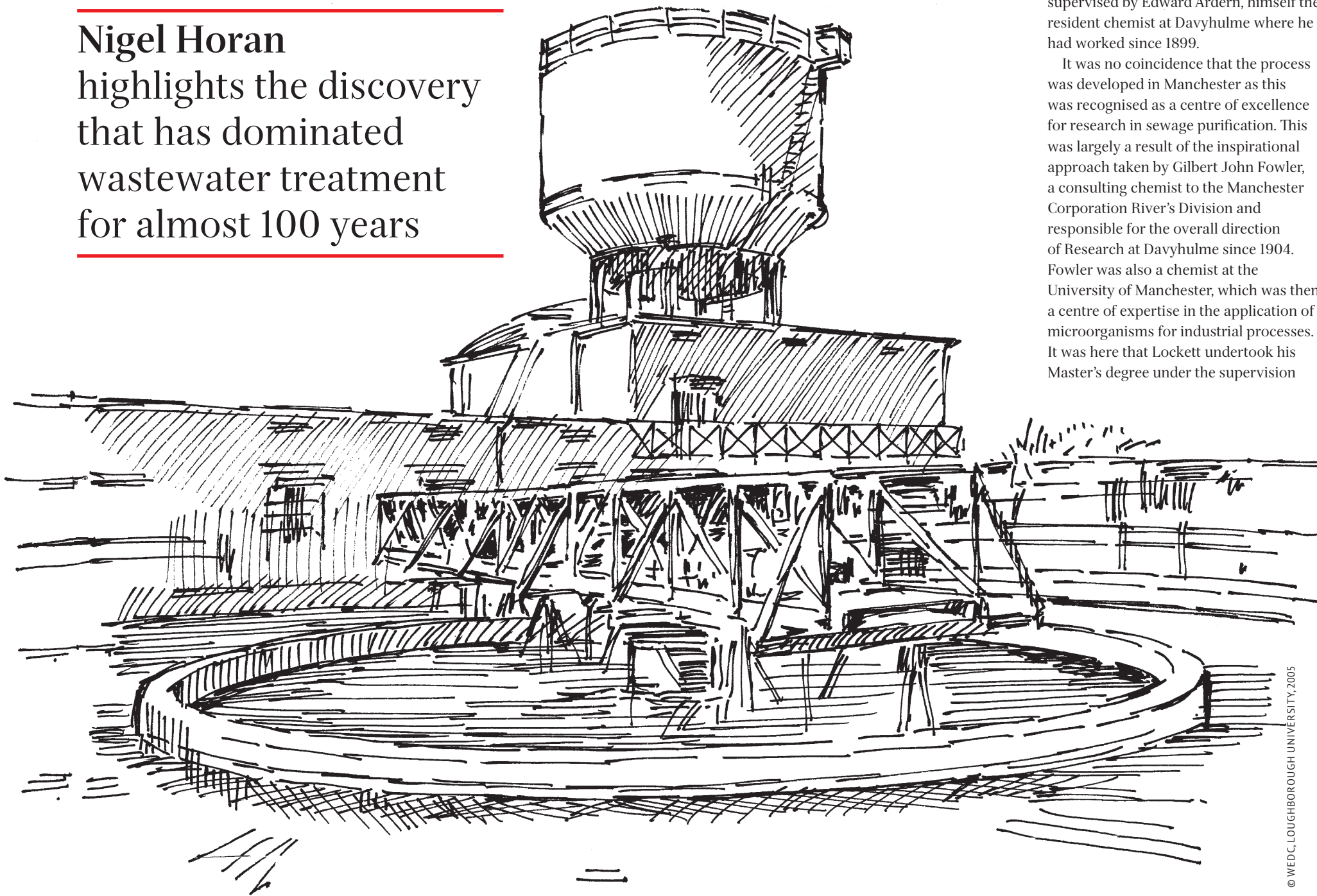


Celebrating THE REVOLUTION

Nigel Horan
highlights the discovery
that has dominated
wastewater treatment
for almost 100 years



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It is generally acknowledged that a presentation to the Society of Chemical Industry at the Grand Hotel in Manchester on 3 April 1914 by Edward Arden and William Lockett entitled: 'Experiments on the oxidation of sewage without the aid of filters' marks the discovery of the activated sludge process. At the time of its discovery, William Lockett was the junior member and working as a chemist employed by the Manchester River's Department undertaking research at the Davyhulme laboratories. This work was supervised by Edward Arden, himself the resident chemist at Davyhulme where he had worked since 1899.

It was no coincidence that the process was developed in Manchester as this was recognised as a centre of excellence for research in sewage purification. This was largely a result of the inspirational approach taken by Gilbert John Fowler, a consulting chemist to the Manchester Corporation River's Division and responsible for the overall direction of Research at Davyhulme since 1904. Fowler was also a chemist at the University of Manchester, which was then a centre of expertise in the application of microorganisms for industrial processes. It was here that Lockett undertook his Master's degree under the supervision

of Chaim Weizman, later to be the first president of the new state of Israel.

Weizman worked closely with Gilbert Fowler and they were responsible for supervising the work of two research assistants E Moore Mumford and Gladys Cliffe, who were later to be married. Mumford was working on a bacterial isolate from a local colliery. Known as M7, it was able to clarify sewage in the presence of air and iron salts. Fowler considered that the use of a naturally occurring microorganism to undertake the treatment of sewage was a great breakthrough.

Much of the inspiration for the discovery at Davyhulme resulted from a visit by Fowler to the USA in November 1912 in connection with the pollution of New York Harbour. In the light of his work on M7 he was ideally placed to benefit from a visit to the Lawrence Experiment Station at Massachusetts, where experiments were underway to aerate sewage in the presence of algae and other organisms, grown as a biofilm on slabs of slate held an inch apart in an aeration basin. Over a period of 24-hour aeration, a well-clarified and partially nitrified effluent could be produced. On his return to Davyhulme, Fowler initiated research along similar lines to be carried out by Arden and Lockett. Thus, in 1913, they undertook the aeration of Manchester raw sewage in 80 oz bottles with a tube inserted that was bent at 90 degrees and through which air was passed to provide continuous and thorough mixing. Although it seems simple and straightforward now, Lockett subsequently commented in 1954 that: 'Forty years ago deliberate mixing of sludge and sewage, in order to obtain or accelerate purification of the sewage was quite an unorthodox and revolutionary procedure.'

Using this revolutionary procedure, after five weeks of continuous aeration they were able to obtain complete nitrification. At the end of this period the clear liquid was decanted and further raw sewage added to the original deposited matter. This process was repeated a number of times and it was observed that as the deposited matter increased, then the time required for the succeeding oxidation was reduced. Eventually a fresh sample of raw sewage could be fully

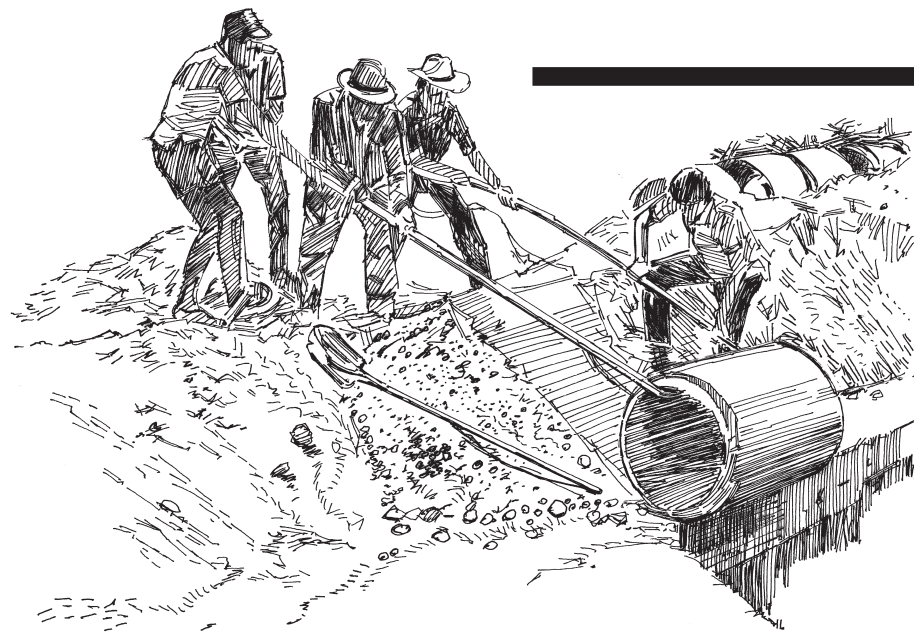
oxidized within 24 hours.

Unfortunately there is no romantic story attached to the naming of the process by which this was achieved and the authors commented: 'For reference purposes and failing a better term, the deposited solids resulting from the complete oxidation of sewage have been designated activated sludge.'

Up to this point, work on the process had been undertaken at laboratory scale and Lockett realised the need to undertake further work at a larger scale in order to establish the economic and practical feasibility of providing the necessary aeration. The funding for this second stage was provided in part by the Worshipful Company of Grocers who offered an annual scholarship for the encouragement of 'Original Work in Sanitary Science'. The terms of the scholarship were that the proposed work should relate to the then prevalent problem of preventing premature death. Almost all previous scholarship holders were of the medical profession, investigating more traditional medical based solutions. However, Lockett was successful with his application, and indeed it was renewed for a further two years before finally being withdrawn in 1918. Lockett attributed his success in obtaining this scholarship to the fact that several eminent members of the Panel of Assessors, had also served on the Royal Commission on Sewage Disposal.

Commercialisation of the process in the UK was rapid and a Messrs Jones and Attwood, a West Midlands manufacturers of greenhouse equipment, showed interest in the patent as they were able to manufacture appropriate air distribution equipment. Fowler's significant contribution to the process now becomes apparent since he allowed Walter Jones of Messrs Jones and Attwood, to patent the process in return for £1,000 in the form of shares. But the Manchester Rivers Committee, who also suspected that Jones and Attwood, as well as themselves, were paying Fowler for his services, did not view this action favourably. A vote of censure by the Council was narrowly lost and shortly after in 1915, Fowler moved to the Indian Institute of Science in Bangalore where he continued to work on the nitrogen cycle and the agricultural use of sewage sludge.

Historically, April 1914 was probably



the worst possible time to unveil the process. Just six weeks later Archduke Franz Ferdinand was assassinated in Sarajevo, initiating the start of the Great War on 28 July of that year. Over the next four years 13,000 soldiers of the Manchester Regiment alone were killed on the western front and one of these, E. Moore Mumford was to die from his war wounds. But war rarely interferes with commerce and construction of new plant continued throughout the war with 12 cities establishing experimental plants in 1915 alone.

In order to allow Lockett to pursue the new lines of research into methods of aeration, as required by his Grocer's scholarship, a full-scale continuous flow unit was constructed at Withington by Jones and Attwood through the conversion of an existing tank, to accept 250,000 gallons per day, about ten per cent of the works total flow. This was commissioned in September 1917 and following a very successful period of operation, a second unit designed to treat a dry weather flow of 1,000,000 gallons per day was constructed at Davyhulme in early 1921.

The majority of the new works being undertaken at that time were awarded to Jones and Attwood. Their success might be attributed to their novel form of contract in which installation was undertaken at their own risk and only when it had demonstrated its worth based on the effluent quality, was it taken over by the client. This arrangement was used for what was effectively the first full-scale activated sludge plant, built at Worcester in 1916 to treat a flow of 626,000 gallons. A similar arrangement was used at the

Stamford plant built in 1922 and which handled a flow of 186,000 gallons per day.

So rapid was the uptake of this invention that in 1927, Arthur Martin, a consulting engineer and past president of both the Institute of Sanitary Engineers and the Association of Managers of Sewage Works (the forerunners of CIWEM) was able to publish a 400-page textbook, *The Activated Sludge Process*.

By this time, however, all of the work of Jones and Attwood in relationship to the activated sludge process was transferred to a new company, Activated Sludge Limited, based in Westminster and established in 1919. It proved to be a very litigious venture and in the late 1920s filed suits for patent infringements against Chicago, Milwaukee, Cleveland and a number of smaller cities. The success of these suits meant that many cities that intended to install activated sludge, simply elected to build filters rather than pay the steep royalties. As a result uptake of the process stalled until the patents expired in the late 1940s.

But from that point onwards the activated sludge process has been the dominant technology worldwide for large, urban treatment plants. It has seen many process advances: nitrogen removal, phosphorus removal and improvements to sludge settling characteristics. But in the performance of its basic function of BOD removal, it has changed little over the past century. It has seen many other processes come and go and in the absence of realistic competition, it may well go on to celebrate its bicentenary.

And what of its acknowledged inventors Ardern and Lockett? Both these men continued to lead distinguished research

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careers after 1914, publishing more than 25 papers in the Institution journal. These ranged from the microscopy of activated sludge and the role of protozoa, the use of sewage sludge as an agricultural amendment and in 1920 they investigated the potential of generating methane as a valuable product from the digestion of sludge. Both of them went on to become presidents of the Institution, Edward Ardern in 1929 - 30 and William Lockett in 1942. Whereas Ardern remained at Manchester until his retirement, Lockett moved on to become the chief chemist of the Middlesex County Council Drainage Department (now Thames Water) in the early 1930s. So, as with all great inventions, there comes a time and a place. The intellectual setting at Davyhulme provided by Fowler proved the ideal environment for the practical and talented chemists Ardern and Lockett. In this age where we strive for more innovation in the water industry, we can learn a lot from this simple and effective model. ●

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To commemorate the achievements of Ardern, Lockett and Fowler at Davyhulme, CIWEM's Wastewater Management Panel is organising a centenary event on 3-4 April 2014. This event, sponsored by United Utilities and supported by the Society of Chemical Industry, will involve two days of invited contributions covering the past, present and future of activated sludge. It will feature a large trade exhibition, as well as an historical exhibition tracing the history and development of the activated sludge process around the world. Further details of the conference can be obtained from sarahhickinson@aquaviro.co.uk. If you have any anecdotes of the early development of the process that would prove of interest for the exhibition, please contact Nigel Horan on n.j.horan@leeds.ac.uk.