XXIII. *On the spontaneous purification of Thames water.* *By* JOHN BOSTOCK, *M.D. F.R.S. &c.*

Read April 30, 1829.

IN the Report respecting the analysis of the water of the Thames, which I presented, in April 1828, to the Commissioners appointed by His Majesty to inquire into the supply of water in the Metropolis, I have stated that when the experiments were nearly brought to a close, a quantity of water was sent to me, purporting to have been "taken in the river, in the current of, and immediately at the mouth of the King's Scholars' Pond sewer." I described it as "in a state of extreme impurity, opaque with filth, and exhaling a highly fœtid odour." When it had been about a week in my possession, a considerable quantity of black water subsided from it, but the fluid was still dark-coloured and opaque, and nearly as offensive as at first, while the odour and colour were only in part removed by being passed through a layer of sand and charcoal, six inches in thickness.

The water remained for some time in my laboratory without being attended to; when after an interval of some weeks, I observed that a great change had taken place in its appearance. It was become much clearer, whilst nearly the whole of the sediment had risen to the surface, where it formed a pretty regular stratum of about half an inch in thickness; the odour, however, still continued extremely offensive, perhaps even more so than at first. From this time the process of depuration, which had thus spontaneously commenced, was continued for about eight weeks, when the water became perfectly transparent, without any unpleasant odour, although still retaining somewhat of its original dingy colour.

After the formation of the scum mentioned above, the next change that I observed was its separation into large masses or flakes; to these, as well as to the scum itself, a number of minute air bubbles were attached, to which, no doubt, they owed their buoyancy; after some time the masses again subsided, leaving the fluid almost totally free from any visible extraneous matter. The quantity of gas discharged was inconsiderable, so that it was difficult to obtain any of it for examination. It seemed to be principally composed of carbonic acid, containing a little sulphuretted, and perhaps carburetted, hydrogen gas.

When the process of depuration appeared to be complete, the water was filtered through paper, and was then subjected to the same mode of analysis which was employed on the former occasion*. It was now perfectly transparent, and without taste or odour, but still retaining a slight brown tinge. It sparkled when agitated or poured from one vessel to another, and by boiling a quantity of gas was disengaged from it: at the same time a thin film of carbonate of lime formed on the surface, which gradually subsided: 10,000 grains left by evaporation a saline crust, of a light brown colour, which, after being thoroughly dried, weighed 7.6 grains. By the appropriate tests, the water was found to contain lime, sulphuric acid, muriatic acid, and magnesia. There was a trace of alumine and an indication of potash; but no ammonia, sulphur, or iron could be detected. The lime, the magnesia, and the sulphuric and muriatic acids were all of them obviously in much greater quantity than in the specimens of the Thames water previously examined. If we suppose the sulphuric acid to be combined with a part of the lime, and the remainder of the lime to be in the state of carbonate, and that a part of the muriatic acid is combined with the magnesia and the remainder with soda, as was conceived to be the case in the Thames water generally, the respective quantities of these salts in 10,000 grains will be as follows:

	grs.	grs. Salts contained in the Lambeth water, which was considered as the most impure of the specimens formerly examined.
Carbonate of lime	4.20	1.55
Sulphate of ditto	.66	.12
Muriate of soda, Muriate of magnesia	2.74	.23
	7.60	1.90

The result of this analysis shows, that although the water has, by this depurating process, freed itself from the great quantity of organic matter which it

* Report, p. 80—81.

contained, and acquired a state of apparent purity, which might render it sufficiently proper for many purposes, yet that the quantity of saline matter is increased as much as four-fold. The greatest proportionate increase is in the muriates, which are very nearly twelve times more in the purified water than in the Thames water in its ordinary state. The carbonate of lime is between two and three times as abundant as before, and the sulphate of lime between five and six times. I may remark, that this water, when examined in its foul state, gave very obvious indications of both sulphur and ammonia, neither of which could be detected after depuration.

This depurating process may be denominated a species of fermentation; *i. e.* an operation, where a substance, without any addition, undergoes a change in the arrangement of its component parts, and a new compound or compounds are produced. The newly formed compounds were, in this case, entirely gaseous, and, except a part of the carbonic acid, were discharged. The saline bodies, being not affected by this process, remained in solution, leaving the fluid free indeed from what are considered as impurities, yet so much loaded with earthy and neutral salts, as to be converted from a soft into a hard water*. The source of the saline bodies may be supposed to be the organic substances, principally of an animal origin, which are so copiously deposited in the Thames; of these the most abundant are the excrementitious matters, as well as the parts of various undecomposed animal bodies. The different species of the softer and more soluble animal compounds act as the ferment, and are themselves destroyed, while the salts which were attached to them are left behind. It may be conceived therefore, that the more foul is the water, the more complete will be the subsequent process of depuration; and we have hence an explanation of the popular opinion, that the Thames water is peculiarly valuable for sea stores, its extreme impurity inducing the fermentative process, and thus removing from it all those substances which can cause it to undergo any further alteration.

The brown colour which the water exhibited after its depuration appeared to depend on the solution of a minute quantity of what is generally termed extractive matter, and which is observed in water that contains decayed vege-

* The terms hard and soft, as applied to water, are obviously relative; but water which contains as much as 5 grains in the pint of saline matter, is generally regarded as too hard for many œconomical and manufacturing processes. The water in question contained 4.36 grains per pint.

table substances; it is almost always present in the beginning of winter in the water of ponds, or of slow streams that have received the falling leaves. After the heavy rains that occurred in December 1827, the New River water, with which my cistern is supplied, was observed to be very turbid and dark-coloured. By remaining some hours at rest, a quantity of earthy matter subsided, and left the water nearly transparent, but the dark colour still continued*.

I found that this colouring matter was not removed by boiling, nor by filtration through sand and charcoal, but that alum and certain metallic salts, especially when heated with it, threw down a precipitate, and left the water without colour. Of the metallic salts the most effectual appeared to be the sulphate of iron; a drop of the solution of this salt, boiled with 500 times its bulk of the water, threw down a flocculent, orange-coloured precipitate, and left the water perfectly colourless. I obtained the same results, only much less in degree, when these re-agents were added to the Thames water after its depuration.

The sediment which was removed from the water by filtration, as mentioned above, appeared to be a heterogeneous mass of various substances, about $\frac{9}{10}$ths of which was siliceous sand; it also contained a black matter, which gave the whole a dark gray colour, and which was removed by a red heat, a number of fine fibres that looked like animal down, and some large fibres probably of vegetable origin; there were also bits of wood, fragments of coal, and small shining particles of a metallic nature, which seemed to be sulphuret of iron. The mass indeed consisted of all those substances which were casually introduced into the Thames, and which had not been decomposed by the fermentative process. They must of course differ, both in quantity and in quality, in every different portion of the water, so to render it unnecessary to attempt a more minute examination of them; in the present instance, the sediment, when completely dried at a temperature of 200°, was in the proportion of about 9 grains in 10,000 grains of the water.

* It is not easy to institute any exact comparative scale of the shades of brown. An infusion formed by digesting, for 10 days, powdered galls in twenty times their weight of water, and afterwards diluting the infusion with an equal bulk of water, will exhibit a colour nearly similar to that of the New River water in the state in which I examined it.