OBSERVATIONS ON THE MOVEMENTS OF THE POLLUTIONS OF THE TYNE ESTUARY DURING THE SUMMER OF 1901.

(Two Figures.)

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The present absence of any Statutory regulations as regards the discharge of sewage and other pollutions into tidal waters has allowed many estuaries in this country to be converted into receptacles for the filth of the sea-port and manufacturing towns situated near the mouth of the larger rivers. Only by an order of the Local Government Board, made after local enquiry and on sanitary grounds, can an estuary be declared a stream and thus brought under the various Rivers Pollutions Acts.

There is good reason to believe that in certain estuaries the polluted water is carried up and down by the tide and is cleared out to sea comparatively slowly. Dibdin (Report to the London County Council, No. 227, 1894) has demonstrated in the Thames the existence of a long zone of such pollution. In parts of this zone the dissolved oxygen at times falls to 0·6 c.c. per litre, or about one-tenth the normal amount—the oxygen being taken up by the micro-organisms for the oxidation of the organic matter present in the water.

Parry and Adeney have this year communicated to the Institution of Civil Engineers the results of their investigations of the condition of the estuary of the Liffey after the discharge into it of the sewage of Dublin. So far these are the only studies of the kind with which I am acquainted.

During the summer of 1901, while studying the influence of pollutions upon fish, I made a series of observations on the estuary of the Tyne, which is of interest in connection with the question of the movements of the polluted waters in that estuary.

In these investigations the amount of dissolved oxygen was taken as the measure of the degree of pollution, since the extent to which the dissolved oxygen is removed from the water depends upon the amount of organic matter undergoing putrefactive or bacterial disintegration in it. From the fishery point of view, it was the only question of interest, since it had been shown that the prejudicial action of such polluted water upon fish is due to the diminution in the oxygen required for respiration and not to the presence of toxic substances.

Method.

Ramsay's method of estimating the dissolved oxygen was adopted, since it is rapid and gives results sufficiently accurate for the present purpose. (*Journal of Chemical Industry*, 30th Nov. 1901.)

It was impossible to carry out these analyses at the river side, and all samples had to be sent by train to Edinburgh. It was therefore essential that some method should be adopted which would give concordant and comparable results. Dibdin's plan of shaking the water up with air to full saturation and then leaving it exposed to air for 24 hours appeared to me the fairest means of measuring the probable condition of the water in the river channel, since the fully oxygenated water of the non-tidal part of the stream is in the estuary exposed to air from which it can take up oxygen.

It was found that with most samples of water an equilibrium was established between the water and the air, so that the amount of oxygen in solution remained the same for considerable periods at the laboratory temperature of about 13° C. The following table, showing the number of c.c. of dissolved oxygen per litre of water, after different periods, illustrates this statement.

Samples of September 4 (Low Tide).

	Days after shaking		
No. of sample	2	4	6
1	1	–	1
2	1	1	1
3	5	3	–
4	2	2	2
5	1	–	2
6	3	–	2

Samples of September 4 (High Tide).

	Days after shaking			
No. of sample	2	4	6	13
1	3	–	2	3
2	3	3	2	
3	3	2		
4	4	2	2	
5	5	–	5	
6	5	5	5	

Samples of July 19th.

	Days after shaking		
Nos. of samples	1	2	3
5 & 6	5—5	4—4	4—4
2 & 3	2·5—2·5	3—3	3—3

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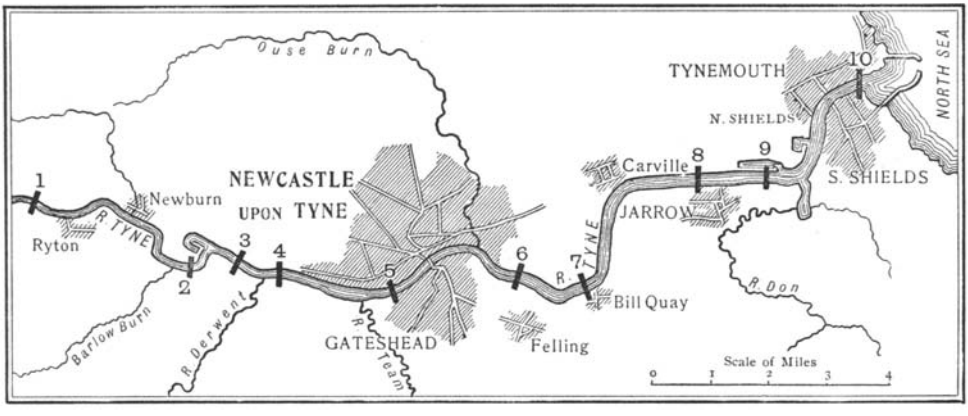
To show the extent to which sea-water was present the chlorine of the various samples was determined by titration with nitrate of silver solution in 10 c.c., and expressed as chloride of sodium per cent.

Description of the Tyne and its Estuary.

The upper reaches of the North Tyne are fairly pure. The South Tyne is said to be polluted by a deposit of lead on the gravel, though the evidence of this is hardly conclusive. From the point where North and South Tyne join, the river runs for 18 miles and becomes tidal at Hedwin Stream between Carlisle and Ryton. The tidal portion of the river (see map) extends from this point for a distance of eighteen miles to the original bar, which is now dredged out, and beyond which two long breakwaters extend seaward for a distance of about a mile.



Into this tidal part Newcastle, Gateshead, Jarrow, South Shields, Tynemouth, and a large number of manufactories discharge their sewage and effluents, and four very much polluted tributaries enter. On the south side the Derwent from the Tyne enters between Scotswood and Benwell, the Team enters just above the Shot Factory in Newcastle, and the Don comes in above Jarrow Slake. On the north side the Ouse Burn enters at Newcastle.

The existence and position of these streams are of importance in understanding the tidal movements of the polluted water.

Particulars of the pollution discharged into the main stream will be found in an appendix to this paper.

As to the condition of the blind part of the river called Bell's Close

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and of the two tributaries, the Team and Derwent, Inspector Dagg writes as follows:—

"The blind piece of river at Bell's Close has only water in it when the tide is in the river: at low water it is dry. It was closed up as shown on the map by the Improvement Commissioners, who made a new watercourse.

"The tide goes some distance up both the Team and the Derwent. In the low part of the Team no fish are ever seen of any kind; it is very much polluted by sewage from several places, colliery water, and a brown-paper mill. The Derwent is the same. It runs through a thickly populated mining country, it has three paper mills, two white, and one brown-paper, and several other works on it. It is also very much polluted, and only at floods are fish seen in the lower part of it."

The Dissolved Oxygen of the Water of the Estuary.

My observations on the amount of dissolved oxygen in the water in this estuary were carried out during the summer of 1901. The season was exceptionally dry, and as the summer advanced the volume of water in the river steadily decreased.

Owing to the pressure of other work it was found impossible to make more than a limited number of examinations or to extend the analyses beyond the determination of the free oxygen.

Method of Procedure.

On May 31st a preliminary survey of the river was made by my assistant Mr Patterson along with Inspector Dagg. Samples of water were then taken from certain places near the banks which the Inspector considered specially foul.

In all subsequent examinations the samples were taken from mid-stream and at a depth of three feet. These samples were taken at various points from the top of the tideway down to the original bar. These points are indicated on the map. As it was desirable to study the state of the river in different conditions of the tide, observations were made both at high and low water, sometimes on the same day, sometimes on different days.

Record of Observations.

I. The first examination was made on May 31st when water was collected at the following points about high tide.

1. Dunston Staithes, close to south bank.

2. Between High Level and Redhaugh Bridges at sewer outflow on north bank.

3. About 50 yards up mouth of Ouse Burn.

4. Bill Quay close to south bank.

5. Mouth of Don River at Jarrow Slake taken at commencing flood tide.

6. Mid-stream opposite Tyne Dock entrance taken at commencing flood tide.

These samples were not shaken with air but were examined on June 1st with the following results:—

	NaCl %	Free oxygen c.c. per litre	
		Individual observations	Average
1.	1·5	2—2—3	2·3
2.	2·0	2—2—2	2
3.	1·3	0—0	0
4.	2·5	3—4	3·5
5.	1·4	0—0	0
6.	2·5	4—4—5	4·3

II. The second examination was made on water collected on June 20th at low tide (overlapping spring), *i.e.* nearer spring than neap.

	NaCl %	Free oxygen c.c. per litre
Hedwin Stream	·02	6
Low Benwell Ferry	1·20	4
Shot Factory	2·16	5
St Peter's	2·12	5
Bill Quay	2·16	3
Jarrow Slake	2·64	5

III. A third examination was made on water collected on July 8th at high tide.

	NaCl %	Free oxygen c.c. per litre
Lower Benwell	1·88	3
Shot Factory	2·16	2·5
St Peter's	2·66	3·5
Bill Quay	2·60	4
Jarrow Slake	2·92	5

IV. and V. The fourth and fifth examinations were made on water collected on July 16th, first at high and second at low tide (spring tide and lower ebb than 20th June).

	High Tide.			Low Tide.		
		Free oxygen c.c. per litre			Free oxygen c.c. per litre	
	NaCl %	Separate observations	Average	NaCl %	Separate observations	Average
Shot Factory	2·14	3—3	3	1·86	4—5	4·5
St Peter's	2·54	4—4	4	1·98	2—3	2·5
Bill Quay	2·64	4—6	5	2·16	3	3
Jarrow Slake	3·0	4—6	5	2·62	5—5	5
Original Bar	3·0	4—6	5	2·82	5—5	5

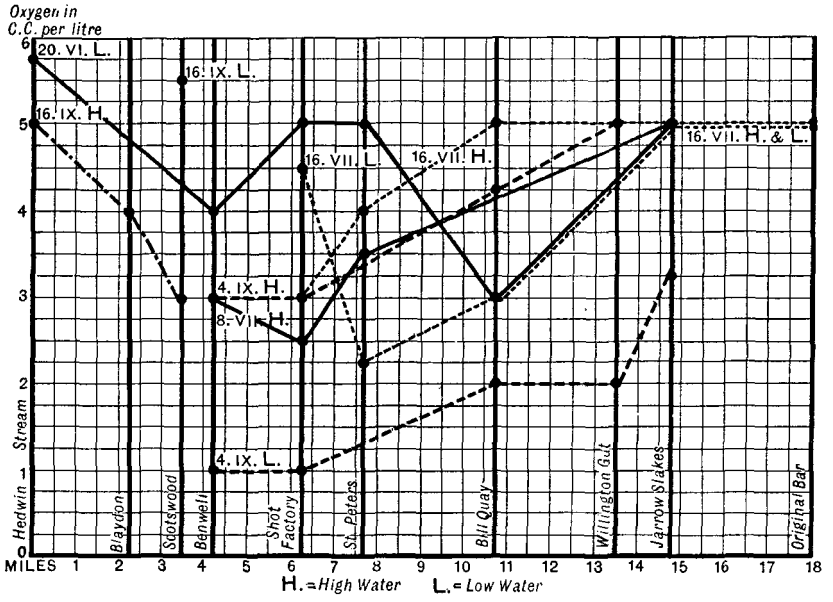
VI. and VII. The sixth and seventh examinations were made on water collected on September 4th at high and at low tide.

	High Tide.		Low Tide.	
	NaCl %	Free oxygen c.c. per litre	NaCl %	Free oxygen c.c. per litre
South Benwell	1·60	3	1·20	1
Shot Factory	1·74	3	1·40	1
Bill Quay	2·20	4	1·86	2
Willington Gut	2·66	5	2·26	2
Jarrow Slake	2·84	5	2·56	3

VIII. and IX. The eighth and ninth examinations were made on September 16th and 17th at high and at low tide.

	High Tide.		Low Tide.	
	NaCl %	Free oxygen c.c. per litre	NaCl %	Free oxygen c.c. per litre
Hedwin Stream	0	5		
Blaydon	1·68	4	Lost	Lost
Scotswood	1·80	3	0·76	5—5

From these tables the following diagram of the distribution of free oxygen in the Tyne Estuary at different parts of the summer has been constructed.



CONCLUSIONS.

The present observations are all too few, but they are published in the hope that they may induce others to take up the study of estuarial pollution. Although so limited they seem however to indicate pretty clearly the main difference between the Tyne and such a river as the Thames, and to explain how it is that salmon can pass through the estuary of the former.

The difference appears to be due to the fact that tributary streams enter the Tyne, and that the polluted water is forced into these by the advancing tide to be again poured out into the main stream as the tide recedes. A fairly pure waterway is thus provided at high tide, while at low tide if the amount of upland water in the main stream is sufficient, as in the earlier part of the summer, the impurities from the tributaries are diluted and partly washed out; but if the upland water is insufficient, as in September, these impurities make themselves manifest and cause a marked and serious diminution in the oxygen in the water of the main river.

While in the Thames the zone of pollution simply moves up and down with the tide and becomes more concentrated as it is forced back

at high water, in the Tyne we have found little evidence of such a concentration, and the river appears to become filled with the purer inflowing sea-water.

At high water the zone of least oxygenated water is between Benwell and Shot Factory, but even here the amount of oxygen does not fall much, if at all, below 50 % of the normal.

At low water the zone of greatest deoxygenation varies. On June 21st it was at Bill Quay, on July 16th at St Peter's, and on September 3rd from Benwell to Shot Factory. As the upland water decreased this zone of pollution extended upwards. In June the dissolved oxygen did not fall below 50 %. In July it fell only slightly below this, but in September it fell as low or lower than 16 %.

In conclusion I desire to acknowledge the very valuable assistance given me by Inspector Dagg, who not only collected all the samples of water analysed but also supplied very valuable information as to the state of the river and its tributaries. Without his intelligent co-operation these investigations would have been impossible.

APPENDIX.

EFFLUENTS (ALL UNTREATED) DISCHARGED INTO THE TIDAL PORTION OF THE TYNE.

Site of Outfall	Nature of Effluent—*i.e.* whether Mineral, Chemical, Sewage or other Effluent
A. *On South Bank of Tyne*	
South Shields, between the Law and Tyne dock	Sewage from South Shields and Westoe, and effluent from Colliery and from Gas Works
The "Don" which enters the River and Jarrow Slake	Water from Boldon Collieries, effluent from Paper Mills, sewage from Tyne Dock, and East and West Harton villages, drainage from chemical refuse heaps
Jarrow	The whole of the sewage refuse from Gas Works, effluent from Chemical Alkali Works, Lead Works, Creosote Works, and drainage from chemical refuse heaps
Hebburn	The whole of the sewage effluent from Sulphur and Copper Works, Acid and Chemical Works, Lead and Paint Works, and Hebburn Colliery
Bill Quay	The whole of the sewage refuse from Lead and Paint Works, effluent from Colliery
Felling and along right bank of Tyne to Gateshead	The whole of the sewage effluent from Alkali Works, Brown-Paper Mill, and a large amount of drainage from chemical refuse heaps
The "Teams" entering at Dunstan	Effluent from Colliery, sewage from Dunston, Gateshead and Low Fell Teams and other villages. Effluent from Brown-Paper Mills, Creosote Works
The "Derwent" entering at "Derwenthaugh"	Effluent from various Paper Mills and numerous Collieries. Sewage from Swalwell and other villages
Blaydon	The whole of the sewage from Blaydon Stella and Addeson village. Effluent from Alkali Works, Manure Works, and Collieries
B. *On North Bank of Tyne*	
Tynemouth at the Black Middens	Part of the sewage from Tynemouth
North Shields	The whole of the sewage from North Shields, Flatworth, Percy Main. Effluent from Gas Works, Collieries, Lead Works, Creosote Works
Howden	The whole of the sewage and effluent from Lead and Antimony Works
Willington Quay	The whole of the sewage and a large filthy and acid discharge from Copper Works
Low Walker	The whole of the sewage effluent from Copper and Acid and Gelatine Works
Wallsend	The whole of the sewage effluent from Collieries and drainage from chemical refuse heaps
Bill Point	Effluent from Colliery and drainage from chemical refuse
St Anthony's	The whole of the sewage effluent from Lead Works and drainage from chemical refuse heaps
St Peter's	The whole of the sewage
Ouseburn	Sewage from several villages—Byker, Jesmond, and part of Newcastle Effluent from Collieries, Lead and Colour Works, Tanneries
Newcastle from Ouseburn to Elswick	The whole of the sewage effluent from several Collieries, from Tanneries, Lead Works, Gas Works
Delavel	Sewage from Delavel, Benwell, and South Benwell villages, and effluent from Colliery
Scotswood	Sewage from Scotswood and Denton Burn villages, and effluent from Colliery and Brown-Paper Mill
Lemington	Sewage from Lemington and Bells Close villages and effluent from Colliery
Newburn	Sewage from Newburn, Walbottle, Throckley, and Heddon villages, and effluent from three Collieries