm. per litre. This was calculated in the first place as sulphuric acid.

After having stood five days, the liquid presented a very lively appearance when viewed under the microscope, and the Rotifers seemed in a very active condition. The total acidity was now raised, by the further addition of sulphuric acid, to 0.084 grm. per litre; but there was no perceptible difference in the appearance of life. On raising the acidity still higher\* (to 0.097 grm. per litre) a very decided difference was observed. The appearance of the liquid was no longer clear, but became of a light brown shade; whilst the Rotifers were apparently unwilling to move, and when any disturbance took place in the fluid their motion was very sluggish. This seemed to be a definite point in the action of the acid. Small "clots" of vegetable matter also became visible, presenting a charred

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<sup>\*</sup> In every case, in these experiments, on the addition of acid, the liquid was allowed to stand an entire day before further addition.

appearance. Acid was again added till the total acidity had reached 0.153 grm. per litre. The appearance now presented was similar to the former, except that life was still more languid, and after an hour all had ceased. The whole solution presented the appearance of being filled with decomposed and decaying organic matter floating about in shreds. Thinking that perhaps the length of time which had elapsed since the Rotifers had been obtained might have had some effect, a portion of the original solution which had been kept apart for the purpose, but to which no acid had been added, was examined, and the life found to be as active as at its first origination.

A number of experiments were also made in order to see what amount of free acid would prevent the origination of life. In the above case it was seen that 0.065 grm. per litre did not prevent it, that being the original acidity of the liquid. The amounts given below were then tried with the following results :—

Time allowed to stand.	Total acidity.	Remarks.
days.	grm. per litre.	
8	0.070	Life abundant.
20	0.074	Little or no life.
26	0.080	No life.

Here, then, we see, the line of demarcation is distinctly marked, 0.004 grm. per litre making a very decided impression on, if not completely stopping, the origination of life, and 0.01 grm. per litre entirely preventing it.

The next acid tried was hydrochloric acid. The same amount of air was taken and treated in a similar manner, the acidity in this case amounting to 0.0085 grm. per litre, calculated as hydrochloric acid.

This, after being left for five days under the same conditions as formerly, was very full of life and in active condition.

The acidity was now raised to 0.01 grm. per litre, and the solution allowed to stand twenty-four hours. The appearance of the solution had not varied to the smallest degree. On further acidification till the amount reached 0.018 grm. per litre, no difference was observed between the present and the original solution. However, on the further addition of 0.001 grm. per litre (that is, on raising the acidity to 0.019 grm. per litre) a very decided difference was noticeable; all life had become extinct. The change from active life to death was almost instantaneous, and could be most distinctly seen by the microscope. The bodies of the Rotifers, generally so clearly white and transparent, became, immediately on the addition of the acid, of a dull opal-like appearance; and all movement was arrested. The solution remained clear; and the bodies of the Rotifers were seen floating in it, becoming rapidly acted upon by the acid. Even while watching, in the short space of ten minutes they became "shredded." Here, then, the line between life and death is very sharp, much more so than in the observations with sulphuric acid.

The present experiments extended over the same space of time as those in the former case—eight days from the time of washing air, or four days from time of first observation.

The same attempts were made as formerly to find the amount of acidity which would prevent life originating, the present results being :—

Time allowed to stand.	Total acidity.	Remarks.
days.	grm. per litre.	Confronte (B)
5	0.0085	Life abundant.
26	0'009	No life.

Thus, then, we see that the addition of 0.0005 grm. per litre of hydrochloric acid prevented the origination of life,

showing that the action of that acid on animal life is much more marked than that of sulphuric.

Sulphurous acid was next tried; and the action of this acid was very marked and rapid.

For these observations I took some Rotifers and placed them in pure water, free from acid. The sulphurous acid was then added.

On the addition of 0.002 grm. sulphurous acid per litre, the appearance of the solution completely changed. The Rotifers became more active, darting about, and making such a great disturbance in the fluid that microscopical examination became a matter of some difficulty. When this acidity was raised to 0.004 grm. per litre, they became quiet and very sluggish, a peculiar twitching action of the tail being the only indication of life.

The solution was now acidified to 0.01 grm. per litre; but by degrees all motion ceased, and about three hours after the last addition of acid all life had become extinct. The action of this acid is not so rapid as either that of hydrochloric or sulphuric acid; a smaller amount, however, is required for the destruction of animal life.

Water, acidified with 0.002 grm. sulphurous acid per litre, was treated similarly to the former solutions, to see if life could originate in water containing that amount of free sulphurous acid; but after standing twenty-one days no life was visible. I could not obtain any symptom of life in water containing this acid.

I do not consider these observations at all complete; they only show the action of these acids on one species of animal life, the Rotifers. If we took either a higher or a lower degree of life, we should probably find that our results would be in some degree different.

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In this case we find that sulphuric acid has the least harmful effect on that species of animal life, hydrochloric and sulphurous acids following in order. I only lay these results before the Society thinking they may have some interest in themselves.

I have put my results into a more compact form in the following Tables :---

Time allowed to stand.	Total acidity.	Remarks.
days.	grm. per litre.	
5	0.062	Animal life very abundant. Rotifers
6	0.084	No perceptible difference in the ap- pearance of life.
7	0*097	Brownish shades now evident in the water; want of clearness in portion examined: small "clots" of vege- table matter become visible. Roti- fers languid, seemingly disinclined to move.
8	0.123	Life continued for about an hour; all traces then disappeared. The water presented the appearance of being filled with decomposing and decay- ing organic matter, which was float- ing about in "shreds."

TABLE I.-Acid used, Sulphuric Acid.

TABLE II.-Acid used, Hydrochloric Acid.

Time allowed to stand.	Total acidity.	Remarks.
days. 5 6 7 8	grm. per litre. 0'0085 0'0109 0'018 0'019	<ul> <li>Same as in Table I.</li> <li>No perceptible difference in the appearance of solution.</li> <li>No difference observable.</li> <li>Life almost immediately extinct. Fluid still clear; bodies of Rotifers seen floating in it, but of a dull opal-like colour, and becoming rapidly acted on by the acid, seemingly becoming "shredded."</li> </ul>

#### IN WATER CONTAINING FREE ACIDS.

#### TABLE III.-Acid used, Sulphurous Acid.

Time allowed to stand.	Total acidity.	Remarks.
days.	grm. per litre.	and a second the second second second second
5		Life very abundant.
ő	0'002	Rotifers more active, causing great dis- turbance in liquid.
7	0.004	Life sluggish; Rotifers not inclined to move.
8	0.01	After <i>three</i> hours all life extinct; no obvious action on the bodies of the animals.

### Experiments on the Amount of Free Acid contained in Water in which Animal Life can originate.

# TABLE IV.-Acid used, Sulphuric Acid.

Time allowed to stand.	Total acidity.	Remarks.
days. 8 20 26	grm. per litre. 0'070 0'074 0'070	Life abundant. Little or no life. No life.

## TABLE V.-Acid used, Hydrochloric Acid.

Time allowed to stand.	Total acidity.	Remarks.
days. 5 26	grm. per litre. 0'0085 0'009	Life abundant. No life.



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