

The Agricultural Pollution of Watercourses: The Precedents Set by the Beet-sugar and Milk Industries

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Abstract

The inter-war years were an important period in the development of an institutional and research response to pollution issues. The paper focuses on the problems arising from the newly-established beet-sugar factories and the increasingly-centralized milk-handling and -processing industries. Through research and development, it proved possible to accommodate the otherwise wholly welcome developments in rural enterprise, without incurring the risk of serious pollution to the nearby watercourses.

IN JUNE 1990, two of the UK Research Councils, namely the Agricultural and Food Research Council and the Science and Engineering Research Council, established a Clean Technology Unit. It was pointed out that 'leaks' and waste products had often occurred within the interlinked processes that characterized farming and the manufacture of farm produce. In some instances they posed a serious environmental threat. The Unit was intended to promote research that forestalled pollution, rather than removed it at the 'end of the pipe'. Through the rigorous analytical approach of process engineering, control strategies would be developed for the whole production process.

The purpose of this paper is to provide an historical context for the concern and commitment embodied in the Clean Technology and other initiatives, being taken to mitigate, if not eliminate, forms of agricultural pollution. The examples are drawn from the inter-war years. Not only were these decades important for the development of an institutional framework to fight pollution in the United Kingdom, but they yielded further examples of how innovation, whilst wholly welcome from an economic, social and political stance, might nevertheless bring unwelcome environmental impacts. The paper will cite the

experiences of the newly-established beet-sugar factories and increasing centralization of milk collection and distribution, and the processing of milk products.

I

An institutional framework that sought to ensure that policy initiatives were underpinned by surveys and experimentation, began to evolve in the 1920s. Mounting concern as to 'the deplorable position of the (inland) fisheries in relation to river pollution' caused the Ministry of Agriculture and Fisheries (MAF) to appoint an advisory Standing Committee on River Pollution (SCORP) in 1921. Representatives of the salmon, trout and coarse fishing interests, which had done so much to highlight the state of the rivers, together with representatives of the Federation of British Industries, made up the membership of the committee, which was chaired initially by the Fisheries Minister and later the Fisheries Secretary, Henry G Maurice. Through a greater knowledge of the condition of individual watercourses, and collaboration between fishing interests and industry, the Ministry hoped to encourage major improvements.¹

¹ J Sheail, 'Pollution and the protection of inland fisheries in inter-war Britain', in M Shortland, ed, *Science and Nature*, Oxford, 1993, pp 41-56.

As each river was surveyed, or re-surveyed, members of the SCORP and their respective fishery bodies, demanded action to tackle the many examples of pollution identified. Whilst refusing to countenance the establishment of a central statutory body to administer the river system, the Government conceded the need for a more comprehensive approach to research. River pollution was a national problem that would require many years' work to resolve. A Water Pollution Research Board was appointed in 1927, under the aegis of the Department of Scientific and Industrial Research (the forerunner of the Science (and Engineering) Research Council). The Board's Director of Research, W T Calvert, was Chemical Inspector for the Ministry of Health, having previously been Chief Chemist to the West Riding of Yorkshire Rivers Board.²

The Board had three research objectives, namely the treatment of water for public supply, purification of sewage, and prevention of pollution by trade effluents. As the Principal Assistant Secretary of the Department of Scientific and Industrial Research (DSIR), Henry T Tizard, told the first meeting, the Government were prepared to meet the costs of purely scientific work; the costs of the industrial applications would be borne by industry. More positively, there were outstanding opportunities to fulfil an avowed intention of the DSIR, namely to bring companies in relevant sectors of industry together jointly to fund and facilitate the necessary research. Annual reports of the Board recounted the close contacts made with companies. Relevant information and facilities were made freely available to the Board's scientists.³

By the outbreak of war in 1939, the volume and reputation of the Board's work warranted the establishment of a central research laboratory. Prominent among the water-pollution issues investigated, that included detailed surveys of the river Tees and Mersey estuary, were investigations as to ways of treating beet-sugar and milk effluents. Temporary war-time accommodation was provided for a Water Pollution Research Laboratory in 1940.⁴

II

The pollution caused by beet-sugar effluent was so serious and novel as to make the factory-owners pioneers in forging the kind of close relationship sought between different industries and the Water Pollution Research Board. Whilst sugar beet (*Beta vulgaris*) had been grown for nearly two centuries, a large-scale processing industry had only developed in the 1920s (Fig 1). The amount of beet sugar manufactured rose from 7000 tons in 1922-3 to over 500,000 tons by 1938-39. A report published by the MAF in 1931, described the establishment of the industry as a 'large-scale experiment without parallel in the recent history of this country'. Direct State support was provided under the British Sugar (Subsidy) Act of 1925. By the time the Water Pollution Research Board was set up in 1927, there were fourteen factories, and the prospect of many more. An inquiry into future support for the industry, in 1935, found them well-equipped; they compared favourably with those on the Continent. Beet-sugar production was 'a technical process of considerable nicety'. As a continuous operation from washing

² Water Pollution Research Board (WPRB), *Water pollution research 1947*, HMSO, p 1.

³ Public Record Office (PRO), DSIR 13, 5; WPRB, *Report for the year ended 29 June 1931*, HMSO, 1931, pp 2 & 6-8; H Melville, *The Department of Scientific and Industrial Research*, 1962.

⁴ PRO, DSIR 13, 93; WPRB, *Water pollution research 1939-1945*, HMSO, 1947.

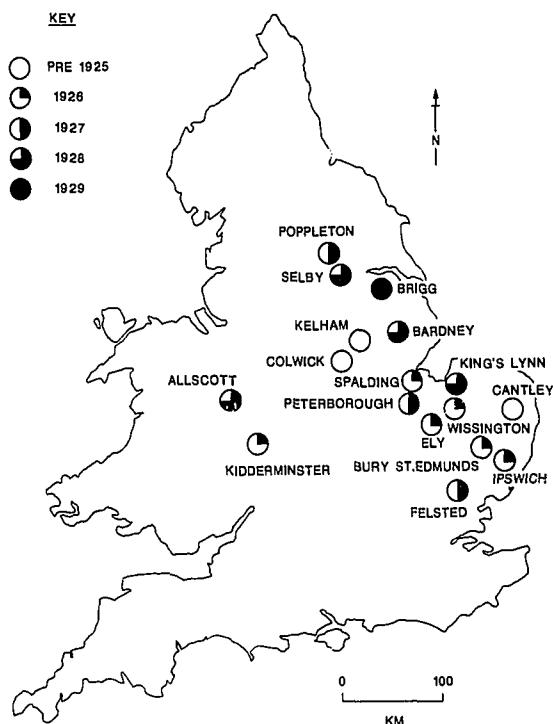


FIGURE 1

Development of beet-sugar factories (after H D Watts, The location of the beet-sugar industry in England and Wales, 1912-36, *Transactions of the Institute of British Geographers*, 53, 1971, p 109)

the roots to the bagging of the sugar, it had to be carefully balanced (Fig 2).⁵

Much publicity was given to the fact that nothing was wasted. If the farmer kept the beet tops, and could be persuaded to use the residues from the manufacturing process (as happened on the Continent and in America), practically everything was returned to the soil. There remained, however, the question of the waste waters, that would have to be discharged to nearby streams or rivers. Whilst they contained scarcely any directly toxic substances, the organic matter decomposed

so rapidly as to reduce the concentration of dissolved oxygen to so low a level as to destroy fish and other aquatic life, characteristic of a healthy river.⁶

When King George V toured the Colwick factory in November 1926, local newspapers highlighted how he enquired as to what became of the waste waters, commenting, 'You must be very careful you do not get in danger of river pollution'. The Managing Director assured him that the water was not returned to the river until it had been filtered and purified. Less than half of one per cent in weight of the beet was lost during the manufacturing process. A month later, however, magistrates fined the company £25, with £15 costs, as a result of an action brought with reluctance, but after due warning, by the Trent Fishery Board. The secretary of the Nottingham City Police Angling Club recounted how hundreds of dead and dying fish had been found. Chemical analysis of the river water, and post-mortem examination of two bream, carried out by lecturers at University College, Nottingham, pointed to their having been killed by the beet effluent.⁷

Visually, the most obvious effect of pollution was the growth of the saprophytic organisms, known collectively as 'sewage fungus'. Whereas it was commonplace to find a small growth within a short distance of the outfall of sewage works, an unmistakable and heavy crop extended for some twenty miles along the river Ouse, below the Ely and Wissingtton factories, and for twelve miles downstream of the Bury St Edmunds works in Suffolk. Besides its unpleasant appearance, portions of the fungus broke loose and floated downstream in masses, adhering to any obstruction. In time, every object in the water might be covered, thereby

⁵ Ministry of Agriculture and Fisheries, *Report on the sugar beet industry at home and abroad*, Economic series 27, HMSO, London, 1931, p i; PP, 1934-35, XI, Ministry of Agriculture, *Report of the UK Sugar Industry Inquiry Committee*, Cmd 4871; H D Watts, 'The location of the beet sugar industry in England and Wales', 1912-36, *Trans Inst Brit Geog*, 53, 1971, pp 95-116; H D Watts, 'Conflict and collusion in the British sugar industry 1924-28', *Jn Hist Geog*, 6, 1980, pp 291-314.

⁶ *Nottingham Journal*, 24 November 1926.

⁷ *Nottingham Guardian*, 17 November 1926; *Nott Jn*, 25 November and 9 December 1926.

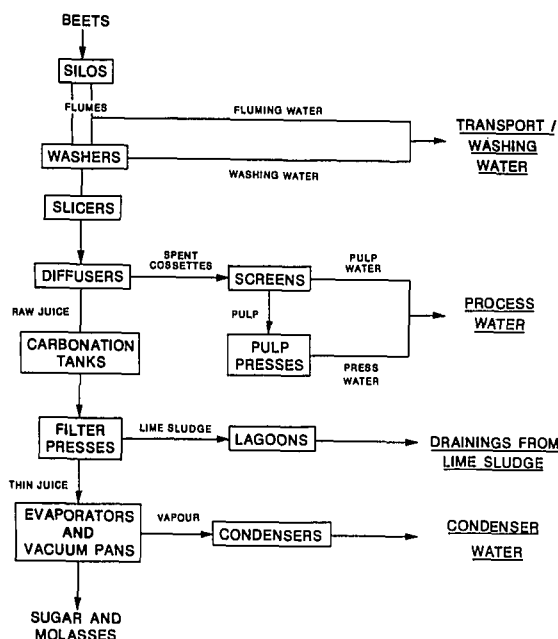


FIGURE 2

Discharges of waste waters from a beet-sugar factory (after B A Southgate, *Treatment and disposal of industrial waste waters*, 1948, p 317)

further displacing the plant and animal life characteristic of the watercourse.⁸

The impact of beet-sugar effluent on river life was most closely studied by MAF fishery biologists on the river Lark, below the Bury St Edmunds factory. They highlighted how some problems could arise from ignorance on the part of those operating the plant as to how effluents behaved. The water used to wash the beets was stored at the beginning of the 1926–7 manufacturing season in the mistaken belief this would improve its quality. The water contained not only mud in suspension, but the tips and parts of the beet. Through fermentation, it became black and so foul-smelling that, after a fortnight, it was discharged, causing a six-mile length of the river Lark to become almost completely deoxygenated. The effect was

disastrous. Fish came to the surface and died, and smaller animals were almost completely wiped out.

Whilst careful management of the effluents might avoid such catastrophic effects, the oxygen content of the water was still too low to support fish during periods when the factory was in use. The fish must either migrate downstream or into tributaries free of the effluent. The additional stock to those waters was likely to lead to over-population, causing semi-starvation and greater incidence of disease and predation. Whilst the fish were observed to re-populate the polluted stretches, after each season, fishery biologists warned of how there could be no guarantee that this would continue. Having been driven away so many times, the surviving fish might abandon the polluted stretch altogether.⁹

As the MAF conceded, in its Economic Report on the industry in 1931, nobody wished to interfere with an industry new to the country and of great potential value to agriculture. There had been 'a fairly general disinclination to set the law in motion against the offending factories'. As an official of the Ministry of Health emphasized, the problem did not arise through a lack of foresight, but rather from the absence of any means to tackle it. Whilst the MAF had obtained, through the Foreign Office, much useful information on practices on the Continent and in America, it was clear that 'no completely successful method of treating effluents' had been found. It was an outstanding example of the need for 'a body of technical information on which remedial measures' could be based. In supporting the case for the establishment of the Water Pollution Research Board, the Ministry of Health insisted on the

⁸R W Butcher, F T K Pentelow and J W A Woodley, 'An investigation of the river Lark and the effect of beet sugar pollution', *Ministry of Agriculture and Fisheries Fishery Investigations Series*, I, vol 3 (3), 1930; PRO, MAF 41, 99.

⁹PRO, MAF 41, 300 & 312.

problem of beet-sugar effluents being placed at the top of its agenda.¹⁰

III

The fact that the research on beet-sugar effluents was to be carried out under the aegis of the Water Pollution Research Board meant there was every opportunity for applying the knowledge and experience gained to other industries, where the incidence of pollution imposed similarly heavy costs, both on the river environment and, ultimately, the industry itself. The benefits of this form of 'technology transfer' were highlighted by the treatment of effluents in the dairying and milk-products industries, and later the search for economies in local-authority sewage disposal works.

The treatment of beet-sugar effluent

At the instigation of the Ministry of Health and MAF, a meeting was held with the Technical Committee of the British Sugar Beet Society, to consider what joint action could be taken. The latter agreed to form an Effluent Subcommittee as a means of sharing information on waste disposal. On the recommendation of the MAF, G Bertram Kershaw (who had acted as engineer to the pre-war Royal Commission on Sewage Disposal) was appointed to visit all factories, so as to advise on immediate measures and to formulate a longer-term programme of research.¹¹

Most factories were designed to deal with 1000 tons of beet a day during the annual 'campaign', which usually lasted a hundred days from the lifting of the first beet in October. From the storage silos, the beets were transported by water flowing in flumes through a washing machine, after which they were cut into slices or

'cossettes' (Fig 2). It was usual to place the cossettes in diffusers, in which they were treated with hot water to dissolve the sugar and other soluble substances. The solution was treated with lime and carbon presses. Finally, the partially purified solution of sugar was concentrated in multiple-effect evaporators and in vacuum pans, to yield crystalline sugar and molasses.

Some three to four million gallons of water a day might be required for the manufacturing process. Kershaw distinguished two forms of waste water, namely the transport/washing water and condenser water, and, secondly, the process water and drainings from lime sludge. In his report of March 1927, he identified a number of remedial measures that could be taken straightaway in dealing with the wash and condenser water. The three million gallons of water, used each day for transporting and washing the beets, might contain over 150 tons of soil and beet debris, together with a small amount of dissolved organic substances. It was usual to pass the water through settling ponds, and to screen it. Whilst standards varied, Kershaw found them to be generally unsatisfactory. The earth-banked ponds were generally large and, except at Peterborough, little thought had been given to their design. Sand banks were easily formed; the deposited material was difficult to remove. Kershaw emphasized how a continuous flow could be maintained if well-designed sedimentation tanks were used in a series, the first being for the removal of grit, sand and other heavy material, the second to extract leaves and other beet debris, and the last for removing the bulk of the remaining suspended solids. Screening should be carried out in stages, final screening by self-cleaning fine-aperture filter.¹²

¹⁰ Ministry of Agriculture, *op. cit.*, 1931; PRO, DSIR 3, 2 & MAF 41, 303.

¹¹ PRO, MAF 41, 303.

¹² WPRB, *Report for the year 1927-28*, HMSO, 1928, pp 7-11; WPRB, *Report for the year ended 30 June 1929*, HMSO, 1930, pp 11-19; PRO, MAF 41, 99.

The 'really taxing problem' was the treatment of the process water and lime sludge. Once the sugar was extracted, the spent-cossettes were pressed to remove excess moisture. This process water, of up to 500,000 gallons a day, contained considerable amounts of organic material in true, or colloidal, solution. One of Kershaw's first moves was to visit the Rothamsted Experimental Station. The Director of the Station, Sir John Russell, and head of the Fermentation Department, Eric Hannaford Richards, agreed, in January 1927, to carry out research (subject to DSIR funding) that might 'shed light upon the useful recovery, or special treatment', of these waters. A DSIR Technical Paper was published in 1933, in which Richards and D Ward Cutler, the head of the General Microbiology Department, reported their research findings.¹³

Three possible means of purification were identified, namely fermentation using lime, bio-aeration with an 'activated' sludge, and thirdly (and by far the most promising) biological filters, whereby purification was achieved through the life processes of bacteria or microbes. In an early report, Richards and Cutler described, in trials at Rothamsted, how filters had achieved a standard of 95 per cent purification of an acid-tank liquor from a jam factory. The combined waste from a large jam factory was almost as polluting as the strong 'portions' of beet-sugar effluent. Effluents of a high standard were obtained in the laboratory, using mangolds and dried beet. Richards and Cutler suspected that attempts at large-scale biological treatment had previously failed, because of inadequate screening and badly-designed filters. Even whole beets might be found in the overloaded filters.¹⁴

¹³ E H Richards and D Ward Cutler, *The purification of waste waters from beet sugar factories*, HMSO, DSIR Water Pollution Research, Technical Paper 3, 1933.

¹⁴ PRO, DSIR 13, 5 & 8.

The Water Pollution Research Board strongly endorsed further trials, both in the laboratory and at a semi-commercial scale, to assess the effect of such factors as the strength of the liquor, rate of flow, and size of medium, upon the oxidation of the press water. Discussions held at the instigation of the Chairman of the Water Pollution Research Board, Sir Robert Robertson (the Government Chemist) led to an agreement, whereby facilities (including laboratory accommodation) were provided free of charge by the Anglo-Scottish Beet Sugar Corporation Ltd at Colwick. The industry as a whole agreed to contribute £3000 towards operating costs over three campaigns. Two filters, each of 25 feet in diameter and 6 feet in depth, were designed by, and constructed under the supervision of, H C Whitehead, the Chief Engineer of the Birmingham, Tame, and Rea District Drainage Board. Whitehead had been appointed to the Water Pollution Research Board in 1927 as 'the man in the sewage world with the most scientific outlook'. Two chemists and biologists from Rothamsted were placed in charge of the trials.¹⁵

Despite exasperating and continuous breakdowns of the screening plant, the trials at Colwick indicated that standards of over 90 per cent purification could be achieved from filters of about 6 feet in depth, if most of the suspended solid matter were removed and the strength of the liquor were diluted to the equivalent in strength of a solution containing about 0.1 per cent sucrose. Dilution might be effected by mixing with river water, effluent from the filter, or transport and washing water. The diluted water should be filtered at a rate not exceeding 100 to 150 gallons per cubic yard of medium per day. The most suitable medium was a

¹⁵ PRO, DSIR 13, 2 & 5.

hard, insoluble material, such as gravel, flint or slag.¹⁶

By the third and last year of the Colwick trials, studies of a more fundamental kind were underway as to how carbohydrates decomposed. A survey provided important insights into the kinds of organisms present on the biological filters.¹⁷ If it were possible to inoculate the filters with selected organisms, and thereby increase the rate of purification and reduce the amount of time needed for new filters to mature, there would be major opportunities for reducing the size and operating costs of such plant. In practice, it was found that inoculation with medium from a sewage-works percolating filter made no apparent difference to the purification of the effluent. There was no difference in the development of the population in the filters, other than the introduction of insect larvae at an earlier stage than occurred in the uninoculated filters.¹⁸

The treatment of milk effluent

The Annual Report of the Water Pollution Research Board for 1931-32 was the first to refer to preliminary experiments with discharges from depots and factories producing milk-products. It was noted how problems were similar, in many respects, to those of beet-sugar effluent. At the meeting of the Board, in April 1933, the Chairman, Sir Roy Robertson, emphasized the need to tackle them before further large depots were established. Whereas few handled over 5000 gallons a day before the war, a through-put of 50,000 gallons a day was becoming commonplace. Under the Agricultural Marketing Act of 1931, proposals had been put forward for a marketing system for England

and Wales, which, if implemented, would lead to much greater concentration of milk collection and distribution. Similar proposals had been made for the Glasgow and Aberdeen areas of Scotland.¹⁹

Because the demand for milk was fairly constant, but output was much higher in spring and summer, some of the surplus was manufactured into butter or cheese. Of the 900 million gallons sold under contract in 1935-36, some 38 per cent was used for manufacturing purposes. Waste waters from these centres consisted mainly of water mixed with milk, and sometimes caustic soda and other detergents. The waters were largely derived from five sources, namely the washings and milk draining from the floors, churns and their lids, the equipment used to wash the churns, the pasteurizing plant, and the cooling plant. Since the processes that gave rise to the milk washings were intermittent, there was a wide fluctuation in the volume and character of waste waters during the day.

On a tour of plant in early 1933, Cutler and Richards found none of the methods used to treat and discharge the variety of effluents to be wholly satisfactory. The washings from the depot at Castle Cary were passed through a septic tank, and then irrigated over land planted with osiers, before being discharged into the river Brue. Under an agreement with the local authority, the effluent from the Evercreech depot (which also made some cheese) was mixed with sewage from a hundred houses, before being treated in the same way and allowed to flow into the river Alham. Up to 3000 gallons of effluent a day were treated by septic tank and percolating filters at the comparatively large depot and seasonal cheese-

¹⁶ PRO, DSIR 13, 6; Richards and Cutler, *op. cit.*, 1933.

¹⁷ PRO, DSIR 13, 8; WPRB, *Report for the year 1927-28*, HMSO, 1928, pp 13-6.

¹⁸ WPRB, *Report for the year ended 20 June 1931*, HMSO, 1931, pp 6-8.

¹⁹ WPRB, *Report for the year ended 30 June 1932*, HMSO, 1933, pp 5-7; WPRB, *Report for the year ended 30 June 1933*, HMSO, 1934, p 6; PRO, DSIR 13, 14; S Baker, *Milk to market: forty years of milk marketing*, London.

making factory at Sparkford, before being discharged into the river Spark.²⁰

A detailed study of the impact of milk wastes was made on the Bristol Avon by the fishery biologists of the MAF between 1934 and 1936. The most obvious effect of the effluents from the factory at Chippenham, producing condensed milk and dried milk food, was the increase in the turbidity of the water and growth of sewage fungus on a scale almost as extensive as that caused by beet-sugar factories. As with beet-sugar effluent, the most promising methods appeared to be much-modified forms of the processes used at sewage disposal works. In a series of trials at Rothamsted, good results were obtained from both biological filtration and the activated sludge process. Whilst a single percolating filter produced effluents of good quality, there was a major limitation. Solid fatty matter soon accumulated in the upper layers of the filtering medium, causing them to become choked. This could be avoided by first allowing the milk washings to ferment in an open tank for one or two days. The fats and other solid matter would be deposited as a sludge at the bottom of the tank, or as scum on the surface. The separated liquid could then be passed through the filter. Not only was there a problem of disposing of so much sludge, but the smell was awful.²¹

During large-scale trials, some years previously at the Minworth works of the Birmingham, Tame, and Rea District Drainage Board, a percolating filter became similarly clogged with sewage. It was cleared by diverting sewage effluent from another filter. Whitehead recollected the incident and, with the Board's Chief Chemist, F R O'Shaughnessy, indepen-

dent trials were conducted in their laboratories. Preliminary fermentation was found to be unnecessary, if the waste waters (after sedimentation) were treated in two percolating filters in series, and the order of these filters was changed every two or three weeks. The slimy, solid matter deposited in the top layers became granular, and was oxidised or washed away, when the filter became the second in the series.²²

The Water Pollution Research Board recognized, as early as July 1933, the need to apply the laboratory findings at a semi-commercial scale. It was the only way to discover how the plant might be designed and constructed at minimum cost, yet consistent with maximum efficiency. Citing the experience of the beet-sugar industry, the Board's Annual Report for 1933-34 urged the dairy industry as a whole to cooperate, both technically and financially. Whilst negotiations began in the autumn of 1933, with the Chairman of the newly-created Milk Marketing Board, Secretary of the National Association of Creamery Proprietors, and Wholesale Dairymen, and personnel in the MAF, it was not until August 1934 that agreement was reached. The Finance Committee of the National Milk Publicity Council was to represent the industry. In the first instance, £2000 per annum would be provided over two years, through the Milk Marketing Board. The Scottish Milk Marketing Board contributed a further £300 a year. A total of £12,050 was eventually raised by the industry.²³

Calvert and Whitehead rejected the factory of Midland County Dairies Ltd at Kilkewydd, near Welshpool, as being too remote as a site for the trials. They accepted, instead, the offer by United Dairies Ltd of a site and laboratory accom-

²⁰ PRO, DSIR 13, 14; F T K Pentelow, R W Butcher, and J Grindley, 'An investigation of the effects of milk wastes on the Bristol Avon', MAF Fish Inv Ser, I, vol 4 (1), 1938.

²¹ PRO, DSIR 13, 10; WPRB, *Report for the year ended 30 June 1934*, HMSO, 1934, pp 4 & 13-8.

²² PRO, DSIR 13, 18; WPRB, *Report for the year ended 30 June 1936*, HMSO, 1937, pp 4-7 & 16-28.

²³ PRO, DSIR 13, 8, 14-6; WPRB, *Report for the year ended 30 June 1934*, HMSO, 1934, p 4.

modation at Ellesmere in Shropshire. The depot handled up to 40,000 gallons of milk a day, of which a small proportion was used for the manufacture of cheese. Whitehead designed and supervised the construction of two sets of experimental plant, both of which were operated over the three-year period, August 1935 until September 1938. One plant consisted of two percolating filters, each 25 feet in diameter. Milk washings or whey washings, or mixtures of the two, could be passed through, after settlement, with the filters working in parallel, or in either order in series. The other plant used the activated sludge process.²⁴

At a meeting of the Board in October 1937, Richards described how trials at Ellesmere, using double filtration, had produced effluents of excellent quality, with a biochemical oxygen demand of less than 1 part per 100,000, when settled and dilute crude liquid (with a biochemical oxygen demand of 20 to 30 parts per 100,000) was discharged at a rate of 160 gallons a day per cubic yard of medium in the two filters together. Not only were the effluents of higher quality, but filtration was likely to be far more robust than the activated sludge process. Operating conditions at a depot or factory would be much more demanding than in a carefully-regulated sewage disposal works. Whereas the 'activated' sludge process was easily upset by flushes of liquid of abnormally high strength, perhaps after a mishap in the factory, there might be only a temporary deterioration in the quality of the final effluent from filters. Any excessive deposition of solid matter could be rapidly removed.²⁵

The Annual Report for 1935-36 reported how several factories had installed, or were planning to instal,

purifying plant on the basis of the information already obtained. The design of the plant at the Whitland factory of the United Dairies Company in Carmarthenshire was directly based on the Ellesmere findings. It produced a final effluent of excellent quality, with a biochemical oxygen demand of between 0.1 and 1.0 part per 100,000. A DSIR Technical Paper, summarising the results of the various trials, was completed in October 1939.²⁶

The treatment of sewage

There was a possibility of a further transfer of skills and experience, this time to the vastly greater challenge of sewage disposal. At a meeting of the Board in July 1937, Whitehead drew particular attention to the quality of the effluents at Ellesmere, despite their being passed through the filtering medium at a much greater rate per cubic yard than that ordinarily adopted for domestic sewage by single filtration. The financial savings would be considerable if double filtration could similarly increase the through-put of domestic sewage. The Water Pollution Research Board accepted the offer of four of the sixty filters at Minworth for large-scale trials, with the Birmingham, Tame and Rea District Drainage Board meeting the cost of £7000 required to adapt them. Staff were transferred from Ellesmere for the commencement of the trials in October 1938.²⁷

Of the studies of the Water Pollution Research Board, under way at the outbreak of war, only the work at Minworth was continued, albeit at a reduced staffing level. With materials and labour in short supply, it was important to find the most efficient methods of constructing and

²⁴ PRO, DSIR 13, 15; WPRB, *Report for the year ended 30 June 1936*, HMSO, 1937, pp 16-7.

²⁵ PRO, DSIR 13, 18. The measurements are cited in the form used in the original documentation.

²⁶ WRPB, *Report for the year ended 30 June 1936*, HMSO, 1937, pp 4-5; PRO, DSIR 13, 93; Department of Scientific and Industrial Research, *The treatment and disposal of waste water from dairies and milk product factories*, HMSO, Water Pollution Research Technical Paper 8, 1941.

²⁷ PRO, DSIR, 13, 18 & 93.

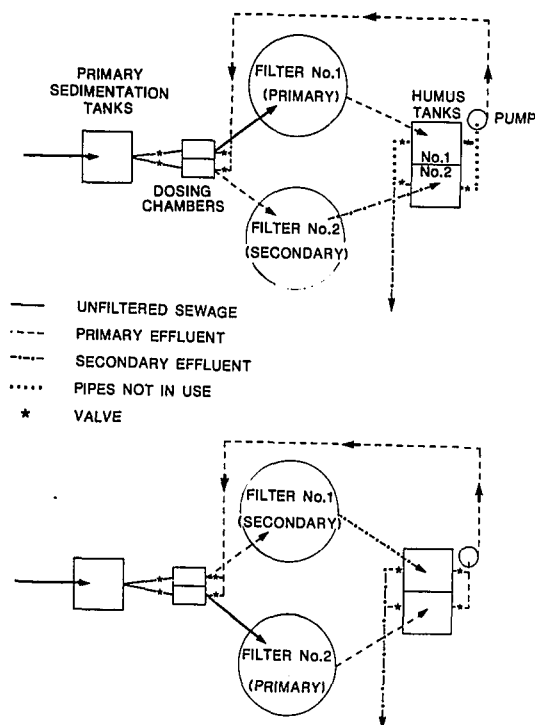


FIGURE 3

Arrangement of plant for treatment of settled sewage by alternating double filtration (after Southgate, *op. cit.* p 62)

operating the new and enlarged sewage-disposal works that would be required for the wartime camps, factories and other establishments. Trials with alternating double filtration, from June 1942 to May 1944, achieved an application rate three to four times that of a single filter, using comparatively weak sewage, as judged by the test of biochemical oxygen demand (Fig 3). Whilst the plant might need twice as many tanks and pumps, there were major capital savings in the number of filters required.²⁸

IV

It quickly became apparent that something more was required than 'end-pipe' treat-

ment for beet-sugar effluents. Not only were there serious doubts on the part of industry as to whether biological filtration on a commercial scale would achieve levels of only 80 per cent purification (the waste waters would still be too polluting for discharge), but the plant would have to be impossibly large and expensive to cope with the considerable volumes of liquor produced during the short, annual campaigns, that corresponded with the coldest months of the year. Whilst farmers were encouraged to 'clamp' down their beet in pits, and factories commonly made clamps in neighbouring fields, there was no satisfactory means of storing beet for long periods so as to enable factories to handle smaller volumes over a longer season.²⁹

The Water Pollution Research Board strove to portray the impasse more positively. Its Annual Report for 1930-31 recounted how, as the work progressed, industry recognized that the intention was to help, rather than hinder, operations. Far from adding to costs, the prevention of pollution could lead to savings. As the Board's first Report pointed out, the real solution was to alter the manufacturing process so as to remove any need for wastes and, therefore, for waste treatment.³⁰

To achieve this end, manufacturing processes had to be reorganized. Visits by Robertson and Calvert to France and Holland provided first hand insights into the procedures adopted, for example, at Marguillies, near Lille, where pollution had been considerably reduced by using the transport and washing waters over and over again. In Britain, the factories at Felsted, Kidderminster, Spalding, and Poppleton (of the Anglo-Scottish group) had adopted the Raabe continuous process, whereby water was returned to the cylin-

²⁸ WPRB, *Water pollution research 1939-1945*, HMSO, B A Southgate, *The treatment and disposal of industrial waste waters*, HMSO, 1948, pp 62-4.

²⁹ MAF, *op. cit.*, 1931, pp 193-7; Southgate, *op. cit.* pp 316-22.

³⁰ WPRB, *Report for the year 1927-8*, HMSO, 1928, pp 7-11; WPRB, *Report for the year ended 20 June 1931*, HMSO, 1931, p 2.

dricul diffuser after the sugar had been extracted from the cossettes. Other groups contended that this would reduce the amount of crystalline sugar that could be extracted from a given weight of beet — a view refuted by later trials conducted by the Water Pollution Research Laboratory. Of much greater weight was the objection that recirculation would increase corrosion of pipelines and lead, therefore, to greater expense and disruption in the manufacturing process.³¹

Whilst the re-use, rather than the treatment, of effluent became the guiding principle of the beet-sugar industry, discharges could not be entirely eliminated. The various liquids of a recirculation system had to be emptied at the end of the campaign. Instances of serious pollution still occurred. At the request of the British Sugar Corporation, the Water Pollution Research Laboratory carried out further trials in the 1944–5 campaign. If the liquor could be run-off at a comparatively low and even rate during the interval between campaigns, it might be possible to treat it effectively in plant of comparatively small size.³²

Again, drawing on the experience of the beet-sugar industry, all parties in the dairy industry recognized the need, wherever practicable, to modify manufacturing processes, so as to reduce the quantity, or the polluting effect, of any waste discharged. Not only were there direct savings to be made, in terms of increasing the amount of milk or milk-derived products to be sold, but there would be significant reductions in the size and cost of the plant needed to treat any waste.

The wastes could be of two kinds. There might be 'wilful losses', where the factory decided not to make use of by-products, such as buttermilk or whey,

from the butter- and cheese-making processes. The Board and its expert advisers were unremitting in their condemnation of such commercial shortsightedness, which also had a devastating effect on watercourses. If the whole of the whey from a cheese factory, handling 10,000 gallons of milk a day, were discharged into a stream, the effect would be comparable to that of the sewage outfall from a town of up to 50,000 people.³³

The second, and more usual, kind of loss arose from the many relatively small losses from different parts of the plant, which in aggregate might represent as much as 0.5 to 1.0 per cent of the volume of the milk handled. Each stage of milk handling and manufacture had to be closely scrutinized. The most important loss from a single source was the drainage of the 10-gallon churns and their lids. By installing a simple drainage rack, with a milk-collecting channel, losses might be halved, if the churns were allowed to stand for between one and two minutes. If very small quantities of water were used for the first washings of the butter- and cheese-making apparatus, they might be added to the buttermilk or whey. Subsequent washings, using larger quantities of water, would have a much less polluting effect, when discharged. Such conservation measures might not only take advantage of the expanding market for dried whey and buttermilk, but they might remove the most serious threats of pollution.

V

As the Board's Annual Report for 1935–36 commented, satisfactory methods had to be quickly found for treating and disposing of sewage and industrial effluents. There would otherwise be considerable difficulty in providing the large volume

³¹ Richards and Ward Cutler, *op. cit.*, pp 1–5.

³² T W Brandon, 'Waste waters from beet-sugar factories. Their treatment and disposal', *International Sugar Journal*, 49, 1947, pp 98–100 & 124–6.

³³ Department of Scientific and Industrial Research, *op. cit.*

of good-quality water required for domestic, agricultural and recreational purposes. As well as long-standing problems still to be resolved, further threats to water purity were bound to arise as the geographical distribution of population and industry changed, industrial processes were modified, and new industries developed.³⁴ This paper has focused on the problems posed by the newly-established beet-sugar factories and increasingly-centralized milk-handling and processing industry. How could these otherwise wholly welcome developments in rural enterprise and employment be promoted and sustained, whilst protecting rivers and streams from the damaging effects of pollution?

Not only was it important for the individual localities and industries that solutions should be found, but the elimination of such forms of pollution would demonstrate, in the most public way possible, the value of the partnership being forged between industry and scientific research, as envisaged by the DSIR in its decision to establish a Water Pollution Research Board. There was no concealing the impatience of Sir Robert Robertson, the Chairman of the Board, to exploit the opportunities offered. From the chair, he expressed disappointment in June 1936, that investigations into the use of biological filtration for treating milk effluents were still incomplete. It was so important 'to publish definite conclusions and precise data as rapidly as possible for the guidance of the industry'. Calvert protested that studies, which simulated as closely as possible the working-conditions of a factory, could not be hurried. At the Ellesmere plant, 'each set of conditions had to be stabilised before changing to another set of conditions, otherwise it would not be

possible to differentiate the effects of the various factors'.³⁵

Even if scientists could not provide the immediate answers sought by policy makers, the Board had no doubt that 'a definite technical advance' had been made, both in terms of transferring technologies from one industry to another, and in the increasing importance attached to modifying manufacturing techniques, as opposed to relying solely on waste treatment. In the Board's view, the experience of its first ten years had given substance to the view that only when all practicable measures had been taken to reduce the quantity of polluting material leaving the factory should methods of purification of the effluents be considered.³⁶

Whilst there was public kudos for industries in enabling such advances to be made through their support, there was no mistaking the unease felt by individual companies as to how the new-found knowledge might be deployed. How far might the availability of new techniques encourage the greater use of statutory controls? The final report of the SCORP, in January 1930, recounted how the beet-sugar industry was 'a pregnant illustration of the useful stimulus that may be given by legal compulsion'. The prospect of a simple and practical method of preventing pollution had already encouraged County Councils to take proceedings against five factories in the 1929-30 campaign, using the powers of the Salmon and Freshwater Fisheries Act of 1923.³⁷

Whilst companies might not complain if legal proceedings brought their competitors up to a common standard, each insisted that the overriding consideration should be 'What was needed to protect the watercourses?', rather than 'What

³⁴ WPRB, *Report for the year ended 30 June 1936*, HMSO, p. 1.

³⁵ PRO, DSIR 13, 17.

³⁶ WPRB, *Report for the year ended 30 June 1937*, HMSO, pp. 14-25.

³⁷ Ministry of Agriculture, *River pollution and fisheries. A non-technical report on the work during 1926, 1927 and 1928 of the Standing Committee on River Pollution*, HMSO; PRO, DSIR 13, 10.

forms of technology are now available?'. The responses to a questionnaire, distributed by the Effluents Sub-committee of the British Beet Sugar Society, gave notice of the anxieties felt by some members. In answer to a question as to how the waste waters were to be dealt with, in the 1930-1 campaign, the Yorkshire Sugar Company protested that not too much should be expected. The factory at Selby was located not only on the tidal part of the Ouse, but the river was very dirty. It would be unjust 'if we were compelled to adopt measures which we quite realise are necessary in some factories but which we are firmly convinced at not at all necessary here'.³⁸

Together with adaptations of the manu-

facturing process and the treatment of wastes, there was increasing recognition of the need for a third dimension in pollution research, namely a fuller understanding of the functional processes of the watercourses themselves and, ultimately, the fragility of the ecosystem. Research agendas were opening up that transcended even the terms of reference of the Water Pollution Research Board. If objective appraisals were to be made of the impacts of pollutants and, therefore, the need for controls, a baseline of knowledge was required as to how the natural environment functioned both in a polluted, and a pristine, state.

ACKNOWLEDGEMENTS

I am grateful for the guidance of Dr H D Watts and the assistance given me by the Cambridge University Library and Public Record Office.

³⁸ PRO, DSIR 13, 8.

Notes and Comments

The 40th AGM was held at 9.00 am in Florence Boot Hall, University of Nottingham, on Tuesday 14 April 1991 with Dr Phillips in the Chair. Mr Havinden was elected as President in succession to Professor Thompson. Dr Collins was re-elected as Treasurer, Dr Perren re-elected as Secretary, Prof. Chartres was re-appointed as Editor. Mr Brassley, Dr Edwards, Professor Thompson, and Dr Phillips were elected as Committee members.

The retiring President thanked the staff at Florence Boot Hall, and Professor Beckett and Mrs Janice Avery of the History Department for their fine work in preparing an enjoyable and memorable conference. The University of Nottingham was thanked for the forthcoming reception before dinner that evening.

Dr Phillips, presented the Committee's report. One meeting of the Executive Committee and two conferences had been held during the year. Dr Collins reported a healthy balance of income over expenditure of £6749 as at 31 January 1992. The accumulated surplus now stood at £1609 compared with a deficit of £5140 on 31 January 1991. We now had 410 UK Ordinary members (a net increase of 1); 73 Overseas Ordinary (a net decrease of 1); 150 UK Library (a net decrease of 3); 119 Overseas Library (a net decrease of 3). This

represents a fall of 6 compared with 1991. Prof. Chartres said that fourteen articles had been submitted from March 1991 to March 1992. The transfer of printing from Leeds University to Charlesworth had been smooth, but the Society would re-tender the printing of its journal every three years to ensure we paid competitive rates. On the subject balance of articles in the *Review*, we still lacked sufficient pieces on the sixteenth to eighteenth centuries. The first of the Supplements was available and others were in hand.

The following changes to the Constitution were agreed. (1) Paragraph 2: replace 'the history of agriculture and rural economy' with 'agricultural history and the history of rural economy and society'. (2) Paragraph 3: delete the sentence 'Candidates for membership shall be nominated by any member of the Society and all such nominations shall be approved by the Executive Committee'. (3) Paragraph 4: delete full point at the end of second sentence and add, 'who may set a lower subscription for those who are registered for a degree and not in full time employment and those who are registered unemployed'.... (4) Paragraph 7: replace 'sixteen' with 'twelve'. (5) Paragraph 8:

(continued on page 70)